Elk Valley Water Quality Plan

2019 Implementation Plan Adjustment

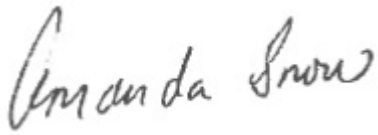
Annex B: Modifications to the Regional Water Quality Model

July 2019

Teck

This report has been prepared by:

GOLDER ASSOCIATES LTD.



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ACRONYMS AND ABBREVIATIONS

Acronym or Abbreviation	Description
AWTF	Active Water Treatment Facility
EVO	Elkview Operations
FRO	Fording River Operations
GHO	Greenhills Operations
IPA	Implementation Plan Adjustment
LCO	Line Creek Operations
PAG	potentially acid generating
RWQM	Regional Water Quality Model
SPO	Site Performance Objective
Teck	Teck Coal Limited
WFTF	West Fork Tailings Storage Facility

UNITS OF MEASURE

Unit of Measure	Description
%	percent
L/s/km^2	Litres per second per square kilometre
m^3/d	cubic metres per day
m^3/s	cubic meters per second
mg/L	milligrams per litre
µg/L	micrograms per litre

1 Introduction

Changes made to the Regional Water Quality Model (RWQM) since submission of the *2017 Elk Valley Regional Water Quality Model Update* (Teck 2017a) on October 31, 2017 are described in this document. The changes were made in support of the 2019 Implementation Plan Adjustment (IPA), and are outlined in Section 2; their effect on model calibration is outlined in Section 3.

2 Changes Made to the Regional Water Quality Model in Support of the 2019 Implementation Plan Adjustment

A total of sixteen (16) changes were made to the model. These changes are detailed in Table 2-1 and summarized as follows:

- Discrepancies between the geochemical source terms reported in Annex A of the 2017 Elk Valley Regional Water Quality Model Update (Teck 2017a) and those reported in Annex D of the same document were corrected (6 of the 16 changes).
- Revisions to historical water management activities in Cedar Pit/Baldy Ridge 6 Pit at Elkview Operations (EVO) were completed, and the chemistry assigned to tailings water directed to the EVO West Fork Tailings Storage Facility (WFTF) in the future was updated (2 of the 16 changes).
- Errors identified in the initial lag times assigned to waste rock in Swift Pit and Lower Fording 2 at Fording River Operations (FRO) were corrected.
- Revisions to historical water management activities in the Clode Creek watershed were completed, to reflect learnings gained through design work being done in support of the Fording River Operations North Active Water Treatment Facility (FRO AWTF-N), and an error in the flow at Eagle 4 Pit at FRO in the future was corrected (2 of the 16 changes).
- Model over-projection in Koocanusa Reservoir was addressed (3 of the 16 changes).
- The ability of the RWQM to replicate observed flow conditions in Erickson Creek at EVO was improved.
- Flexibility in the modelling of AWTFs was improved.

Eight of the 16 changes were minor corrections to geochemical source terms or minor revisions to water management. The remaining eight changes were larger in scope and are discussed in more detail below in Sections 2.1 to 2.5. They relate to the last five bullets listed above.

Twelve of the 16 changes affect model performance over the calibration period. The remaining four changes (i.e., adjustment of the initial lag time applied to Swift Pit and Lower Fording 2, update to the chemistry assigned to tailings water at the EVO WFTF, correction of an error in the flow at Eagle 4 Pit at FRO and adding flexibility in the representation of AWTFs) only affect future projections.

With one exception, the changes made to the RWQM had a small effect on model performance over the calibration period. The exception consisted of the update to historical water management in the Clode Creek watershed; this change triggered a recalibration of the model in the Clode Creek watershed,

including a change to the initial lag time assigned to waste rock in this watershed (as detailed below). At all other locations, the calibration factors and initial lag times for nitrate, selenium and sulphate remain unchanged from those outlined in the *2017 Elk Valley Regional Water Quality Model Update* (Teck 2017a). Model performance over the calibration period, before and after changes were made, is illustrated in figures included in Section 3, along with tables of error and bias statistics for nitrate, selenium and sulphate.

With one exception, the changes made to the RWQM had no effect on the mitigation (i.e., biologically-based AWTFs and clean water diversions) in the 2019 IPA. The exception consisted of the correction of an error in the flow at Eagle 4 Pit at FRO; this change resulted in an increase in the hydraulic capacity of the Greenhills Operations (GHO) Phase I AWTF from 2,500 m^3/d to 5,000 m^3/d and a decrease in the hydraulic capacity of the GHO Phase II AWTF from 5,000 m^3/d to 2,500 m^3/d (as detailed below).

Table 2-1 Updates Made to the 2017 Regional Water Quality Model in Support of the 2019 Implementation Plan

Nature of the Change	Description	2017 Regional Water Quality Model	2019 Implementation Plan Adjustment	Rationale
Correcting geochemical source terms	Constituent release from waste rock: • sulphate solubility limit • calcium to magnesium ratio • flow relationship at West Line Creek	• Sulphate solubility limit of 2,400 mg/L • Calculation of magnesium concentrations based on a magnesium-to-calcium molar ratio of 1.1: $C_{Mg} = 1.1 \cdot \left(\frac{24}{40}\right) \cdot C_{Ca}$ • No flow relationship applied at West Line Creek.	• Sulphate solubility limit of 2,540 mg/L • Calculation of magnesium concentrations based on a magnesium-to-calcium molar ratio of 1.18: $C_{Mg} = 1.18 \cdot \left(\frac{24}{40}\right) \cdot C_{Ca}$ • Flow relationship applied at West Line Creek, consistent with other mine-influenced areas.	• Reflects feedback received from ENV, EMPR and the KNC during the review of the 2017 RWQM. • Eliminates discrepancies between the geochemical source terms reported in Annexes A and D of Teck (2017a). • With respect to West Line Creek, brings greater level of consistency in the methods used to project selenium, nitrate and sulphate concentrations among watersheds.
	Constituent release from coal rejects	• Constituent concentrations in waters draining from coal rejects from Appendix B2.2.4-3 of Teck (2015).	• Constituent concentrations in waters draining from coal rejects from Annex A of Teck (2017a).	
	Constituent release from tailings storage	• Concentrations of nitrate and selenium in seepage from Turnbull South Pit and flow from the South Tailings Pond at FRO defined using information from Shaw (2017).	• Concentrations of nitrate and selenium in seepage from Turnbull South Pit and flow from the South Tailings Pond at FRO defined using information from Annex A of Teck (2017a).	
	Pit walls at Greenhills Operations (GHO)	• Pit walls include benched, potentially acid generating (PAG) Morrissey Formation, as described in Annex C of Teck (2017a)[(a)].	• Pit walls classified as benched, PAG Morrissey Formation changed to benched, non-PAG Mist Mountain Formation.	• Inclusion of benched, PAG Morrissey Formation resulted in poor model performance with respect to cadmium. • Reclassification of this pit wall type improved the manner in which this issue was addressed, relative to that used in the 2017 RWQM Update.

Table 2-1 Updates Made to the 2017 Regional Water Quality Model in Support of the 2019 Implementation Plan

Nature of the Change	Description	2017 Regional Water Quality Model	2019 Implementation Plan Adjustment	Rationale
Changes to water management at Elkview Operations	Chemistry assigned to tailings water at the EVO WFTF was updated to better reflect source water quality	• Chemistry assigned to tailings water reflected Elk River water quality from September 2005 to September 2017 and mine-influenced water quality (i.e., tunnel water) from October 2017 onward.	• Chemistry assigned to tailings water reflects Elk River water quality from September 2005 to March 2018. • From April 2018 onward, chemistry assigned to tailings water reflects the understanding that a portion of the tailings water will originate from the Elk River and a portion (i.e., up to 2,200 m^3/d) will originate from the raw coal conveyance tunnel (i.e., tunnel water); it will not all be mine-influenced water as previously assumed.	• Providing a more accurate representation of expected tailings water quality discharged to the EVO WFTF.
	Revisions to historical water management activities in Cedar Pit/Baldy Ridge 6 Pit	From 2012 to 2016, water from Cedar Pit/Baldy Ridge 6 Pit was modelled to be discharged as follows: • 20% of pumped flow released to EVO Dry Creek seasonally from April to October • Remaining flow released to Goddard Creek	From 2012 to 2016, water from Cedar Pit/Baldy Ridge 6 Pit was modelled to be discharged as follows: EVO Dry Creek • April to June - 60% of pumped flow • July to October - 10% of pumped flow • November to March – no release Natal Pit • April to June - 20% of flow • July to March - 80% of flow Goddard Creek • remaining flow that is not pumped to EVO Dry Creek or Natal Pit	• Reflects a better understanding of historical water management activities

Table 2-1 Updates Made to the 2017 Regional Water Quality Model in Support of the 2019 Implementation Plan

Nature of the Change	Description	2017 Regional Water Quality Model	2019 Implementation Plan Adjustment	Rationale
Correcting initial lag time in Swift pit and Lower Fording 2	Adjustment of the initial lag time applied to Swift Pit and Lower Fording 2	• A 10-year initial lag time was assumed to start as historical waste rock was transferred from the Lower Fording 2 watershed at FRO into the Swift Pit watershed.	• The RWQM has been updated to track waste rock age from year of placement through transfer from one watershed to another as watershed boundaries change.	• Eliminates an error in the 2017 RWQM related to the application of lag time to waste rock in Swift Pit.
Update to water management activities in the Clode Creek watershed	Adjustment to discharge locations related to Turnbull South Pit, Eagle 4 Pit and Eagle 6 Pits	• Flow from Turnbull South Pit was modelled to be sent to the Fording River. • Flows from Eagle 4 Pit and Eagle 6 Pit were modelled to be sent to Clode Creek Sediment Pond Decant (FR_CC1).	• Flow from Turnbull South Pit is modelled to be sent to Clode Creek Sediment Pond Decant (FR_CC1) from September 2012 to December 2015 (seasonal pumping from April to July and from mid-September to October each year). • Flow from Eagle 4 Pit is modelled to be sent to South Tailings Pond from 1995 to 2013 (seasonal pumping from April to July and from mid-September to October each year). • Flow of 363 m^3/d from Eagle 6 Pit is modelled to be sent to Eagle 4 Pit from 1995 to 2016. • Flow of 545 m^3/d from Eagle 6 Pit is modelled to be sent to Kilmarnock Creek from 2015 to 2016.	• Reflects a better understanding of historical water management activities
	Correction of an error in the flow at Eagle 4 Pit at FRO	• No outflow from Eagle 4 Pit at FRO from 2016 onward. The error resulted in an underestimation of flows reporting to Clode Creek and the Fording River from 2016 onward.	• The RWQM has been updated to correct the error at Eagle 4 Pit at FRO so that the pit is modelled to begin filling with water in 2016 and to spill to the receiving environment (i.e., Clode Creek) in 2018.	• Eliminates an error in the 2017 RWQM related to the timing of when water in Eagle 4 Pit is modelled to spill to the receiving environment

Table 2-1 Updates Made to the 2017 Regional Water Quality Model in Support of the 2019 Implementation Plan

Nature of the Change	Description	2017 Regional Water Quality Model	2019 Implementation Plan Adjustment	Rationale
Improving model projections in Koocanusa Reservoir	Constituent release from natural areas	• Single annual geometric mean used to define selenium, nitrate and sulphate concentrations in Kootenay River and other tributaries to Koocanusa Reservoir, with the exception of the Elk River.	• Monthly geometric means used to define selenium, nitrate and sulphate concentrations in Kootenay River and other tributaries to Koocanusa Reservoir, with the exception of the Elk River.	• Improves the accuracy of model projections in Koocanusa Reservoir, particularly for sulphate, through consideration of seasonal variability in constituent concentrations in background sources to the reservoir.
	Monitoring stations used for comparison of model predictions to monitoring data to assess ability of the model to reflect fully mixed concentrations in Koocanusa Reservoir	• Model predictions compared to monitoring data collected from Station RG_DSELK.	• Model predictions compared to monitoring data collected from Stations RG_DSELK, RG_GRASMERE, RG_USGOLD and RG_BORDER.	• Analysis of monitoring data in Koocanusa Reservoir indicates that the reservoir is not fully mixed laterally or vertically. However, in the 2017 RWQM, Koocanusa Reservoir is configured as a fully mixed system. Comparing model predictions to monitoring data collected from Stations RG_DSELK, RG_GRASMERE, RG_USGOLD and RG_BORDER provides a better estimate of fully mixed concentrations in Koocanusa Reservoir downstream of the Elk River, thereby allowing for a more consistent comparison between modelled and monitored information.

Table 2-1 Updates Made to the 2017 Regional Water Quality Model in Support of the 2019 Implementation Plan

Nature of the Change	Description	2017 Regional Water Quality Model	2019 Implementation Plan Adjustment	Rationale
Improving model projections in Koocanusa Reservoir	Bias correction in Koocanusa Reservoir	• Not included.	• Bias correction has been added, based on differences observed between model projections and monitoring data collected from stations RG_DSELK, RG_GRASMERE, RG_USGOLD and RG_BORDER over the calibration period.	• Improves the reliability of selenium projections in Koocanusa Reservoir, which makes them more informative when evaluating the merits of different mitigation options.
Improving simulation of flow conditions in Erickson Creek	Alteration to calibration of flows in Erickson Creek at EVO	• Flow simulation based on Hosmer Creek hydrograph for undisturbed areas and Cataract Creek areas for mine areas, with the application of a calibration factor to match observed annual yield (Teck 2017a).	• No changes made to the representative hydrographs used or the calibration factor for mean annual yield. Seasonal adjustments were added to reflect the observed pattern of dampened open-water flows and higher than projected winter flows.	• Improves the ability of the model to replicate observed flow conditions in Erickson Creek at Elkview Operations (EVO).
Increased flexibility in representation of active water treatment facilities	Effluent concentrations and nitrate design load removal	• Effluent concentrations and nitrate design load removal cannot change over time at a given facility. • Total volume of water directed from source tributaries to each AWTF was based only on the hydraulic capacity of the plant; nitrate design load removal was considered only after incoming water was mixed at the inlet to the facility.	• Effluent concentrations and nitrate design load removal can change over time at a given facility. • Total volume of water directed from source tributaries to each AWTF was based on both the hydraulic capacity of the plant and its nitrate design load removal.	• Expands the range of mitigation options considered in the 2019 IPA, in terms of how active water treatment may be applied.

(a) Benched, potentially acid generating (PAG) Morrissey Formation represented less than 10% of total pit wall area in 2016.

AWTF = active water treatment facility; EMPR = Ministry of Energy, Mines and Petroleum Resources; ENV = Ministry of Environment and Climate Change Strategy; EVO = Elkview Operations; FRO = Fording River Operations; GHO = Greenhills Operations; KNC = Ktunaxa Nation Council; PAG = potentially acid generating; RWQM = regional water quality model; WFTF = West Fork Tailings Storage Facility; mg/L – milligrams per litre.

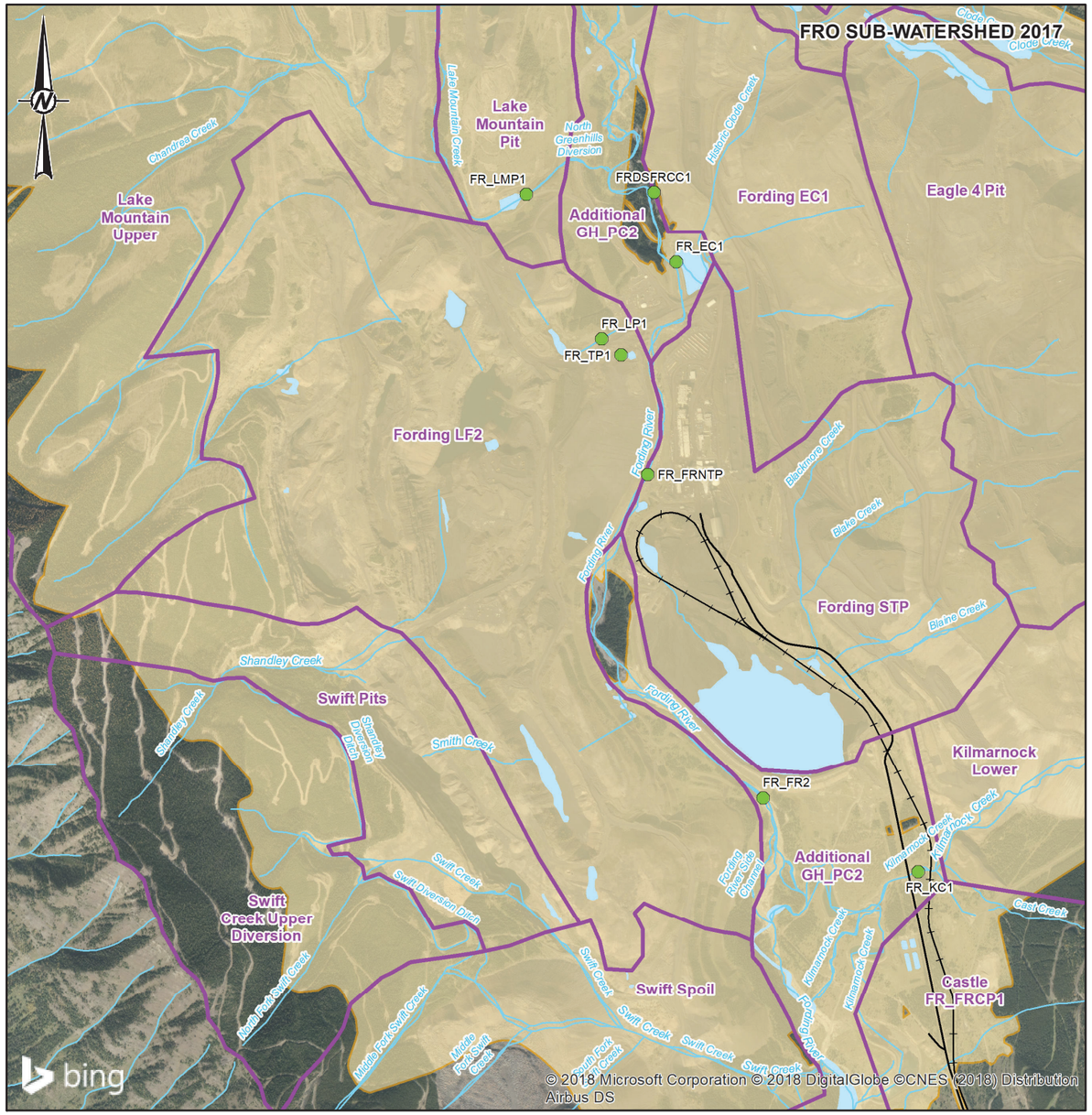
2.1 Adjustment to Lag Period Applied to Swift Pit and Lower Fording 2

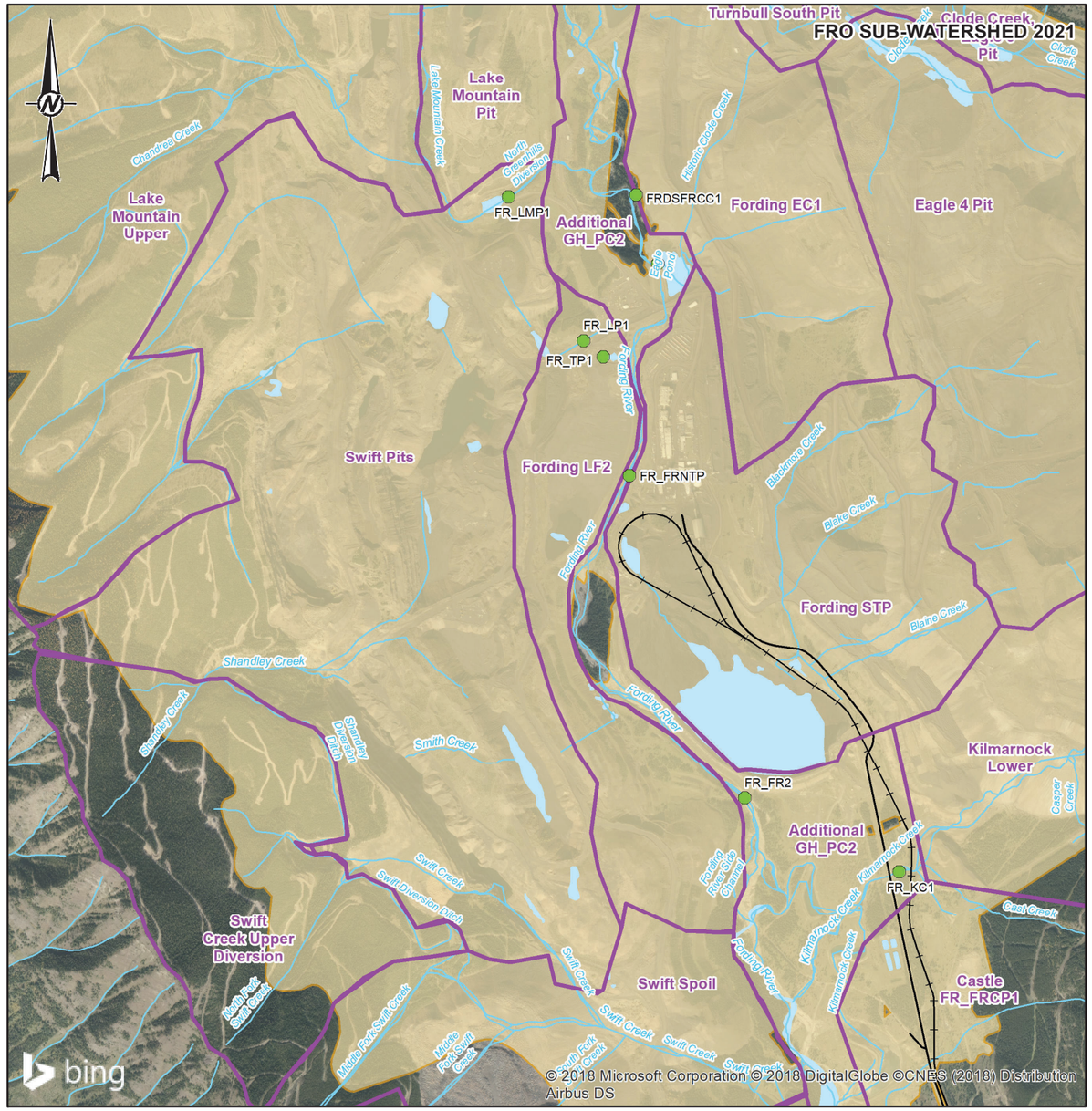
Mining in the Swift Pit area will result in changes to the watershed boundaries of Lower Fording 2 and Swift Pit. Beginning in 2017, the area of the Lower Fording 2 watershed at FRO (and waste rock volume contained therein) decreases in the 2017 RWQM as the area of the Swift Pit watershed (and waste rock volume contained therein) increases, because of changes to topography and water management as the Swift Pit area is mined out (Figure 2-1).

There is a 10-year initial lag time associated with the waste rock in the Lower Fording 2 watershed. In the 2017 RWQM, as described in Teck (2017a), the 10-year initial lag was assumed to start as the waste rock was transferred from the Lower Fording 2 watershed into the Swift Pit watershed. This approach resulted in increased projected selenium and sulphate concentrations in Swift Pit in 2027 (i.e., 10 years after the change in watershed boundaries [Figures 2-2a and 2-4a]) and reduced projected concentrations in Lower Fording 2 at the same time (Figures 2-3a and 2-5a).

The waste rock being transferred between watersheds was deposited in the Lower Fording 2 watershed from 1972 to 1988. As a result, selenium and sulphate release from the waste rock in question should not have been affected by initial lag time as outlined above. In the Swift Pit and Lower Fording 2 watersheds, projected concentrations of selenium and sulphate should have changed in step with the changes to watershed areas that begin in 2017.

The RWQM has been updated to correct this item. Projected concentrations in the Swift Pit watershed now increase and those in the Lower Fording 2 watershed decrease with the change in watershed boundaries, reflecting the age of the rock in question (Figures 2-2b, 2-3b, 2-4b and 2-5b).





LEGEND

- MONITORING / MODELLING NODE
- CITY/TOWN/COMMUNITY
- ROAD
- CANADIAN PACIFIC RAILWAY
- WATERCOURSE
- WATERBODY
- BRITISH COLUMBIA - ALBERTA PROVINCIAL BOUNDARY
- FORDING RIVER OPERATIONS C-3 PERMIT BOUNDARY
- FRO SUB-WATERSHED
- FORDING STP — SUB-WATERSHED NAME

NOTE(S)

REFERENCE(S)

1. BASE DATA: CANVEC, GEOGRATIS 2017
2. IMAGERY: LIDAR IMAGERY PROVIDED BY TECK. ADDITIONAL IMAGERY BY MICROSOFT BING © 2017 MICROSOFT CORPORATION AND ITS DATA SUPPLIERS.
3. PROJECTION: TRANSVERSE MERCATOR DATUM: NAD 83 COORDINATE SYSTEM: UTM ZONE 11N

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CLIENT
TECK COAL LIMITED

CONSULTANT
GOLDER

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APPROVED	AG

PROJECT
TECK COAL ELK VALLEY

TITLE
FORDING RIVER OPERATIONS WATERSHEDS 2017 SNAPSHOT AND 2021 SNAPSHOT

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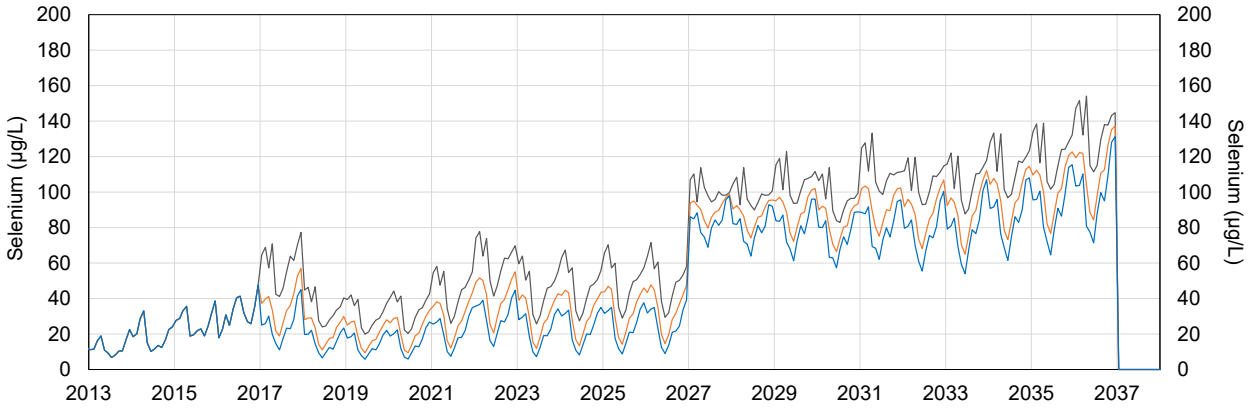
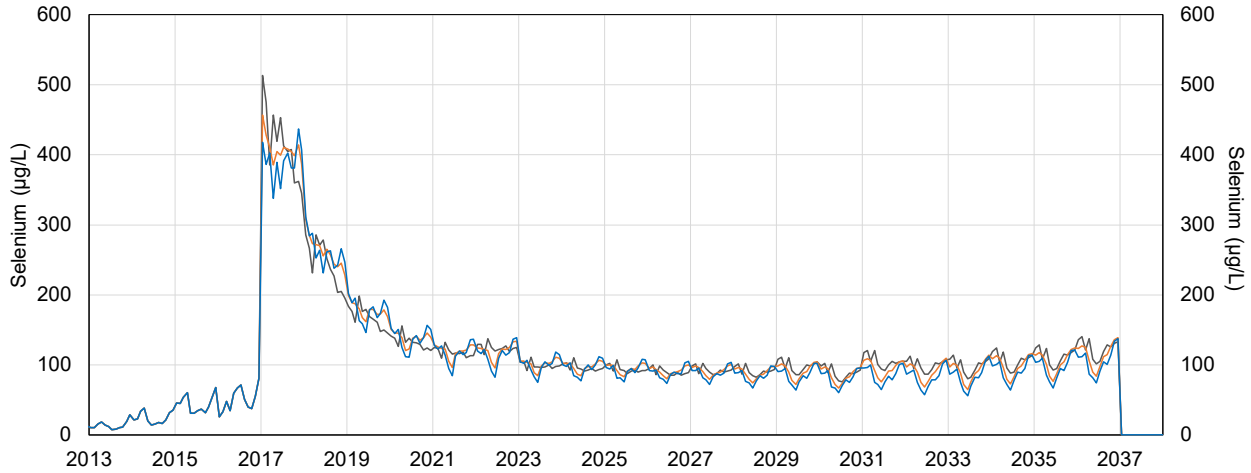
Figure 2-2 Projected Monthly Concentrations of Selenium in Swift Pit between 2013 and 2037

a) 2017 Regional Water Quality Model Prior to Adjustment



b) 2017 Regional Water Quality Model After Adjustment

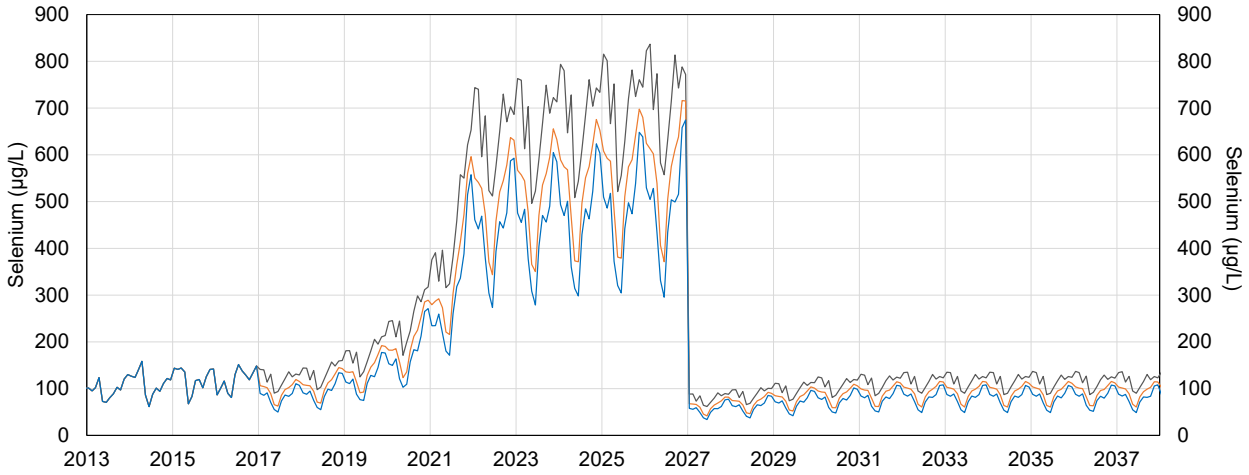


—Projected Monthly Average Concentrations under Low Flows
—Projected Monthly Average Concentrations under Average Flows
—Projected Monthly Average Concentrations under High Flows

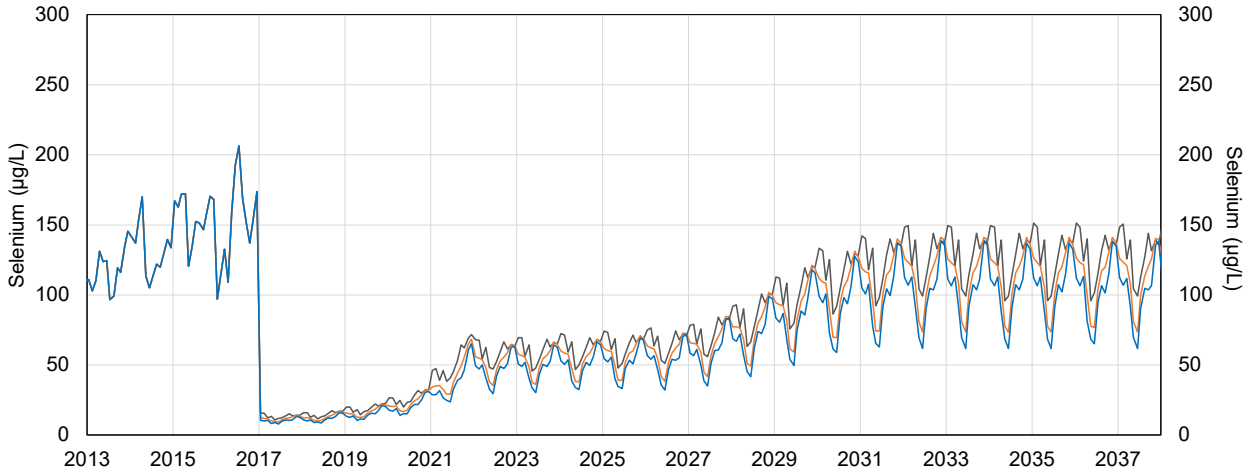
Note: Mining in Swift Pit is modelled to be completed by the end of 2036 after which the pit is modelled to fill. In Pane (b), concentrations are projected to gradually decrease, because the transfer of waste rock from the Lower Fording 2 watershed to the Swift Pit watershed occurs instantaneously, while the area of the Swift Pit watershed gradually increases.

Figure 2-3 Projected Monthly Concentrations of Selenium in Lower Fording 2 between 2013 and 2037

a) 2017 Elk Valley Regional Water Quality Model Update



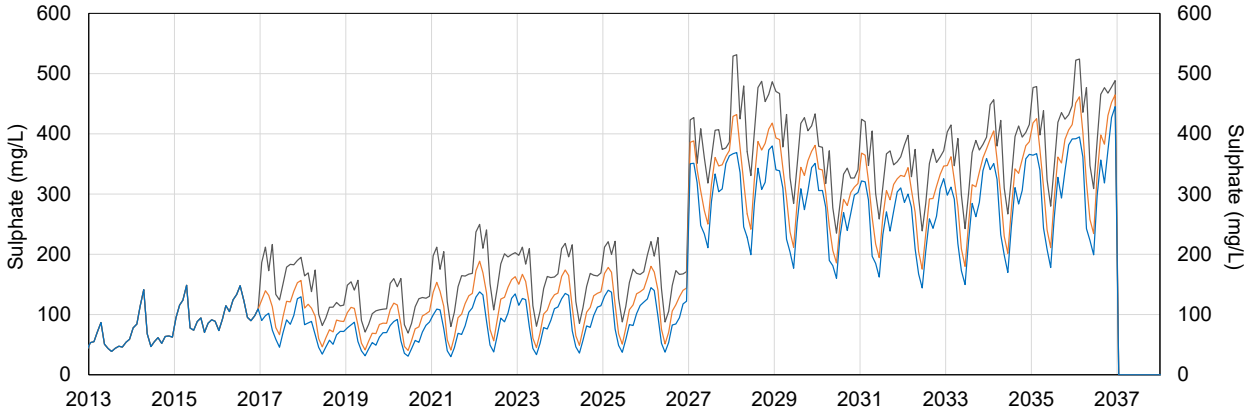
b) 2019 Implementation Plan Adjustment



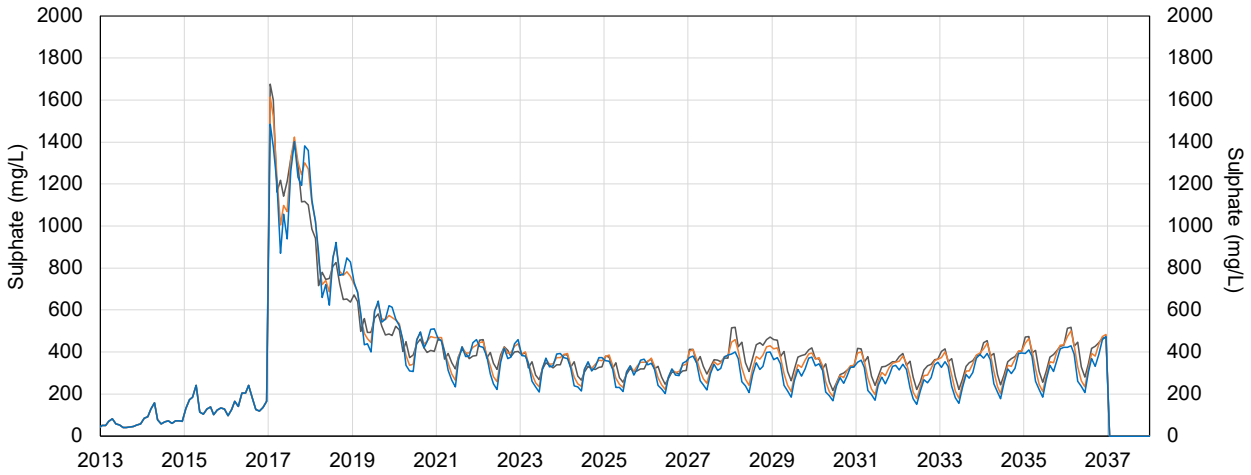
—Projected Monthly Average Concentrations under Low Flows
—Projected Monthly Average Concentrations under Average Flows
—Projected Monthly Average Concentrations under High Flows

Figure 2-4 Projected Monthly Concentrations of Sulphate in Swift Pit between 2013 and 2037

a) 2017 Elk Valley Regional Water Quality Model Update



b) 2019 Implementation Plan Adjustment

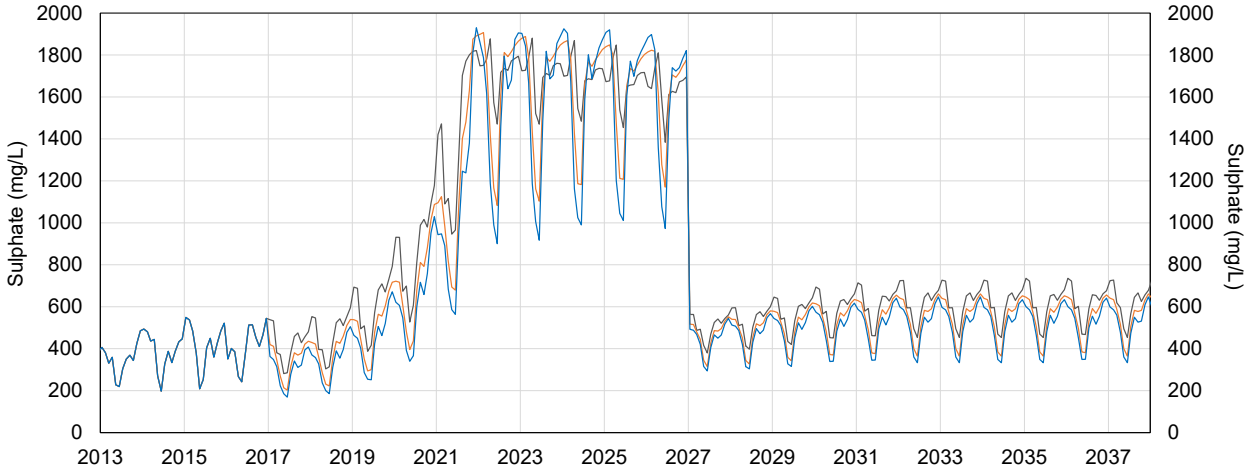


—Projected Monthly Average Concentrations under Low Flows
—Projected Monthly Average Concentrations under Average Flows
—Projected Monthly Average Concentrations under High Flows

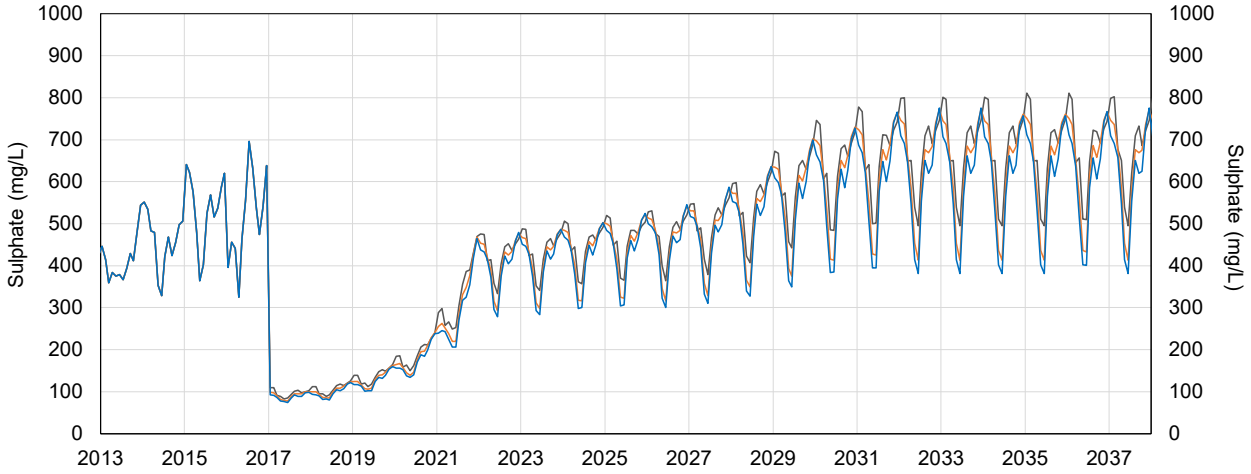
Note: Mining in Swift Pit is modelled to be completed by the end of 2036 after which the pit is allowed to fill. In Pane (b), concentrations are projected to gradually decrease, because the transfer of waste rock from the Lower Fording 2 watershed to the Swift Pit watershed occurs instantaneously, while the area of the Swift Pit watershed gradually increases.

Figure 2-5 Projected Monthly Concentrations of Sulphate in Lower Fording 2 between 2013 and 2037

a) 2017 Elk Valley Regional Water Quality Model Update



b) 2019 Implementation Plan Adjustment



2.2 Revisions to Water Management Activities in the Clode Creek Watershed

Historical water management activities in the Clode Creek watershed were re-examined as part of ongoing work to support the design of the FRO AWTF-N. Several inconsistencies were identified between historical water management activities and information contained in the *2017 Elk Valley Regional Water Quality Model Update* (Teck 2017a). Consequently, the following updates were made to the RWQM:

- Flow from Turnbull South Pit was modelled to be sent to Clode Creek Sediment Pond Decant (FR_CC1) from September 2012 to December 2015 (seasonal pumping from April to July and from mid-September to October).
- Flow from Eagle 4 Pit was modelled to be sent to South Tailings Pond from 1995 to 2013 (seasonal pumping from April to July and from mid-September to October [up to 10,000 m^3/d]).
- Flow from Eagle 6 Pit was modelled to be sent to Eagle 4 Pit from 1995 to 2016 (363 m^3/d).
- Flow from Eagle 6 Pit was modelled to be sent to Kilmarnock Creek from 2015 to 2016 (545 m^3/d).
- Filling of Eagle 4 Pit with water was explicitly included in the RWQM using a reservoir element. The pit was assigned a water volume of 2,177,989 m^3 and was modelled to begin filling in January 2014 and to spill in July 2015.

Recalibration of the RWQM was required in the Clode Creek watershed following the updates to historical water management activities. The calibration process followed the methods outlined in Annex D of the *2017 Elk Valley Regional Water Quality Model Update* (Teck 2017a). The initial lag time in the Clode Creek watershed was reduced from 5 years to 3 years, while the final values assigned to the calibration factors for nitrate, selenium and sulphate were the same as those reported in the *2017 Elk Valley Regional Water Quality Model Update* (Teck 2017a). Changes to model performance over the calibration period at Clode Creek and downstream locations are presented in Section 3.

An error was also identified at Eagle 4 Pit at FRO in the flow component of the 2017 RWQM. Eagle 4 Pit was modelled to begin filling with water in 2016 and to report to Clode Creek Sediment Pond Decant (FR_CC1) in 2018 in the 2017 RWQM. However, there was no flow from Eagle 4 Pit from 2016 onward in the flow component of the 2017 RWQM resulting in an underestimation of flow in Clode Creek and the Fording River and an overestimation of flow in the upper Elk River in the flow component of the 2017 RWQM. Flows in the upper Elk River (i.e., at the GHO Elk River Compliance Point [GH_ERC; E300090] and in the Elk River upstream of Boivin Creek [GH_ER1; E206661]) were overestimated because they are derived by taking the difference between monitored flows in the Elk River upstream of Grave Creek (EV_ER4; 0200027) and modelled flows in the Fording River downstream of Line Creek (LC_LC5; 0200028) and prorating by watershed area. Because the flow at LC_LC5 was underestimated, the total flow in the upper Elk River (i.e., GH_ERC and GH_ER1) was overestimated. It is acknowledged that there is no physical connection between pit water management at FRO and flows in the upper Elk River. However, the methods for estimating flows in the upper Elk River in the 2017 RWQM were retained and adjustments to flows were made for consistency.

When the error in flow at Eagle 4 Pit at FRO was corrected, it resulted in projected monthly average selenium concentrations above the Compliance Limit at the GHO Elk River Compliance Point (GH_ERC; E300090):

- 8.1 µg/L in February 2036 under high flows
- 8.1 µg/L in February 2037 under high flows

To eliminate projected monthly average selenium concentrations above the Compliance Limit at the GHO Elk River Compliance Point (GH_ERC; E300090), the hydraulic capacity of the GHO Phase I AWTF was increased from 2,500 m^3/d to 5,000 m^3/d and the hydraulic capacity of the GHO Phase II AWTF was decreased from 5,000 m^3/d to 2,500 m^3/d. No changes were made to total treatment requirements in the Elk Valley.

2.3 Improving Model Projections in Koocanusa Reservoir

The 2017 RWQM tends to over-estimate observed concentrations of nitrate, selenium and sulphate in Koocanusa Reservoir, as noted in Annex D of the *2017 Elk Valley Regional Water Quality Model Update* (Teck 2017a). The over-estimation of observed nitrate and sulphate concentrations does not affect mitigation planning, as projected concentrations now and into the future remain well below Site Performance Objectives (SPO). In contrast, projected selenium concentrations are much closer to or exceed the SPO (Figure 2-6), which is problematic from a planning perspective. It results in reduced confidence in the model projections and makes it difficult to identify the benefits of different mitigation scenarios on selenium concentrations in Koocanusa Reservoir.

The following changes were made to the RWQM to improve model projections in Koocanusa Reservoir:

- The values used to describe selenium, nitrate and sulphate concentrations in the Kootenay and Bull rivers were changed from single values to monthly means to capture seasonal variability in background inflows to Koocanusa Reservoir.
- The number of monitoring stations used in the comparison of simulated and monitored data was expanded from one to four; this change was made based on the results of a review of the available monitoring data, which indicated that fully-mixed concentrations in the reservoir are better described by combining the information collected from the four monitoring stations located in the reservoir downstream of the Elk River, rather than only using data from Station RG_DSELK.
- Projected selenium concentrations in Koocanusa Reservoir were corrected for model bias.

Projected nitrate and sulphate concentrations were not corrected for model bias, because the degree of over-estimation inherent in the projections does not hinder mitigation planning.

These three changes to the RWQM are discussed in detail below.

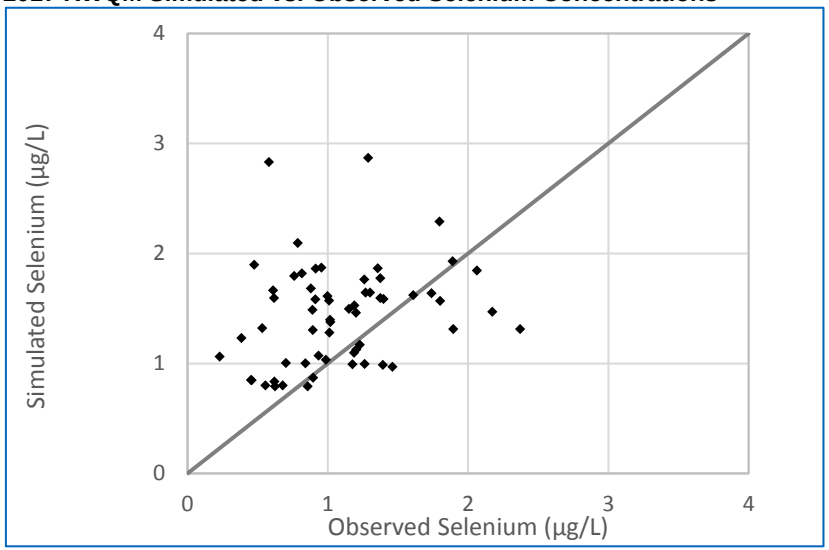
Figure 2-6 Selenium Calibration Information for Node RG_DSELK - Koocanusa Reservoir - South of the Elk River (EMS E300230)

Observed and Simulated Selenium Data and Calibration Statistics

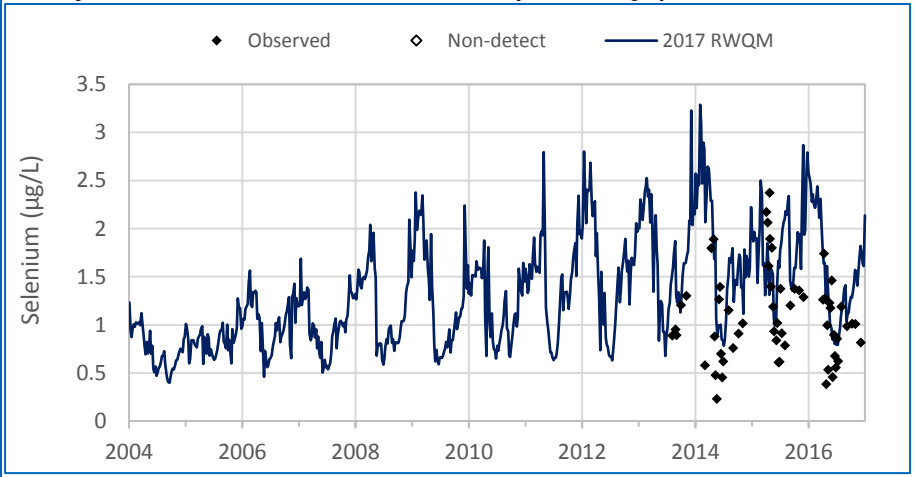
Statistic	2017 RWQM		2014 RWQM
Model Averaging Period	Weekly	Monthly	Monthly
Calibration Period	2004 to 2016		2004 to 2012
First Observed Sample	8/7/2013		-
Last Observed Sample	12/6/2016		-
Data Points Available for Comparison, n	60	31	0
Non-Detect Count	0	0	0
Observed Mean (µg/L)	1.1	1.1	-
Simulated Mean (µg/L)	1.4	1.6	-
Bias (µg/L)	0.36	0.5	-
Relative Bias	1.3	1.5	-
Error (µg/L)	0.51	0.53	-
Percent Error	47%	51%	-

Note: - = not available

2017 RWQM Simulated vs. Observed Selenium Concentrations

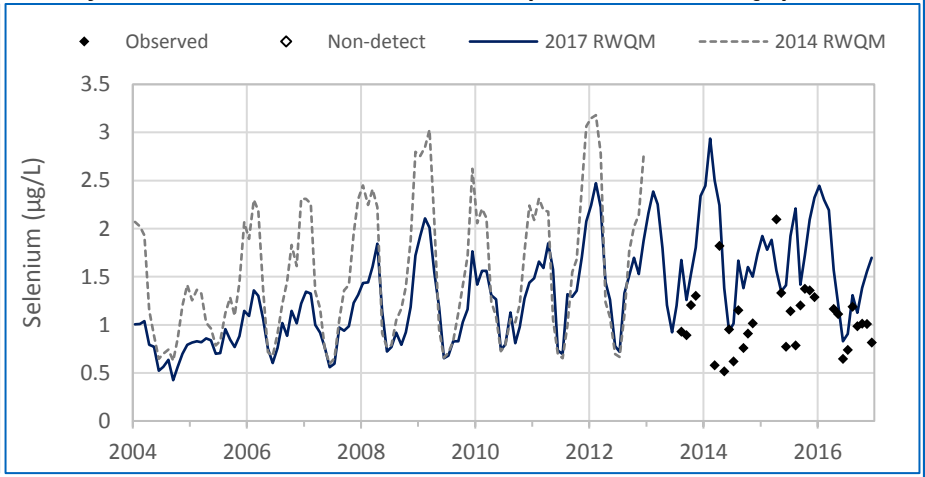


Weekly Simulated Selenium Concentrations (2017 RWQM)



Note: Observed data are individual sample results

Monthly Simulated Selenium Concentrations (2017 and 2014 RWQM)



Note: Observed data are monthly averages of sample results

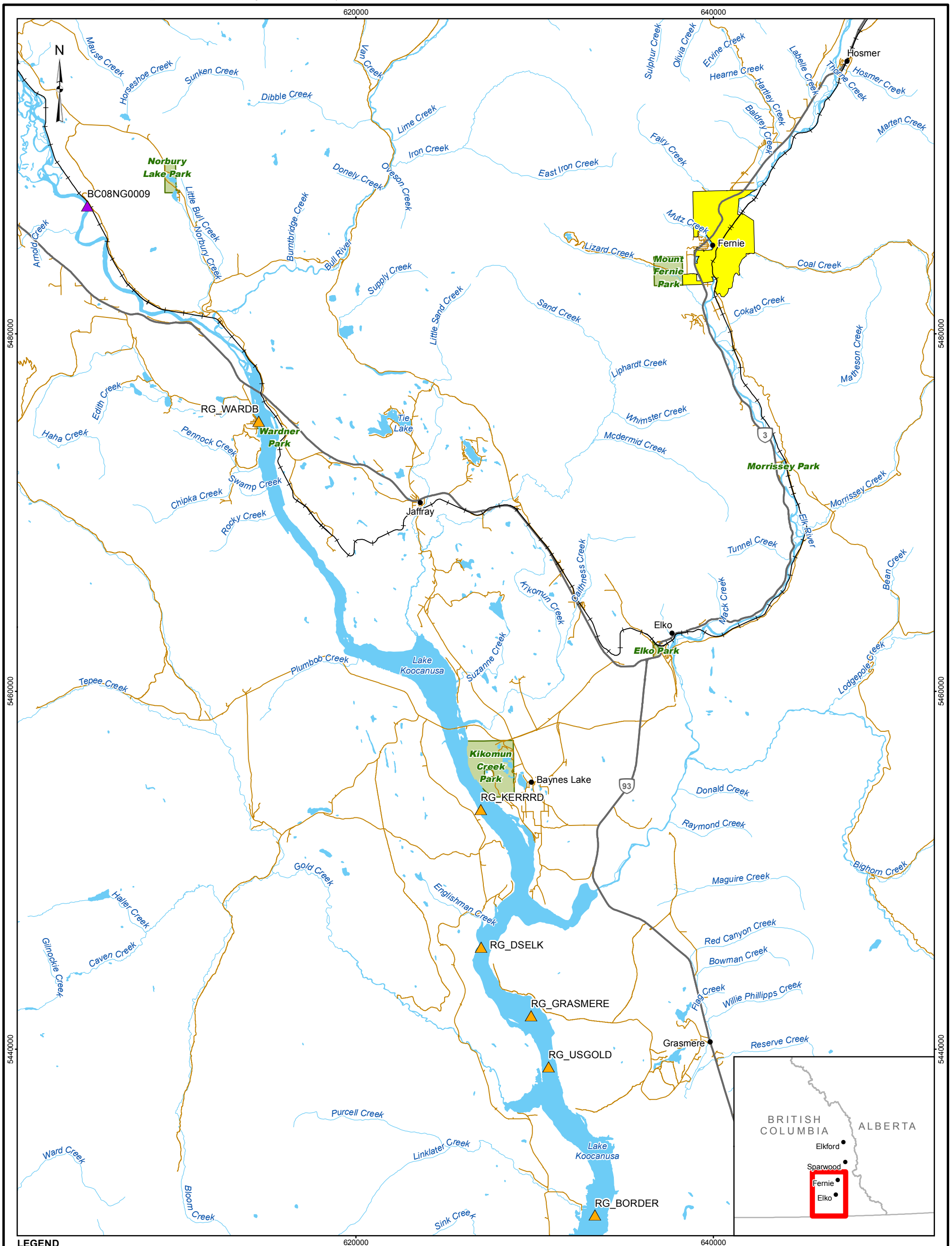
2.3.1 Loading from Natural Areas

In the 2017 RWQM, as described in Teck (2017a), surface flows from watershed areas not affected by Teck's coal mining operations (i.e., the Kootenay River and Bull River watersheds) were assigned a source term concentration derived from the geometric mean of monitored data from the Kootenay River near Fenwick Station (BC08NG0009; Figure 2-7). A geometric mean, rather than arithmetic mean, was used to generate these values to avoid potential biases introduced by occasional high values that may be related to spring freshet. Monitored data from the Kootenay River near Fenwick Station were used to define background conditions for the following reasons:

- this station has a long-term monitoring record (i.e., data available from 1984 onward);
- monitored data were not available for the Bull River; and
- the Kootenay River accounts for 62% of the mean annual inflow to Koocanusa Reservoir, while the Bull River accounts for 11% of the mean annual inflow (Minnow 2017).

This approach was updated to improve model projections in Koocanusa Reservoir. The background dataset was expanded to include information from a second monitoring station located on the Kootenay River (i.e., Kootenay River at Wardner, identified as RG_WARDB in Figure 2-7). Monitoring at this station began in 2013. It was selected for inclusion, because it is located closer to Koocanusa Reservoir than the Fenwick Station (see Figure 2-7). In addition, background concentrations of selenium, sulphate and nitrate in the Kootenay and Bull rivers were defined using monthly geometric means, rather than single annual values (Table 2-2). This approach was used to capture seasonal variability in constituent concentrations in these two background sources to the reservoir.

Document Path: I:\CLIENTS\TECK_COAL\1792554\Mapping\MXD\WaterQuality\1792554_FIG_C3_1792554_Water_Quality_Monitoring_Stations_in_the_Kootenay_River_and_Lake_Koocanusa.mxd



LEGEND

- POPULATED PLACE
- PRIMARY HIGHWAY
- LOCAL ROAD
- RAILROAD
- WATERCOURSE
- PARK / PROTECTED AREA
- WATER BODY
- POPULATED PLACE

WATER QUALITY MONITORING STATIONS

- ENVIRONMENT CANADA
- TECK

5 0 5

SCALE 1:200,000 KILOMETRES

REFERENCE

PARKS AND HYDROGRAPHY OBTAINED FROM IHS MARKIT CANADA LIMITED. ROADS AND POPULATED PLACES OBTAINED FROM GEOGRATIS, © DEPARTMENT OF NATURAL RESOURCES CANADA. ALL RIGHTS RESERVED.
PROJECTION: UTM ZONE 11 DATUM: NAD 83

WATER QUALITY IMPLEMENTATION PLAN

TITLE

WATER QUALITY MONITORING STATIONS IN THE KOOTENAY RIVER AND LAKE KOOCANUSA

Teck

PROJECT		1792554	FILE No.	5000
DESIGN	AS	14 June 2018	SCALE AS SHOWN	REV. 0
GIS	LB	24 Aug. 2018		
CHECK	AS	24 Aug. 2018		
REVIEW	JPB	24 Aug. 2018		

FIGURE: 2-7

Table 2-2 Monthly Average Constituent Concentrations Assigned to Inflows from the Kootenay and Bull Rivers Flowing into Koocanusa Reservoir

Month	Nitrate (mg/L)	Selenium (µg/L)	Sulphate (mg/L)
January	0.15	0.15	49
February	0.12	0.12	50
March	0.10	0.10	38
April	0.15	0.09	19
May	0.09	0.08	14
June	0.05	0.07	18
July	0.06	0.09	26
August	0.06	0.12	33
September	0.07	0.10	34
October	0.10	0.11	40
November	0.14	0.10	44
December	0.10	0.10	30

mg/L = milligram per litre; µg/L = microgram per litre.
Source: Teck (2017b) and Environment Canada (2017).

2.3.2 Point of Comparison

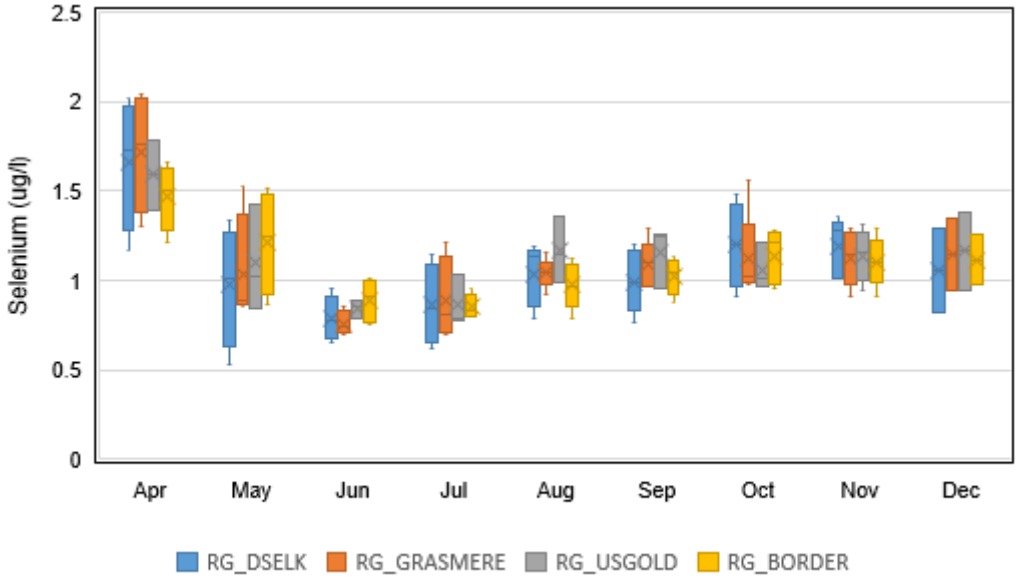
Teck Coal Limited (Teck) began water quality monitoring in Koocanusa Reservoir in 2013. Water quality samples are collected weekly from March 15th to July 15th and monthly for the remainder of the year when access is not restricted by safety concerns related to ice cover and flowing water. The samples are collected from five stations (Figure 2-3). One station, Koocanusa Reservoir downstream of Kikkoman Creek (RG_KERRRD, E300095), is located upstream of the Elk River. The other four stations are located downstream of the Elk River; they consist of the following:

- Koocanusa Reservoir south of the Elk River (RG_DSELK; E300230)
- Koocanusa Reservoir west of Grasmere (RG_GRASMERE; E300092)
- Koocanusa Reservoir upstream of Gold Creek (RG_USGOLD; E300093)
- Koocanusa Reservoir upstream of the Canada/US border (RG_BORDER; E300094)

Projected concentrations in Koocanusa Reservoir were compared to monitored data at RG_DSELK in the *2017 Elk Valley Regional Water Quality Model Update* (Teck 2017a).

During the completion of the 2019 IPA, it was identified that constituent concentrations among the four downstream stations are similar (Figure 2-8); however, they can vary from one station to another. As a result, data from the four stations were pooled and used for comparison to model projections. This approach was adopted, because the projections produced by the RWQM represent fully mixed concentrations in the reservoir after influent from the Elk River mixes with inflows from the Kootenay River and Bull River, and average concentrations across the four stations provide the best estimate of fully mixed concentrations in the portion of the reservoir being modelled.

Figure 2-8 Monthly Average Observed Selenium Concentrations in Koocanusa Reservoir



Source: Teck (2017b).

2.3.3 Bias Correction

As previously noted, the tendency of the RWQM to over-predict selenium concentrations in Koocanusa Reservoir is problematic from a planning perspective, as it can lead to an inability to rely on projected concentrations in Koocanusa Reservoir. Projected selenium concentrations in Koocanusa Reservoir were bias corrected to address this issue.

Bias provides an indication of the degree to which the RWQM over or under-estimates observed concentrations. Bias is calculated as the average difference between individual simulated and measured data points over a period of time, using the following equation:

$$Bias_p = \frac{\sum \left(C_{Mod_{xp}} - C_{Obs_{xp}} \right)}{n_p}$$

Where:

$Bias_p$ = bias over period “p”

C_{Mod} = modelled concentration on date “x” in period “p”

C_{Obs} = corresponding observed concentration

n_p = number of paired modelled and observed data points over period “p”

For the 2019 IPA, bias was calculated over the entire calibration period, as well as for months wherein more than a total of eight observed data points were available between 2013 and 2016.

The bias values were then transformed into expressions of relative bias using the following equation:

$$Relative\ Bias = \frac{Bias + \overline{C_{Obs}}}{\overline{C_{Obs}}}$$

Relative bias provides a means of easy comparison among different watercourses or time periods within the same watercourse. The relative bias values calculated for Koocanusa Reservoir are summarized in Table 2-3 and shown in Figure 2-9.

Table 2-3 Relative Bias Values Calculated for Selenium in Koocanusa Reservoir, based on Model Projections and Monitored Data Between 2013 to 2016

Month	Relative Bias
January	-
February	-
March	-
April	1.00
May	1.12
June	1.20
July	1.32
August	1.58
September	1.38
October	1.25
November	1.44
December	2.09
Annual	1.25

- = Relative bias was not calculated due to limited or no observed data (i.e., less than 3 samples available for the month in question).

To correct for bias, projected selenium concentrations in Koocanusa Reservoir were reduced using the following equation:

$$C_{Se} = \frac{\left(\sum_{i=1}^{n} R_{Se,i}\right) / Relative\ Bias}{\sum_{i=1}^{n} q_i}$$

Where:

C_{Se} = projected concentration of selenium in Koocanusa Reservoir (mass per unit volume)

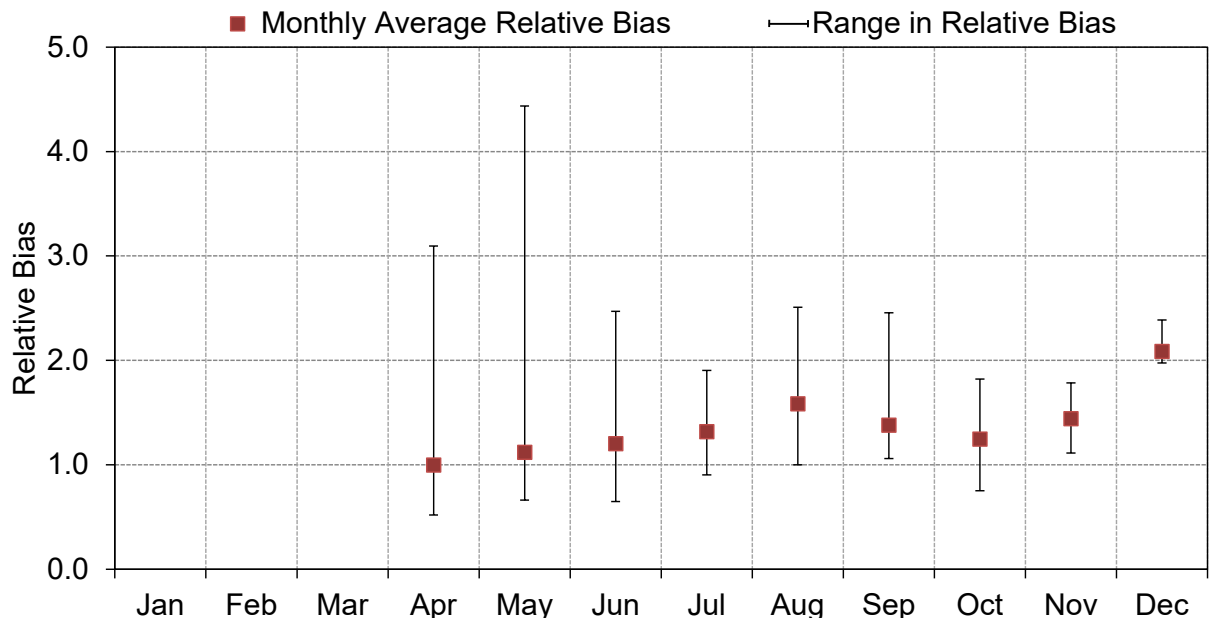
$R_{Se,i}$ = mass of selenium associated with source 'i' reporting to Koocanusa Reservoir, expressed as a rate (mass per unit time)

q_i = flow rate of source 'i' (volume per unit time)

n = number of sources entering Koocanusa Reservoir

Projected concentrations from April to December were reduced by the corresponding monthly average relative bias value listed in Table 2-3. Monthly average relative bias values could not be calculated for January, February, and March, due to a lack of winter data. Projected concentrations in Koocanusa Reservoir for these three months were reduced by the annual average relative bias calculated over the entire period.

Figure 2-9 Monthly Relative Bias Values Calculated for Selenium in Koocanusa Reservoir, based on Model Projections and Monitoring Data from 2013 to 2016



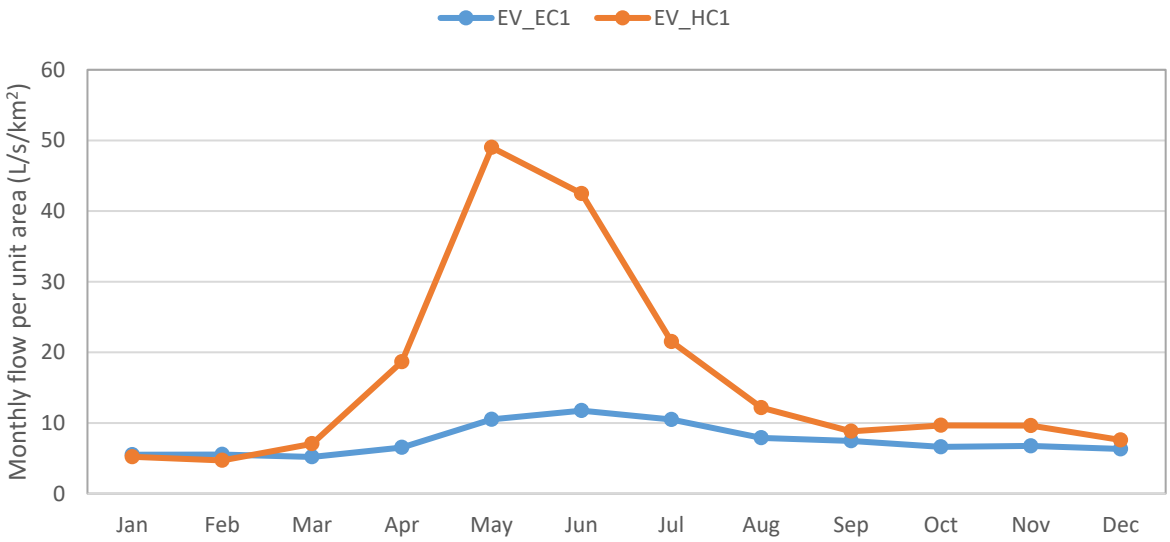
2.4 Erickson Creek Flows

This section describes changes made to the 2017 RWQM to improve flow projections in Erickson Creek. Erickson Creek is targeted for treatment at the EVO AWTF. Refinements to projected flows in Erickson Creek were required to support an improved understanding of influent characteristics to the planned AWTF.

2.4.1 Erickson Creek Watershed

Typical hydrographs from monitoring locations in the Elk Valley have a dominant freshet peak between May and July, a recession through the summer and fall and relatively constant winter baseflows from December to March. Measured flows in Erickson Creek near the mouth (EV_EC1) have a relatively “flat” annual distribution that is unlike other watersheds in the Elk Valley. The Erickson Creek watershed also tends to have a lower mean annual watershed yield compared to regional stations. These characteristics are illustrated in Figure 2-10, wherein mean annual hydrographs from Erickson Creek (EV_EC1) and Harmer Creek (EV_HC1) are compared.

Figure 2-10 Mean Monthly Flow per Unit Area for Harmer Creek (EV_HC1) and Erickson Creek (EV_EC1), based on Monitored Data from 2006 to 2017



The factors that contribute to the flow patterns observed in Erickson Creek are not entirely known. However, field surveys (Golder 2017) confirm that surface flows are not present in a reach of Erickson Creek between the Erickson dam to just upstream of groundwater well at EV_ECgw, a distance of several hundred meters (Figure 2-11). In this reach, water is travelling through sub-surface materials. This sub-surface flow path, together with the upstream existing waste rock spoil, attenuate freshet flows, which partially explains the flat hydrograph.

Other contributing factors could include a hypothesis that Erickson Creek may receive less precipitation than other tributary watersheds, because of localized rain shadow effects. Similarly, the effective drainage area at monitoring station EV_EC1 may be less than the delineated drainage area. The presence of a small ridge to the east of Erickson Creek along the lower watershed may be acting as a local drainage divide, causing runoff to infiltrate to ground and follow a different subsurface flow path, one that discharges directly to Michel Creek instead of to the local topographic low of Erickson Creek. This latter hypothesis is supported by a single set of flow accretion measurements taken in November 2016, which indicated that flows remained relatively constant between the “headwaters” upstream of EV_ECgw and the mouth of Erickson Creek (EV_EC1).

Programs are currently underway to address these uncertainties in Erickson Creek flows; they include geophysical surveys, additional surface flow measurements, additional flow accretion studies and climate data collection. As required by Permit 107517, data from these programs will be used to support refinements to the RWQM.

S:\Clients\Teck_Resources\ElkValley\99_PROJ\1792554_Teck\40_PROD\0004_IPA_Annex_C\1792554-0004-CS-0001.mxd

Dry Creek

Harmer above EVO Dry Creek

Brewer Lake

EV_WF_SW

GEHO

Erickson Creek Other

F2 Pit

Natal Pit

Natal Pit 2

Gate Creek

Erickson Dam

Thresher Creek

Milligan Creek

EV_TC1

South Pit Creek

Erickson Creek Clean

EV_ECgw

Michel Creek

EV_MG1

3

South Pit Diversion

EV_SP1

EV_EC1

EV_MC3

Additional Area to EV MC2

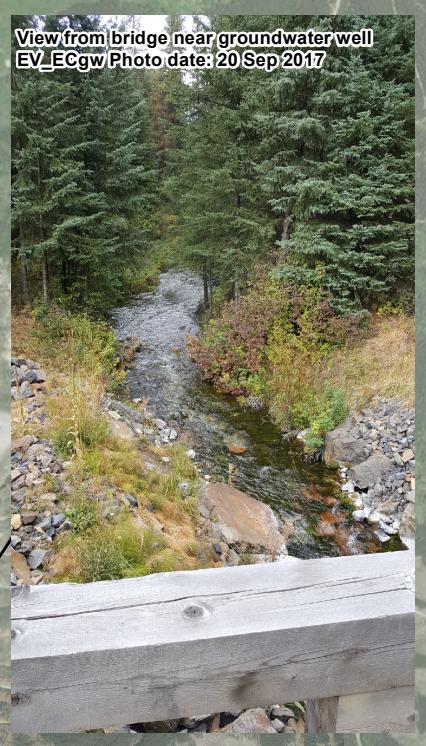
Lower Alexander Creek

Unnamed Watershed Lower Alexander

bing

Dry channel transitioning to surface flow (looking downstream)
Photo date: 20 Sep 2017

View from bridge near groundwater well EV_ECgw Photo date: 20 Sep 2017



Hydrometric Station ear the mouth (EV_EC1)
Photo date: 20 Sep 2017

LEGEND

- PRIMARY HIGHWAY
- CANADIAN PACIFIC RAILWAY
- WATER MANAGEMENT LINE
- WATER MANAGEMENT AREA
- WATERBODY
- BRITISH COLUMBIA - ALBERTA PROVINCIAL BOUNDARY
- SUB-WATERSHED
- ERICKSON CREEK WATERSHED
- ELKVIEW OPERATIONS C-2 PERMIT BOUNDARY
- SUBSURFACE DRAINAGE PATH
- PHOTO LOCATION

MONITORING LOCATIONS

- GROUNDWATER
- SURFACE WATER - PERMITTED (FLOW AND WQ)
- SURFACE WATER - PERMITTED (WQ ONLY)

ELKVIEW OPERATIONS

Map Extent

0 500 1,000 1,500 2,000

1:30,000 METERS

REFERENCE(S)

1. BASE DATA: CANVEC, GEOGRATIS 2017
2. IMAGERY: LIDAR IMAGERY PROVIDED BY TECK. ADDITIONAL IMAGERY BY MICROSOFT BING © 2017 MICROSOFT CORPORATION AND ITS DATA SUPPLIERS.
3. PROJECTION: TRANSVERSE MERCATOR DATUM: NAD 83 COORDINATE SYSTEM: UTM ZONE 11N

CLIENT
TECK COAL LIMITED

Teck

PROJECT
ELKVIEW OPERATIONS AWTF DESIGN BASIS SUPPORT

TITLE
ERICKSON CREEK WATERSHED

CONSULTANT
GOLDER

YYYY-MM-DD	2018-07-13
DESIGNED	PR
PREPARED	PR
REVIEWED	AG
APPROVED	AG

PROJECT NO.	CONTROL	REV.	FIGURE
1792554	0004	0	2-11

IF THIS MEASUREMENT DOES NOT MATCH WHAT IS SHOWN, THE SHEET SIZE HAS BEEN MODIFIED FROM:
25mm
0

2.4.2 Changes to Flow Calibration

The 2017 RWQM, configured as per Teck (2017a), tended to over-estimate freshet flows and under-estimate winter flows. In the 2017 RWQM, Hosmer Creek is the representative hydrograph for natural areas in Erickson Creek and Cataract Creek is the representative hydrograph for mine areas (Teck 2017a). A yield reduction factor is applied to both representative hydrographs, so that modelled mean annual yields match measured mean annual yields in this watershed. The performance of the 2017 RWQM in Erickson Creek was better than previous model versions (e.g., 2014 RWQM), but was rated as "poor" (Teck 2017a). The additional improvements outlined below were implemented to better represent the observed seasonal pattern, recognizing that the adopted approach will be revisited and refined once data from watershed-specific field investigations are available.

Improvement to the flow calibration in Erickson Creek was accomplished using an empirical approach, considering available data (from 2006 to 2017) and reflective of the currently incomplete understanding of watershed dynamics in Erickson Creek. Adjustment factors were derived by reallocating the model over-estimation during freshet (i.e., May and June) over the remainder of the year. The mean difference between observed data to modelled data (from the 2017 RWQM) for each calendar month is shown in Table 2-4. The differences range from -0.097 cubic metres per second (m^3/s) in August to 0.52 m^3/s in June.

Table 2-4 Difference between Mean Monitored Flow and Modelled Flow from the 2017 RWQM in Erickson Creek at EV_EC1

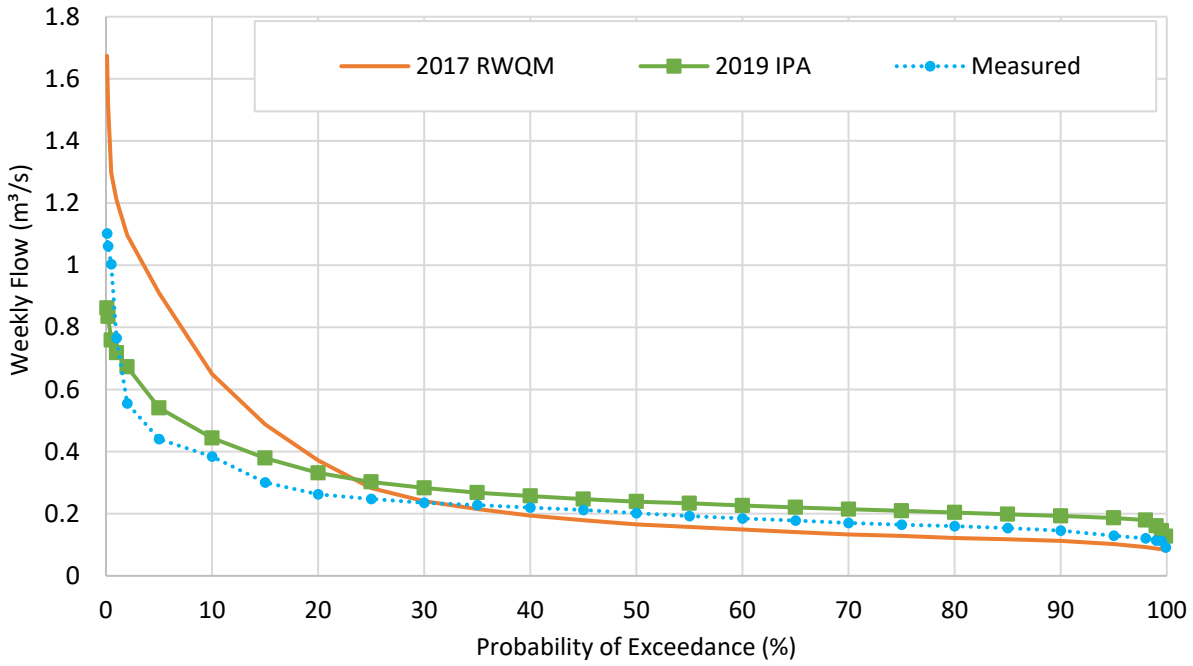
Month	Absolute Difference (m^3/s)
January	-0.068
February	-0.053
March	-0.028
April	0.038
May	0.249
June	0.520
July	0.041
August	-0.097
September	-0.092
October	-0.063
November	-0.037
December	-0.045

m^3/s = cubic metres per second

For simplicity, the flow reallocation was accomplished by applying a constant adjustment factor to modelled winter and fall flow. The adjustment factor was calculated as an absolute increase in flow per unit drainage area (i.e., 2.35 litres per second per square kilometre [$L/s/km^2$] for average flow conditions). A proportional reduction was applied through freshet, with May and June flows decreasing, on average, by 61% and 40%, respectively. The reductions were applied with the goal of maintaining an approximate overall annual balance in watershed yield. The changes were applied uniformly to natural and disturbed areas within the watershed (i.e., were applied to both the Hosmer Creek and Cataract Creek representative hydrographs).

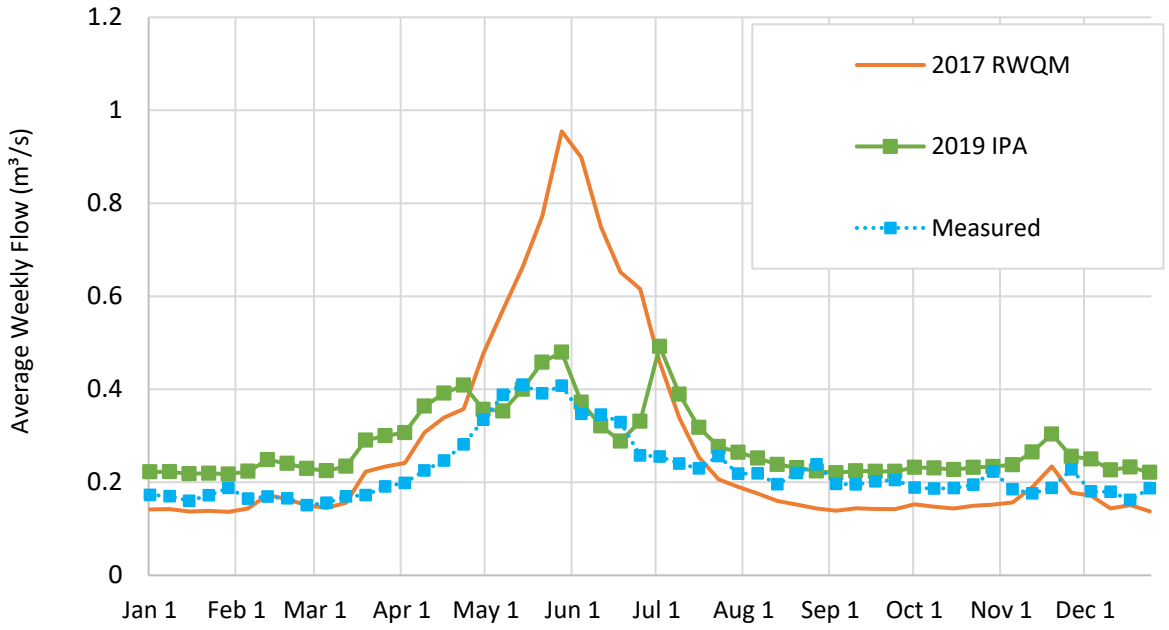
The resulting improvement in the weekly flow exceedance curve from 2014 to 2018, when compared against the measured data at EV_EC1, are illustrated in Figure 2-12. The improvement to the mean weekly hydrograph are demonstrated in Figure 2-13.

Figure 2-12 Weekly Flow Exceedance Curve for Erickson Creek (EV_EC1), based on Monitored and Projected Data from 2006 to 2017



RWQM = Regional Water Quality Model; IPA = Implementation Plan Adjustment

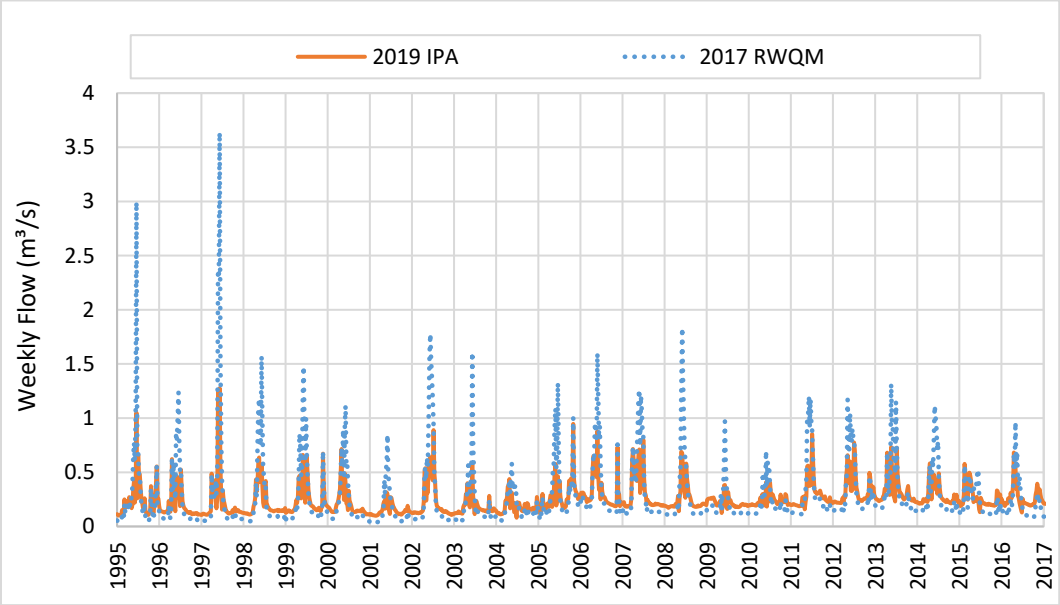
Figure 2-13 Mean Weekly Flow for Erickson Creek (EV_EC1), based on Monitored and Predicted Data from 2006 to 2017



RWQM = Regional Water Quality Model; IPA = Implementation Plan Adjustment

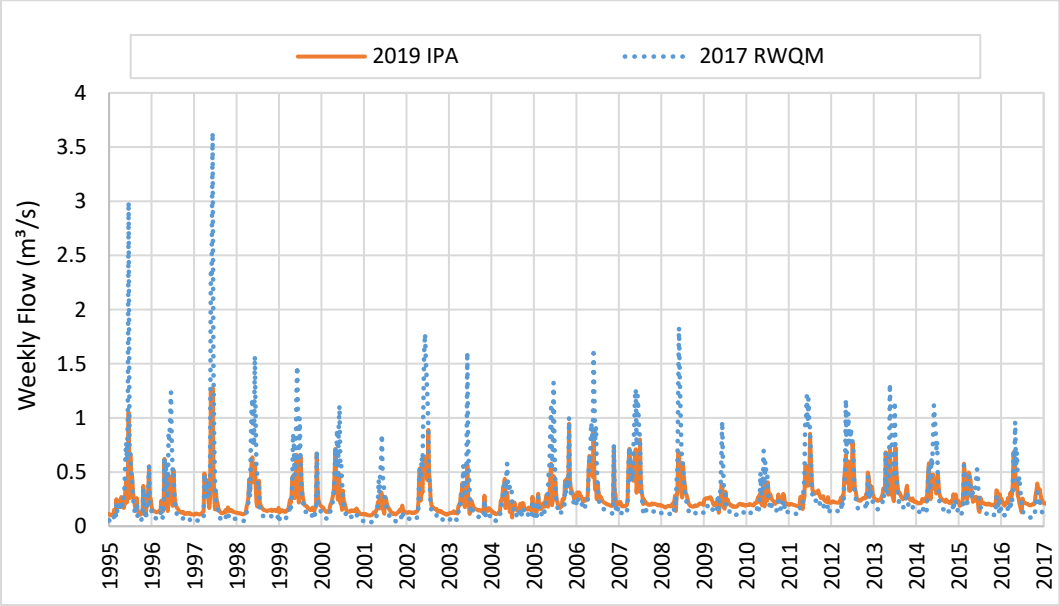
The changes made to the flow calibration in Erickson Creek resulted in some minor changes to predicted flows in Michel Creek downstream of Erickson Creek (Figure 2-14); they had a negligible effect on predicted flows in the Elk River (Figure 2-15). Changes to predicted flows in Michel Creek consisted of a 1.9% increase in average late summer, fall and winter flows (August through March), with a corresponding 1% decrease in freshet (May and June) flows.

Figure 2-14 Projected Mean Weekly Flows in Michel Creek (EV_MC1) from 1995 to 2017



RWQM = Regional Water Quality Model; IPA = Implementation Plan Adjustment

Figure 2-15 Projected Mean Weekly Flows in the Elk River downstream of Michel Creek (EV_ER1), 1995 to 2017



RWQM = Regional Water Quality Model; IPA = Implementation Plan Adjustment

2.4.3 Changes to Future Flow Projections

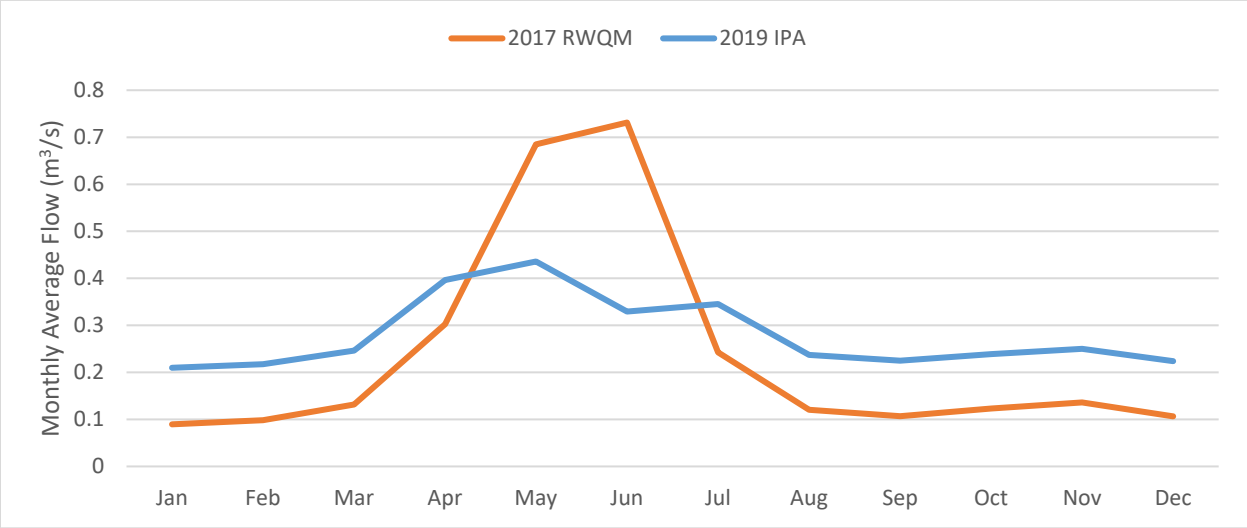
Future flow projections for Erickson Creek were adjusted following a similar process to that outlined above. Three sets of empirical adjustment factors were used, one for each flow condition (Table 2-5). A baseflow adjustment was applied to the model projections in the increment shown in Table 2-5 from July through April. May and June projections were similarly reduced by the percentages shown in Table 2-5 to approximately maintain a balance in annual yield. The resulting effect on the projected flow hydrograph is shown in Figure 2-16 using average flow conditions.

Table 2-5 Empirical Adjustments Factors Used to Adjust Future Flow Projections in Erickson Creek

Flow Condition	Flow Reduction (%)		Baseflow Adjustment ($L/s/km^2$) (July to April)
	May	June	
Low	55	50	1.65
Average	61	40	2.35
High	80	60	2.60

% = percent; $L/s/km^2$ = litres per second per square kilometre

Figure 2-16 Projected Mean Monthly Flows at the Mouth of Erickson Creek under Average Flow Conditions (2018 data shown as an example)



2.4.4 Changes to Water Quality Projections

Changes to projected flows in Erickson Creek resulted in changes to projected constituent concentrations. However, the changes were not large enough to warrant recalibration of the 2017 RWQM, as discussed below in Section 3 (see Figures 3-1, 3-3 and 3-5). Changes to water quality projections in Michel Creek and the Elk River were negligible, as discussed below in Section 3.

2.5 Representation of Water Treatment

Six potential AWTFs are incorporated into the water quality component of the RWQM. They are associated with Teck's operations as follows:

- two at FRO
- two at LCO
- one at GHO
- one at EVO

AWTFs in the RWQM are characterized by hydraulic capacity and the projected maximum nitrate load removal capacity the facility. Hydraulic capacity, expressed in terms of cubic metres per day (m^3/d), refers to the amount of water a facility can treat. Based on the current understanding of biological active water treatment, the nitrate load entering the facility influences retention time and removal performance; there is a limit to the nitrate load a facility can receive while still achieving the desired level of treatment. This limit is modelled and referred to as the nitrate design load removal, expressed in terms of kg/d, and is the maximum nitrate mass that a facility can accept and still achieve expected removal rates.

In the *2017 Elk Valley Regional Water Quality Model Update* (Teck 2017a), mine-affected waters targeted for treatment were directed to each treatment facility sequentially from the source with the highest selenium concentration to the source with the lowest, until either the hydraulic capacity of the treatment facility was reached or all available sources were treated. If the hydraulic capacity of the treatment facility was reached before all available sources were treated, then excess water would bypass the treatment facility and remain in the source tributaries. Once the hydraulic capacity of the treatment facility was reached or all available sources were treated, the influent waters were mixed, a nitrate load was calculated and compared to the nitrate design load removal. When the nitrate load exceeded the nitrate design load removal, a portion of the incoming fully-mixed influent flow would bypass the treatment facility and discharge directly to the downstream environment, at the location of the AWTF.

The RWQM has been updated so that source waters targeted for treatment are directed to each treatment facility sequentially from the source with the highest selenium concentration to the source with the lowest, until the hydraulic capacity is reached, the nitrate design load removal of the treatment facility is reached, or all available sources are treated. If the hydraulic capacity or the nitrate design load removal of the treatment facility is reached before all available sources are treated, then excess water would bypass the treatment facility and remain in the source tributaries. This is more consistent with the way the AWTFs would be operated.

The RWQM has also been updated so that user-defined effluent concentrations of selenium, nitrate and sulphate, in addition to hydraulic capacities and nitrate loading limits, can vary over time at a given facility, along with surface water availabilities of the sources targeted for treatment.

3 Effect to Model Performance

Changes to model performance over the calibration period, due to changes made to the RWQM and updates to site conditions, are presented in this section. Final values assigned to the calibration factors and initial lag times for nitrate, selenium and sulphate were the same as those reported in the *2017 Elk Valley Regional Water Quality Model Update* (Teck 2017a), with the exception of initial lag time in Clode Creek, which was reduced from 5 years to 3 years.

Error and bias statistics are also presented for nitrate, selenium and sulphate.

3.1 Nitrate

3.1.1 Tributaries

Model performance over the calibration period is almost identical to that in the *2017 Elk Valley Regional Water Quality Model Update* (Teck 2017a) in most mine-affected tributaries. Simulated results in mine-affected tributaries to the Fording River and Elk River continue to match reasonably well with measured data, in terms of replicating the range of measured concentrations and matching seasonal, yearly and longer-term trends. Comparisons of model outputs to monitored data are shown for selected tributaries in Figure 3-1; comparable plots for all modelled tributaries are included in Appendix A.

The performance of the model in simulating concentrations of nitrate has improved compared to that reported in Teck (2017a) at the following mine-affected tributaries:

- Leask Creek at GHO where the relative bias decreased from 1.2 to 1.1 and the percent error decreased from 70% to 66% (Table 3-1). Improvements in the ability of the model to simulate concentrations of nitrate in Leask Creek are due to an update to how pit walls are categorized at GHO.
- Wolfram Creek at GHO where the relative bias increased from 0.55 to 0.62 and the percent error decreased from 67% to 65% (Table 3-1). Improvements in the ability of the model to simulate concentrations of nitrate in Wolfram Creek are due to updates to how pit walls are categorized at GHO and the pumping record for the Cougar Phase 3 Pit in 2015.
- Erickson Creek at EVO where the relative bias decreased from 1.1 to 0.95 and the percent error was unchanged at 15% (Table 3-1). Improvement in the ability of the model to simulate concentrations of nitrate in Erickson Creek are due to updates in flow estimates for Erickson Creek and tailings flows from the West Fork Tailings Storage Facility (WFTF) from 2005 to the end of the calibration period.
- Gate Creek at EVO where the relative bias decreased from 1.1 to 0.94 and the percent error decreased from 65% to 51% (Table 3-1). Improvements in the ability of the model to simulate concentrations of nitrate in Gate Creek are due to an update to water management at Cedar Pit/Baldy Ridge Pit 6 from 2012 to the end of the calibration period.

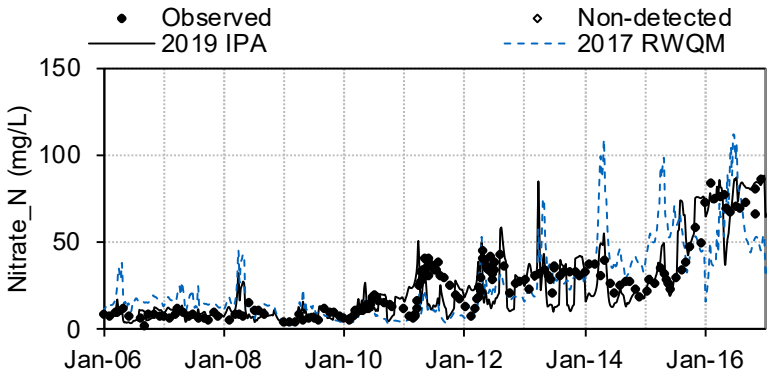
The performance of the model in simulating concentrations of nitrate has weakened slightly compared to that reported in Teck (2017a) in Michel Creek at the mouth, where the relative bias increased from 1.0 to 1.1 and the percent error increased from 40% to 41% (Table 3-1). Changes to the ability of the model to simulate concentrations of nitrate in Michel Creek are due to updates to flows in Erickson Creek and to water management at Cedar Pit/Baldy Ridge Pit 6 from 2012 to the end of the calibration period.

The performance of the model in simulating concentrations of nitrate is changed compared to that reported in Teck (2017a) at the following mine-affected tributaries:

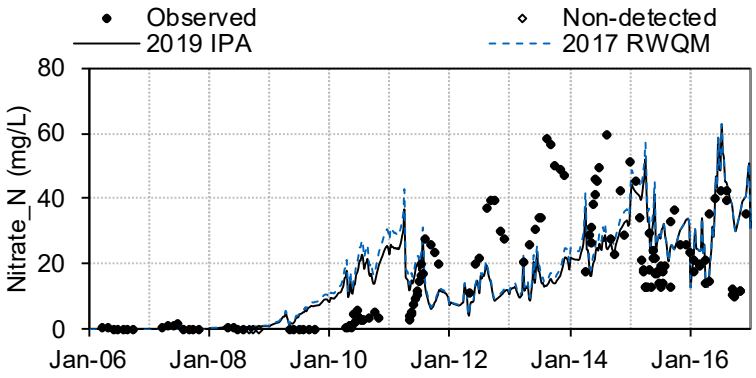
- Clode Creek at FRO where the relative bias decreased from 0.95 to 0.93, while the percent error decreased from 49% to 37% (Table 3-1). These changes are due to the updates to historical water management activities in the Clode Creek watershed described in Section 2.2. The reduction in initial lag time from 5 years to 3 years resulted in simulated nitrate concentrations more closely following observed inflection points in the historical record and also a better match between observed and simulated concentrations in some years (i.e., 2014 to 2016).
- Bodie Creek at EVO where the relative bias decreased from 1.0 to 0.88 and the percent error decreased from 43% to 35% (Table 3-1). These changes are due to an update to water management at Cedar Pit/Baldy Ridge Pit 6 from 2012 to the end of the calibration period. Although relative bias over the entire calibration period has decreased, the update to water management at Cedar Pit/Baldy Ridge Pit 6 results in improvements to both relative bias and percent error between 2012 and 2016, with relative bias decreasing from 1.2 to 1.0 and percent error decreasing from 41% to 28%. Thus, the changes made have a more positive influence on model performance than the change to the overall relative bias statistic would suggest.

Figure 3-1 Projected Nitrate Concentrations in Tributaries between 2006 and 2016

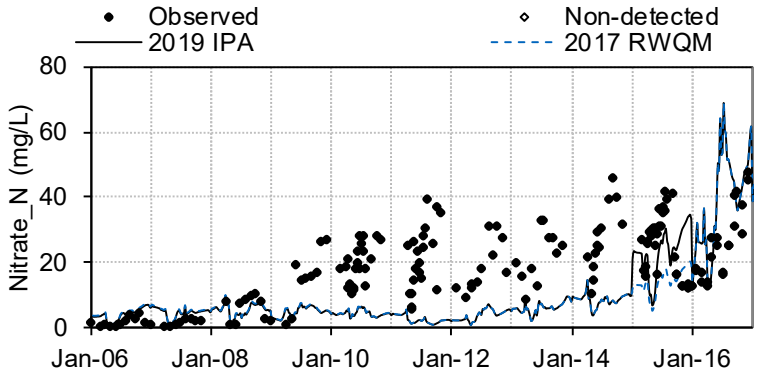
(a) Clode Creek Sediment Pond Decant (FR_CC1)



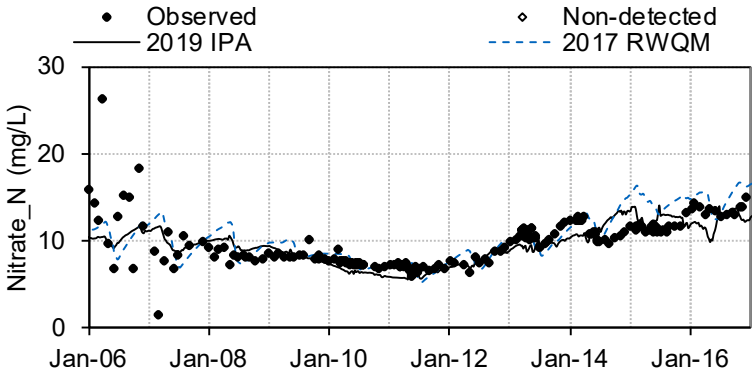
(b) Leask Creek Sediment Pond Decant (GH_LC1)



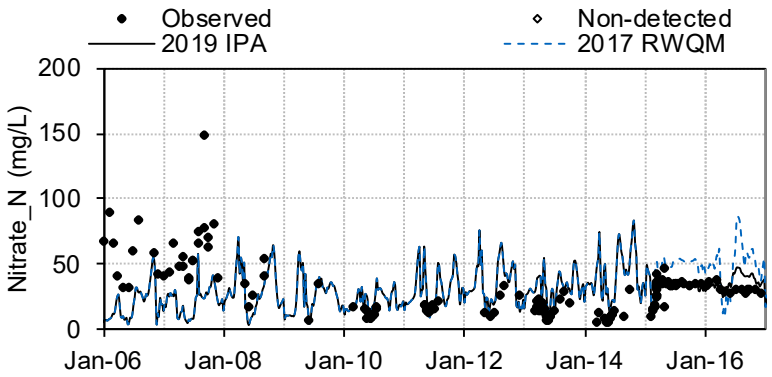
(c) Wolfram Creek Sediment Pond Decant (GH_WC1)



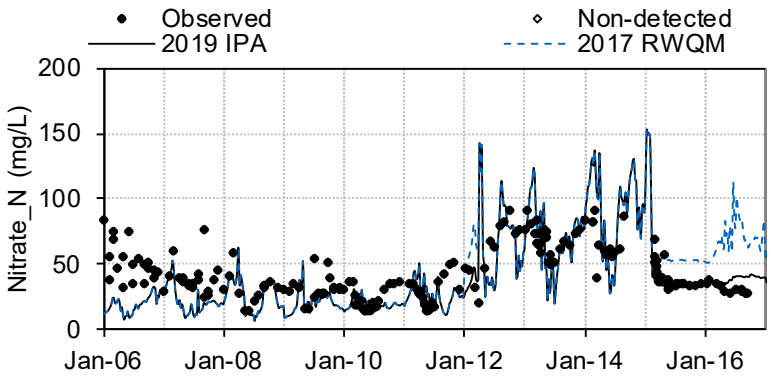
(d) Erickson Creek at Mouth (EV_EC1)



(e) Gate Creek Sediment Pond Decant (EV_GT1)



(f) Bodie Creek Sediment Pond Decant (EV_BC1)



(g) Michel Creek u/s of Highway 43 Bridge (EV_MC1)

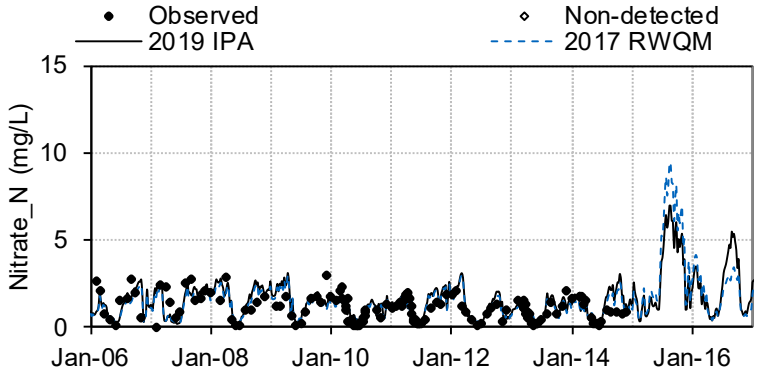


Table 3-1 Error and Bias Results for Nitrate Calibration for the 2017 RWQM and 2019 IPA, 2006-2016

Operation	Node	Node Description	2017 Regional Water Quality Model Update				2019 Implementation Plan Adjustment				Difference[a]	
			Bias (mg/L)[b]	Relative Bias[c]	Error (mg/L)[d]	Percent Error[e]	Bias (mg/L)[b]	Relative Bias[c]	Error (mg/L)[d]	Percent Error[e]	Relative Bias	Percent Error
Fording River Operations	FR_HC1	Henretta Creek u/s of Fording River	-0.63	0.85	1.4	32%	-0.6	0.86	1.4	32%	1%	0%
	FR_CC1	Clode Creek Sediment Pond Decant	-1.2	0.95	13	49%	-1.9	0.93	9.6	37%	-3%	-24%
	FR_LMP1	Lake Mountain Pond	0.072	1.1	0.53	49%	0.07	1.1	0.53	49%	0%	0%
	FR_KC1	Kilmarnock Creek d/s of Rock Drain	-5.0	0.91	13	24%	-5.2	0.9	13	24%	0%	-1%
	GH_SC1	Swift Creek Sediment Pond Discharge	9.2	1.3	17	48%	9.2	1.3	17	48%	0%	0%
	GH_CC1	Cataract Creek Sediment Pond Decant	-0.62	0.98	7.4	22%	-0.62	0.98	7.4	22%	0%	0%
	GH_PC1	Porter Creek Sediment Pond Decant	0.22	1.1	1.2	53%	0.22	1.1	1.2	53%	0%	0%
Greenhills Operations	GH_GH1	Greenhills Creek Sediment Pond Decant	0.52	1.2	1.7	51%	0.52	1.2	1.7	51%	0%	0%
	GH_LC1	Leask Creek Sediment Pond Decant	3.2	1.2	12	70%	1.7	1.1	12	66%	-7%	-5%
	GH_WC1	Wolfram Creek Sediment Pond Decant	-8.8	0.55	13	67%	-7.3	0.62	13	65%	13%	-3%
	GH_TC1	Thompson Creek at LRP Road	4.2	1.6	4.9	68%	4.2	1.6	4.9	68%	0%	0%
Line Creek Operations	LC_DC1	Dry Creek near mouth (at bridge)	0.0071	1.1	0.12	111%	0.0071	1.1	0.12	111%	0%	0%
	LC_LCUSWLC	Line Creek u/s of West Line Creek	0.3	1.0	3.8	34%	-0.21	0.98	3.8	35%	-5%	2%
	LC_WLC	West Line Creek	-1.6	0.95	9.0	31%	-2.3	0.92	8.8	30%	-3%	-3%
	LC_LC4	Line Creek u/s of Process Plant	0.12	1.0	1.8	28%	0.074	1.0	1.9	28%	-1%	3%
Elkview Operations	EV_EC1	Erickson Creek at Mouth	0.51	1.1	1.4	15%	-0.53	0.95	1.4	15%	-10%	-1%
	EV_GT1	Gate Creek Sediment Pond Decant	3.1	1.1	20	65%	-1.8	0.94	16	51%	-14%	-21%
	EV_BC1	Bodie Creek Sediment Pond Decant	-0.17	1.0	18	43%	-5.2	0.88	15	35%	-12%	-18%
	EV_DC1	EVO Dry Creek Sediment Pond Decant	-1.9	0.52	2.0	50%	-1.9	0.53	2.0	49%	1%	-1%
	EV_HC1	EVO Harmer Compliance Point	-0.055	0.94	0.22	22%	-0.043	0.96	0.21	22%	1%	-1%
Fording River	FR_FR1	Fording River d/s of Henretta Creek	-0.97	0.62	1.1	43%	-0.96	0.62	1.1	42%	1%	-1%
	FR_FR2	Fording River u/s of Kilmarnock Creek	-2.5	0.62	3.0	44%	-2.9	0.57	3.0	45%	-8%	2%
	FR_FR4	Fording River between Swift and Cataract Creeks	0.76	1.1	2.7	37%	0.29	1.0	2.3	31%	-6%	-15%
	GH_PC2	Fording River d/s of Porter Creek	-0.92	0.95	4.8	26%	-1.8	0.9	4.8	26%	-5%	0%
	GH_FR1 (EMS 0200378)	**GHO Fording River Compliance Point - Upper Fording River, 205 m d/s of Greenhills Creek**	0.14	1.0	1.8	23%	0.11	1.0	1.9	24%	0%	1%
	LC_LC5 (EMS 0200028)	**Fording River downstream of Line Creek**	-0.19	0.97	1.6	22%	-0.32	0.96	1.6	22%	-2%	4%
Michel Creek	**CM_MC2 (EMS E258937)**	**Michel Creek d/s CMO Compliance Point**	-0.057	0.96	0.86	56%	-0.054	0.96	0.86	56%	0%	0%
	EV_MC3	Michel Creek upstream of Erickson Creek	0.07	1.4	0.17	91%	0.071	1.4	0.17	91%	0%	0%
	EV_MC1	Michel Creek u/s Highway 43 Bridge	0.0013	1.0	0.44	40%	0.075	1.1	0.45	41%	7%	3%
Elk River	**GH_ER1 (EMS E206661)**	**Elk River u/s of Boivin Creek and (u/s of Fording River)**	0.016	1.1	0.092	44%	0.0026	1.0	0.087	42%	-6%	-5%
	EV_ER4 (EMS 0200389)	**Elk River u/s of Grave Creek**	-0.003	1.0	0.75	30%	-0.048	0.98	0.76	30%	-2%	2%
	EV_ER1 (EMS 0200393)	**Elk River downstream of Michel Creek**	0.051	1.0	0.44	27%	0.017	1.0	0.43	26%	-2%	-1%
	RG_ELKMOUTH	Elk River at Highway 93 near Elko	-0.022	0.98	0.23	24%	-0.031	0.97	0.22	23%	-1%	-4%
	RG_DSELK (EMS E300230)[f]	**Koocanusa Reservoir**	0.08	1.3	0.12	46%	0.052	1.2	0.094	35%	-8%	-22%

CMO = Coal Mountain Operations; EVO = Elkview Operations; GHO = Greenhills Operations; mg/L = milligrams per litre; u/s = upstream; d/s = downstream.

(a) The difference in relative bias was calculated using the following equation: (Relative $Bias_{2019\ IPA}$ – Relative $Bias_{2017\ RWQM}$)/Relative $Bias_{2017\ RWQM}$ x 100. The difference in percent error was calculated using the following equation: (Percent $Error_{2019\ IPA}$ – Percent $Error_{2017\ RWQM}$)/Percent $Error_{2017\ RWQM}$ x 100.

(b) Bias represents the average difference between simulated and observed concentrations. A positive bias indicates that modelled concentrations are greater, on average, than observed concentrations.

(c) A relative bias greater than one indicates that modelled concentrations are greater, on average, than observed concentrations.

(d) The error represents the average absolute difference between simulated and observed concentrations.

(e) The percent error represents the ratio of the error to the average observed concentration.

(f) In Teck (2017a), projected concentrations in Koocanusa Reservoir were compared to monitored data at RG_DSELK. The comparison of simulated to monitored data has been expanded to include data at the four stations located downstream of the Elk River: RG_DSELK, RG_GRASMERE, RG_USGOLD and RG_BORDER. Projected concentrations of nitrate in Koocanusa Reservoir were not corrected for model bias.

Notes:

Sites in **bold** font correspond to Order Stations and Compliance Points listed in EMA Permit 107517; Order Stations are indicated by underlined font node IDs.

Calibration statistics have not been provided for the Elk River at Elko Reservoir, because of the limited amount of monitoring data available. Similarly, calibration statistics have not been provided for the FRO Compliance Point (FR_FRCP1), the LCO Compliance Point (LC_LCDSSLCC), the GHO Elk River Compliance Point (GH_ERC) or the EVO Michel Creek Compliance Point (EV_MC2), because monitoring data were only available from 2014 to 2016 at these locations.

3.1.2 Fording River and Elk River

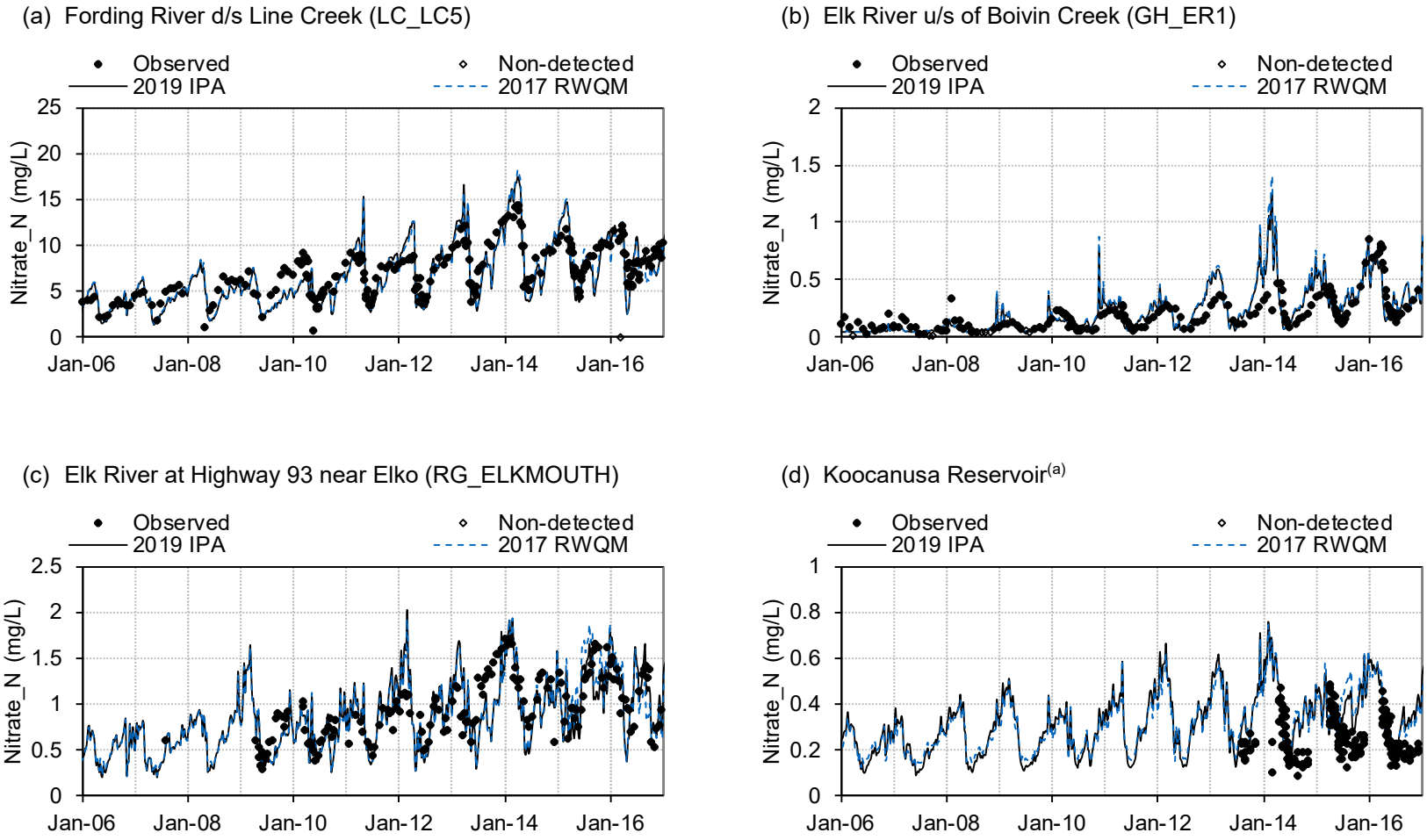
Model performance over the calibration period is almost identical to that reported in Teck (2017a) at most locations in the Fording River and Elk River. The model projections continue to accurately reflect observed seasonal and longer-term annual trends in nitrate concentrations in both the Fording River and Elk River, as well as simulate the observed range (Figure 3-2 and Appendix A). Both versions of the model tend to over-predict nitrate concentrations during lower winter flow periods in the lower Fording River and most of the Elk River, when instream concentrations peak.

The performance of the model in simulating concentrations of nitrate has improved compared to that reported in Teck (2017a) at the following locations:

- Elk River upstream of Boivin Creek, where the relative bias decreased from 1.1 to 1.0 and the percent error decreased from 44% to 42% (Table 3-1). These improvements result from the previously discussed improvements in Leask Creek and Wolfram Creek.
- Koocanusa Reservoir, where the relative bias decreased from 1.3 to 1.2 and the percent error decreased from 46% to 35% (Table 3-1). These changes are not reflective of corrections of model bias, because bias correction was only applied to selenium. Improvements in the ability of the model to simulate concentrations of nitrate in Koocanusa Reservoir are due to updates to upstream watersheds, an update to the source term concentration for nitrate used to define background conditions in the Kootenay River and Bull River, and the inclusion of a larger number of monitoring stations to define observed concentrations in the reservoir.

The performance of the model in simulating concentrations of nitrate has changed compared to that reported in Teck (2017a) in the Elk River at the mouth where the relative bias decreased from 0.98 to 0.97 and the percent error decreased from 24% to 22% (Table 3-1). These changes indicate that model accuracy and precision have marginally decreased and increased, respectively. Changes to the ability of the model to simulate concentrations of nitrate in the Elk River are due to updates to upstream watersheds.

Figure 3-2 Projected Nitrate Concentrations in Fording River, Elk River and Koocanusa Reservoir between 2006 and 2016



(a) In Teck (2017a), projected concentrations in Koocanusa Reservoir were compared to monitored data at RG_DSELK. The comparison of simulated to monitored data has been expanded to include data at the four stations located downstream of the Elk River: RG_DSELK, RG_GRASMERE, RG_USGOLD and RG_BORDER. Projected concentrations of nitrate in Koocanusa Reservoir were not corrected for model bias.

3.2 Selenium

3.2.1 Tributaries

As with nitrate, model performance with respect to projected selenium concentrations over the calibration period is almost identical to that reported in Teck (2017a) in most mine-affected tributaries. Simulated results continue to match reasonably well with measured data, in terms of replicating the range of measured concentrations and matching seasonal, yearly and longer-term trends. Comparisons of model outputs to monitored data are shown for selected tributaries in Figure 3-3; comparable plots for all modelled tributaries are included in Appendix B.

The performance of the model in simulating concentrations of selenium has improved compared to that reported in Teck (2017a) at the following mine-affected tributaries:

- Line Creek upstream of West Line Creek, where the relative bias remained the same at 1.2, but the percent error decreased from 39% to 34% (Table 3-2). Improvement in the ability of the model to simulate concentrations of selenium in Line Creek upstream of West Line Creek is due to updates at the West Line Creek Active Water Treatment Facility, where the hydraulic capacity was updated from 6,000 m^3/d to 5,500 m^3/d, an intake efficiency of 95% was assumed and Mine Services Area-West was sent to the treatment facility as the second source.
- Gate Creek at EVO, where the relative bias decreased from 1.2 to 1.1 and the percent error decreased from 51% to 42% (Table 3-2). Similar to nitrate, improvements in the ability of the model to simulate concentrations of selenium in Gate Creek are due to an update to water management at Cedar Pit/Baldy Ridge Pit 6 from 2012 to the end of the calibration period.
- Bodie Creek at EVO where the relative bias decreased from 1.1 to 1.0 and the percent error decreased from 51% to 42% (Table 3-2). Similar to Gate Creek, improvements in the ability of the model to simulate concentrations of selenium in Bodie Creek are due to an update to water management at Cedar Pit/Baldy Ridge Pit 6 from 2012 to the end of the calibration period.

The performance of the model in simulating concentrations of nitrate has weakened from that reported in Teck (2017a) at the following mine-affected tributaries:

- Clode Creek at FRO, where the relative bias decreased from 1.0 to 0.77 and the percent error increased from 40% to 54% (Table 3-2). Performance over the calibration period was mixed; the change to initial lag time and historical water management practices resulted in a closer match to observed concentrations in some months / years, and more divergence in others.
- Wolfram Creek at GHO, where the relative bias is unchanged at 0.79, but the percent error increased from 60% to 65% (Table 3-2). These changes indicate that the precision of the model has decreased in this tributary. Changes to the ability of the model to simulate concentrations of selenium in Wolfram Creek are due to an update to how pit walls are categorized at GHO, as well as an update to the pumping record for the Cougar Phase 3 Pit in 2015.

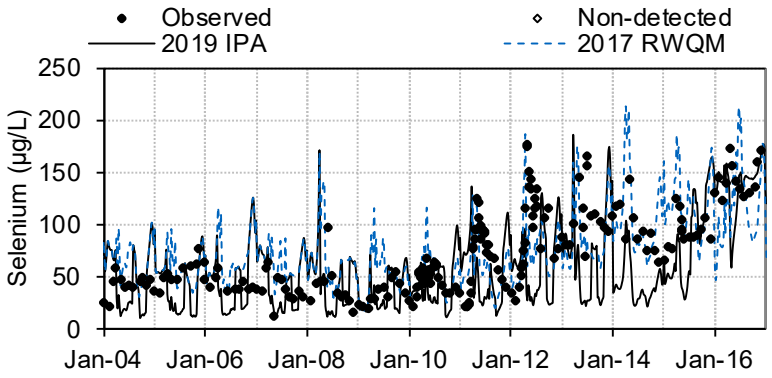
- Michel Creek at the mouth, where the relative bias increased from 0.98 to 1.1 and the percent error increased from 36% to 38% (Table 3-2). These changes indicate that the accuracy and precision of the model at this location have both decreased slightly. Changes to the ability of the model to simulate concentrations of selenium in Michel Creek are due to updates to flows in Erickson Creek and to water management at Cedar Pit/Baldy Ridge Pit 6 from 2012 to the end of the calibration period.

The performance of the model in simulating concentrations of selenium has changed compared to that reported in Teck (2017a) at the following mine-affected tributaries:

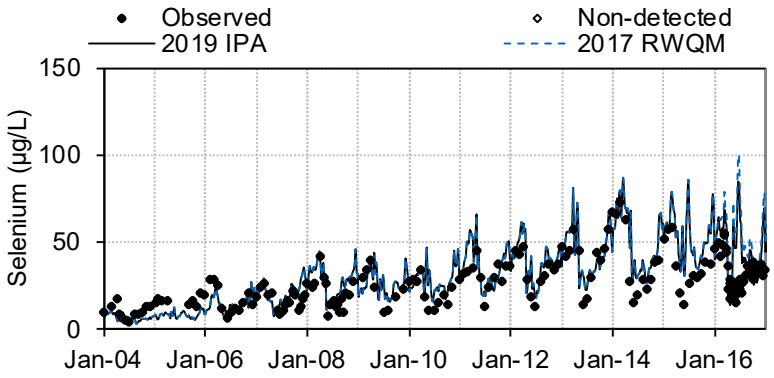
- Leask Creek at GHO, where the relative bias decreased from 1.4 to 1.3, but the percent error increased from 68% to 71% (Table 3-2). These changes indicate that model accuracy and precision have increased and decreased, respectively. Changes to the ability of the model to simulate concentrations of selenium in Leask Creek are due to an update to how pit walls are categorized at GHO.
- Erickson Creek at EVO, where the relative bias decreased from 1.0 to 0.93, but the percent error decreased from 14% to 12% (Table 3-2). These changes indicate that model accuracy and precision have decreased and increased, respectively. Changes to the ability of the model to simulate concentrations of selenium in Erickson Creek are due to an update to flows in Erickson Creek, as well as an update to tailings flows from WFTF from 2005 to the end of the calibration of the calibration period.

Figure 3-3 Projected Selenium Concentrations in Tributaries between 2004 and 2016

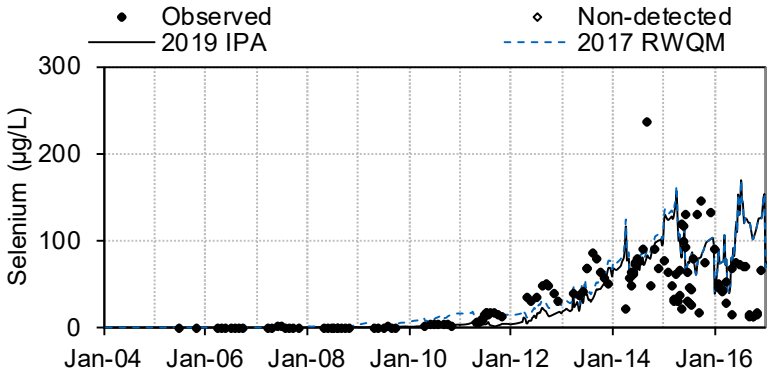
(a) Clode Creek Sediment Pond Decant (FR_CC1)



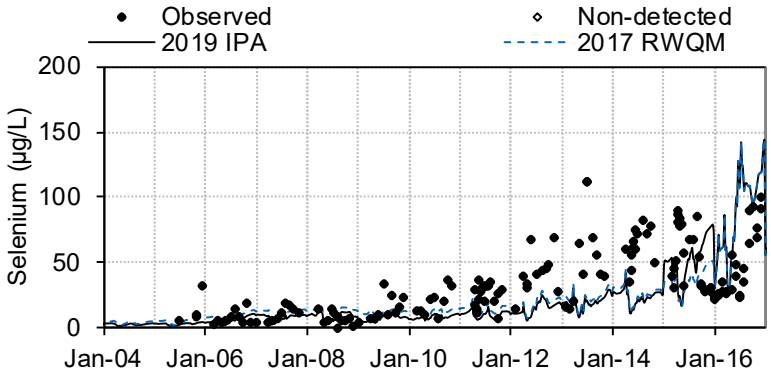
(b) Line Creek u/s of West Line Creek (LC_LCUSWLC)



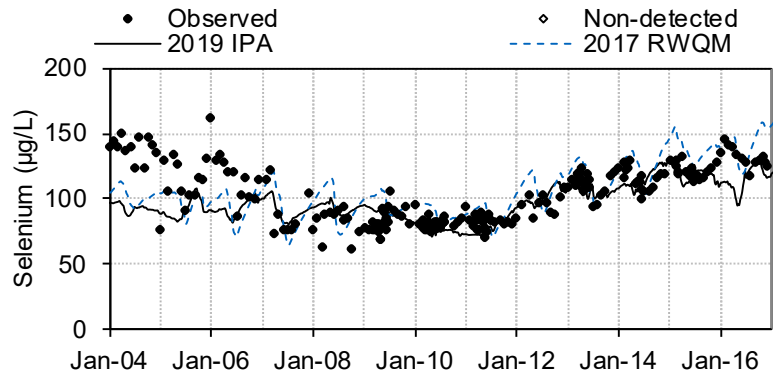
(c) Leask Creek Sediment Pond Decant (GH_LC1)



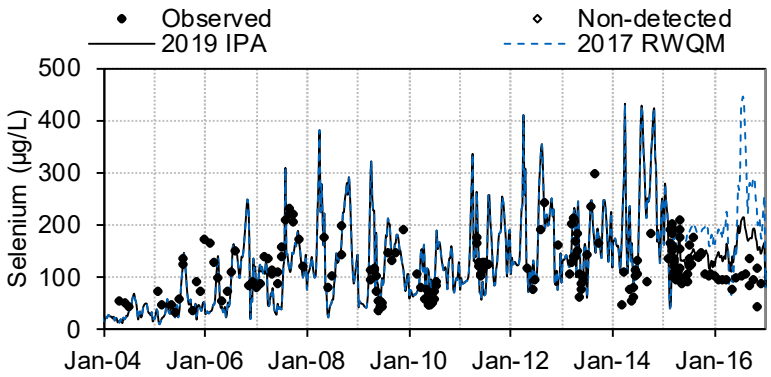
(d) Wolfram Creek Sediment Pond Decant (GH_WC1)



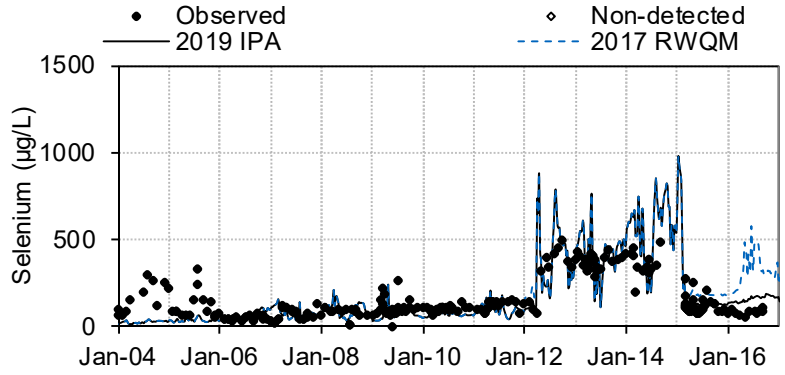
(e) Erickson Creek at Mouth (EV_EC1)



(f) Gate Creek Sediment Pond Decant (EV_GT1)



(g) Bodie Creek Sediment Pond Decant (EV_BC1)



(h) Michel Creek u/s Highway 43 Bridge (EV_MC1)

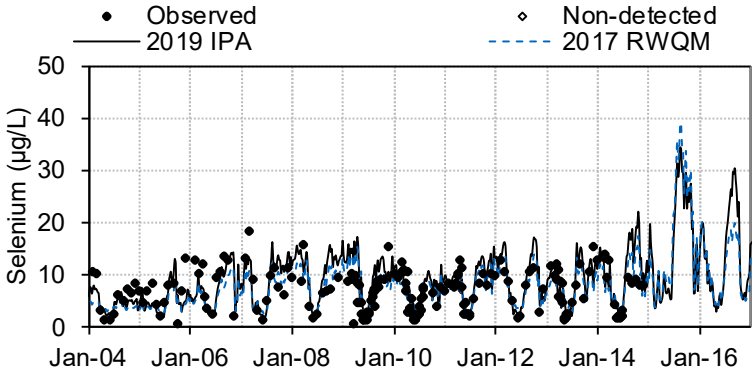


Table 3-2 Error and Bias Results for Selenium Calibration for the 2017 RWQM and 2019 IPA, 2004-2016

Operation	Node	Node Description	2017 Regional Water Quality Model Update				2019 Implementation Plan Adjustment				Difference[a]	
			Bias (µg/L)[b]	Relative Bias[c]	Error (µg/L)[d]	Percent Error[e]	Bias (µg/L)[b]	Relative Bias[c]	Error (µg/L)[d]	Percent Error[e]	Relative Bias	Percent Error
Fording River Operations	FR_HC1	Henretta Creek u/s of Fording River	-0.35	0.98	4.0	27%	-0.24	0.98	4.0	27%	1%	1%
	FR_CC1	Clode Creek Sediment Pond Decant	3.3	1.0	29	40%	-17	0.77	39	54%	-27%	36%
	FR_LMP1	Lake Mountain Pond	-2.9	0.86	7.2	34%	-3.1	0.86	7.2	34%	-1%	0%
	FR_KC1	Kilmarnock Creek d/s of Rock Drain	-1.1	0.99	23	25%	-1.6	0.98	23	25%	0%	0%
	GH_SC1	Swift Creek Sediment Pond Discharge	72	1.2	137	35%	72	1.2	137	35%	0%	0%
	GH_CC1	Cataract Creek Sediment Pond Decant	53	1.1	99	22%	53	1.1	99	22%	0%	0%
	GH_PC1	Porter Creek Sediment Pond Decant	-1.6	0.98	17	24%	-1.6	0.98	17	24%	0%	0%
Greenhills Operations	GH_GH1	Greenhills Creek Sediment Pond Decant	32	1.4	46	62%	31	1.4	46	62%	0%	0%
	GH_LC1	Leask Creek Sediment Pond Decant	14	1.4	26	68%	9.7	1.3	27	71%	-8%	4%
	GH_WC1	Wolfram Creek Sediment Pond Decant	-7.3	0.79	21	60%	-7.5	0.79	23	65%	-1%	8%
	GH_TC1	Thompson Creek at LRP Road	11	1.2	24	39%	11	1.2	24	39%	0%	0%
Line Creek Operations	LC_DC1	Dry Creek near mouth (at bridge)	-0.55	0.74	0.85	41%	-0.55	0.74	0.85	41%	0%	0%
	LC_LCUSWLC	Line Creek u/s of West Line Creek	6.7	1.2	11	39%	4.9	1.2	9.5	34%	-5%	-12%
	LC_WLC	West Line Creek	-88	0.79	125	30%	-94	0.77	129	31%	-2%	3%
	LC_LC4	Line Creek u/s of Process Plant	-0.74	0.98	7.5	25%	-1.2	0.96	7.7	25%	-1%	3%
Elkview Operations	EV_EC1	Erickson Creek at Mouth	4.1	1.0	15	14%	-7.4	0.93	13	12%	-11%	-13%
	EV_GT1	Gate Creek Sediment Pond Decant	24	1.2	61	51%	8.4	1.1	50	42%	-11%	-19%
	EV_BC1	Bodie Creek Sediment Pond Decant	19	1.1	79	51%	1.9	1.0	65	42%	-10%	-18%
	EV_DC1	EVO Dry Creek Sediment Pond Decant	-54	0.59	59	45%	-54	0.59	58	45%	0%	0%
	EV_HC1	EVO Harmer Compliance Point	-1.5	0.95	6.4	23%	-1.3	0.95	6.4	23%	1%	-1%
Fording River	FR_FR1	Fording River d/s of Henretta Creek	-2.4	0.77	3.6	35%	-2.3	0.77	3.5	35%	1%	-1%
	FR_FR2	Fording River u/s of Kilmarnock Creek	-0.17	0.99	5.7	24%	-2.0	0.92	5.4	23%	-8%	-6%
	FR_FR4	Fording River between Swift and Cataract Creeks	1.9	1.1	11	31%	0.14	1.0	9.9	29%	-5%	-6%
	GH_PC2	Fording River d/s of Porter Creek	0.048	1.0	12	21%	-1.5	0.97	12	21%	-3%	0%
	GH_FR1 (EMS 0200378)	GHO Fording River Compliance Point - Upper Fording River, 205 m d/s of Greenhills Creek	1.3	1.0	6.3	20%	0.96	1.0	6.4	21%	-1%	2%
	LC_LC5 (EMS 0200028)	Fording River downstream of Line Creek	-0.89	0.97	5.8	21%	-1.4	0.95	6.1	22%	-2%	4%
Michel Creek	**CM_MC2 (EMS E258937)**	Michel Creek d/s CMO Compliance Point	0.47	1.1	2.0	44%	0.26	1.1	1.9	43%	-4%	-2%
	EV_MC3	Michel Creek upstream of Erickson Creek	0.39	1.3	0.61	51%	0.35	1.3	0.59	49%	-2%	-4%
	EV_MC1	Michel Creek u/s Highway 43 Bridge	-0.14	0.98	2.5	36%	0.66	1.1	2.7	38%	12%	6%
Elk River	**GH_ER1 (EMS E206661)**	Elk River u/s of Boivin Creek and (u/s of Fording River)	-0.033	0.97	0.39	30%	-0.08	0.94	0.37	29%	-4%	-5%
	EV_ER4 (EMS 0200389)	Elk River u/s of Grave Creek	-0.034	1.0	3.1	30%	-0.24	0.98	3.2	31%	-2%	3%
	EV_ER1 (EMS 0200393)	Elk River downstream of Michel Creek	-0.11	0.99	1.7	22%	-0.096	0.99	1.7	23%	0%	2%
	RG_ELKMOUTH	Elk River at Highway 93 near Elko	-0.085	0.98	0.83	19%	-0.058	0.99	0.8	19%	1%	-3%
	RG_DSELK (EMS E300230)[f,g]	Koocanusa Reservoir	0.36	1.3	0.51	47%	0.019	1.0	0.26	23%	-23%	-50%

CMO = Coal Mountain Operations; EVO = Elkview Operations; GHO = Greenhills Operations; µg/L = microgram per litre; u/s = upstream; d/s = downstream.

(a) The difference in relative bias was calculated using the following equation: (Relative $Bias_{2019\ IPA}$ – Relative $Bias_{2017\ RWQM}$)/Relative $Bias_{2017\ RWQM}$ x 100. The difference in percent error was calculated using the following equation: (Percent $Error_{2019\ IPA}$ – Percent $Error_{2017\ RWQM}$)/Percent $Error_{2017\ RWQM}$ x 100.

(b) Bias represents the average difference between simulated and observed concentrations. A positive bias indicates that modelled concentrations are greater, on average, than observed concentrations.

(c) A relative bias greater than one indicates that modelled concentrations are greater, on average, than observed concentrations.

(d) The error represents the average absolute difference between simulated and observed concentrations.

(e) The percent error represents the ratio of the error to the average observed concentration.

(f) In Teck (2017a), projected concentrations in Koocanusa Reservoir were compared to monitored data at RG_DSELK. The comparison of simulated to monitored data has been expanded to include data at the four stations located downstream of the Elk River: RG_DSELK, RG_GRASMERE, RG_USGOLD and RG_BORDER.

(g) In the 2017 RWQM Update, projected concentrations in Koocanusa Reservoir were not corrected for model bias. In the 2019 IPA, projected concentrations in Koocanusa Reservoir were corrected for model bias.

Notes:

Sites in **bold** font correspond to Order Stations and Compliance Points listed in EMA Permit 107517; Order Stations are indicated by underlined font node IDs.

Calibration statistics have not been provided for the Elk River at Elko Reservoir, because of the limited amount of monitoring data available. Similarly, calibration statistics have not been provided for the FRO Compliance Point (FR_FRCP1), the LCO Compliance Point (LC_LCDSSLCC), the GHO Elk River Compliance Point (GH_ERC) or the EVO Michel Creek Compliance Point (EV_MC2), because monitoring data were only available from 2014 to 2016 at these locations.

3.2.2 Fording River and Elk River

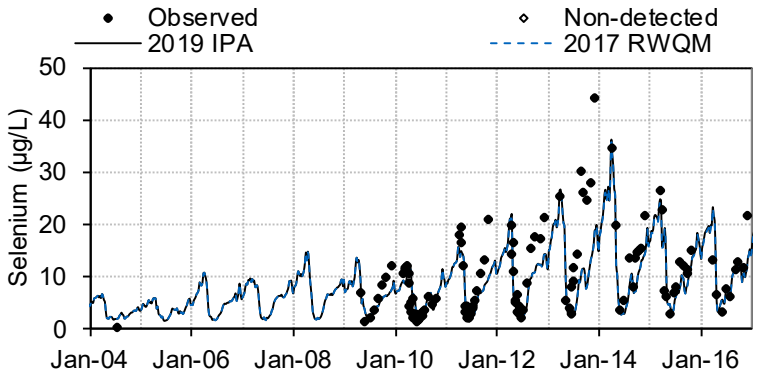
Model performance over the calibration period is almost identical to that reported in Teck (2017a) for most locations in the Fording River and Elk River. Simulated results in the Fording River and Elk River continue to match reasonably well with the range of measured concentrations and seasonal, yearly and longer-term trends (Figure 2-9 and Appendix B). The model maintained a near-neutral bias (Table 3-2) throughout most of the Fording River and Elk River, with some under-prediction occurring in the upper Fording River downstream of Henretta Creek. Model error in the Fording River ranged from 21 to 35%; in the Elk River, it ranged from 19 to 31% (Table 3-2), with some over-prediction of observed winter concentrations. Overall, model performance over the calibration period is comparable to the 2017 RWQM, as illustrated in the plots included in Figure 3-4 and Appendix B.

The performance of the model in simulating concentrations of selenium has improved compared to that reported in Teck (2017a) in Koocanusa Reservoir where the relative bias decreased from 1.3 to 1.0 and the percent error decreased from 47 to 23%. Improvements in the ability of the model to simulate concentrations of selenium in Koocanusa Reservoir are due to:

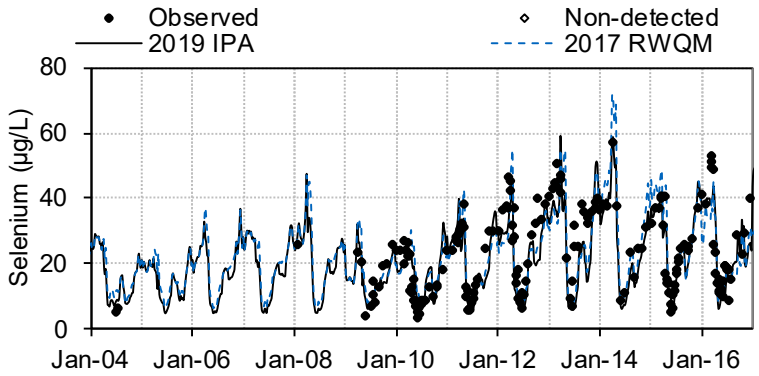
- updates to upstream watersheds
- an update to the source term concentration for selenium used to define background conditions in the Kootenay River and Bull River
- the inclusion of a larger number of monitoring stations to define observed concentrations in the reservoir
- bias correction

Figure 3-4 Projected Selenium Concentrations in Fording River, Elk River and Koocanusa Reservoir between 2004 and 2016

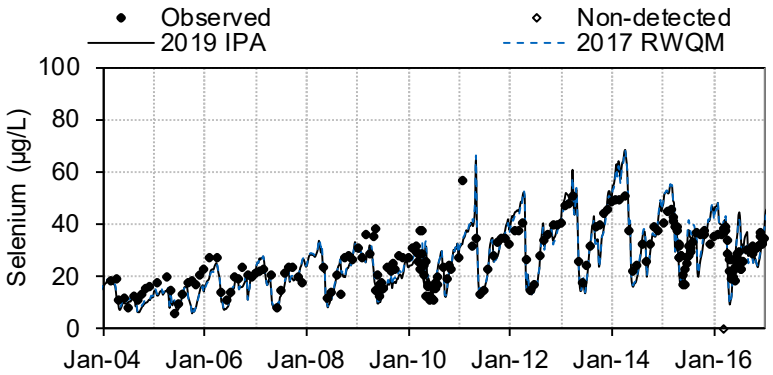
(a) Fording River d/s of Henretta Creek (FR_FR1)



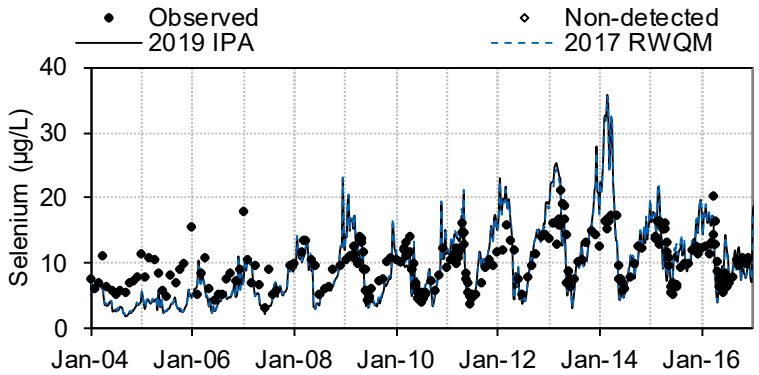
(b) Fording River u/s of Kilmarnock Creek (FR_FR2)



(c) Fording River d/s Line Creek (LC_LC5)

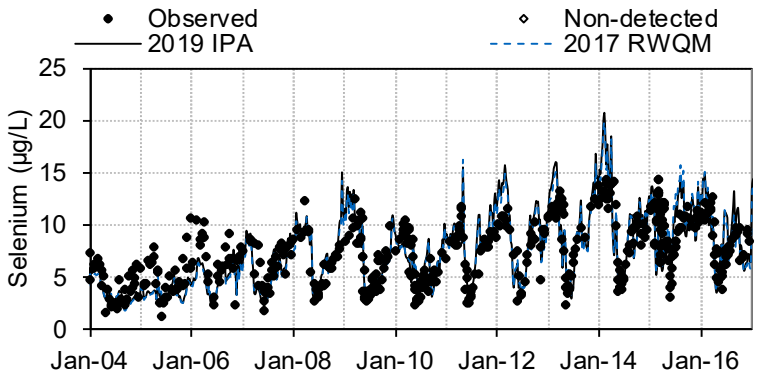


(d) Elk River u/s of Grave Creek (EV_ER4)

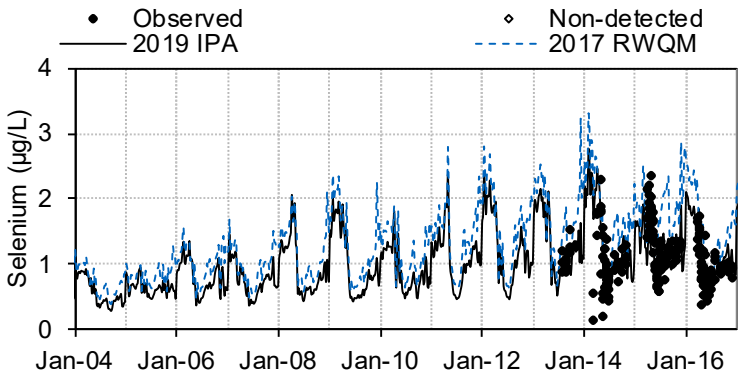


Note: A measurement of 102 µg/L recorded on March 7, 2006 is not shown

(e) Elk River downstream of Michel Creek (EV_ER1)



(f) Koocanusa Reservoir[(a)]



(a) In Teck (2017a), projected concentrations in Koocanusa Reservoir were compared to monitored data at RG_DSELK. The comparison of simulated to monitored data has been expanded to include data at the four stations located downstream of the Elk River: RG_DSELK, RG_GRASMERE, RG_USGOLD and RG_BORDER. Projected concentrations of selenium in Koocanusa Reservoir have also been corrected for model bias.

3.3 Sulphate

3.3.1 Tributaries

Model performance for sulphate over the calibration period is almost identical to that reported in Teck (2017a) in most mine-affected tributaries to the Fording River and Elk River. Simulated results continue to match reasonably well with measured data in terms of replicating the range of measured concentrations and matching seasonal, yearly and longer-term trends (Figure 3-5 and additional plots in Appendix C).

The performance of the model in simulating concentrations of sulphate has improved compared to that reported in Teck (2017a) at the following mine-affected tributaries.

- West Line Creek at LCO, where the relative bias increased from 0.84 to 0.88 and the percent error decreased from 23 to 21% (Table 3-3). Improvements in the ability of the model to simulate concentrations of sulphate are due primarily to inclusion of a flow relationship at West Line Creek, as well as an increase in the sulphate solubility limit.
- Erickson Creek at EVO where the relative bias increased 0.87 to 0.90 and the percent error decreased from 15% to 14% (Table 3-3). Improvements in the ability of the model to simulate concentrations of sulphate in Erickson Creek are due to an update to flows in Erickson Creek (Section 2.3), an increase in the sulphate solubility limit, as well as an update to tailings flows from the WFTF from 2005 to the end of the calibration period.
- Gate Creek at EVO where the relative bias decreased from 1.2 to 1.1 and the percent error decreased from 41% to 36% (Table 3-3). Improvements in the ability of the model to simulate concentrations of sulphate in Gate Creek are due primarily to an update to water management at Cedar Pit/Baldy Ridge Pit 6 from 2012 to the end of the calibration period, as well as an increase in the sulphate solubility limit.
- Bodie Creek at EVO where the relative bias decreased from 1.1 to 0.98 and the percent error decreased from 42% to 34% (Table 3-3). Similar to Gate Creek, improvements in the ability of the model to simulate concentrations of sulphate in Bodie Creek are due primarily to an update to water management at Cedar Pit/Baldy Ridge Pit 6 from 2012 to the end of the calibration period, as well as an increase in the sulphate solubility limit.

The performance of the model in simulating concentrations of sulphate has weakened compared to that reported in Teck (2017a) at the following mine-affected tributaries.

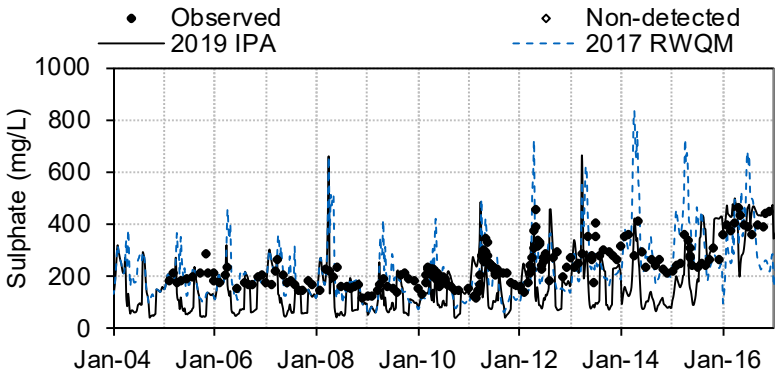
- Clode Creek at FRO where the relative bias decreased from 1.0 to 0.73 and the percent error increased from 32% to 42% (Table 3-3). Performance over the calibration period was mixed; the change to initial lag time and historical water management practices resulted in a closer match to observed concentrations in some months / years, and more divergence in others with a general tendency to reduce the peaks predicted by the 2017 RWQM during freshet.

- Swift Creek at GHO where the relative bias remained unchanged at 1.2, but the percent error increased from 28% to 31% (Table 3-3). Changes in the ability of the model to simulate concentrations of sulphate in Swift Creek are due to an increase in the sulphate solubility limit.
- Wolfram Creek at GHO where the relative bias decreased from 0.53 to 0.42 and the percent error increased from 50% to 59% (Table 3-3). Changes in the ability of the model to simulate concentrations of sulphate in Wolfram Creek are due to an increase in the sulphate solubility limit, and updates to how pit walls are categorized at GHO and the pumping record for the Cougar Phase 3 Pit in 2015.
- Michel Creek at the mouth where the relative bias increased from 1.0 to 1.1 and the percent error increased from 32% to 34% (Table 3-3). Changes in the ability of the model to simulate concentrations of sulphate in Michel Creek are due to an update to flows in Erickson Creek, an update to water management at Cedar Pit/Baldy Ridge Pit 6 from 2012 to the end of the calibration period and an increase in the sulphate solubility limit.

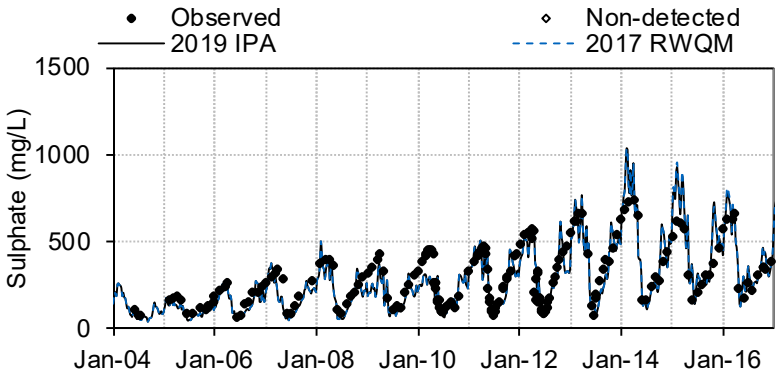
The performance of the model in simulating concentrations of sulphate has changed from that reported in Teck (2017a) at Leask Creek at GHO where the relative bias decreased from 1.1 to 0.84, but the percent error decreased from 49% to 39% (Table 3-3). These changes indicate that model accuracy and precision have decreased and increased, respectively. Changes to the ability of the model to simulate concentrations of sulphate in Leask Creek are due to an update to how pit walls are categorized at GHO, as well as an increase in the sulphate solubility limit.

Figure 3-5 Projected Sulphate Concentrations in Tributaries between 2004 and 2016

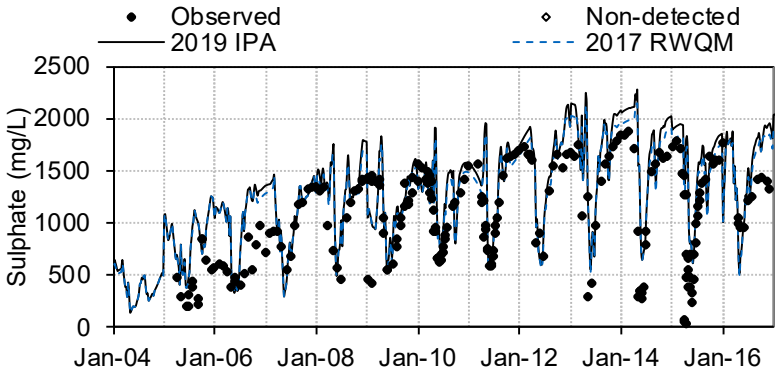
(a) Clode Creek Sediment Pond Decant (FR_CC1)



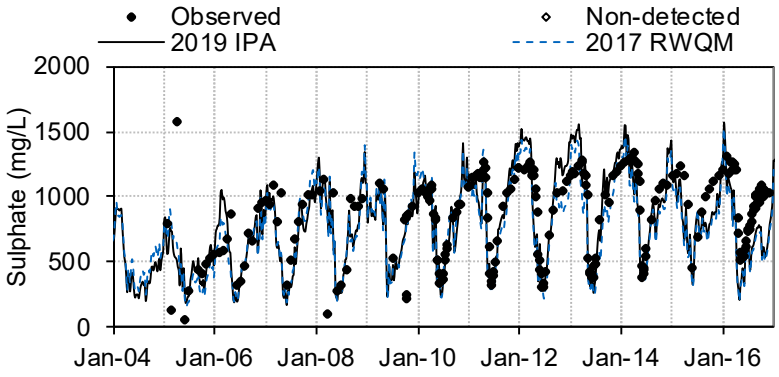
(b) Kilmarnock Creek d/s of Rock Drain (FR_KC1)



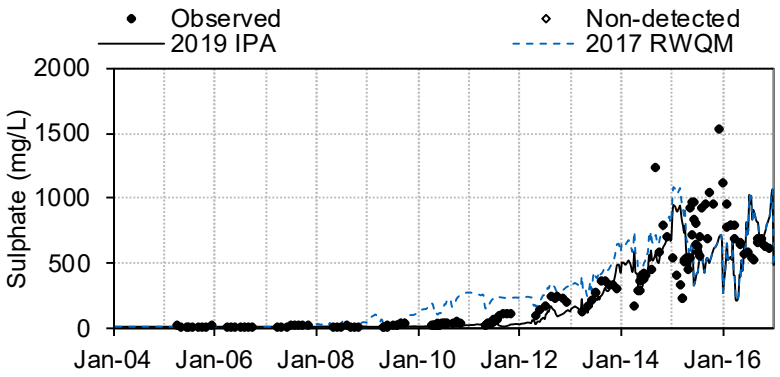
(c) Swift Creek Settling Pond Decant (GH_SC1)



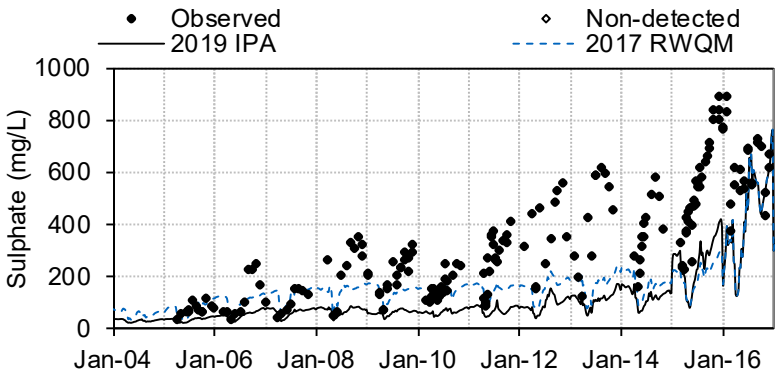
(d) West Line Creek (LC_WLC)



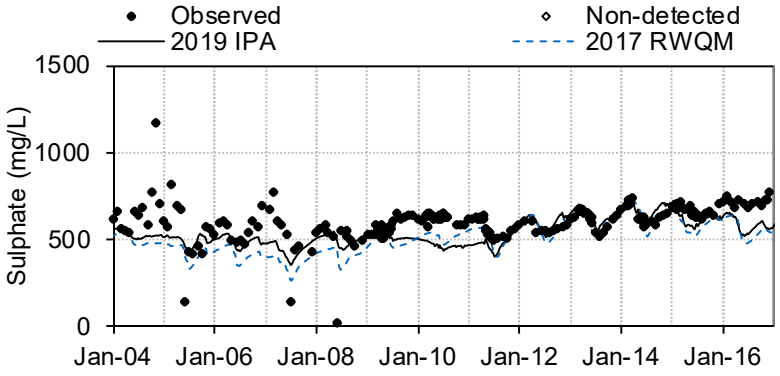
(e) Leask Creek Sediment Pond Decant (GH_LC1)



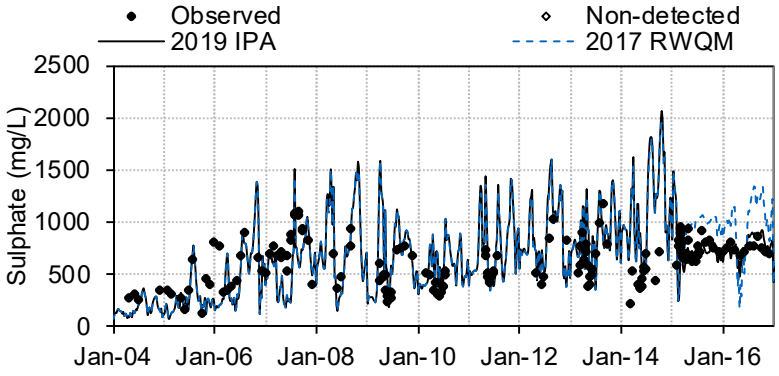
(f) Wolfram Creek Sediment Pond Decant (GH_WC1)



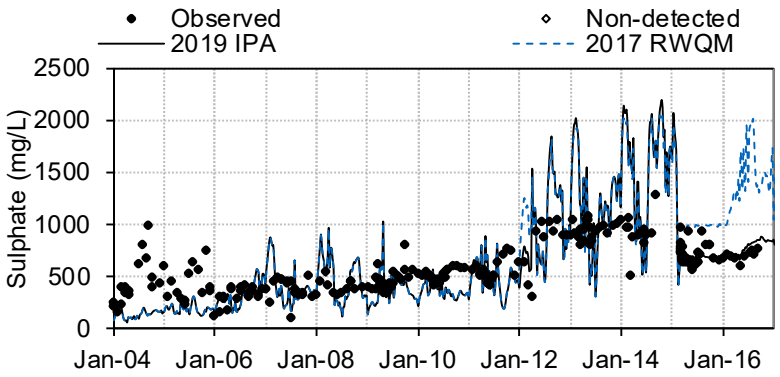
(g) Erickson Creek at Mouth (EV_EC1)



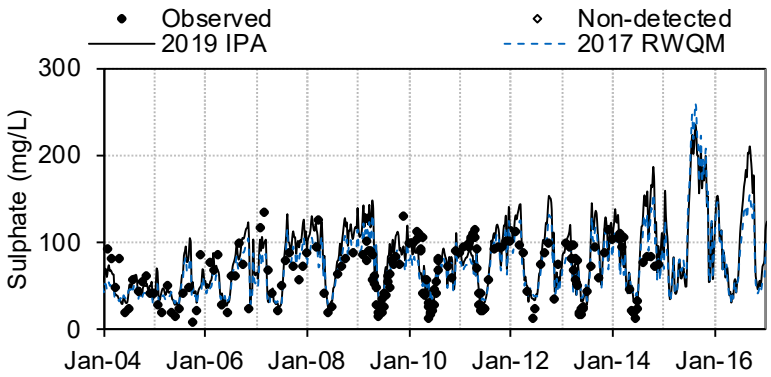
(h) Gate Creek Sediment Pond Decant (EV_GT1)



(i) Bodie Creek Sediment Pond Decant (EV_BC1)



(j) Michel Creek u/s Highway 43 Bridge (EV_MC1)



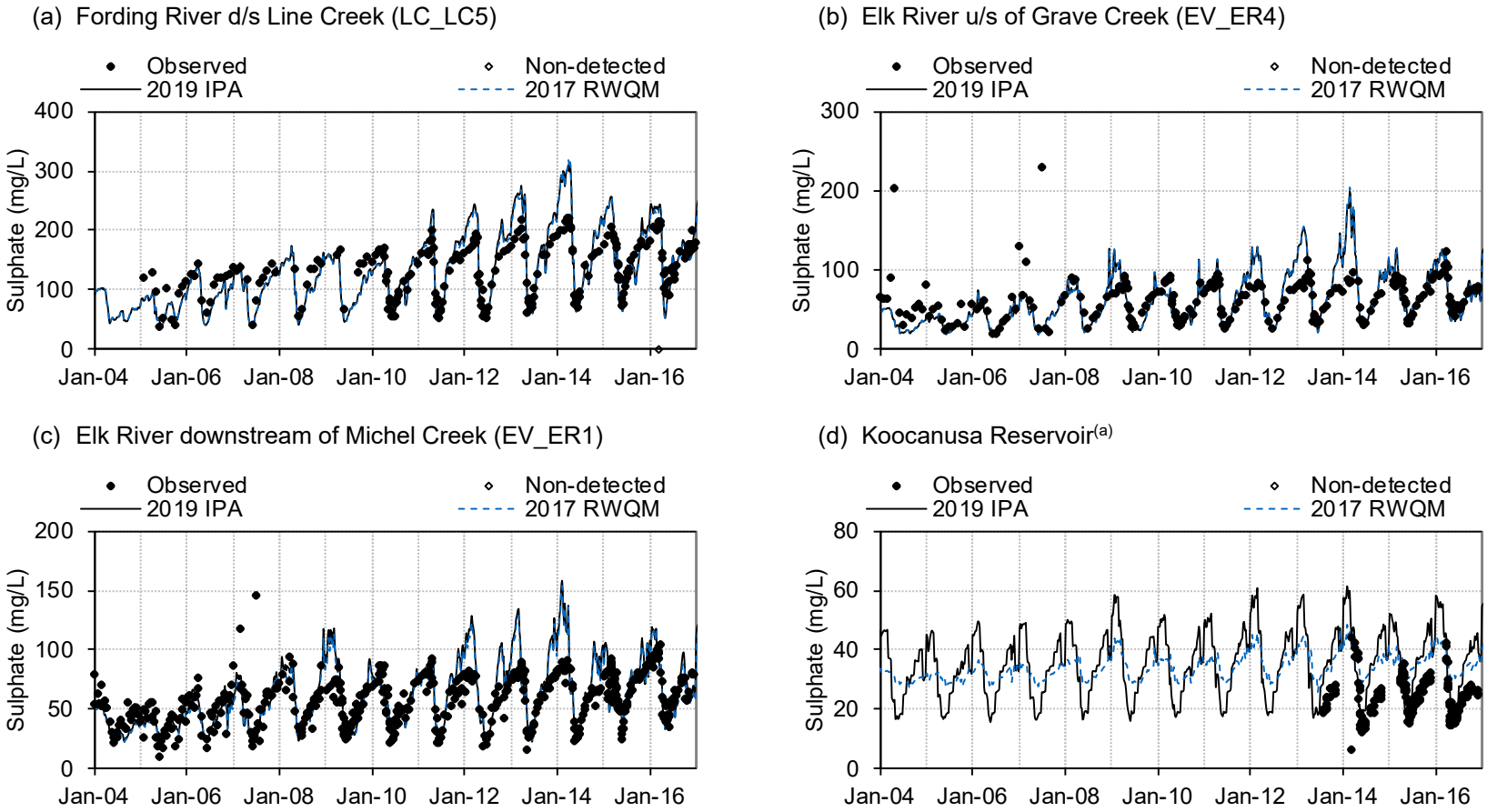
3.3.2 Fording River and Elk River

Simulated sulphate concentrations in the Fording River and Elk River continue to match reasonably well with measured data in terms of replicating the range of measured concentrations and matching seasonal, yearly and longer-term trends (Figure 3-6 and Appendix C).

The model maintained a near-neutral bias throughout most of the Fording River and Elk River (Table 3-3), with some under-prediction occurring in the upper Fording River upstream of Kilmarnock Creek. Model error in the Fording River ranged from 17% to 30%, which is less than that associated with either nitrate or selenium. Similarly, in the Elk River, it ranged from 19% to 25% (Table 3-3), with some over-prediction of observed winter concentrations.

The performance of the model in simulating concentrations of sulphate is improved from that reported in Teck (2017a) in Koocanusa Reservoir where the relative bias decreased from 1.4 to 1.2 and the percent error decreased from 40% to 32%. Improvements in the ability of the model to simulate concentrations of sulphate in Koocanusa Reservoir are due to updates to upstream watersheds, an update to the source term concentration for sulphate used to define background conditions in the Kootenay River and Bull River and the inclusion of a larger number of monitoring stations to define observed concentrations in the reservoir.

Figure 3-6 Projected Sulphate Concentrations in Fording River, Elk River and Koocanusa Reservoir between 2004 and 2016



Note: Measurements of 225 and 537 mg/L recorded on May 4, 2004 and June 3, 2008, respectively are not shown.

(a) In Teck (2017a), projected concentrations in Koocanusa Reservoir were compared to monitored data at RG_DSELK. The comparison of simulated to monitored data has been expanded to include data at the four stations located downstream of the Elk River: RG_DSELK, RG_GRASMERE, RG_USGOLD and RG_BORDER. Projected concentrations of sulphate in Koocanusa Reservoir were not corrected for model bias.

Table 3-3 Error and Bias Results for Sulphate Calibration for the 2017 RWQM and 2019 IPA, 2004-2016

Operation	Node	Node Description	2017 Regional Water Quality Model Update				2019 Implementation Plan Adjustment				Difference[a]	
			Bias (mg/L)[b]	Relative Bias[c]	Error (mg/L)[d]	Percent Error[e]	Bias (mg/L)[b]	Relative Bias[c]	Error (mg/L)[d]	Percent Error[e]	Relative Bias	Percent Error
Fording River Operations	FR_HC1	Henretta Creek u/s of Fording River	14	1.1	30	30%	15	1.1	30	30%	1%	1%
	FR_CC1	Clode Creek Sediment Pond Decant	1.2	1.0	78	32%	-66	0.73	102	42%	-28%	31%
	FR_LMP1	Lake Mountain Pond	-13	0.87	32	31%	-14	0.87	32	31%	0%	0%
	FR_KC1	Kilmarnock Creek d/s of Rock Drain	-25	0.92	70	23%	-26	0.91	70	23%	0%	-1%
	GH_SC1	Swift Creek Sediment Pond Discharge	201	1.2	289	28%	245	1.2	321	31%	3%	11%
	GH_CC1	Cataract Creek Sediment Pond Decant	191	1.1	266	19%	200	1.1	274	20%	1%	3%
	GH_PC1	Porter Creek Sediment Pond Decant	-23	0.94	78	21%	-23	0.94	78	21%	0%	0%
Greenhills Operations	GH_GH1	Greenhills Creek Sediment Pond Decant	44	1.1	148	35%	64	1.2	155	37%	4%	5%
	GH_LC1	Leask Creek Sediment Pond Decant	31	1.1	153	49%	-49	0.84	120	39%	-24%	-22%
	GH_WC1	Wolfram Creek Sediment Pond Decant	-154	0.53	164	50%	-192	0.42	195	59%	-22%	19%
	GH_TC1	Thompson Creek at LRP Road	18	1.0	111	28%	17	1.0	111	28%	0%	0%
Line Creek Operations	LC_DC1	Dry Creek near mouth (at bridge)	-0.14	0.98	1.8	22%	-0.14	0.98	1.8	22%	0%	0%
	LC_LCUSWLC	Line Creek u/s of West Line Creek	18	1.1	46	27%	12	1.1	43	26%	-3%	-5%
	LC_WLC	West Line Creek	-140	0.84	199	23%	-104	0.88	181	21%	5%	-9%
	LC_LC4	Line Creek u/s of Process Plant	-6.1	0.96	29	22%	-4.7	0.97	29	22%	1%	1%
Elkview Operations	EV_EC1	Erickson Creek at Mouth	-79	0.87	91	15%	-62	0.9	85	14%	3%	-7%
	EV_GT1	Gate Creek Sediment Pond Decant	95	1.2	260	41%	34	1.1	229	36%	-8%	-12%
	EV_BC1	Bodie Creek Sediment Pond Decant	54	1.1	254	42%	-13	0.98	204	34%	-10%	-20%
	EV_DC1	EVO Dry Creek Sediment Pond Decant	-89	0.86	176	28%	-91	0.85	170	27%	0%	-3%
	EV_HC1	EVO Harmer Compliance Point	-8.0	0.95	39	24%	-6.0	0.96	39	24%	1%	0%
Fording River	FR_FR1	Fording River d/s of Henretta Creek	-1.7	0.98	18	27%	-1.3	0.98	18	27%	1%	0%
	FR_FR2	Fording River u/s of Kilmarnock Creek	-25	0.83	45	30%	-23	0.85	42	29%	2%	-6%
	FR_FR4	Fording River between Swift and Cataract Creeks	-17	0.9	43	26%	-15	0.91	42	25%	2%	-3%
	GH_PC2	Fording River d/s of Porter Creek	-13	0.95	46	18%	-12	0.95	47	18%	0%	1%
	GH_FR1 (EMS 0200378)	GHO Fording River Compliance Point - Upper Fording River, 205 m d/s of Greenhills Creek	-9.1	0.94	26	17%	-6.8	0.96	27	17%	2%	3%
	LC_LC5 (EMS 0200028)	Fording River downstream of Line Creek	0.57	1.0	24	18%	2.2	1.0	25	18%	1%	4%
Michel Creek	**CM_MC2 (EMS E258937)**	Michel Creek d/s CMO Compliance Point	-16	0.92	69	36%	-14	0.93	70	36%	1%	0%
	EV_MC3	Michel Creek upstream of Erickson Creek	9.3	1.3	15	47%	9.7	1.3	15	47%	1%	2%
	EV_MC1	Michel Creek u/s Highway 43 Bridge	0.73	1.0	21	32%	7.7	1.1	22	34%	11%	4%
Elk River	**GH_ER1 (EMS E206661)**	Elk River u/s of Boivin Creek and (u/s of Fording River)	2.0	1.1	5.7	24%	0.49	1.0	4.8	20%	-6%	-17%
	EV_ER4 (EMS 0200389)	Elk River u/s of Grave Creek	-2.7	0.96	16	25%	-3.0	0.95	16	25%	0%	0%
	EV_ER1 (EMS 0200393)	Elk River downstream of Michel Creek	-0.071	1.0	13	22%	1.4	1.0	13	23%	2%	2%
	RG_ELKMOUTH	Elk River at Highway 93 near Elko	0.8	1.0	7.3	19%	1.7	1.0	7.2	19%	2%	-2%
	RG_DSELK (EMS E300230)[f]	Koocanusa Reservoir	9.5	1.4	9.6	40%	4.7	1.2	7.7	32%	-14%	-19%

CMO = Coal Mountain Operations; EVO = Elkview Operations; GHO = Greenhills Operations; mg/L = milligram per litre; u/s = upstream; d/s = downstream.

(a) The difference in relative bias was calculated using the following equation: (Relative $Bias_{2019\ IPA}$ – Relative $Bias_{2017\ RWQM}$)/Relative $Bias_{2017\ RWQM}$ x 100. The difference in percent error was calculated using the following equation: (Percent $Error_{2019\ IPA}$ – Percent $Error_{2017\ RWQM}$)/Percent $Error_{2017\ RWQM}$ x 100.

(b) Bias represents the average difference between simulated and observed concentrations. A positive bias indicates that modelled concentrations are greater, on average, than observed concentrations.

(c) A relative bias greater than one indicates that modelled concentrations are greater, on average, than observed concentrations.

(d) The error represents the average absolute difference between simulated and observed concentrations.

(e) The percent error represents the ratio of the error to the average observed concentration.

(f) In Teck (2017a), projected concentrations in Koocanusa Reservoir were compared to monitored data at RG_DSELK. The comparison of simulated to monitored data has been expanded to include data at the four stations located downstream of the Elk River: RG_DSELK, RG_GRASMERE, RG_USGOLD and RG_BORDER. Projected concentrations of sulphate in Koocanusa Reservoir were not corrected for model bias.

Notes:

Sites in **bold** font correspond to Order Stations and Compliance Points listed in EMA Permit 107517; Order Stations are indicated by underlined font node IDs.

Calibration statistics have not been provided for the Elk River at Elko Reservoir, because of the limited amount of monitoring data available. Similarly, calibration statistics have not been provided for the FRO Compliance Point (FR_FRCP1), the LCO Compliance Point (LC_LCDSSLCC), the GHO Elk River Compliance Point (GH_ERC) or the EVO Michel Creek Compliance Point (EV_MC2), because monitoring data were only available from 2014 to 2016 at these locations.

4 References

Golder Associates Ltd. (Golder). 2017. Teck Elkview Operations – Water Quantity Data Assessment (Environmental Management Act Permit 107517 Section 4.4). Technical Memorandum prepared for Teck Coal Limited. October 31. 2017. Ref: 1786196.1000.Rev0

Minnow Environmental Inc. (Minnow). 2017. Koocanusa Reservoir Monitoring Report, 2014 to 2016. Prepared for Teck Coal Limited by Minnow Environmental Inc., Georgetown, Ontario. June 2017.

Shaw S. 2017. STP sources terms. Email to Dennis Kramer, Golder Associates Ltd. 30 August 2017.

Teck Coal Limited (Teck). 2017a. *2017 Elk Valley Regional Water Quality Model Update Overview Report.* Prepared by Teck Coal Limited and submitted to the British Columbia Minister of Environment. October 31, 2017.

Teck. 2017b. Water quality and flow data 2006 to 2016 from EQUIS database. Provided January 2017.

Teck. 2015. *Elkview Operations Baldy Ridge Extension Project,* Prepared for Teck Coal by Golder Associates Ltd, October 2015.

Appendix A - Model Calibration Results for Nitrate

July 2019

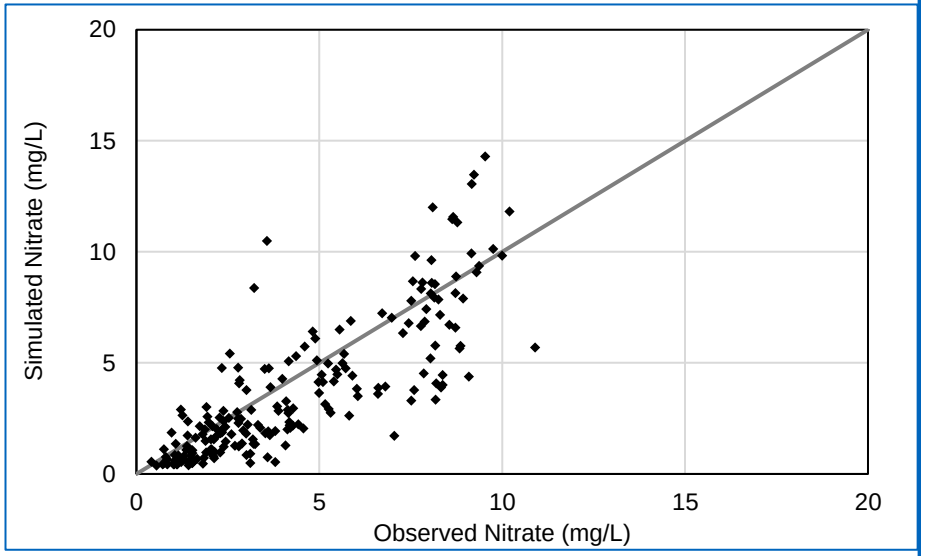
Teck

A1-1: Nitrate Calibration Information for Node FR_HC1 - Henretta Creek u/s of Fording River (EMS E216778)

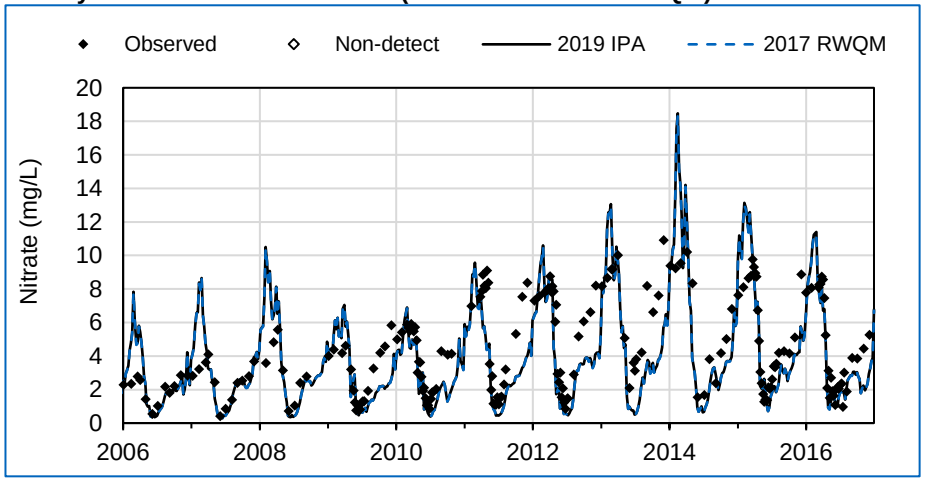
Observed and Simulated Nitrate Data and Calibration Statistics

Statistic	2017 RWQM	2019 IPA	
Model Averaging Period	Weekly	Weekly	Monthly
Calibration Period	2006 to 2016		
First Observed Sample	1/3/2006		
Last Observed Sample	12/7/2016		
Data Points Available for Comparison, n	209	209	123
Non-Detect Count	0	0	0
Observed Mean (mg/L)	4.3	4.3	4.5
Simulated Mean (mg/L)	3.6	3.7	4.0
Bias (mg/L)	-0.63	-0.6	-0.47
Relative Bias	0.85	0.86	0.9
Error (mg/L)	1.4	1.4	1.5
Percent Error	32%	32%	33%

2019 IPA Simulated vs. Observed Nitrate Concentrations

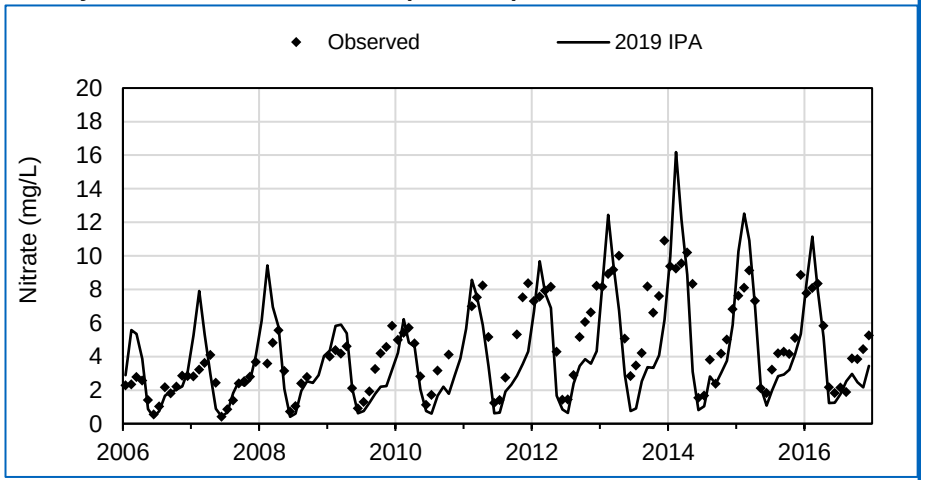


Weekly Simulated Concentrations (2019 IPA and 2017 RWQM)



Note: Observed data are individual sample results

Monthy Simulated Concentrations (2019 IPA)



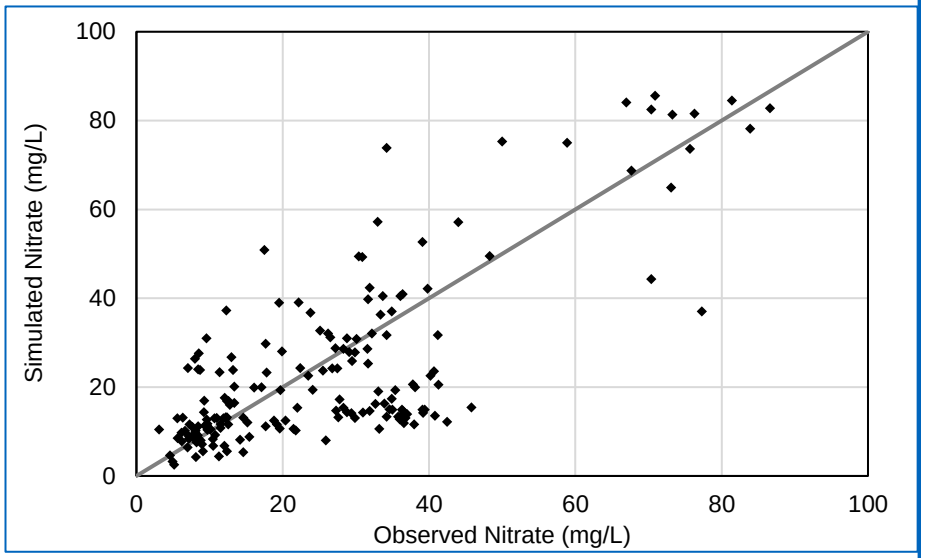
Note: Observed data are monthly averages of sample results

A1-2: Nitrate Calibration Information for Node FR_CC1 - Clode Creek Sediment Pond Decant (EMS E102481)

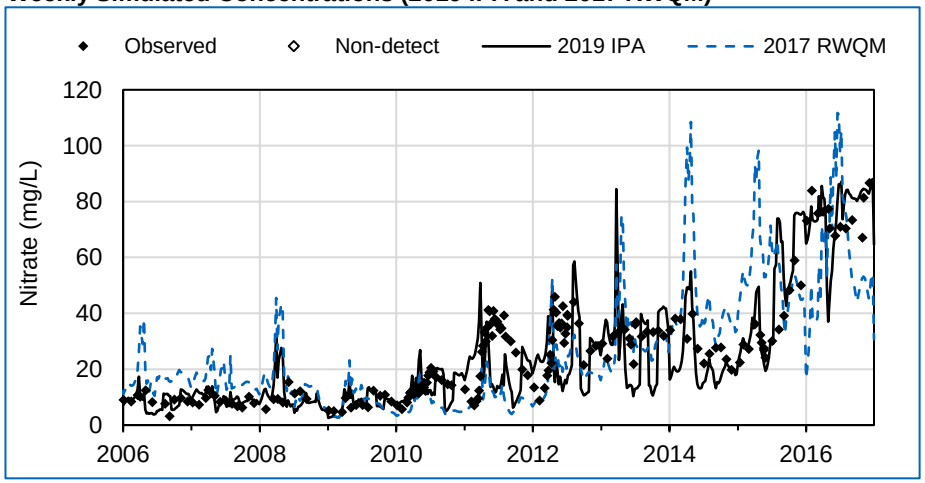
Observed and Simulated Nitrate Data and Calibration Statistics

Statistic	2017 RWQM	2019 IPA	
Model Averaging Period	Weekly	Weekly	Monthly
Calibration Period	2006 to 2016		
First Observed Sample	1/3/2006		
Last Observed Sample	12/7/2016		
Data Points Available for Comparison, n	180	180	125
Non-Detect Count	0	0	0
Observed Mean (mg/L)	26	26	26
Simulated Mean (mg/L)	25	24	25
Bias (mg/L)	-1.2	-1.9	-0.32
Relative Bias	0.95	0.93	0.99
Error (mg/L)	13	9.6	7.8
Percent Error	49%	37%	30%

2019 IPA Simulated vs. Observed Nitrate Concentrations

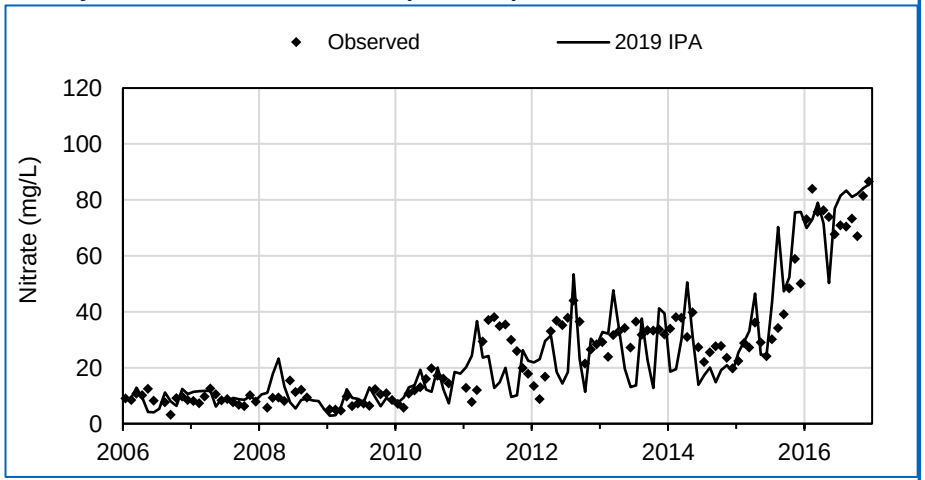


Weekly Simulated Concentrations (2019 IPA and 2017 RWQM)



Note: Observed data are individual sample results

Monthy Simulated Concentrations (2019 IPA)



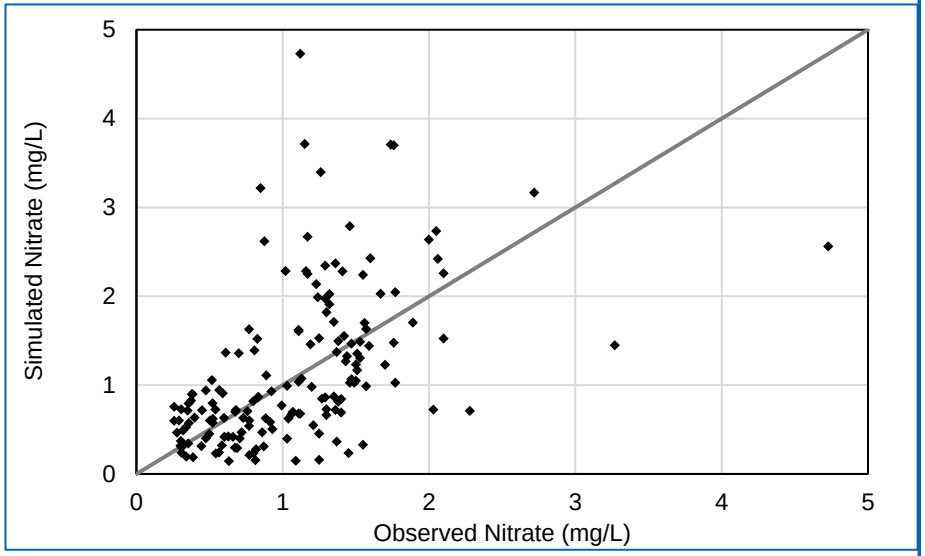
Note: Observed data are monthly averages of sample results

A1-3: Nitrate Calibration Information for Node FR_LMP1 - Lake Mountain Pond

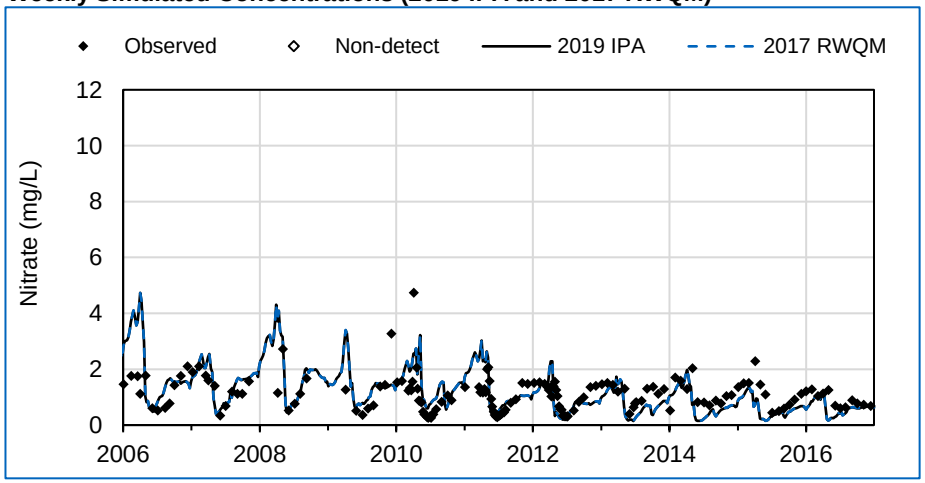
Observed and Simulated Nitrate Data and Calibration Statistics

Statistic	2017 RWQM	2019 IPA	
Model Averaging Period	Weekly	Weekly	Monthly
Calibration Period	2006 to 2016		
First Observed Sample	1/3/2006		
Last Observed Sample	12/14/2016		
Data Points Available for Comparison, n	161	161	118
Non-Detect Count	0	0	0
Observed Mean (mg/L)	1.1	1.1	1.1
Simulated Mean (mg/L)	1.2	1.1	1.1
Bias (mg/L)	0.072	0.07	0.0065
Relative Bias	1.1	1.1	1.0
Error (mg/L)	0.53	0.53	0.5
Percent Error	49%	49%	44%

2019 IPA Simulated vs. Observed Nitrate Concentrations

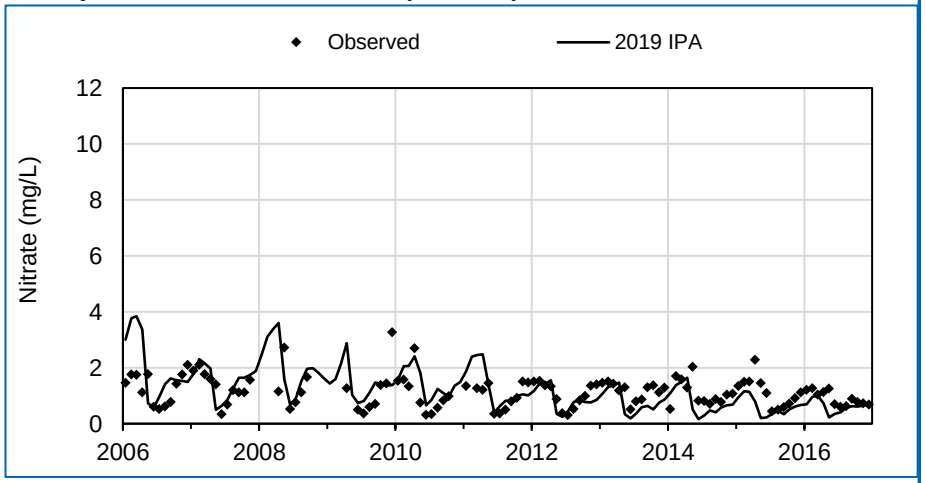


Weekly Simulated Concentrations (2019 IPA and 2017 RWQM)



Note: Observed data are individual sample results

Monthy Simulated Concentrations (2019 IPA)



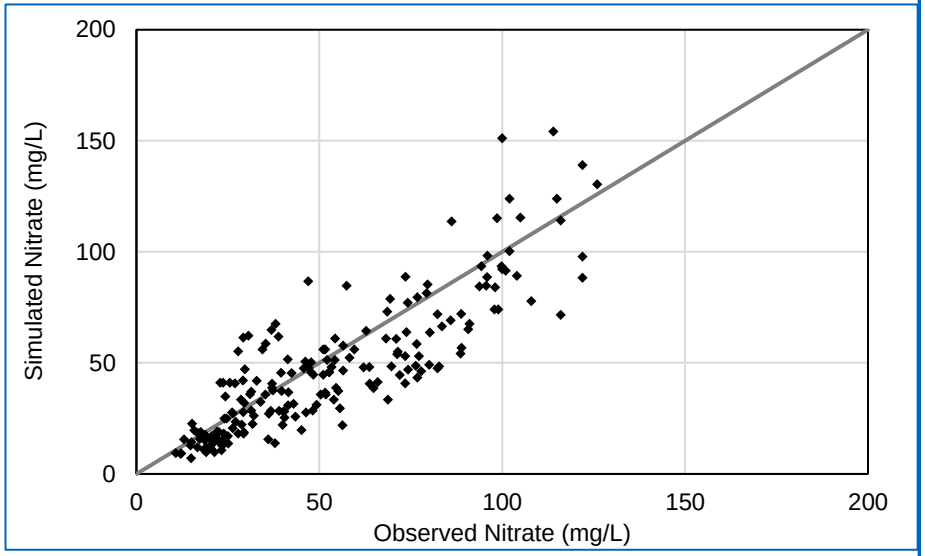
Note: Observed data are monthly averages of sample results

A1-4: Nitrate Calibration Information for Node FR_KC1 - Kilmarnock Creek d/s of Rock Drain (EMS 0200252)

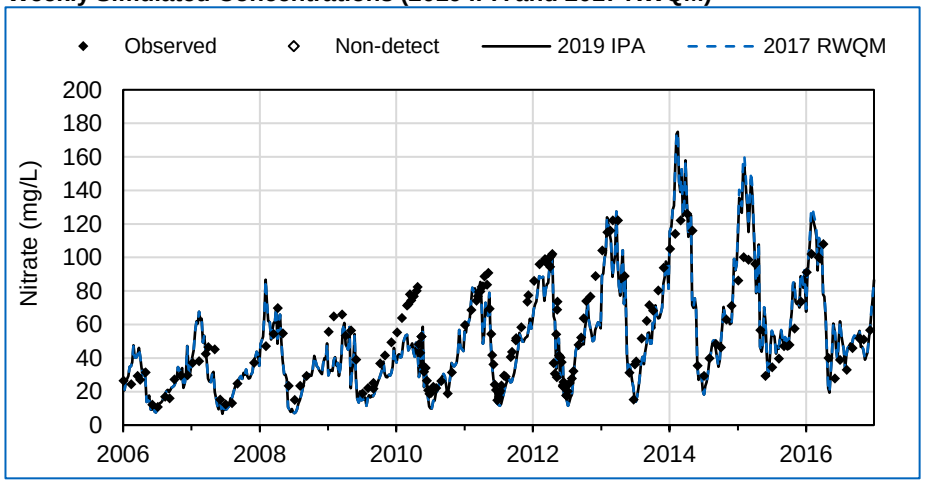
Observed and Simulated Nitrate Data and Calibration Statistics

Statistic	2017 RWQM	2019 IPA	
Model Averaging Period	Weekly	Weekly	Monthly
Calibration Period	2006 to 2016		
First Observed Sample	1/3/2006		
Last Observed Sample	12/12/2016		
Data Points Available for Comparison, n	191	191	123
Non-Detect Count	0	0	0
Observed Mean (mg/L)	53	53	54
Simulated Mean (mg/L)	48	48	52
Bias (mg/L)	-5.0	-5.2	-2.6
Relative Bias	0.91	0.9	0.95
Error (mg/L)	13	13	12
Percent Error	24%	24%	22%

2019 IPA Simulated vs. Observed Nitrate Concentrations

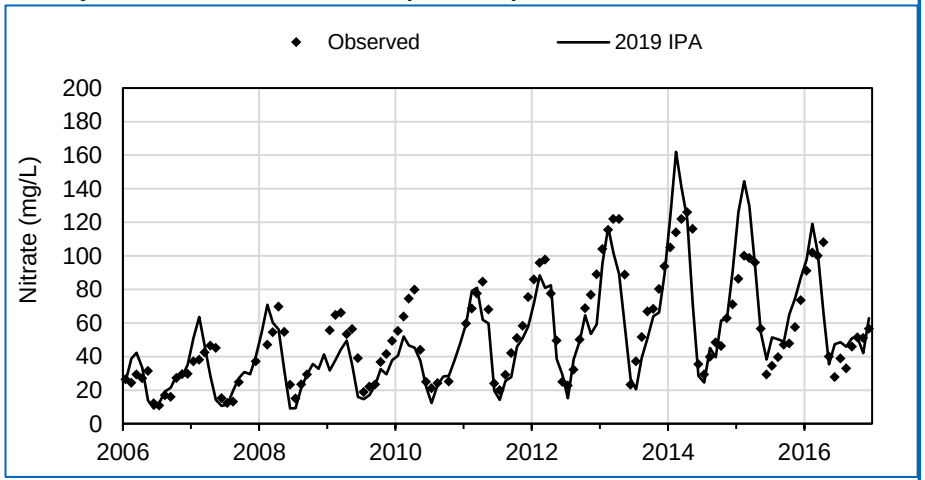


Weekly Simulated Concentrations (2019 IPA and 2017 RWQM)



Note: Observed data are individual sample results

Monthy Simulated Concentrations (2019 IPA)



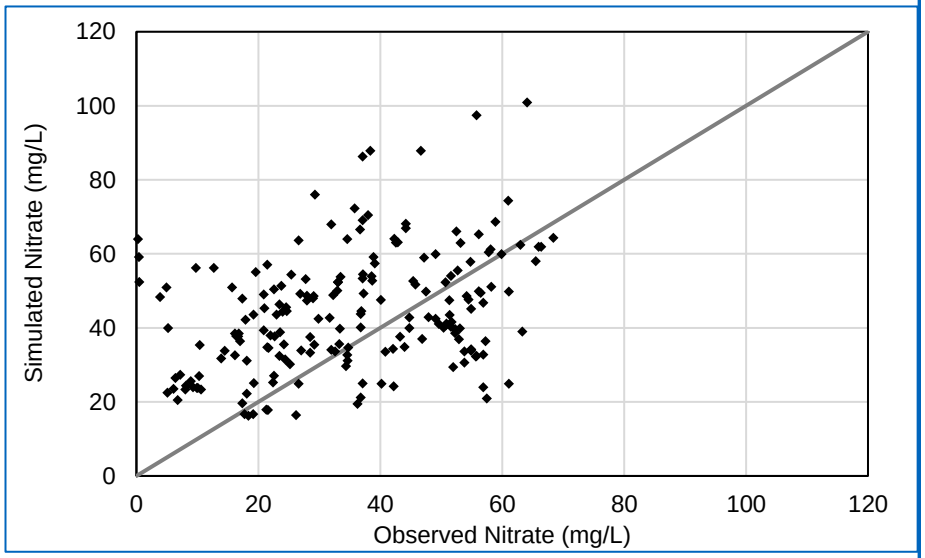
Note: Observed data are monthly averages of sample results

A1-5: Nitrate Calibration Information for Node GH_SC1 - Swift Creek Sediment Pond Decant (EMS E221329)

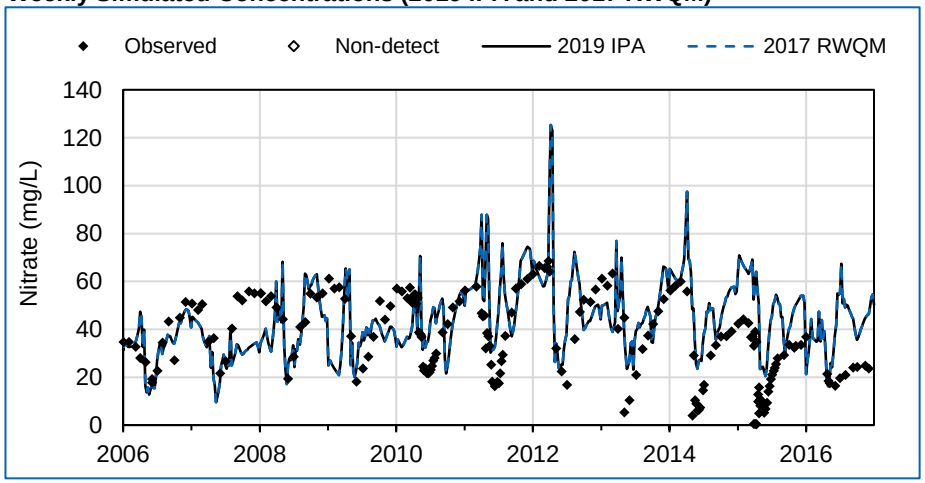
Observed and Simulated Nitrate Data and Calibration Statistics

Statistic	2017 RWQM	2019 IPA	
Model Averaging Period	Weekly	Weekly	Monthly
Calibration Period	2006 to 2016		
First Observed Sample	1/4/2006		
Last Observed Sample	12/5/2016		
Data Points Available for Comparison, n	193	193	128
Non-Detect Count	0	0	0
Observed Mean (mg/L)	35	35	39
Simulated Mean (mg/L)	44	44	44
Bias (mg/L)	9.2	9.2	4.8
Relative Bias	1.3	1.3	1.1
Error (mg/L)	17	17	14
Percent Error	48%	48%	35%

2019 IPA Simulated vs. Observed Nitrate Concentrations

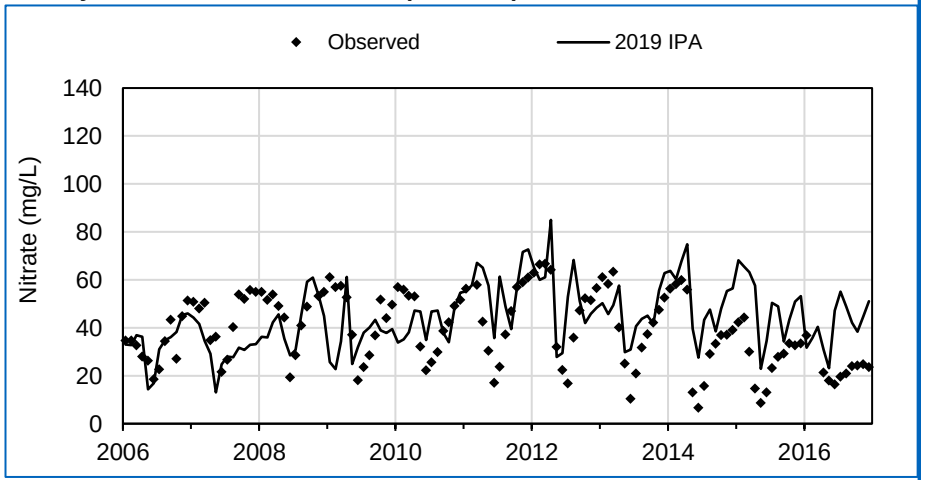


Weekly Simulated Concentrations (2019 IPA and 2017 RWQM)



Note: Observed data are individual sample results

Monthy Simulated Concentrations (2019 IPA)



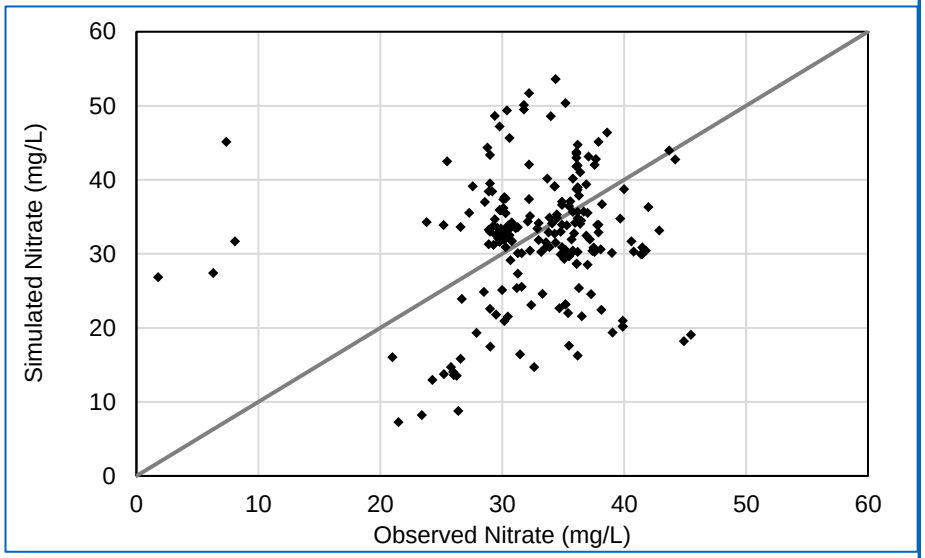
Note: Observed data are monthly averages of sample results

A1-6: Nitrate Calibration Information for Node GH_CC1 - Cataract Creek Sediment Pond Decant (EMS 0200384)

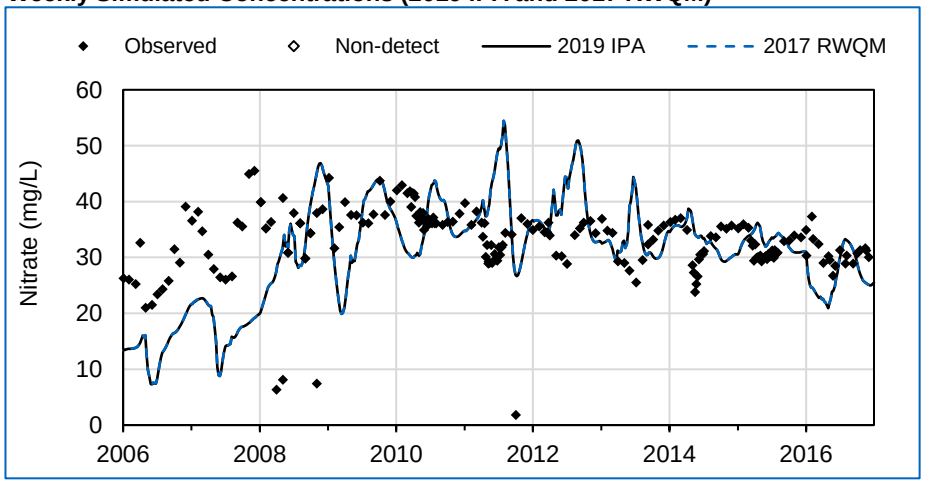
Observed and Simulated Nitrate Data and Calibration Statistics

Statistic	2017 RWQM	2019 IPA	
Model Averaging Period	Weekly	Weekly	Monthly
Calibration Period	2006 to 2016		
First Observed Sample	1/4/2006		
Last Observed Sample	12/5/2016		
Data Points Available for Comparison, n	201	201	131
Non-Detect Count	0	0	0
Observed Mean (mg/L)	33	33	33
Simulated Mean (mg/L)	32	32	31
Bias (mg/L)	-0.62	-0.62	-2.2
Relative Bias	0.98	0.98	0.93
Error (mg/L)	7.4	7.4	7.6
Percent Error	22%	22%	23%

2019 IPA Simulated vs. Observed Nitrate Concentrations

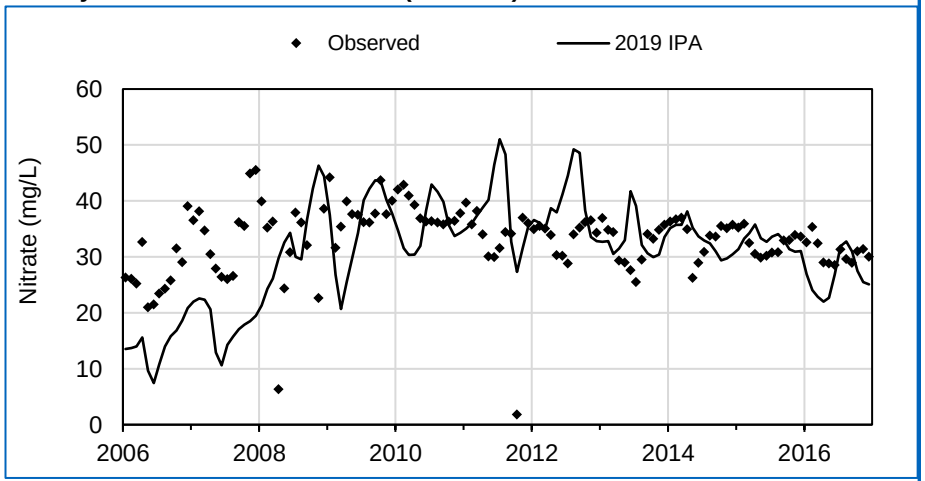


Weekly Simulated Concentrations (2019 IPA and 2017 RWQM)



Note: Observed data are individual sample results

Monthy Simulated Concentrations (2019 IPA)



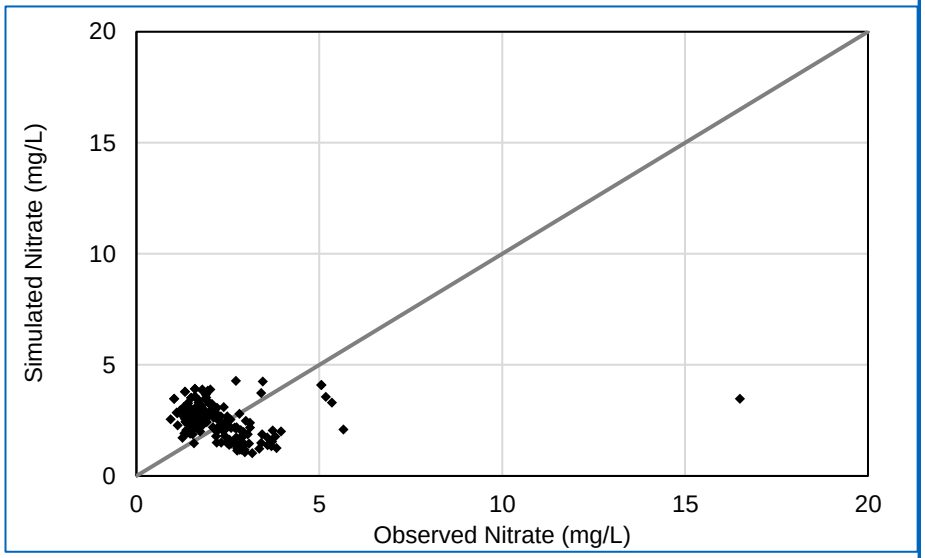
Note: Observed data are monthly averages of sample results

A1-7: Nitrate Calibration Information for Node GH_PC1 - Porter Creek Sediment Pond Decant (EMS 0200385)

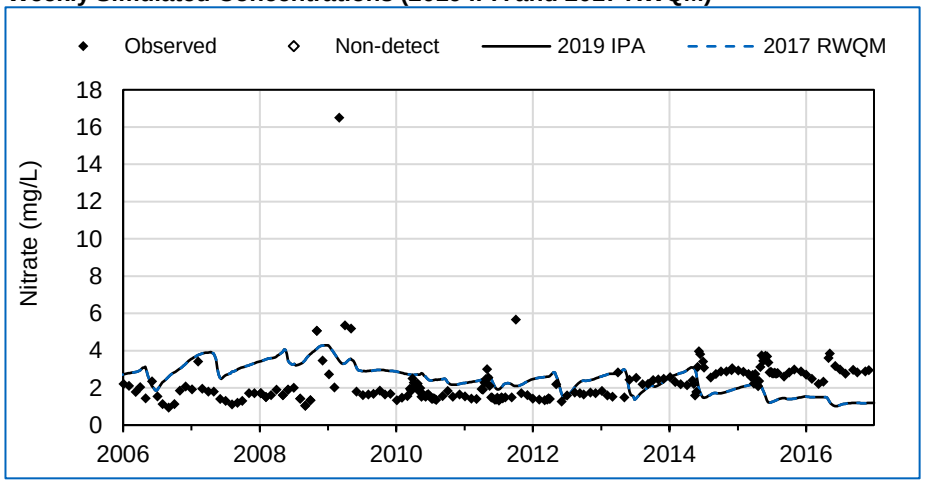
Observed and Simulated Nitrate Data and Calibration Statistics

Statistic	2017 RWQM	2019 IPA	
Model Averaging Period	Weekly	Weekly	Monthly
Calibration Period	2006 to 2016		
First Observed Sample	1/4/2006		
Last Observed Sample	12/5/2016		
Data Points Available for Comparison, n	194	194	131
Non-Detect Count	0	0	0
Observed Mean (mg/L)	2.2	2.2	2.3
Simulated Mean (mg/L)	2.5	2.5	2.5
Bias (mg/L)	0.22	0.22	0.22
Relative Bias	1.1	1.1	1.1
Error (mg/L)	1.2	1.2	1.2
Percent Error	53%	53%	55%

2019 IPA Simulated vs. Observed Nitrate Concentrations

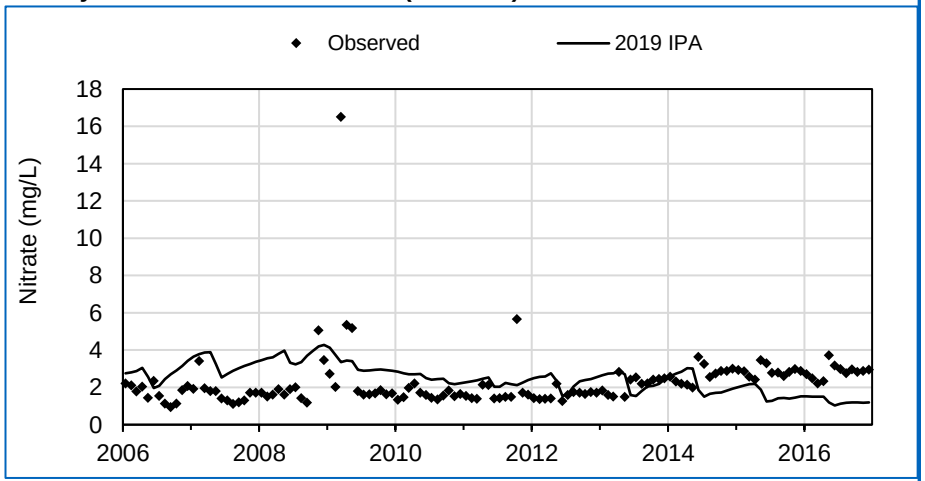


Weekly Simulated Concentrations (2019 IPA and 2017 RWQM)



Note: Observed data are individual sample results

Monthy Simulated Concentrations (2019 IPA)



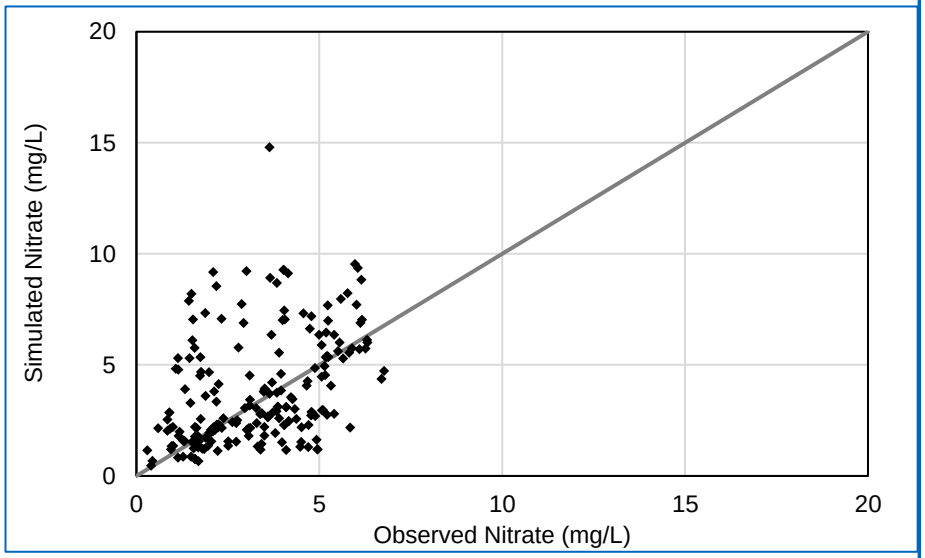
Note: Observed data are monthly averages of sample results

A1-8: Nitrate Calibration Information for Node GH_GH1 - Greenhills Creek Sediment Pond Decant (EMS E102709)

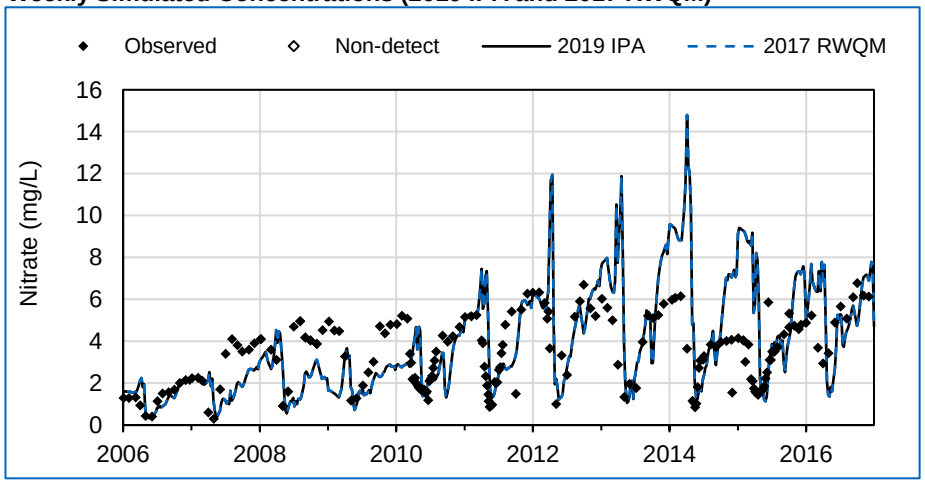
Observed and Simulated Nitrate Data and Calibration Statistics

Statistic	2017 RWQM	2019 IPA	
Model Averaging Period	Weekly	Weekly	Monthly
Calibration Period	2006 to 2016		
First Observed Sample	1/4/2006		
Last Observed Sample	12/5/2016		
Data Points Available for Comparison, n	196	196	130
Non-Detect Count	0	0	0
Observed Mean (mg/L)	3.3	3.3	3.6
Simulated Mean (mg/L)	3.8	3.8	4.0
Bias (mg/L)	0.52	0.52	0.33
Relative Bias	1.2	1.2	1.1
Error (mg/L)	1.7	1.7	1.4
Percent Error	51%	51%	40%

2019 IPA Simulated vs. Observed Nitrate Concentrations

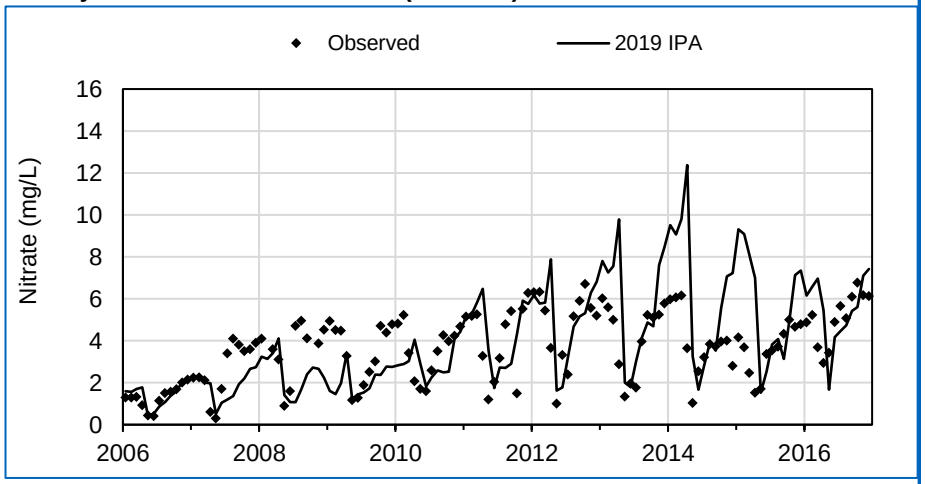


Weekly Simulated Concentrations (2019 IPA and 2017 RWQM)



Note: Observed data are individual sample results

Monthy Simulated Concentrations (2019 IPA)



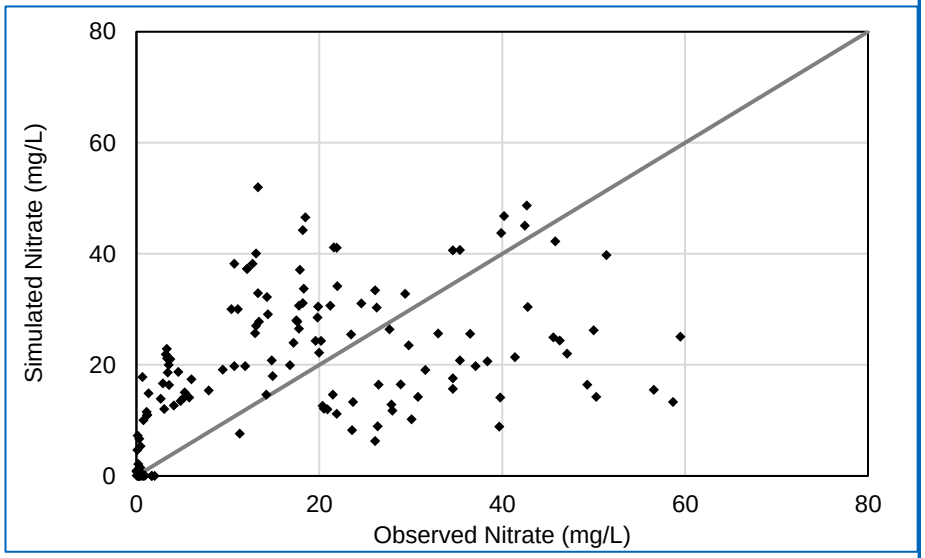
Note: Observed data are monthly averages of sample results

A1-9: Nitrate Calibration Information for Node GH_LC1 - Leask Creek Sediment Pond Decant (EMS E257796)

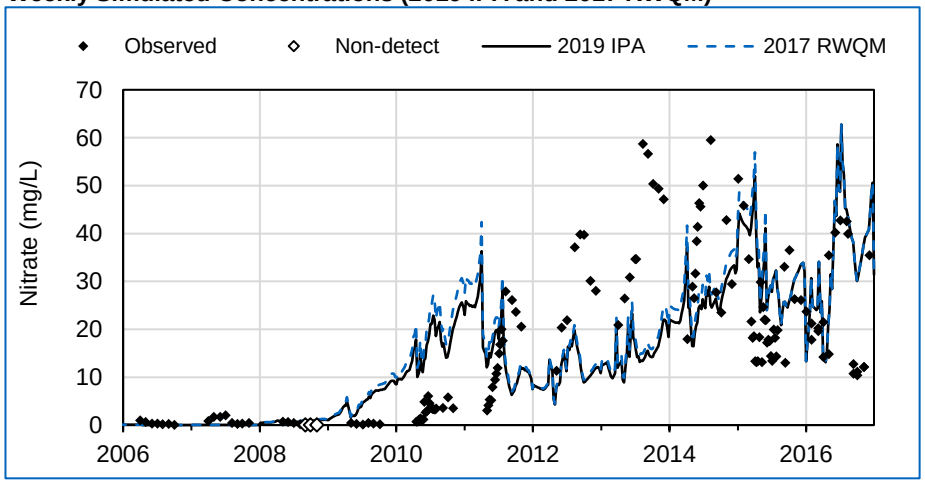
Observed and Simulated Nitrate Data and Calibration Statistics

Statistic	2017 RWQM	2019 IPA	
Model Averaging Period	Weekly	Weekly	Monthly
Calibration Period	2006 to 2016		
First Observed Sample	4/3/2006		
Last Observed Sample	12/7/2016		
Data Points Available for Comparison, n	144	144	92
Non-Detect Count	3	3	0
Observed Mean (mg/L)	18	18	19
Simulated Mean (mg/L)	21	19	17
Bias (mg/L)	3.2	1.7	-1.8
Relative Bias	1.2	1.1	0.9
Error (mg/L)	12	12	10
Percent Error	70%	66%	56%

2019 IPA Simulated vs. Observed Nitrate Concentrations

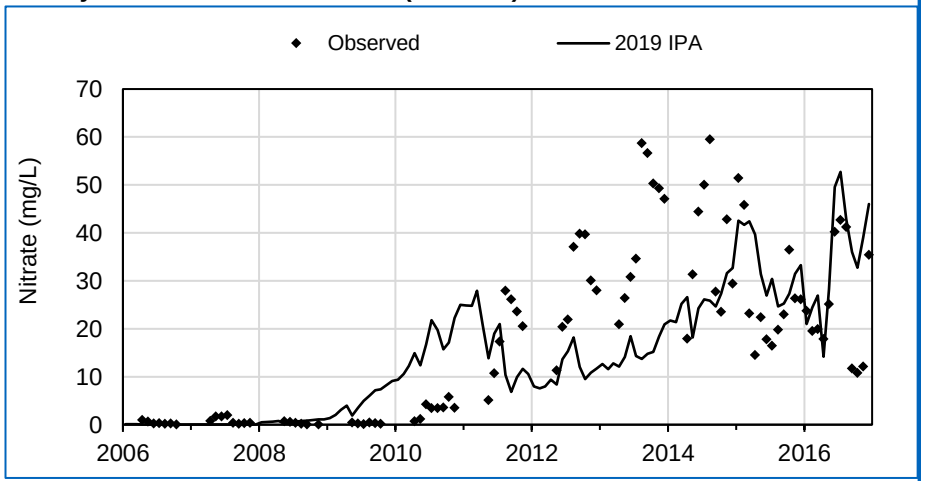


Weekly Simulated Concentrations (2019 IPA and 2017 RWQM)



Note: Observed data are individual sample results

Monthy Simulated Concentrations (2019 IPA)



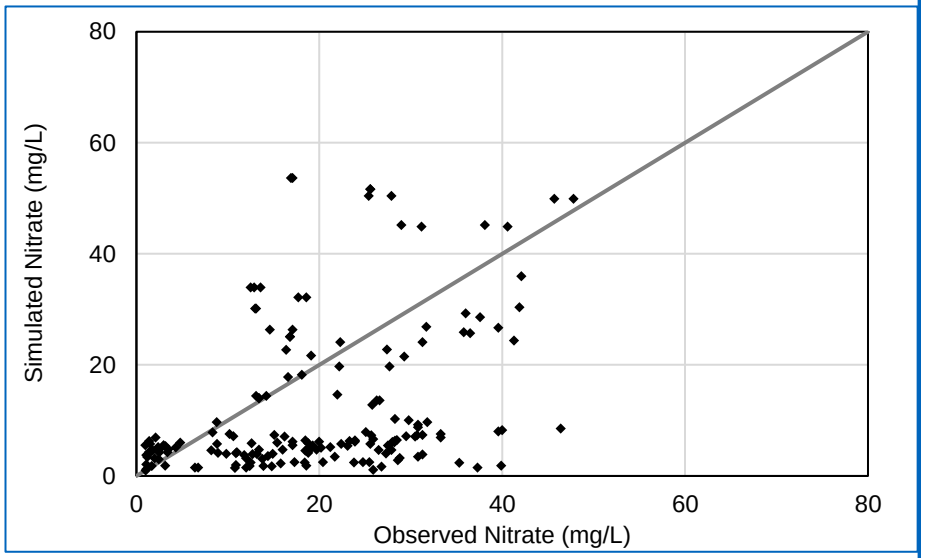
Note: Observed data are monthly averages of sample results

A1-10: Nitrate Calibration Information for Node GH_WC1 - Wolfram Creek Sediment Pond Decant (EMS E257796)

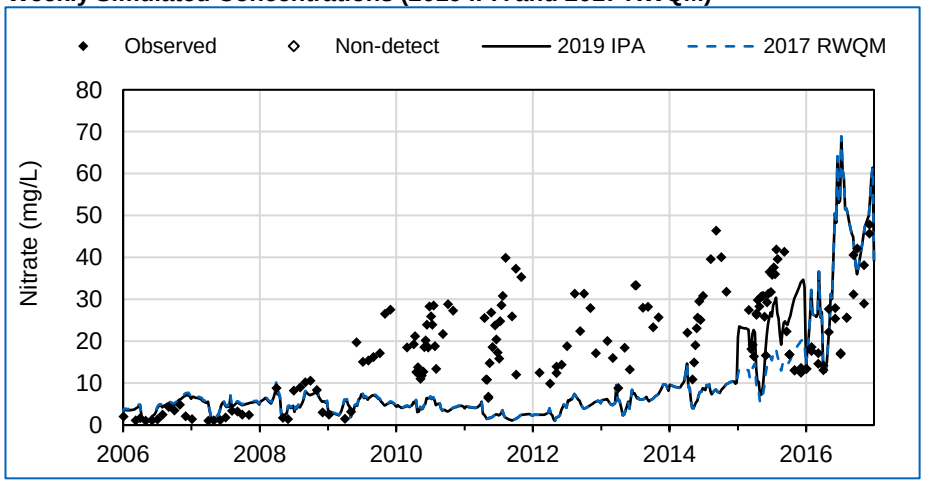
Observed and Simulated Nitrate Data and Calibration Statistics

Statistic	2017 RWQM	2019 IPA	
Model Averaging Period	Weekly	Weekly	Monthly
Calibration Period	2006 to 2016		
First Observed Sample	1/4/2006		
Last Observed Sample	12/7/2016		
Data Points Available for Comparison, n	170	170	105
Non-Detect Count	0	0	0
Observed Mean (mg/L)	20	20	18
Simulated Mean (mg/L)	11	12	11
Bias (mg/L)	-8.8	-7.3	-7.1
Relative Bias	0.55	0.62	0.6
Error (mg/L)	13	13	12
Percent Error	67%	65%	68%

2019 IPA Simulated vs. Observed Nitrate Concentrations

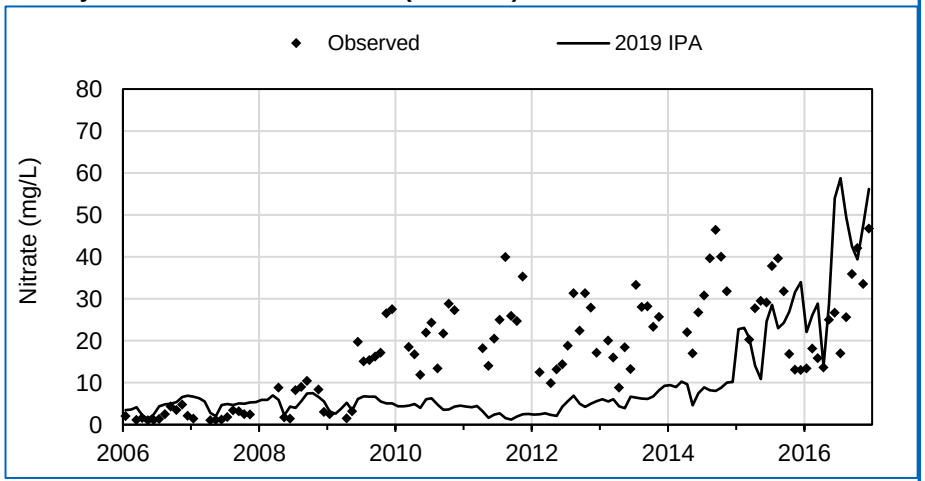


Weekly Simulated Concentrations (2019 IPA and 2017 RWQM)



Note: Observed data are individual sample results

Monthy Simulated Concentrations (2019 IPA)



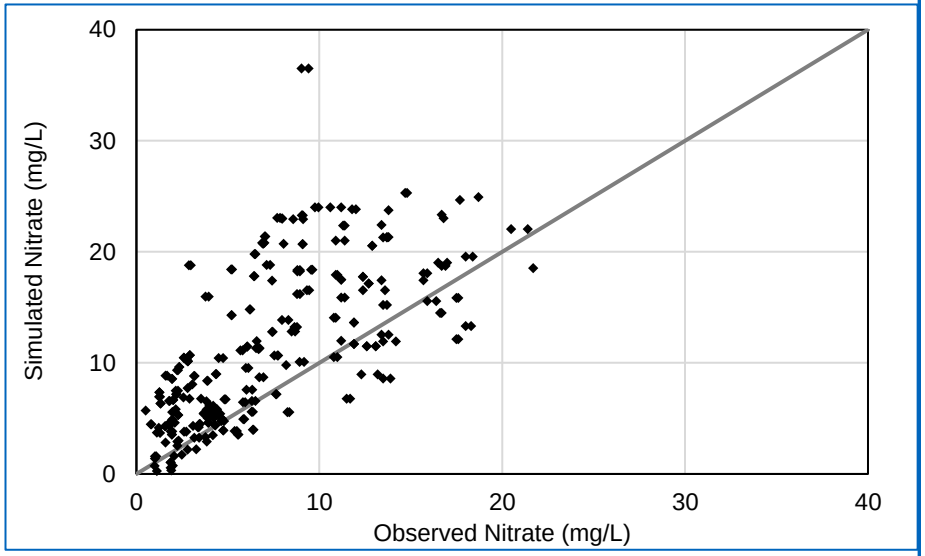
Note: Observed data are monthly averages of sample results

A1-11: Nitrate Calibration Information for Node GH_TC1 - Thompson Creek at LRP Road (EMS E102714)

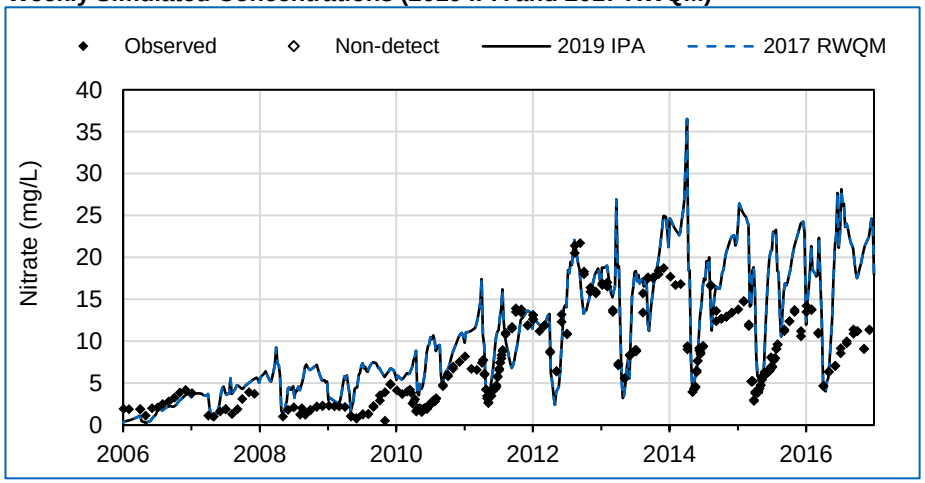
Observed and Simulated Nitrate Data and Calibration Statistics

Statistic	2017 RWQM	2019 IPA	
Model Averaging Period	Weekly	Weekly	Monthly
Calibration Period	2006 to 2016		
First Observed Sample	1/4/2006		
Last Observed Sample	12/7/2016		
Data Points Available for Comparison, n	304	304	124
Non-Detect Count	0	0	0
Observed Mean (mg/L)	7.2	7.2	7.7
Simulated Mean (mg/L)	11	11	11
Bias (mg/L)	4.2	4.2	3.5
Relative Bias	1.6	1.6	1.5
Error (mg/L)	4.9	4.9	4.2
Percent Error	68%	68%	54%

2019 IPA Simulated vs. Observed Nitrate Concentrations

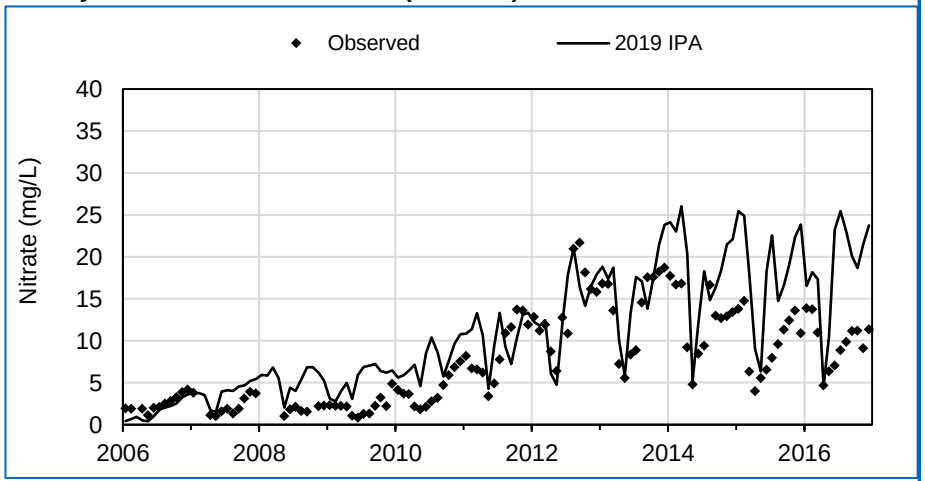


Weekly Simulated Concentrations (2019 IPA and 2017 RWQM)



Note: Observed data are individual sample results

Monthy Simulated Concentrations (2019 IPA)



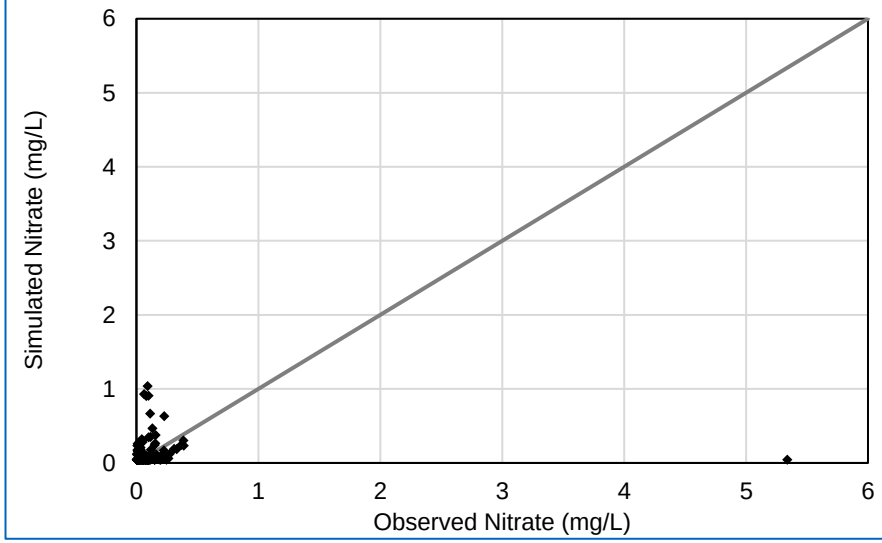
Note: Observed data are monthly averages of sample results

A1-12: Nitrate Calibration Information for Node LC_DC1 - Dry Creek near mouth (at bridge) (EMS E288270)

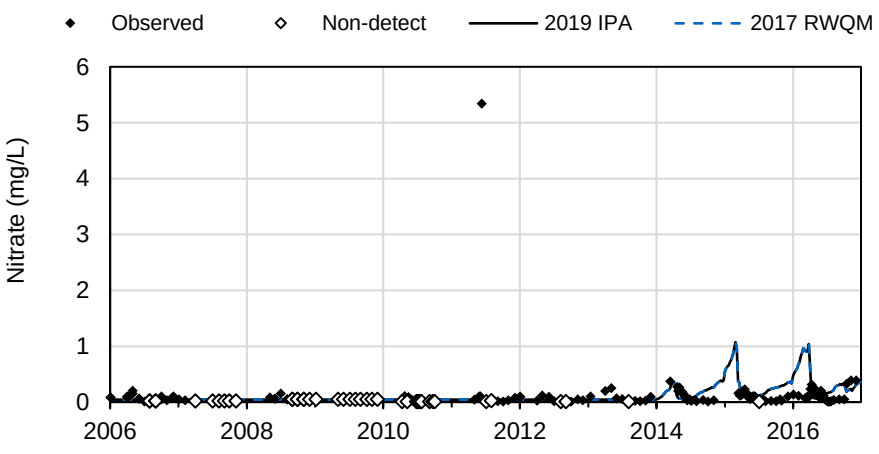
Observed and Simulated Nitrate Data and Calibration Statistics

Statistic	2017 RWQM	2019 IPA	
Model Averaging Period	Weekly	Weekly	Monthly
Calibration Period	2006 to 2016		
First Observed Sample	1/4/2006		
Last Observed Sample	12/6/2016		
Data Points Available for Comparison, n	175	175	100
Non-Detect Count	42	42	0
Observed Mean (mg/L)	0.11	0.11	0.097
Simulated Mean (mg/L)	0.11	0.11	0.11
Bias (mg/L)	0.0071	0.0071	0.018
Relative Bias	1.1	1.1	1.2
Error (mg/L)	0.12	0.12	0.11
Percent Error	111%	111%	112%

2019 IPA Simulated vs. Observed Nitrate Concentrations

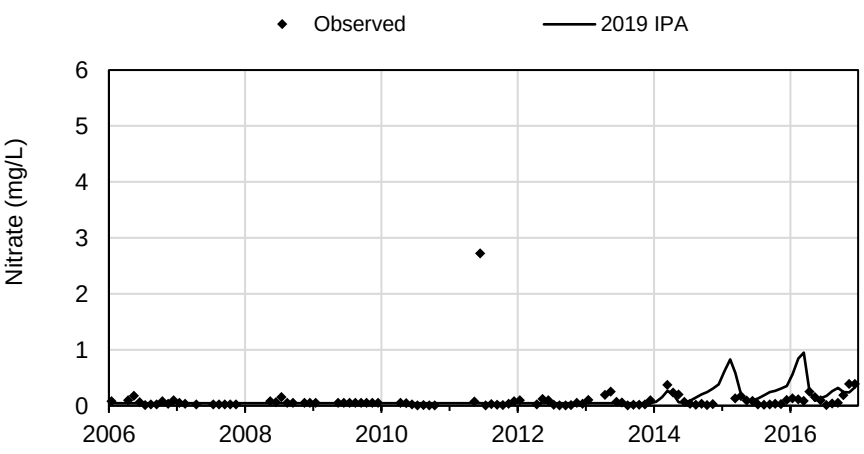


Weekly Simulated Concentrations (2019 IPA and 2017 RWQM)



Note: Observed data are individual sample results

Monthy Simulated Concentrations (2019 IPA)



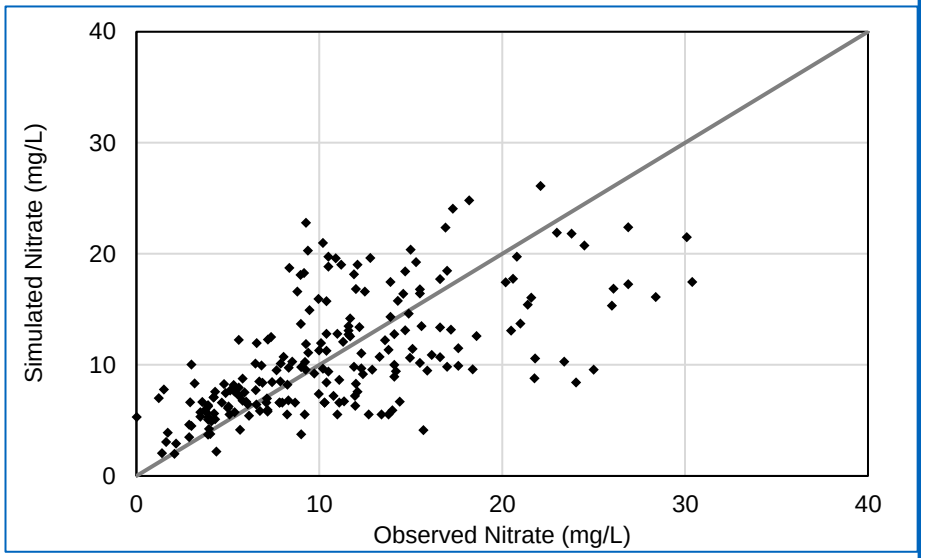
Note: Observed data are monthly averages of sample results

A1-13: Nitrate Calibration Information for Node LC_LCUSWLC - Line Creek u/s of West Line Creek (EMS E293369)

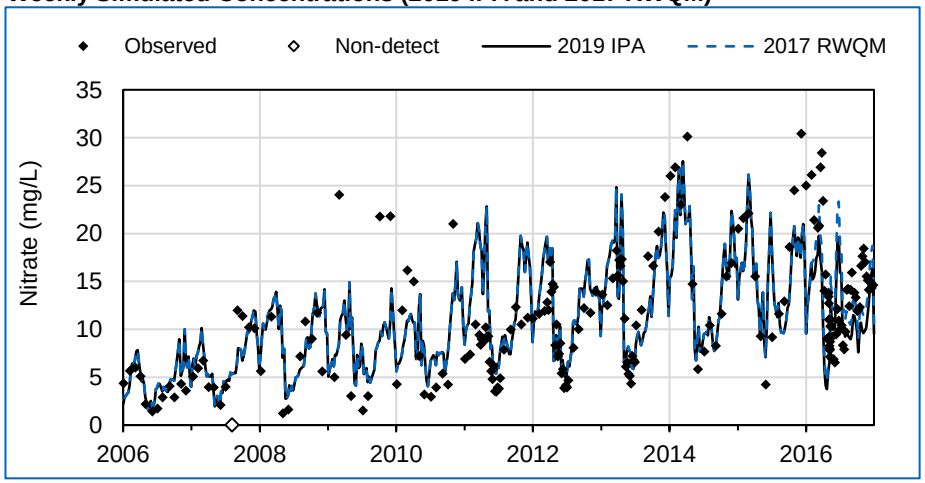
Observed and Simulated Nitrate Data and Calibration Statistics

Statistic	2017 RWQM	2019 IPA	
Model Averaging Period	Weekly	Weekly	Monthly
Calibration Period	2006 to 2016		
First Observed Sample	1/3/2006		
Last Observed Sample	12/28/2016		
Data Points Available for Comparison, n	207	207	124
Non-Detect Count	1	1	0
Observed Mean (mg/L)	11	11	11
Simulated Mean (mg/L)	11	11	11
Bias (mg/L)	0.3	-0.21	0.11
Relative Bias	1.0	0.98	1.0
Error (mg/L)	3.8	3.8	3.4
Percent Error	34%	35%	31%

2019 IPA Simulated vs. Observed Nitrate Concentrations

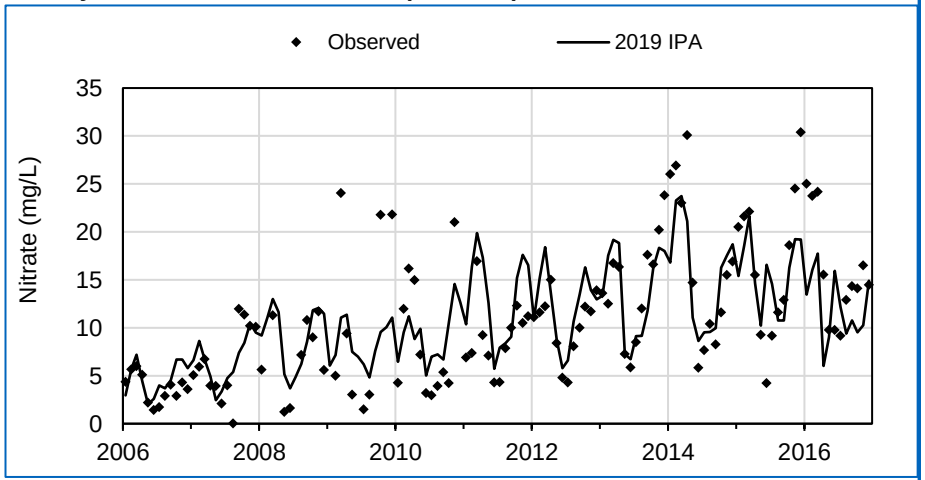


Weekly Simulated Concentrations (2019 IPA and 2017 RWQM)



Note: Observed data are individual sample results

Monthy Simulated Concentrations (2019 IPA)



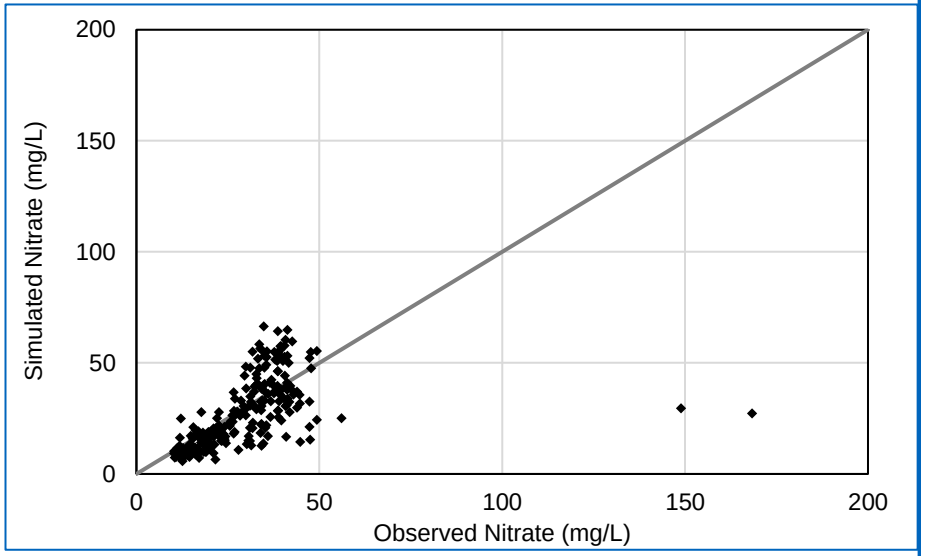
Note: Observed data are monthly averages of sample results

A1-14: Nitrate Calibration Information for Node LC_WLC - West Line Creek (EMS E261958)

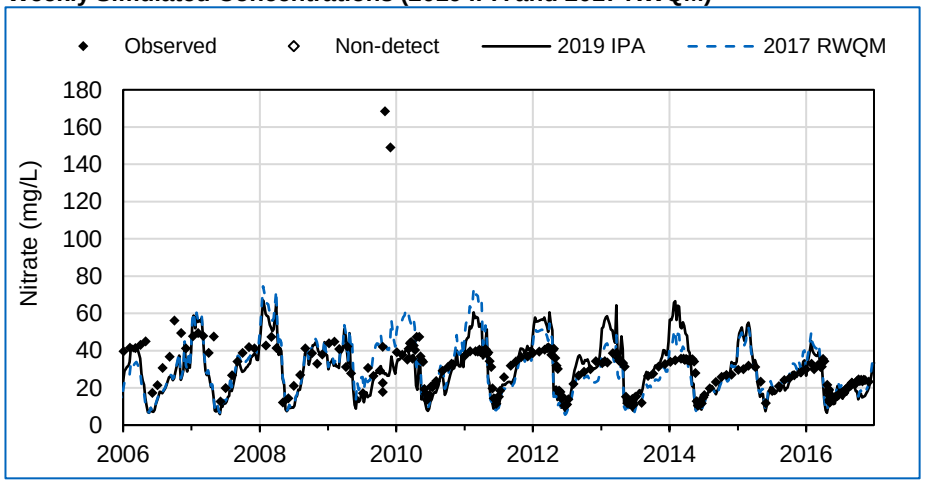
Observed and Simulated Nitrate Data and Calibration Statistics

Statistic	2017 RWQM	2019 IPA	
Model Averaging Period	Weekly	Weekly	Monthly
Calibration Period	2006 to 2016		
First Observed Sample	1/3/2006		
Last Observed Sample	12/5/2016		
Data Points Available for Comparison, n	244	244	129
Non-Detect Count	0	0	0
Observed Mean (mg/L)	29	29	32
Simulated Mean (mg/L)	27	27	30
Bias (mg/L)	-1.6	-2.3	-2.6
Relative Bias	0.95	0.92	0.92
Error (mg/L)	9.0	8.8	9.3
Percent Error	31%	30%	29%

2019 IPA Simulated vs. Observed Nitrate Concentrations

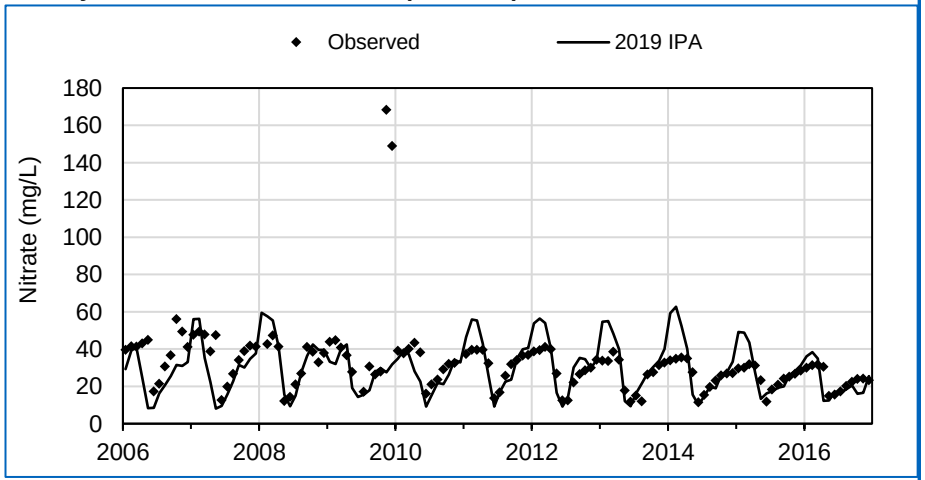


Weekly Simulated Concentrations (2019 IPA and 2017 RWQM)



Note: Observed data are individual sample results

Monthy Simulated Concentrations (2019 IPA)



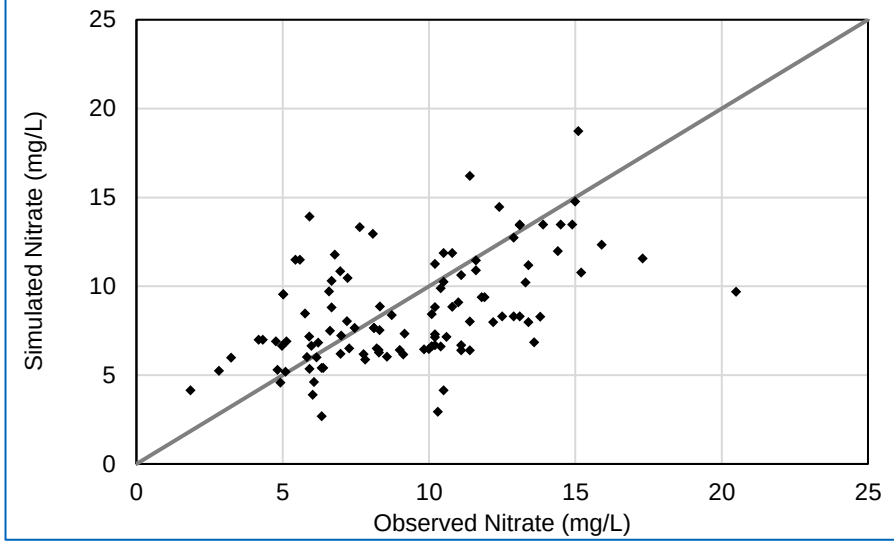
Note: Observed data are monthly averages of sample results

A1-15: Nitrate Calibration Information for Node LC_LCDSSLCC - LCO Compliance Point - Line Creek d/s of South Line Creek (EMS E297110)

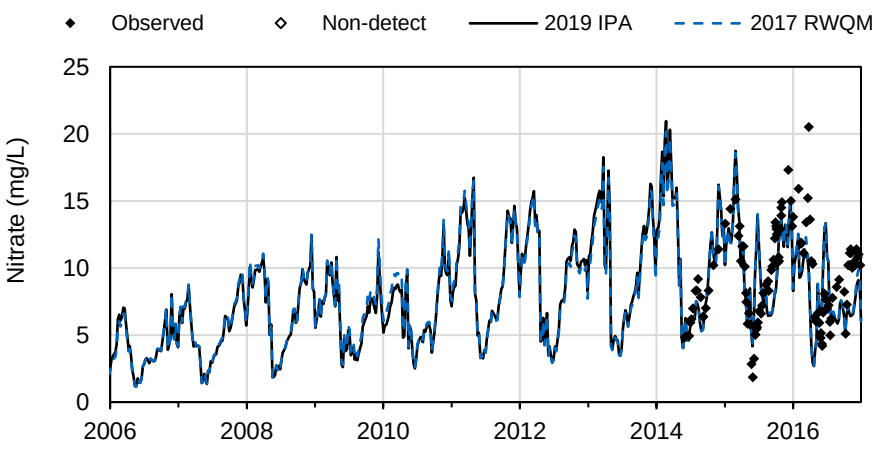
Observed and Simulated Nitrate Data and Calibration Statistics

Statistic	2017 RWQM	2019 IPA	
Model Averaging Period	Weekly	Weekly	Monthly
Calibration Period	2006 to 2016		
First Observed Sample	6/4/2014		
Last Observed Sample	12/28/2016		
Data Points Available for Comparison, n	108	108	31
Non-Detect Count	0	0	0
Observed Mean (mg/L)	9.3	9.3	9.8
Simulated Mean (mg/L)	8.7	8.6	9.2
Bias (mg/L)	-0.57	-0.68	-0.6
Relative Bias	0.94	0.93	0.94
Error (mg/L)	2.5	2.6	2.2
Percent Error	27%	28%	23%

2019 IPA Simulated vs. Observed Nitrate Concentrations

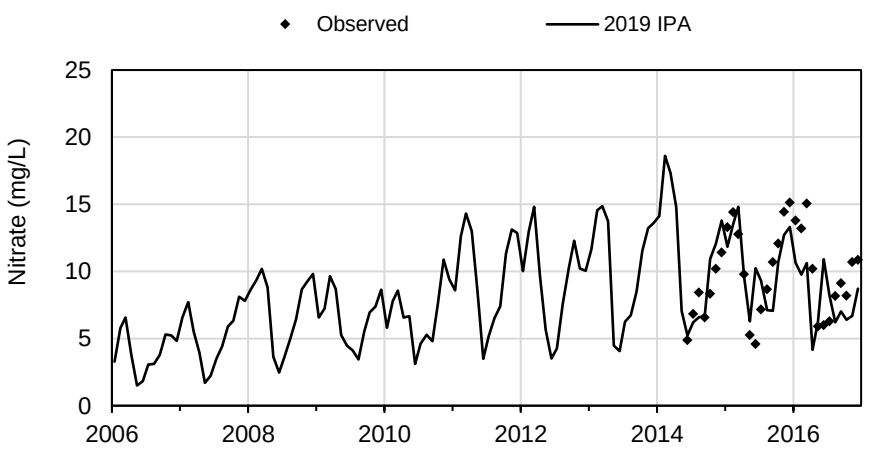


Weekly Simulated Concentrations (2019 IPA and 2017 RWQM)



Note: Observed data are individual sample results

Monthy Simulated Concentrations (2019 IPA)



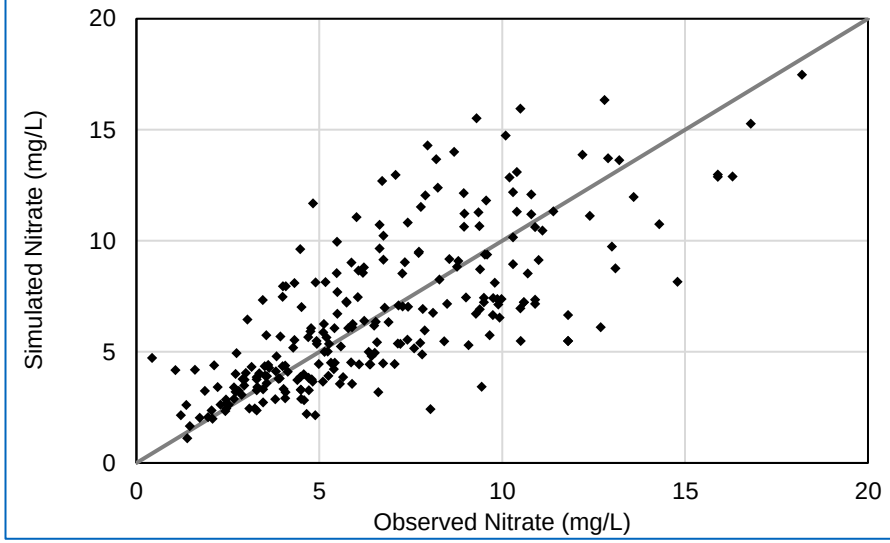
Note: Observed data are monthly averages of sample results

A1-16: Nitrate Calibration Information for Node LC_LC4 - Line Creek u/s of Process Plant (EMS 0200044)

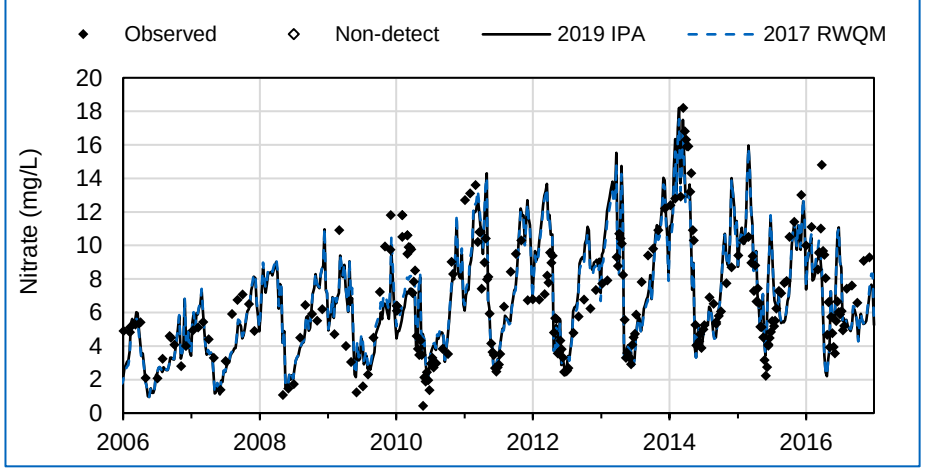
Observed and Simulated Nitrate Data and Calibration Statistics

Statistic	2017 RWQM	2019 IPA	
Model Averaging Period	Weekly	Weekly	Monthly
Calibration Period	2006 to 2016		
First Observed Sample	1/3/2006		
Last Observed Sample	12/7/2016		
Data Points Available for Comparison, n	241	241	125
Non-Detect Count	0	0	0
Observed Mean (mg/L)	6.6	6.6	6.6
Simulated Mean (mg/L)	6.8	6.7	6.9
Bias (mg/L)	0.12	0.074	0.23
Relative Bias	1.0	1.0	1.0
Error (mg/L)	1.8	1.9	1.6
Percent Error	28%	28%	25%

2019 IPA Simulated vs. Observed Nitrate Concentrations

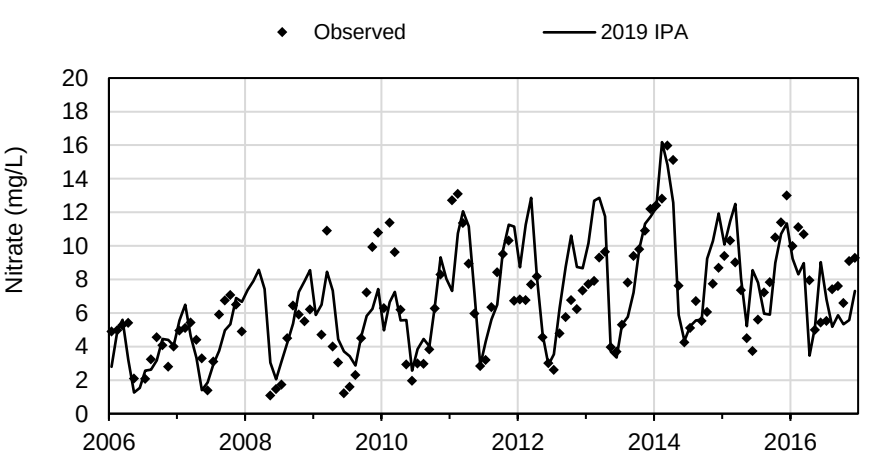


Weekly Simulated Concentrations (2019 IPA and 2017 RWQM)



Note: Observed data are individual sample results

Monthy Simulated Concentrations (2019 IPA)



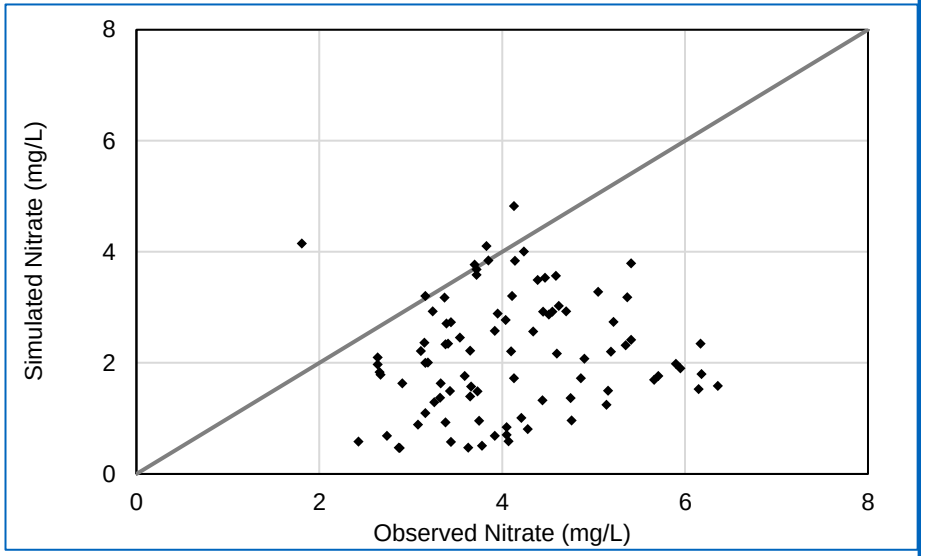
Note: Observed data are monthly averages of sample results

A1-17: Nitrate Calibration Information for Node EV_DC1 - EVO Dry Creek Sediment Pond Decant (EMS E298590)

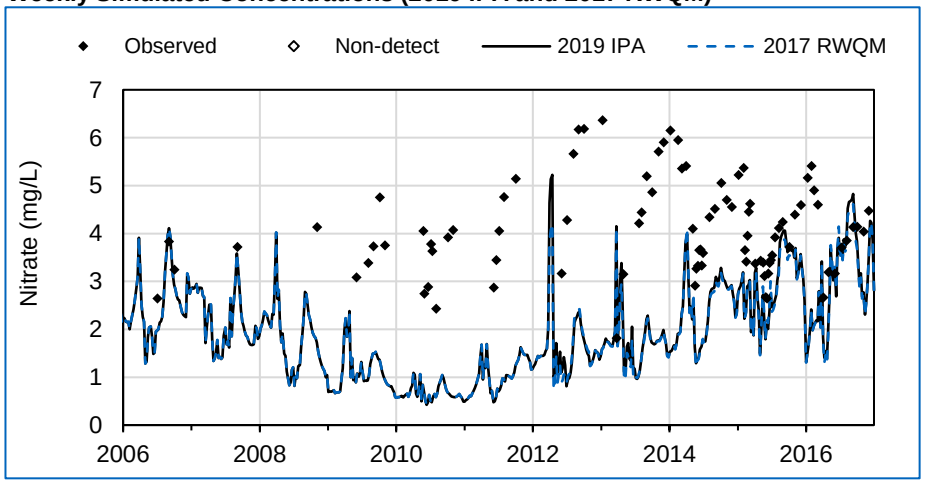
Observed and Simulated Nitrate Data and Calibration Statistics

Statistic	2017 RWQM	2019 IPA	
Model Averaging Period	Weekly	Weekly	Monthly
Calibration Period	2006 to 2016		
First Observed Sample	7/4/2006		
Last Observed Sample	12/5/2016		
Data Points Available for Comparison, n	90	90	70
Non-Detect Count	0	0	0
Observed Mean (mg/L)	4.1	4.1	4.2
Simulated Mean (mg/L)	2.1	2.1	2.1
Bias (mg/L)	-1.9	-1.9	-2.1
Relative Bias	0.52	0.53	0.51
Error (mg/L)	2.0	2.0	2.1
Percent Error	50%	49%	50%

2019 IPA Simulated vs. Observed Nitrate Concentrations

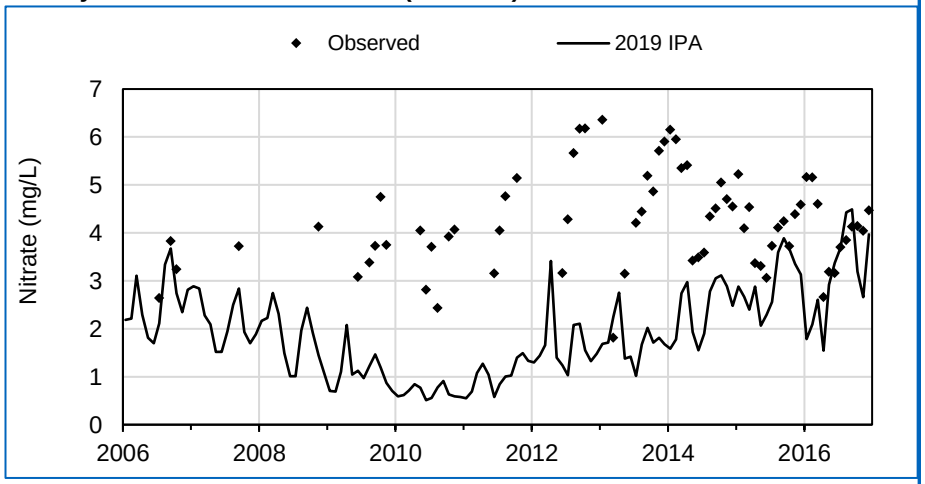


Weekly Simulated Concentrations (2019 IPA and 2017 RWQM)



Note: Observed data are individual sample results

Monthy Simulated Concentrations (2019 IPA)



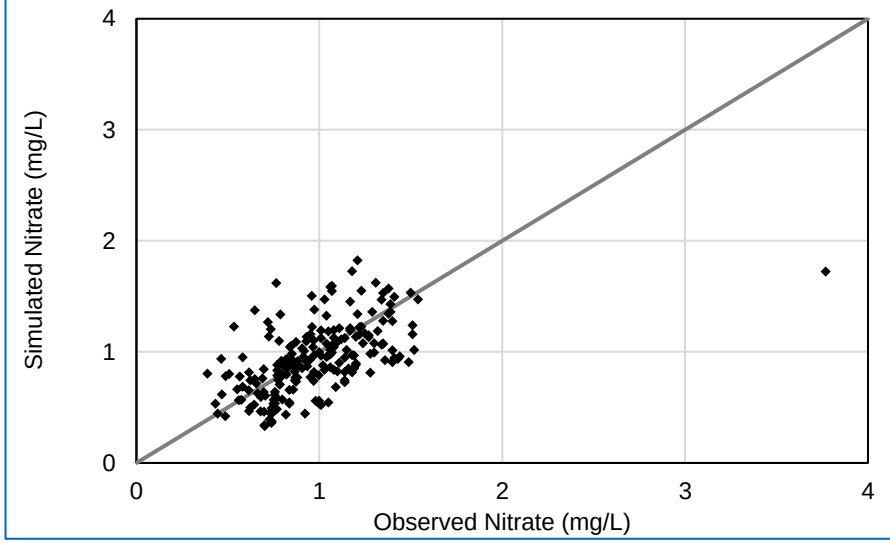
Note: Observed data are monthly averages of sample results

A1-18: Nitrate Calibration Information for Node EV_HC1 - EVO Harmer Compliance Point - Harmer Spillway (EMS E102682)

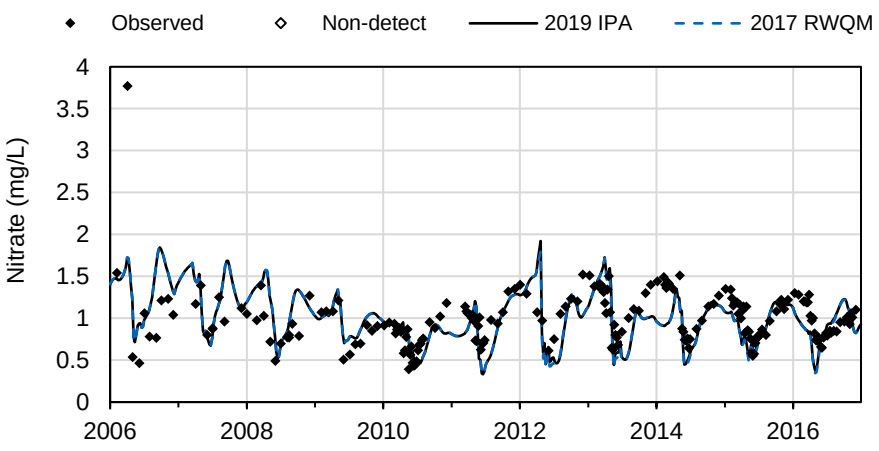
Observed and Simulated Nitrate Data and Calibration Statistics

Statistic	2017 RWQM	2019 IPA	
Model Averaging Period	Weekly	Weekly	Monthly
Calibration Period	2006 to 2016		
First Observed Sample	2/7/2006		
Last Observed Sample	12/5/2016		
Data Points Available for Comparison, n	213	213	119
Non-Detect Count	0	0	0
Observed Mean (mg/L)	0.98	0.98	1.0
Simulated Mean (mg/L)	0.92	0.93	1.0
Bias (mg/L)	-0.055	-0.043	-0.023
Relative Bias	0.94	0.96	0.98
Error (mg/L)	0.22	0.21	0.22
Percent Error	22%	22%	21%

2019 IPA Simulated vs. Observed Nitrate Concentrations

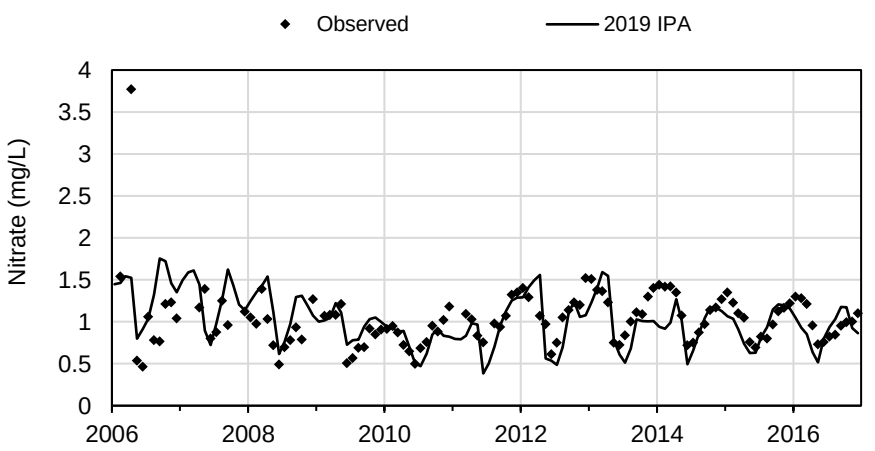


Weekly Simulated Concentrations (2019 IPA and 2017 RWQM)



Note: Observed data are individual sample results

Monthy Simulated Concentrations (2019 IPA)



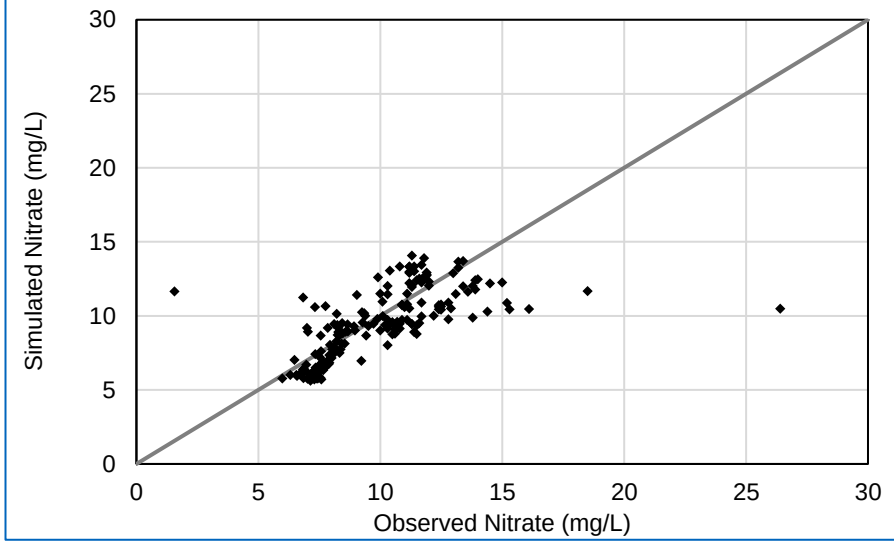
Note: Observed data are monthly averages of sample results

A1-19: Nitrate Calibration Information for Node EV_EC1 - Erickson Creek at Mouth (EMS 0200097)

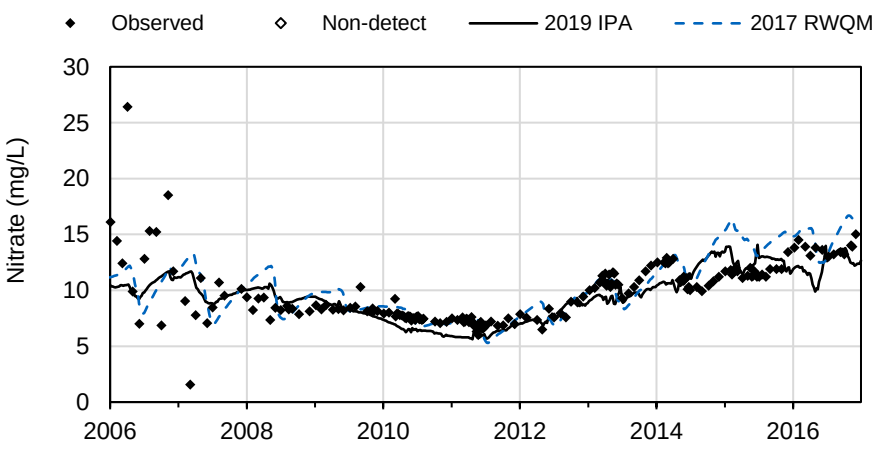
Observed and Simulated Nitrate Data and Calibration Statistics

Statistic	2017 RWQM	2019 IPA	
Model Averaging Period	Weekly	Weekly	Monthly
Calibration Period	2006 to 2016		
First Observed Sample	1/3/2006		
Last Observed Sample	12/5/2016		
Data Points Available for Comparison, n	191	191	126
Non-Detect Count	0	0	0
Observed Mean (mg/L)	9.8	9.8	10
Simulated Mean (mg/L)	10	9.3	9.6
Bias (mg/L)	0.51	-0.53	-0.42
Relative Bias	1.1	0.95	0.96
Error (mg/L)	1.4	1.4	1.5
Percent Error	15%	15%	15%

2019 IPA Simulated vs. Observed Nitrate Concentrations

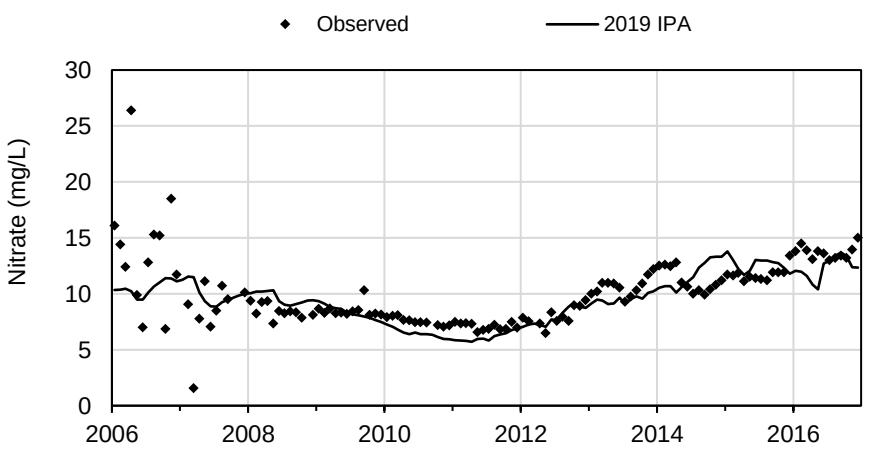


Weekly Simulated Concentrations (2019 IPA and 2017 RWQM)



Note: Observed data are individual sample results

Monthy Simulated Concentrations (2019 IPA)



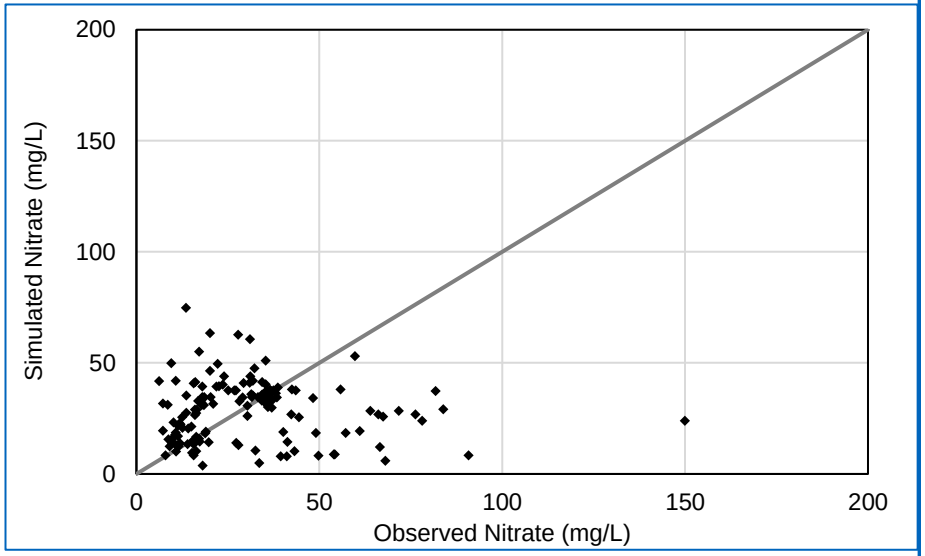
Note: Observed data are monthly averages of sample results

A1-20: Nitrate Calibration Information for Node EV_GT1 - Gate Creek Sediment Pond Decant (EMS E206231)

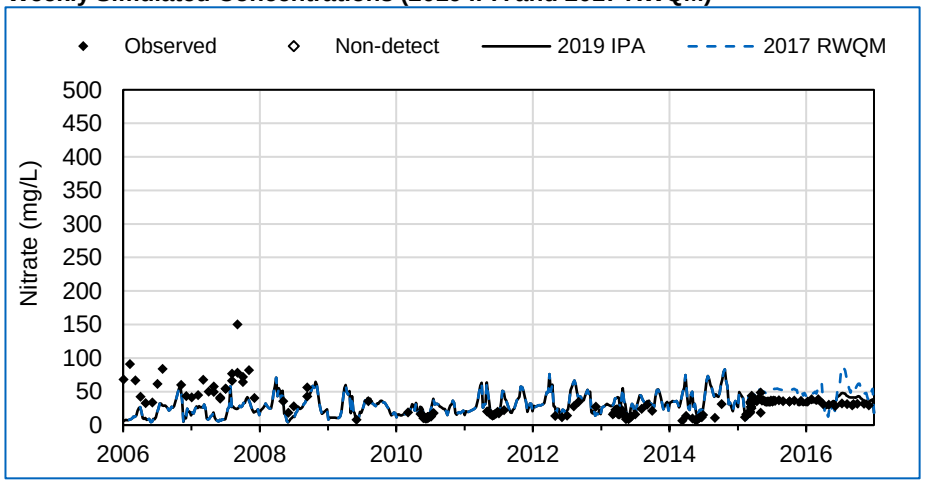
Observed and Simulated Nitrate Data and Calibration Statistics

Statistic	2017 RWQM	2019 IPA	
Model Averaging Period	Weekly	Weekly	Monthly
Calibration Period	2006 to 2016		
First Observed Sample	1/3/2006		
Last Observed Sample	12/5/2016		
Data Points Available for Comparison, n	151	151	80
Non-Detect Count	0	0	0
Observed Mean (mg/L)	31	31	39
Simulated Mean (mg/L)	34	29	30
Bias (mg/L)	3.1	-1.8	-9.2
Relative Bias	1.1	0.94	0.76
Error (mg/L)	20	16	23
Percent Error	65%	51%	60%

2019 IPA Simulated vs. Observed Nitrate Concentrations

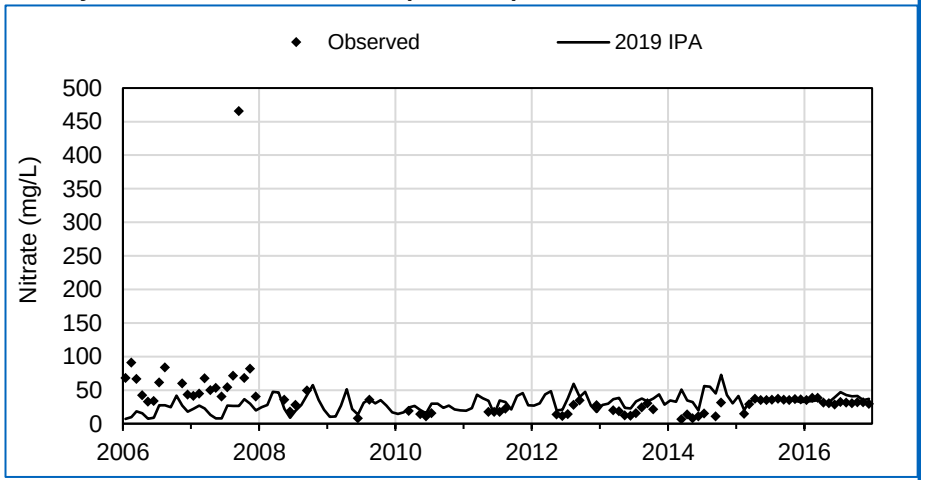


Weekly Simulated Concentrations (2019 IPA and 2017 RWQM)



Note: Observed data are individual sample results

Monthy Simulated Concentrations (2019 IPA)



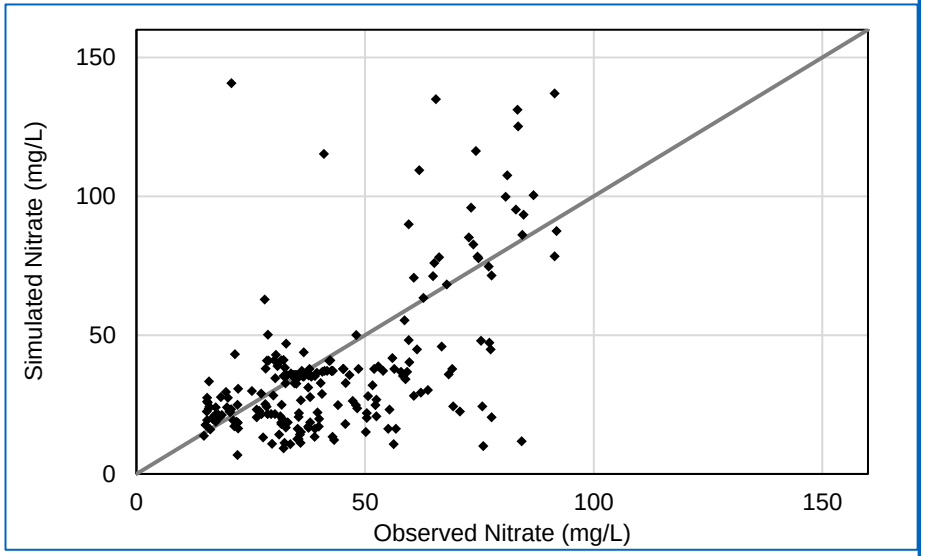
Note: Observed data are monthly averages of sample results

A1-21: Nitrate Calibration Information for Node EV_BC1 - Bodie Creek Sediment Pond Decant (EMS E102685)

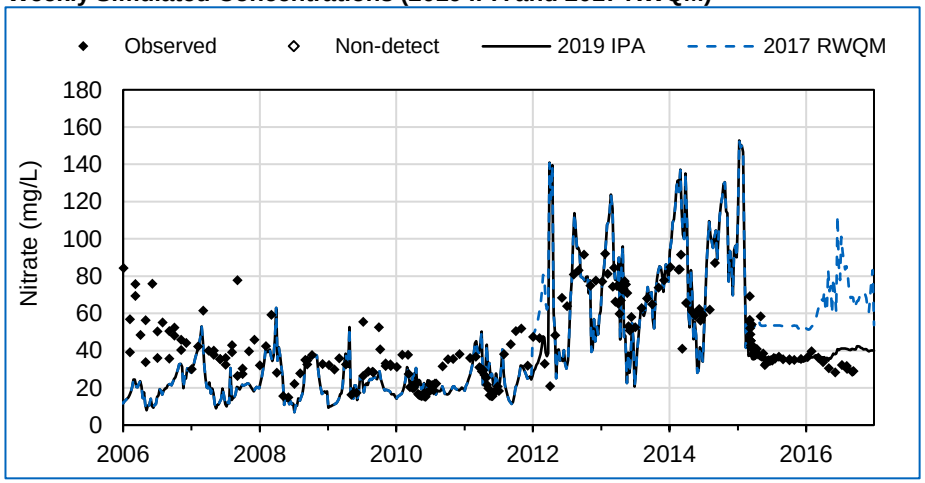
Observed and Simulated Nitrate Data and Calibration Statistics

Statistic	2017 RWQM	2019 IPA	
Model Averaging Period	Weekly	Weekly	Monthly
Calibration Period	2006 to 2016		
First Observed Sample	1/3/2006		
Last Observed Sample	9/14/2016		
Data Points Available for Comparison, n	219	219	122
Non-Detect Count	0	0	0
Observed Mean (mg/L)	43	43	44
Simulated Mean (mg/L)	43	37	38
Bias (mg/L)	-0.17	-5.2	-6.4
Relative Bias	1.0	0.88	0.86
Error (mg/L)	18	15	15
Percent Error	43%	35%	34%

2019 IPA Simulated vs. Observed Nitrate Concentrations

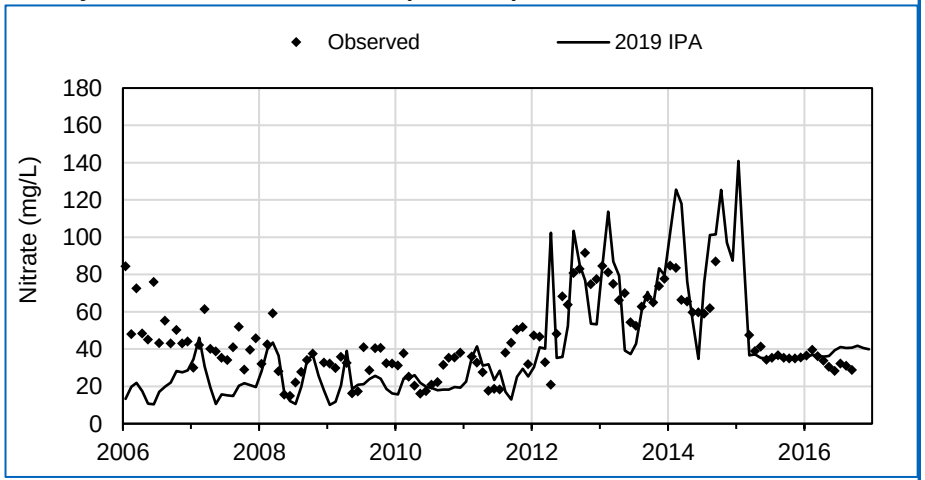


Weekly Simulated Concentrations (2019 IPA and 2017 RWQM)



Note: Observed data are individual sample results

Monthy Simulated Concentrations (2019 IPA)



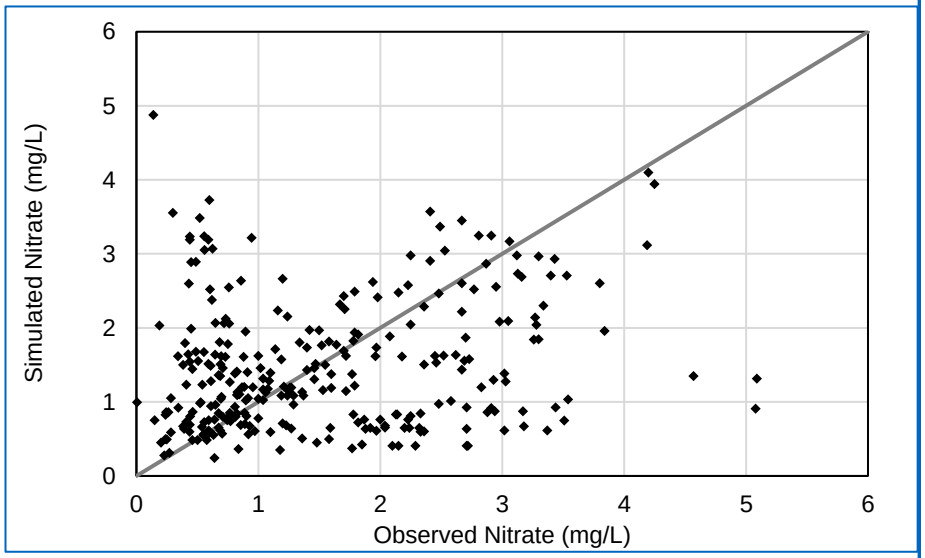
Note: Observed data are monthly averages of sample results

A1-22: Nitrate Calibration Information for Node CM_MC2 - Michel Creek d/s CMO near Andy Goode Creek Junction (EMS E258937)

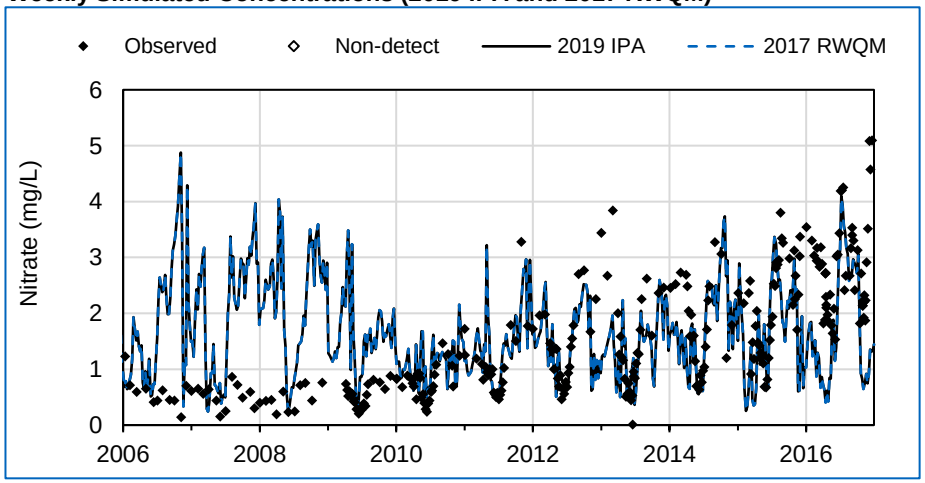
Observed and Simulated Nitrate Data and Calibration Statistics

Statistic	2017 RWQM	2019 IPA	
Model Averaging Period	Weekly	Weekly	Monthly
Calibration Period	2006 to 2016		
First Observed Sample	1/11/2006		
Last Observed Sample	12/21/2016		
Data Points Available for Comparison, n	283	283	126
Non-Detect Count	0	0	0
Observed Mean (mg/L)	1.5	1.5	1.5
Simulated Mean (mg/L)	1.5	1.5	1.7
Bias (mg/L)	-0.057	-0.054	0.22
Relative Bias	0.96	0.96	1.2
Error (mg/L)	0.86	0.86	0.9
Percent Error	56%	56%	62%

2019 IPA Simulated vs. Observed Nitrate Concentrations

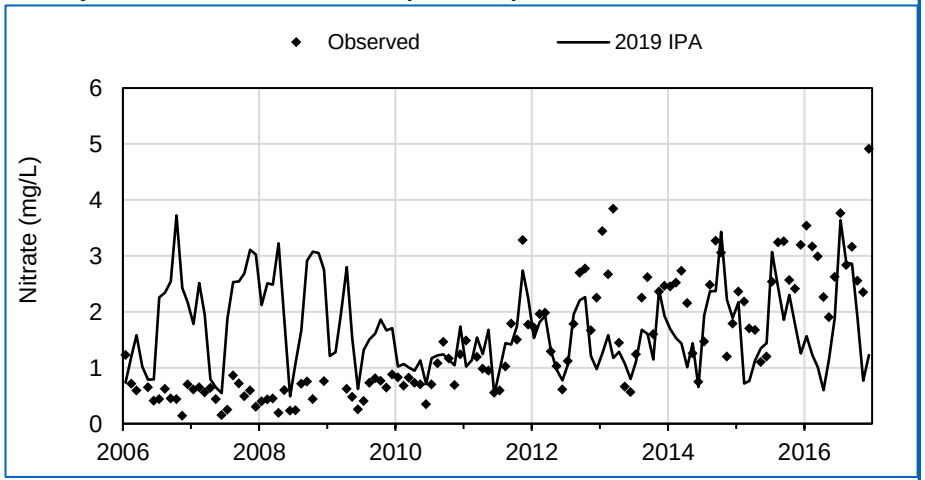


Weekly Simulated Concentrations (2019 IPA and 2017 RWQM)



Note: Observed data are individual sample results

Monthy Simulated Concentrations (2019 IPA)



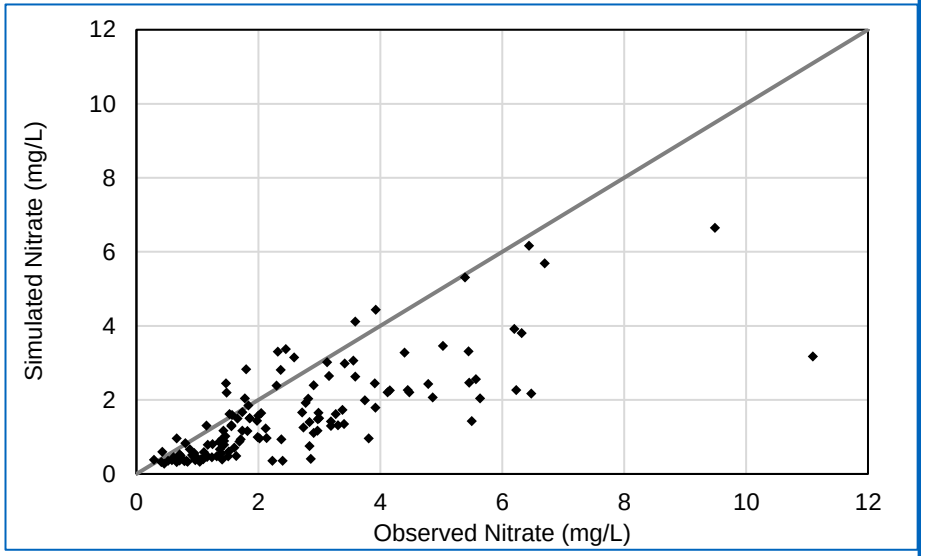
Note: Observed data are monthly averages of sample results

A1-23: Nitrate Calibration Information for Node FR_FR1 - Fording River d/s of Henretta Creek (EMS 0200251)

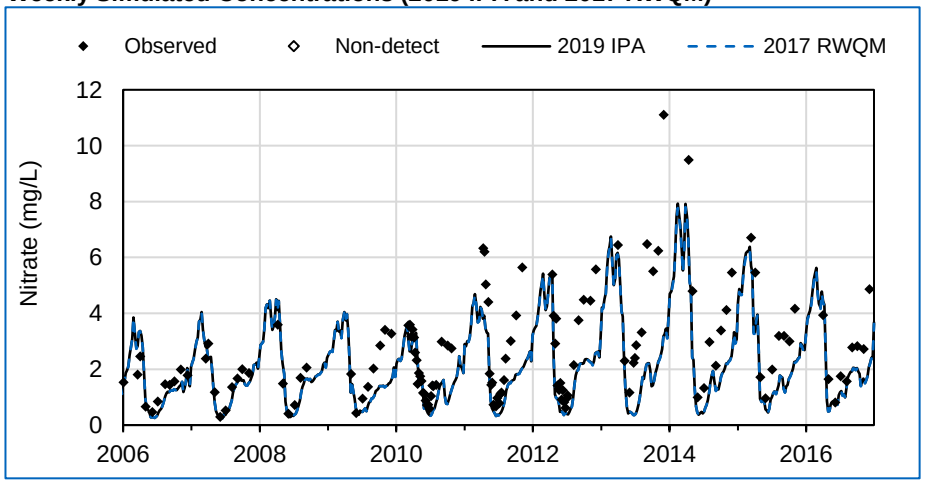
Observed and Simulated Nitrate Data and Calibration Statistics

Statistic	2017 RWQM	2019 IPA	
Model Averaging Period	Weekly	Weekly	Monthly
Calibration Period	2006 to 2016		
First Observed Sample	1/3/2006		
Last Observed Sample	12/7/2016		
Data Points Available for Comparison, n	133	133	95
Non-Detect Count	0	0	0
Observed Mean (mg/L)	2.5	2.5	2.7
Simulated Mean (mg/L)	1.6	1.6	1.7
Bias (mg/L)	-0.97	-0.96	-1.1
Relative Bias	0.62	0.62	0.61
Error (mg/L)	1.1	1.1	1.1
Percent Error	43%	42%	42%

2019 IPA Simulated vs. Observed Nitrate Concentrations

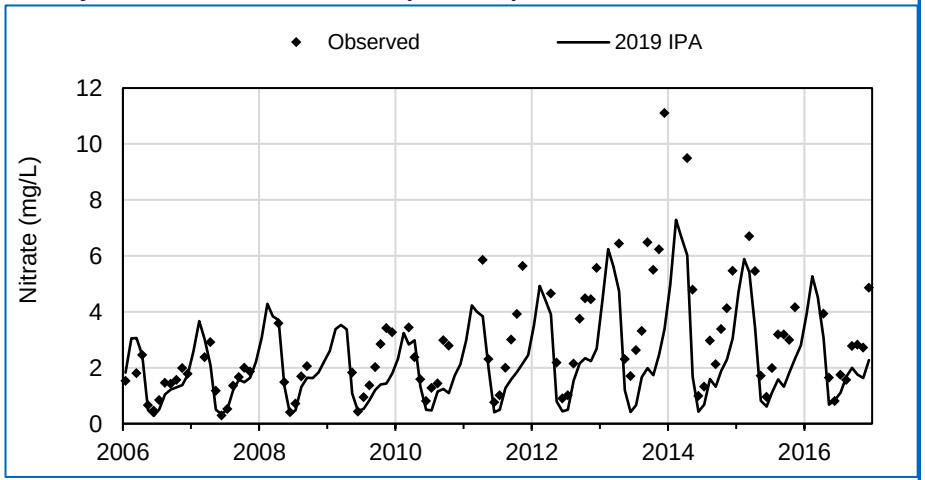


Weekly Simulated Concentrations (2019 IPA and 2017 RWQM)



Note: Observed data are individual sample results

Monthy Simulated Concentrations (2019 IPA)



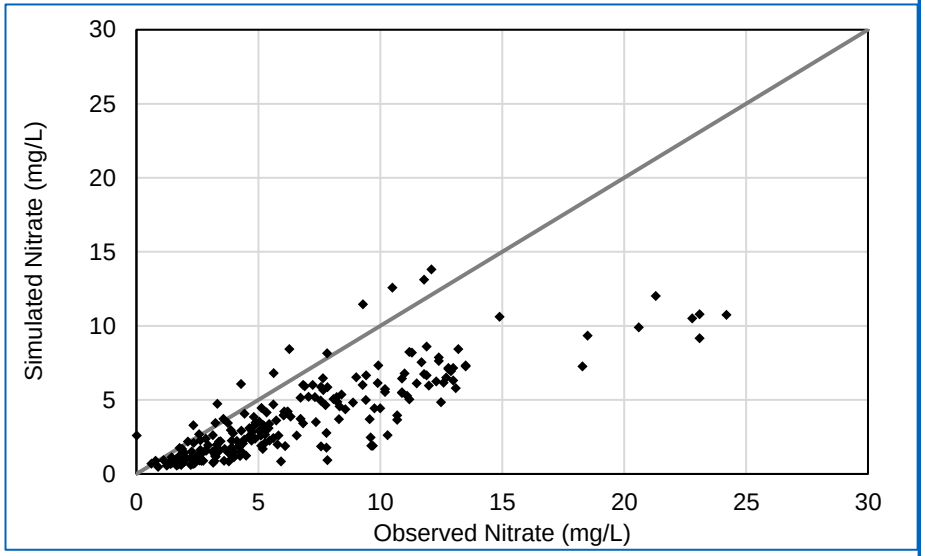
Note: Observed data are monthly averages of sample results

A1-24: Nitrate Calibration Information for Node FR_FR2 - Fording River u/s of Kilmarnock Creek (EMS 0200201)

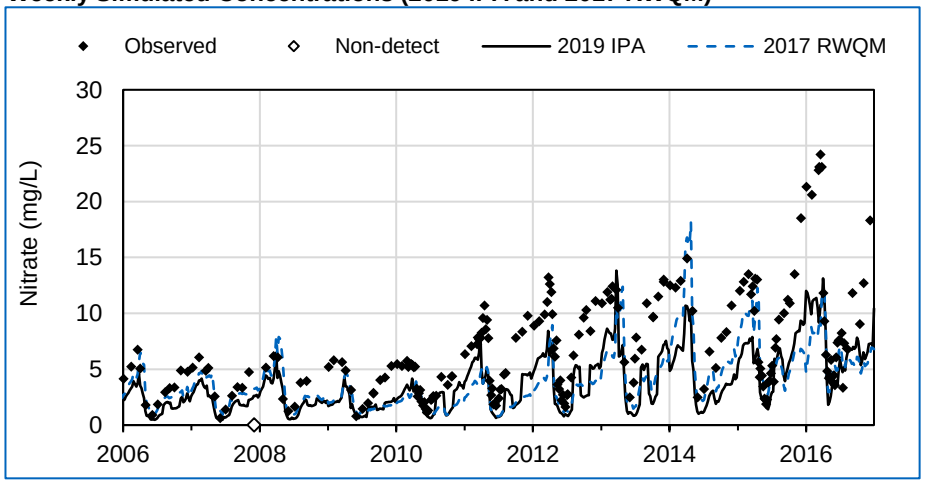
Observed and Simulated Nitrate Data and Calibration Statistics

Statistic	2017 RWQM	2019 IPA	
Model Averaging Period	Weekly	Weekly	Monthly
Calibration Period	2006 to 2016		
First Observed Sample	1/3/2006		
Last Observed Sample	12/12/2016		
Data Points Available for Comparison, n	213	213	124
Non-Detect Count	1	1	0
Observed Mean (mg/L)	6.7	6.7	6.8
Simulated Mean (mg/L)	4.2	3.9	3.8
Bias (mg/L)	-2.5	-2.9	-3.0
Relative Bias	0.62	0.57	0.56
Error (mg/L)	3.0	3.0	3.1
Percent Error	44%	45%	45%

2019 IPA Simulated vs. Observed Nitrate Concentrations

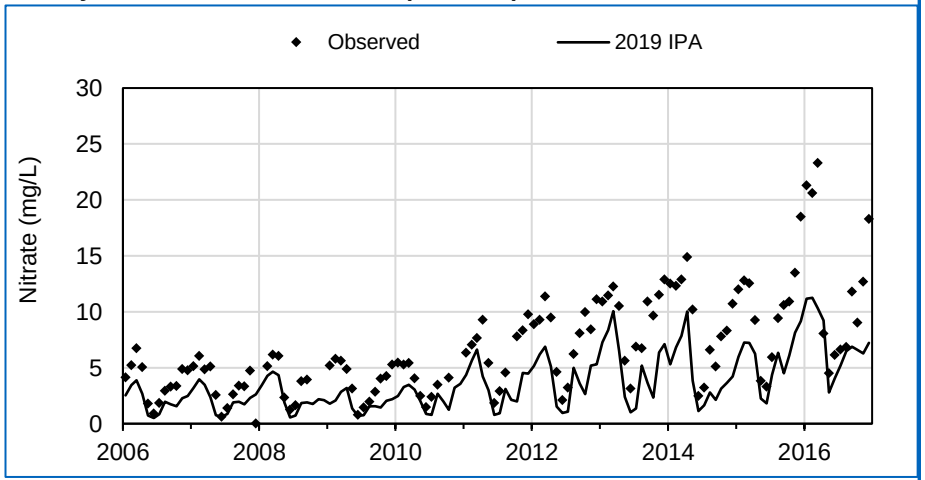


Weekly Simulated Concentrations (2019 IPA and 2017 RWQM)



Note: Observed data are individual sample results

Monthy Simulated Concentrations (2019 IPA)



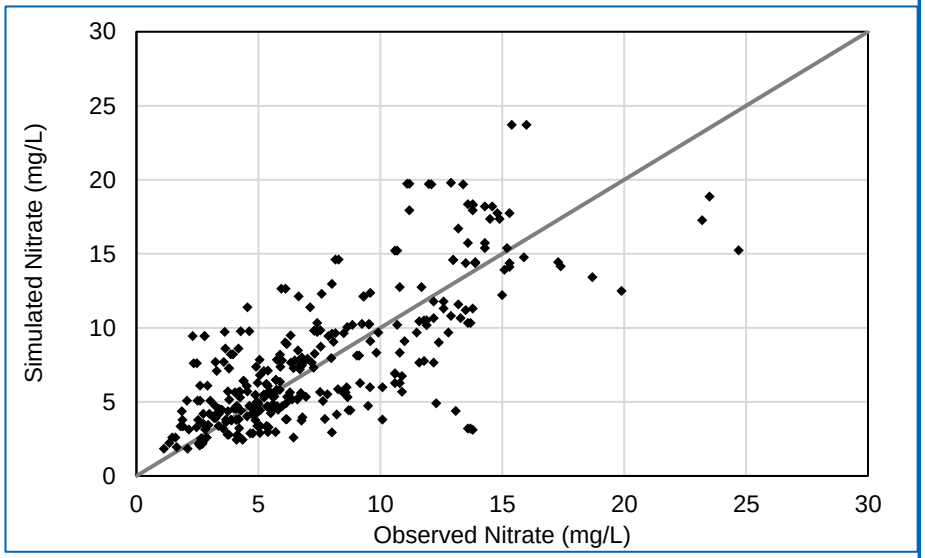
Note: Observed data are monthly averages of sample results

A1-25: Nitrate Calibration Information for Node FR_FR4 - Fording River between Swift and Cataract creeks (EMS 0200311)

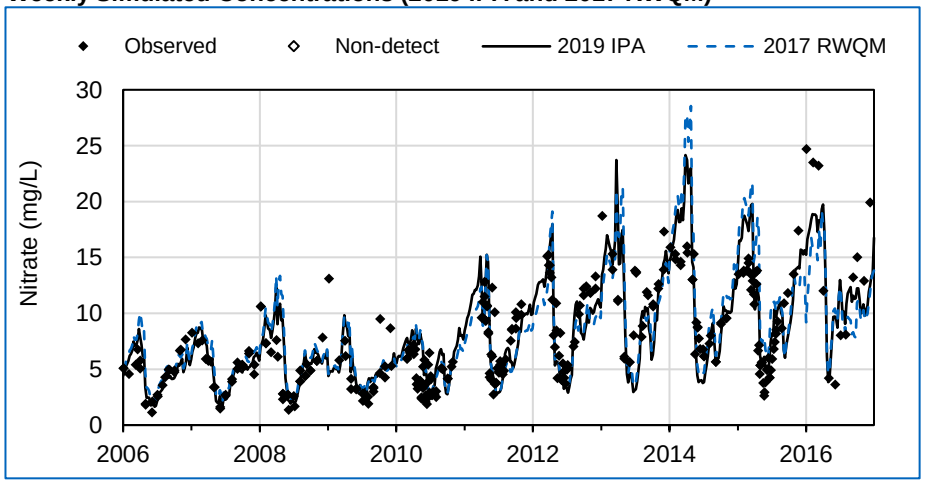
Observed and Simulated Nitrate Data and Calibration Statistics

Statistic	2017 RWQM	2019 IPA	
Model Averaging Period	Weekly	Weekly	Monthly
Calibration Period	2006 to 2016		
First Observed Sample	1/3/2006		
Last Observed Sample	12/12/2016		
Data Points Available for Comparison, n	318	318	118
Non-Detect Count	0	0	0
Observed Mean (mg/L)	7.4	7.4	8.2
Simulated Mean (mg/L)	8.2	7.7	8.2
Bias (mg/L)	0.76	0.29	-0.039
Relative Bias	1.1	1.0	1.0
Error (mg/L)	2.7	2.3	2.0
Percent Error	37%	31%	24%

2019 IPA Simulated vs. Observed Nitrate Concentrations

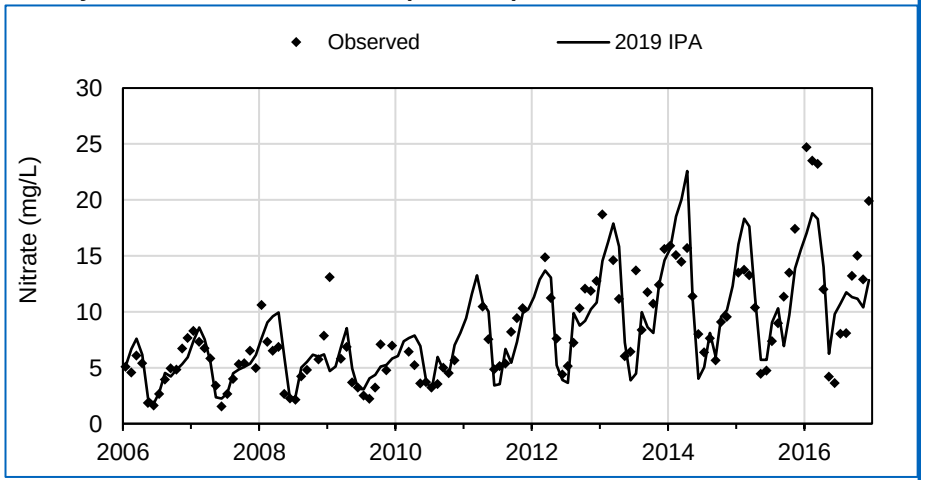


Weekly Simulated Concentrations (2019 IPA and 2017 RWQM)



Note: Observed data are individual sample results

Monthy Simulated Concentrations (2019 IPA)



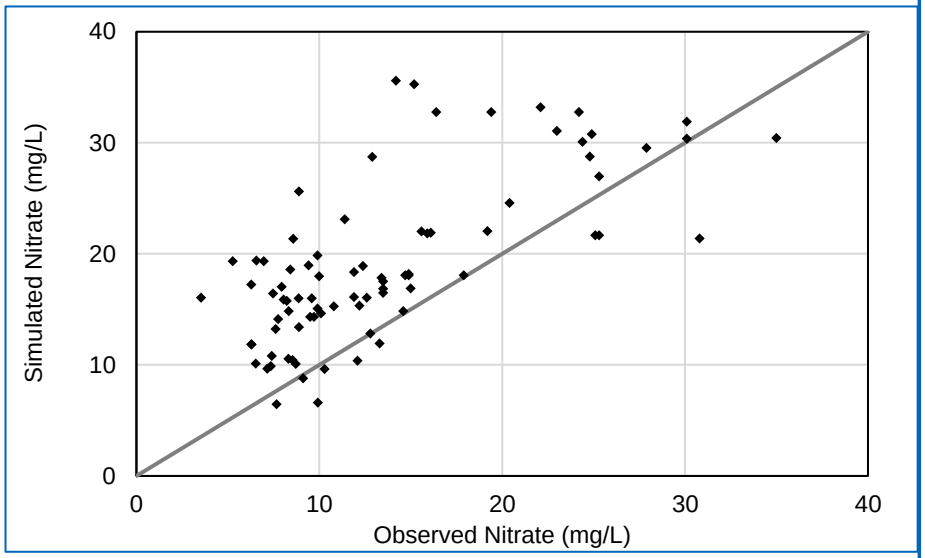
Note: Observed data are monthly averages of sample results

A1-26: Nitrate Calibration Information for Node FR_FRCP1 - FRO Compliance Point - Fording R., 525 m d/s of Cataract Creek (EMS E300071)

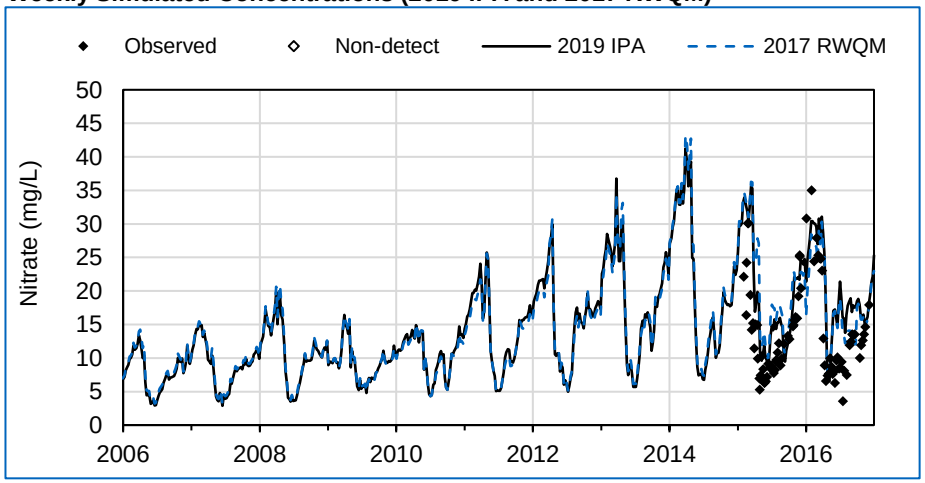
Observed and Simulated Nitrate Data and Calibration Statistics

Statistic	2017 RWQM	2019 IPA	
Model Averaging Period	Weekly	Weekly	Monthly
Calibration Period	2006 to 2016		
First Observed Sample	2/3/2015		
Last Observed Sample	12/6/2016		
Data Points Available for Comparison, n	82	82	23
Non-Detect Count	0	0	0
Observed Mean (mg/L)	14	14	15
Simulated Mean (mg/L)	19	19	19
Bias (mg/L)	5.7	5.4	4.6
Relative Bias	1.4	1.4	1.3
Error (mg/L)	6.8	6.2	5.2
Percent Error	50%	45%	35%

2019 IPA Simulated vs. Observed Nitrate Concentrations

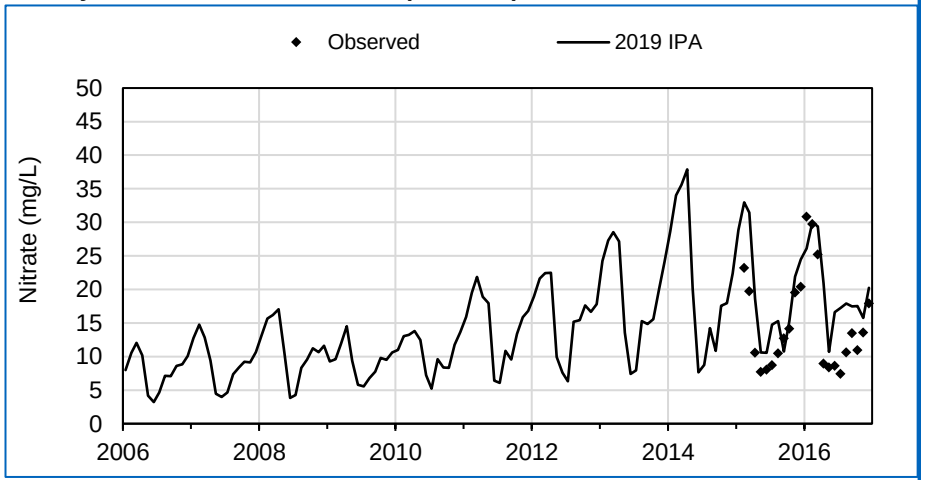


Weekly Simulated Concentrations (2019 IPA and 2017 RWQM)



Note: Observed data are individual sample results

Monthy Simulated Concentrations (2019 IPA)



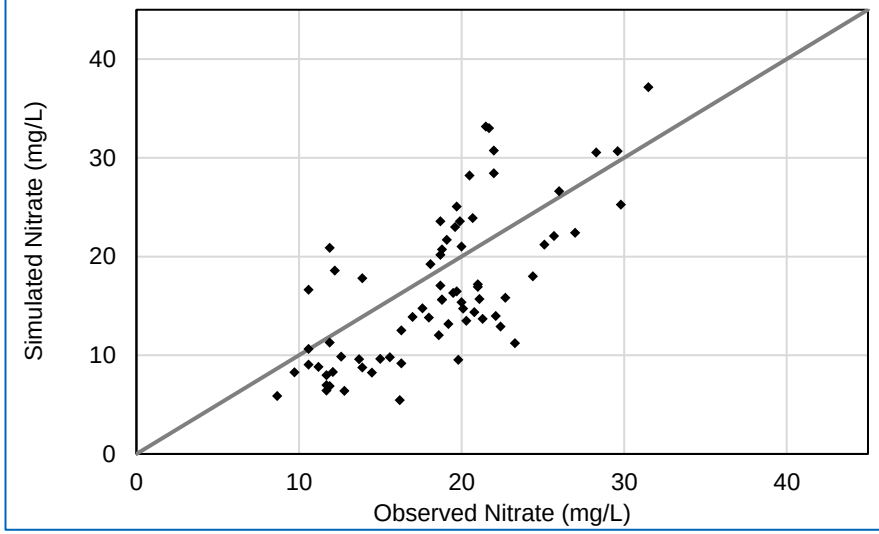
Note: Observed data are monthly averages of sample results

A1-27: Nitrate Calibration Information for Node GH_PC2 - Fording River d/s of Porter Creek (EMS E287431)

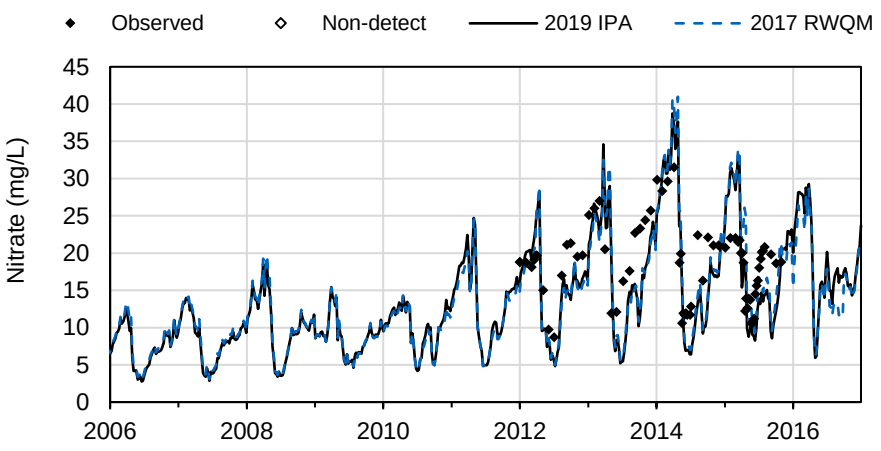
Observed and Simulated Nitrate Data and Calibration Statistics

Statistic	2017 RWQM	2019 IPA	
Model Averaging Period	Weekly	Weekly	Monthly
Calibration Period	2006 to 2016		
First Observed Sample	1/3/2012		
Last Observed Sample	11/2/2015		
Data Points Available for Comparison, n	72	72	47
Non-Detect Count	0	0	0
Observed Mean (mg/L)	18	18	20
Simulated Mean (mg/L)	18	17	18
Bias (mg/L)	-0.92	-1.8	-2.0
Relative Bias	0.95	0.9	0.9
Error (mg/L)	4.8	4.8	4.2
Percent Error	26%	26%	22%

2019 IPA Simulated vs. Observed Nitrate Concentrations

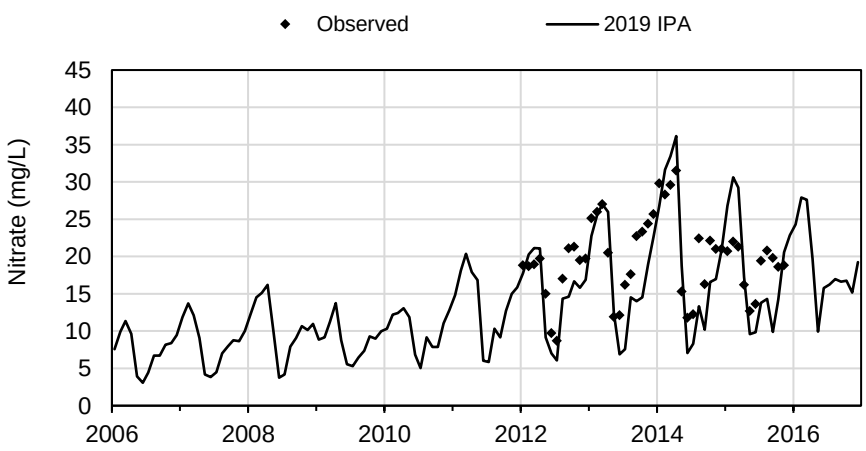


Weekly Simulated Concentrations (2019 IPA and 2017 RWQM)



Note: Observed data are individual sample results

Monthy Simulated Concentrations (2019 IPA)



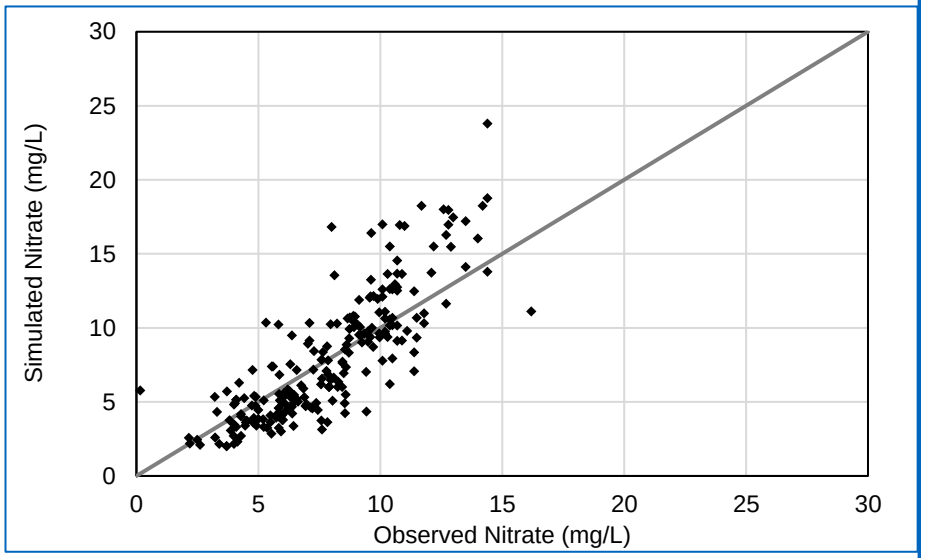
Note: Observed data are monthly averages of sample results

A1-28: Nitrate Calibration Information for Node GH_FR1 - GHO Fording River Compliance Point (EMS 0200378)

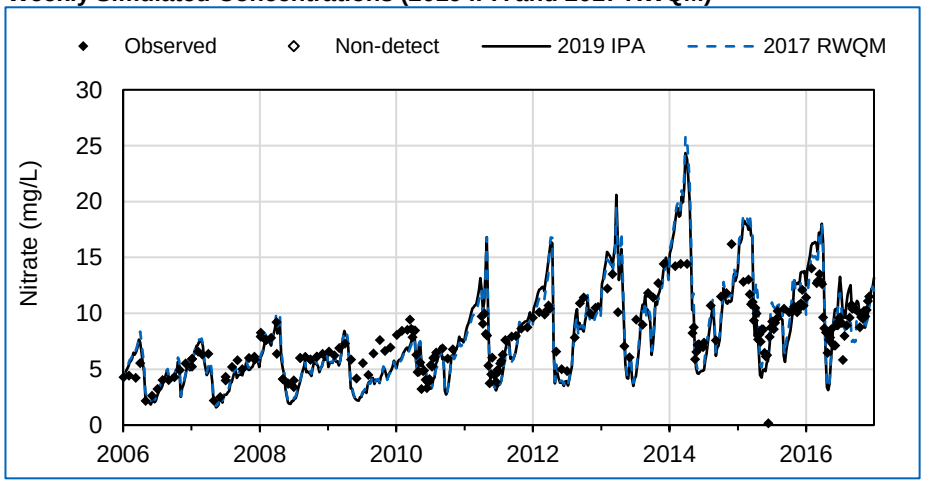
Observed and Simulated Nitrate Data and Calibration Statistics

Statistic	2017 RWQM	2019 IPA	
Model Averaging Period	Weekly	Weekly	Monthly
Calibration Period	2006 to 2016		
First Observed Sample	1/4/2006		
Last Observed Sample	12/6/2016		
Data Points Available for Comparison, n	229	229	124
Non-Detect Count	0	0	0
Observed Mean (mg/L)	7.8	7.8	7.8
Simulated Mean (mg/L)	8.0	7.9	7.7
Bias (mg/L)	0.14	0.11	-0.065
Relative Bias	1.0	1.0	0.99
Error (mg/L)	1.8	1.9	1.5
Percent Error	23%	24%	19%

2019 IPA Simulated vs. Observed Nitrate Concentrations

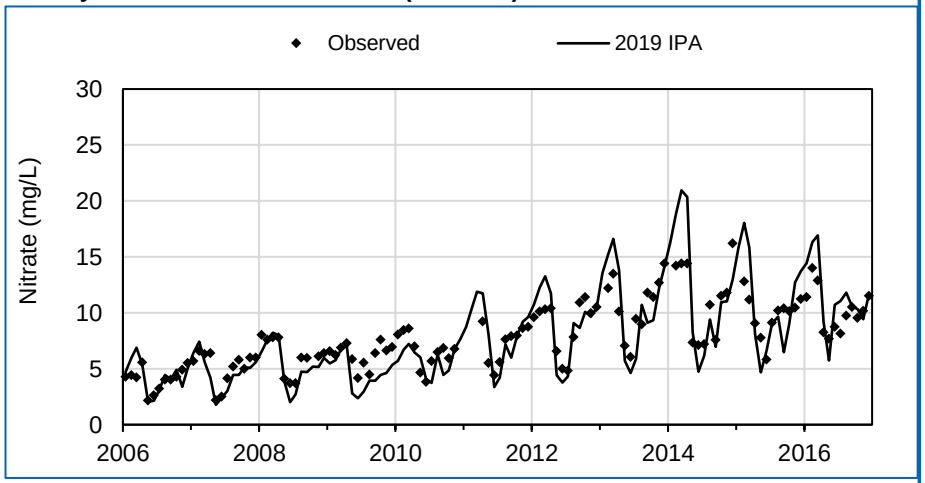


Weekly Simulated Concentrations (2019 IPA and 2017 RWQM)



Note: Observed data are individual sample results

Monthy Simulated Concentrations (2019 IPA)



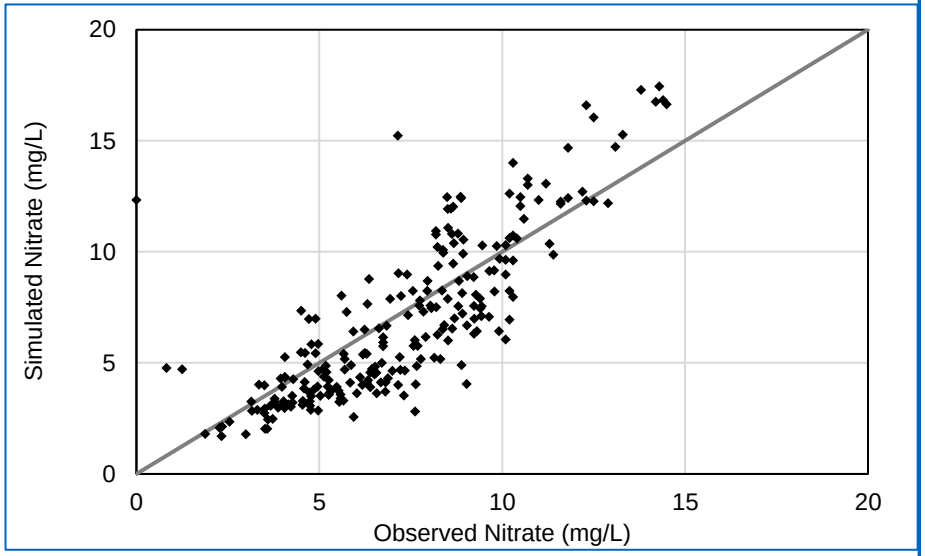
Note: Observed data are monthly averages of sample results

A1-29: Nitrate Calibration Information for Node LC_LC5 - Fording River d/s of Line Creek (EMS 0200028)

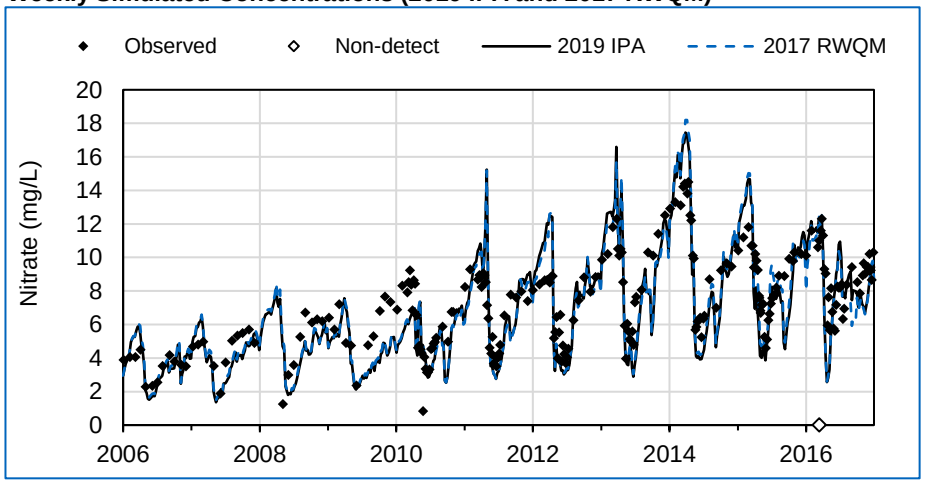
Observed and Simulated Nitrate Data and Calibration Statistics

Statistic	2017 RWQM	2019 IPA	
Model Averaging Period	Weekly	Weekly	Monthly
Calibration Period	2006 to 2016		
First Observed Sample	1/3/2006		
Last Observed Sample	12/28/2016		
Data Points Available for Comparison, n	238	238	125
Non-Detect Count	1	1	0
Observed Mean (mg/L)	7.2	7.2	7.0
Simulated Mean (mg/L)	7.0	6.9	6.7
Bias (mg/L)	-0.19	-0.32	-0.28
Relative Bias	0.97	0.96	0.96
Error (mg/L)	1.6	1.6	1.2
Percent Error	22%	22%	17%

2019 IPA Simulated vs. Observed Nitrate Concentrations

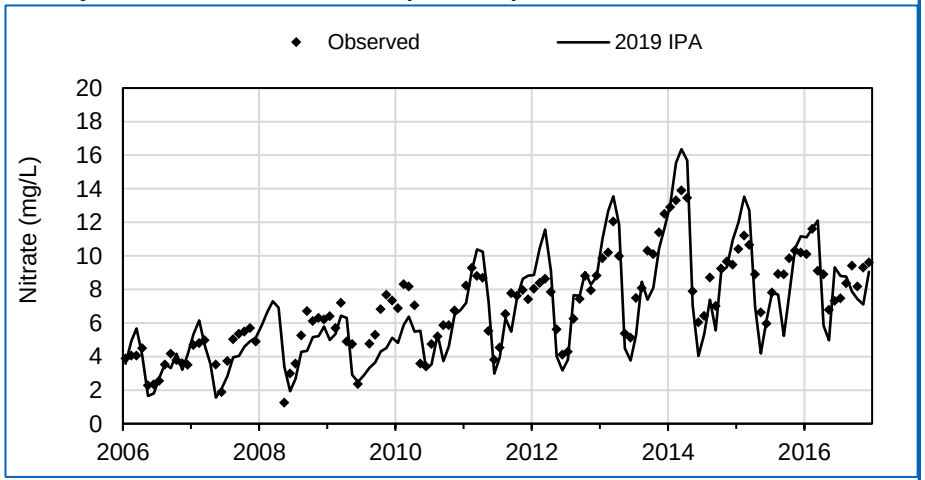


Weekly Simulated Concentrations (2019 IPA and 2017 RWQM)



Note: Observed data are individual sample results

Monthy Simulated Concentrations (2019 IPA)



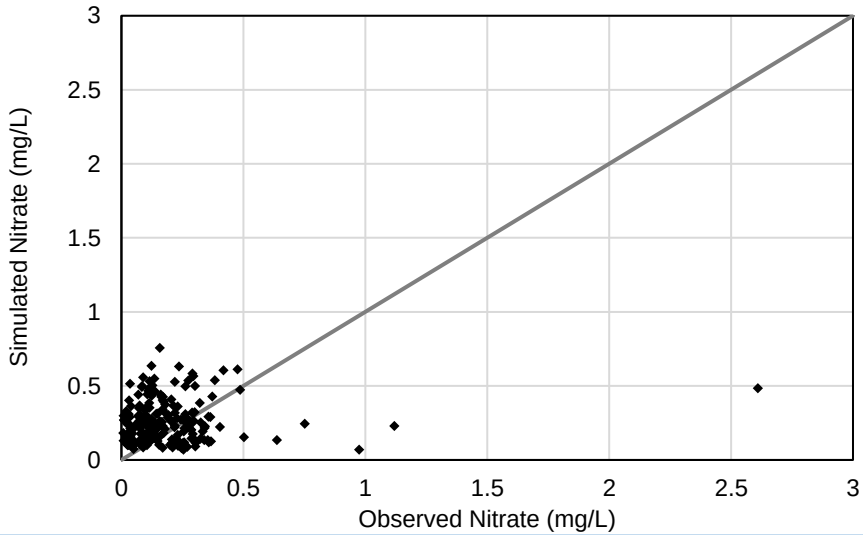
Note: Observed data are monthly averages of sample results

A1-30: Nitrate Calibration Information for Node EV_MC3 - Michel Creek u/s of Erickson Creek (EMS 0200203)

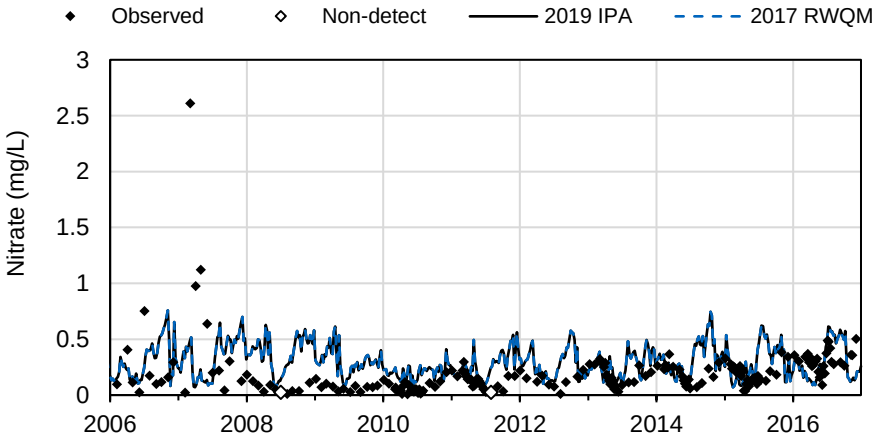
Observed and Simulated Nitrate Data and Calibration Statistics

Statistic	2017 RWQM	2019 IPA	
Model Averaging Period	Weekly	Weekly	Monthly
Calibration Period	2006 to 2016		
First Observed Sample	2/7/2006		
Last Observed Sample	12/6/2016		
Data Points Available for Comparison, n	210	210	125
Non-Detect Count	2	2	0
Observed Mean (mg/L)	0.19	0.19	0.2
Simulated Mean (mg/L)	0.26	0.26	0.29
Bias (mg/L)	0.07	0.071	0.097
Relative Bias	1.4	1.4	1.5
Error (mg/L)	0.17	0.17	0.21
Percent Error	91%	91%	107%

2019 IPA Simulated vs. Observed Nitrate Concentrations

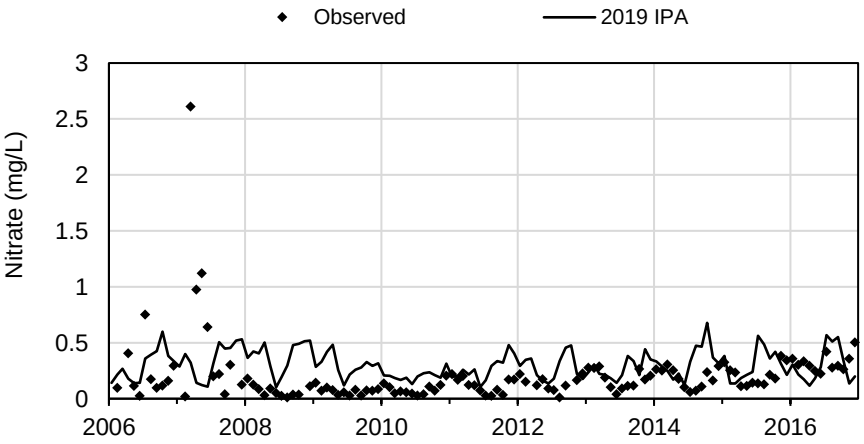


Weekly Simulated Concentrations (2019 IPA and 2017 RWQM)



Note: Observed data are individual sample results

Monthy Simulated Concentrations (2019 IPA)



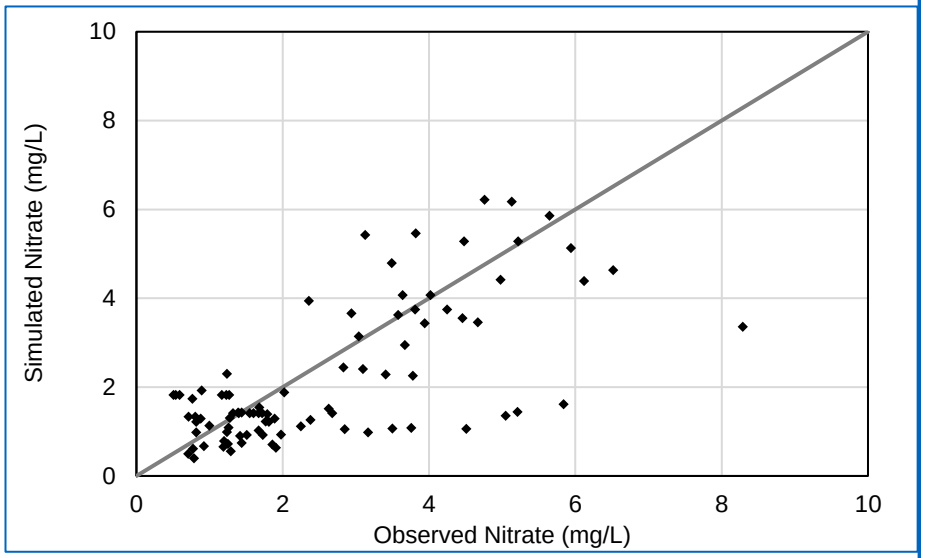
Note: Observed data are monthly averages of sample results

A1-31: Nitrate Calibration Information for Node EV_MC2 - EVO Michel Creek Compliance Point (EMS E300091)

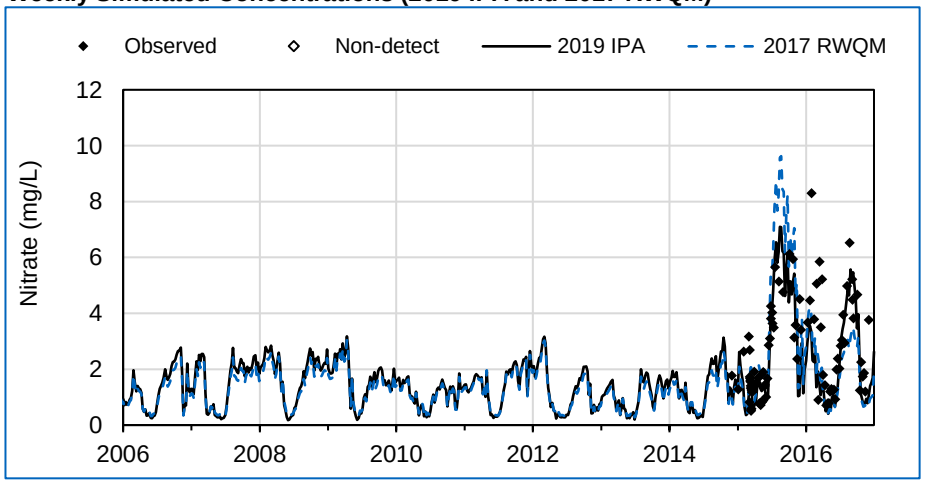
Observed and Simulated Nitrate Data and Calibration Statistics

Statistic	2017 RWQM	2019 IPA	
Model Averaging Period	Weekly	Weekly	Monthly
Calibration Period	2006 to 2016		
First Observed Sample	12/3/2014		
Last Observed Sample	12/5/2016		
Data Points Available for Comparison, n	89	89	25
Non-Detect Count	0	0	0
Observed Mean (mg/L)	2.6	2.6	3.2
Simulated Mean (mg/L)	2.4	2.2	2.6
Bias (mg/L)	-0.16	-0.42	-0.6
Relative Bias	0.94	0.84	0.81
Error (mg/L)	1.2	0.93	0.98
Percent Error	46%	36%	31%

2019 IPA Simulated vs. Observed Nitrate Concentrations

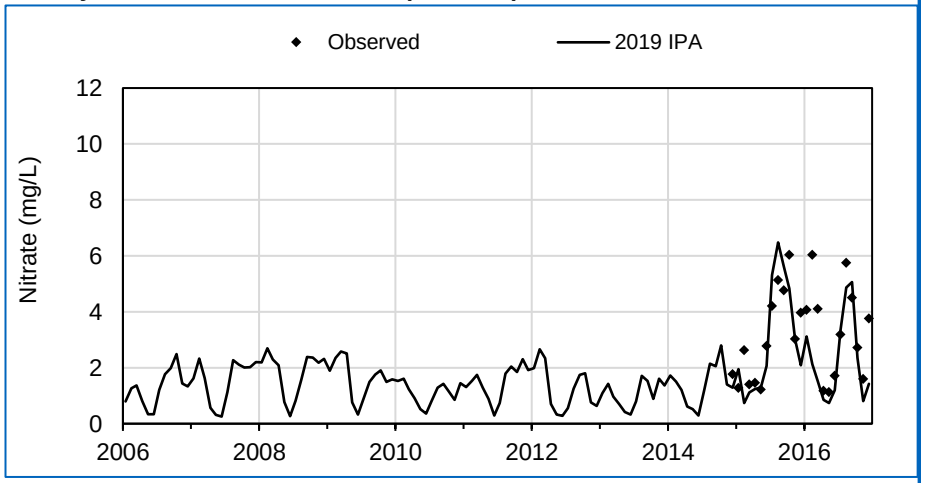


Weekly Simulated Concentrations (2019 IPA and 2017 RWQM)



Note: Observed data are individual sample results

Monthy Simulated Concentrations (2019 IPA)



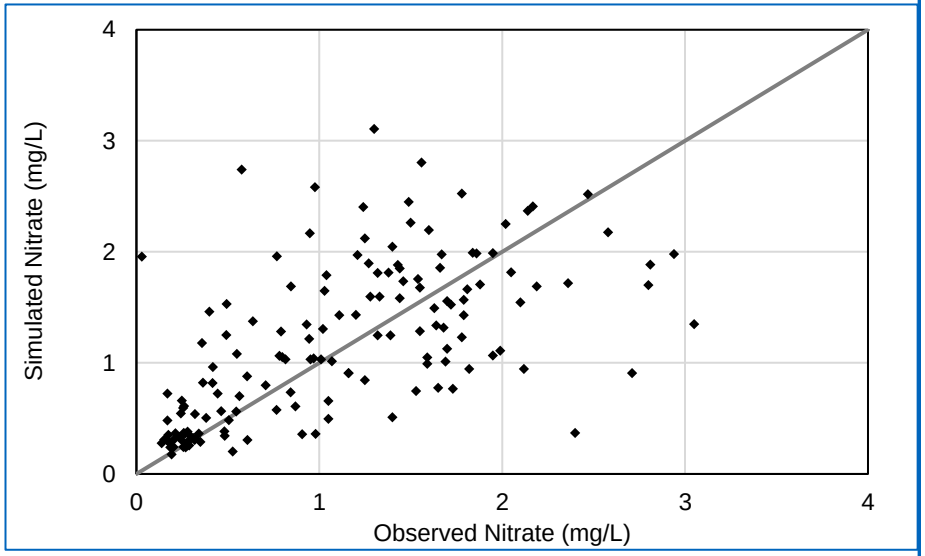
Note: Observed data are monthly averages of sample results

A1-32: Nitrate Calibration Information for Node EV_MC1 - Michel Creek u/s of Highway 43 Bridge (EMS 0200425)

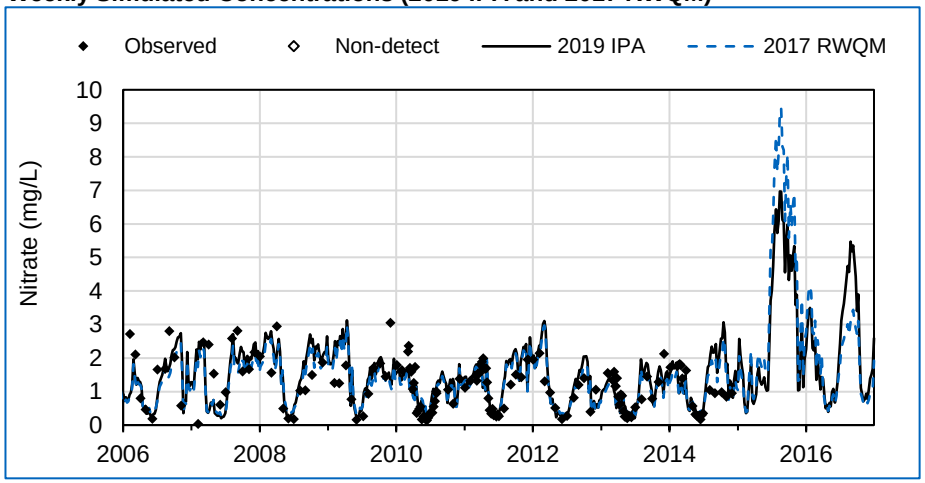
Observed and Simulated Nitrate Data and Calibration Statistics

Statistic	2017 RWQM	2019 IPA	
Model Averaging Period	Weekly	Weekly	Monthly
Calibration Period	2006 to 2016		
First Observed Sample	2/7/2006		
Last Observed Sample	12/3/2014		
Data Points Available for Comparison, n	151	151	100
Non-Detect Count	0	0	0
Observed Mean (mg/L)	1.1	1.1	1.2
Simulated Mean (mg/L)	1.1	1.2	1.4
Bias (mg/L)	0.0013	0.075	0.14
Relative Bias	1.0	1.1	1.1
Error (mg/L)	0.44	0.45	0.48
Percent Error	40%	41%	39%

2019 IPA Simulated vs. Observed Nitrate Concentrations

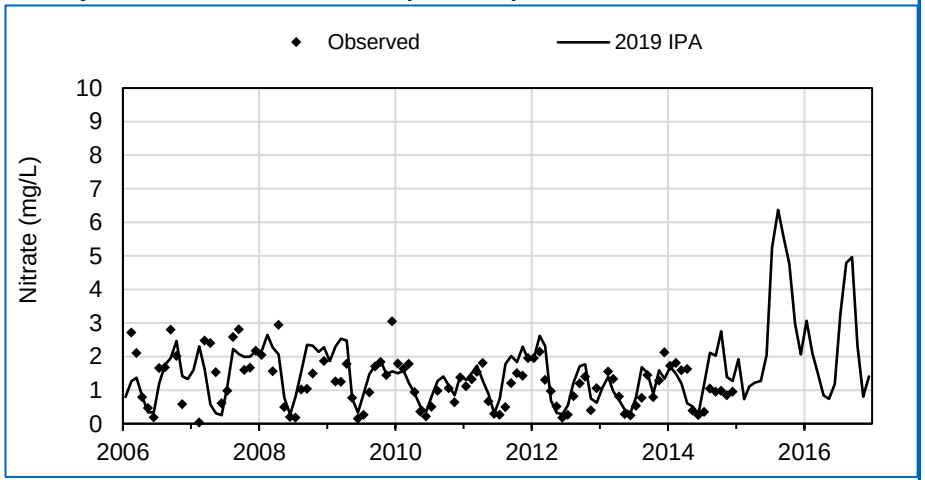


Weekly Simulated Concentrations (2019 IPA and 2017 RWQM)



Note: Observed data are individual sample results

Monthy Simulated Concentrations (2019 IPA)



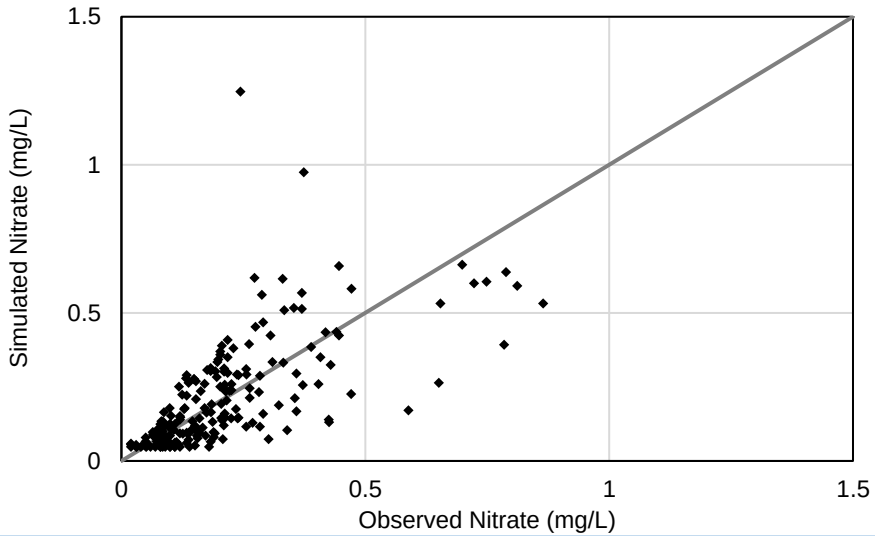
Note: Observed data are monthly averages of sample results

A1-33: Nitrate Calibration Information for Node GH_ER1 - Elk River u/s of Boivin Creek and u/s of Fording River (EMS E206661)

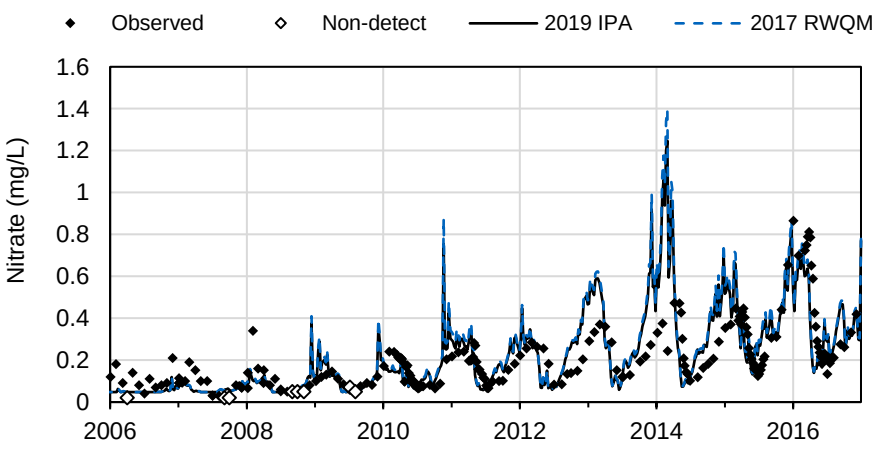
Observed and Simulated Nitrate Data and Calibration Statistics

Statistic	2017 RWQM	2019 IPA	
Model Averaging Period	Weekly	Weekly	Monthly
Calibration Period	2006 to 2016		
First Observed Sample	1/4/2006		
Last Observed Sample	12/7/2016		
Data Points Available for Comparison, n	204	204	130
Non-Detect Count	8	8	0
Observed Mean (mg/L)	0.21	0.21	0.19
Simulated Mean (mg/L)	0.22	0.21	0.23
Bias (mg/L)	0.016	0.0026	0.031
Relative Bias	1.1	1.0	1.2
Error (mg/L)	0.092	0.087	0.096
Percent Error	44%	42%	49%

2019 IPA Simulated vs. Observed Nitrate Concentrations

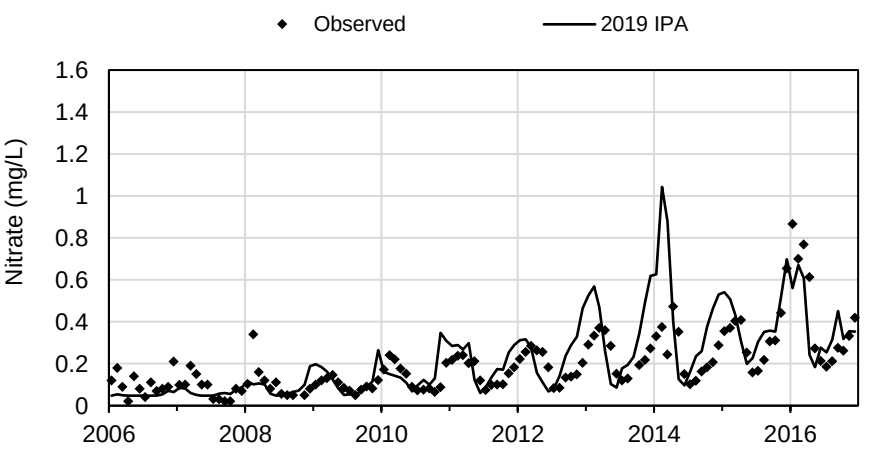


Weekly Simulated Concentrations (2019 IPA and 2017 RWQM)



Note: Observed data are individual sample results

Monthy Simulated Concentrations (2019 IPA)



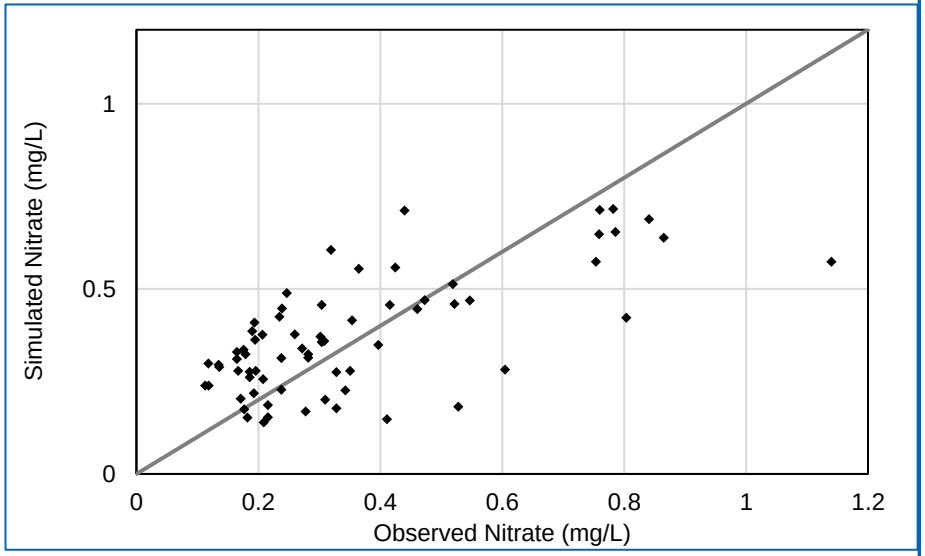
Note: Observed data are monthly averages of sample results

A1-34: Nitrate Calibration Information for Node GH_ERC - GHO Elk River Compliance Point (EMS E300090)

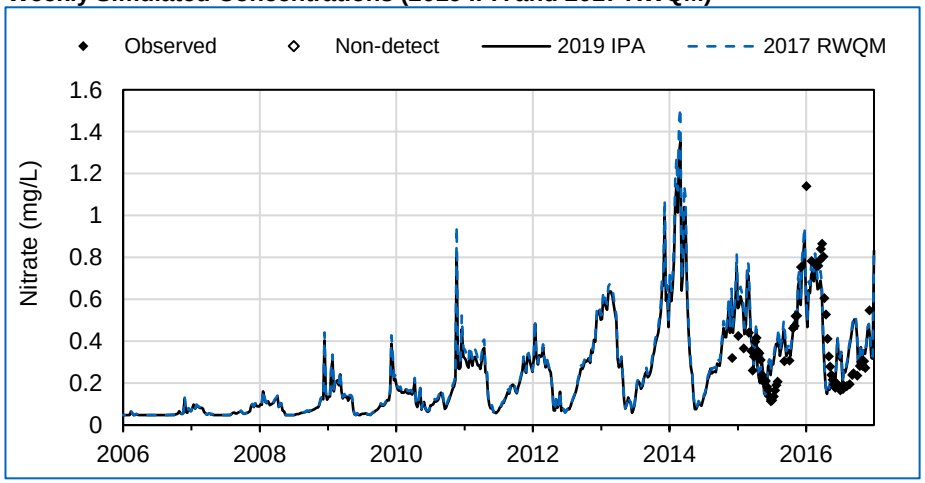
Observed and Simulated Nitrate Data and Calibration Statistics

Statistic	2017 RWQM	2019 IPA	
Model Averaging Period	Weekly	Weekly	Monthly
Calibration Period	2006 to 2016		
First Observed Sample	12/4/2014		
Last Observed Sample	12/7/2016		
Data Points Available for Comparison, n	68	68	25
Non-Detect Count	0	0	0
Observed Mean (mg/L)	0.35	0.35	0.4
Simulated Mean (mg/L)	0.39	0.37	0.43
Bias (mg/L)	0.036	0.015	0.027
Relative Bias	1.1	1.0	1.1
Error (mg/L)	0.13	0.13	0.14
Percent Error	37%	36%	34%

2019 IPA Simulated vs. Observed Nitrate Concentrations

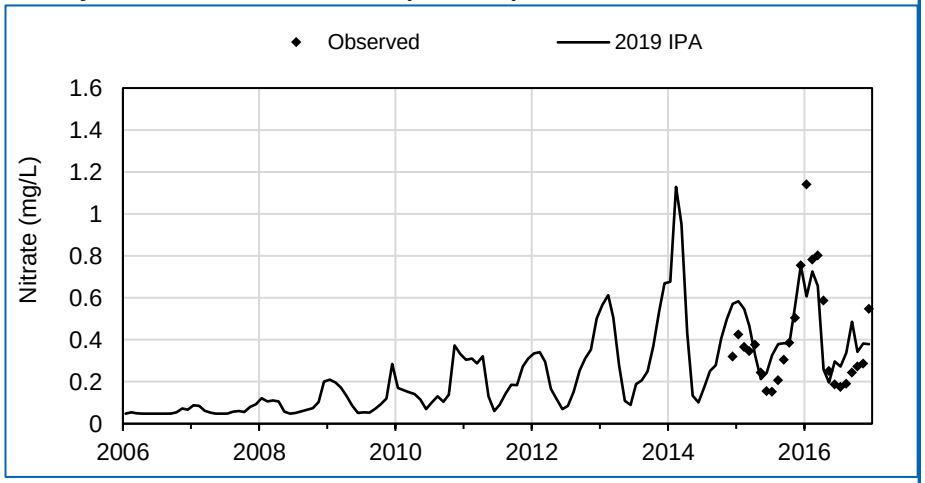


Weekly Simulated Concentrations (2019 IPA and 2017 RWQM)



Note: Observed data are individual sample results

Monthy Simulated Concentrations (2019 IPA)



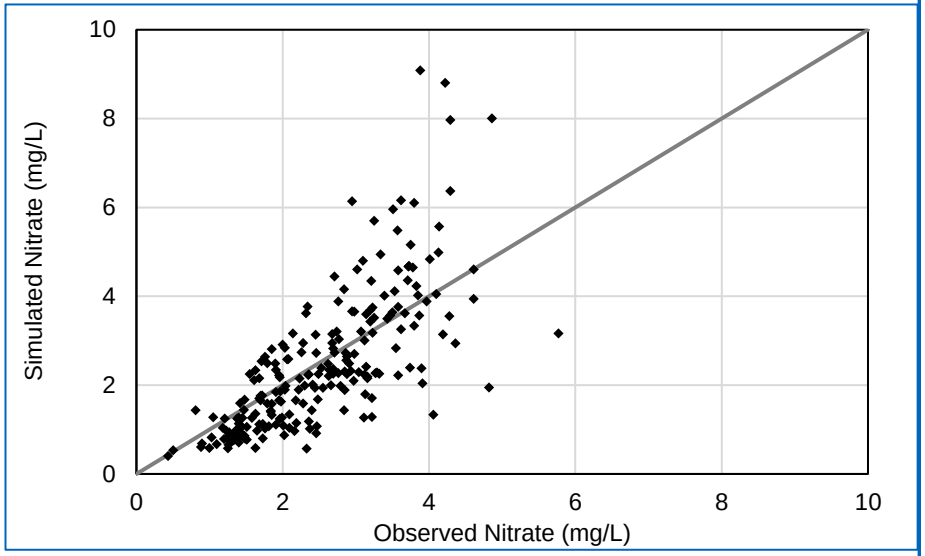
Note: Observed data are monthly averages of sample results

A1-35: Nitrate Calibration Information for Node EV_ER4 - Elk River u/s of Grave Creek (EMS 0200027)

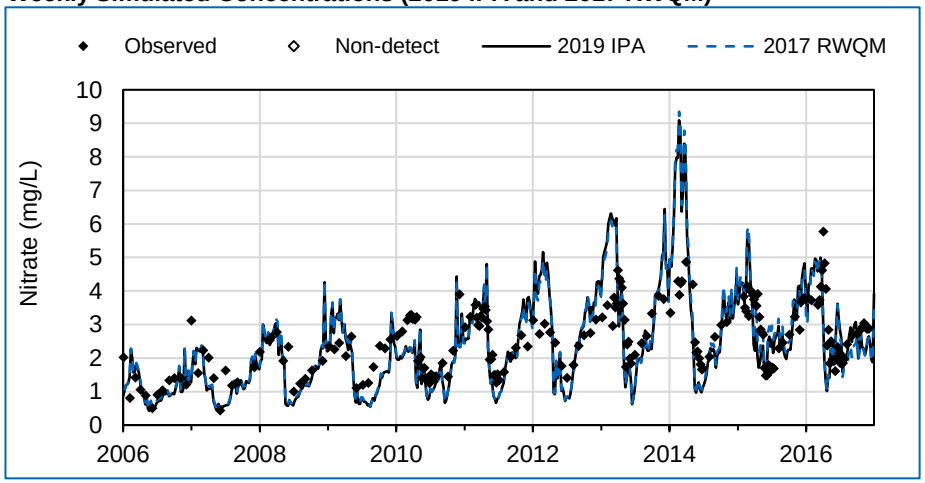
Observed and Simulated Nitrate Data and Calibration Statistics

Statistic	2017 RWQM	2019 IPA	
Model Averaging Period	Weekly	Weekly	Monthly
Calibration Period	2006 to 2016		
First Observed Sample	1/3/2006		
Last Observed Sample	12/6/2016		
Data Points Available for Comparison, n	217	217	127
Non-Detect Count	0	0	0
Observed Mean (mg/L)	2.5	2.5	2.4
Simulated Mean (mg/L)	2.5	2.5	2.4
Bias (mg/L)	-0.003	-0.048	0.048
Relative Bias	1.0	0.98	1.0
Error (mg/L)	0.75	0.76	0.65
Percent Error	30%	30%	27%

2019 IPA Simulated vs. Observed Nitrate Concentrations

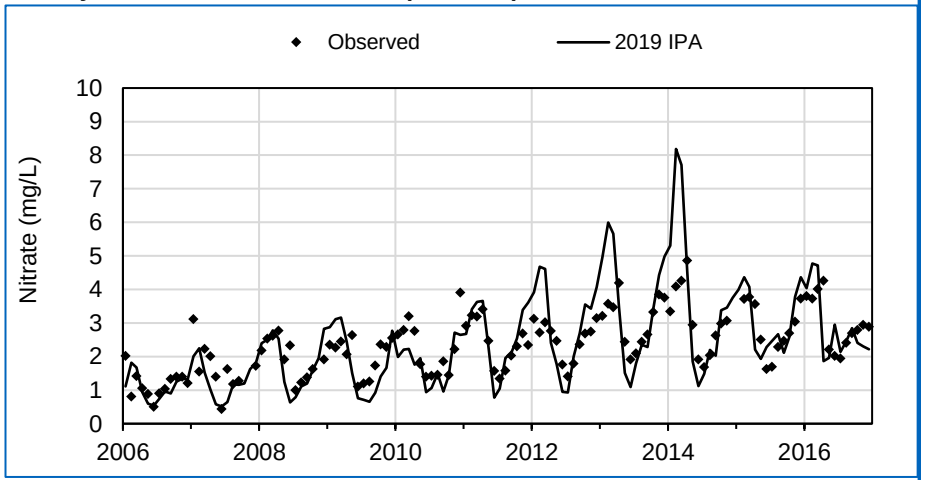


Weekly Simulated Concentrations (2019 IPA and 2017 RWQM)



Note: Observed data are individual sample results

Monthy Simulated Concentrations (2019 IPA)



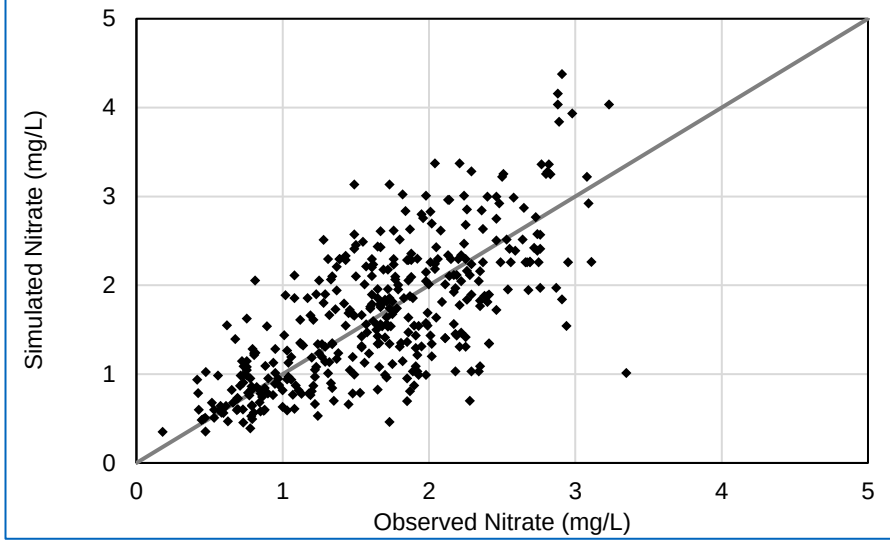
Note: Observed data are monthly averages of sample results

A1-36: Nitrate Calibration Information for Node EV_ER1 - Elk River downstream of Michel Creek (EMS 0200393)

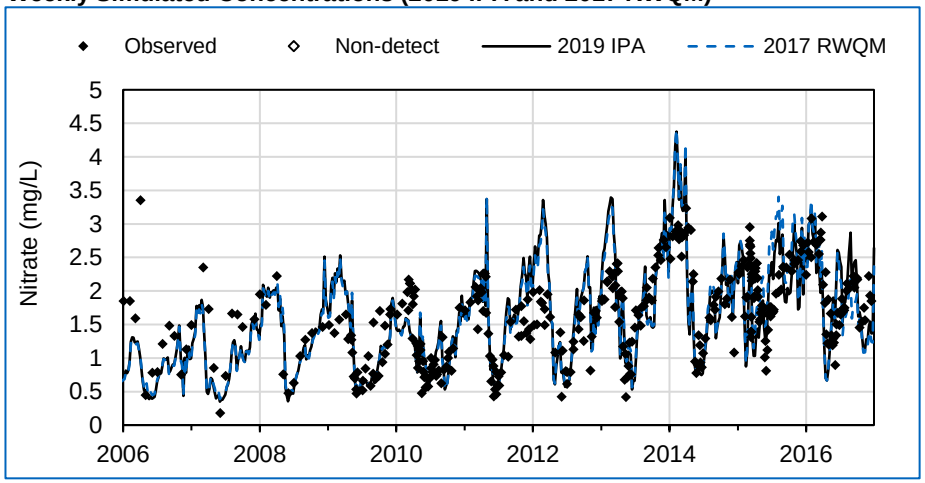
Observed and Simulated Nitrate Data and Calibration Statistics

Statistic	2017 RWQM	2019 IPA	
Model Averaging Period	Weekly	Weekly	Monthly
Calibration Period	2006 to 2016		
First Observed Sample	1/3/2006		
Last Observed Sample	12/18/2016		
Data Points Available for Comparison, n	387	387	128
Non-Detect Count	0	0	0
Observed Mean (mg/L)	1.6	1.6	1.6
Simulated Mean (mg/L)	1.7	1.7	1.6
Bias (mg/L)	0.051	0.017	0.0034
Relative Bias	1.0	1.0	1.0
Error (mg/L)	0.44	0.43	0.37
Percent Error	27%	26%	24%

2019 IPA Simulated vs. Observed Nitrate Concentrations

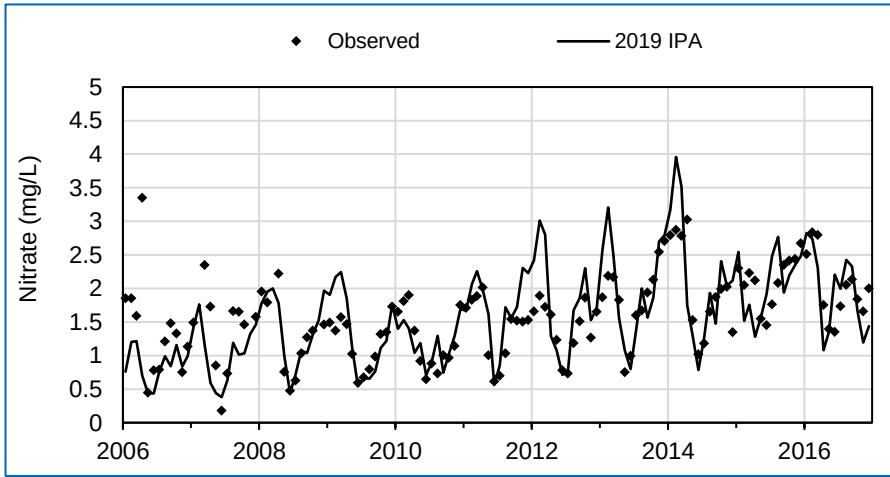


Weekly Simulated Concentrations (2019 IPA and 2017 RWQM)



Note: Observed data are individual sample results

Monthy Simulated Concentrations (2019 IPA)



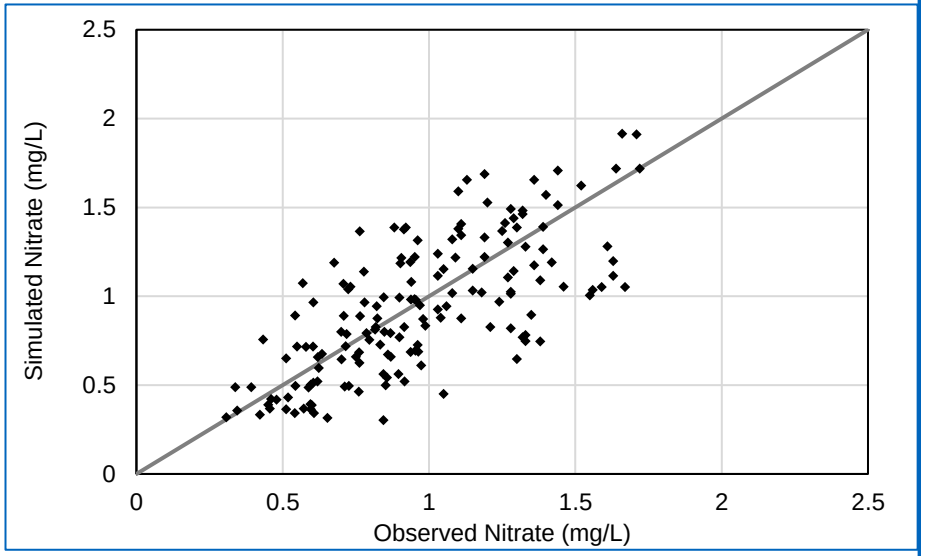
Note: Observed data are monthly averages of sample results

A1-37: Nitrate Calibration Information for Node RG_ELKMOUTH - Elk River at Highway 93 near Elko

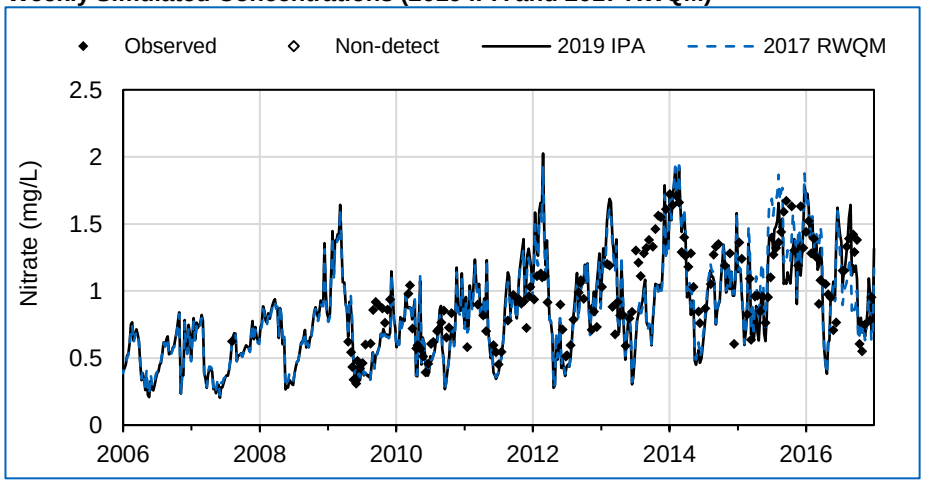
Observed and Simulated Nitrate Data and Calibration Statistics

Statistic	2017 RWQM	2019 IPA	
Model Averaging Period	Weekly	Weekly	Monthly
Calibration Period	2006 to 2016		
First Observed Sample	8/6/2007		
Last Observed Sample	12/18/2016		
Data Points Available for Comparison, n	161	161	85
Non-Detect Count	0	0	0
Observed Mean (mg/L)	0.97	0.97	0.97
Simulated Mean (mg/L)	0.95	0.94	0.95
Bias (mg/L)	-0.022	-0.031	-0.024
Relative Bias	0.98	0.97	0.98
Error (mg/L)	0.23	0.22	0.2
Percent Error	24%	23%	21%

2019 IPA Simulated vs. Observed Nitrate Concentrations

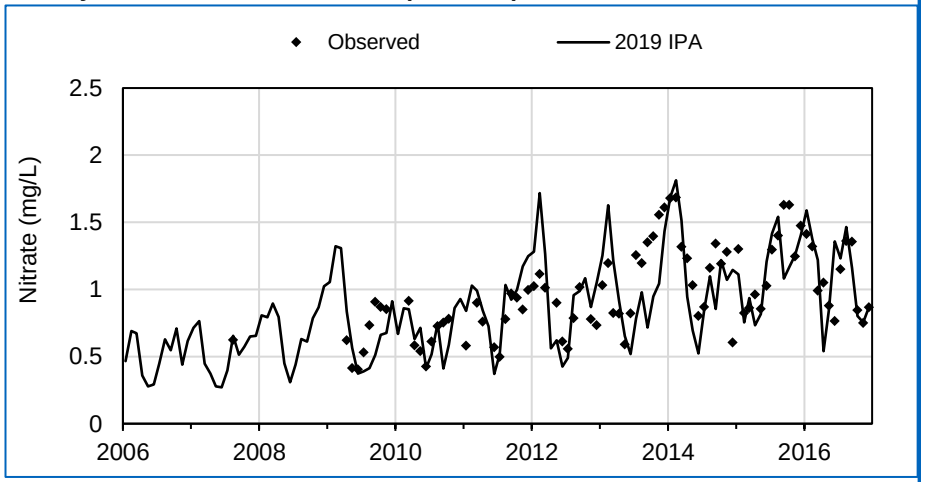


Weekly Simulated Concentrations (2019 IPA and 2017 RWQM)



Note: Observed data are individual sample results

Monthy Simulated Concentrations (2019 IPA)



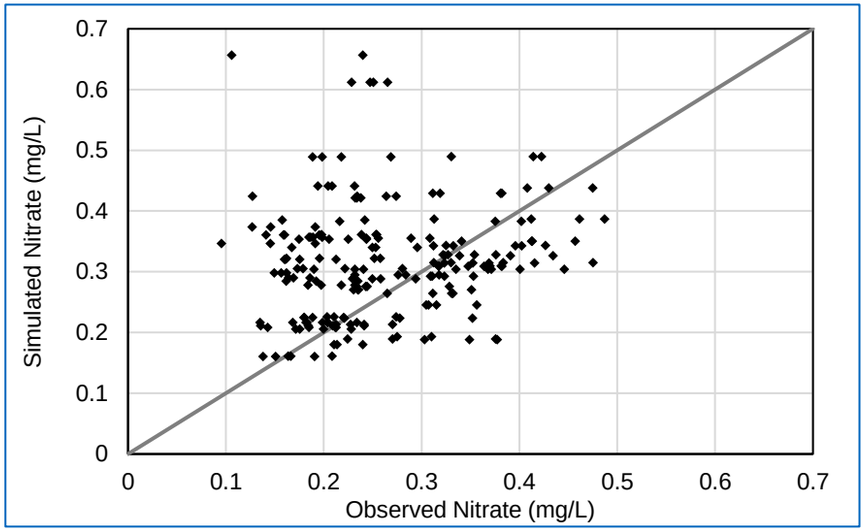
Note: Observed data are monthly averages of sample results

A1-38: Nitrate Calibration Information for Node RG_DSELK - Koocanusa Reservoir (EMS E300230)

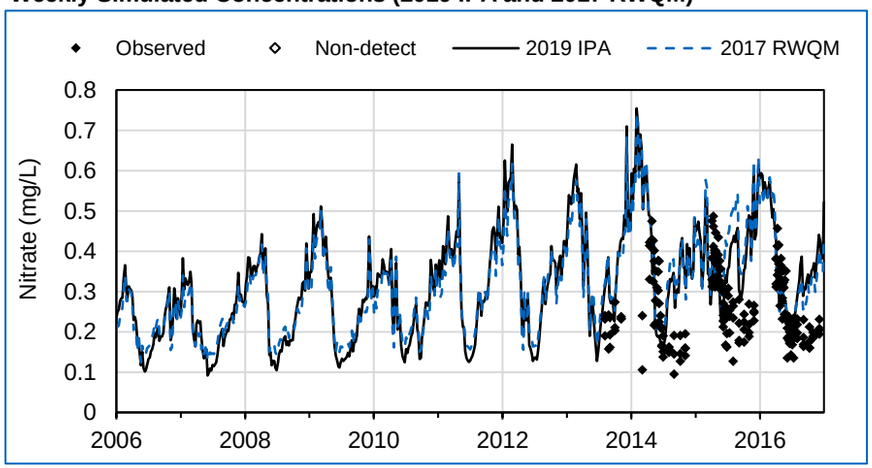
Observed and Simulated Nitrate Data and Calibration Statistics

Statistic	2017 RWQM	2019 IPA	
Model Averaging Period	Weekly	Weekly	Monthly
Calibration Period	2006 to 2016		
First Observed Sample	08/07/2013		
Last Observed Sample	12/06/2016		
Data Points Available for Comparison, n	60	217	31
Non-Detect Count	0	0	0
Observed Mean (mg/L)	0.26	0.26	0.23
Simulated Mean (mg/L)	0.34	0.32	0.35
Bias (mg/L)	0.08	0.052	0.12
Relative Bias	1.3	1.2	1.5
Error (mg/L)	0.12	0.094	0.13
Percent Error	46%	35%	58%

2019 IPA Simulated vs. Observed Nitrate Concentrations

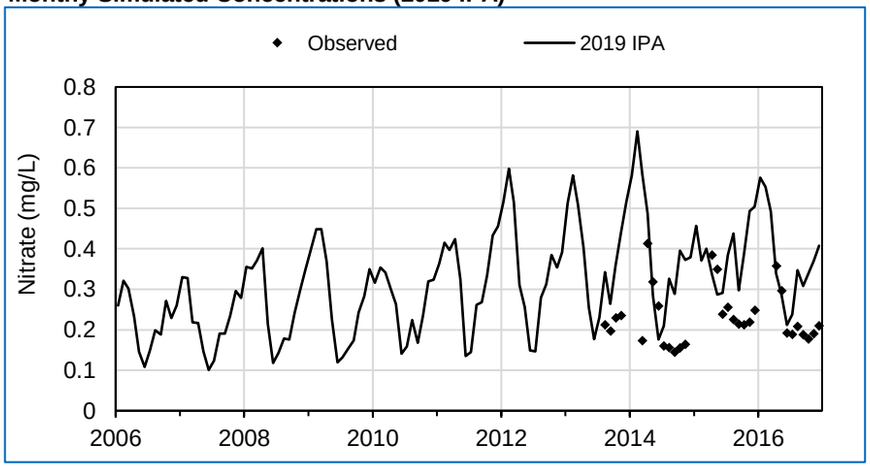


Weekly Simulated Concentrations (2019 IPA and 2017 RWQM)



Note: Observed data are individual sample results

Monthy Simulated Concentrations (2019 IPA)



Note: Observed data are monthly averages of sample results

Note: In the 2017 RWQM Update, projected concentrations in Koocanusa Reservoir were compared to monitored data at RG_DSELK. In the 2019 IPA, the comparison of simulated to monitored data was expanded to include data at the four statiions located downstream of the Elk River: RG_DSELK, RG_GRASMERE, RG_USGOLD and RG_BORDER. Projected concentrations of nitrate in Koocanusa Reservoir were not corrected for model bias.

Figure A-2 Simulated and Observed Nitrate_N Concentrations in the Elk Valley, 2006 to 2016

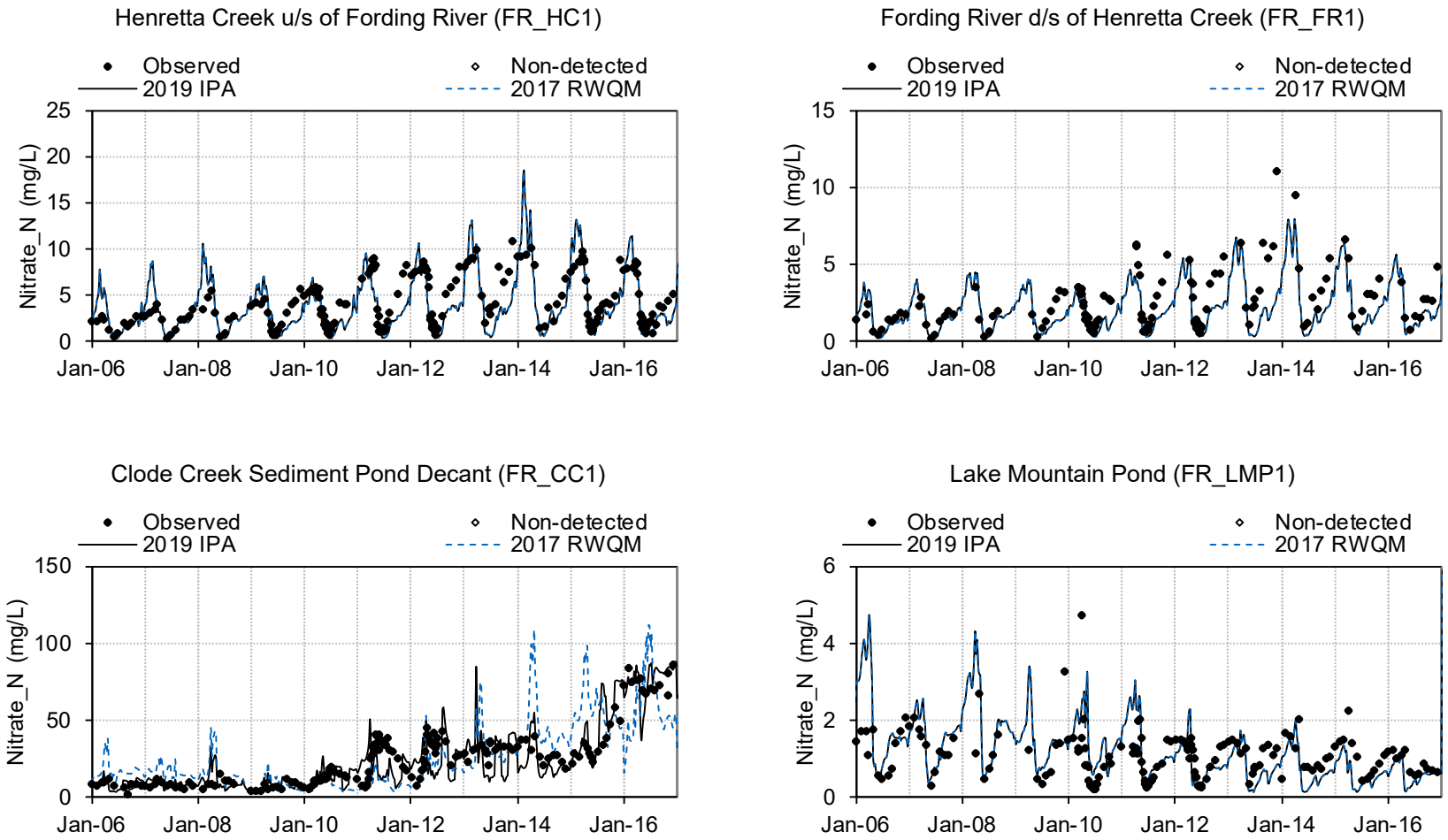


Figure A-2 Simulated and Observed Nitrate_N Concentrations in the Elk Valley, 2006 to 2016

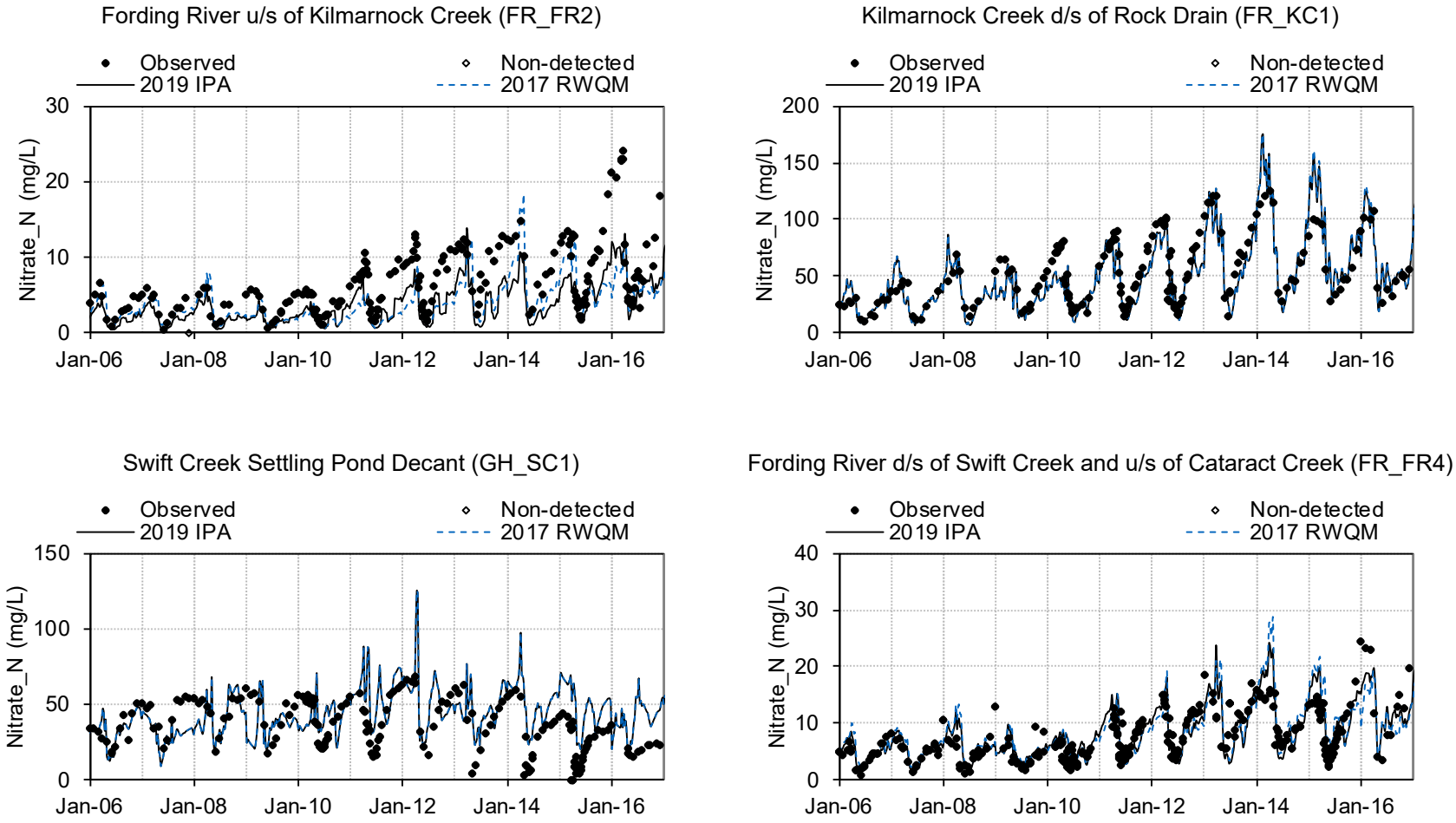


Figure A-2 Simulated and Observed Nitrate_N Concentrations in the Elk Valley, 2006 to 2016

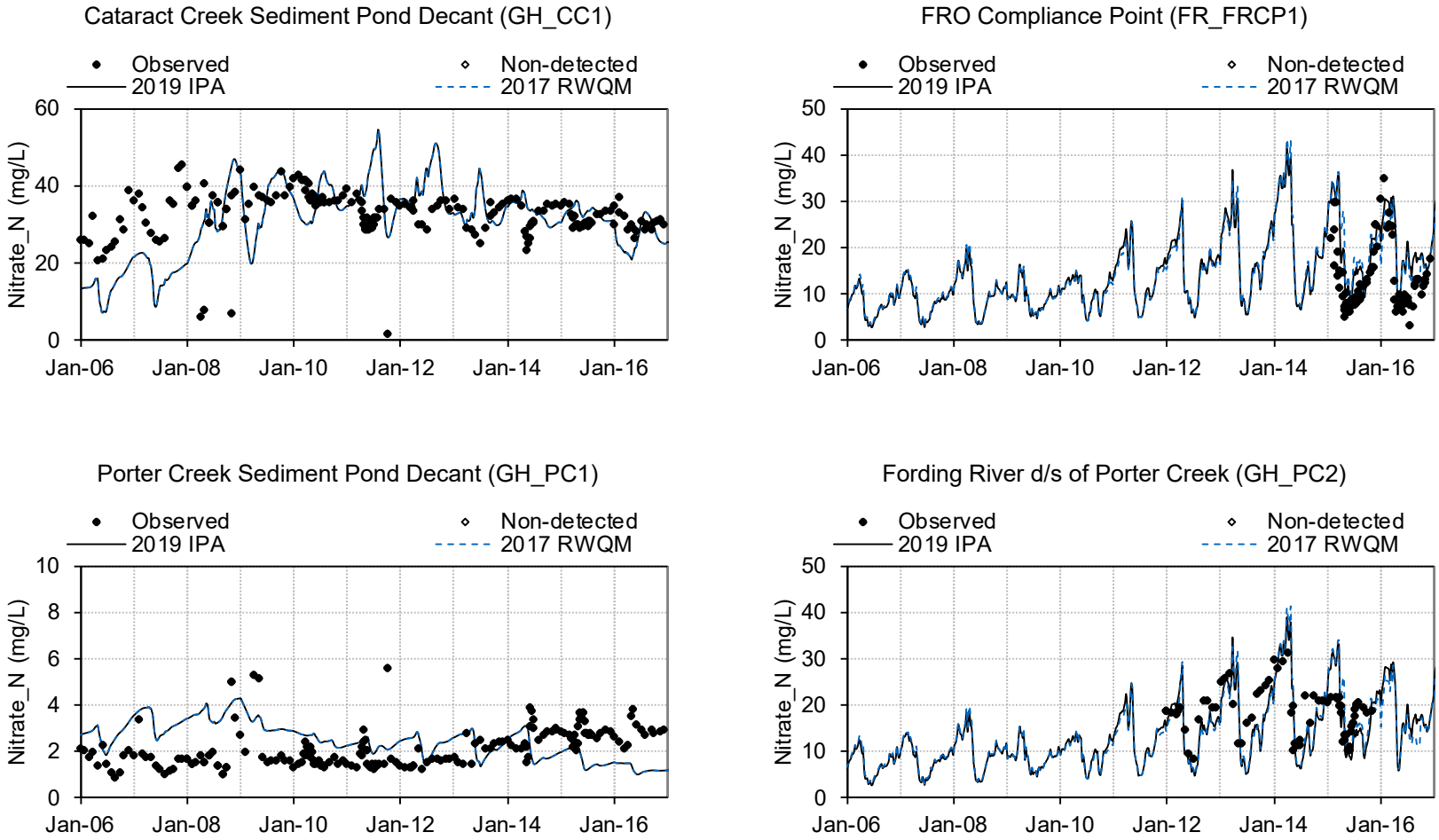


Figure A-2 Simulated and Observed Nitrate_N Concentrations in the Elk Valley, 2006 to 2016

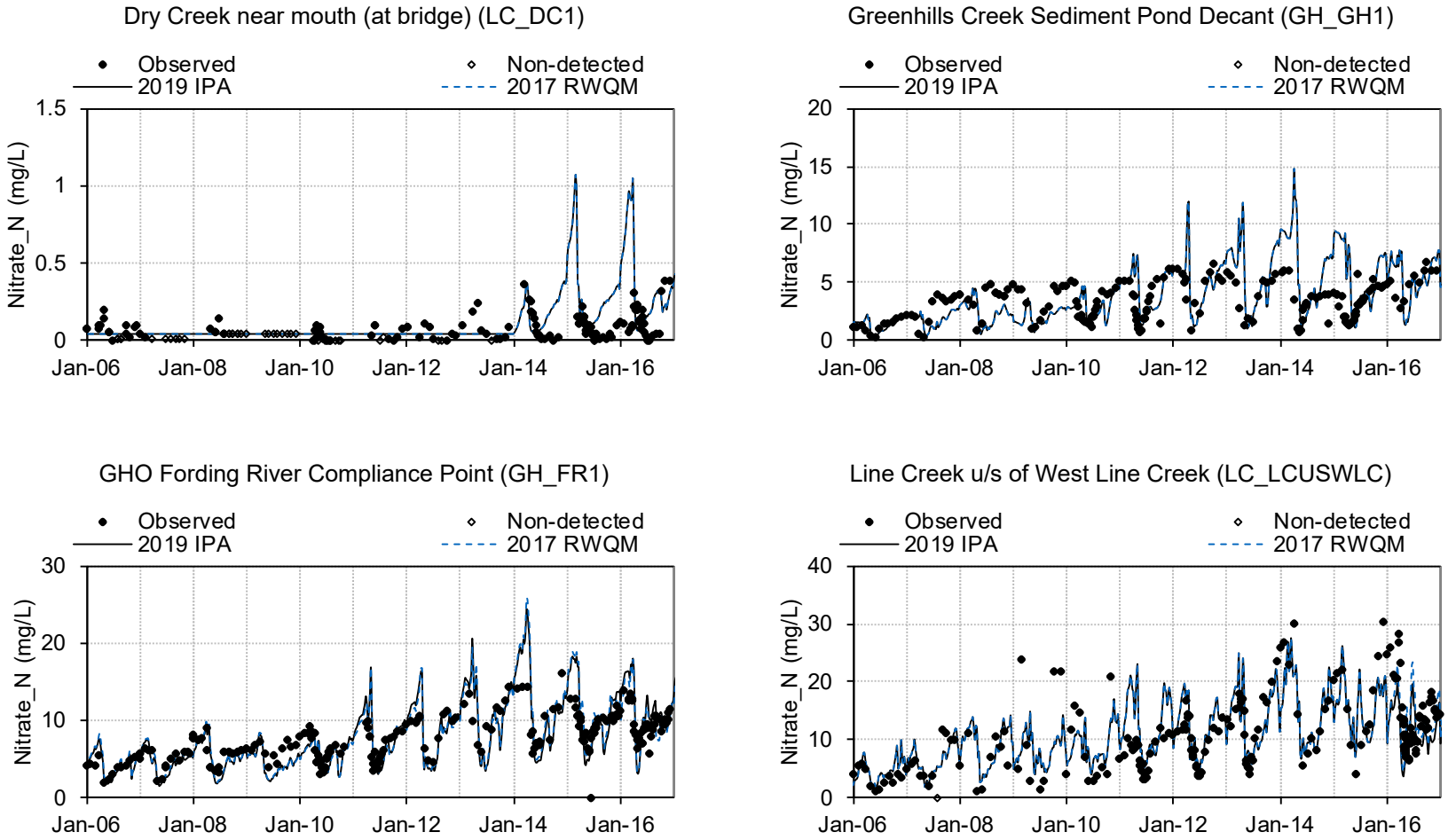


Figure A-2 Simulated and Observed Nitrate_N Concentrations in the Elk Valley, 2006 to 2016

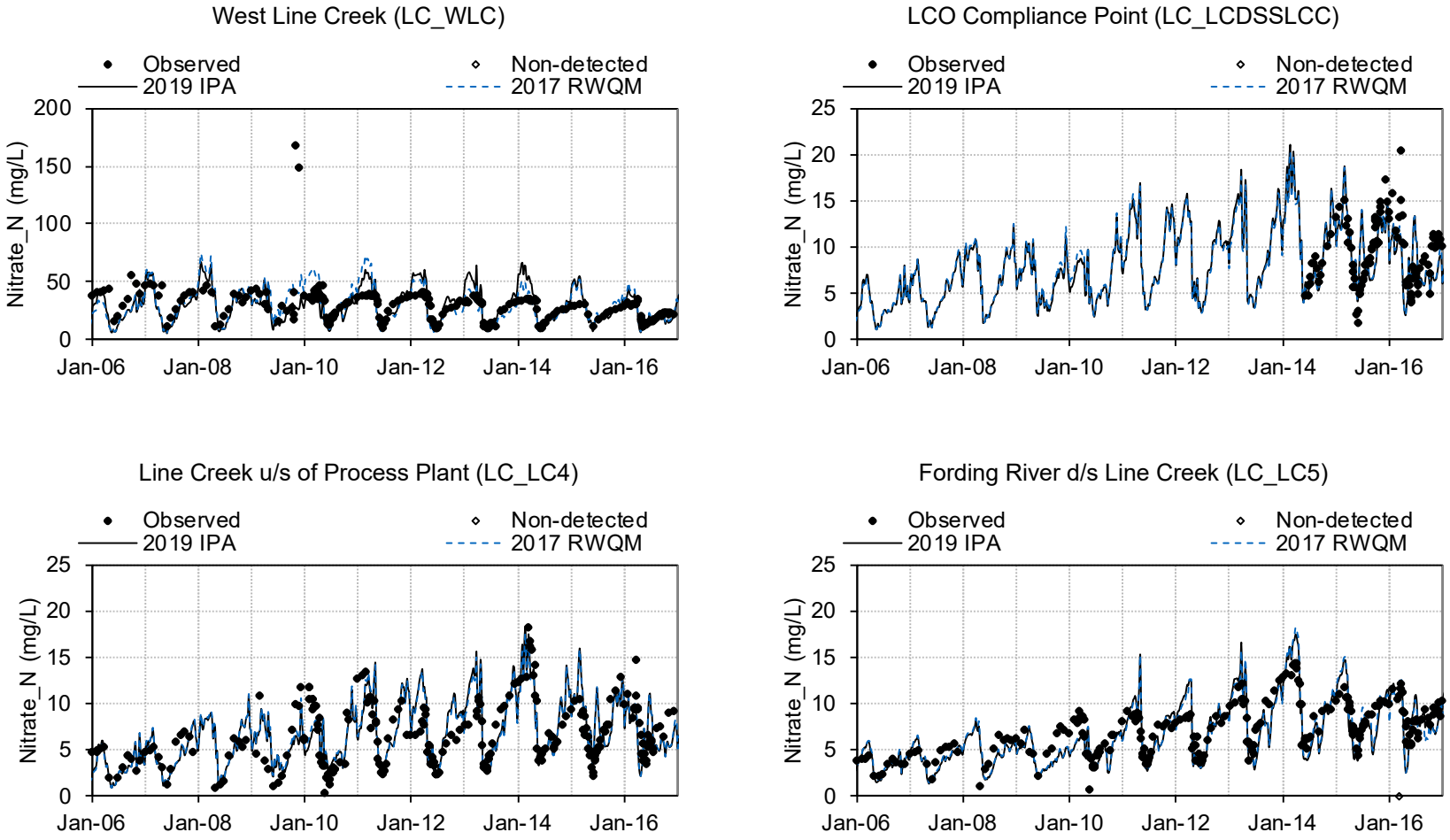


Figure A-2 Simulated and Observed Nitrate_N Concentrations in the Elk Valley, 2006 to 2016

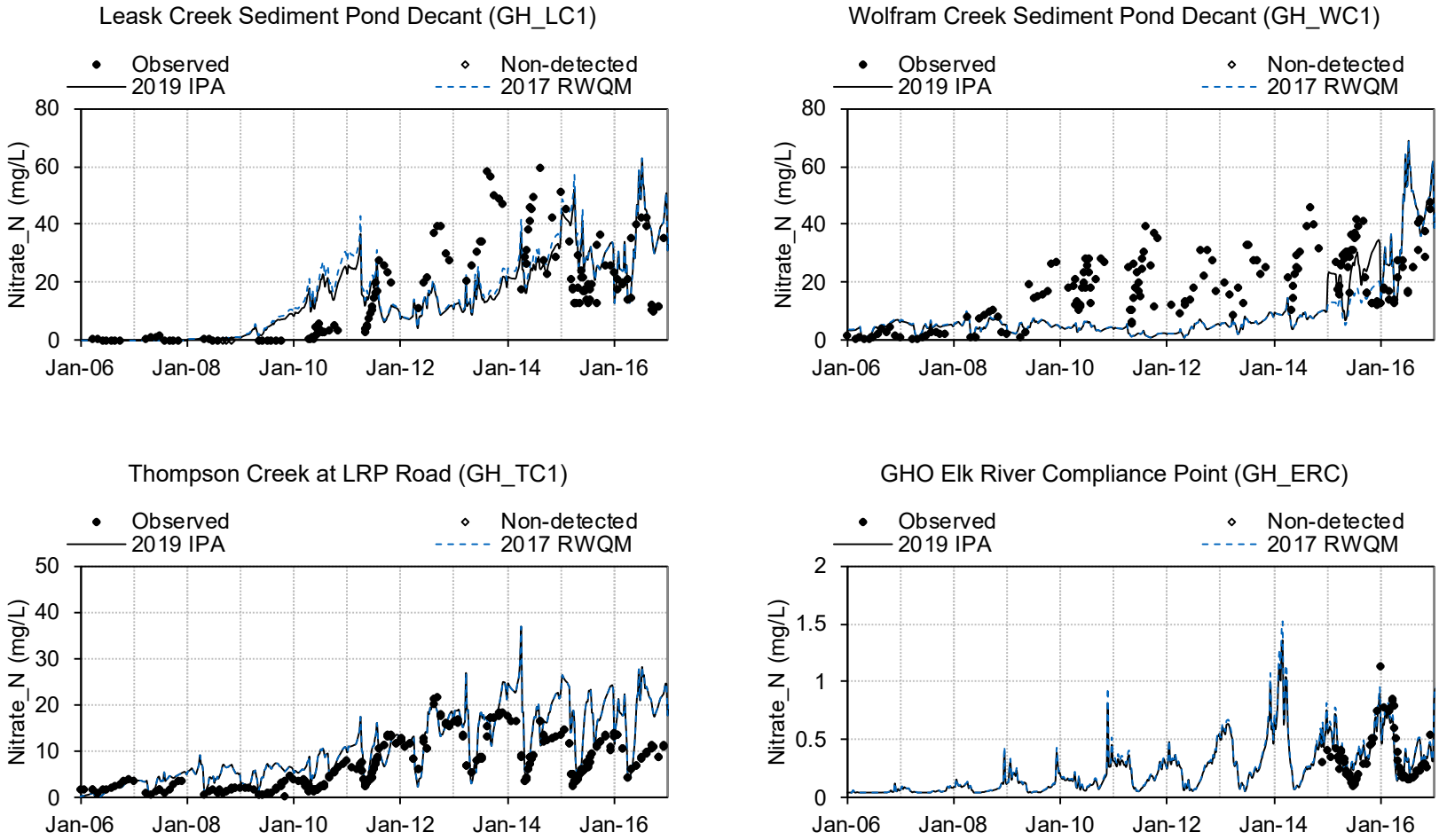


Figure A-2 Simulated and Observed Nitrate_N Concentrations in the Elk Valley, 2006 to 2016

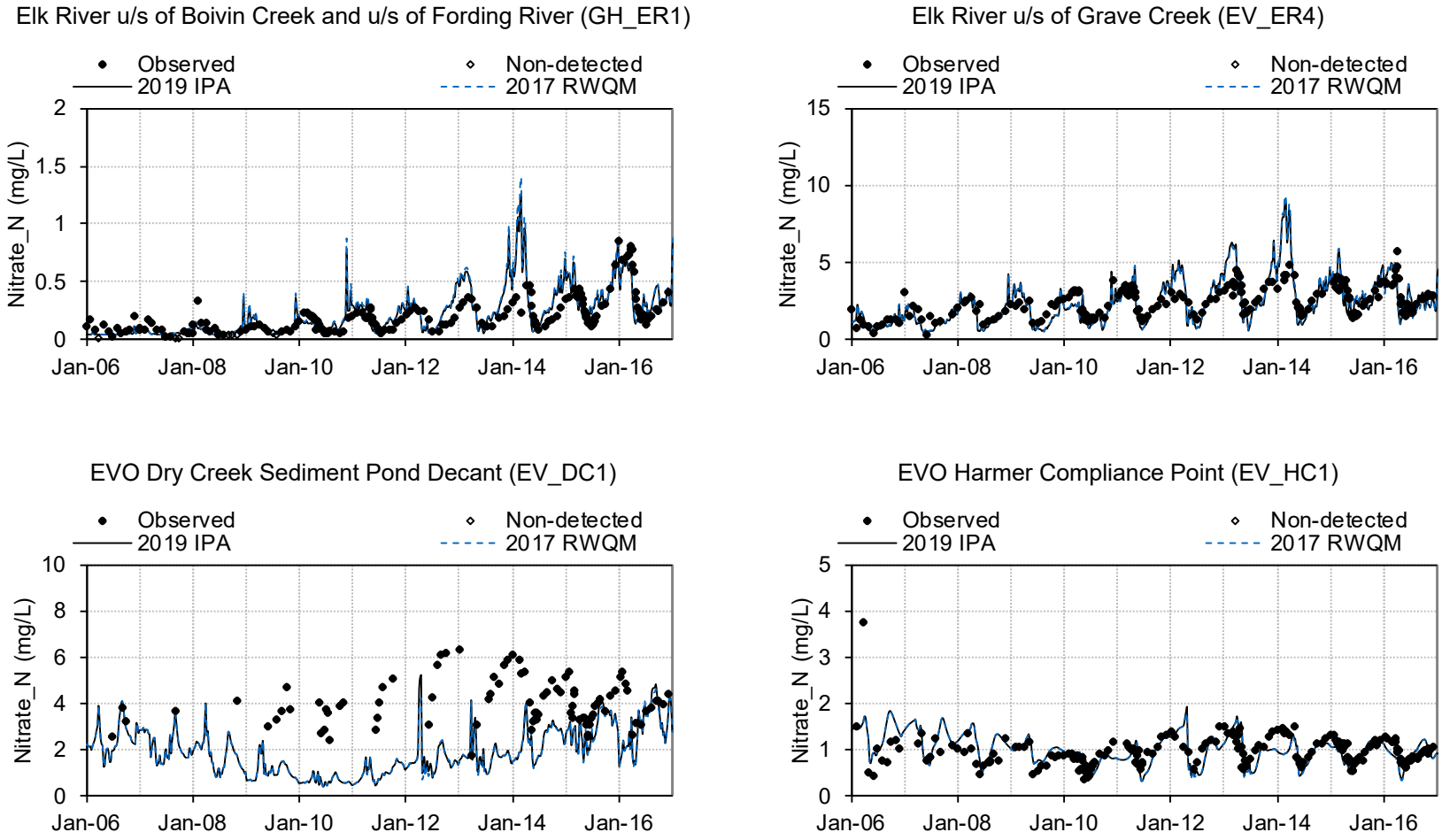


Figure A-2 Simulated and Observed Nitrate_N Concentrations in the Elk Valley, 2006 to 2016

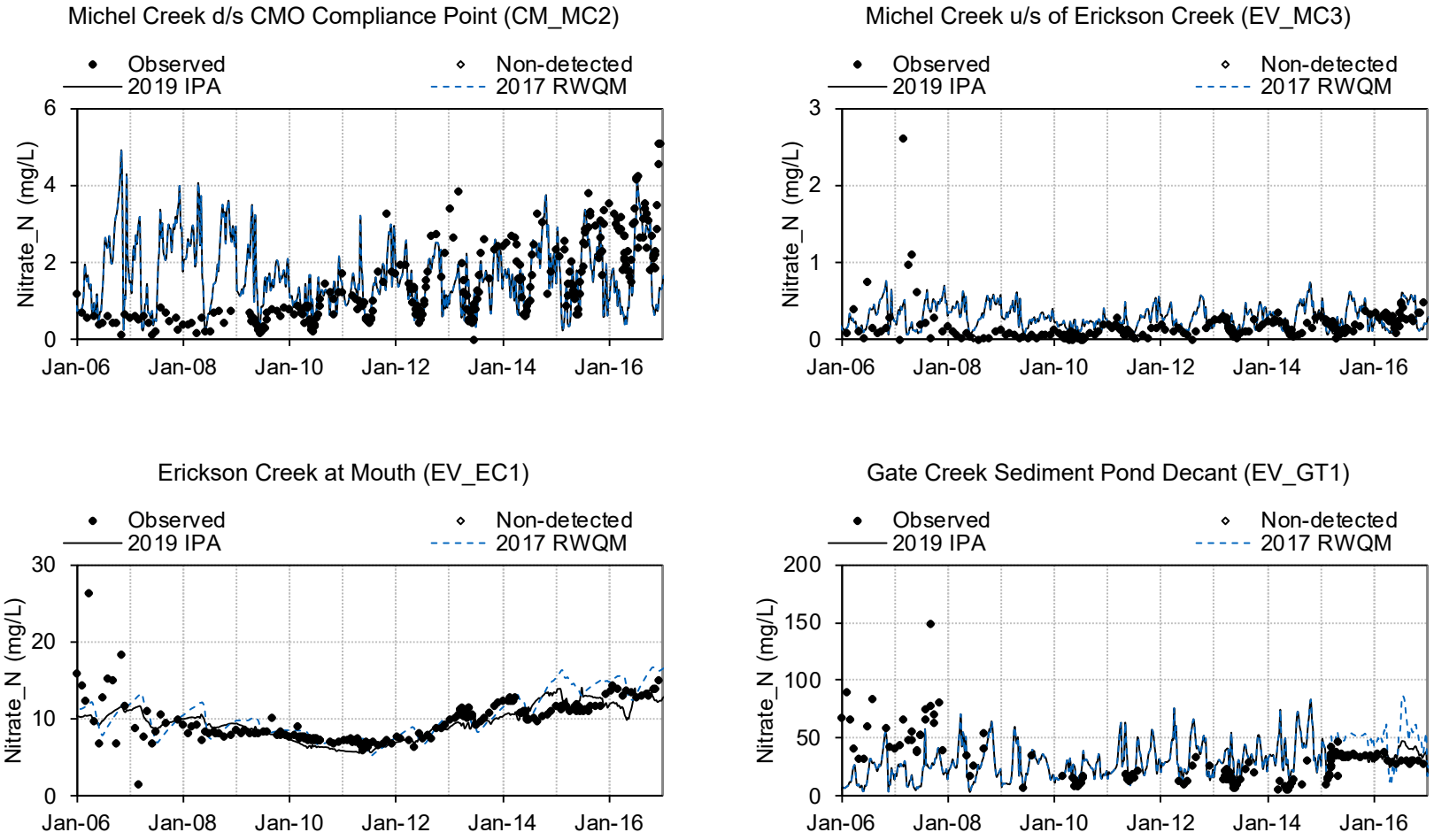


Figure A-2 Simulated and Observed Nitrate_N Concentrations in the Elk Valley, 2006 to 2016

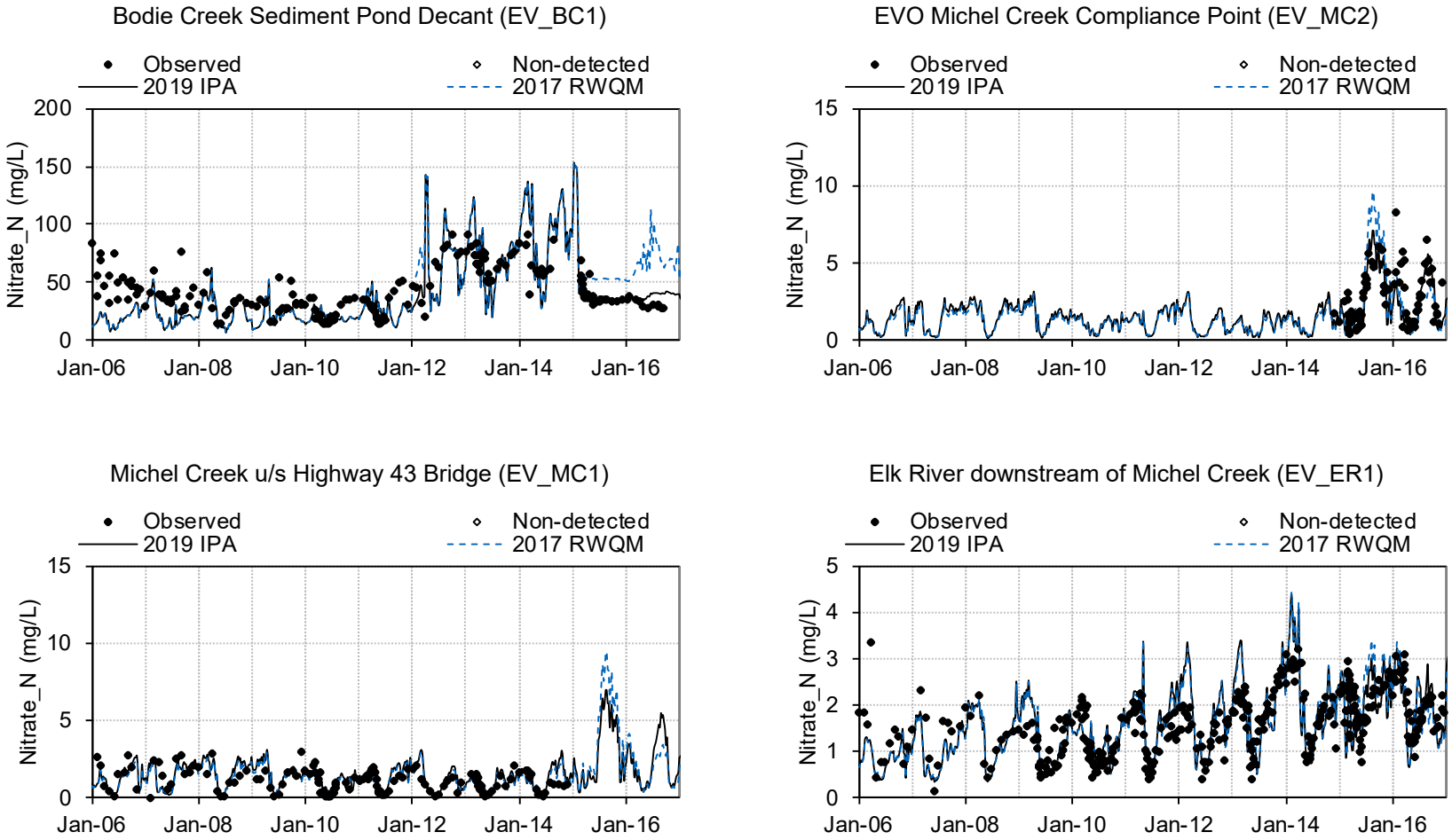
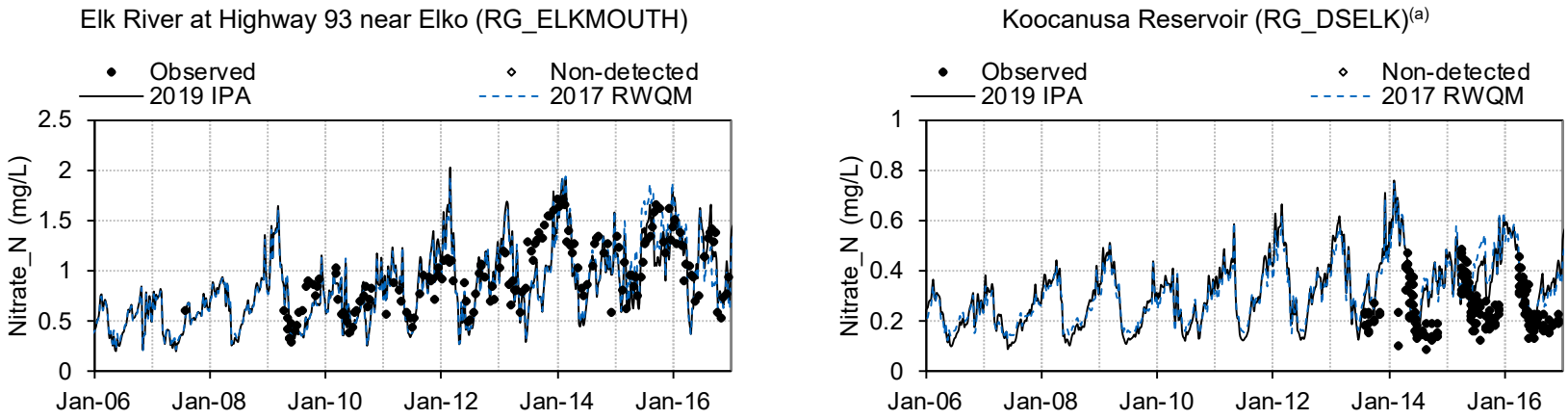


Figure A-2 Simulated and Observed Nitrate_N Concentrations in the Elk Valley, 2006 to 2016



(a) In the 2017 RWQM Update, projected concentrations in Koocanusa Reservoir were compared to monitored data at RG_DSELK. In the 2019 IPA, the comparison of simulated to monitored data was expanded to include data at the four stations located downstream of the Elk River: RG_DSELK, RG_GRASMERE, RG_USGOLD and RG_BORDER. Projected concentrations of nitrate in Koocanusa Reservoir were not corrected for model bias.

Appendix B - Model Calibration Results for Selenium

July 2019

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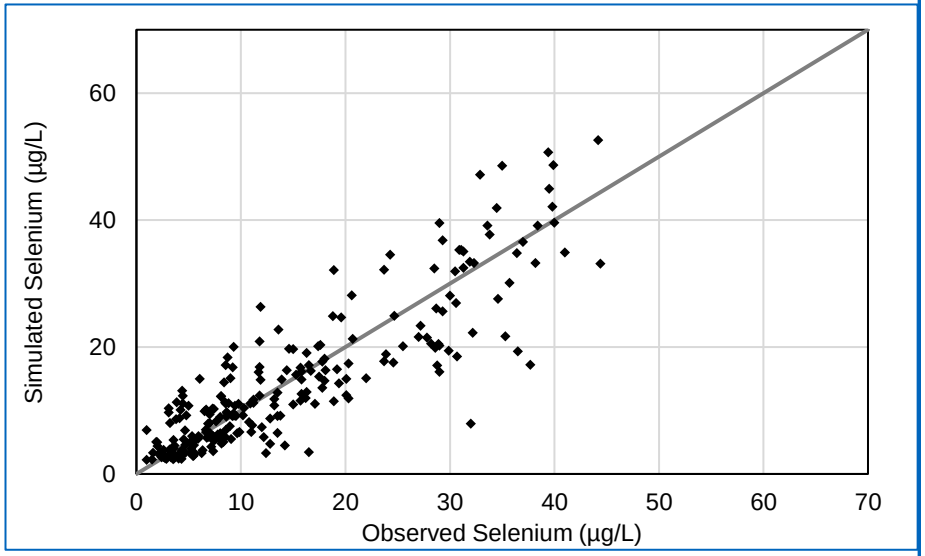
B1-1: Selenium Calibration Information for Node FR_HC1 - Henretta Creek u/s of Fording River (EMS E216778)

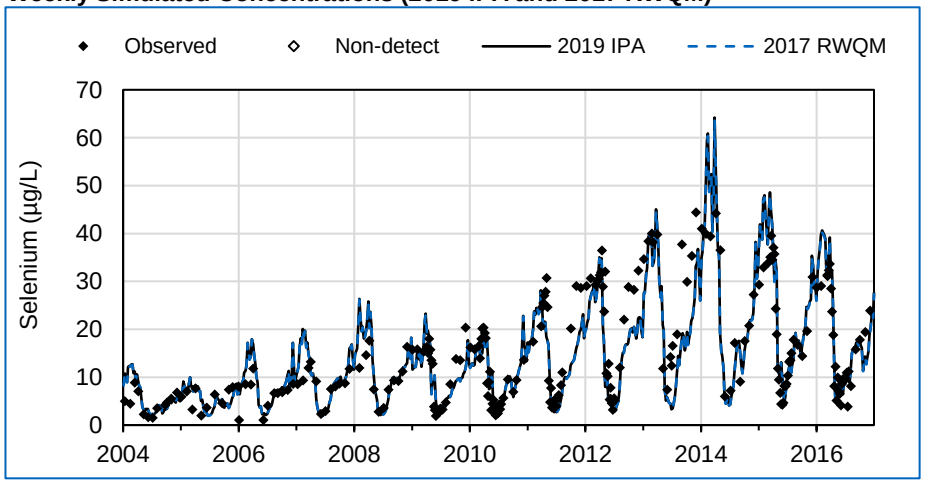
Observed and Simulated Selenium Data and Calibration Statistics

Statistic	2017 RWQM	2019 IPA	
Model Averaging Period	Weekly	Weekly	Monthly
Calibration Period	2004 to 2016		
First Observed Sample	1/12/2004		
Last Observed Sample	12/7/2016		
Data Points Available for Comparison, n	239	239	149
Non-Detect Count	0	0	0
Observed Mean (mg/L)	15	15	15
Simulated Mean (mg/L)	14	14	15
Bias (mg/L)	-0.35	-0.24	-0.2
Relative Bias	0.98	0.98	0.99
Error (mg/L)	4.0	4.0	3.6
Percent Error	27%	27%	24%

2019 IPA Simulated vs. Observed Selenium Concentrations

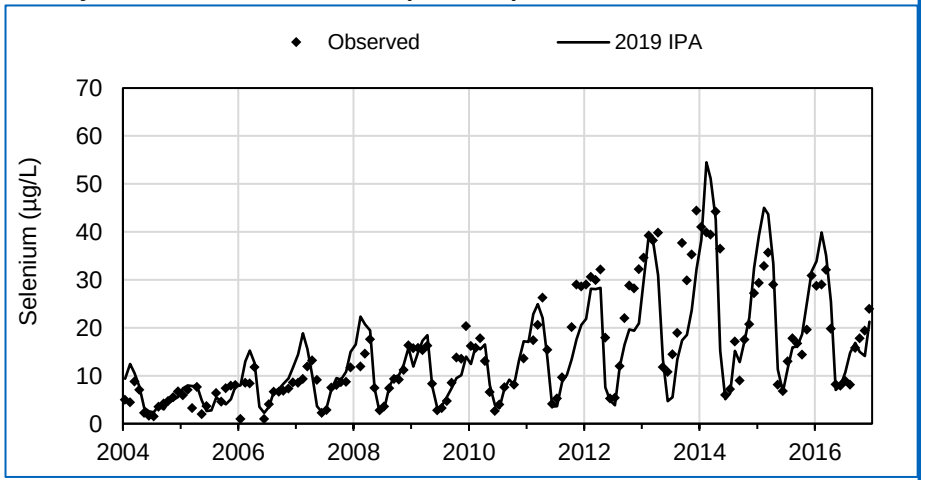


Weekly Simulated Concentrations (2019 IPA and 2017 RWQM)



Note: Observed data are individual sample results

Monthy Simulated Concentrations (2019 IPA)



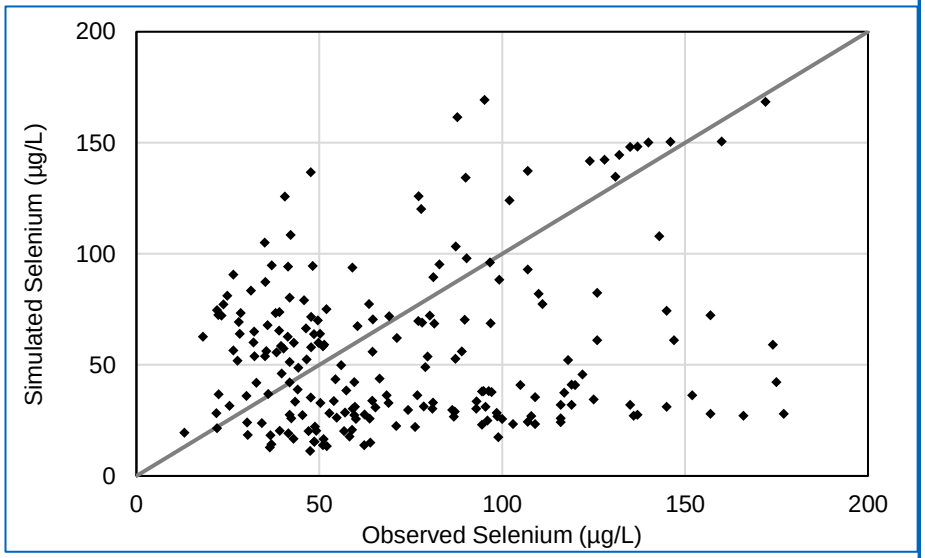
Note: Observed data are monthly averages of sample results

B1-2: Selenium Calibration Information for Node FR_CC1 - Clode Creek Sediment Pond Decant (EMS E102481)

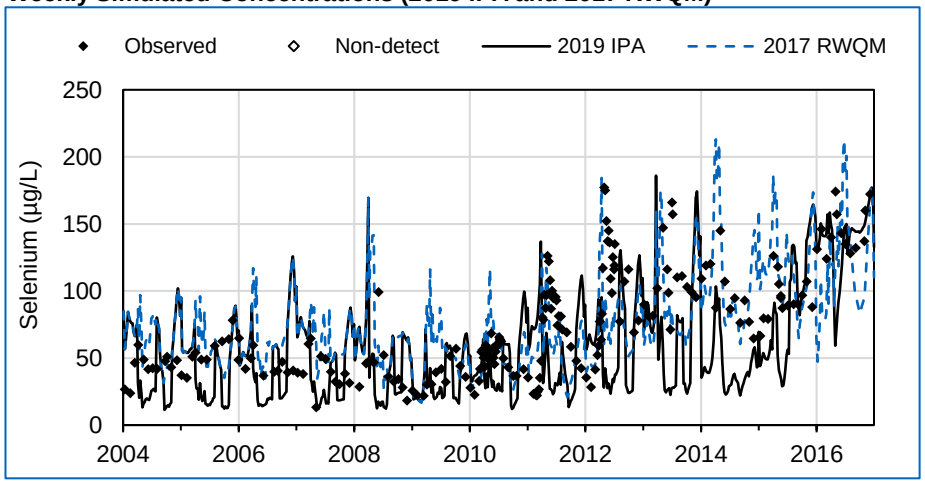
Observed and Simulated Selenium Data and Calibration Statistics

Statistic	2017 RWQM	2019 IPA	
Model Averaging Period	Weekly	Weekly	Monthly
Calibration Period	2004 to 2016		
First Observed Sample	1/12/2004		
Last Observed Sample	12/7/2016		
Data Points Available for Comparison, n	207	207	151
Non-Detect Count	0	0	0
Observed Mean (mg/L)	73	73	70
Simulated Mean (mg/L)	77	56	60
Bias (mg/L)	3.3	-17	-9.9
Relative Bias	1.0	0.77	0.86
Error (mg/L)	29	39	33
Percent Error	40%	54%	48%

2019 IPA Simulated vs. Observed Selenium Concentrations

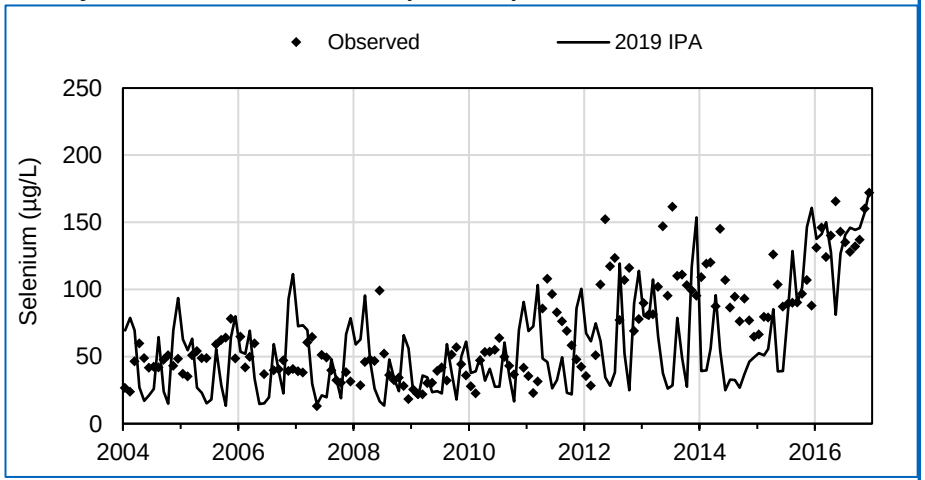


Weekly Simulated Concentrations (2019 IPA and 2017 RWQM)



Note: Observed data are individual sample results

Monthy Simulated Concentrations (2019 IPA)



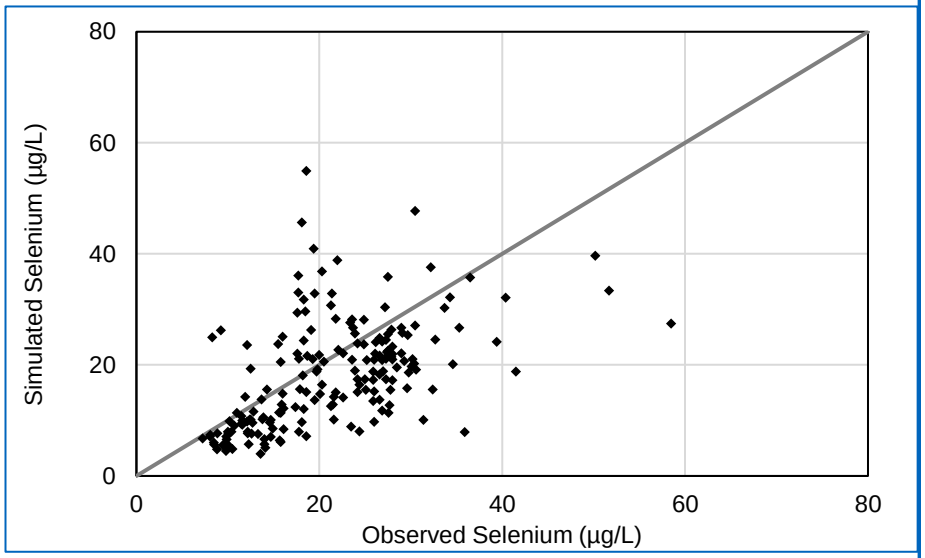
Note: Observed data are monthly averages of sample results

B1-3: Selenium Calibration Information for Node FR_LMP1 - Lake Mountain Pond

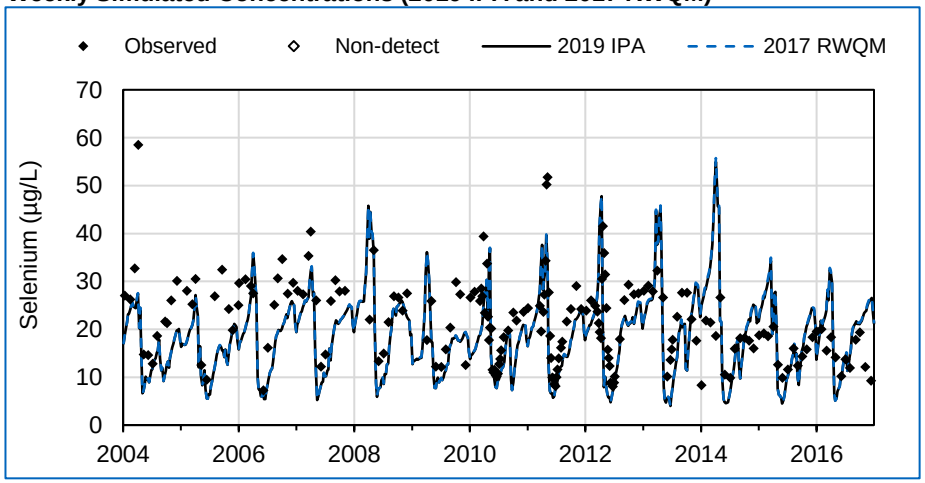
Observed and Simulated Selenium Data and Calibration Statistics

Statistic	2017 RWQM	2019 IPA	
Model Averaging Period	Weekly	Weekly	Monthly
Calibration Period	2004 to 2016		
First Observed Sample	1/12/2004		
Last Observed Sample	12/14/2016		
Data Points Available for Comparison, n	187	187	144
Non-Detect Count	0	0	0
Observed Mean (mg/L)	21	21	22
Simulated Mean (mg/L)	18	18	19
Bias (mg/L)	-2.9	-3.1	-2.8
Relative Bias	0.86	0.86	0.87
Error (mg/L)	7.2	7.2	6.7
Percent Error	34%	34%	31%

2019 IPA Simulated vs. Observed Selenium Concentrations

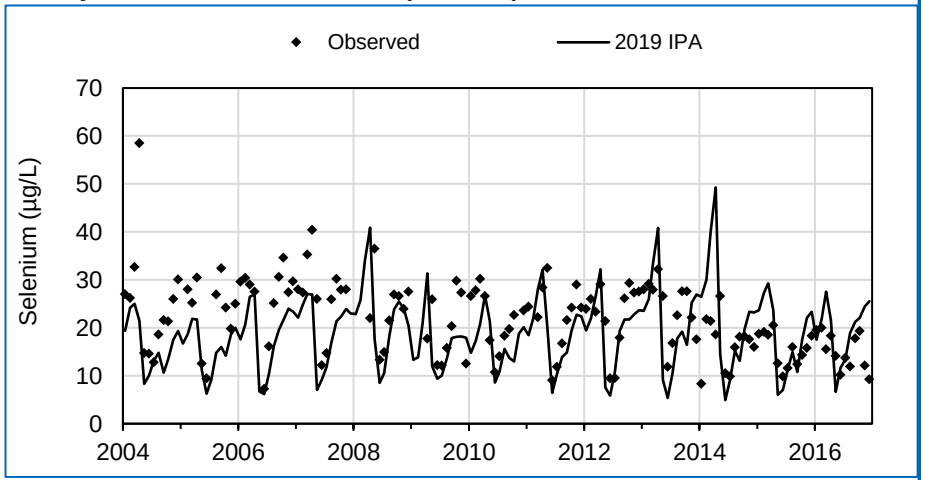


Weekly Simulated Concentrations (2019 IPA and 2017 RWQM)



Note: Observed data are individual sample results

Monthy Simulated Concentrations (2019 IPA)



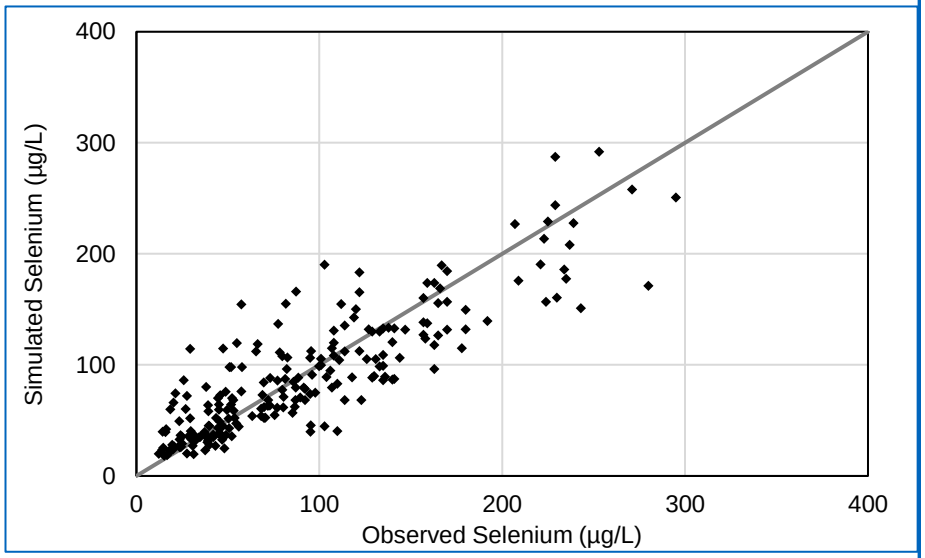
Note: Observed data are monthly averages of sample results

B1-4: Selenium Calibration Information for Node FR_KC1 - Kilmarnock Creek d/s of Rock Drain (EMS 0200252)

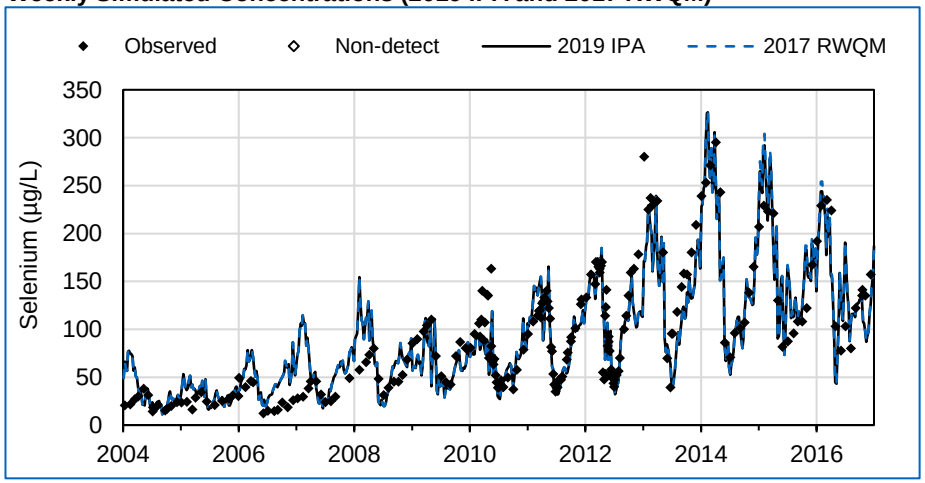
Observed and Simulated Selenium Data and Calibration Statistics

Statistic	2017 RWQM	2019 IPA	
Model Averaging Period	Weekly	Weekly	Monthly
Calibration Period	2004 to 2016		
First Observed Sample	1/12/2004		
Last Observed Sample	12/12/2016		
Data Points Available for Comparison, n	218	218	149
Non-Detect Count	0	0	0
Observed Mean (mg/L)	92	92	93
Simulated Mean (mg/L)	91	91	94
Bias (mg/L)	-1.1	-1.6	1.1
Relative Bias	0.99	0.98	1.0
Error (mg/L)	23	23	22
Percent Error	25%	25%	24%

2019 IPA Simulated vs. Observed Selenium Concentrations

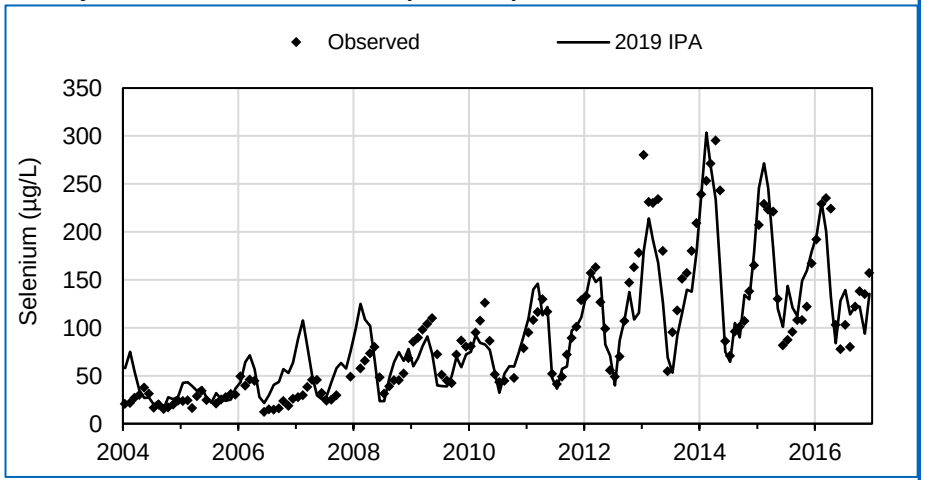


Weekly Simulated Concentrations (2019 IPA and 2017 RWQM)



Note: Observed data are individual sample results

Monthy Simulated Concentrations (2019 IPA)



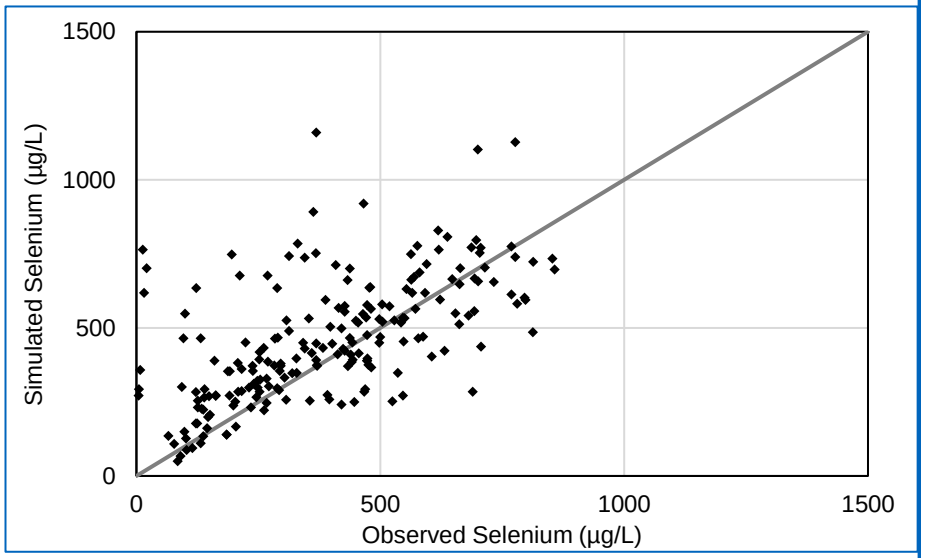
Note: Observed data are monthly averages of sample results

B1-5: Selenium Calibration Information for Node GH_SC1 - Swift Creek Sediment Pond Decant (EMS E221329)

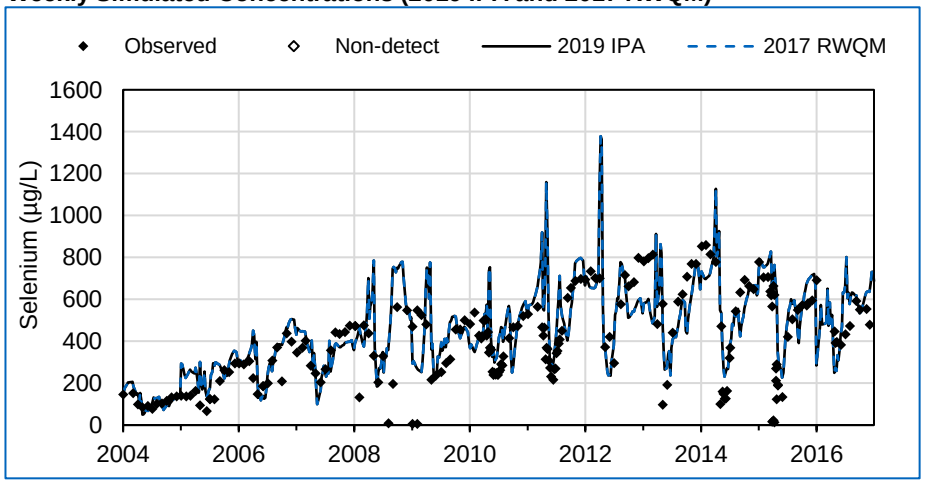
Observed and Simulated Selenium Data and Calibration Statistics

Statistic	2017 RWQM	2019 IPA	
Model Averaging Period	Weekly	Weekly	Monthly
Calibration Period	2004 to 2016		
First Observed Sample	1/2/2004		
Last Observed Sample	12/5/2016		
Data Points Available for Comparison, n	205	205	150
Non-Detect Count	0	0	0
Observed Mean (mg/L)	388	388	410
Simulated Mean (mg/L)	460	460	451
Bias (mg/L)	72	72	40
Relative Bias	1.2	1.2	1.1
Error (mg/L)	137	137	101
Percent Error	35%	35%	25%

2019 IPA Simulated vs. Observed Selenium Concentrations

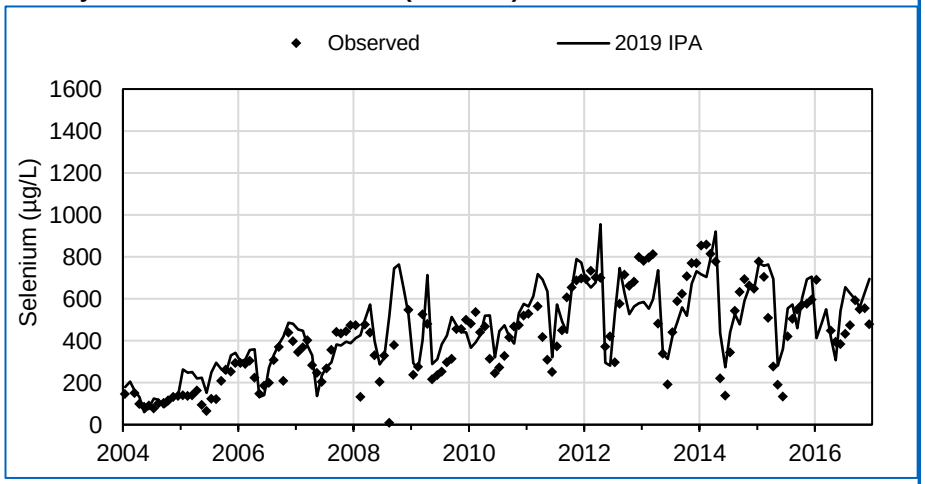


Weekly Simulated Concentrations (2019 IPA and 2017 RWQM)



Note: Observed data are individual sample results

Monthy Simulated Concentrations (2019 IPA)



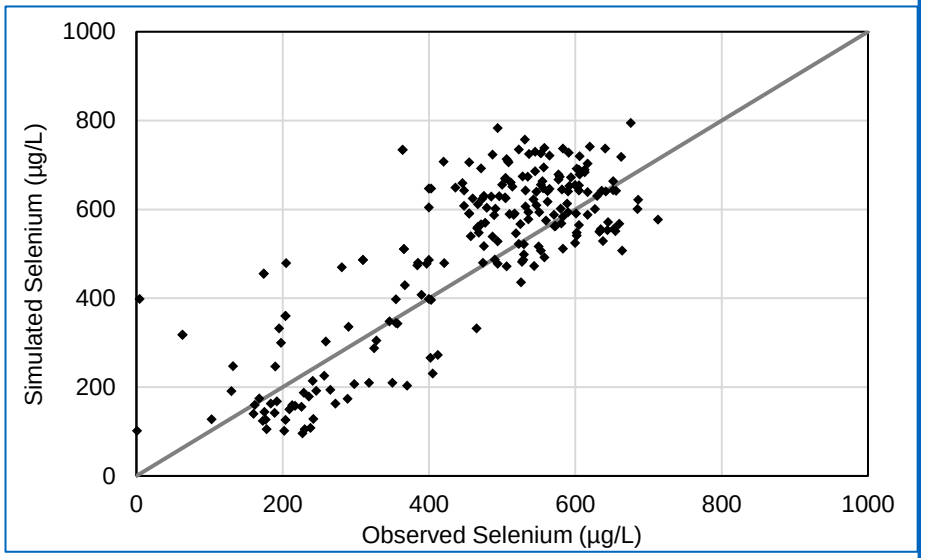
Note: Observed data are monthly averages of sample results

B1-6: Selenium Calibration Information for Node GH_CC1 - Cataract Creek Sediment Pond Decant (EMS 0200384)

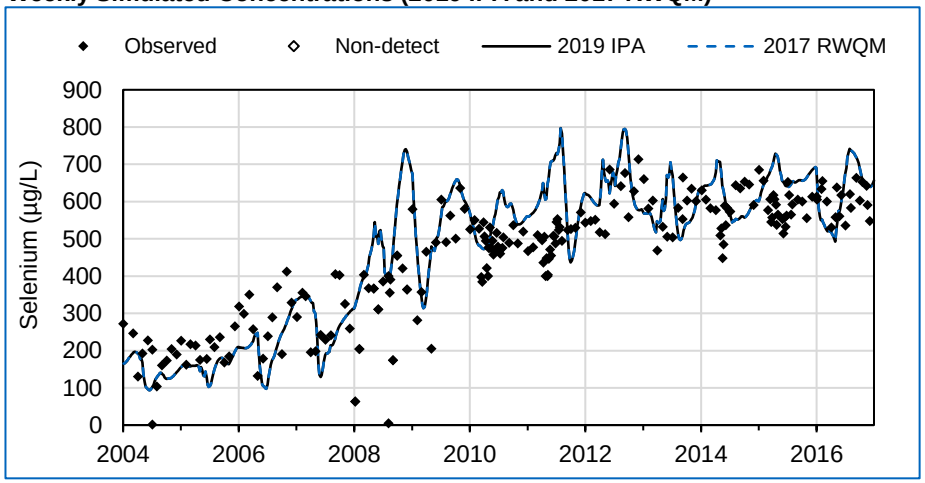
Observed and Simulated Selenium Data and Calibration Statistics

Statistic	2017 RWQM	2019 IPA	
Model Averaging Period	Weekly	Weekly	Monthly
Calibration Period	2004 to 2016		
First Observed Sample	1/2/2004		
Last Observed Sample	12/5/2016		
Data Points Available for Comparison, n	221	221	154
Non-Detect Count	0	0	0
Observed Mean (mg/L)	453	453	442
Simulated Mean (mg/L)	506	506	470
Bias (mg/L)	53	53	27
Relative Bias	1.1	1.1	1.1
Error (mg/L)	99	99	80
Percent Error	22%	22%	18%

2019 IPA Simulated vs. Observed Selenium Concentrations

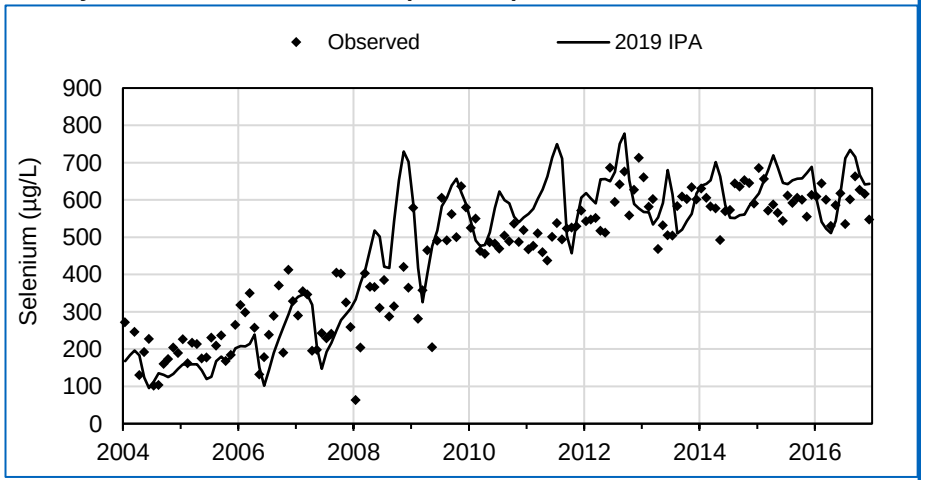


Weekly Simulated Concentrations (2019 IPA and 2017 RWQM)



Note: Observed data are individual sample results

Monthy Simulated Concentrations (2019 IPA)



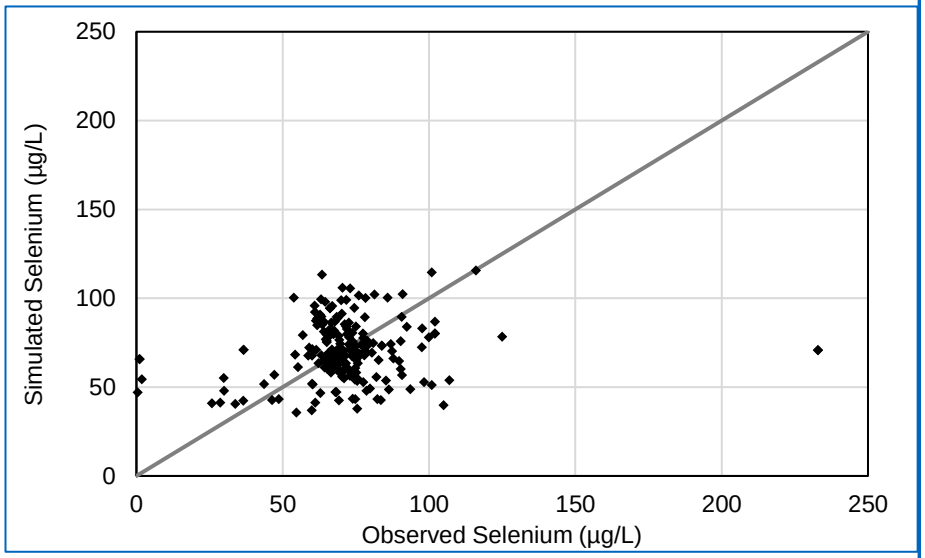
Note: Observed data are monthly averages of sample results

B1-7: Selenium Calibration Information for Node GH_PC1 - Porter Creek Sediment Pond Decant (EMS 0200385)

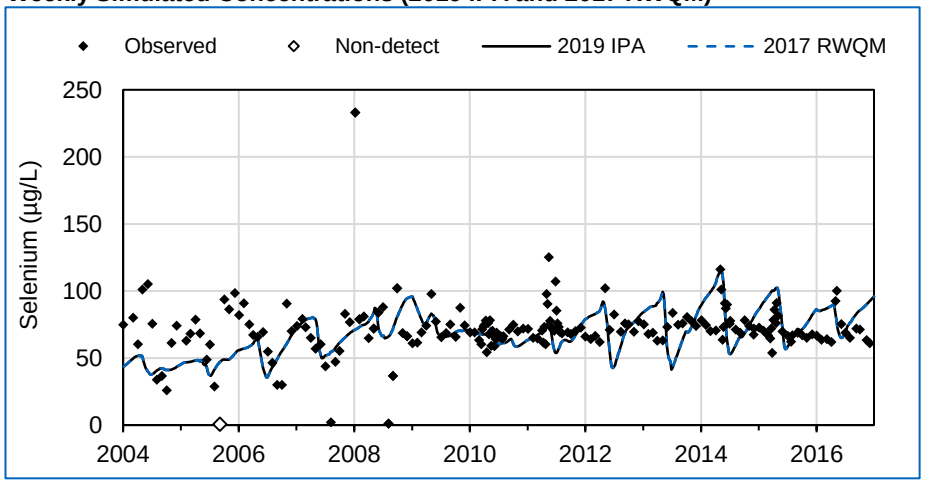
Observed and Simulated Selenium Data and Calibration Statistics

Statistic	2017 RWQM	2019 IPA	
Model Averaging Period	Weekly	Weekly	Monthly
Calibration Period	2004 to 2016		
First Observed Sample	1/2/2004		
Last Observed Sample	12/5/2016		
Data Points Available for Comparison, n	205	205	153
Non-Detect Count	1	1	0
Observed Mean (mg/L)	72	72	70
Simulated Mean (mg/L)	70	70	68
Bias (mg/L)	-1.6	-1.6	-1.6
Relative Bias	0.98	0.98	0.98
Error (mg/L)	17	17	17
Percent Error	24%	24%	24%

2019 IPA Simulated vs. Observed Selenium Concentrations

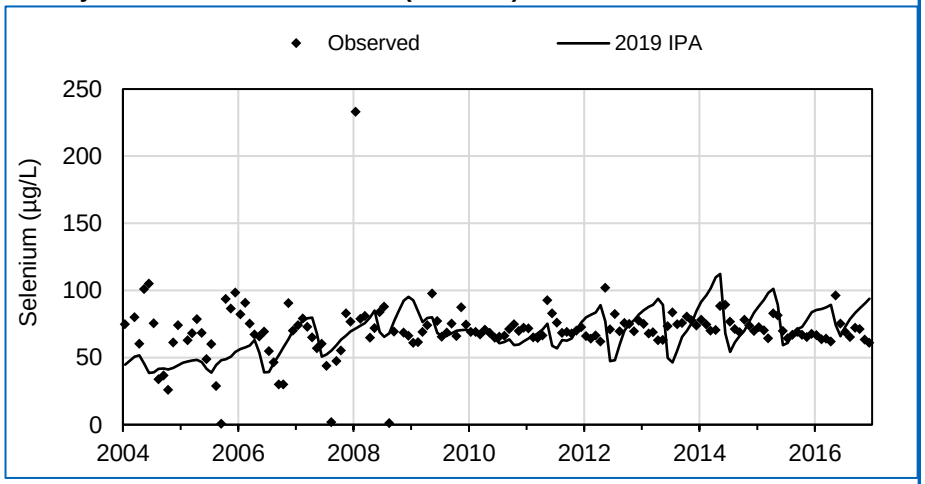


Weekly Simulated Concentrations (2019 IPA and 2017 RWQM)



Note: Observed data are individual sample results

Monthy Simulated Concentrations (2019 IPA)



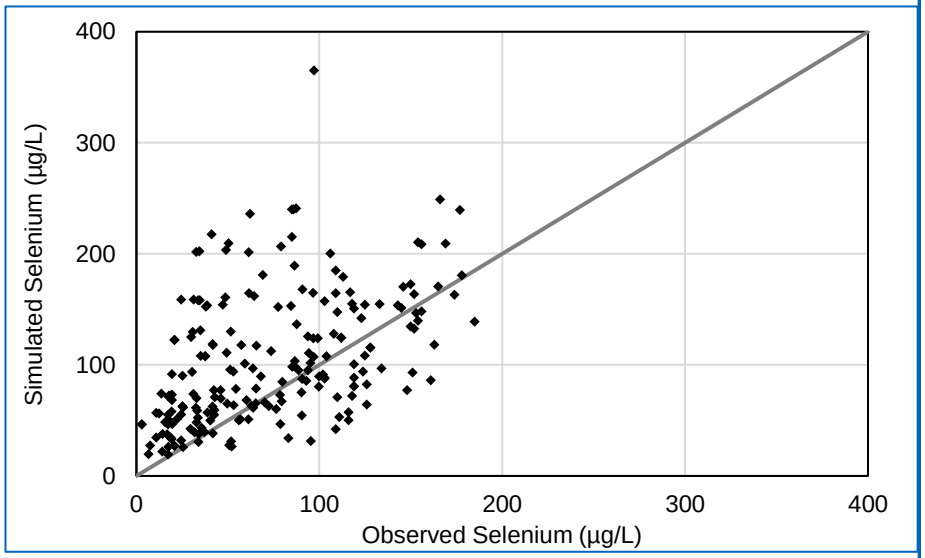
Note: Observed data are monthly averages of sample results

B1-8: Selenium Calibration Information for Node GH_GH1 - Greenhills Creek Sediment Pond Decant (EMS E102709)

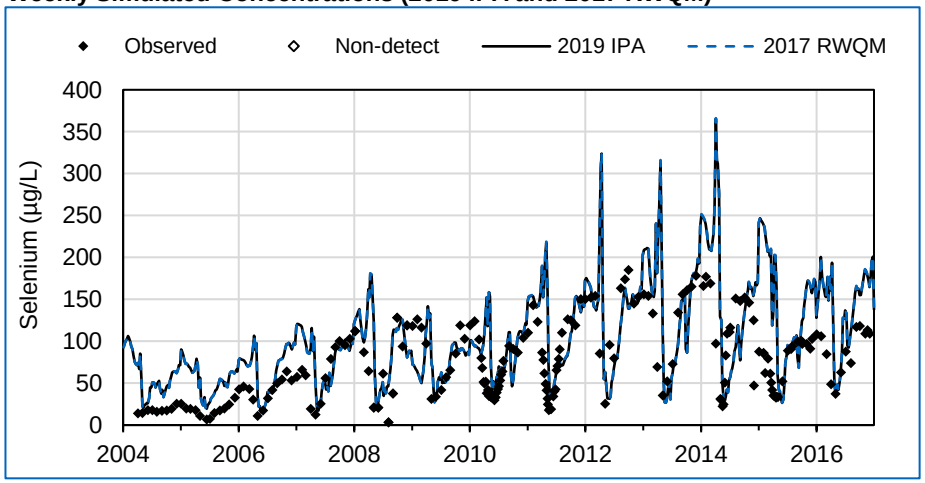
Observed and Simulated Selenium Data and Calibration Statistics

Statistic	2017 RWQM	2019 IPA	
Model Averaging Period	Weekly	Weekly	Monthly
Calibration Period	2004 to 2016		
First Observed Sample	4/4/2004		
Last Observed Sample	12/5/2016		
Data Points Available for Comparison, n	207	207	151
Non-Detect Count	0	0	0
Observed Mean (mg/L)	73	73	79
Simulated Mean (mg/L)	105	105	105
Bias (mg/L)	32	31	25
Relative Bias	1.4	1.4	1.3
Error (mg/L)	46	46	38
Percent Error	62%	62%	47%

2019 IPA Simulated vs. Observed Selenium Concentrations

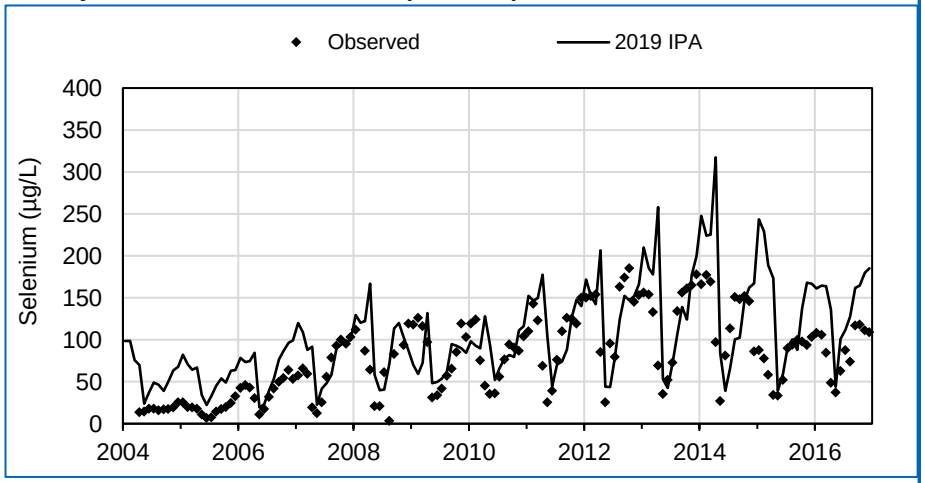


Weekly Simulated Concentrations (2019 IPA and 2017 RWQM)



Note: Observed data are individual sample results

Monthy Simulated Concentrations (2019 IPA)



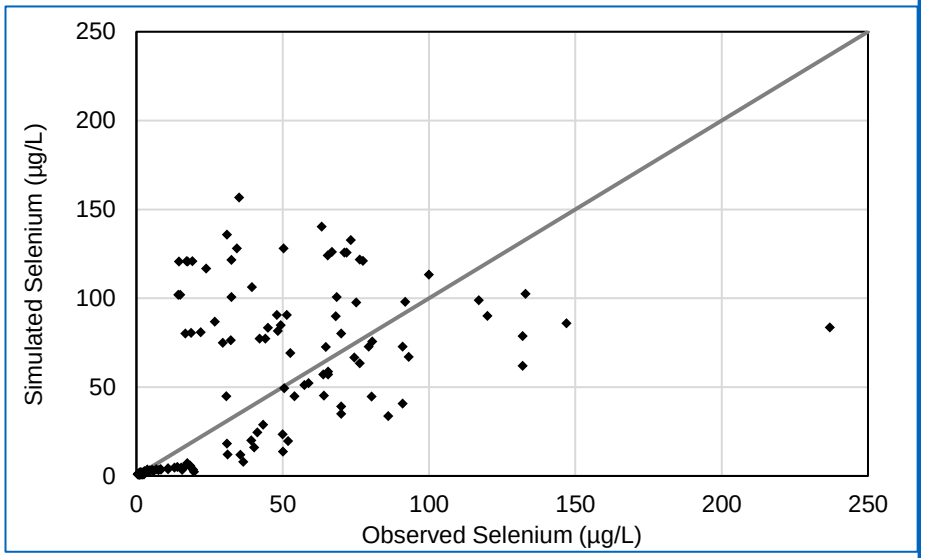
Note: Observed data are monthly averages of sample results

B1-9: Selenium Calibration Information for Node GH_LC1 - Leask Creek Sediment Pond Decant (EMS E257796)

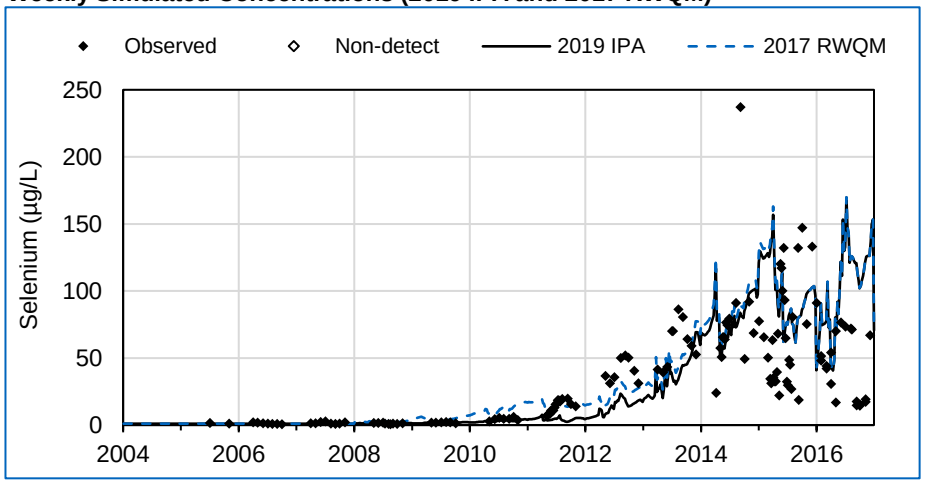
Observed and Simulated Selenium Data and Calibration Statistics

Statistic	2017 RWQM	2019 IPA	
Model Averaging Period	Weekly	Weekly	Monthly
Calibration Period	2004 to 2016		
First Observed Sample	7/3/2005		
Last Observed Sample	12/7/2016		
Data Points Available for Comparison, n	136	136	93
Non-Detect Count	0	0	0
Observed Mean (mg/L)	38	38	36
Simulated Mean (mg/L)	52	48	40
Bias (mg/L)	14	9.7	4.2
Relative Bias	1.4	1.3	1.1
Error (mg/L)	26	27	21
Percent Error	68%	71%	59%

2019 IPA Simulated vs. Observed Selenium Concentrations

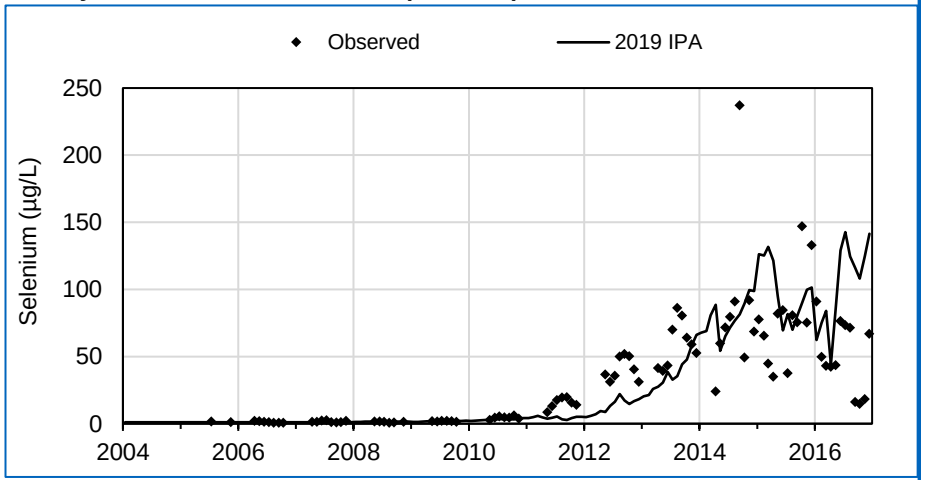


Weekly Simulated Concentrations (2019 IPA and 2017 RWQM)



Note: Observed data are individual sample results

Monthy Simulated Concentrations (2019 IPA)



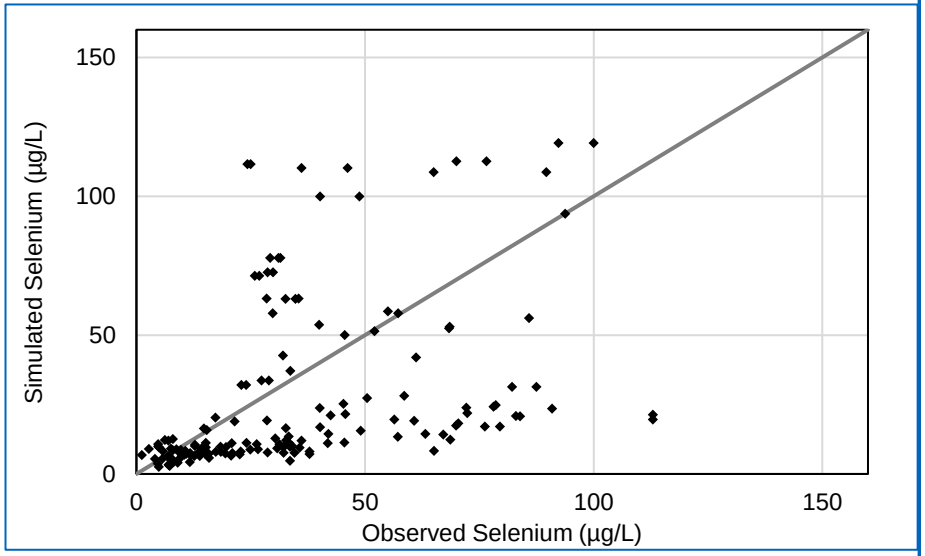
Note: Observed data are monthly averages of sample results

B1-10: Selenium Calibration Information for Node GH_WC1 - Wolfram Creek Sediment Pond Decant (EMS E257796)

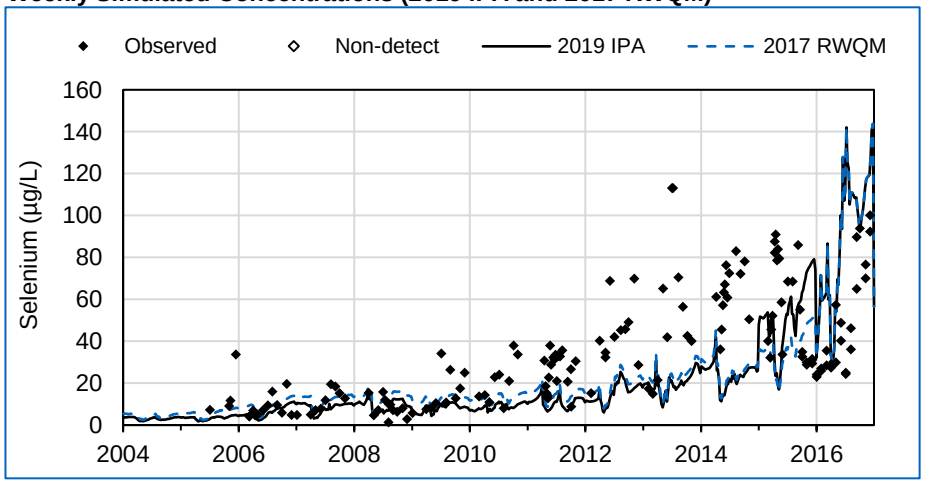
Observed and Simulated Selenium Data and Calibration Statistics

Statistic	2017 RWQM	2019 IPA	
Model Averaging Period	Weekly	Weekly	Monthly
Calibration Period	2004 to 2016		
First Observed Sample	7/3/2005		
Last Observed Sample	12/7/2016		
Data Points Available for Comparison, n	155	155	107
Non-Detect Count	0	0	0
Observed Mean (mg/L)	35	35	32
Simulated Mean (mg/L)	28	28	24
Bias (mg/L)	-7.3	-7.5	-8.0
Relative Bias	0.79	0.79	0.75
Error (mg/L)	21	23	20
Percent Error	60%	65%	62%

2019 IPA Simulated vs. Observed Selenium Concentrations

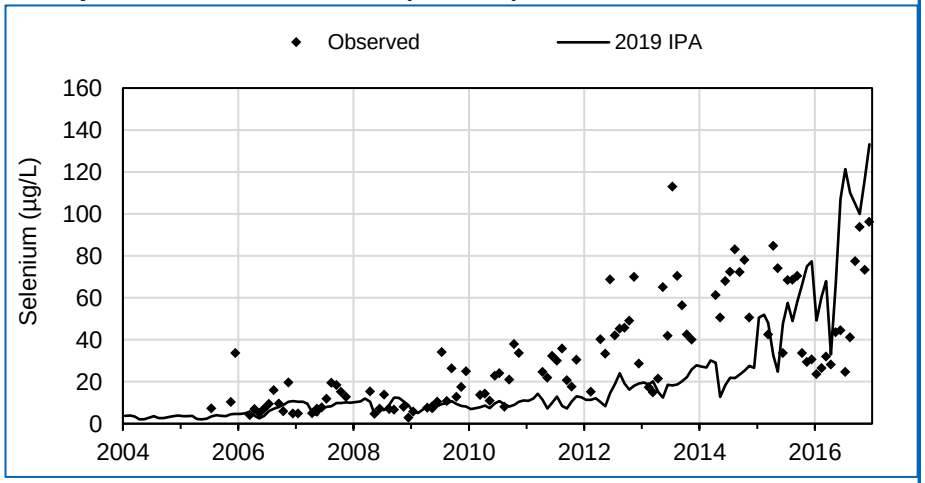


Weekly Simulated Concentrations (2019 IPA and 2017 RWQM)



Note: Observed data are individual sample results

Monthy Simulated Concentrations (2019 IPA)



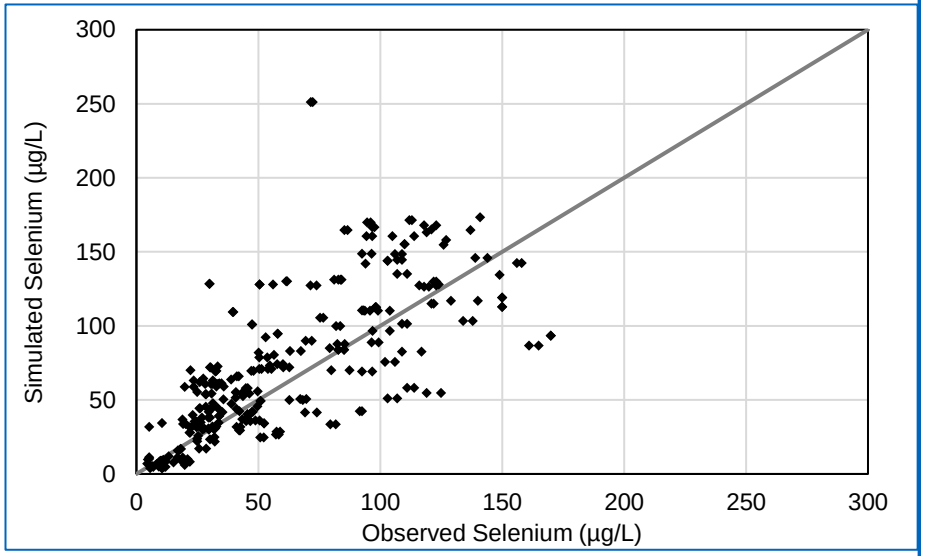
Note: Observed data are monthly averages of sample results

B1-11: Selenium Calibration Information for Node GH_TC1 - Thompson Creek at LRP Road (EMS E102714)

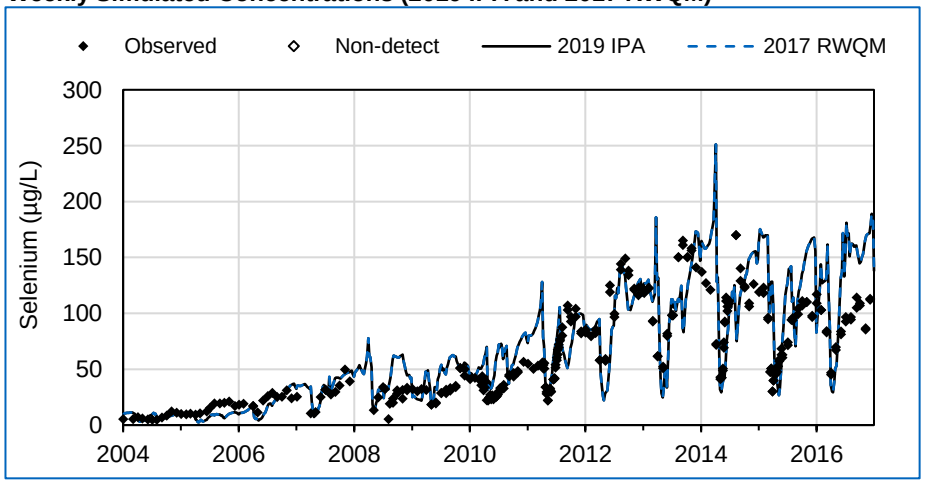
Observed and Simulated Selenium Data and Calibration Statistics

Statistic	2017 RWQM	2019 IPA	
Model Averaging Period	Weekly	Weekly	Monthly
Calibration Period	2004 to 2016		
First Observed Sample	1/2/2004		
Last Observed Sample	12/7/2016		
Data Points Available for Comparison, n	302	302	147
Non-Detect Count	0	0	0
Observed Mean (mg/L)	63	63	60
Simulated Mean (mg/L)	73	73	70
Bias (mg/L)	11	11	9.9
Relative Bias	1.2	1.2	1.2
Error (mg/L)	24	24	19
Percent Error	39%	39%	32%

2019 IPA Simulated vs. Observed Selenium Concentrations

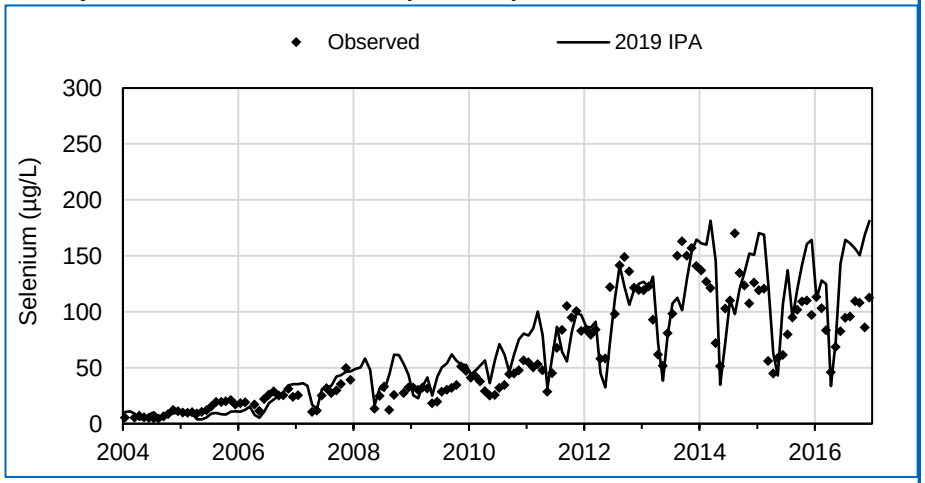


Weekly Simulated Concentrations (2019 IPA and 2017 RWQM)



Note: Observed data are individual sample results

Monthy Simulated Concentrations (2019 IPA)



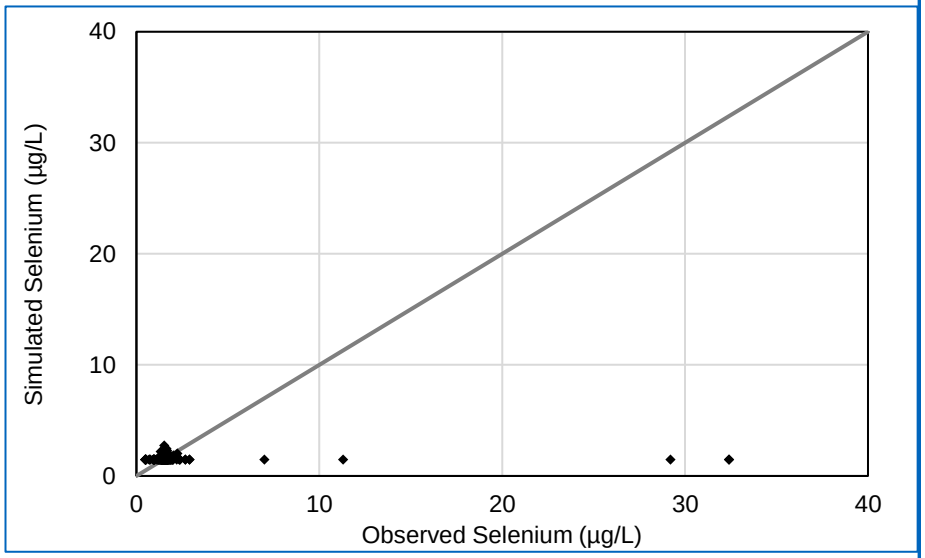
Note: Observed data are monthly averages of sample results

B1-12: Selenium Calibration Information for Node LC_DC1 - Dry Creek near mouth (at bridge) (EMS E288270)

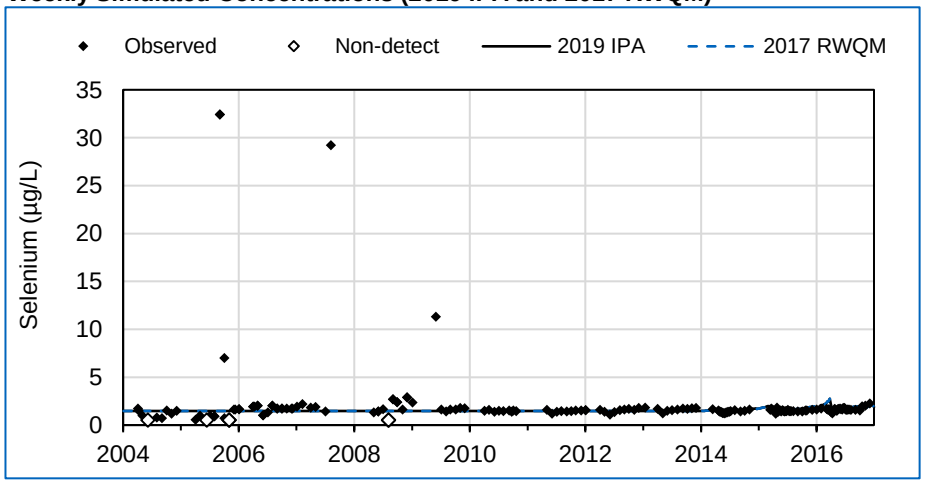
Observed and Simulated Selenium Data and Calibration Statistics

Statistic	2017 RWQM	2019 IPA	
Model Averaging Period	Weekly	Weekly	Monthly
Calibration Period	2004 to 2016		
First Observed Sample	4/4/2004		
Last Observed Sample	12/6/2016		
Data Points Available for Comparison, n	182	182	114
Non-Detect Count	6	6	0
Observed Mean (mg/L)	2.1	2.1	2.1
Simulated Mean (mg/L)	1.6	1.6	1.5
Bias (mg/L)	-0.55	-0.55	-0.59
Relative Bias	0.74	0.74	0.72
Error (mg/L)	0.85	0.85	0.88
Percent Error	41%	41%	41%

2019 IPA Simulated vs. Observed Selenium Concentrations

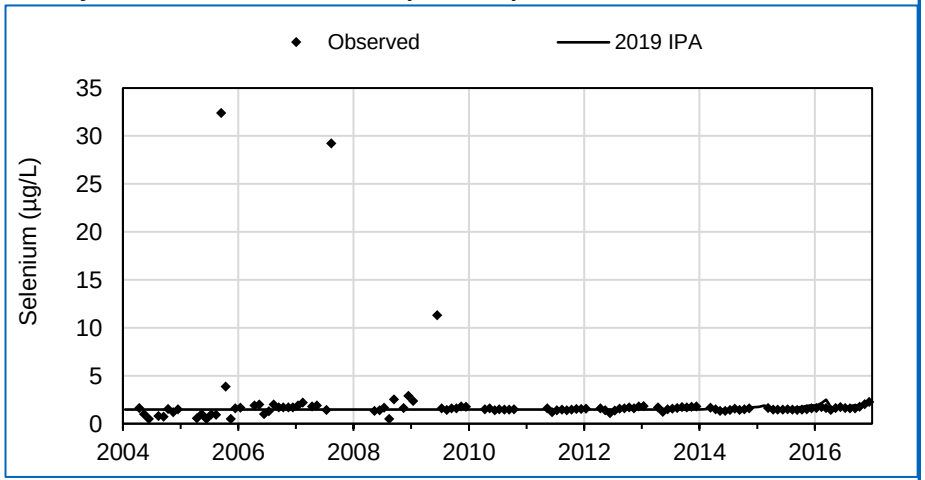


Weekly Simulated Concentrations (2019 IPA and 2017 RWQM)



Note: Observed data are individual sample results

Monthy Simulated Concentrations (2019 IPA)



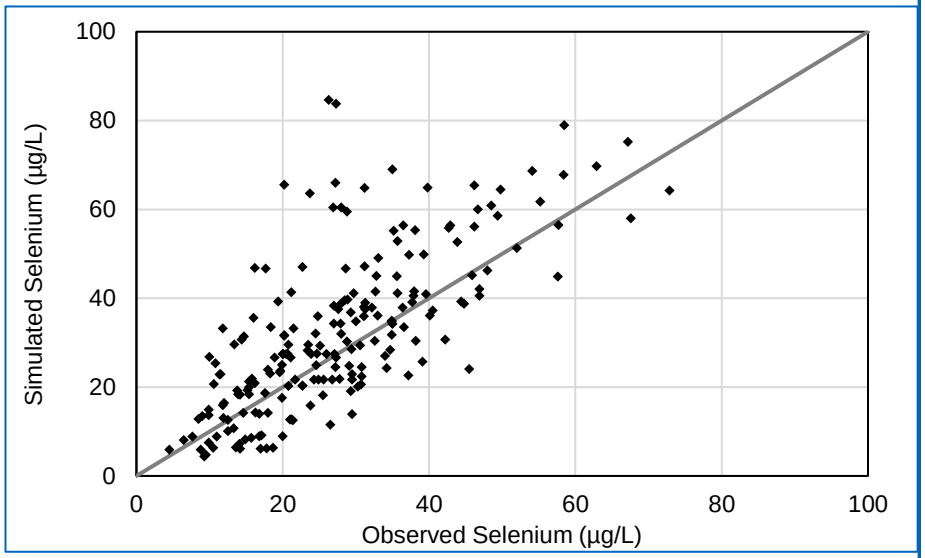
Note: Observed data are monthly averages of sample results

B1-13: Selenium Calibration Information for Node LC_LCUSWLC - Line Creek u/s of West Line Creek (EMS E293369)

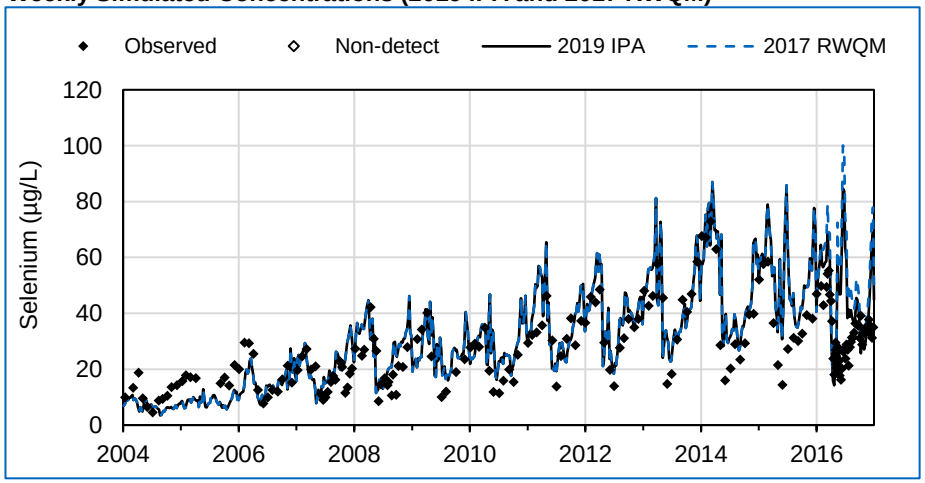
Observed and Simulated Selenium Data and Calibration Statistics

Statistic	2017 RWQM	2019 IPA	
Model Averaging Period	Weekly	Weekly	Monthly
Calibration Period	2004 to 2016		
First Observed Sample	1/13/2004		
Last Observed Sample	12/28/2016		
Data Points Available for Comparison, n	203	203	146
Non-Detect Count	0	0	0
Observed Mean (mg/L)	27	27	28
Simulated Mean (mg/L)	34	32	32
Bias (mg/L)	6.7	4.9	4.5
Relative Bias	1.2	1.2	1.2
Error (mg/L)	11	9.5	8.5
Percent Error	39%	34%	31%

2019 IPA Simulated vs. Observed Selenium Concentrations

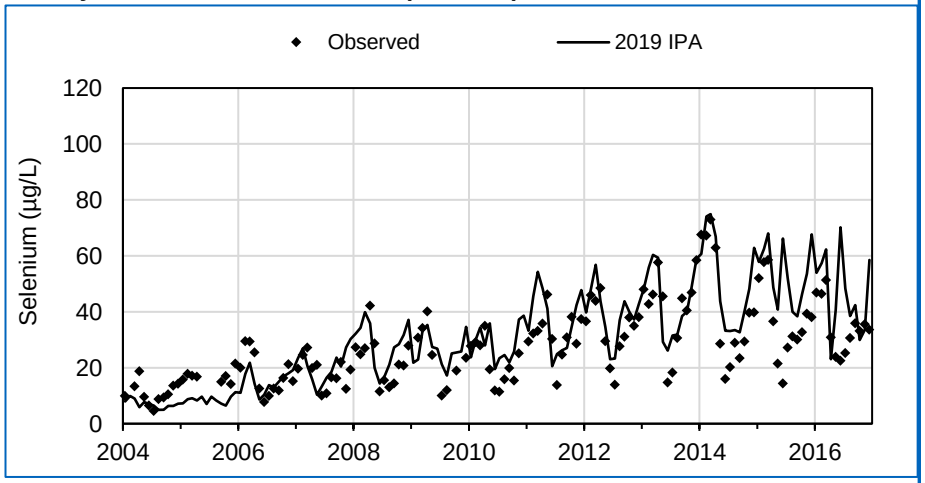


Weekly Simulated Concentrations (2019 IPA and 2017 RWQM)



Note: Observed data are individual sample results

Monthy Simulated Concentrations (2019 IPA)



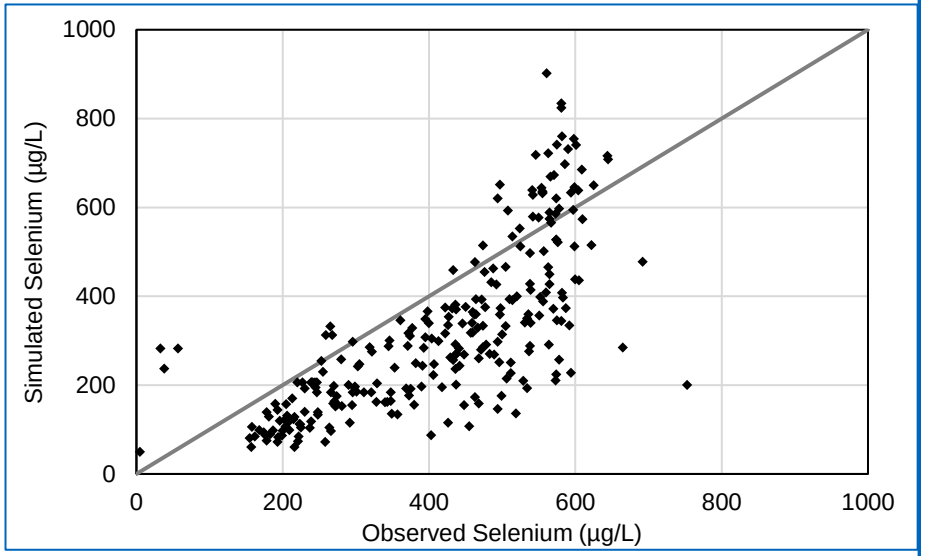
Note: Observed data are monthly averages of sample results

B1-14: Selenium Calibration Information for Node LC_WLC - West Line Creek (EMS E261958)

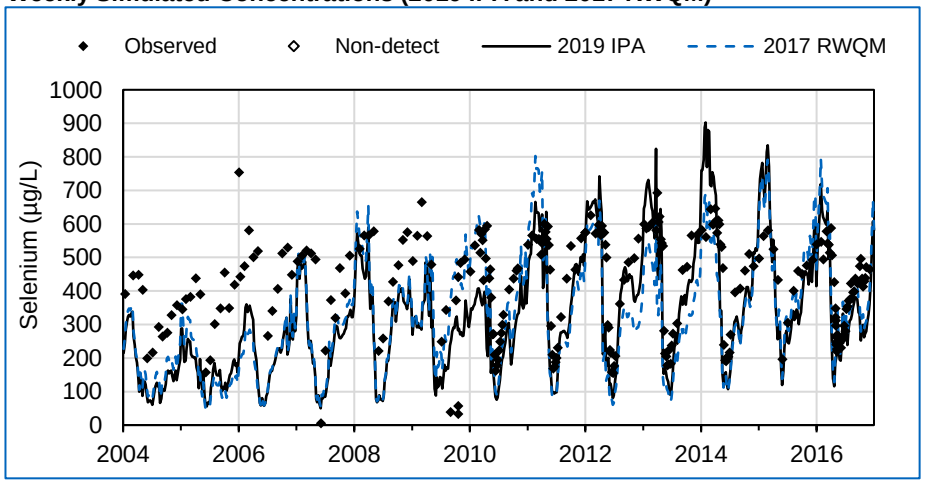
Observed and Simulated Selenium Data and Calibration Statistics

Statistic	2017 RWQM	2019 IPA	
Model Averaging Period	Weekly	Weekly	Monthly
Calibration Period	2004 to 2016		
First Observed Sample	1/13/2004		
Last Observed Sample	12/5/2016		
Data Points Available for Comparison, n	265	265	151
Non-Detect Count	0	0	0
Observed Mean (mg/L)	412	412	427
Simulated Mean (mg/L)	324	319	326
Bias (mg/L)	-88	-94	-101
Relative Bias	0.79	0.77	0.76
Error (mg/L)	125	129	132
Percent Error	30%	31%	31%

2019 IPA Simulated vs. Observed Selenium Concentrations

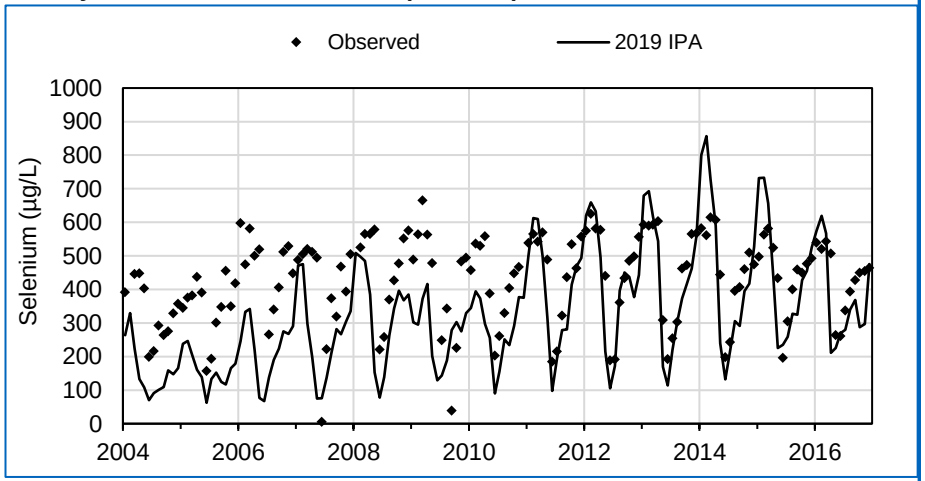


Weekly Simulated Concentrations (2019 IPA and 2017 RWQM)



Note: Observed data are individual sample results

Monthy Simulated Concentrations (2019 IPA)



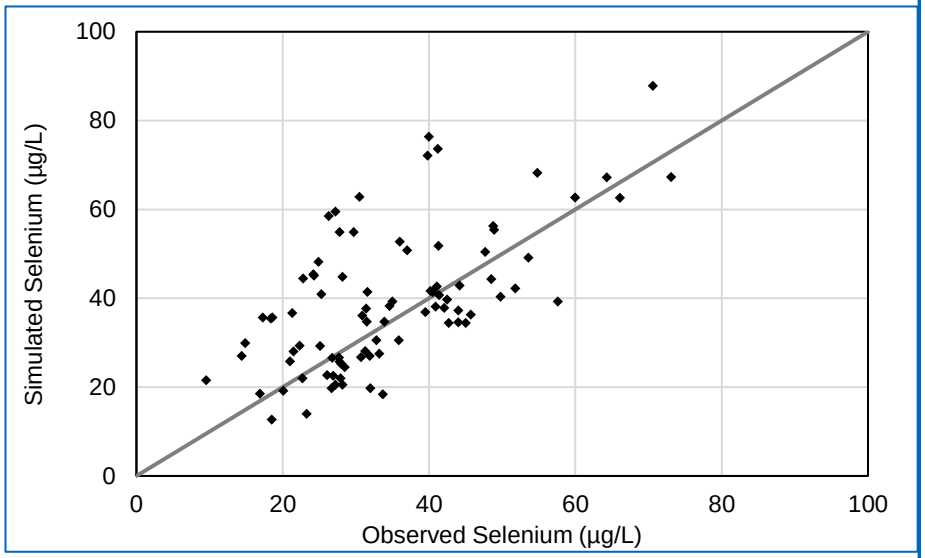
Note: Observed data are monthly averages of sample results

B1-15: Selenium Calibration Information for Node LC_LCDSSLCC - LCO Compliance Point - Line Creek d/s of South Line Creek (EMS E297110)

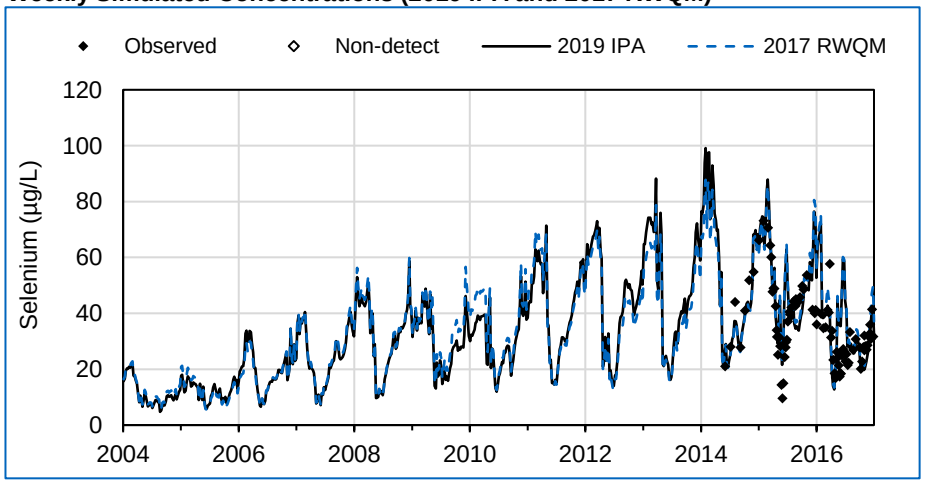
Observed and Simulated Selenium Data and Calibration Statistics

Statistic	2017 RWQM	2019 IPA	
Model Averaging Period	Weekly	Weekly	Monthly
Calibration Period	2004 to 2016		
First Observed Sample	6/4/2014		
Last Observed Sample	12/28/2016		
Data Points Available for Comparison, n	87	87	31
Non-Detect Count	0	0	0
Observed Mean (mg/L)	35	35	38
Simulated Mean (mg/L)	41	39	42
Bias (mg/L)	6.2	4.7	4.0
Relative Bias	1.2	1.1	1.1
Error (mg/L)	10	9.9	7.8
Percent Error	29%	29%	20%

2019 IPA Simulated vs. Observed Selenium Concentrations

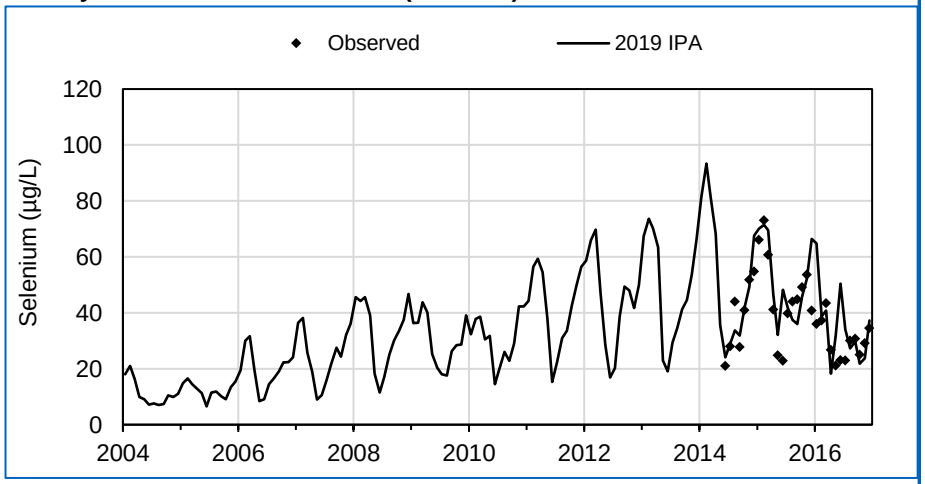


Weekly Simulated Concentrations (2019 IPA and 2017 RWQM)



Note: Observed data are individual sample results

Monthy Simulated Concentrations (2019 IPA)



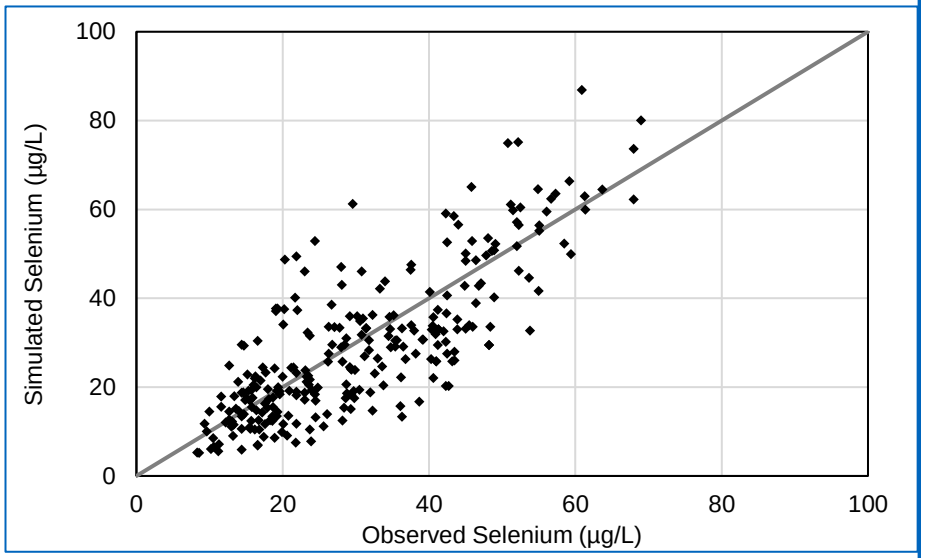
Note: Observed data are monthly averages of sample results

B1-16: Selenium Calibration Information for Node LC_LC4 - Line Creek u/s of Process Plant (EMS 0200044)

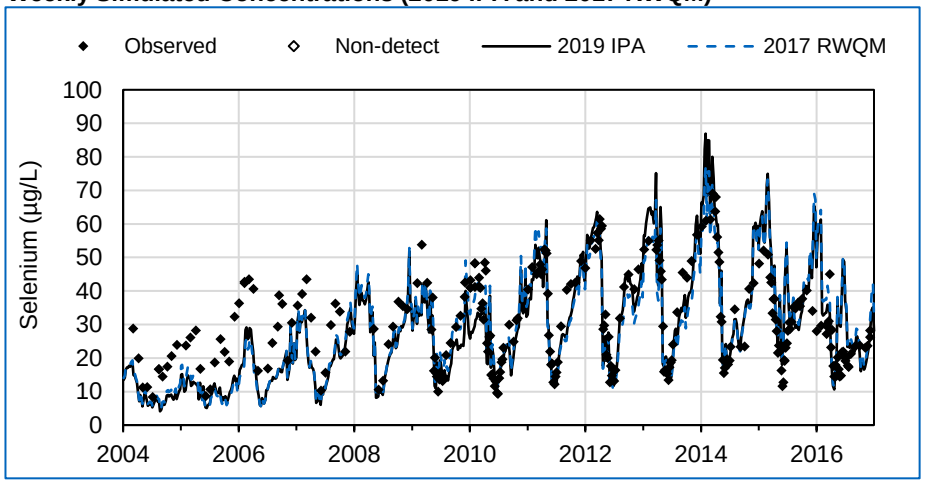
Observed and Simulated Selenium Data and Calibration Statistics

Statistic	2017 RWQM	2019 IPA	
Model Averaging Period	Weekly	Weekly	Monthly
Calibration Period	2004 to 2016		
First Observed Sample	3/4/2004		
Last Observed Sample	12/7/2016		
Data Points Available for Comparison, n	270	270	146
Non-Detect Count	0	0	0
Observed Mean (mg/L)	30	30	31
Simulated Mean (mg/L)	30	29	29
Bias (mg/L)	-0.74	-1.2	-2.5
Relative Bias	0.98	0.96	0.92
Error (mg/L)	7.5	7.7	7.4
Percent Error	25%	25%	24%

2019 IPA Simulated vs. Observed Selenium Concentrations

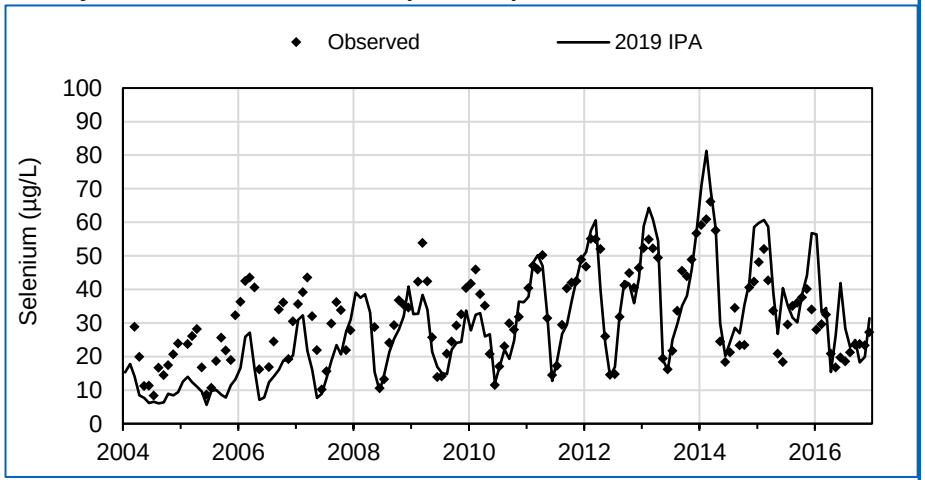


Weekly Simulated Concentrations (2019 IPA and 2017 RWQM)



Note: Observed data are individual sample results

Monthy Simulated Concentrations (2019 IPA)



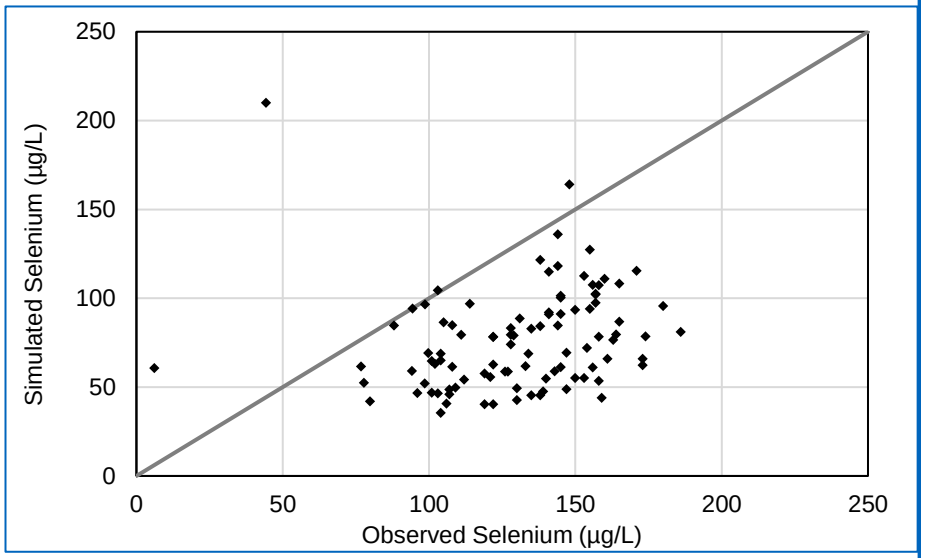
Note: Observed data are monthly averages of sample results

B1-17: Selenium Calibration Information for Node EV_DC1 - EVO Dry Creek Sediment Pond Decant (EMS E298590)

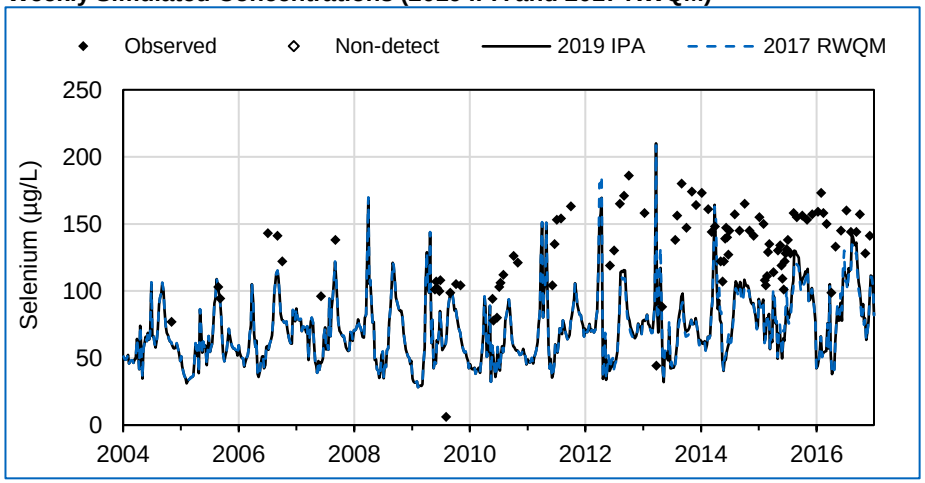
Observed and Simulated Selenium Data and Calibration Statistics

Statistic	2017 RWQM	2019 IPA	
Model Averaging Period	Weekly	Weekly	Monthly
Calibration Period	2004 to 2016		
First Observed Sample	11/2/2004		
Last Observed Sample	12/5/2016		
Data Points Available for Comparison, n	97	97	74
Non-Detect Count	0	0	0
Observed Mean (mg/L)	130	130	133
Simulated Mean (mg/L)	77	77	78
Bias (mg/L)	-54	-54	-55
Relative Bias	0.59	0.59	0.59
Error (mg/L)	59	58	59
Percent Error	45%	45%	44%

2019 IPA Simulated vs. Observed Selenium Concentrations

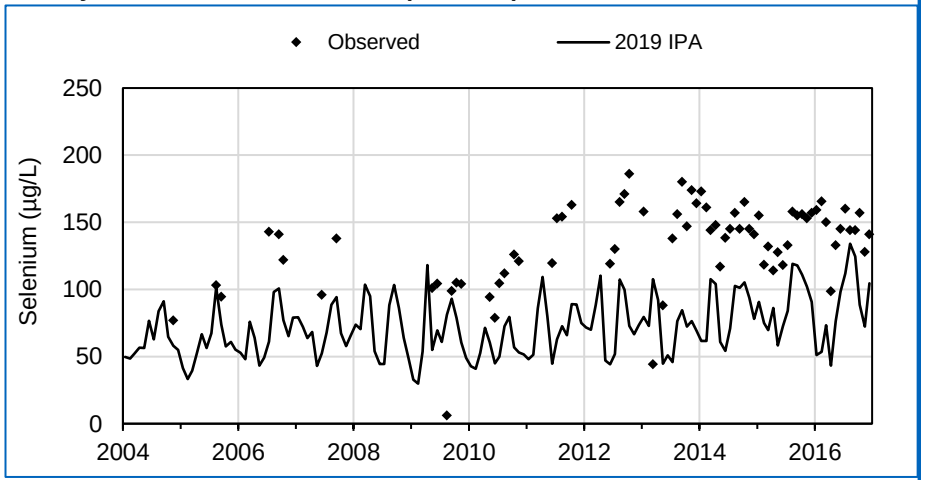


Weekly Simulated Concentrations (2019 IPA and 2017 RWQM)



Note: Observed data are individual sample results

Monthy Simulated Concentrations (2019 IPA)



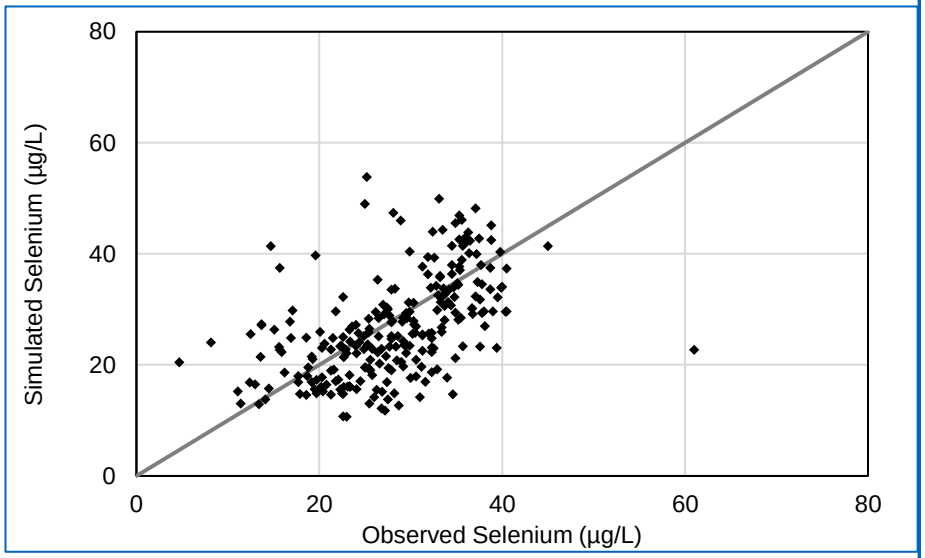
Note: Observed data are monthly averages of sample results

B1-18: Selenium Calibration Information for Node EV_HC1 - EVO Harmer Compliance Point - Harmer Spillway (EMS E102682)

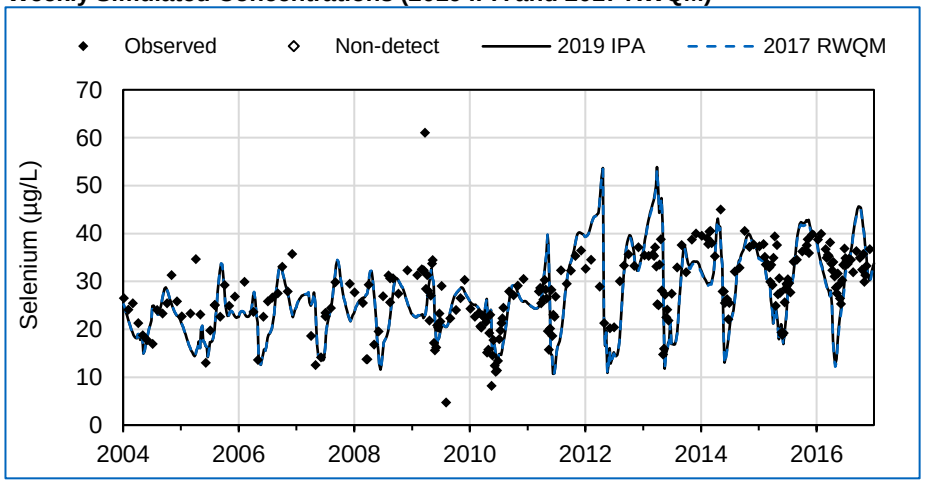
Observed and Simulated Selenium Data and Calibration Statistics

Statistic	2017 RWQM	2019 IPA	
Model Averaging Period	Weekly	Weekly	Monthly
Calibration Period	2004 to 2016		
First Observed Sample	1/6/2004		
Last Observed Sample	12/5/2016		
Data Points Available for Comparison, n	252	252	142
Non-Detect Count	0	0	0
Observed Mean (mg/L)	28	28	28
Simulated Mean (mg/L)	27	27	27
Bias (mg/L)	-1.5	-1.3	-0.96
Relative Bias	0.95	0.95	0.97
Error (mg/L)	6.4	6.4	5.0
Percent Error	23%	23%	18%

2019 IPA Simulated vs. Observed Selenium Concentrations

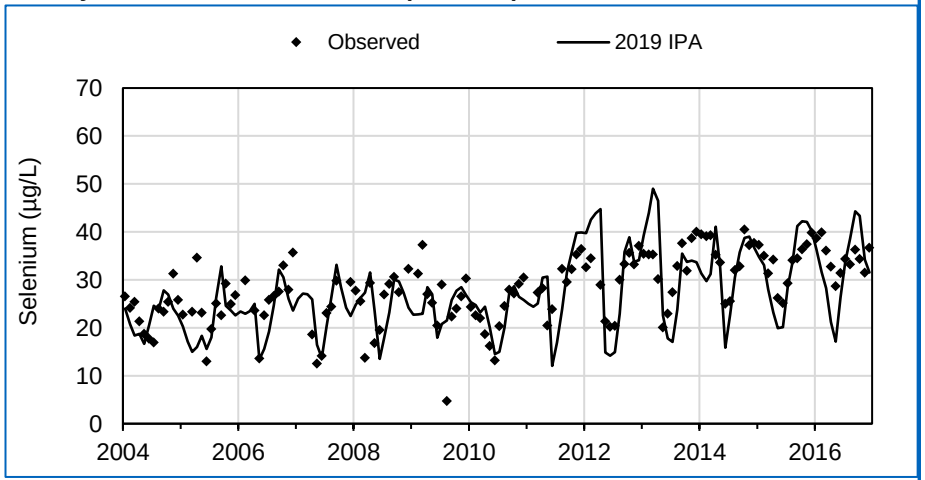


Weekly Simulated Concentrations (2019 IPA and 2017 RWQM)



Note: Observed data are individual sample results

Monthy Simulated Concentrations (2019 IPA)



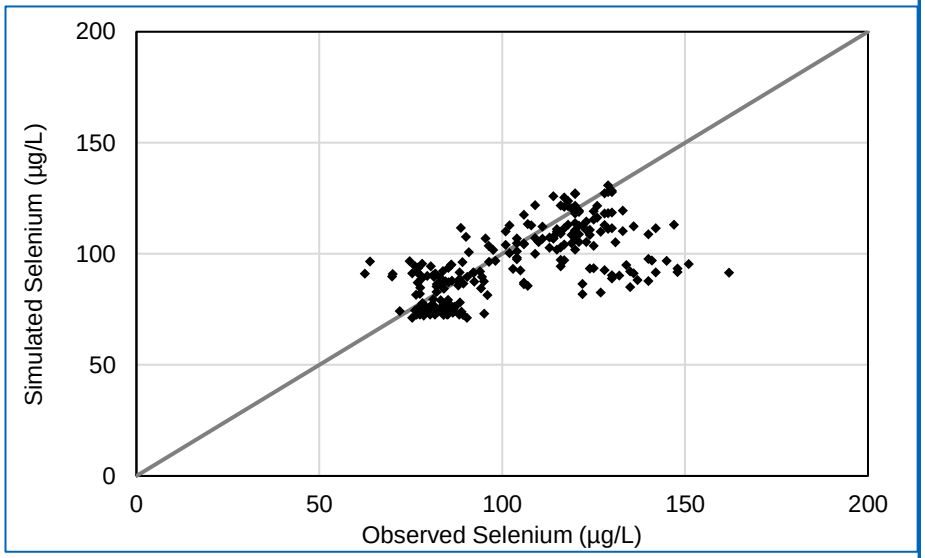
Note: Observed data are monthly averages of sample results

B1-19: Selenium Calibration Information for Node EV_EC1 - Erickson Creek at Mouth (EMS 0200097)

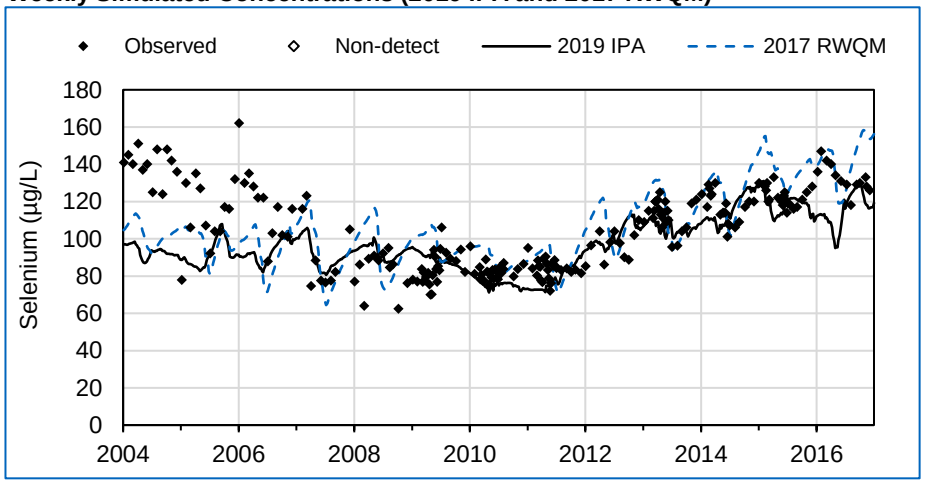
Observed and Simulated Selenium Data and Calibration Statistics

Statistic	2017 RWQM	2019 IPA	
Model Averaging Period	Weekly	Weekly	Monthly
Calibration Period	2004 to 2016		
First Observed Sample	1/6/2004		
Last Observed Sample	12/5/2016		
Data Points Available for Comparison, n	227	227	150
Non-Detect Count	0	0	0
Observed Mean (mg/L)	103	103	107
Simulated Mean (mg/L)	108	96	97
Bias (mg/L)	4.1	-7.4	-9.3
Relative Bias	1.0	0.93	0.91
Error (mg/L)	15	13	15
Percent Error	14%	12%	14%

2019 IPA Simulated vs. Observed Selenium Concentrations

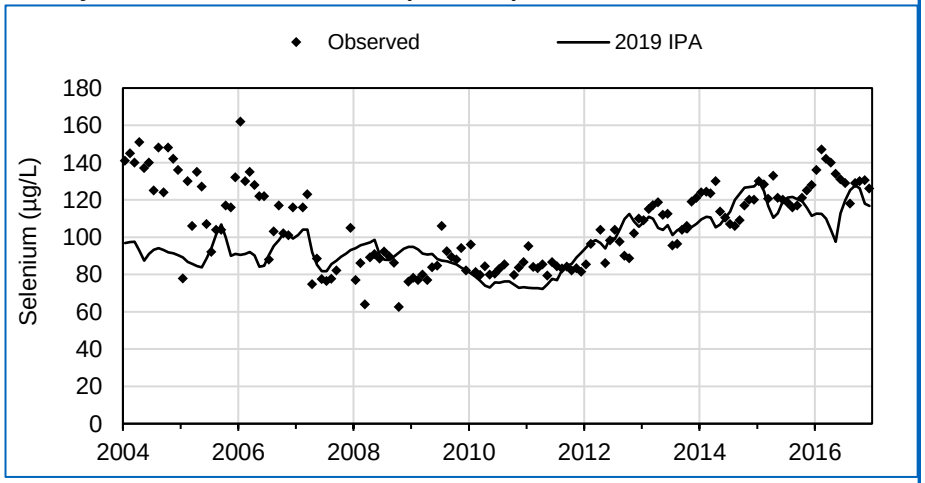


Weekly Simulated Concentrations (2019 IPA and 2017 RWQM)



Note: Observed data are individual sample results

Monthy Simulated Concentrations (2019 IPA)



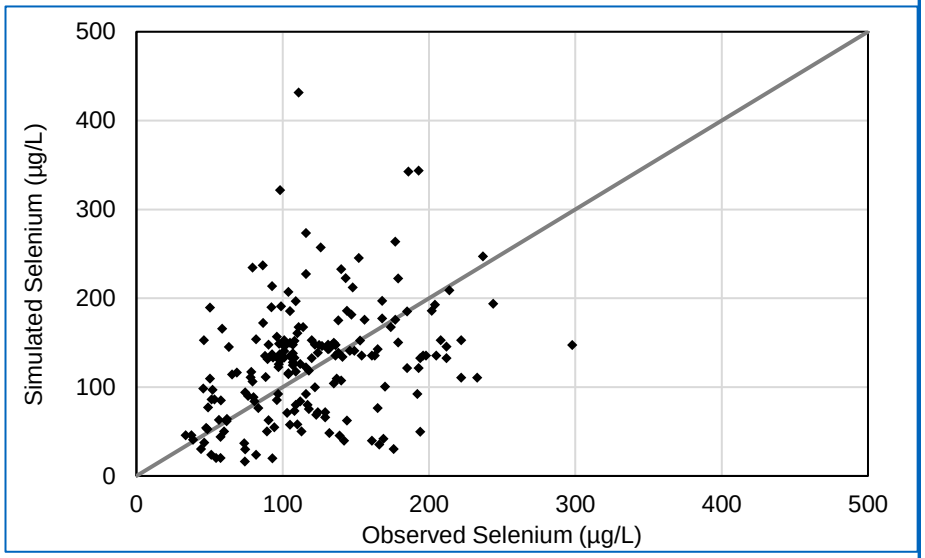
Note: Observed data are monthly averages of sample results

B1-20: Selenium Calibration Information for Node EV_GT1 - Gate Creek Sediment Pond Decant (EMS E206231)

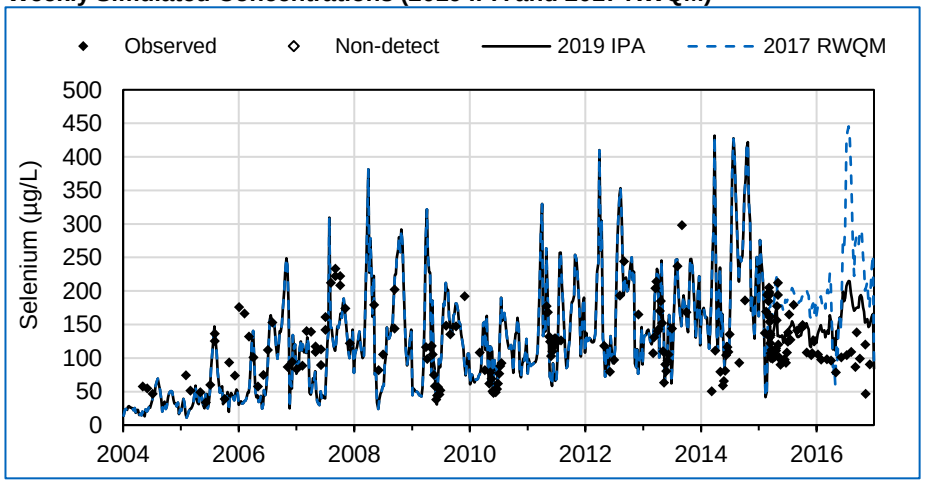
Observed and Simulated Selenium Data and Calibration Statistics

Statistic	2017 RWQM	2019 IPA	
Model Averaging Period	Weekly	Weekly	Monthly
Calibration Period	2004 to 2016		
First Observed Sample	5/4/2004		
Last Observed Sample	12/5/2016		
Data Points Available for Comparison, n	185	185	99
Non-Detect Count	0	0	0
Observed Mean (mg/L)	120	120	119
Simulated Mean (mg/L)	144	128	129
Bias (mg/L)	24	8.4	10
Relative Bias	1.2	1.1	1.1
Error (mg/L)	61	50	48
Percent Error	51%	42%	41%

2019 IPA Simulated vs. Observed Selenium Concentrations

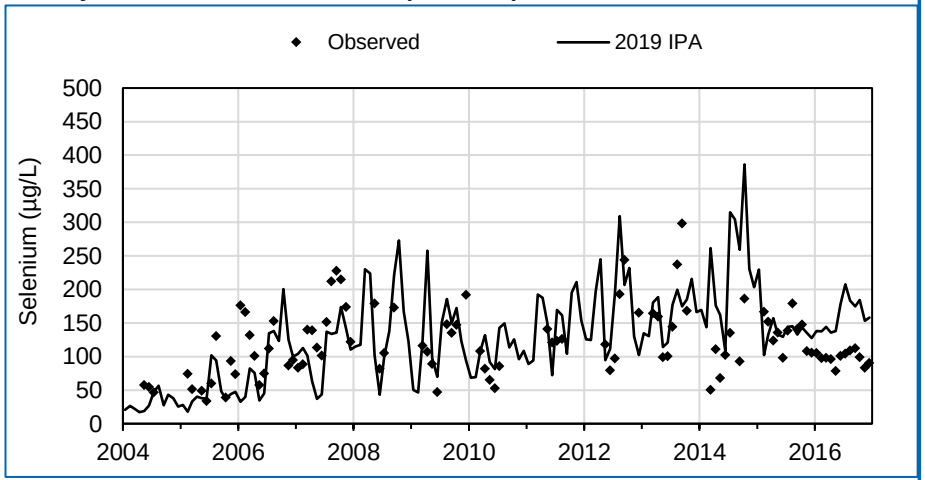


Weekly Simulated Concentrations (2019 IPA and 2017 RWQM)



Note: Observed data are individual sample results

Monthy Simulated Concentrations (2019 IPA)



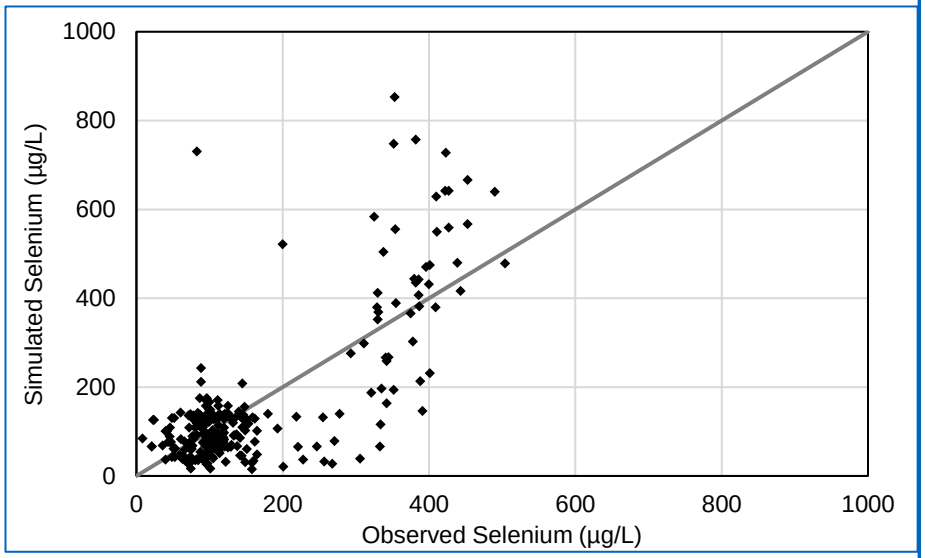
Note: Observed data are monthly averages of sample results

B1-21: Selenium Calibration Information for Node EV_BC1 - Bodie Creek Sediment Pond Decant (EMS E102685)

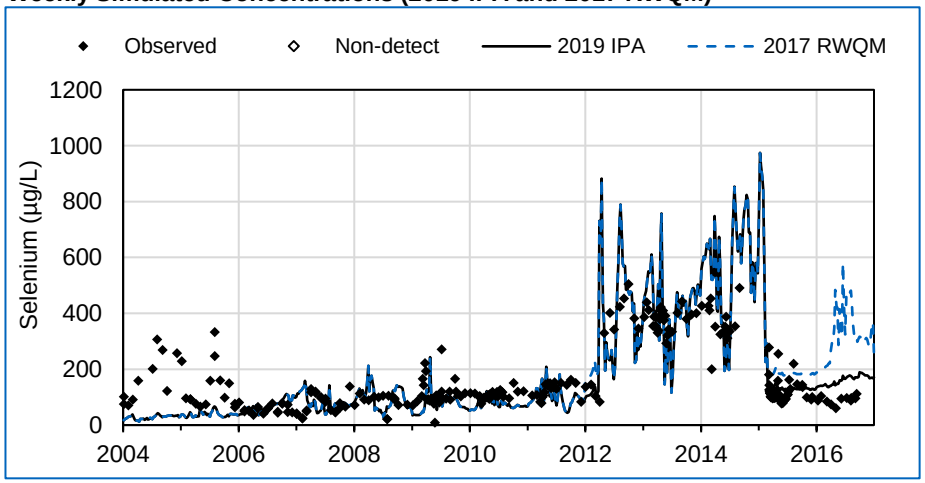
Observed and Simulated Selenium Data and Calibration Statistics

Statistic	2017 RWQM	2019 IPA	
Model Averaging Period	Weekly	Weekly	Monthly
Calibration Period	2004 to 2016		
First Observed Sample	1/6/2004		
Last Observed Sample	9/14/2016		
Data Points Available for Comparison, n	267	267	143
Non-Detect Count	0	0	0
Observed Mean (mg/L)	156	156	164
Simulated Mean (mg/L)	175	158	163
Bias (mg/L)	19	1.9	-1.2
Relative Bias	1.1	1.0	0.99
Error (mg/L)	79	65	68
Percent Error	51%	42%	42%

2019 IPA Simulated vs. Observed Selenium Concentrations

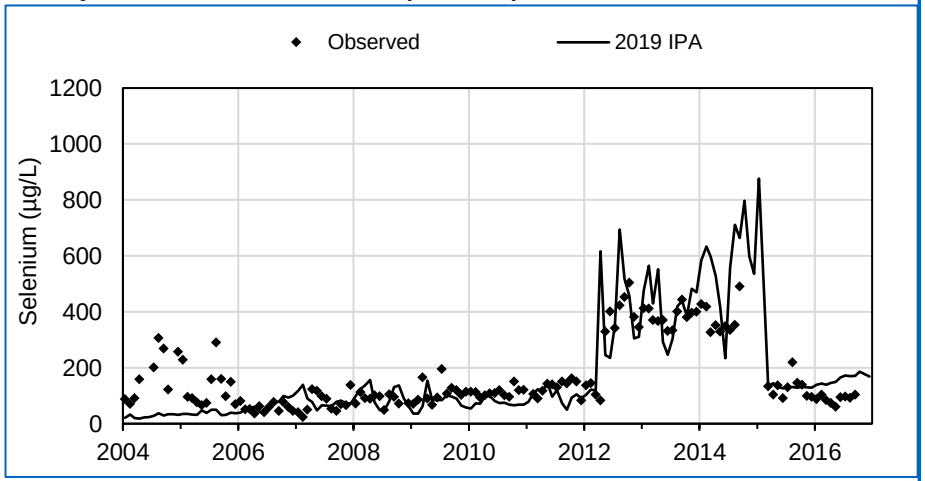


Weekly Simulated Concentrations (2019 IPA and 2017 RWQM)



Note: Observed data are individual sample results

Monthy Simulated Concentrations (2019 IPA)



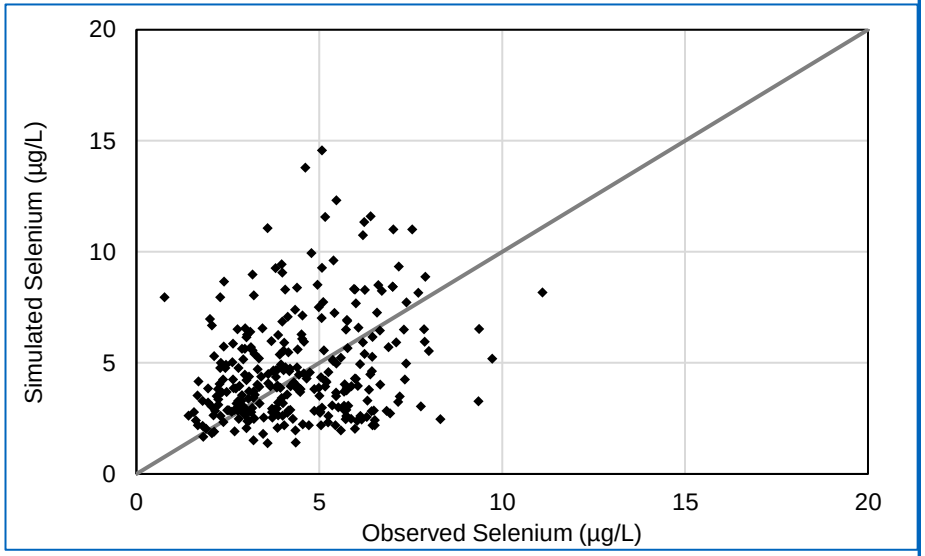
Note: Observed data are monthly averages of sample results

B1-22: Selenium Calibration Information for Node CM_MC2 - Michel Creek d/s CMO near Andy Goode Creek Junction (EMS E258937)

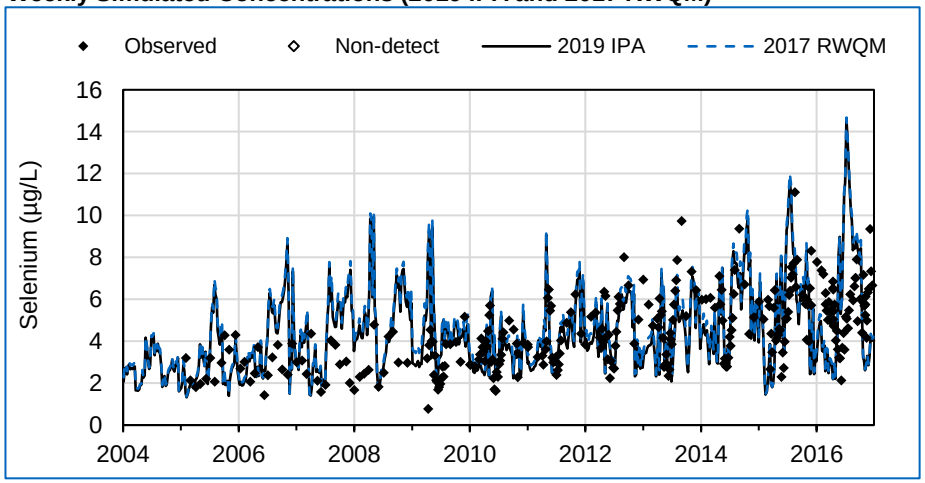
Observed and Simulated Selenium Data and Calibration Statistics

Statistic	2017 RWQM	2019 IPA	
Model Averaging Period	Weekly	Weekly	Monthly
Calibration Period	2004 to 2016		
First Observed Sample	2/2/2005		
Last Observed Sample	12/21/2016		
Data Points Available for Comparison, n	291	291	138
Non-Detect Count	0	0	0
Observed Mean (mg/L)	4.4	4.4	4.3
Simulated Mean (mg/L)	4.9	4.7	4.6
Bias (mg/L)	0.47	0.26	0.25
Relative Bias	1.1	1.1	1.1
Error (mg/L)	2.0	1.9	1.5
Percent Error	44%	43%	35%

2019 IPA Simulated vs. Observed Selenium Concentrations

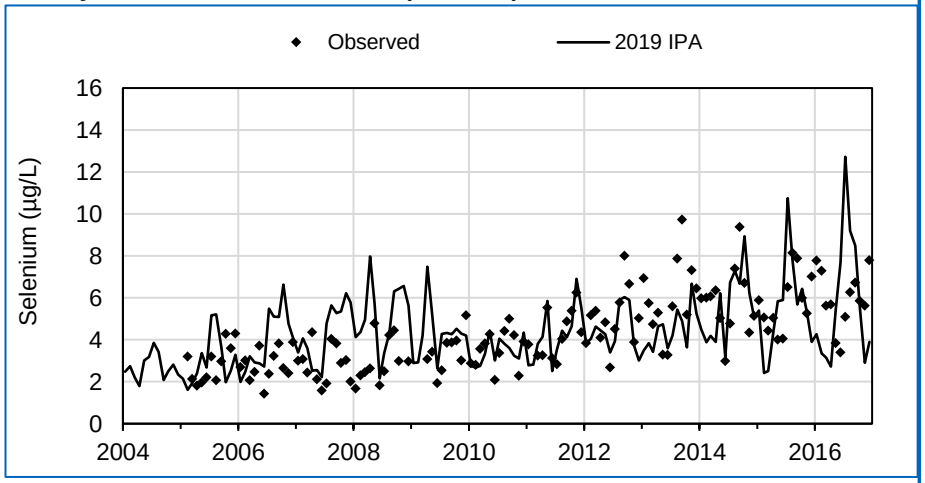


Weekly Simulated Concentrations (2019 IPA and 2017 RWQM)



Note: Observed data are individual sample results

Monthy Simulated Concentrations (2019 IPA)



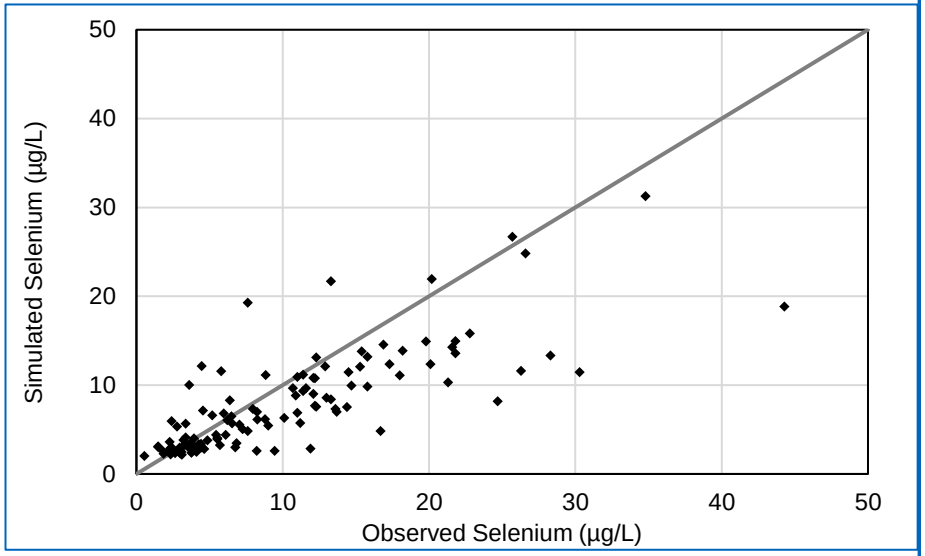
Note: Observed data are monthly averages of sample results

B1-23: Selenium Calibration Information for Node FR_FR1 - Fording River d/s of Henretta Creek (EMS 0200251)

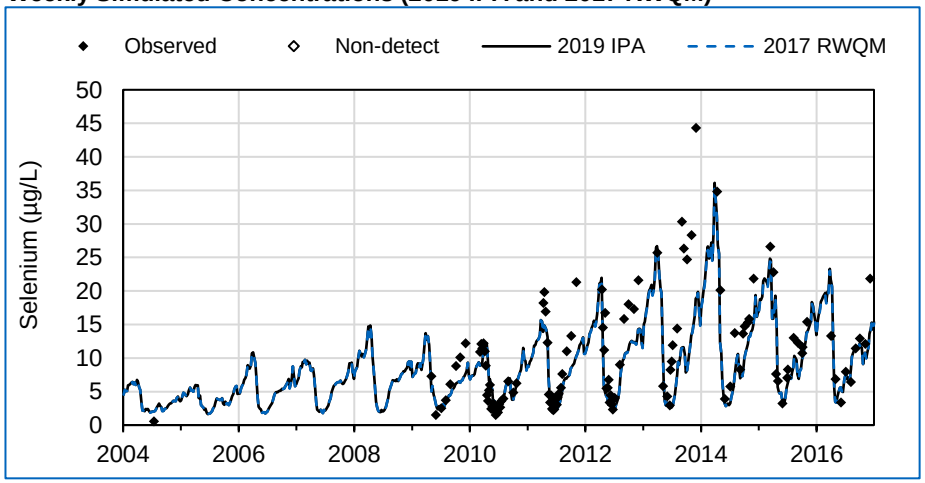
Observed and Simulated Selenium Data and Calibration Statistics

Statistic	2017 RWQM	2019 IPA	
Model Averaging Period	Weekly	Weekly	Monthly
Calibration Period	2004 to 2016		
First Observed Sample	7/13/2004		
Last Observed Sample	12/7/2016		
Data Points Available for Comparison, n	115	115	70
Non-Detect Count	0	0	0
Observed Mean (mg/L)	10	10	12
Simulated Mean (mg/L)	7.9	7.9	8.9
Bias (mg/L)	-2.4	-2.3	-3.0
Relative Bias	0.77	0.77	0.75
Error (mg/L)	3.6	3.5	3.6
Percent Error	35%	35%	31%

2019 IPA Simulated vs. Observed Selenium Concentrations

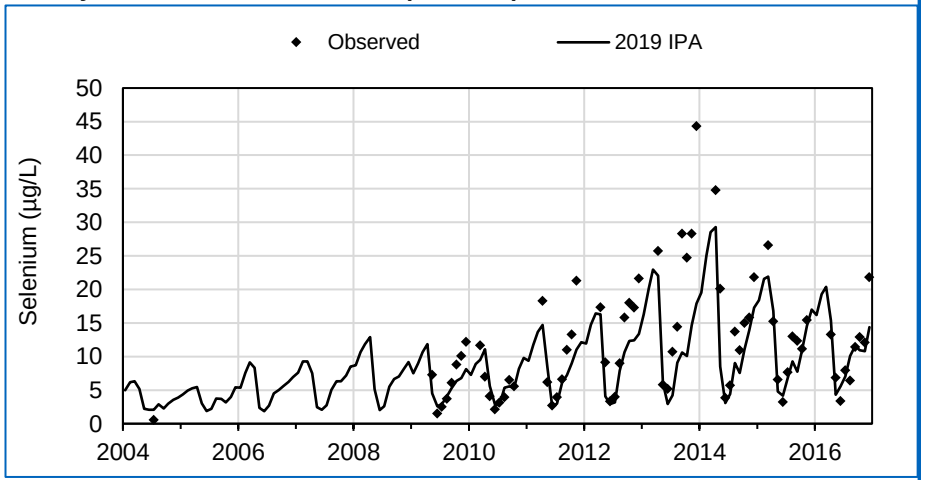


Weekly Simulated Concentrations (2019 IPA and 2017 RWQM)



Note: Observed data are individual sample results

Monthy Simulated Concentrations (2019 IPA)



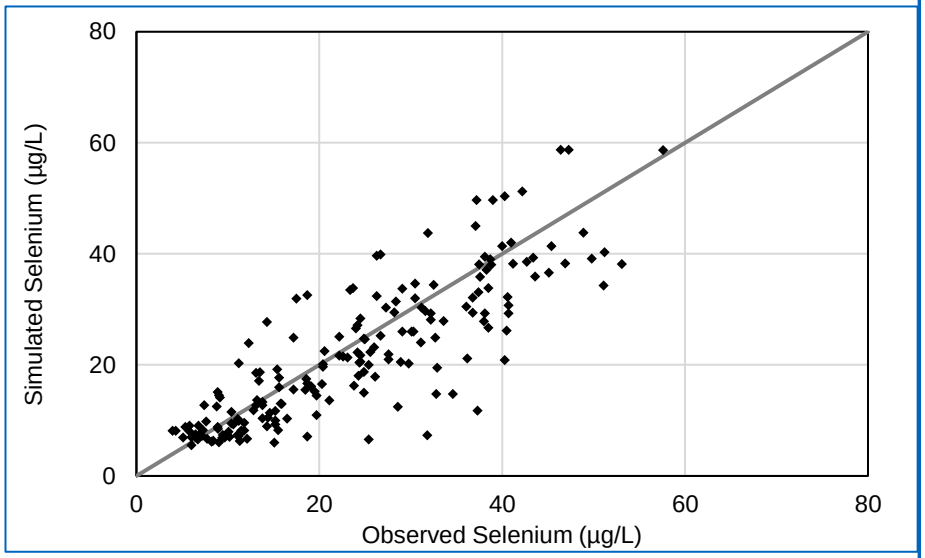
Note: Observed data are monthly averages of sample results

B1-24: Selenium Calibration Information for Node FR_FR2 - Fording River u/s of Kilmarnock Creek (EMS 0200201)

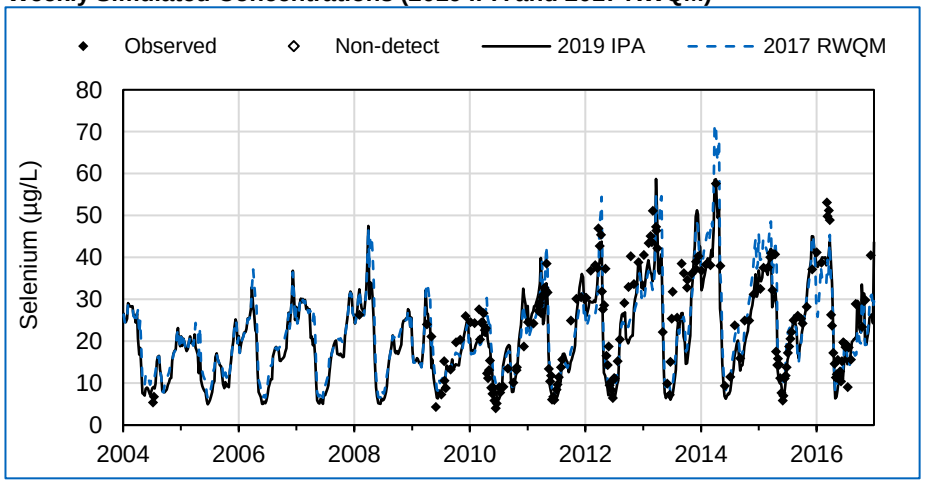
Observed and Simulated Selenium Data and Calibration Statistics

Statistic	2017 RWQM	2019 IPA	
Model Averaging Period	Weekly	Weekly	Monthly
Calibration Period	2004 to 2016		
First Observed Sample	7/7/2004		
Last Observed Sample	12/12/2016		
Data Points Available for Comparison, n	187	187	92
Non-Detect Count	0	0	0
Observed Mean (mg/L)	24	24	25
Simulated Mean (mg/L)	23	22	23
Bias (mg/L)	-0.17	-2.0	-2.1
Relative Bias	0.99	0.92	0.92
Error (mg/L)	5.7	5.4	4.6
Percent Error	24%	23%	18%

2019 IPA Simulated vs. Observed Selenium Concentrations

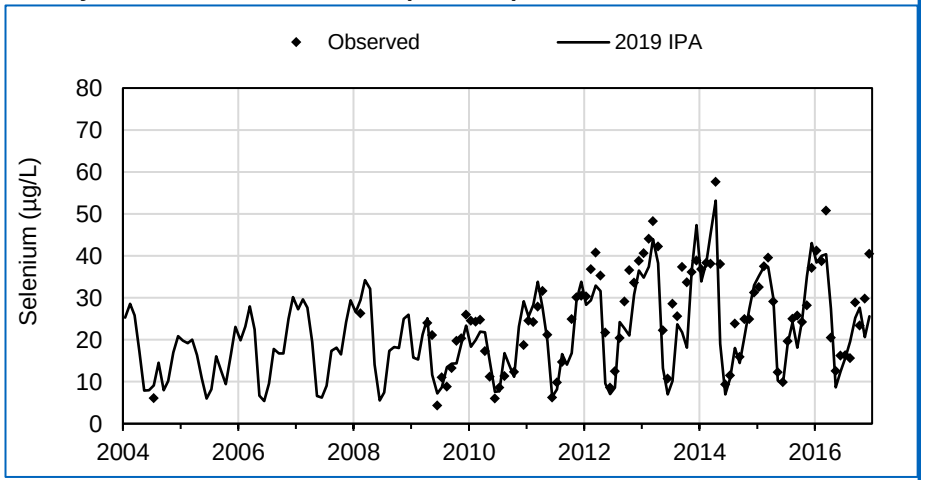


Weekly Simulated Concentrations (2019 IPA and 2017 RWQM)



Note: Observed data are individual sample results

Monthy Simulated Concentrations (2019 IPA)



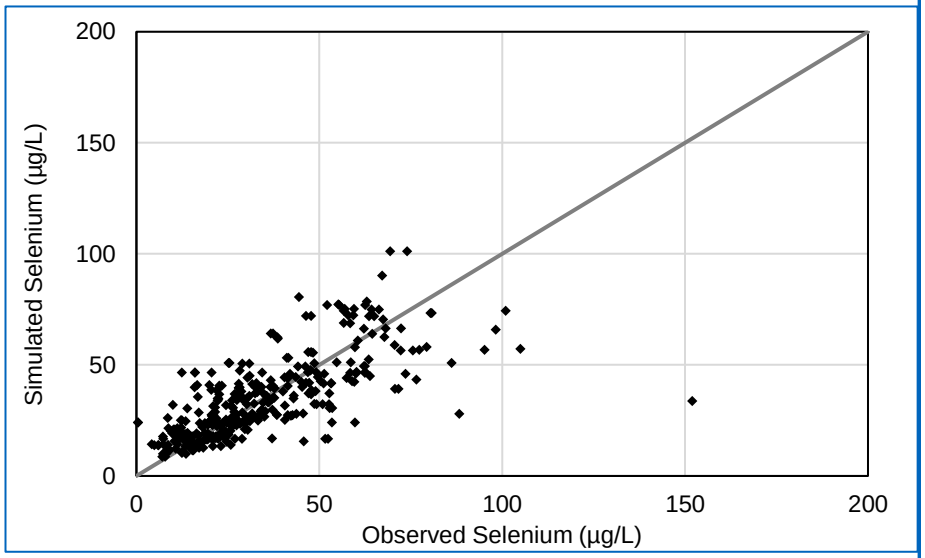
Note: Observed data are monthly averages of sample results

B1-25: Selenium Calibration Information for Node FR_FR4 - Fording River between Swift and Cataract creeks (EMS 0200311)

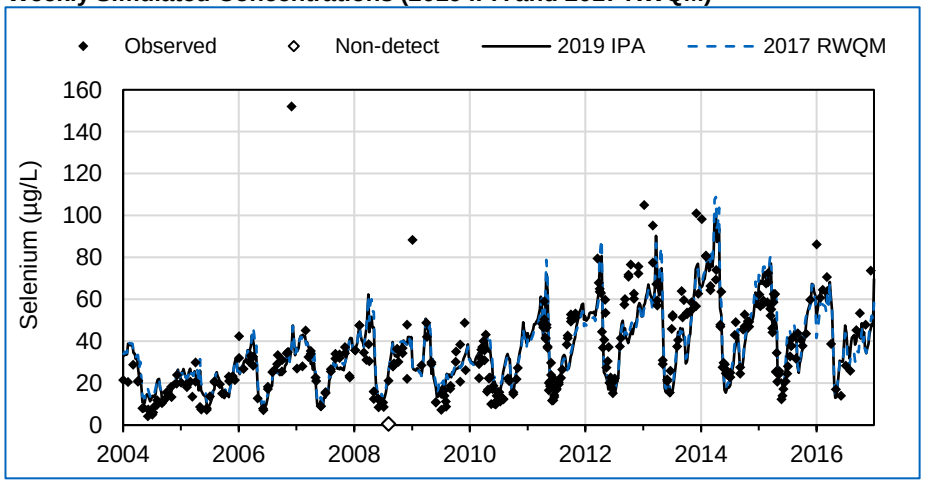
Observed and Simulated Selenium Data and Calibration Statistics

Statistic	2017 RWQM	2019 IPA	
Model Averaging Period	Weekly	Weekly	Monthly
Calibration Period	2004 to 2016		
First Observed Sample	1/2/2004		
Last Observed Sample	12/12/2016		
Data Points Available for Comparison, n	355	355	143
Non-Detect Count	2	2	0
Observed Mean (mg/L)	34	34	35
Simulated Mean (mg/L)	36	34	34
Bias (mg/L)	1.9	0.14	-0.94
Relative Bias	1.1	1.0	0.97
Error (mg/L)	11	9.9	8.7
Percent Error	31%	29%	25%

2019 IPA Simulated vs. Observed Selenium Concentrations

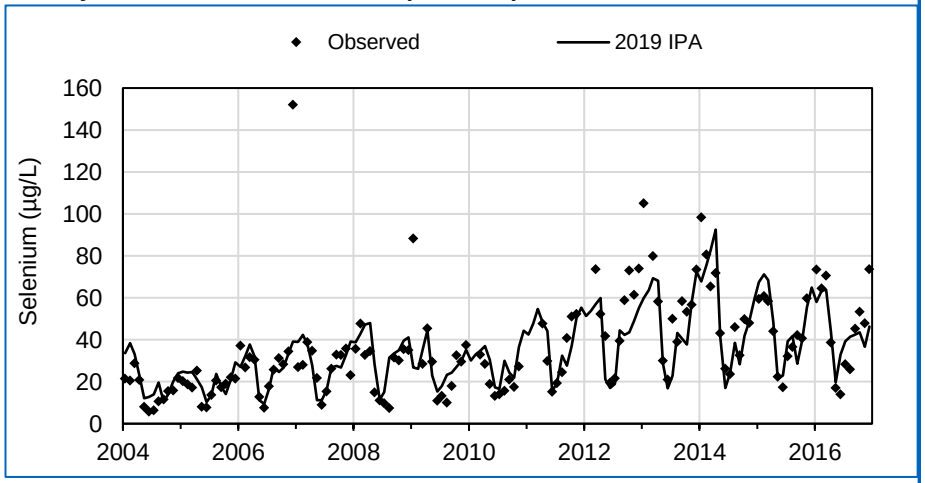


Weekly Simulated Concentrations (2019 IPA and 2017 RWQM)



Note: Observed data are individual sample results

Monthy Simulated Concentrations (2019 IPA)



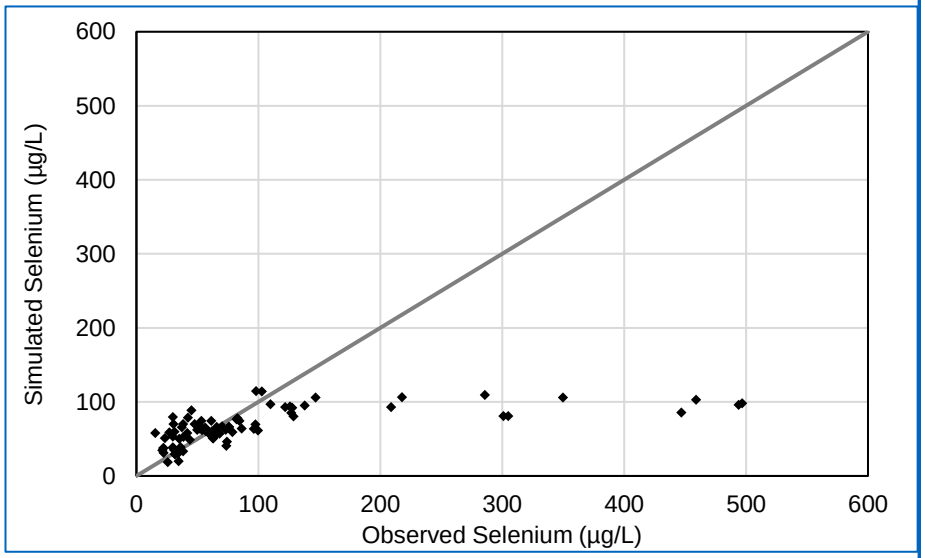
Note: Observed data are monthly averages of sample results

B1-26: Selenium Calibration Information for Node FR_FRCP1 - FRO Compliance Point - Fording R., 525 m d/s of Cataract Creek (EMS E300071)

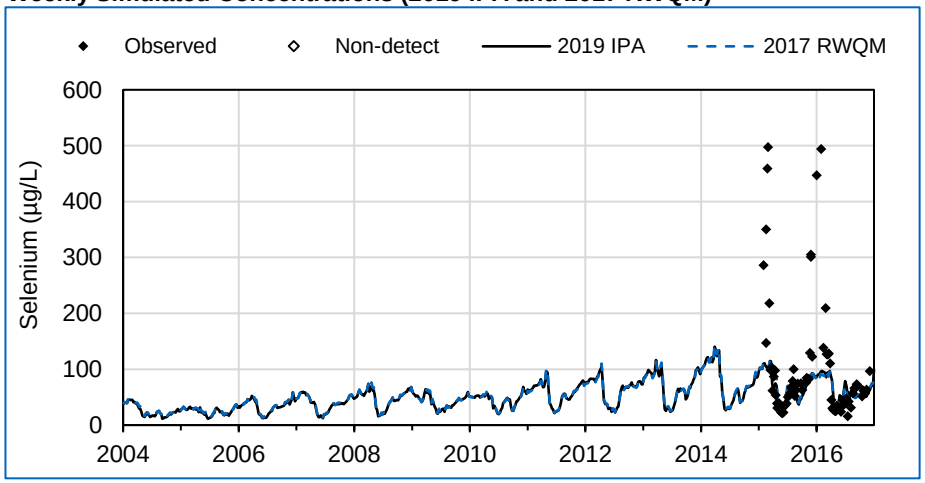
Observed and Simulated Selenium Data and Calibration Statistics

Statistic	2017 RWQM	2019 IPA	
Model Averaging Period	Weekly	Weekly	Monthly
Calibration Period	2004 to 2016		
First Observed Sample	2/3/2015		
Last Observed Sample	12/6/2016		
Data Points Available for Comparison, n	82	82	23
Non-Detect Count	0	0	0
Observed Mean (mg/L)	97	97	113
Simulated Mean (mg/L)	66	66	67
Bias (mg/L)	-31	-31	-46
Relative Bias	0.68	0.68	0.6
Error (mg/L)	48	48	56
Percent Error	50%	49%	50%

2019 IPA Simulated vs. Observed Selenium Concentrations

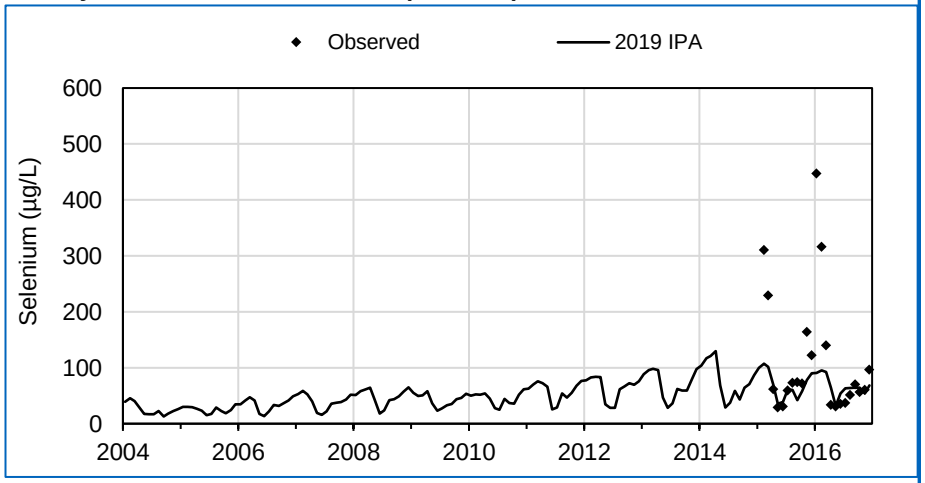


Weekly Simulated Concentrations (2019 IPA and 2017 RWQM)



Note: Observed data are individual sample results

Monthy Simulated Concentrations (2019 IPA)



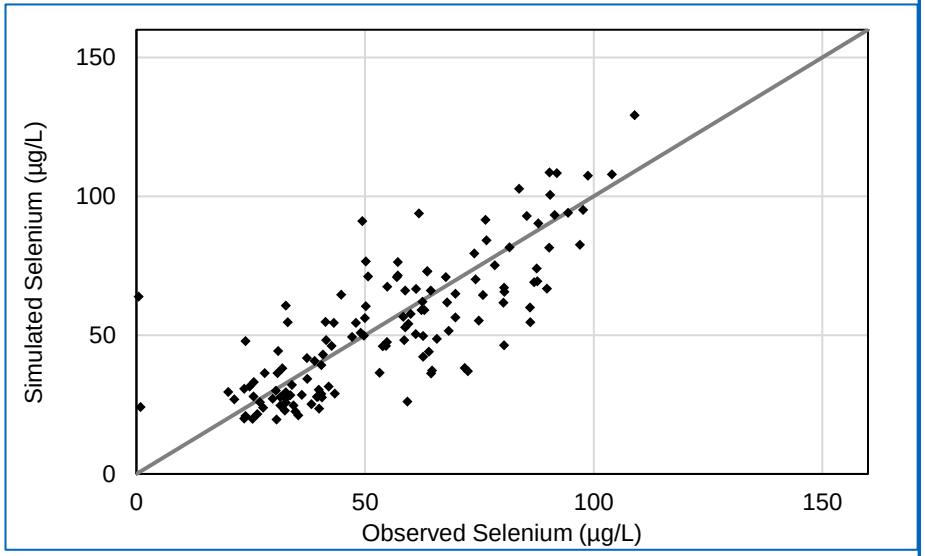
Note: Observed data are monthly averages of sample results

B1-27: Selenium Calibration Information for Node GH_PC2 - Fording River d/s of Porter Creek (EMS E287431)

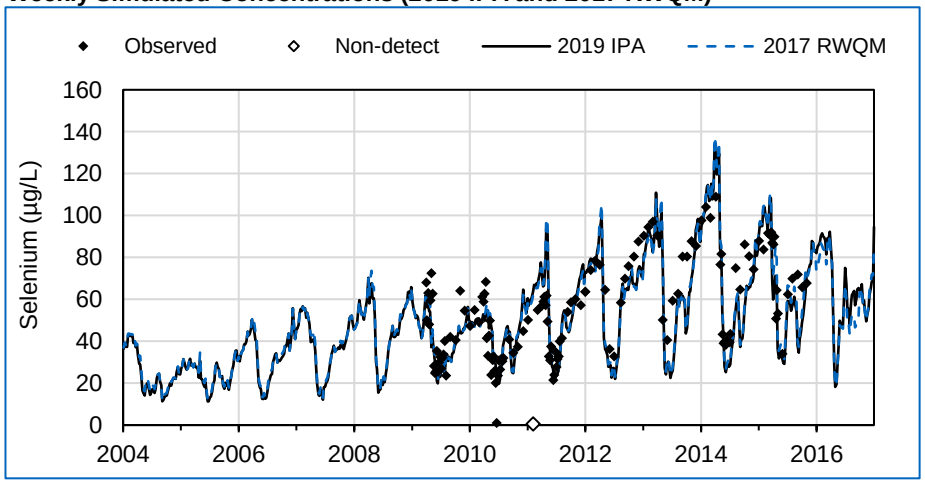
Observed and Simulated Selenium Data and Calibration Statistics

Statistic	2017 RWQM	2019 IPA	
Model Averaging Period	Weekly	Weekly	Monthly
Calibration Period	2004 to 2016		
First Observed Sample	4/1/2009		
Last Observed Sample	11/2/2015		
Data Points Available for Comparison, n	134	134	80
Non-Detect Count	1	1	0
Observed Mean (mg/L)	55	55	60
Simulated Mean (mg/L)	55	53	59
Bias (mg/L)	0.048	-1.5	-1.7
Relative Bias	1.0	0.97	0.97
Error (mg/L)	12	12	10
Percent Error	21%	21%	17%

2019 IPA Simulated vs. Observed Selenium Concentrations

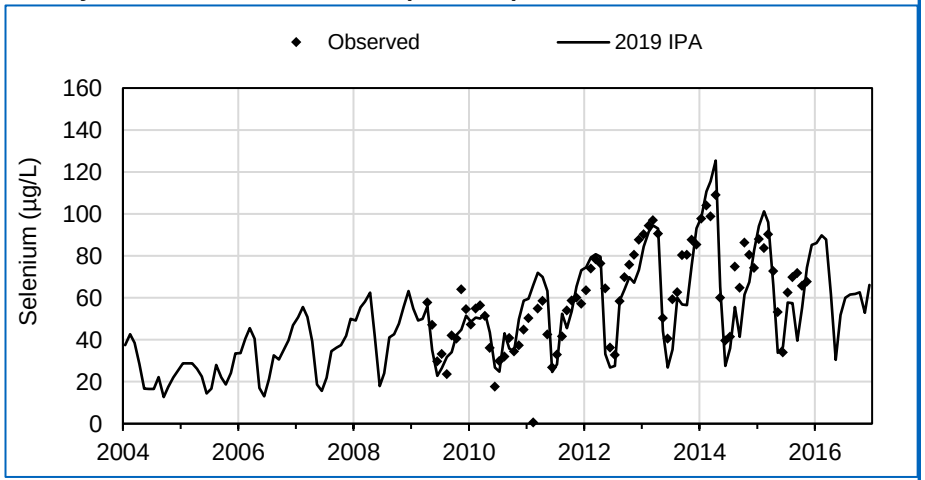


Weekly Simulated Concentrations (2019 IPA and 2017 RWQM)



Note: Observed data are individual sample results

Monthy Simulated Concentrations (2019 IPA)



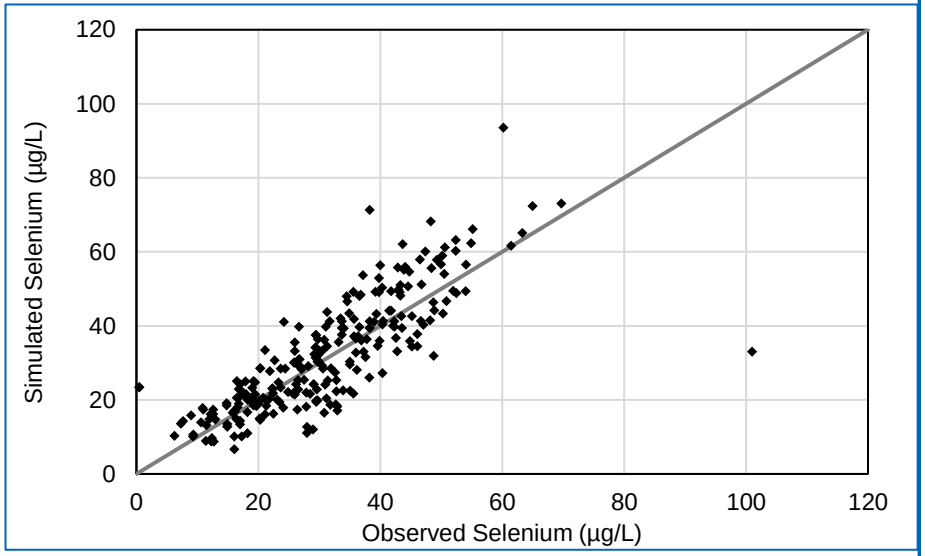
Note: Observed data are monthly averages of sample results

B1-28: Selenium Calibration Information for Node GH_FR1 - GHO Fording River Compliance Point (EMS 0200378)

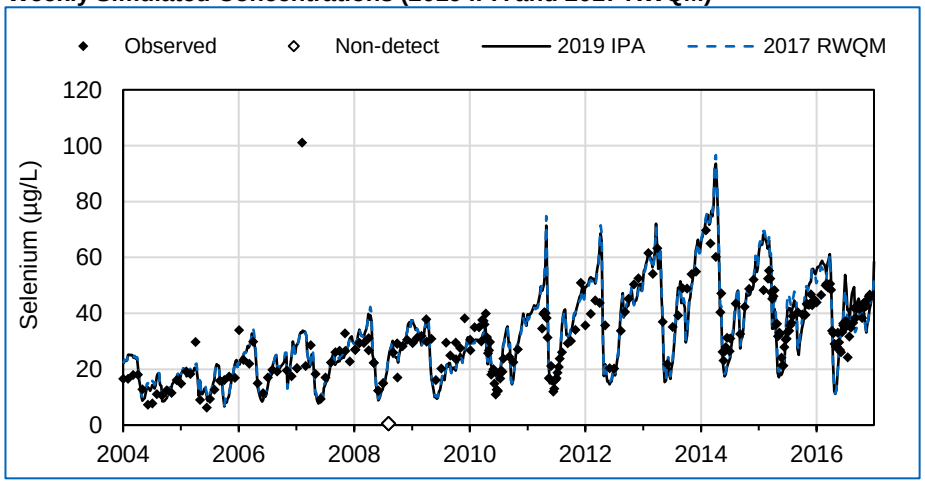
Observed and Simulated Selenium Data and Calibration Statistics

Statistic	2017 RWQM	2019 IPA	
Model Averaging Period	Weekly	Weekly	Monthly
Calibration Period	2004 to 2016		
First Observed Sample	1/2/2004		
Last Observed Sample	12/6/2016		
Data Points Available for Comparison, n	253	253	148
Non-Detect Count	2	2	0
Observed Mean (mg/L)	31	31	30
Simulated Mean (mg/L)	32	32	31
Bias (mg/L)	1.3	0.96	0.88
Relative Bias	1.0	1.0	1.0
Error (mg/L)	6.3	6.4	6.1
Percent Error	20%	21%	20%

2019 IPA Simulated vs. Observed Selenium Concentrations

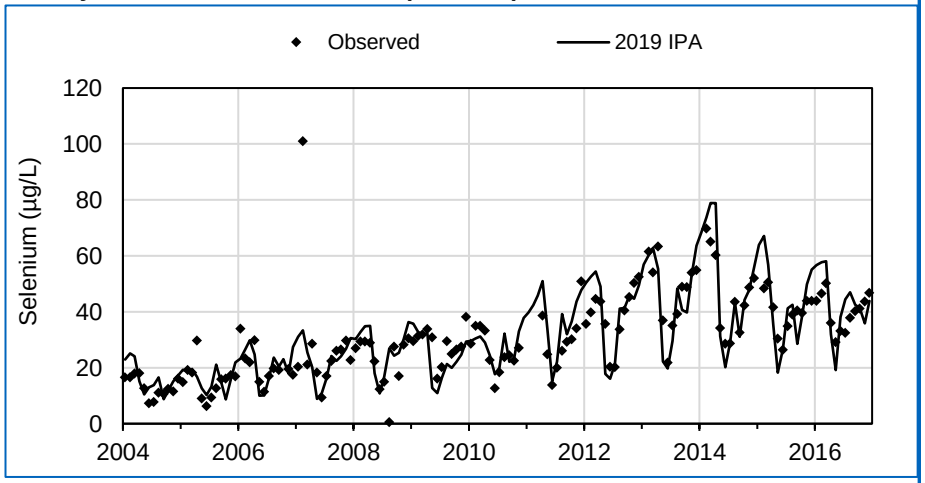


Weekly Simulated Concentrations (2019 IPA and 2017 RWQM)



Note: Observed data are individual sample results

Monthy Simulated Concentrations (2019 IPA)



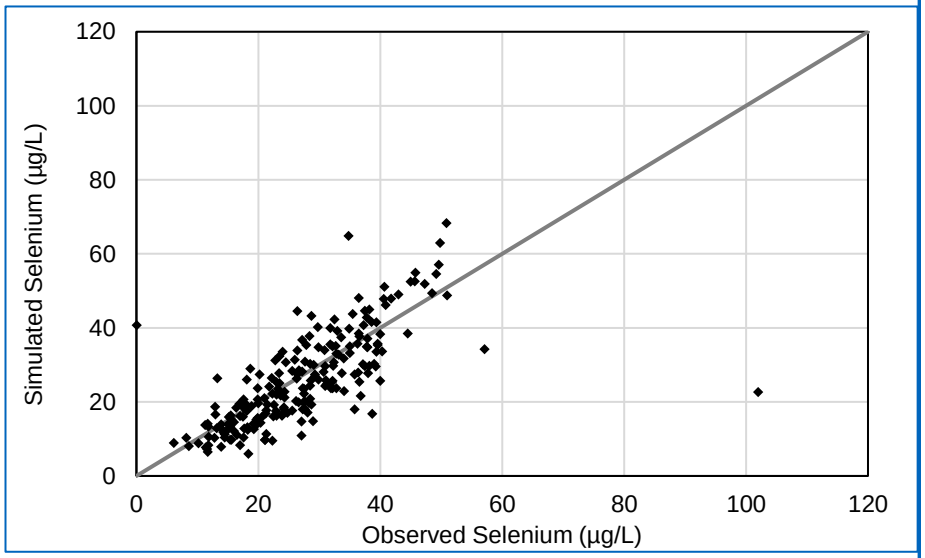
Note: Observed data are monthly averages of sample results

B1-29: Selenium Calibration Information for Node LC_LC5 - Fording River d/s of Line Creek (EMS 0200028)

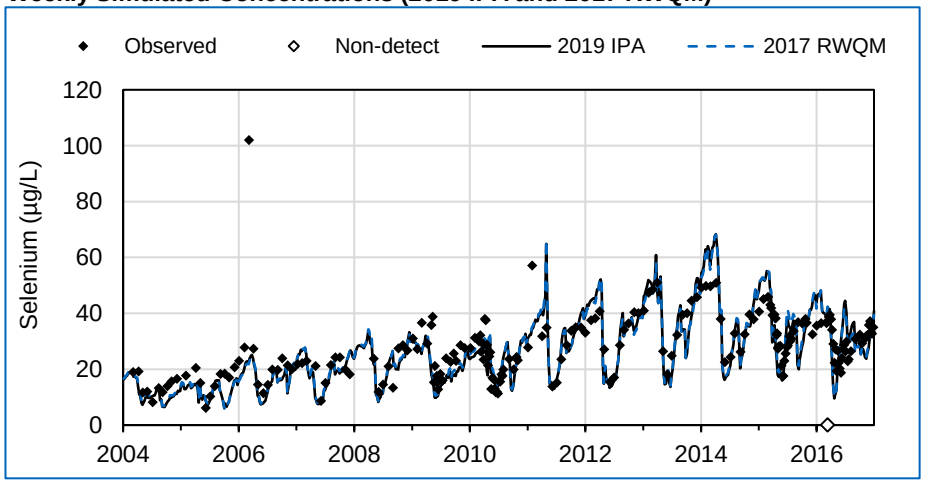
Observed and Simulated Selenium Data and Calibration Statistics

Statistic	2017 RWQM	2019 IPA	
Model Averaging Period	Weekly	Weekly	Monthly
Calibration Period	2004 to 2016		
First Observed Sample	3/4/2004		
Last Observed Sample	12/28/2016		
Data Points Available for Comparison, n	215	215	145
Non-Detect Count	1	1	0
Observed Mean (mg/L)	27	27	28
Simulated Mean (mg/L)	26	26	26
Bias (mg/L)	-0.89	-1.4	-1.2
Relative Bias	0.97	0.95	0.96
Error (mg/L)	5.8	6.1	5.6
Percent Error	21%	22%	20%

2019 IPA Simulated vs. Observed Selenium Concentrations

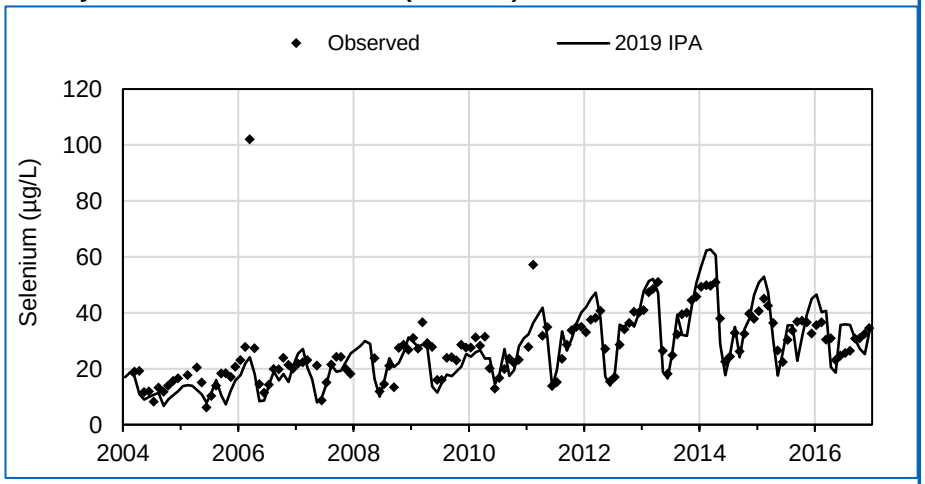


Weekly Simulated Concentrations (2019 IPA and 2017 RWQM)



Note: Observed data are individual sample results

Monthy Simulated Concentrations (2019 IPA)



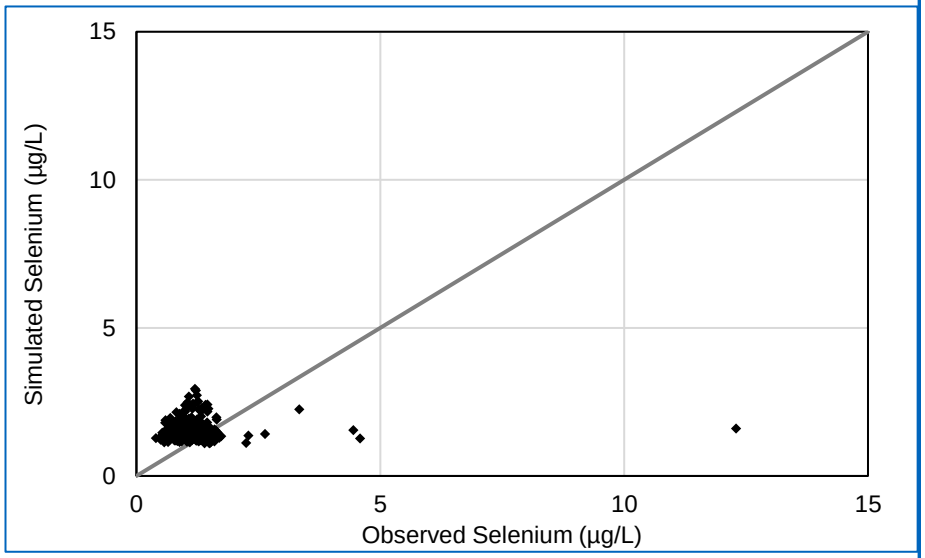
Note: Observed data are monthly averages of sample results

B1-30: Selenium Calibration Information for Node EV_MC3 - Michel Creek u/s of Erickson Creek (EMS 0200203)

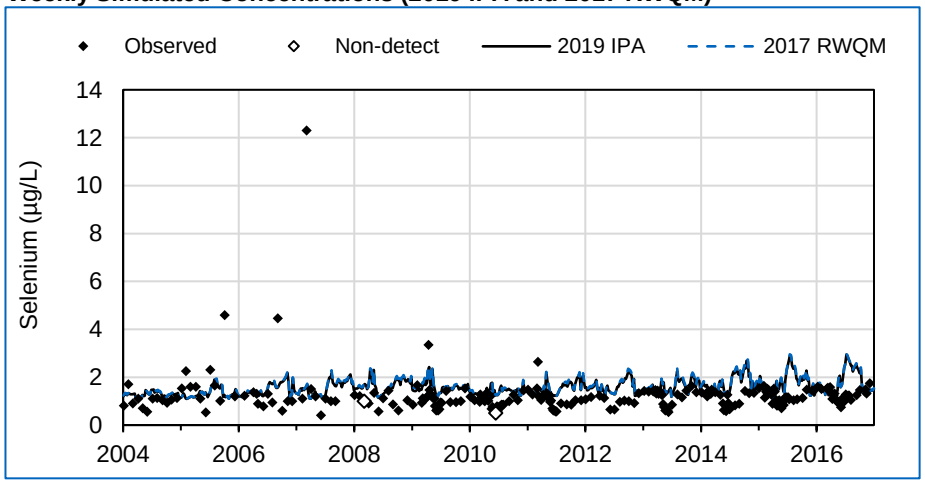
Observed and Simulated Selenium Data and Calibration Statistics

Statistic	2017 RWQM	2019 IPA	
Model Averaging Period	Weekly	Weekly	Monthly
Calibration Period	2004 to 2016		
First Observed Sample	1/6/2004		
Last Observed Sample	12/6/2016		
Data Points Available for Comparison, n	244	244	147
Non-Detect Count	2	2	0
Observed Mean (mg/L)	1.2	1.2	1.3
Simulated Mean (mg/L)	1.6	1.6	1.6
Bias (mg/L)	0.39	0.35	0.31
Relative Bias	1.3	1.3	1.2
Error (mg/L)	0.61	0.59	0.61
Percent Error	51%	49%	48%

2019 IPA Simulated vs. Observed Selenium Concentrations

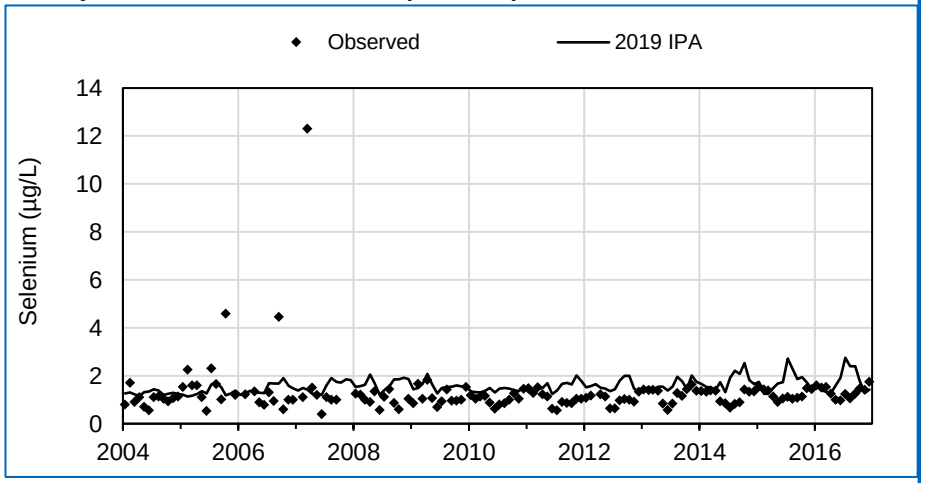


Weekly Simulated Concentrations (2019 IPA and 2017 RWQM)



Note: Observed data are individual sample results

Monthy Simulated Concentrations (2019 IPA)



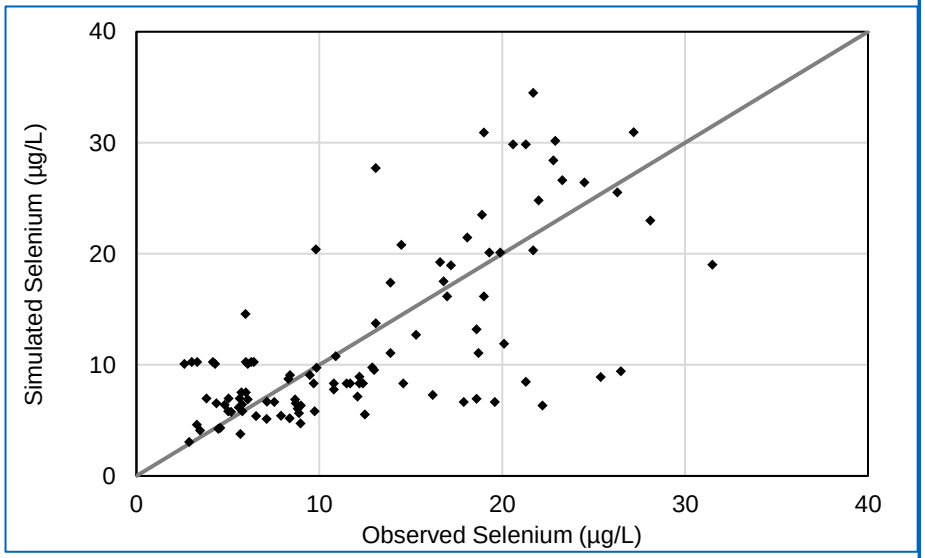
Note: Observed data are monthly averages of sample results

B1-31: Selenium Calibration Information for Node EV_MC2 - EVO Michel Creek Compliance Point (EMS E300091)

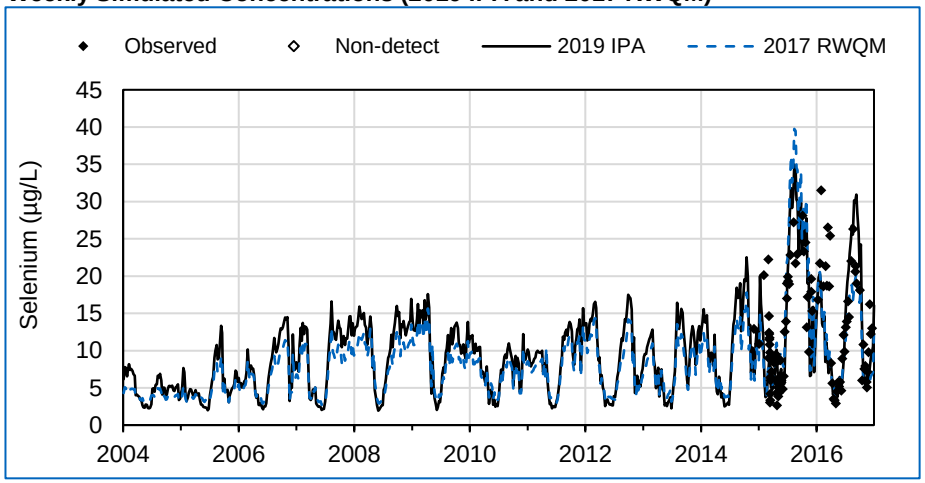
Observed and Simulated Selenium Data and Calibration Statistics

Statistic	2017 RWQM	2019 IPA	
Model Averaging Period	Weekly	Weekly	Monthly
Calibration Period	2004 to 2016		
First Observed Sample	12/3/2014		
Last Observed Sample	12/19/2016		
Data Points Available for Comparison, n	101	101	25
Non-Detect Count	0	0	0
Observed Mean (mg/L)	13	13	15
Simulated Mean (mg/L)	12	12	15
Bias (mg/L)	-0.28	-0.44	-0.63
Relative Bias	0.98	0.97	0.96
Error (mg/L)	4.6	4.3	4.3
Percent Error	37%	34%	28%

2019 IPA Simulated vs. Observed Selenium Concentrations

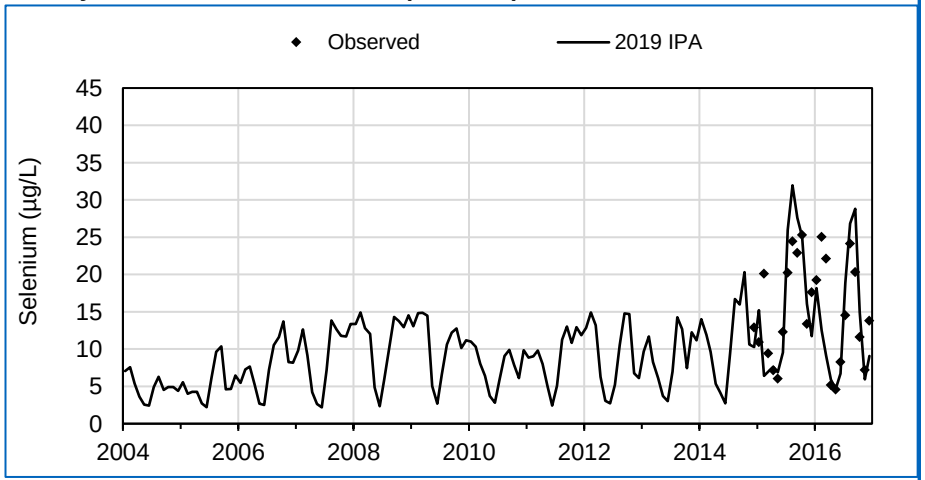


Weekly Simulated Concentrations (2019 IPA and 2017 RWQM)



Note: Observed data are individual sample results

Monthy Simulated Concentrations (2019 IPA)



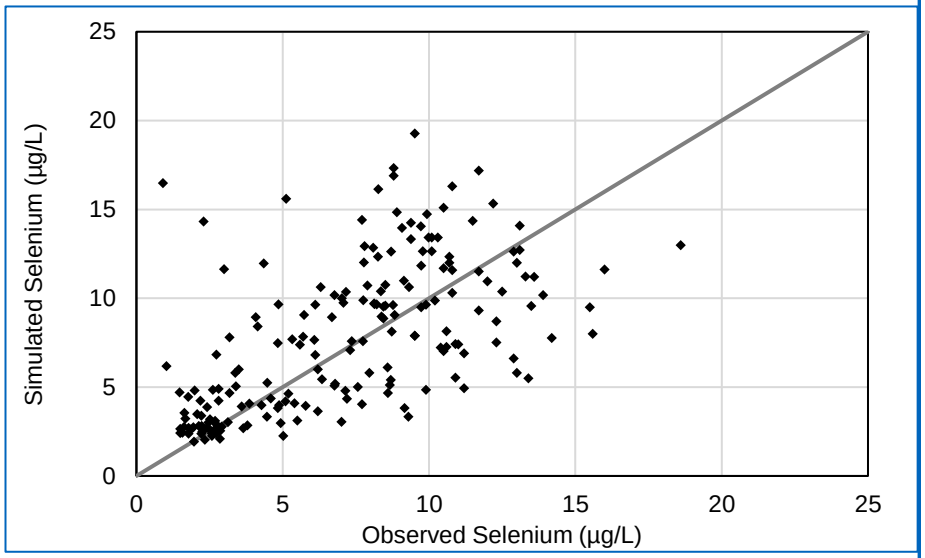
Note: Observed data are monthly averages of sample results

B1-32: Selenium Calibration Information for Node EV_MC1 - Michel Creek u/s of Highway 43 Bridge (EMS 0200425)

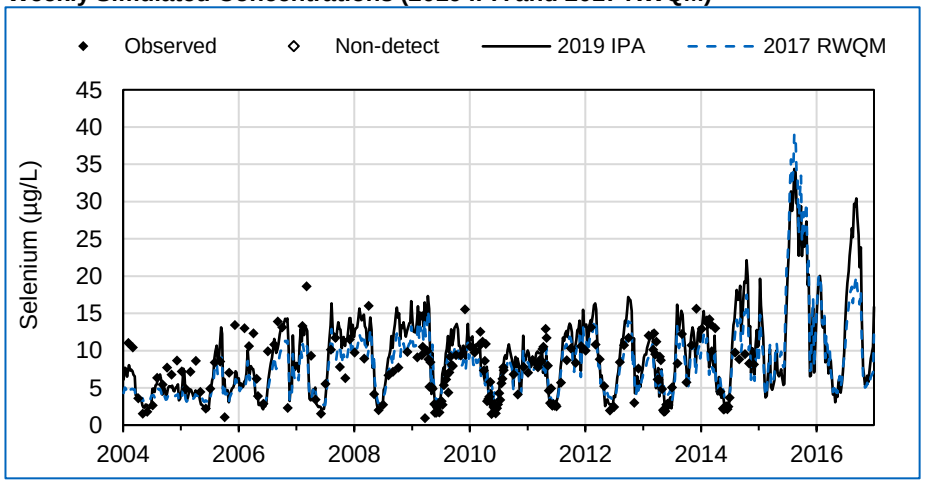
Observed and Simulated Selenium Data and Calibration Statistics

Statistic	2017 RWQM	2019 IPA	
Model Averaging Period	Weekly	Weekly	Monthly
Calibration Period	2004 to 2016		
First Observed Sample	2/3/2004		
Last Observed Sample	12/3/2014		
Data Points Available for Comparison, n	193	193	123
Non-Detect Count	0	0	0
Observed Mean (mg/L)	7.1	7.1	7.7
Simulated Mean (mg/L)	6.9	7.7	8.4
Bias (mg/L)	-0.14	0.66	0.71
Relative Bias	0.98	1.1	1.1
Error (mg/L)	2.5	2.7	2.6
Percent Error	36%	38%	34%

2019 IPA Simulated vs. Observed Selenium Concentrations

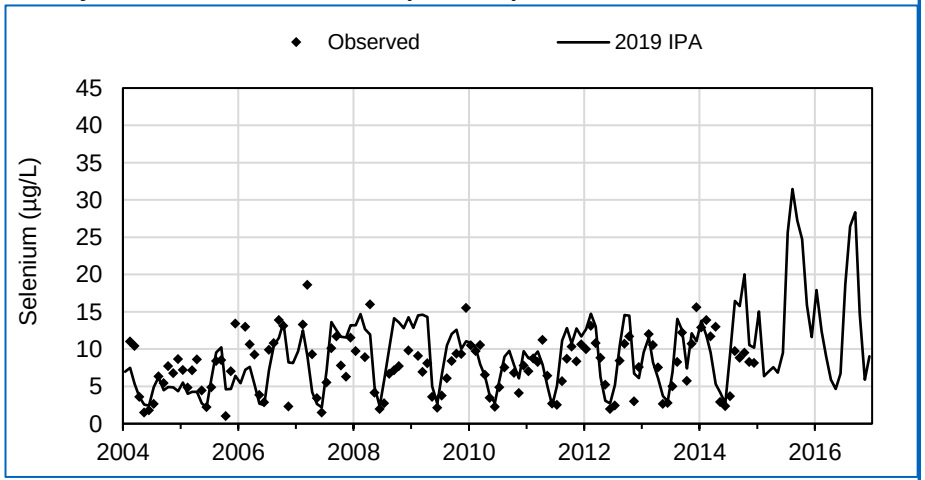


Weekly Simulated Concentrations (2019 IPA and 2017 RWQM)



Note: Observed data are individual sample results

Monthy Simulated Concentrations (2019 IPA)



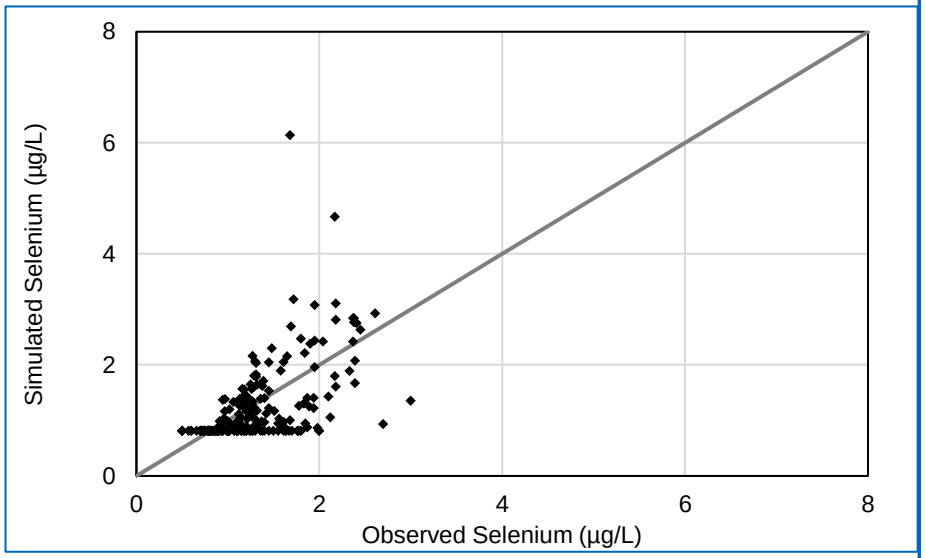
Note: Observed data are monthly averages of sample results

B1-33: Selenium Calibration Information for Node GH_ER1 - Elk River u/s of Boivin Creek and u/s of Fording River (EMS E206661)

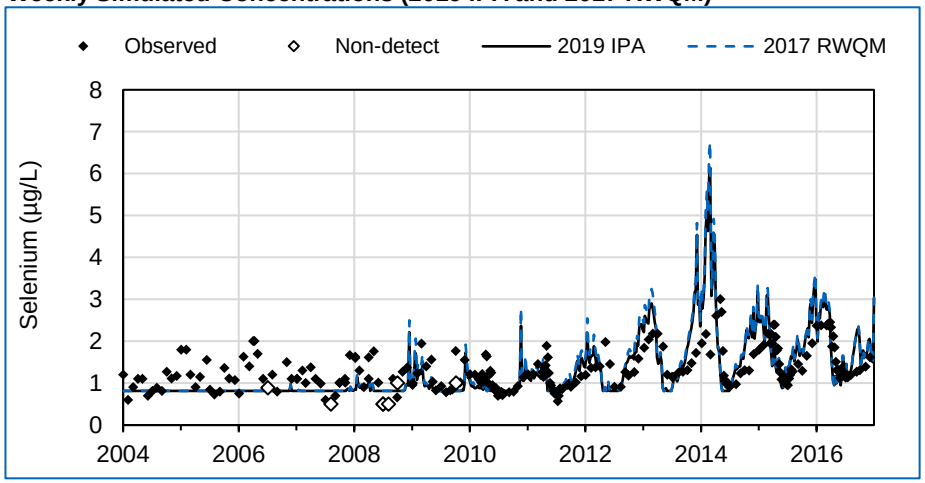
Observed and Simulated Selenium Data and Calibration Statistics

Statistic	2017 RWQM	2019 IPA	
Model Averaging Period	Weekly	Weekly	Monthly
Calibration Period	2004 to 2016		
First Observed Sample	1/2/2004		
Last Observed Sample	12/7/2016		
Data Points Available for Comparison, n	233	233	155
Non-Detect Count	7	7	0
Observed Mean (mg/L)	1.3	1.3	1.3
Simulated Mean (mg/L)	1.3	1.2	1.3
Bias (mg/L)	-0.033	-0.08	-0.0086
Relative Bias	0.97	0.94	0.99
Error (mg/L)	0.39	0.37	0.4
Percent Error	30%	29%	31%

2019 IPA Simulated vs. Observed Selenium Concentrations

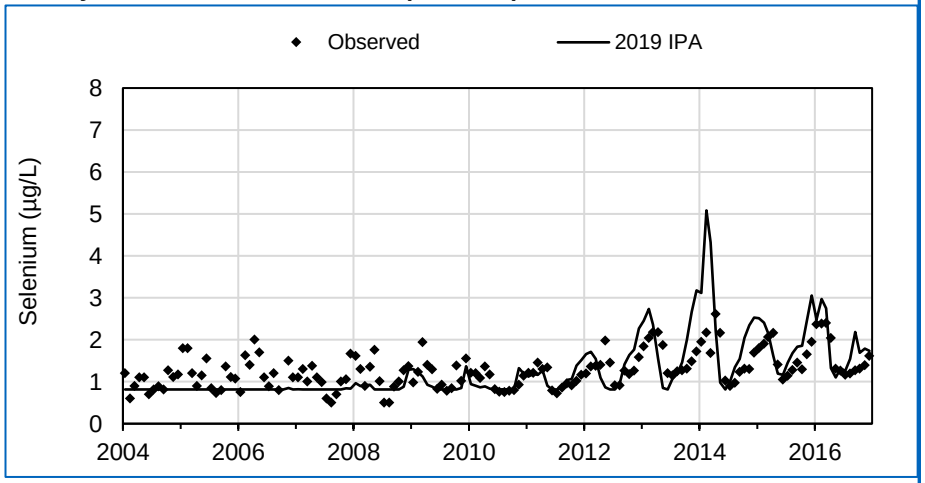


Weekly Simulated Concentrations (2019 IPA and 2017 RWQM)



Note: Observed data are individual sample results

Monthy Simulated Concentrations (2019 IPA)



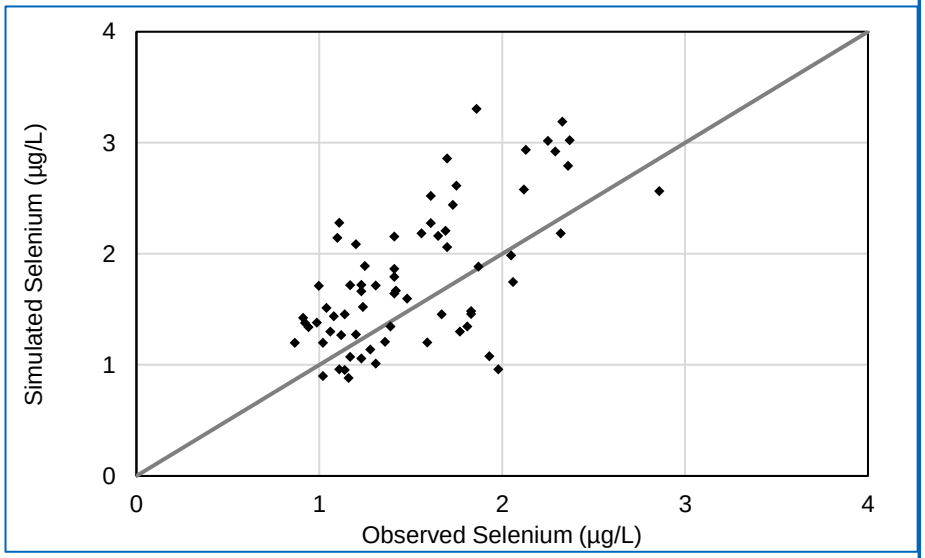
Note: Observed data are monthly averages of sample results

B1-34: Selenium Calibration Information for Node GH_ERC - GHO Elk River Compliance Point (EMS E300090)

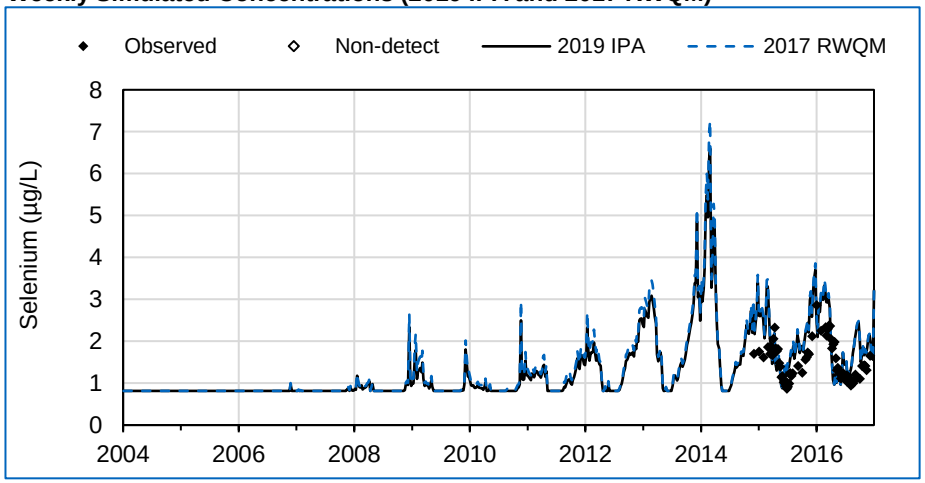
Observed and Simulated Selenium Data and Calibration Statistics

Statistic	2017 RWQM	2019 IPA	
Model Averaging Period	Weekly	Weekly	Monthly
Calibration Period	2004 to 2016		
First Observed Sample	12/4/2014		
Last Observed Sample	12/7/2016		
Data Points Available for Comparison, n	68	68	25
Non-Detect Count	0	0	0
Observed Mean (mg/L)	1.5	1.5	1.6
Simulated Mean (mg/L)	1.8	1.8	2.0
Bias (mg/L)	0.32	0.27	0.43
Relative Bias	1.2	1.2	1.3
Error (mg/L)	0.5	0.47	0.56
Percent Error	33%	31%	35%

2019 IPA Simulated vs. Observed Selenium Concentrations

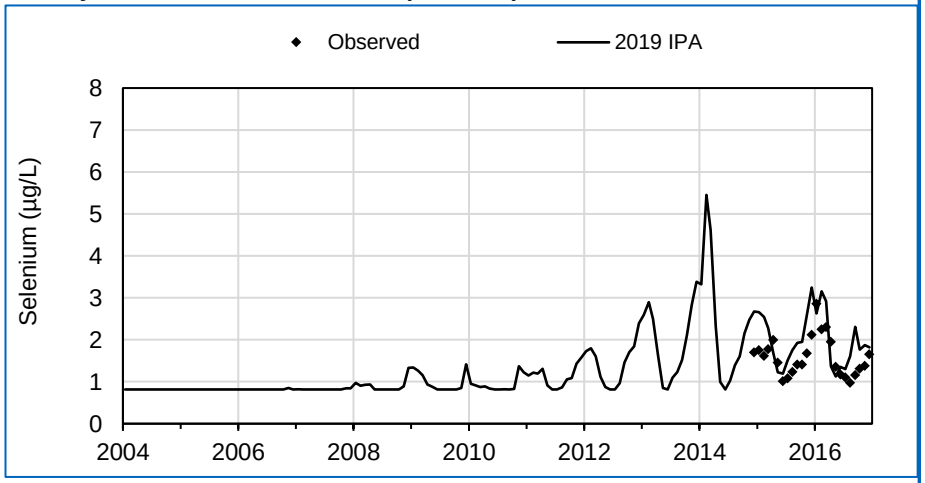


Weekly Simulated Concentrations (2019 IPA and 2017 RWQM)



Note: Observed data are individual sample results

Monthy Simulated Concentrations (2019 IPA)



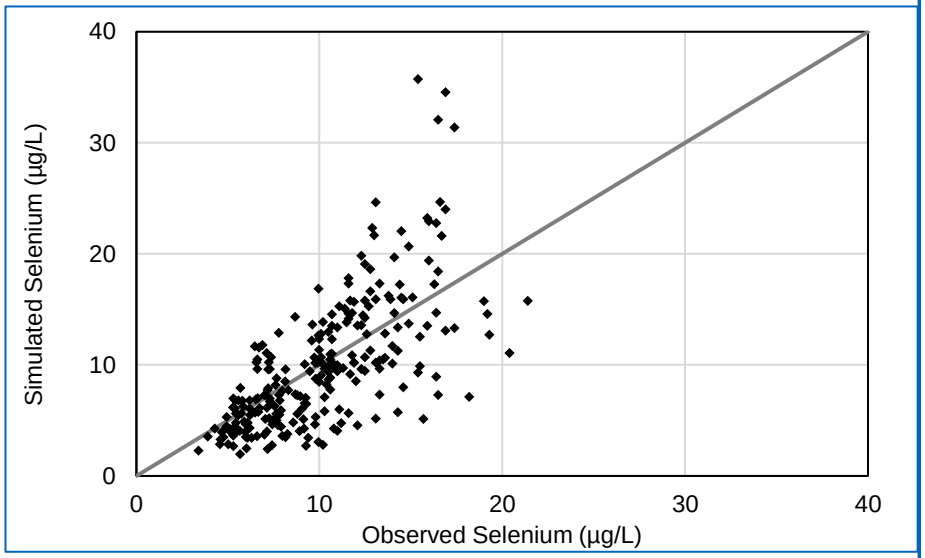
Note: Observed data are monthly averages of sample results

B1-35: Selenium Calibration Information for Node EV_ER4 - Elk River u/s of Grave Creek (EMS 0200027)

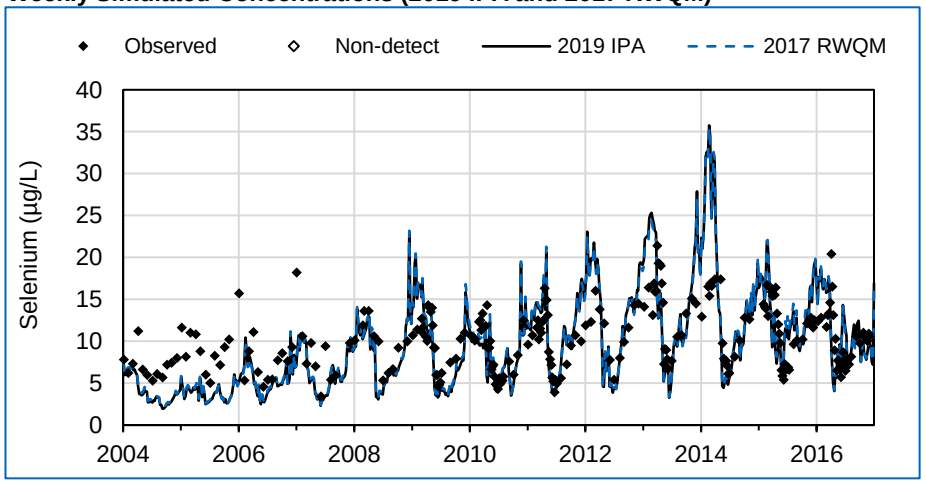
Observed and Simulated Selenium Data and Calibration Statistics

Statistic	2017 RWQM	2019 IPA	
Model Averaging Period	Weekly	Weekly	Monthly
Calibration Period	2004 to 2016		
First Observed Sample	1/6/2004		
Last Observed Sample	12/6/2016		
Data Points Available for Comparison, n	252	252	149
Non-Detect Count	0	0	0
Observed Mean (mg/L)	10	10	9.8
Simulated Mean (mg/L)	10	9.9	9.6
Bias (mg/L)	-0.034	-0.24	-0.19
Relative Bias	1.0	0.98	0.98
Error (mg/L)	3.1	3.2	3.1
Percent Error	30%	31%	32%

2019 IPA Simulated vs. Observed Selenium Concentrations

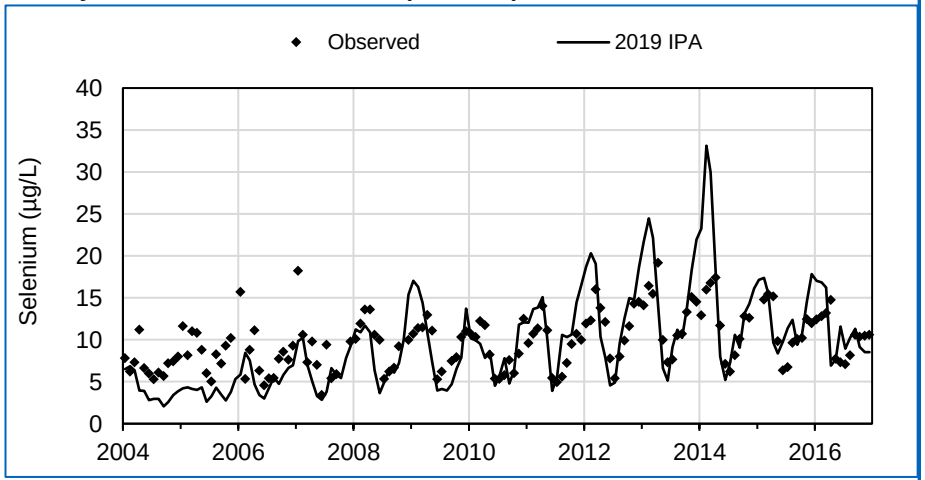


Weekly Simulated Concentrations (2019 IPA and 2017 RWQM)



Note: Observed data are individual sample results

Monthy Simulated Concentrations (2019 IPA)



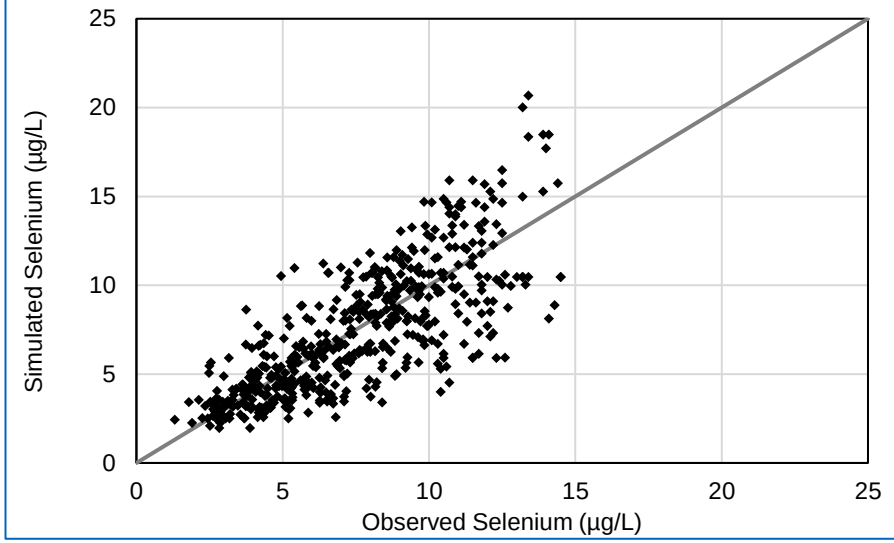
Note: Observed data are monthly averages of sample results

B1-36: Selenium Calibration Information for Node EV_ER1 - Elk River downstream of Michel Creek (EMS 0200393)

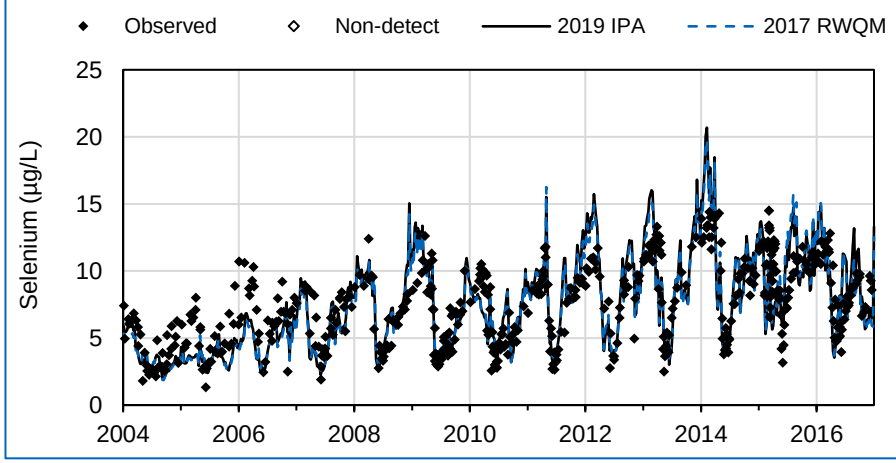
Observed and Simulated Selenium Data and Calibration Statistics

Statistic	2017 RWQM	2019 IPA	
Model Averaging Period	Weekly	Weekly	Monthly
Calibration Period	2004 to 2016		
First Observed Sample	1/6/2004		
Last Observed Sample	12/18/2016		
Data Points Available for Comparison, n	525	525	156
Non-Detect Count	0	0	0
Observed Mean (mg/L)	7.5	7.5	7.4
Simulated Mean (mg/L)	7.4	7.4	7.5
Bias (mg/L)	-0.11	-0.096	0.091
Relative Bias	0.99	0.99	1.0
Error (mg/L)	1.7	1.7	1.5
Percent Error	22%	23%	20%

2019 IPA Simulated vs. Observed Selenium Concentrations

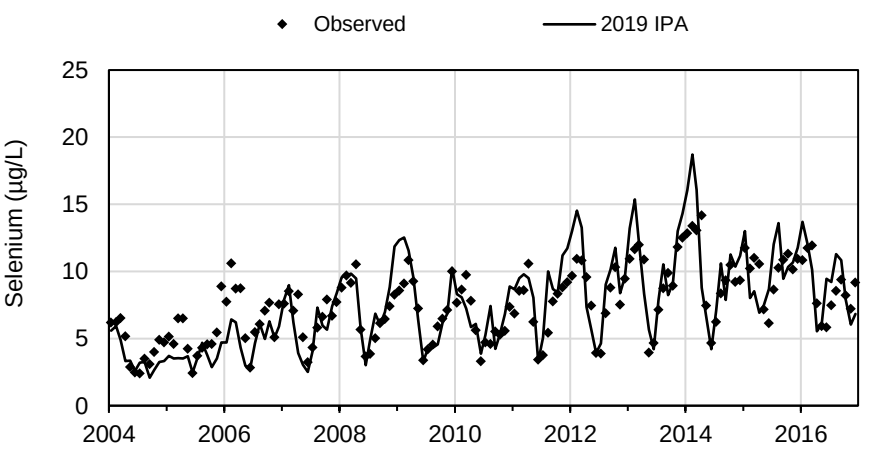


Weekly Simulated Concentrations (2019 IPA and 2017 RWQM)



Note: Observed data are individual sample results

Monthy Simulated Concentrations (2019 IPA)



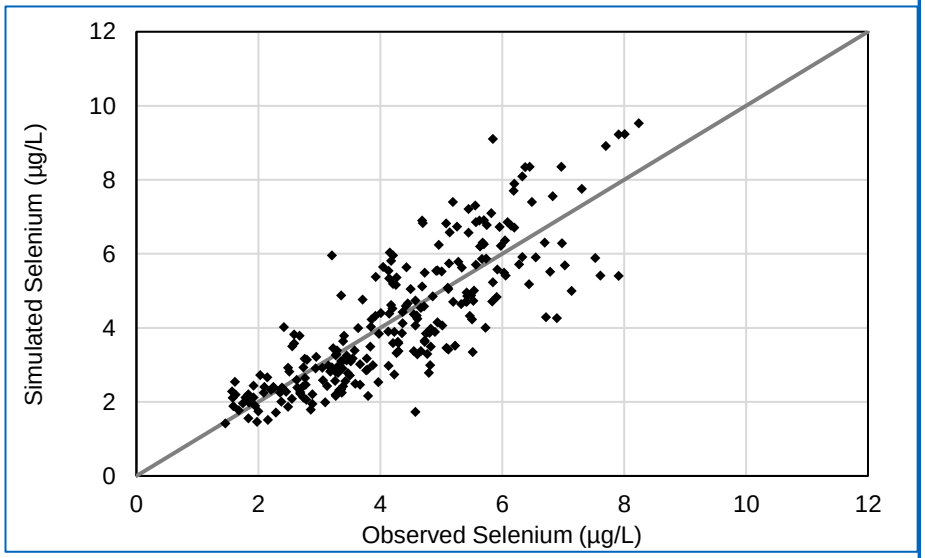
Note: Observed data are monthly averages of sample results

B1-37: Selenium Calibration Information for Node RG_ELKMOUTH - Elk River at Highway 93 near Elko

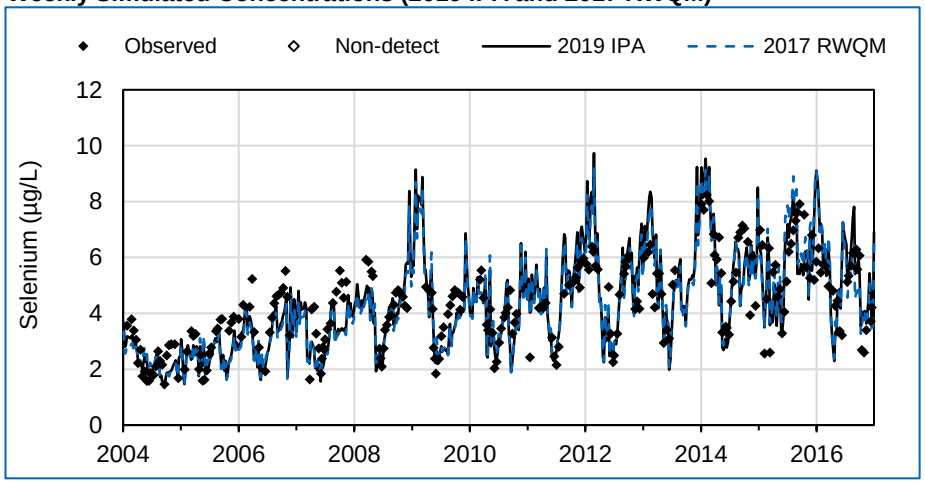
Observed and Simulated Selenium Data and Calibration Statistics

Statistic	2017 RWQM	2019 IPA	
Model Averaging Period	Weekly	Weekly	Monthly
Calibration Period	2004 to 2016		
First Observed Sample	1/26/2004		
Last Observed Sample	12/18/2016		
Data Points Available for Comparison, n	251	251	129
Non-Detect Count	0	0	0
Observed Mean (mg/L)	4.3	4.3	4.3
Simulated Mean (mg/L)	4.2	4.2	4.3
Bias (mg/L)	-0.085	-0.058	0.0052
Relative Bias	0.98	0.99	1.0
Error (mg/L)	0.83	0.8	0.77
Percent Error	19%	19%	18%

2019 IPA Simulated vs. Observed Selenium Concentrations

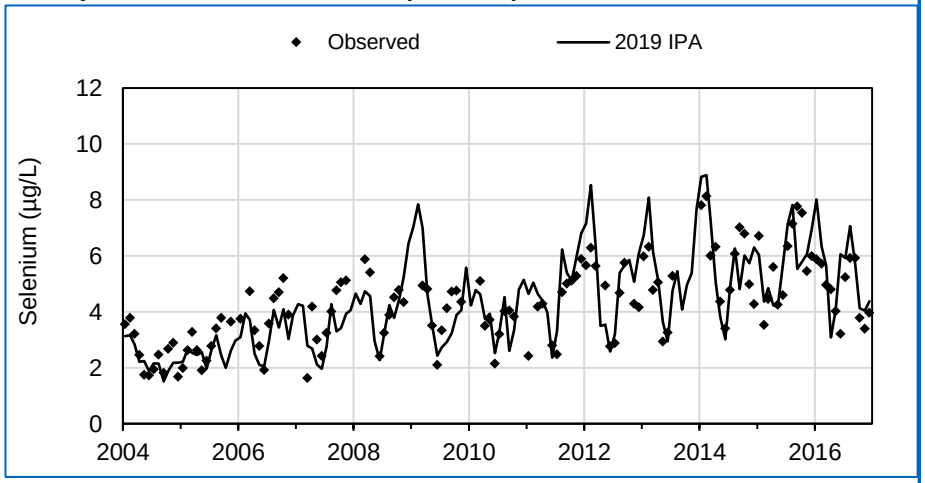


Weekly Simulated Concentrations (2019 IPA and 2017 RWQM)



Note: Observed data are individual sample results

Monthy Simulated Concentrations (2019 IPA)



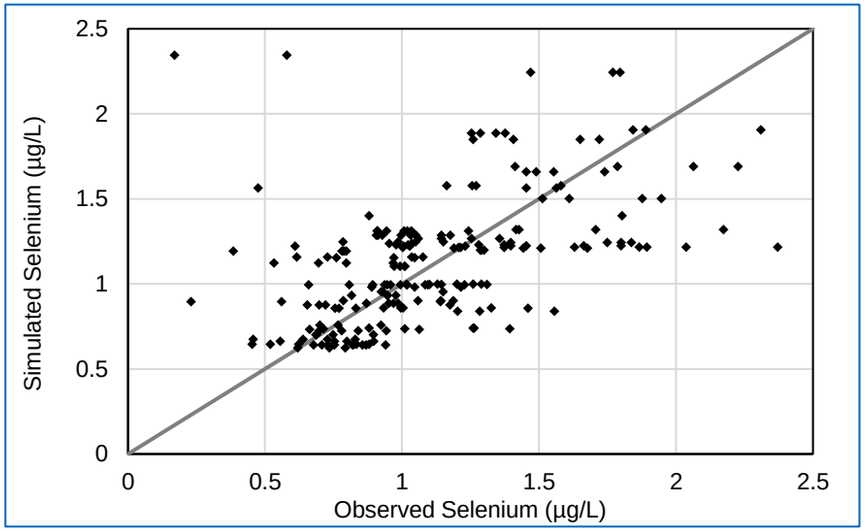
Note: Observed data are monthly averages of sample results

B1-38: Selenium Calibration Information for Node RG_DSELK - Koocanusa Reservoir (EMS E300230)

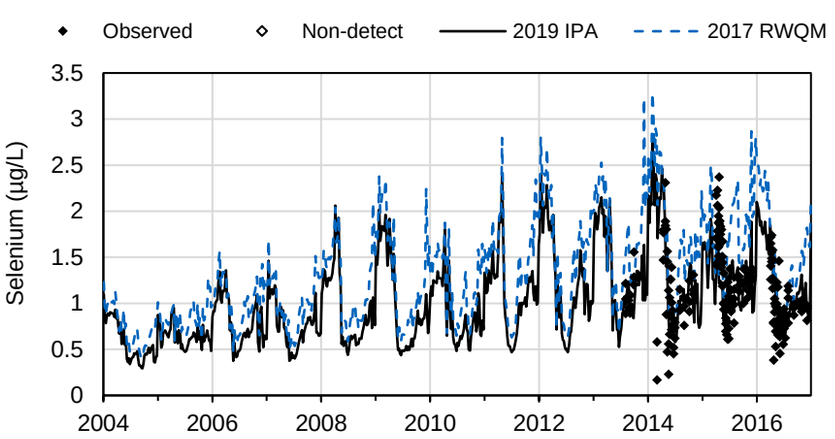
Observed and Simulated Selenium Data and Calibration Statistics

Statistic	2017 RWQM	2019 IPA	
Model Averaging Period	Weekly	Weekly	Monthly
Calibration Period	2004 to 2016		
First Observed Sample	08/07/2013		
Last Observed Sample	12/06/2016		
Data Points Available for Comparison, n	60	217	31
Non-Detect Count	0	0	0
Observed Mean (mg/L)	1.1	1.1	1.1
Simulated Mean (mg/L)	1.4	1.1	1.2
Bias (mg/L)	0.36	0.019	0.084
Relative Bias	1.3	1.0	1.1
Error (mg/L)	0.51	0.26	0.21
Percent Error	47%	23%	20%

2019 IPA Simulated vs. Observed Selenium Concentrations

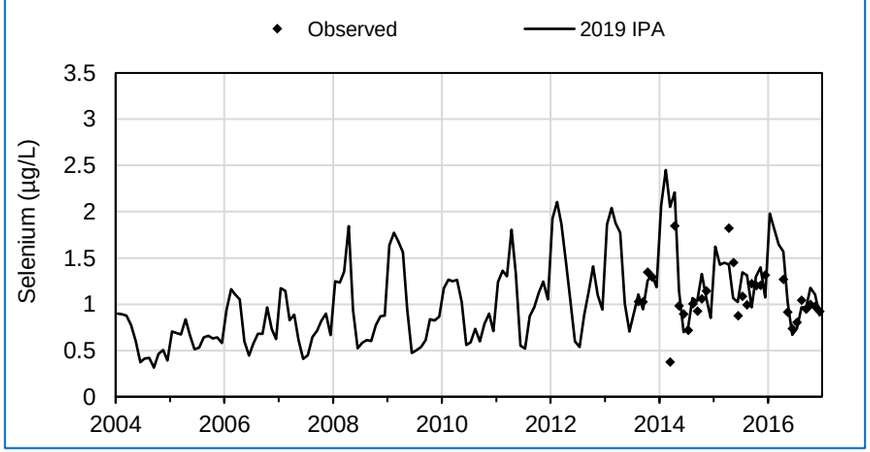


Weekly Simulated Concentrations (2019 IPA and 2017 RWQM)



Note: Observed data are individual sample results

Monthy Simulated Concentrations (2019 IPA)



Note: Observed data are monthly averages of sample results

Note: In the 2017 RWQM Update, projected concentrations in Koocanusa Reservoir were compared to monitored data at RG_DSELK. In the 2019 IPA, the comparison of simulated to monitored data was expanded to include data at the four statiions located downstream of the Elk River: RG_DSELK, RG_GRASMERE, RG_USGOLD and RG_BORDER. Projected concentrations of selenium in Koocanusa Reservoir were corrected for model bias.

Figure B-2 Simulated and Observed Selenium Concentrations in the Elk Valley, 2004 to 2016

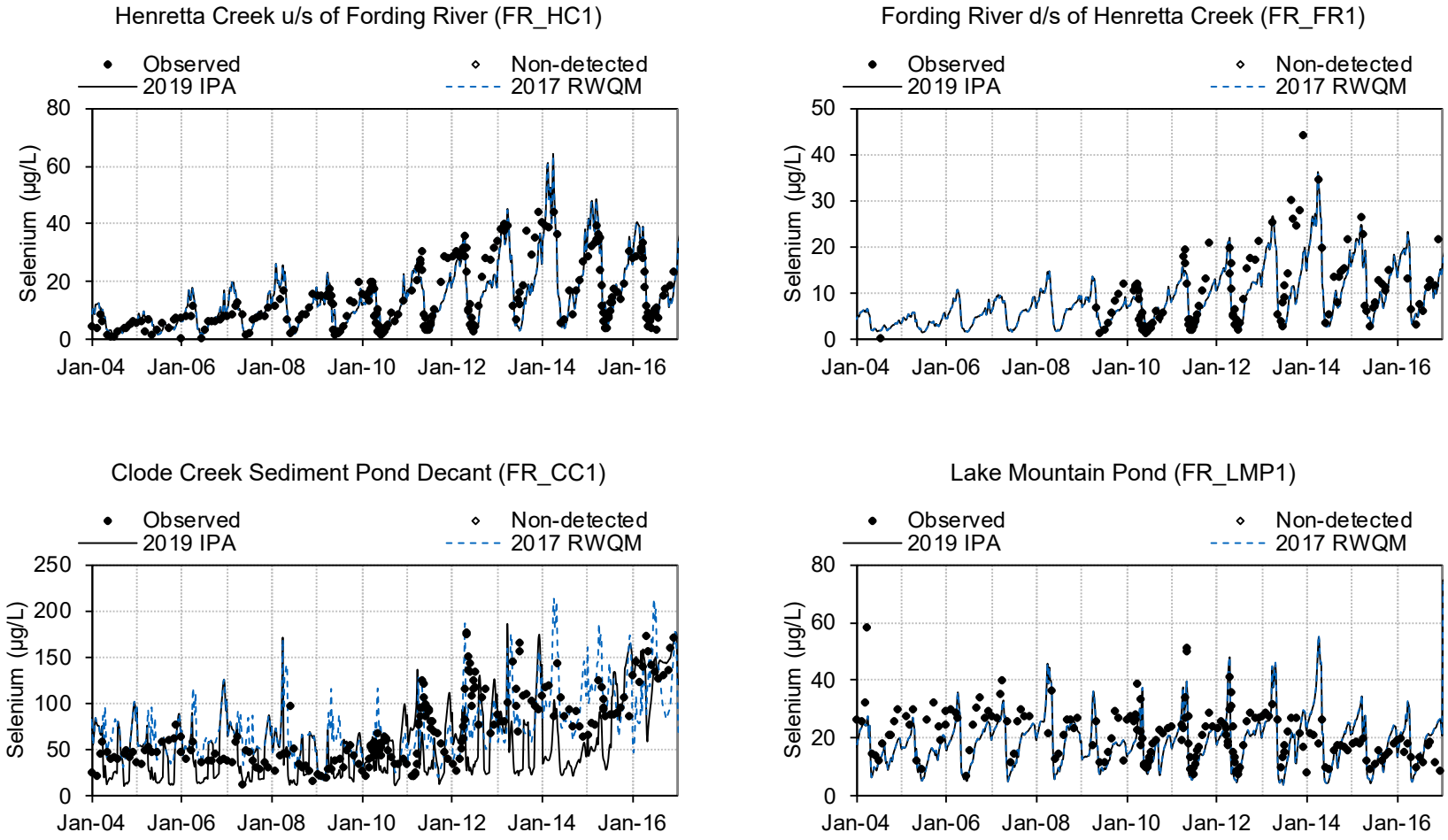


Figure B-2 Simulated and Observed Selenium Concentrations in the Elk Valley, 2004 to 2016

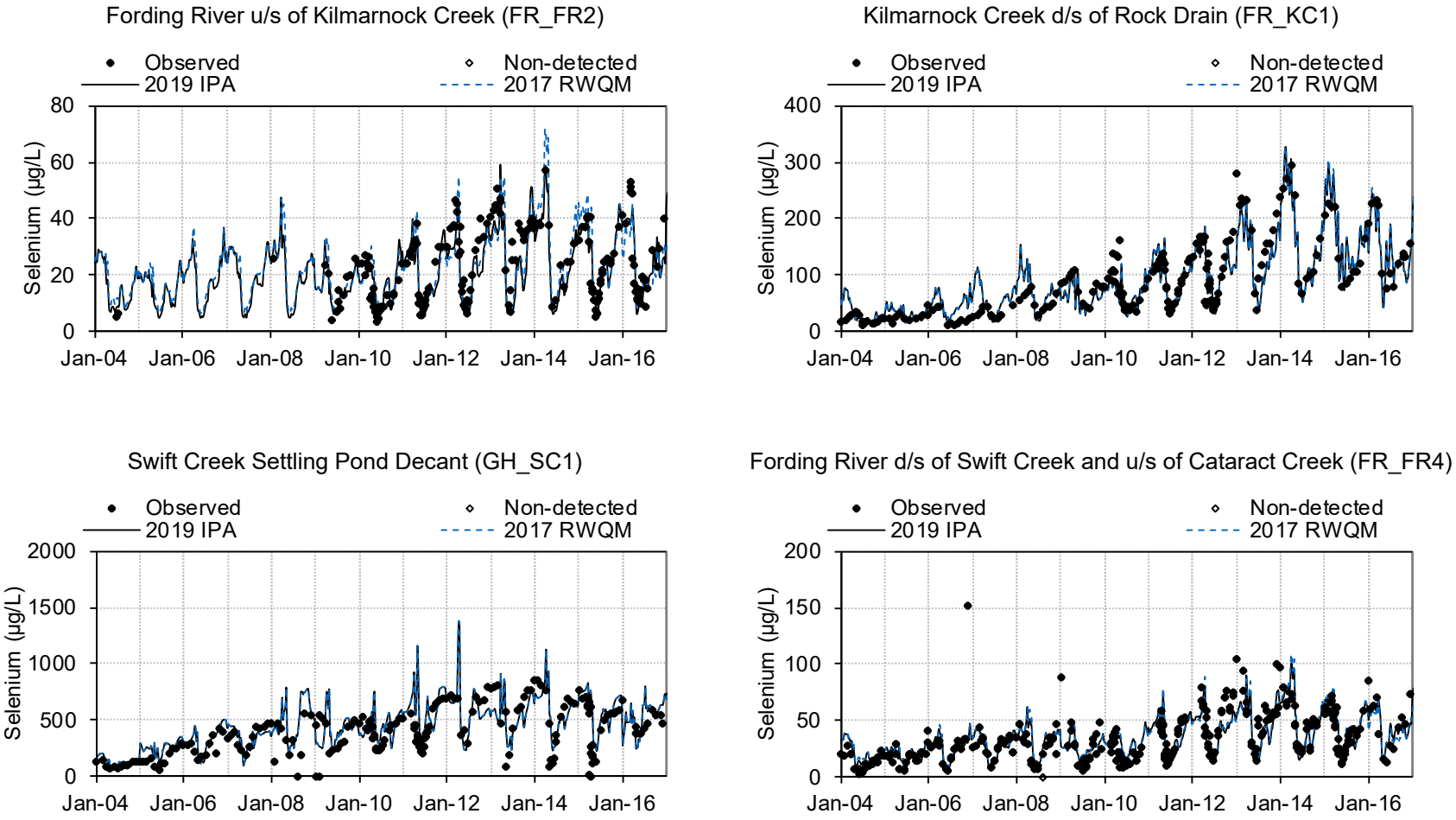
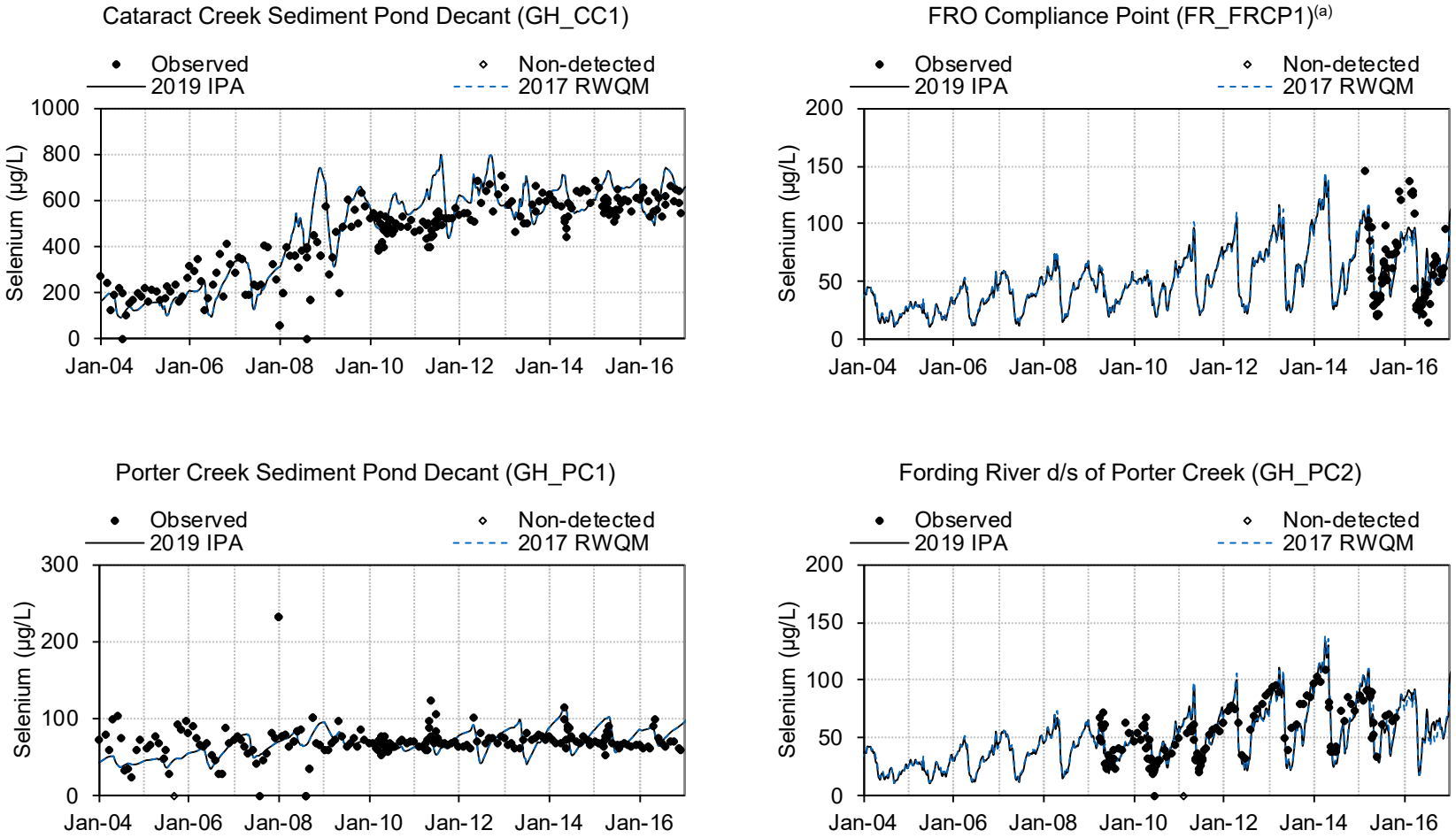


Figure B-2 Simulated and Observed Selenium Concentrations in the Elk Valley, 2004 to 2016



(a) At FR_FRCP1, monitored data are presented from January 2015 to December 2016. Ten monitored data points are not presented on the plot, because at certain times of the year (i.e., winter) monitored concentrations at the FRO Compliance Point are not representative of concentrations in the Fording River. The ten monitored data points (i.e., weekly monitored concentrations) that are not presented on the plot are: 286 µg/L (02/03/2015), 350 µg/L (02/19/2015), 459 µg/L (02/26/2015), 497 µg/L (03/02/2015), 218 µg/L (03/11/2015), 301 µg/L (11/30/2015), 305 µg/L (11/30/2015), 447 µg/L (01/05/2016), 494 µg/L (02/02/2016), 209 µg/L (03/01/2016). Model projections at FR_FRCP1 reflect fully mixed conditions, whereas monitoring data collected during low flow periods reflect primarily the quality of Cataract Creek water; hence, the difference between model projections and monitored concentrations during low flow periods

Figure B-2 Simulated and Observed Selenium Concentrations in the Elk Valley, 2004 to 2016

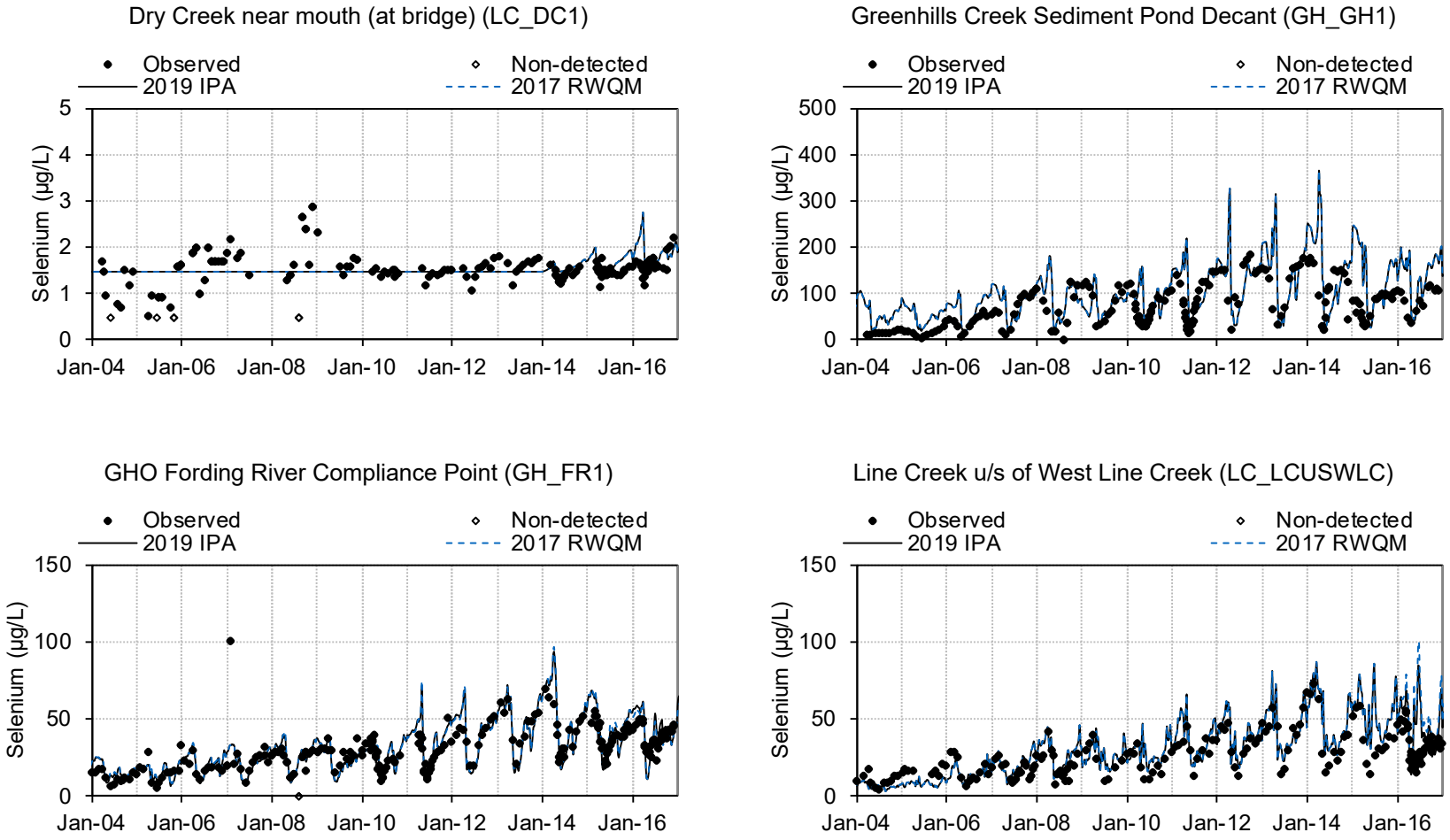


Figure B-2 Simulated and Observed Selenium Concentrations in the Elk Valley, 2004 to 2016

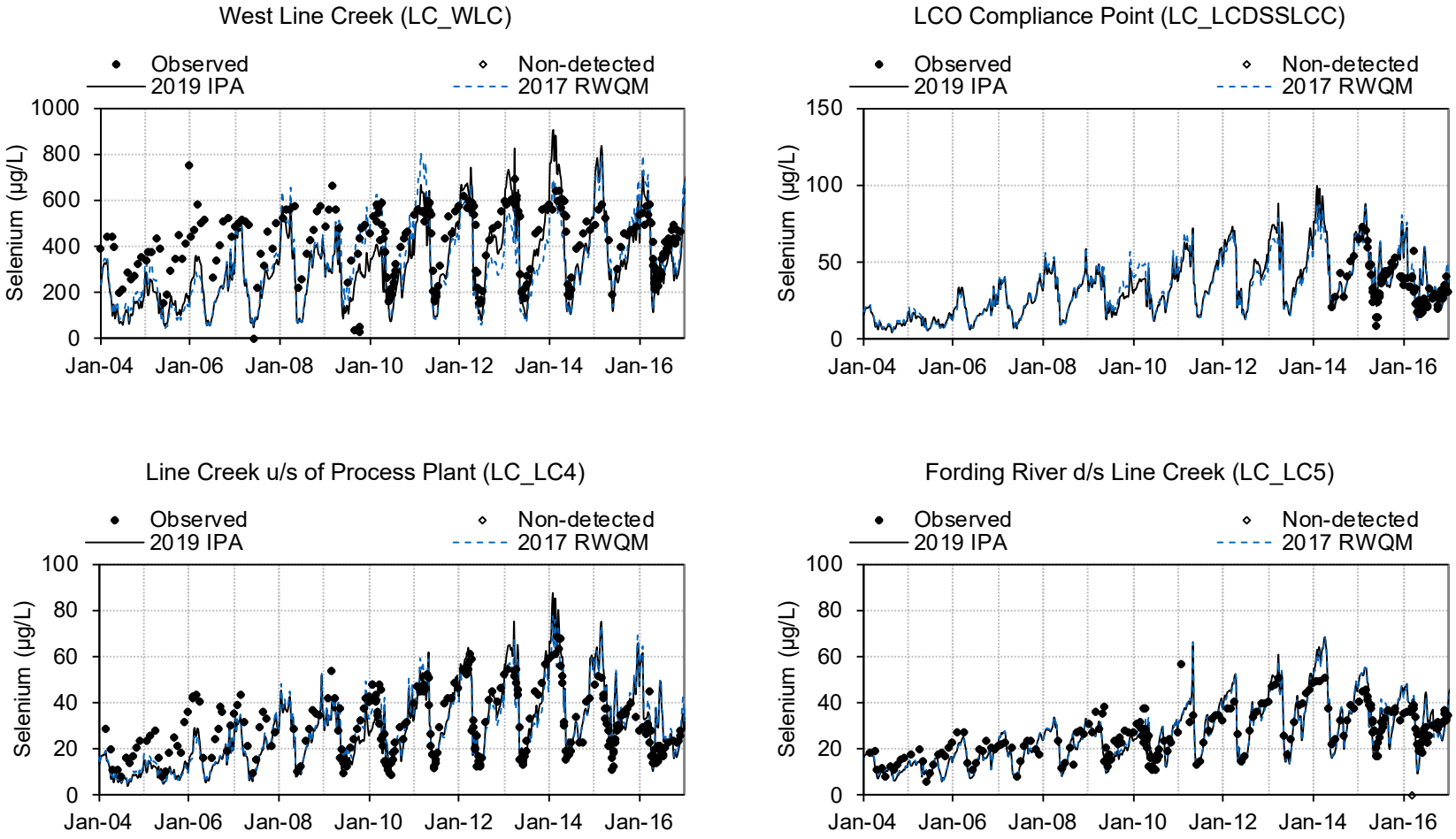


Figure B-2 Simulated and Observed Selenium Concentrations in the Elk Valley, 2004 to 2016

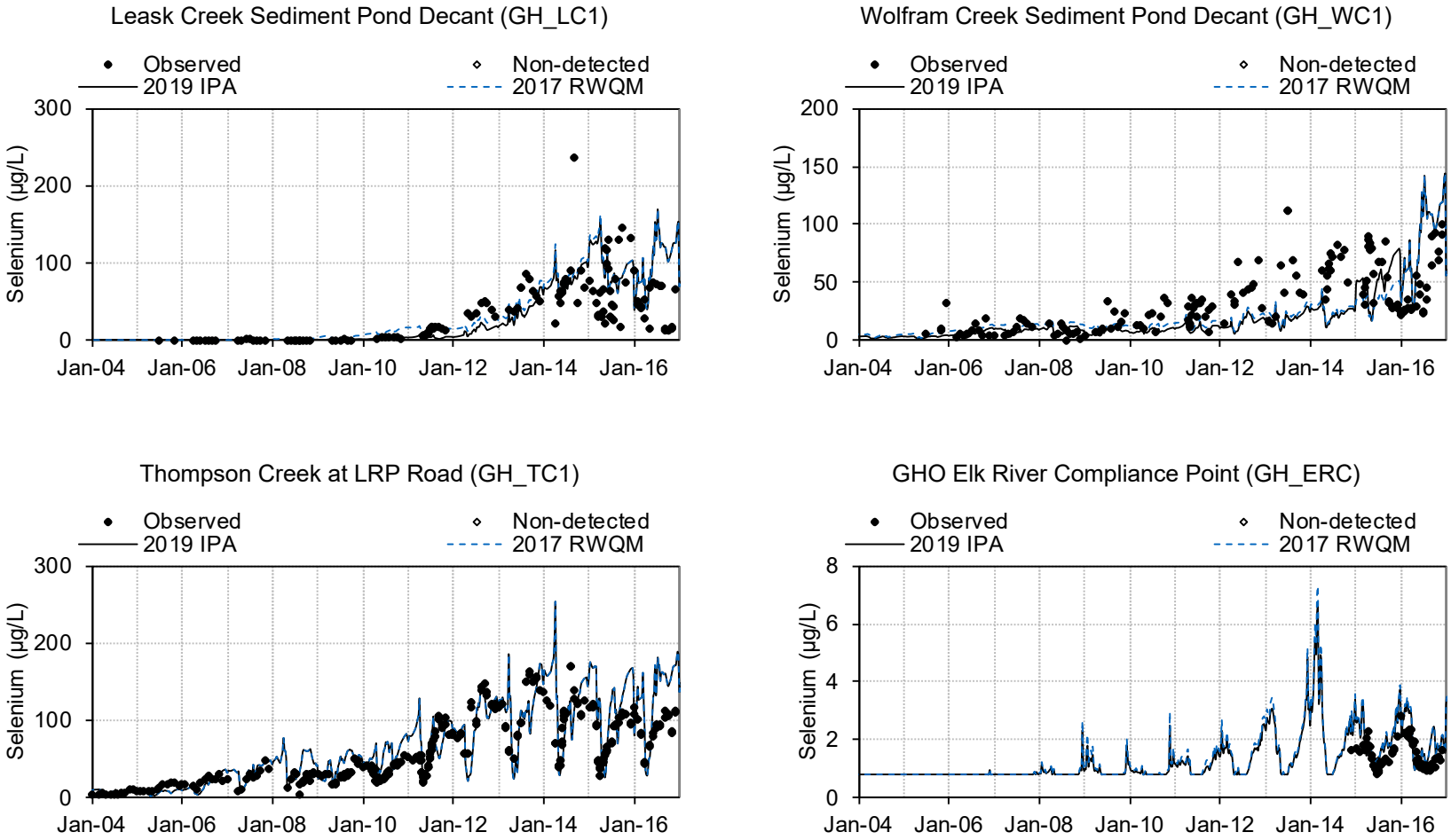


Figure B-2 Simulated and Observed Selenium Concentrations in the Elk Valley, 2004 to 2016

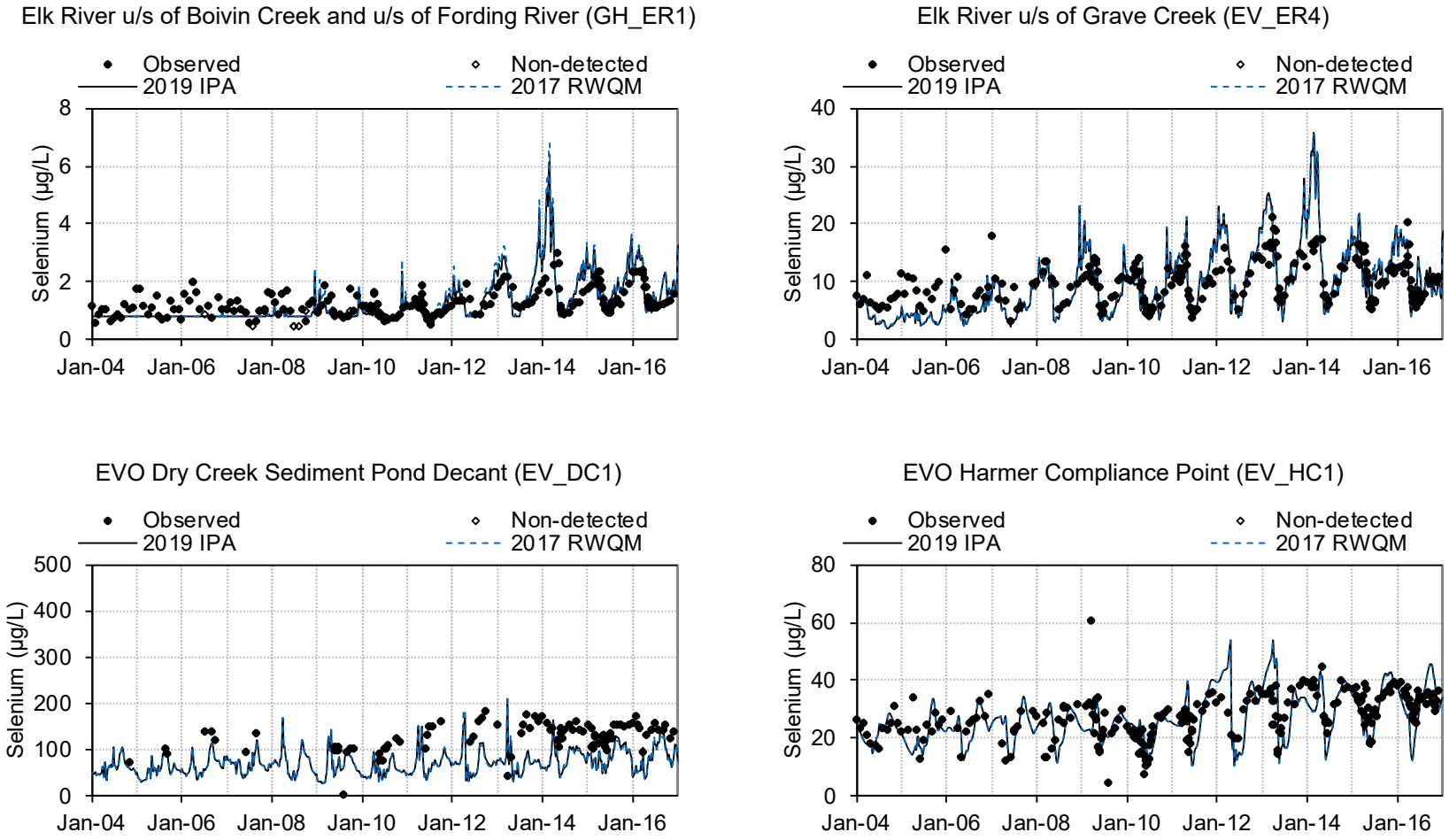


Figure B-2 Simulated and Observed Selenium Concentrations in the Elk Valley, 2004 to 2016

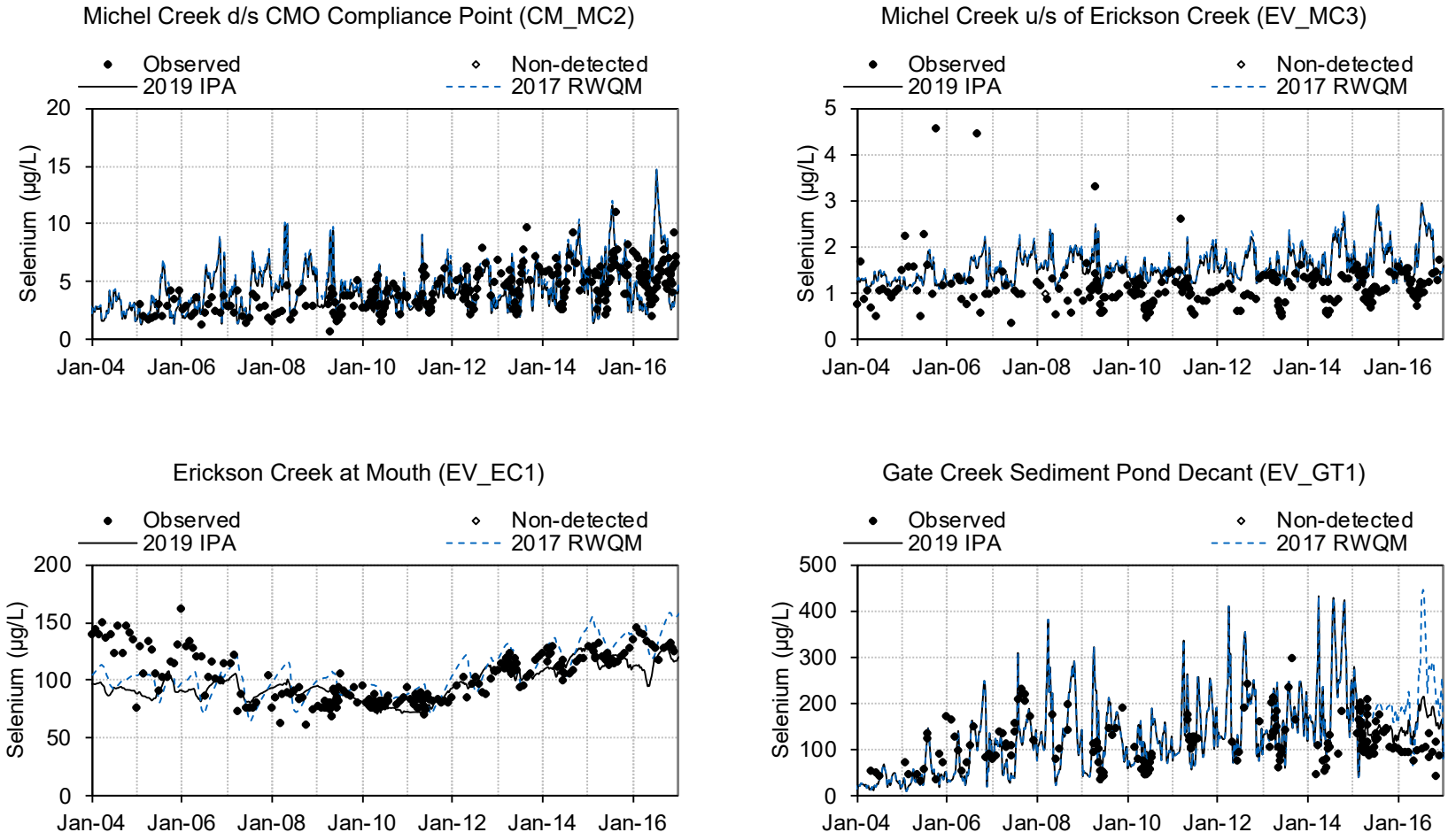


Figure B-2 Simulated and Observed Selenium Concentrations in the Elk Valley, 2004 to 2016

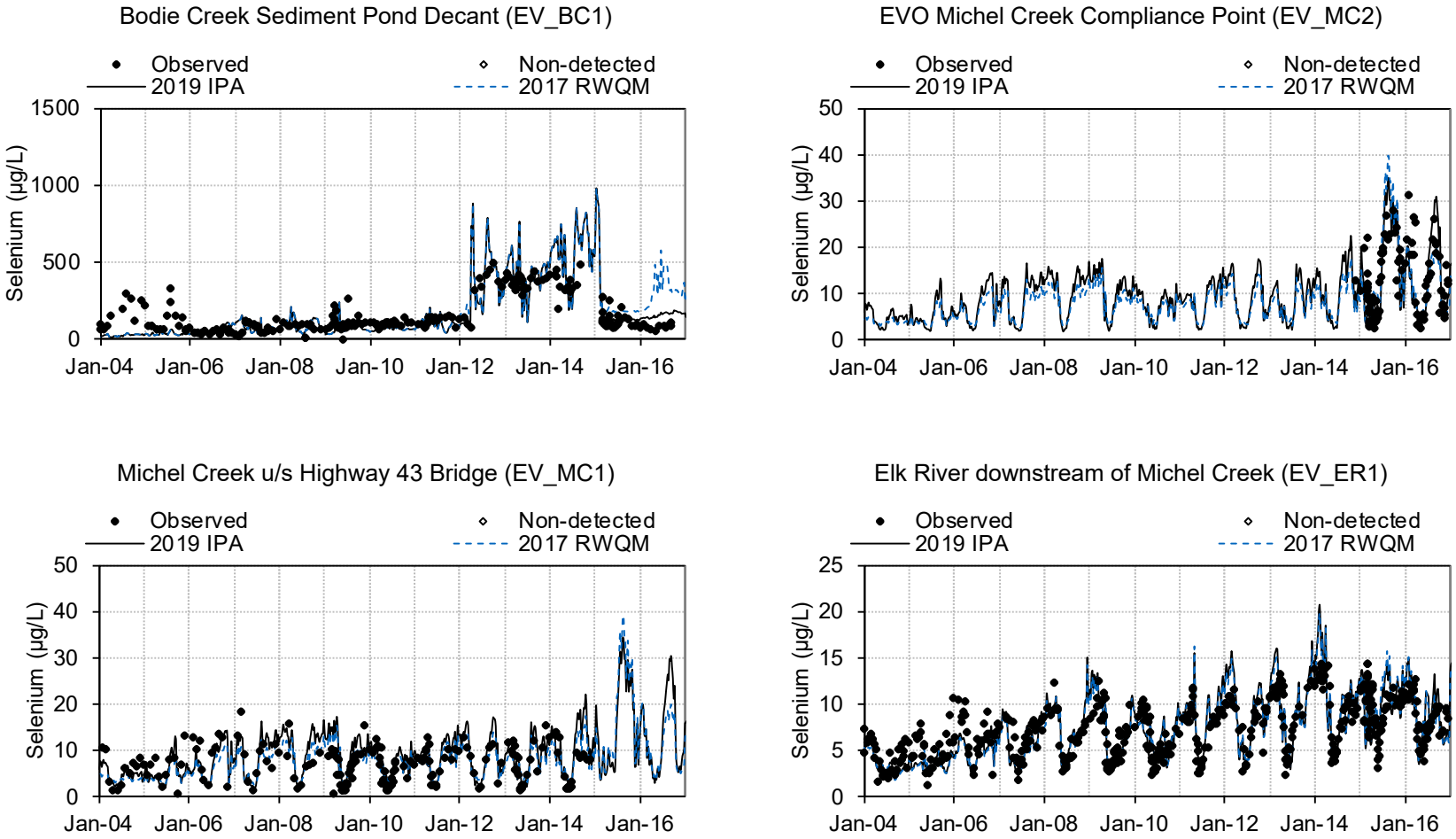
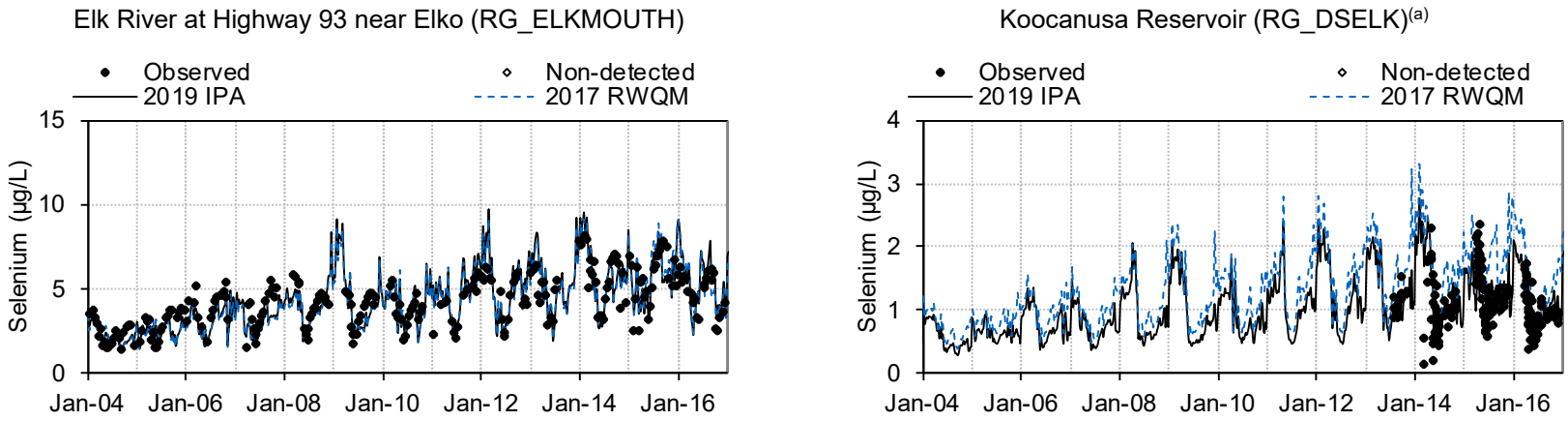


Figure B-2 Simulated and Observed Selenium Concentrations in the Elk Valley, 2004 to 2016



(a) In the 2017 RWQM Update, projected concentrations in Koocanusa Reservoir were compared to monitored data at RG_DSELK. In the 2019 IPA, the comparison of simulated to monitored data was expanded to include data at the four stations located downstream of the Elk River: RG_DSELK, RG_GRASMERE, RG_USGOLD and RG_BORDER. In the 2017 RWQM Update, projected concentrations of selenium in Koocanusa Reservoir were not corrected for model bias. In the 2019 IPA, projected concentrations of selenium in Koocanusa were corrected for model bias.

Appendix C - Model Calibration Results for Sulphate

July 2019

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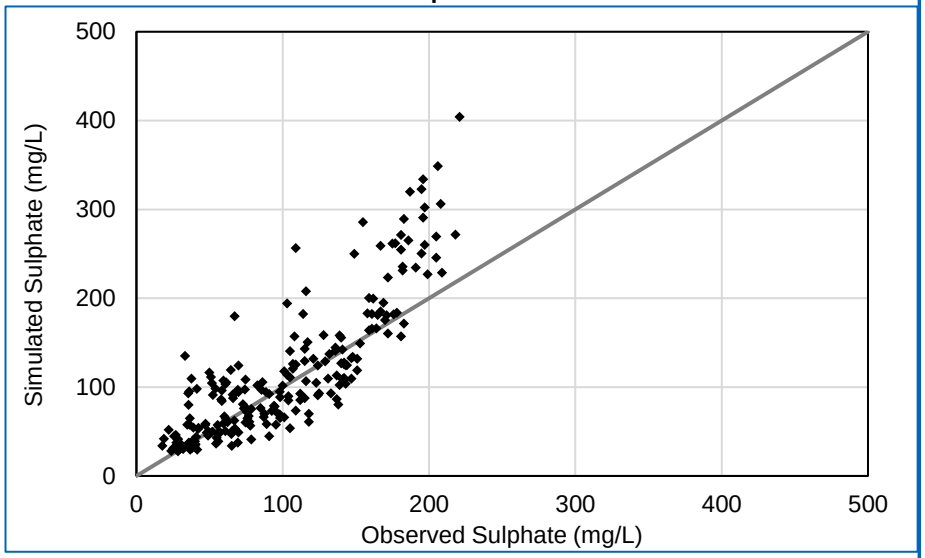
C1-1: Sulphate Calibration Information for Node FR_HC1 - Henretta Creek u/s of Fording River (EMS E216778)

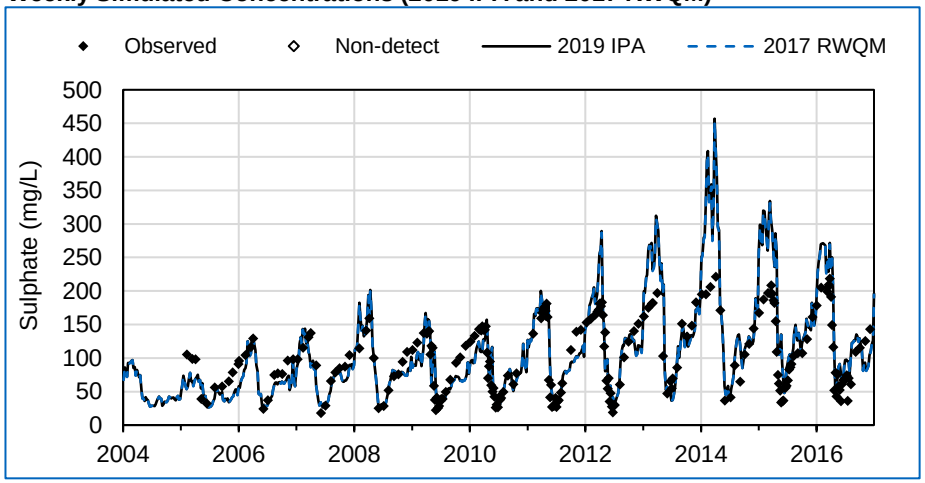
Observed and Simulated Sulphate Data and Calibration Statistics

Statistic	2017 RWQM	2019 IPA	
Model Averaging Period	Weekly	Weekly	Monthly
Calibration Period	2004 to 2016		
First Observed Sample	2/7/2005		
Last Observed Sample	12/7/2016		
Data Points Available for Comparison, n	225	225	135
Non-Detect Count	0	0	0
Observed Mean (mg/L)	100	100	105
Simulated Mean (mg/L)	114	115	115
Bias (mg/L)	14	15	10.0
Relative Bias	1.1	1.1	1.1
Error (mg/L)	30	30	27
Percent Error	30%	30%	26%

2019 IPA Simulated vs. Observed Sulphate Concentrations

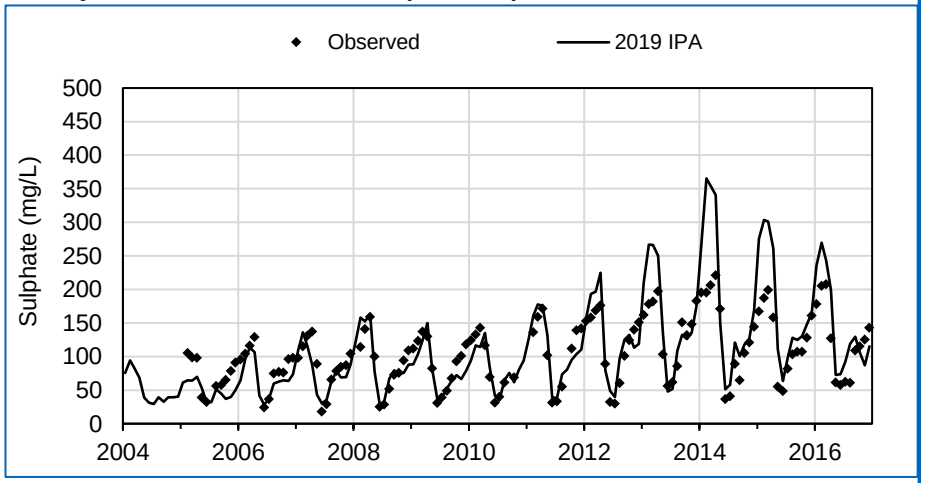


Weekly Simulated Concentrations (2019 IPA and 2017 RWQM)



Note: Observed data are individual sample results

Monthy Simulated Concentrations (2019 IPA)



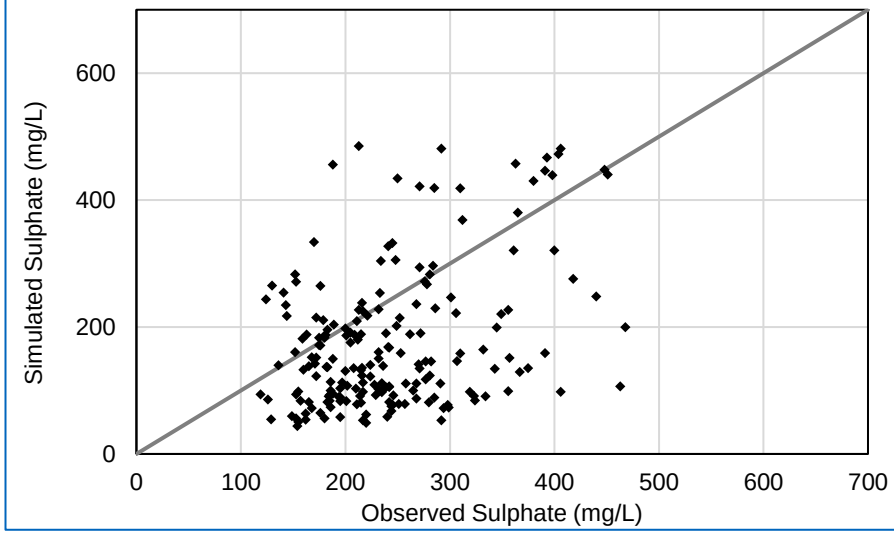
Note: Observed data are monthly averages of sample results

C1-2: Sulphate Calibration Information for Node FR_CC1 - Clode Creek Sediment Pond Decant (EMS E102481)

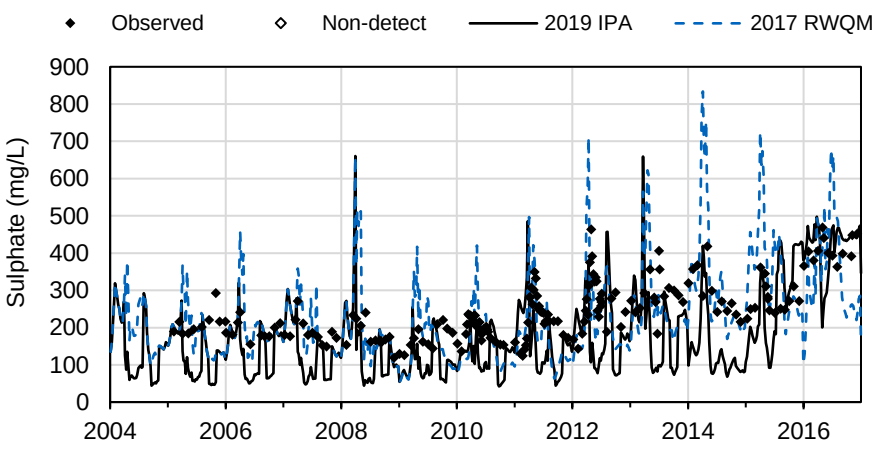
Observed and Simulated Sulphate Data and Calibration Statistics

Statistic	2017 RWQM	2019 IPA	
Model Averaging Period	Weekly	Weekly	Monthly
Calibration Period	2004 to 2016		
First Observed Sample	2/7/2005		
Last Observed Sample	12/7/2016		
Data Points Available for Comparison, n	192	192	137
Non-Detect Count	0	0	0
Observed Mean (mg/L)	243	243	239
Simulated Mean (mg/L)	244	177	182
Bias (mg/L)	1.2	-66	-56
Relative Bias	1.0	0.73	0.76
Error (mg/L)	78	102	90
Percent Error	32%	42%	38%

2019 IPA Simulated vs. Observed Sulphate Concentrations

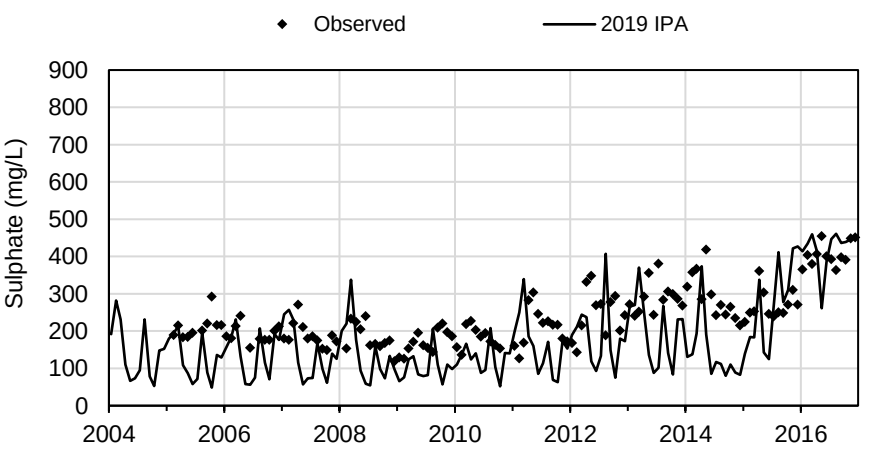


Weekly Simulated Concentrations (2019 IPA and 2017 RWQM)



Note: Observed data are individual sample results

Monthy Simulated Concentrations (2019 IPA)



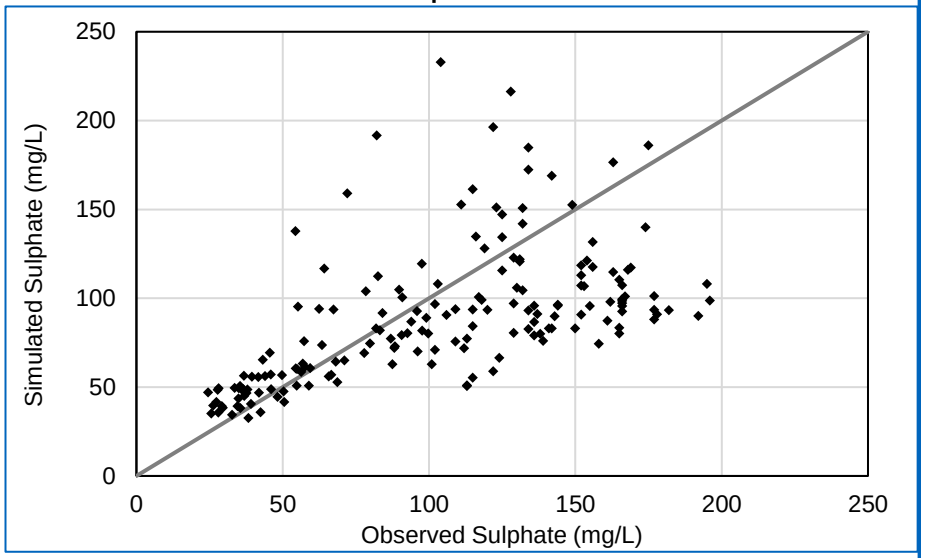
Note: Observed data are monthly averages of sample results

C1-3: Sulphate Calibration Information for Node FR_LMP1 - Lake Mountain Pond

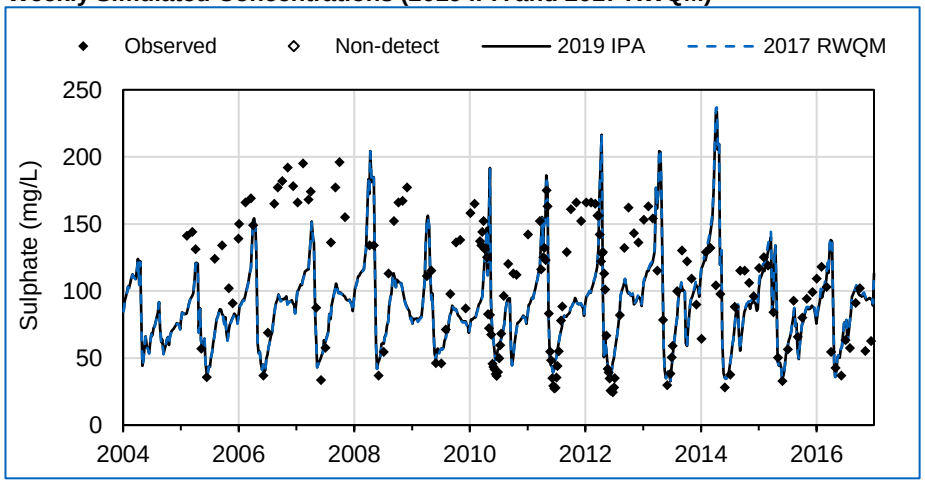
Observed and Simulated Sulphate Data and Calibration Statistics

Statistic	2017 RWQM	2019 IPA	
Model Averaging Period	Weekly	Weekly	Monthly
Calibration Period	2004 to 2016		
First Observed Sample	2/7/2005		
Last Observed Sample	12/14/2016		
Data Points Available for Comparison, n	174	174	131
Non-Detect Count	0	0	0
Observed Mean (mg/L)	103	103	109
Simulated Mean (mg/L)	89	89	90
Bias (mg/L)	-13	-14	-19
Relative Bias	0.87	0.87	0.83
Error (mg/L)	32	32	34
Percent Error	31%	31%	31%

2019 IPA Simulated vs. Observed Sulphate Concentrations

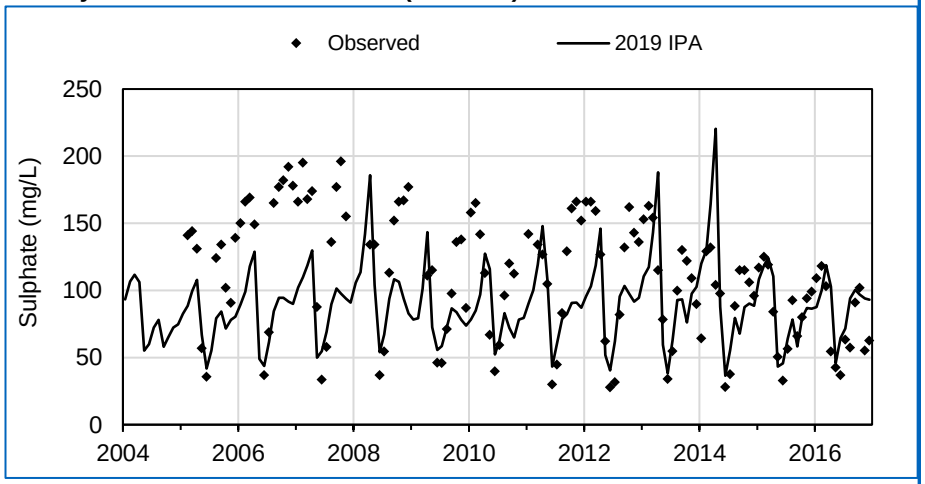


Weekly Simulated Concentrations (2019 IPA and 2017 RWQM)



Note: Observed data are individual sample results

Monthy Simulated Concentrations (2019 IPA)



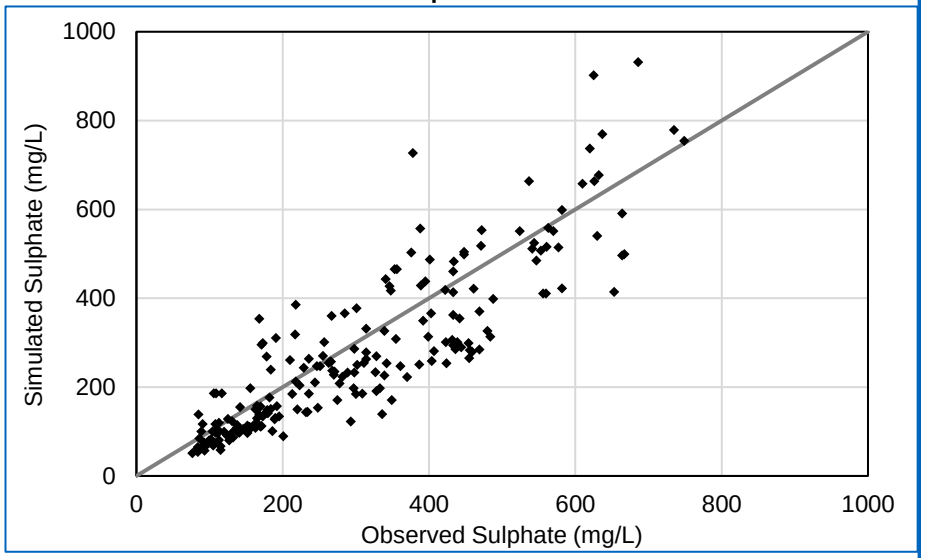
Note: Observed data are monthly averages of sample results

C1-4: Sulphate Calibration Information for Node FR_KC1 - Kilmarnock Creek d/s of Rock Drain (EMS 0200252)

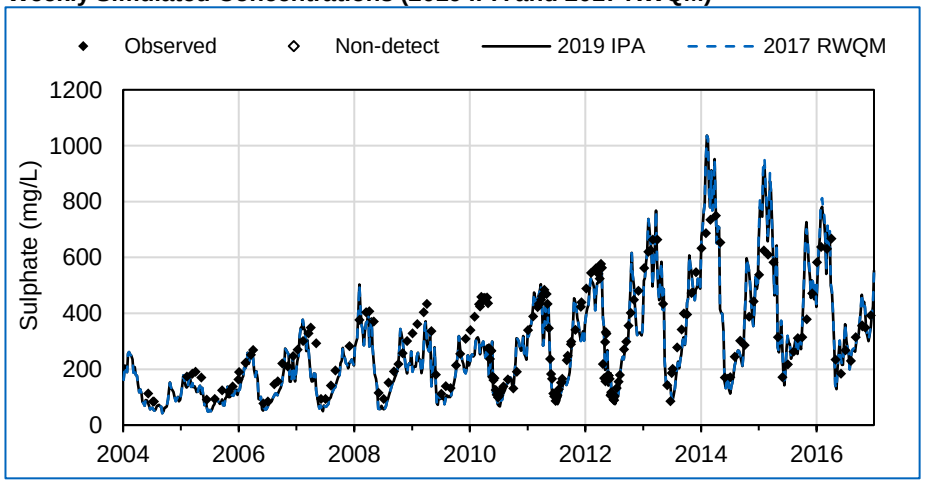
Observed and Simulated Sulphate Data and Calibration Statistics

Statistic	2017 RWQM	2019 IPA	
Model Averaging Period	Weekly	Weekly	Monthly
Calibration Period	2004 to 2016		
First Observed Sample	6/7/2004		
Last Observed Sample	12/12/2016		
Data Points Available for Comparison, n	205	205	137
Non-Detect Count	0	0	0
Observed Mean (mg/L)	301	301	313
Simulated Mean (mg/L)	276	275	295
Bias (mg/L)	-25	-26	-18
Relative Bias	0.92	0.91	0.94
Error (mg/L)	70	70	63
Percent Error	23%	23%	20%

2019 IPA Simulated vs. Observed Sulphate Concentrations

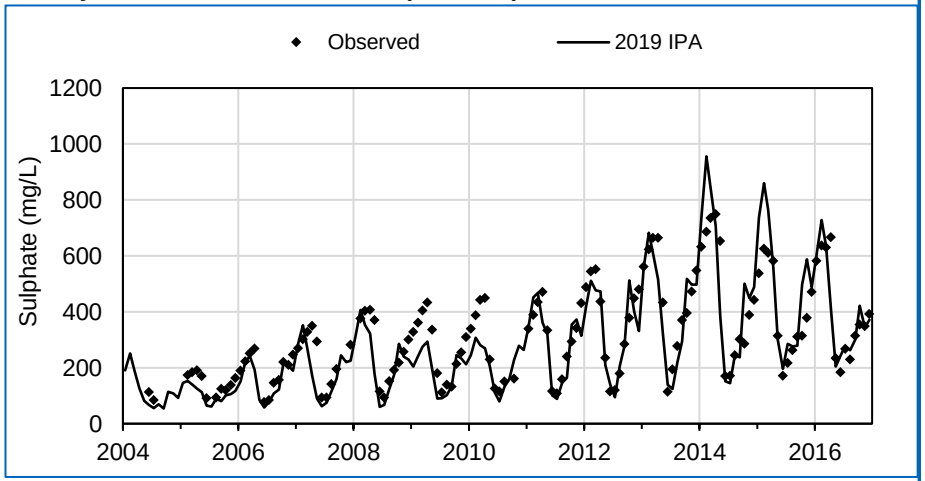


Weekly Simulated Concentrations (2019 IPA and 2017 RWQM)



Note: Observed data are individual sample results

Monthy Simulated Concentrations (2019 IPA)



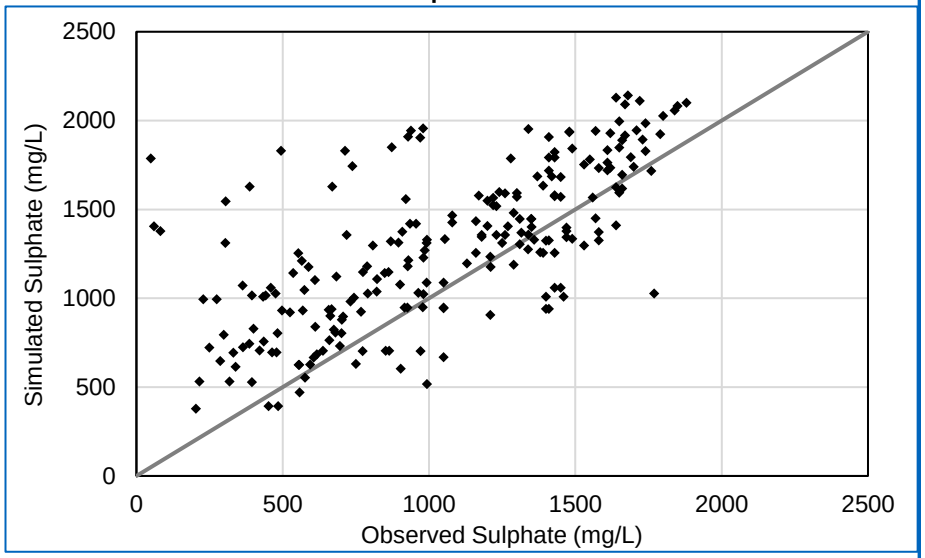
Note: Observed data are monthly averages of sample results

C1-5: Sulphate Calibration Information for Node GH_SC1 - Swift Creek Sediment Pond Decant (EMS E221329)

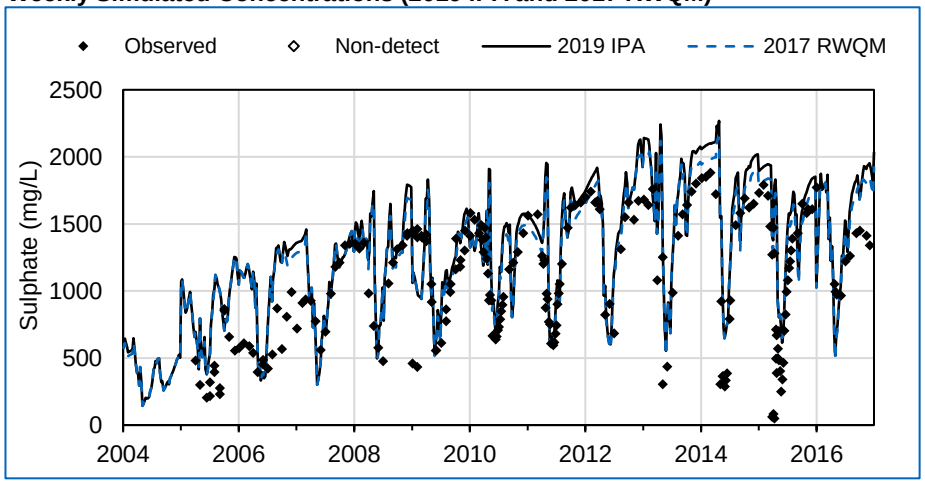
Observed and Simulated Sulphate Data and Calibration Statistics

Statistic	2017 RWQM	2019 IPA	
Model Averaging Period	Weekly	Weekly	Monthly
Calibration Period	2004 to 2016		
First Observed Sample	4/3/2005		
Last Observed Sample	12/5/2016		
Data Points Available for Comparison, n	221	221	137
Non-Detect Count	0	0	0
Observed Mean (mg/L)	1045	1045	1128
Simulated Mean (mg/L)	1247	1290	1369
Bias (mg/L)	201	245	241
Relative Bias	1.2	1.2	1.2
Error (mg/L)	289	321	280
Percent Error	28%	31%	25%

2019 IPA Simulated vs. Observed Sulphate Concentrations

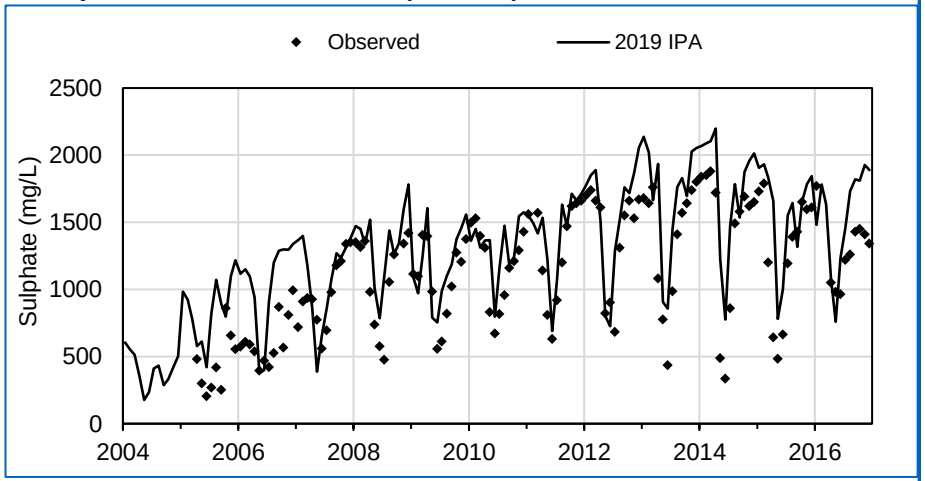


Weekly Simulated Concentrations (2019 IPA and 2017 RWQM)



Note: Observed data are individual sample results

Monthy Simulated Concentrations (2019 IPA)



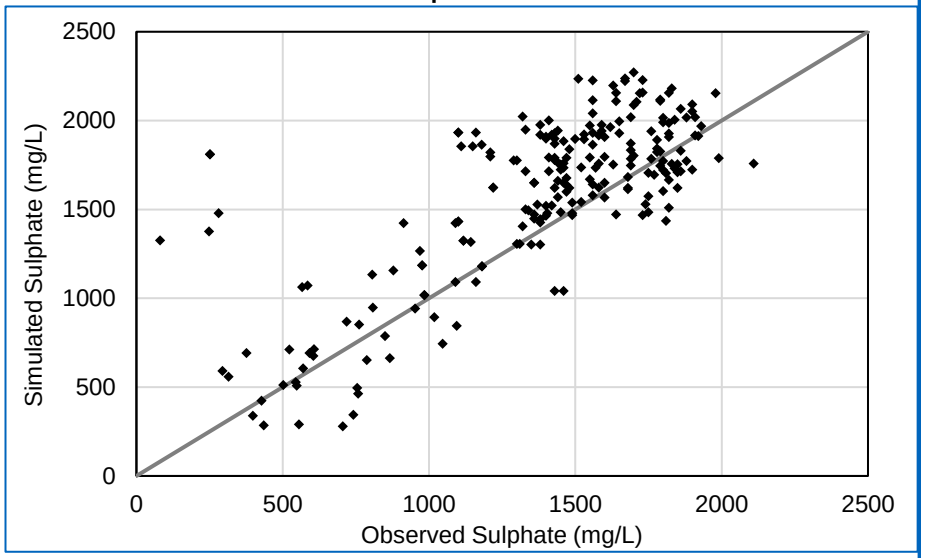
Note: Observed data are monthly averages of sample results

C1-6: Sulphate Calibration Information for Node GH_CC1 - Cataract Creek Sediment Pond Decant (EMS 0200384)

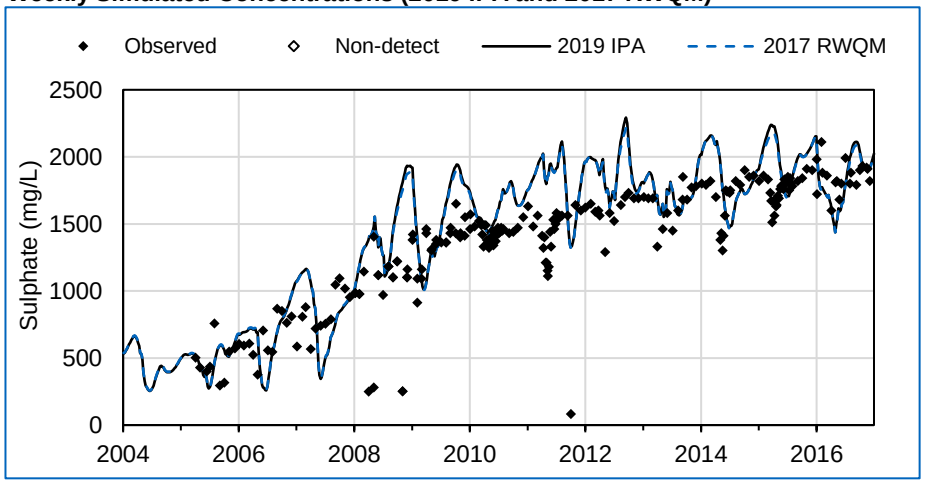
Observed and Simulated Sulphate Data and Calibration Statistics

Statistic	2017 RWQM	2019 IPA	
Model Averaging Period	Weekly	Weekly	Monthly
Calibration Period	2004 to 2016		
First Observed Sample	4/3/2005		
Last Observed Sample	12/5/2016		
Data Points Available for Comparison, n	224	224	140
Non-Detect Count	0	0	0
Observed Mean (mg/L)	1380	1380	1329
Simulated Mean (mg/L)	1570	1580	1498
Bias (mg/L)	191	200	169
Relative Bias	1.1	1.1	1.1
Error (mg/L)	266	274	240
Percent Error	19%	20%	18%

2019 IPA Simulated vs. Observed Sulphate Concentrations

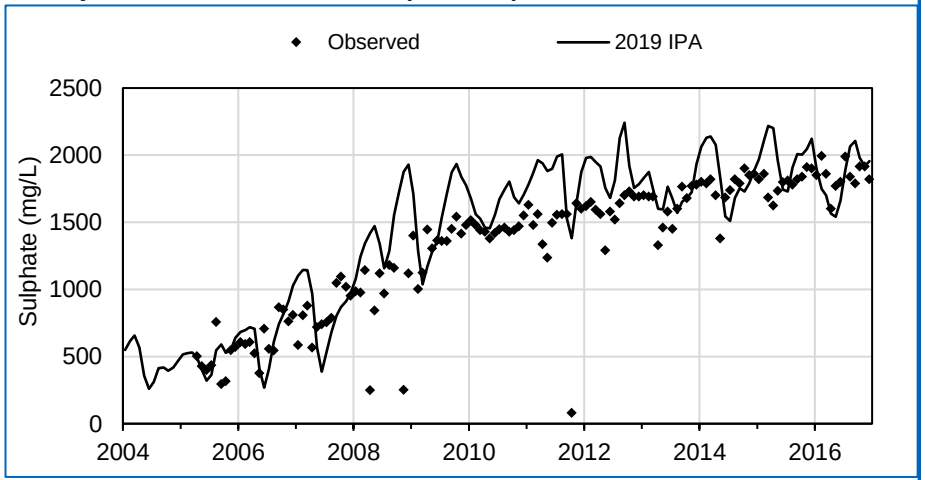


Weekly Simulated Concentrations (2019 IPA and 2017 RWQM)



Note: Observed data are individual sample results

Monthy Simulated Concentrations (2019 IPA)



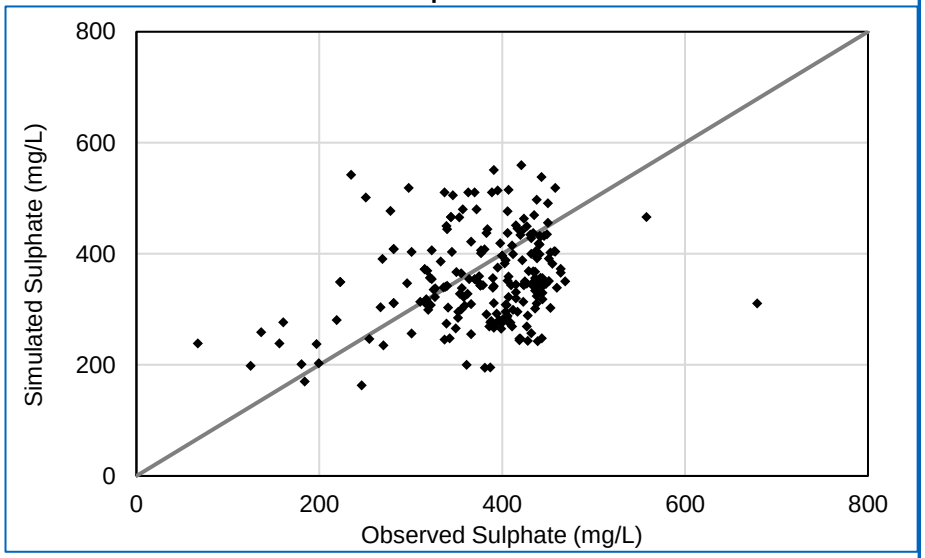
Note: Observed data are monthly averages of sample results

C1-7: Sulphate Calibration Information for Node GH_PC1 - Porter Creek Sediment Pond Decant (EMS 0200385)

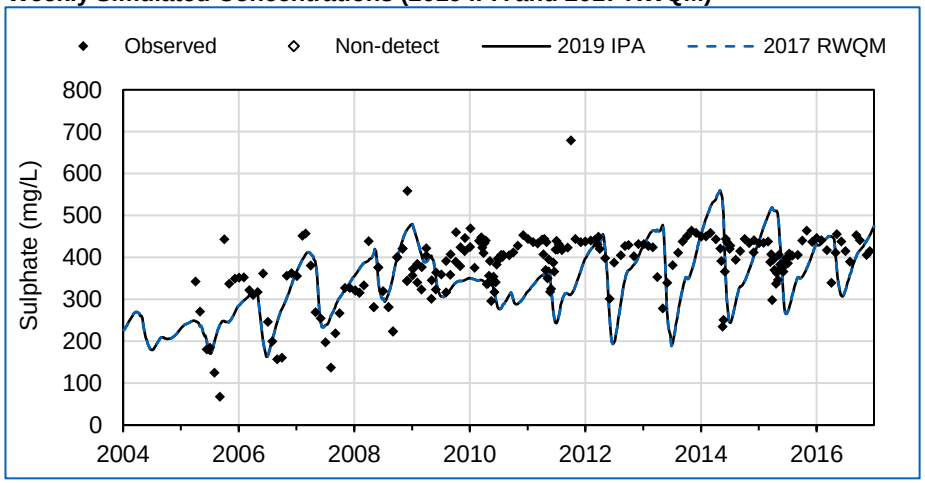
Observed and Simulated Sulphate Data and Calibration Statistics

Statistic	2017 RWQM	2019 IPA	
Model Averaging Period	Weekly	Weekly	Monthly
Calibration Period	2004 to 2016		
First Observed Sample	4/3/2005		
Last Observed Sample	12/5/2016		
Data Points Available for Comparison, n	217	217	140
Non-Detect Count	0	0	0
Observed Mean (mg/L)	378	378	377
Simulated Mean (mg/L)	356	356	350
Bias (mg/L)	-23	-23	-26
Relative Bias	0.94	0.94	0.93
Error (mg/L)	78	78	72
Percent Error	21%	21%	19%

2019 IPA Simulated vs. Observed Sulphate Concentrations

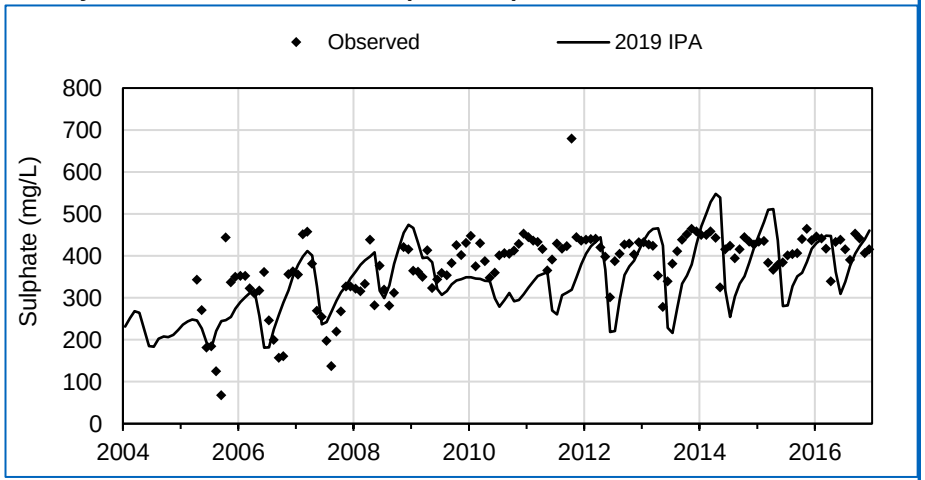


Weekly Simulated Concentrations (2019 IPA and 2017 RWQM)



Note: Observed data are individual sample results

Monthy Simulated Concentrations (2019 IPA)



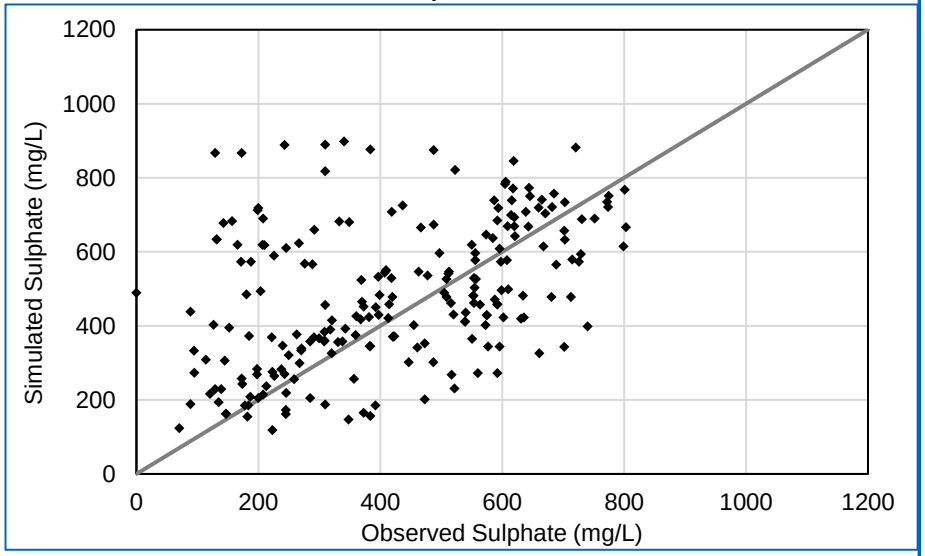
Note: Observed data are monthly averages of sample results

C1-8: Sulphate Calibration Information for Node GH_GH1 - Greenhills Creek Sediment Pond Decant (EMS E102709)

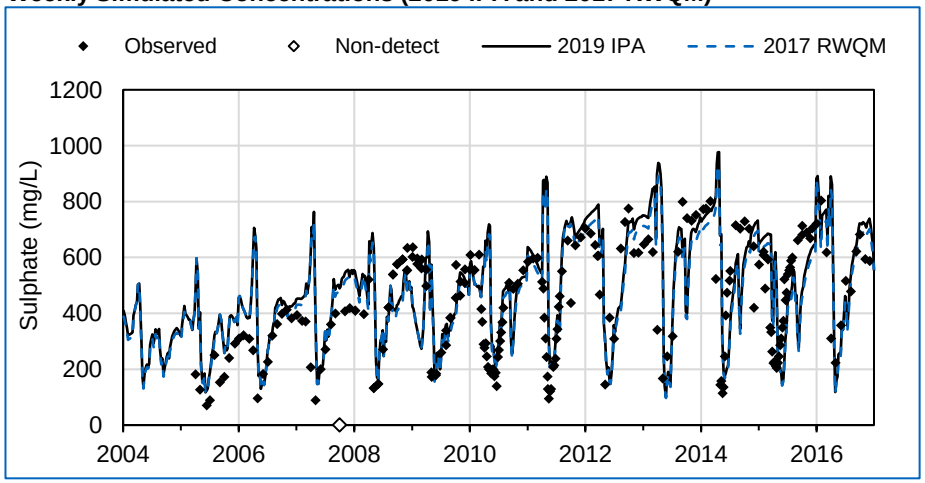
Observed and Simulated Sulphate Data and Calibration Statistics

Statistic	2017 RWQM	2019 IPA	
Model Averaging Period	Weekly	Weekly	Monthly
Calibration Period	2004 to 2016		
First Observed Sample	4/3/2005		
Last Observed Sample	12/5/2016		
Data Points Available for Comparison, n	219	219	139
Non-Detect Count	1	1	0
Observed Mean (mg/L)	421	421	447
Simulated Mean (mg/L)	464	484	504
Bias (mg/L)	44	64	56
Relative Bias	1.1	1.2	1.1
Error (mg/L)	148	155	122
Percent Error	35%	37%	27%

2019 IPA Simulated vs. Observed Sulphate Concentrations

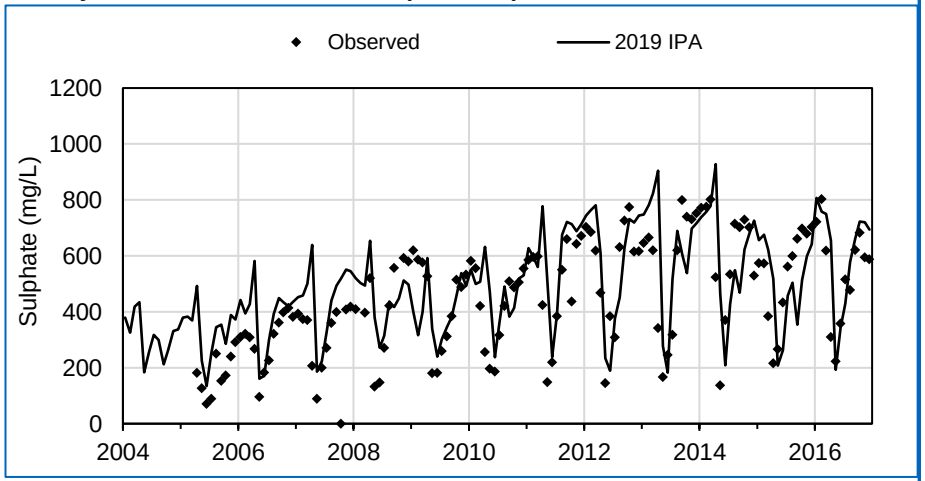


Weekly Simulated Concentrations (2019 IPA and 2017 RWQM)



Note: Observed data are individual sample results

Monthy Simulated Concentrations (2019 IPA)



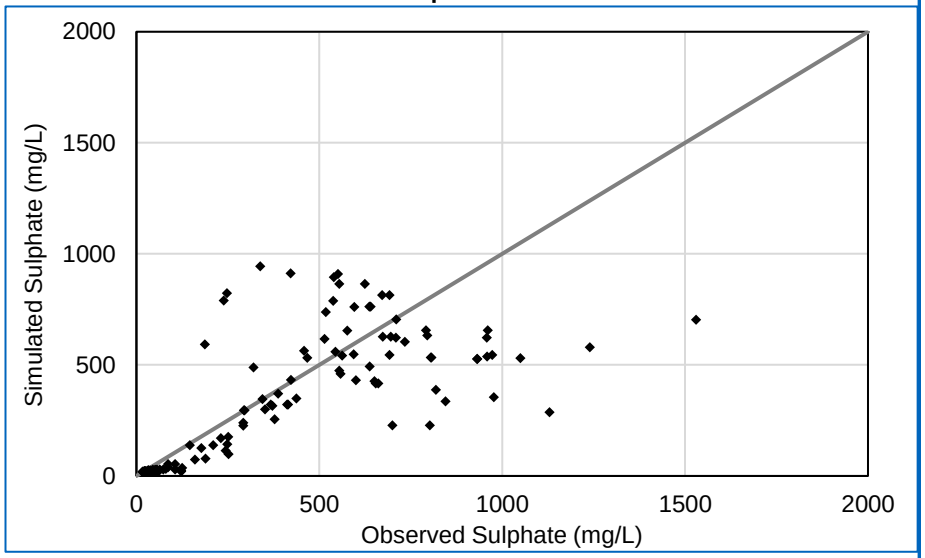
Note: Observed data are monthly averages of sample results

C1-9: Sulphate Calibration Information for Node GH_LC1 - Leask Creek Sediment Pond Decant (EMS E257796)

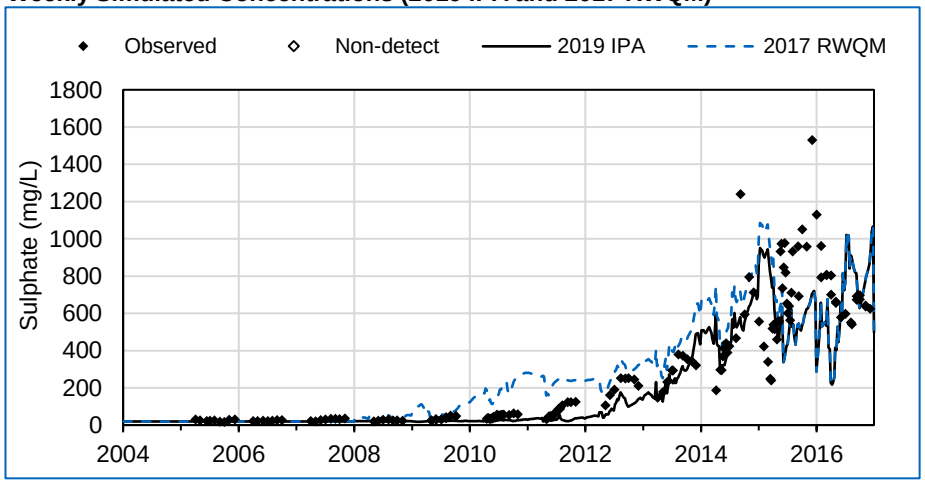
Observed and Simulated Sulphate Data and Calibration Statistics

Statistic	2017 RWQM	2019 IPA	
Model Averaging Period	Weekly	Weekly	Monthly
Calibration Period	2004 to 2016		
First Observed Sample	4/3/2005		
Last Observed Sample	12/7/2016		
Data Points Available for Comparison, n	158	158	101
Non-Detect Count	0	0	0
Observed Mean (mg/L)	311	311	291
Simulated Mean (mg/L)	342	261	246
Bias (mg/L)	31	-49	-45
Relative Bias	1.1	0.84	0.85
Error (mg/L)	153	120	114
Percent Error	49%	39%	39%

2019 IPA Simulated vs. Observed Sulphate Concentrations

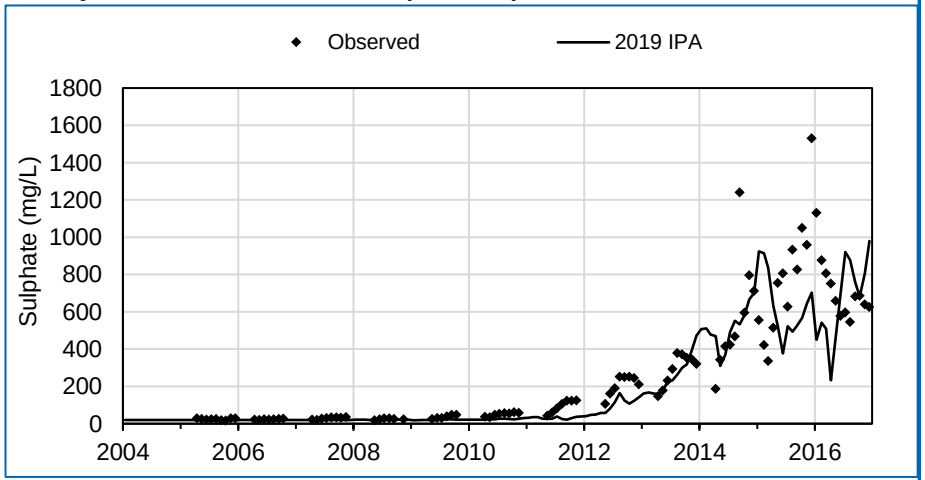


Weekly Simulated Concentrations (2019 IPA and 2017 RWQM)



Note: Observed data are individual sample results

Monthy Simulated Concentrations (2019 IPA)



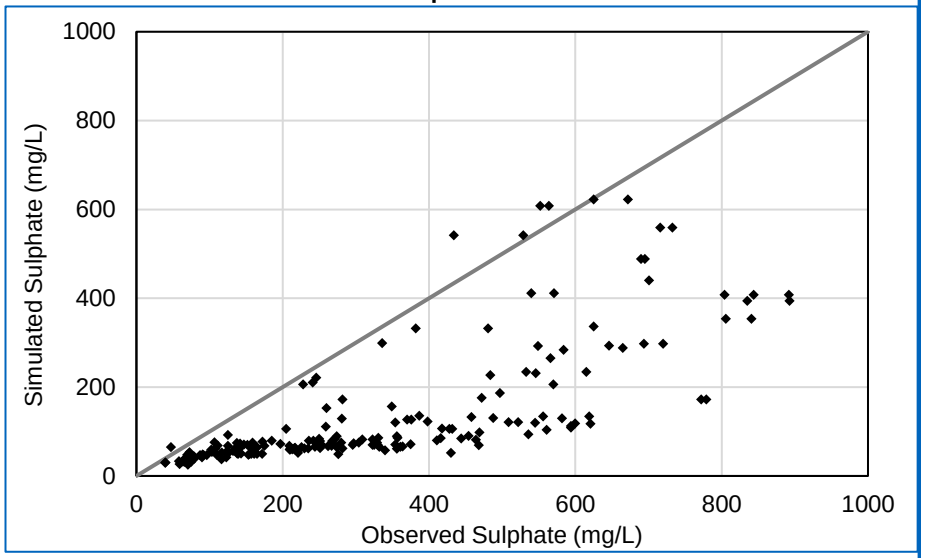
Note: Observed data are monthly averages of sample results

C1-10: Sulphate Calibration Information for Node GH_WC1 - Wolfram Creek Sediment Pond Decant (EMS E257796)

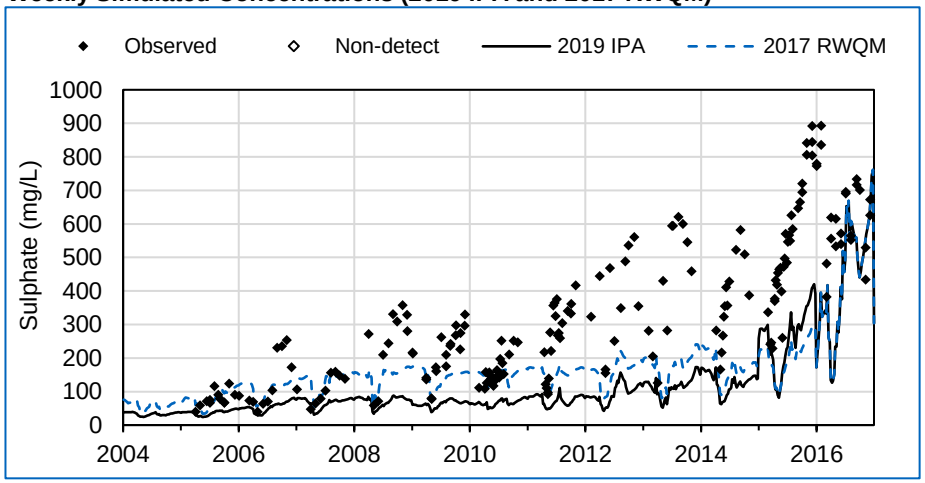
Observed and Simulated Sulphate Data and Calibration Statistics

Statistic	2017 RWQM	2019 IPA	
Model Averaging Period	Weekly	Weekly	Monthly
Calibration Period	2004 to 2016		
First Observed Sample	4/3/2005		
Last Observed Sample	12/7/2016		
Data Points Available for Comparison, n	192	192	114
Non-Detect Count	0	0	0
Observed Mean (mg/L)	329	329	314
Simulated Mean (mg/L)	175	137	129
Bias (mg/L)	-154	-192	-185
Relative Bias	0.53	0.42	0.41
Error (mg/L)	164	195	188
Percent Error	50%	59%	60%

2019 IPA Simulated vs. Observed Sulphate Concentrations

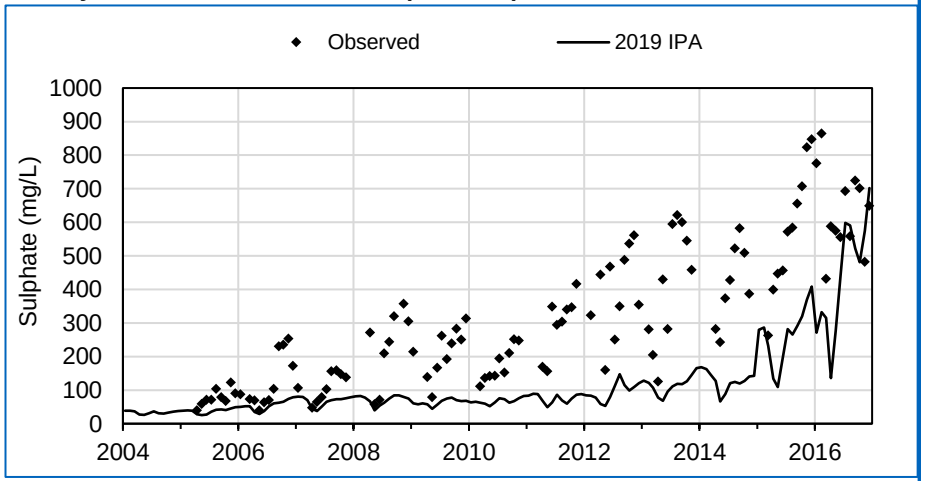


Weekly Simulated Concentrations (2019 IPA and 2017 RWQM)



Note: Observed data are individual sample results

Monthy Simulated Concentrations (2019 IPA)



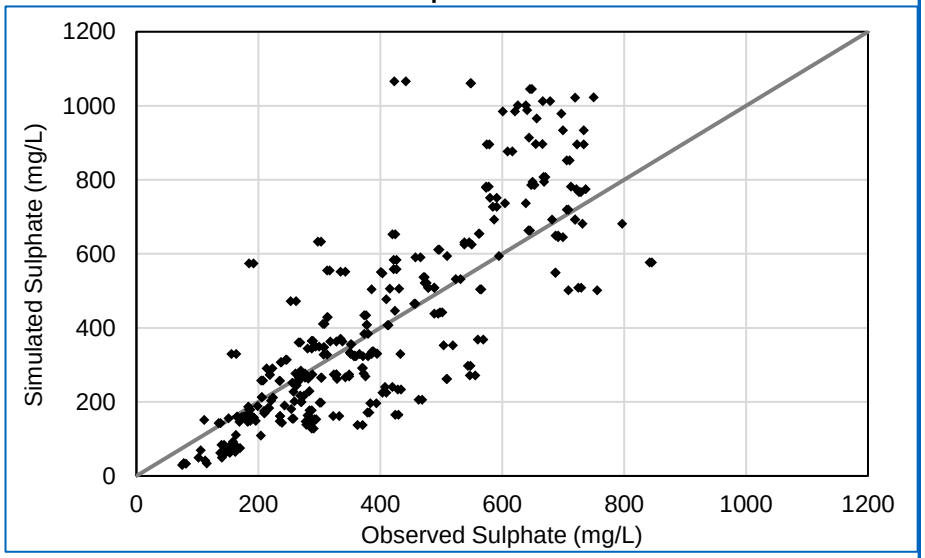
Note: Observed data are monthly averages of sample results

C1-11: Sulphate Calibration Information for Node GH_TC1 - Thompson Creek at LRP Road (EMS E102714)

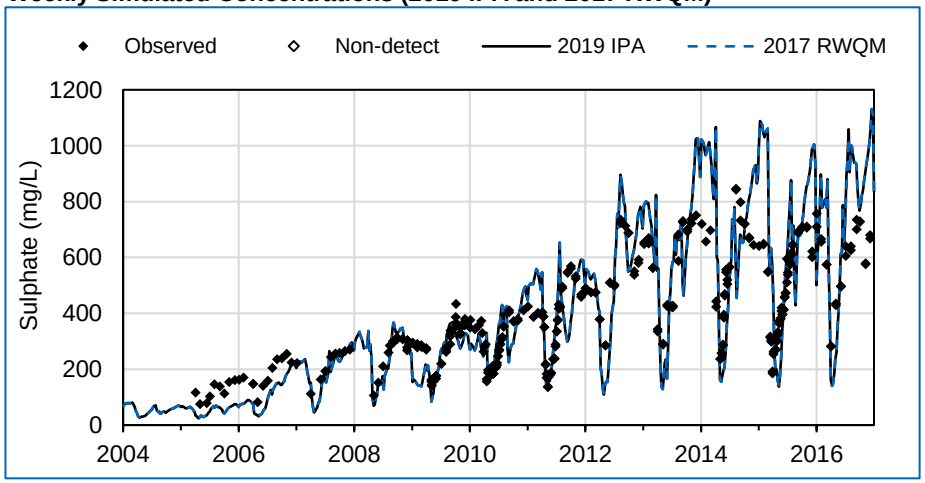
Observed and Simulated Sulphate Data and Calibration Statistics

Statistic	2017 RWQM	2019 IPA	
Model Averaging Period	Weekly	Weekly	Monthly
Calibration Period	2004 to 2016		
First Observed Sample	4/3/2005		
Last Observed Sample	12/7/2016		
Data Points Available for Comparison, n	333	333	132
Non-Detect Count	0	0	0
Observed Mean (mg/L)	392	392	405
Simulated Mean (mg/L)	410	409	430
Bias (mg/L)	18	17	25
Relative Bias	1.0	1.0	1.1
Error (mg/L)	111	111	102
Percent Error	28%	28%	25%

2019 IPA Simulated vs. Observed Sulphate Concentrations

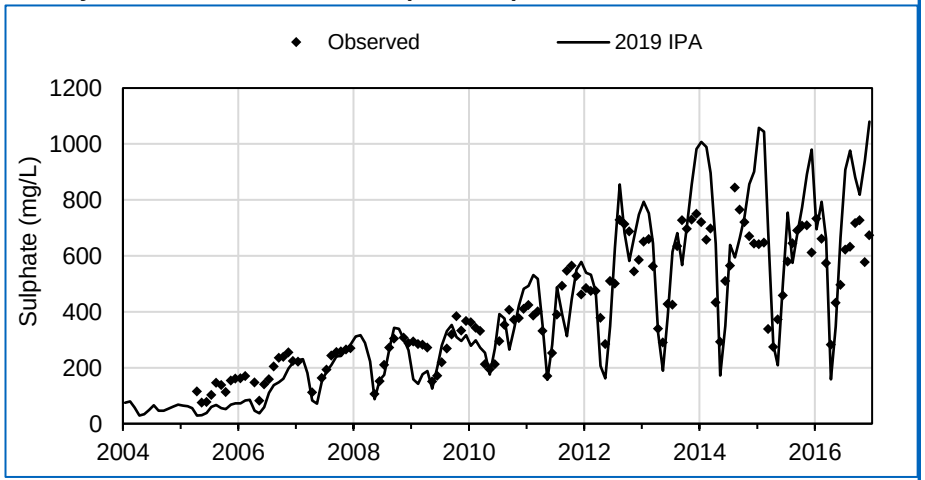


Weekly Simulated Concentrations (2019 IPA and 2017 RWQM)



Note: Observed data are individual sample results

Monthy Simulated Concentrations (2019 IPA)



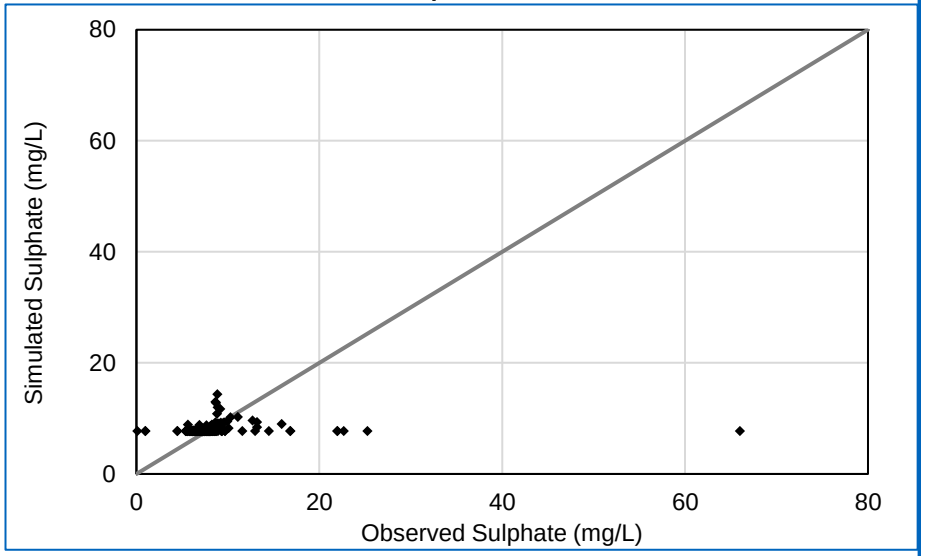
Note: Observed data are monthly averages of sample results

C1-12: Sulphate Calibration Information for Node LC_DC1 - Dry Creek near mouth (at bridge) (EMS E288270)

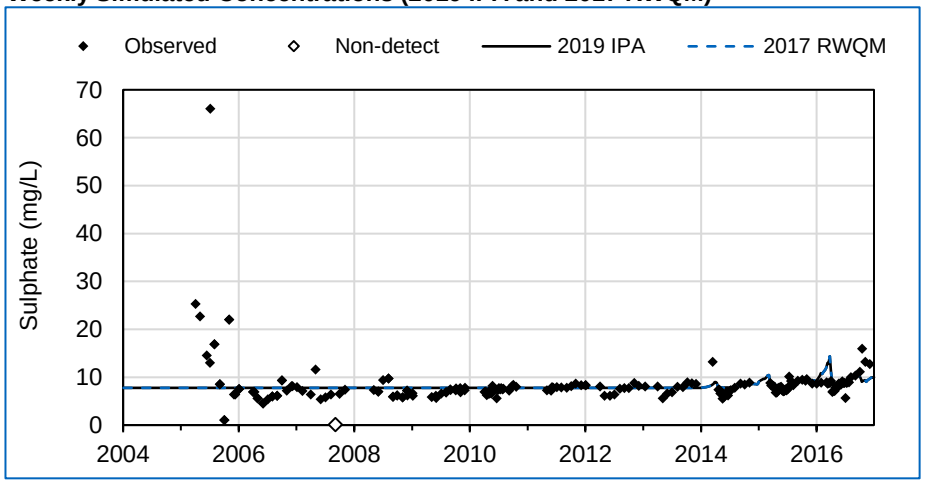
Observed and Simulated Sulphate Data and Calibration Statistics

Statistic	2017 RWQM	2019 IPA	
Model Averaging Period	Weekly	Weekly	Monthly
Calibration Period	2004 to 2016		
First Observed Sample	4/3/2005		
Last Observed Sample	12/6/2016		
Data Points Available for Comparison, n	202	202	111
Non-Detect Count	1	1	0
Observed Mean (mg/L)	8.3	8.3	8.5
Simulated Mean (mg/L)	8.1	8.1	8.1
Bias (mg/L)	-0.14	-0.14	-0.39
Relative Bias	0.98	0.98	0.95
Error (mg/L)	1.8	1.8	2.0
Percent Error	22%	22%	23%

2019 IPA Simulated vs. Observed Sulphate Concentrations

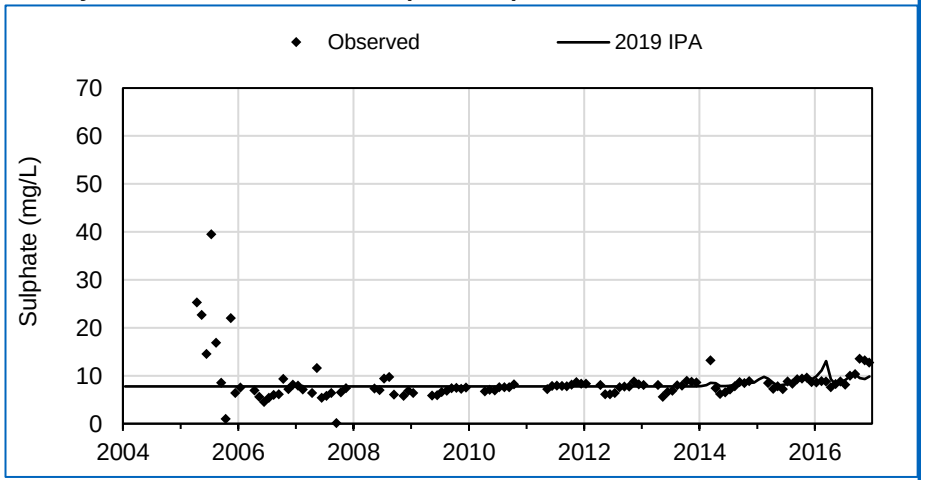


Weekly Simulated Concentrations (2019 IPA and 2017 RWQM)



Note: Observed data are individual sample results

Monthy Simulated Concentrations (2019 IPA)



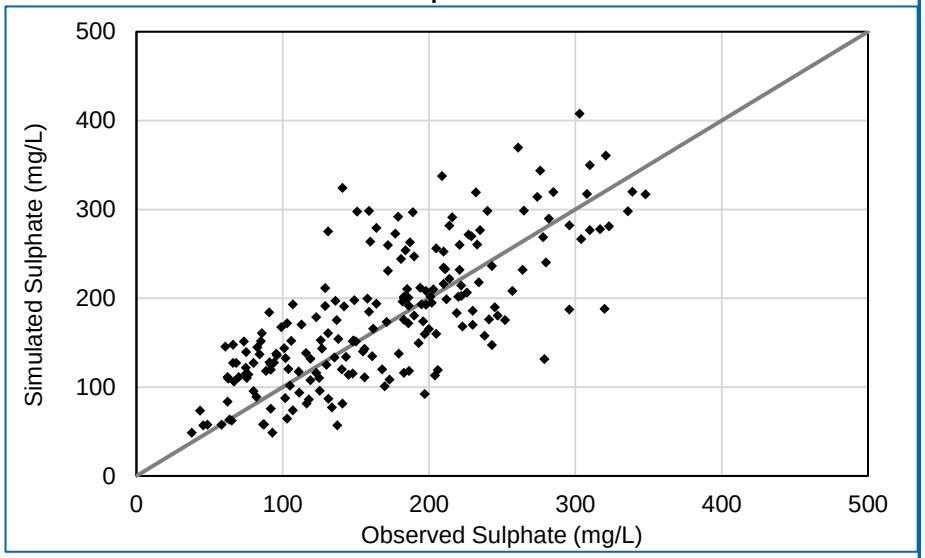
Note: Observed data are monthly averages of sample results

C1-13: Sulphate Calibration Information for Node LC_LCUSWLC - Line Creek u/s of West Line Creek (EMS E293369)

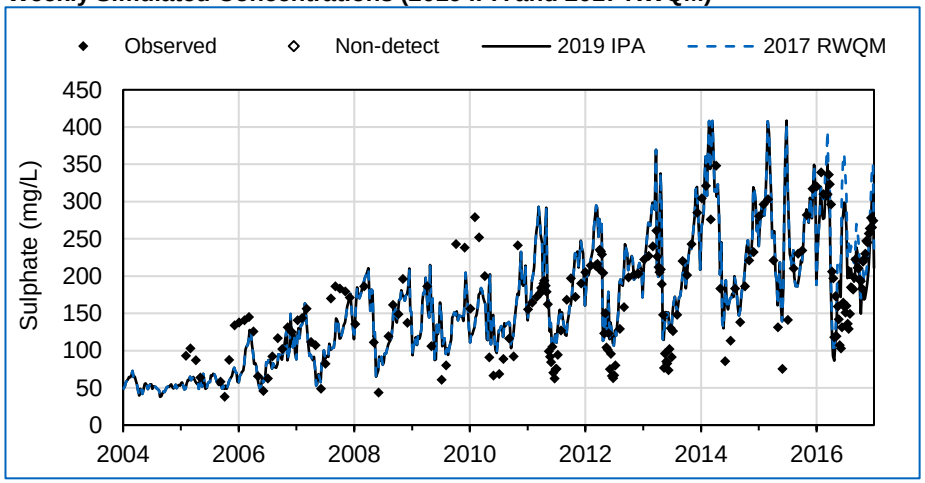
Observed and Simulated Sulphate Data and Calibration Statistics

Statistic	2017 RWQM	2019 IPA	
Model Averaging Period	Weekly	Weekly	Monthly
Calibration Period	2004 to 2016		
First Observed Sample	2/2/2005		
Last Observed Sample	12/28/2016		
Data Points Available for Comparison, n	201	201	130
Non-Detect Count	0	0	0
Observed Mean (mg/L)	168	168	168
Simulated Mean (mg/L)	187	180	174
Bias (mg/L)	18	12	6.4
Relative Bias	1.1	1.1	1.0
Error (mg/L)	46	43	38
Percent Error	27%	26%	22%

2019 IPA Simulated vs. Observed Sulphate Concentrations

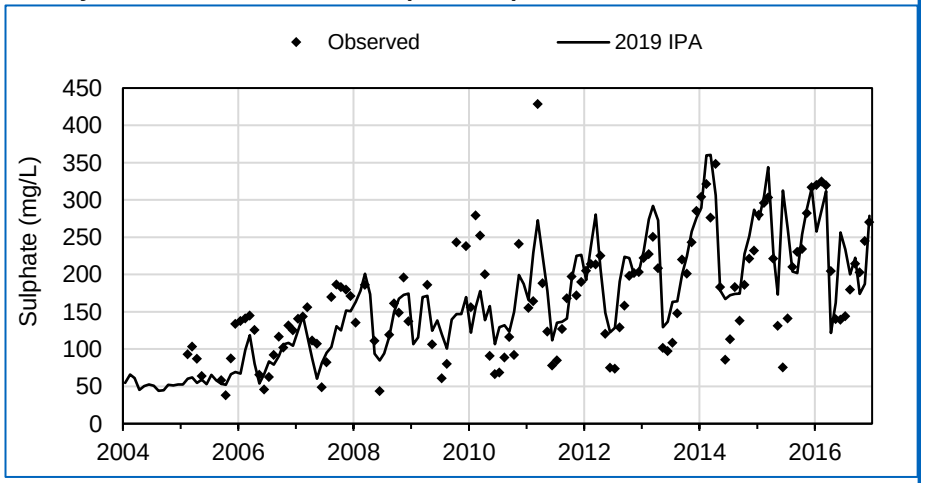


Weekly Simulated Concentrations (2019 IPA and 2017 RWQM)



Note: Observed data are individual sample results

Monthy Simulated Concentrations (2019 IPA)



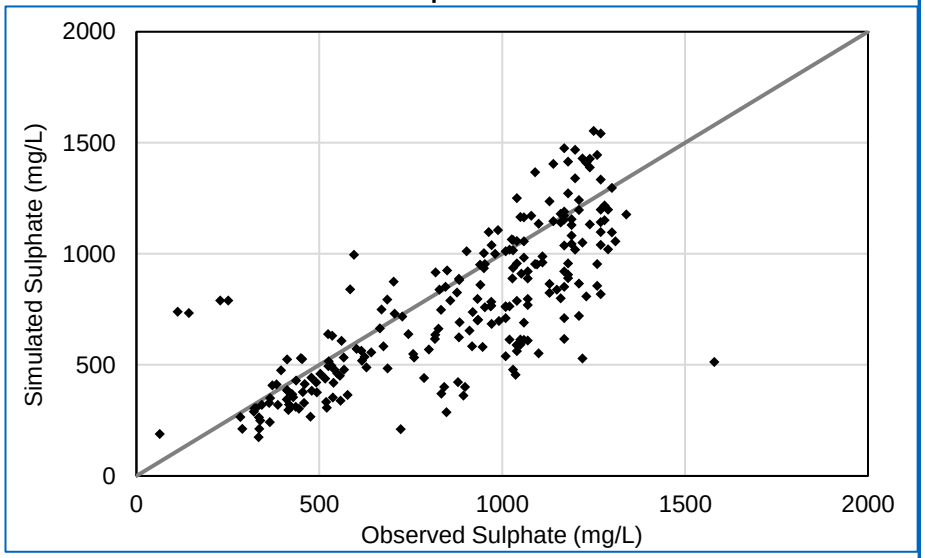
Note: Observed data are monthly averages of sample results

C1-14: Sulphate Calibration Information for Node LC_WLC - West Line Creek (EMS E261958)

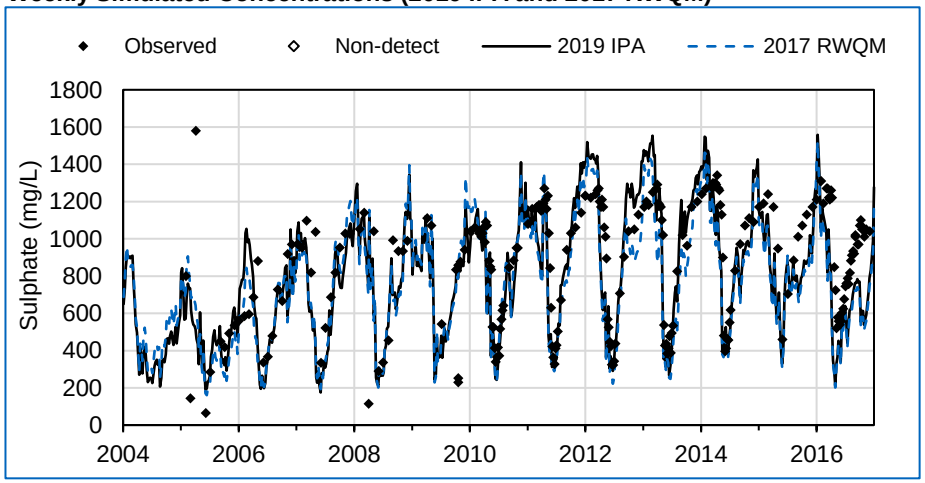
Observed and Simulated Sulphate Data and Calibration Statistics

Statistic	2017 RWQM	2019 IPA	
Model Averaging Period	Weekly	Weekly	Monthly
Calibration Period	2004 to 2016		
First Observed Sample	2/2/2005		
Last Observed Sample	12/5/2016		
Data Points Available for Comparison, n	235	235	133
Non-Detect Count	0	0	0
Observed Mean (mg/L)	865	865	869
Simulated Mean (mg/L)	725	760	821
Bias (mg/L)	-140	-104	-48
Relative Bias	0.84	0.88	0.95
Error (mg/L)	199	181	183
Percent Error	23%	21%	21%

2019 IPA Simulated vs. Observed Sulphate Concentrations

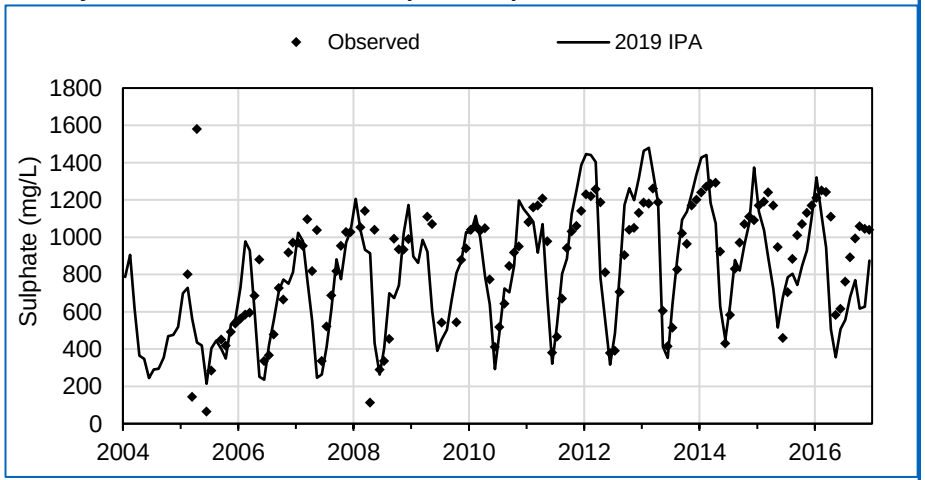


Weekly Simulated Concentrations (2019 IPA and 2017 RWQM)



Note: Observed data are individual sample results

Monthy Simulated Concentrations (2019 IPA)



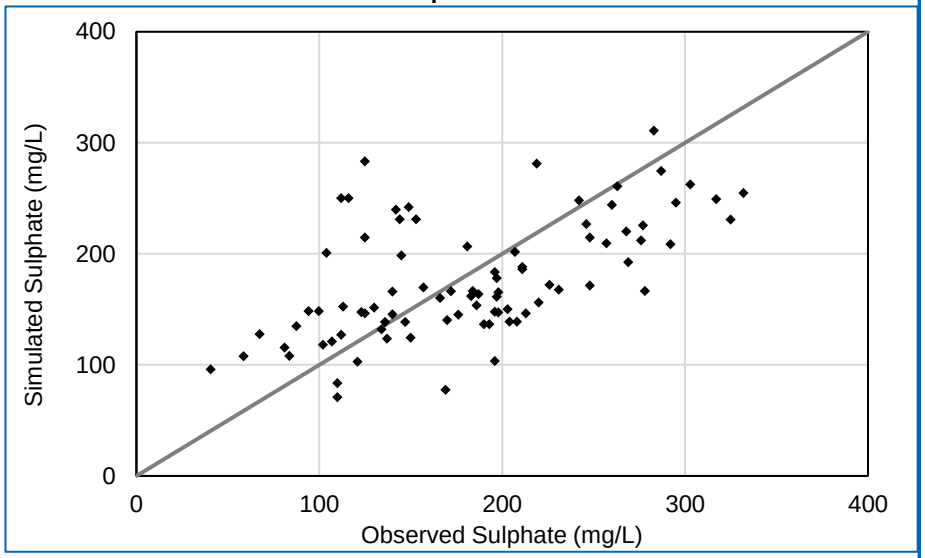
Note: Observed data are monthly averages of sample results

C1-15: Sulphate Calibration Information for Node LC_LCDSSLCC - LCO Compliance Point - Line Creek d/s of South Line Creek (EMS E297110)

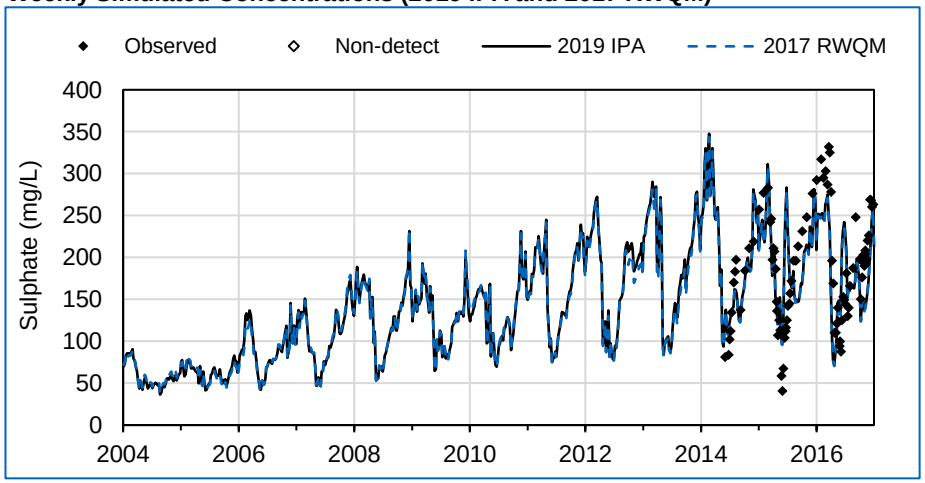
Observed and Simulated Sulphate Data and Calibration Statistics

Statistic	2017 RWQM	2019 IPA	
Model Averaging Period	Weekly	Weekly	Monthly
Calibration Period	2004 to 2016		
First Observed Sample	6/4/2014		
Last Observed Sample	12/28/2016		
Data Points Available for Comparison, n	86	86	31
Non-Detect Count	0	0	0
Observed Mean (mg/L)	182	182	200
Simulated Mean (mg/L)	174	176	189
Bias (mg/L)	-8.0	-6.0	-11
Relative Bias	0.96	0.97	0.95
Error (mg/L)	46	46	37
Percent Error	25%	25%	19%

2019 IPA Simulated vs. Observed Sulphate Concentrations

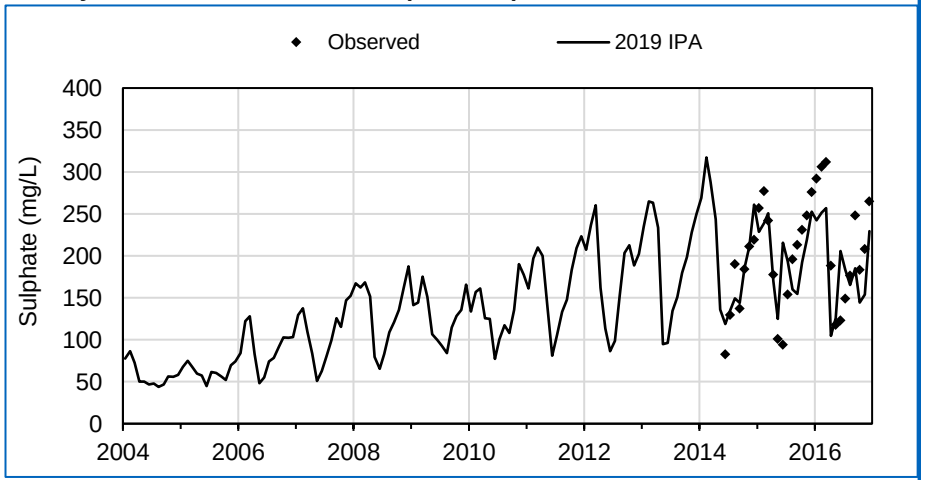


Weekly Simulated Concentrations (2019 IPA and 2017 RWQM)



Note: Observed data are individual sample results

Monthy Simulated Concentrations (2019 IPA)



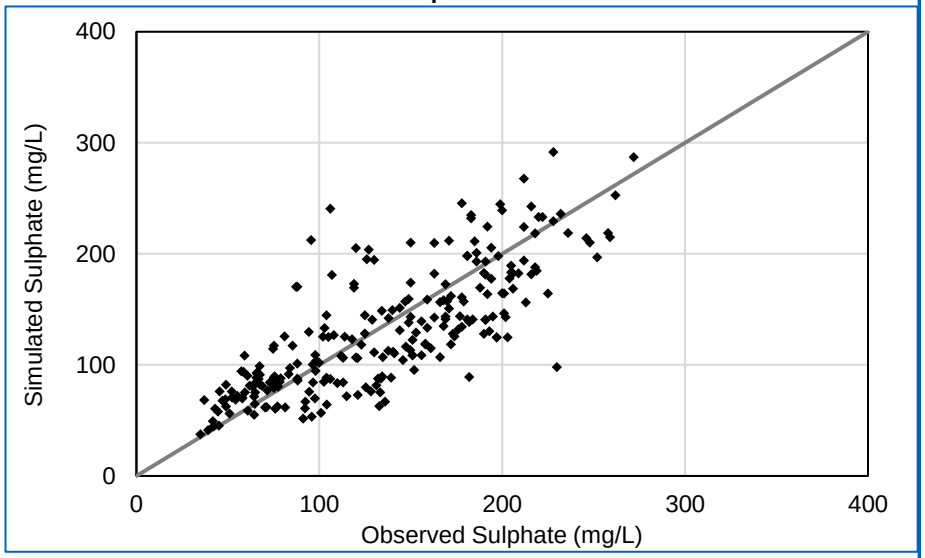
Note: Observed data are monthly averages of sample results

C1-16: Sulphate Calibration Information for Node LC_LC4 - Line Creek u/s of Process Plant (EMS 0200044)

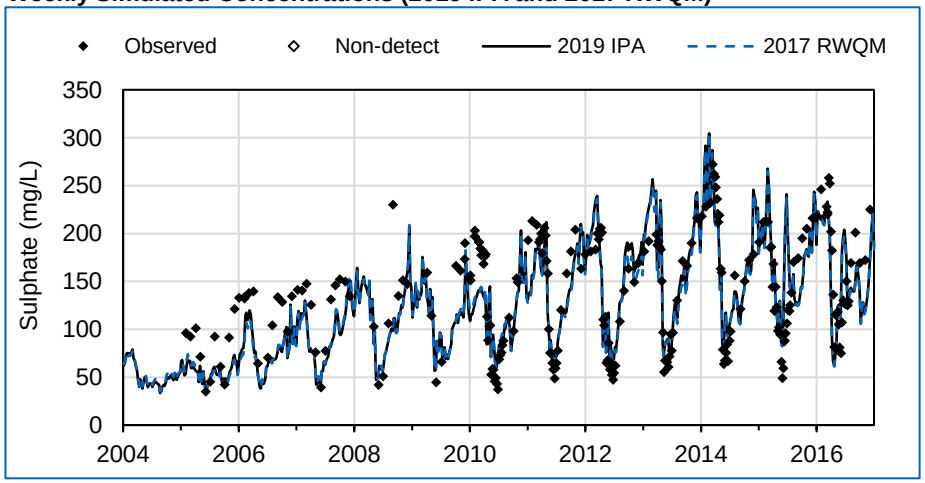
Observed and Simulated Sulphate Data and Calibration Statistics

Statistic	2017 RWQM	2019 IPA	
Model Averaging Period	Weekly	Weekly	Monthly
Calibration Period	2004 to 2016		
First Observed Sample	2/2/2005		
Last Observed Sample	12/7/2016		
Data Points Available for Comparison, n	242	242	132
Non-Detect Count	0	0	0
Observed Mean (mg/L)	135	135	138
Simulated Mean (mg/L)	129	130	130
Bias (mg/L)	-6.1	-4.7	-8.4
Relative Bias	0.96	0.97	0.94
Error (mg/L)	29	29	27
Percent Error	22%	22%	19%

2019 IPA Simulated vs. Observed Sulphate Concentrations

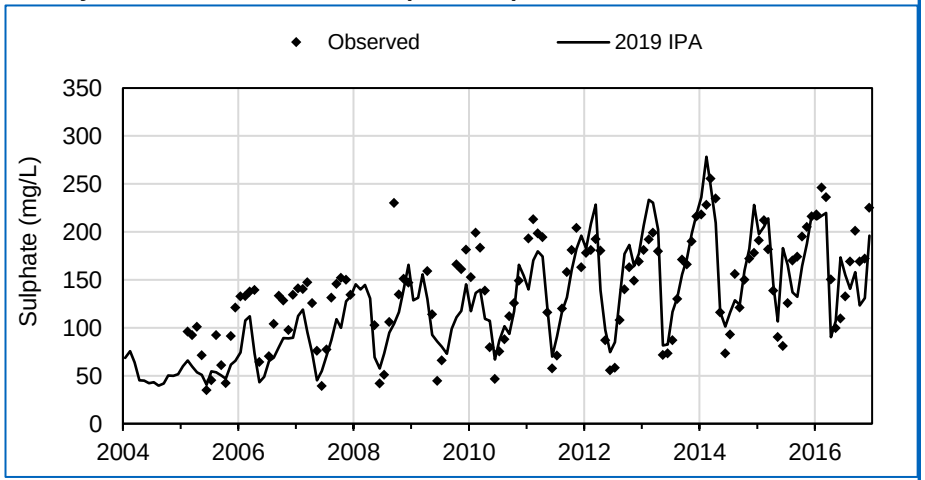


Weekly Simulated Concentrations (2019 IPA and 2017 RWQM)



Note: Observed data are individual sample results

Monthy Simulated Concentrations (2019 IPA)



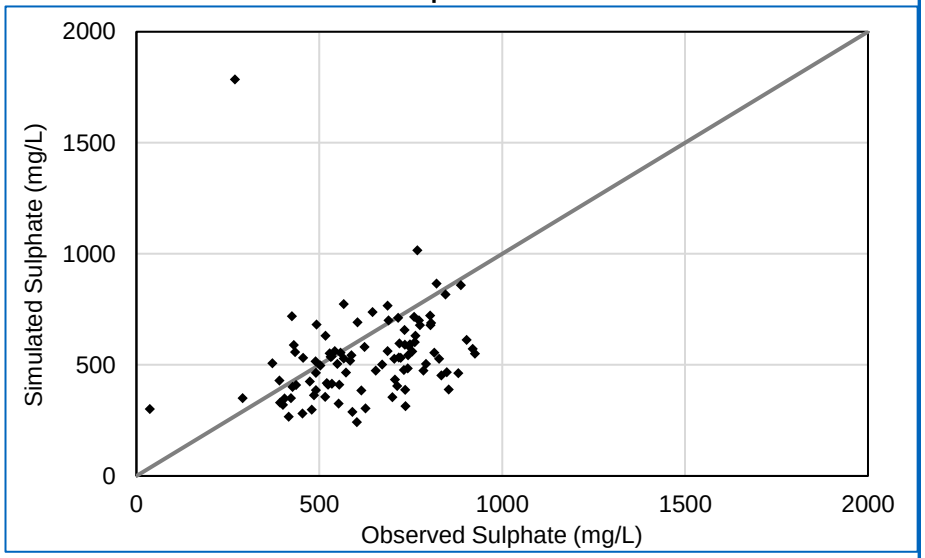
Note: Observed data are monthly averages of sample results

C1-17: Sulphate Calibration Information for Node EV_DC1 - EVO Dry Creek Sediment Pond Decant (EMS E298590)

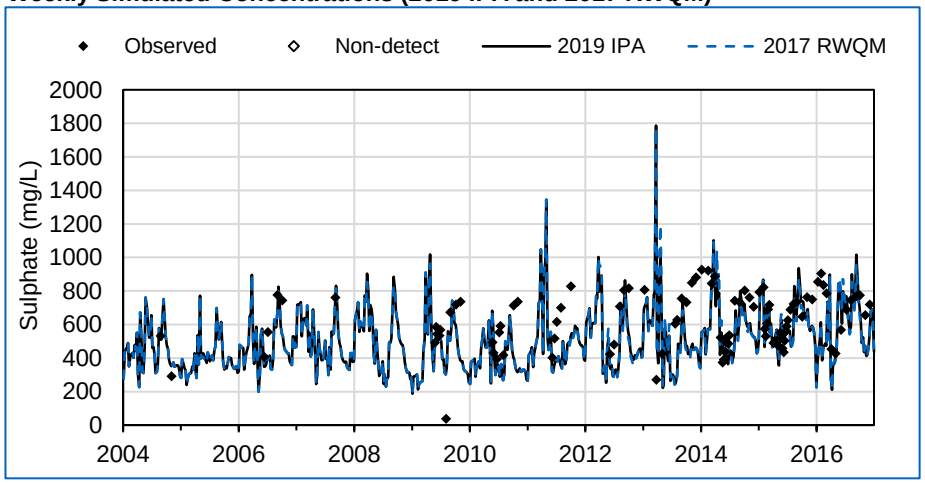
Observed and Simulated Sulphate Data and Calibration Statistics

Statistic	2017 RWQM	2019 IPA	
Model Averaging Period	Weekly	Weekly	Monthly
Calibration Period	2004 to 2016		
First Observed Sample	8/26/2004		
Last Observed Sample	12/5/2016		
Data Points Available for Comparison, n	96	96	73
Non-Detect Count	0	0	0
Observed Mean (mg/L)	625	625	649
Simulated Mean (mg/L)	536	534	532
Bias (mg/L)	-89	-91	-117
Relative Bias	0.86	0.85	0.82
Error (mg/L)	176	170	168
Percent Error	28%	27%	26%

2019 IPA Simulated vs. Observed Sulphate Concentrations

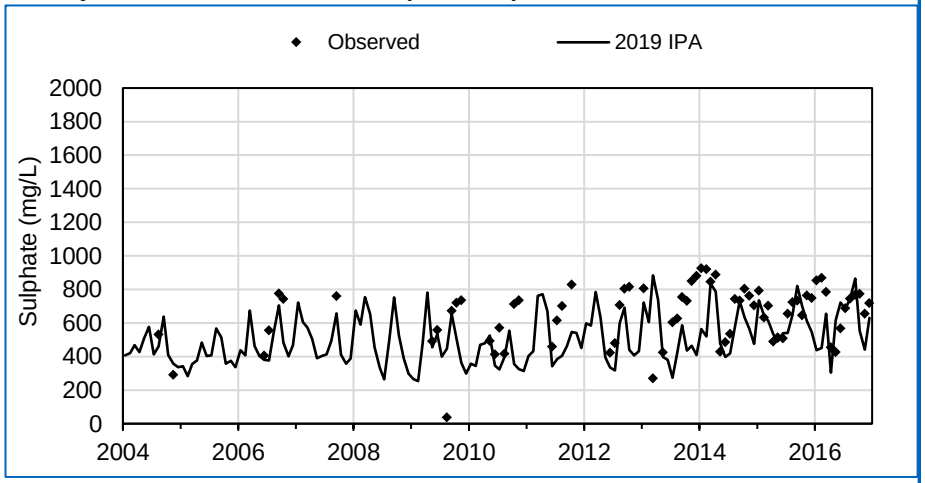


Weekly Simulated Concentrations (2019 IPA and 2017 RWQM)



Note: Observed data are individual sample results

Monthy Simulated Concentrations (2019 IPA)



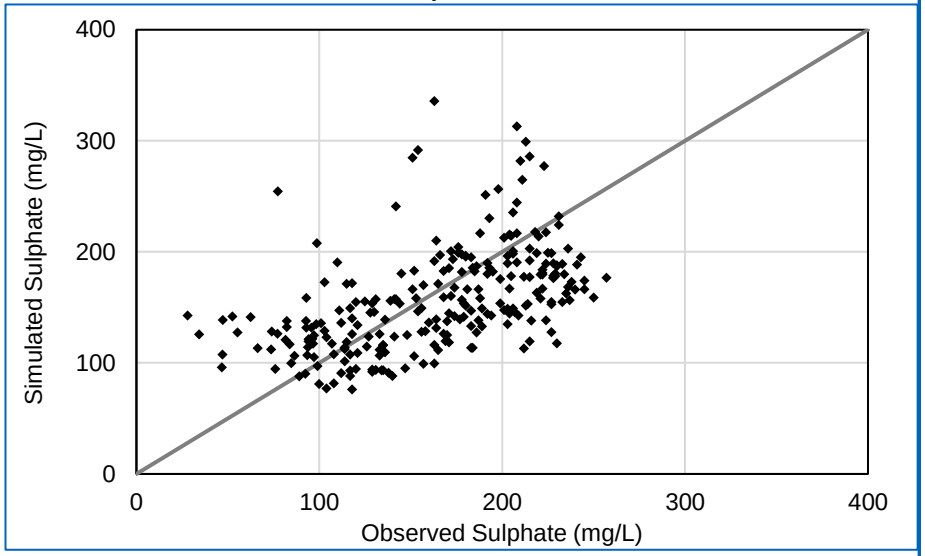
Note: Observed data are monthly averages of sample results

C1-18: Sulphate Calibration Information for Node EV_HC1 - EVO Harmer Compliance Point - Harmer Spillway (EMS E102682)

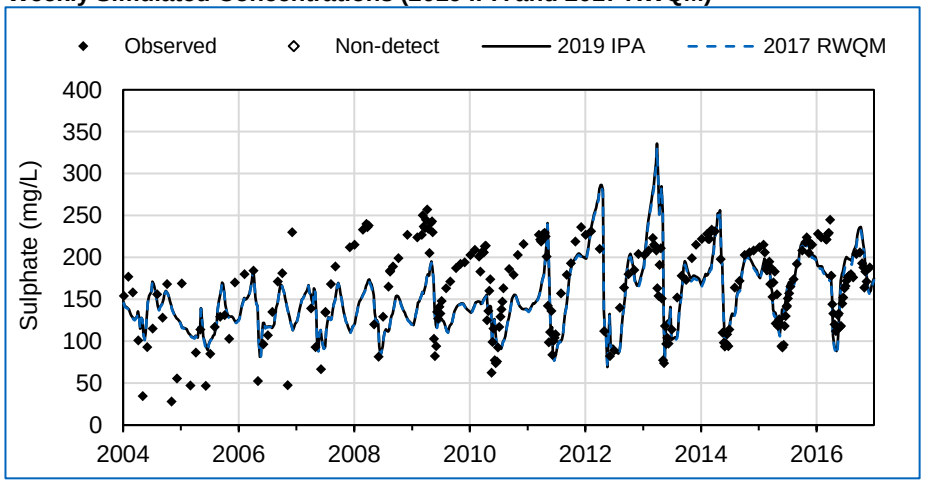
Observed and Simulated Sulphate Data and Calibration Statistics

Statistic	2017 RWQM	2019 IPA	
Model Averaging Period	Weekly	Weekly	Monthly
Calibration Period	2004 to 2016		
First Observed Sample	1/6/2004		
Last Observed Sample	12/5/2016		
Data Points Available for Comparison, n	251	251	142
Non-Detect Count	0	0	0
Observed Mean (mg/L)	163	163	163
Simulated Mean (mg/L)	155	157	154
Bias (mg/L)	-8.0	-6.0	-9.4
Relative Bias	0.95	0.96	0.94
Error (mg/L)	39	39	33
Percent Error	24%	24%	20%

2019 IPA Simulated vs. Observed Sulphate Concentrations

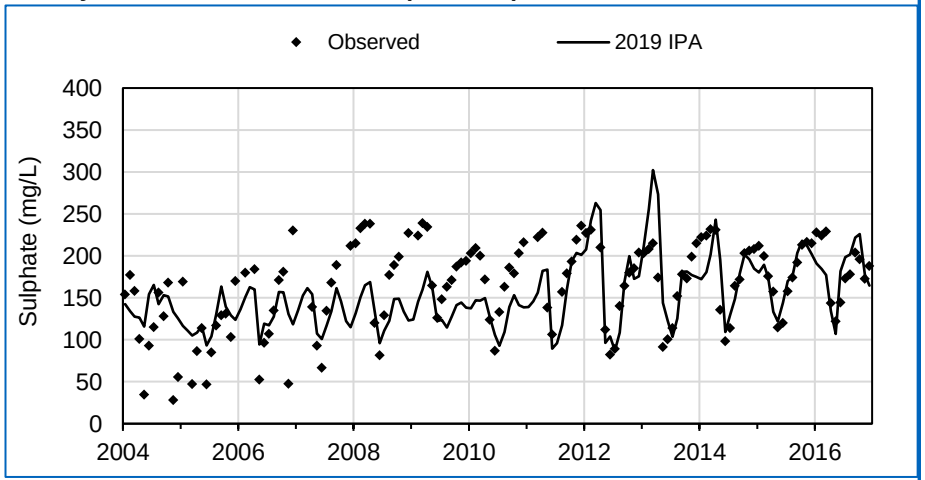


Weekly Simulated Concentrations (2019 IPA and 2017 RWQM)



Note: Observed data are individual sample results

Monthy Simulated Concentrations (2019 IPA)



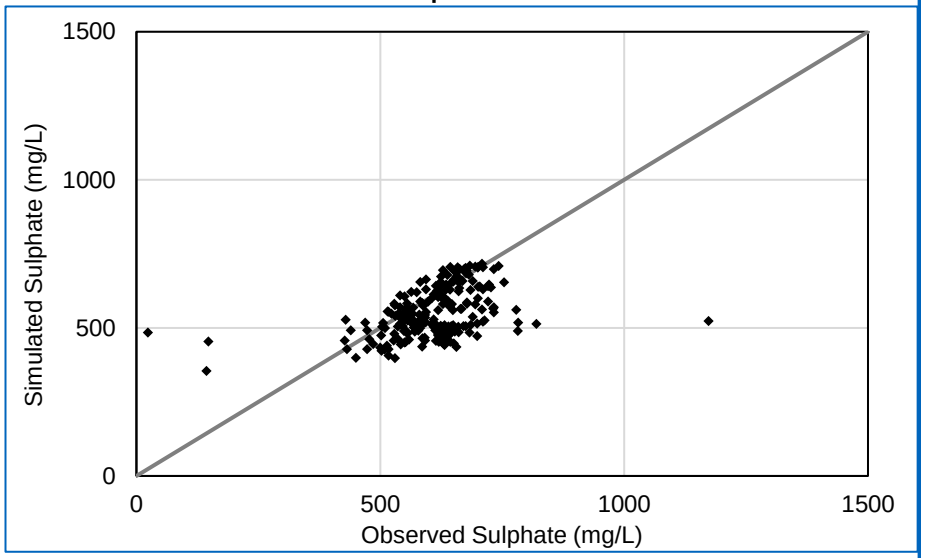
Note: Observed data are monthly averages of sample results

C1-19: Sulphate Calibration Information for Node EV_EC1 - Erickson Creek at Mouth (EMS 0200097)

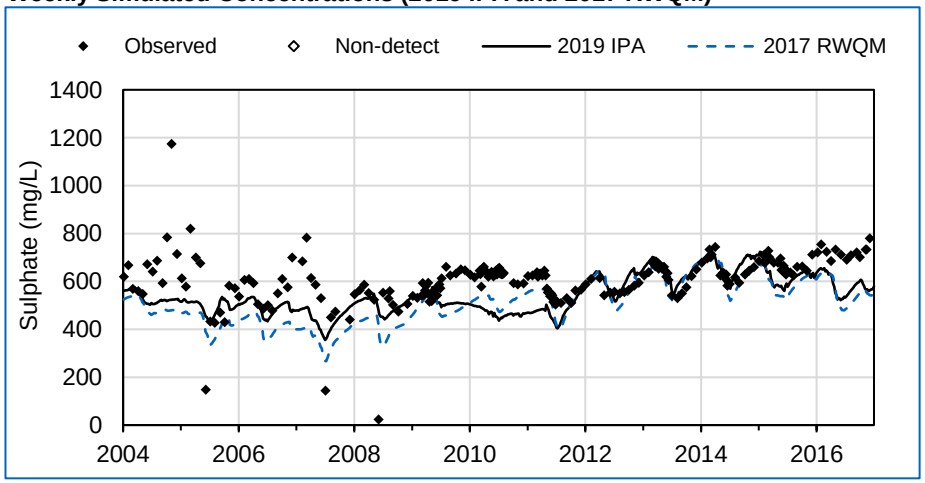
Observed and Simulated Sulphate Data and Calibration Statistics

Statistic	2017 RWQM	2019 IPA	
Model Averaging Period	Weekly	Weekly	Monthly
Calibration Period	2004 to 2016		
First Observed Sample	1/6/2004		
Last Observed Sample	12/5/2016		
Data Points Available for Comparison, n	228	228	150
Non-Detect Count	0	0	0
Observed Mean (mg/L)	609	609	602
Simulated Mean (mg/L)	530	547	545
Bias (mg/L)	-79	-62	-57
Relative Bias	0.87	0.9	0.9
Error (mg/L)	91	85	88
Percent Error	15%	14%	15%

2019 IPA Simulated vs. Observed Sulphate Concentrations

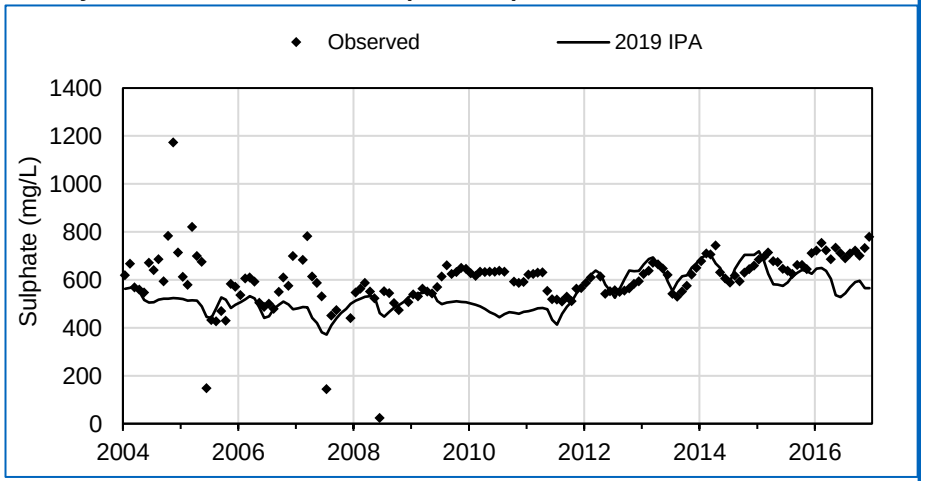


Weekly Simulated Concentrations (2019 IPA and 2017 RWQM)



Note: Observed data are individual sample results

Monthy Simulated Concentrations (2019 IPA)



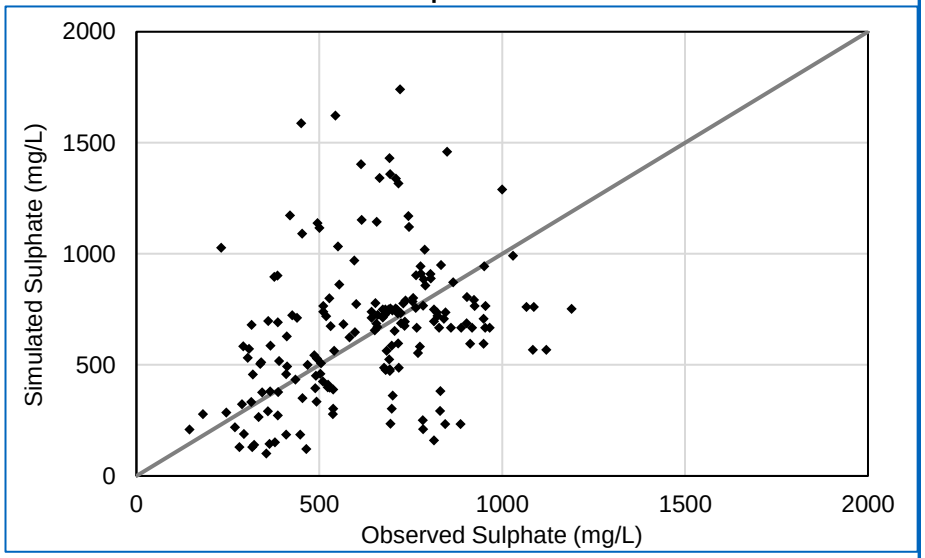
Note: Observed data are monthly averages of sample results

C1-20: Sulphate Calibration Information for Node EV_GT1 - Gate Creek Sediment Pond Decant (EMS E206231)

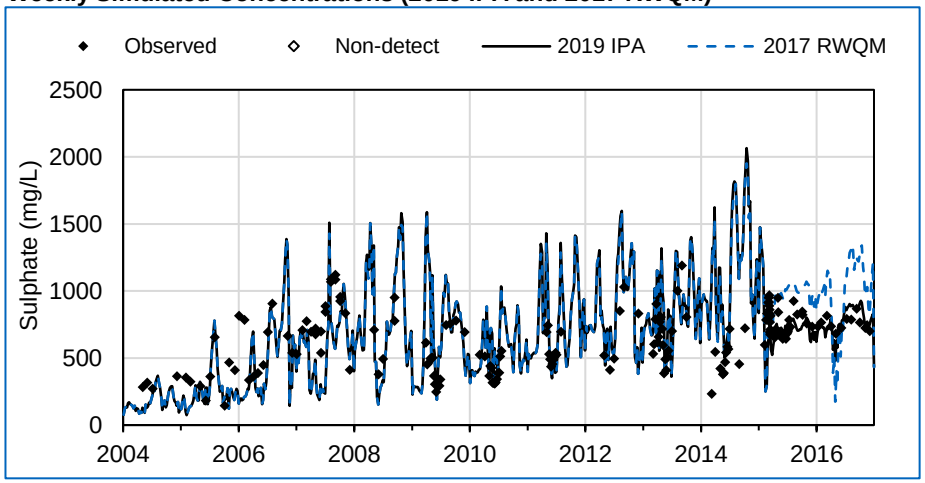
Observed and Simulated Sulphate Data and Calibration Statistics

Statistic	2017 RWQM	2019 IPA	
Model Averaging Period	Weekly	Weekly	Monthly
Calibration Period	2004 to 2016		
First Observed Sample	5/4/2004		
Last Observed Sample	12/5/2016		
Data Points Available for Comparison, n	179	179	100
Non-Detect Count	0	0	0
Observed Mean (mg/L)	630	630	628
Simulated Mean (mg/L)	725	665	667
Bias (mg/L)	95	34	39
Relative Bias	1.2	1.1	1.1
Error (mg/L)	260	229	198
Percent Error	41%	36%	32%

2019 IPA Simulated vs. Observed Sulphate Concentrations

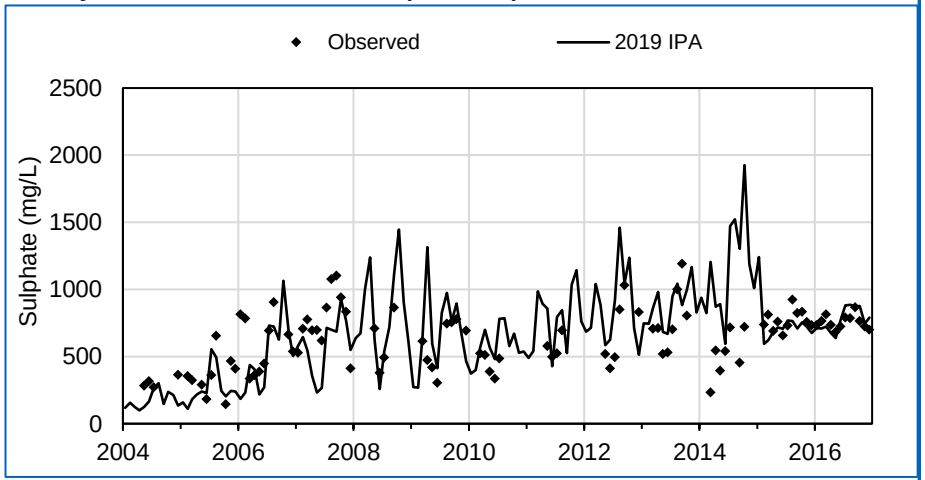


Weekly Simulated Concentrations (2019 IPA and 2017 RWQM)



Note: Observed data are individual sample results

Monthy Simulated Concentrations (2019 IPA)



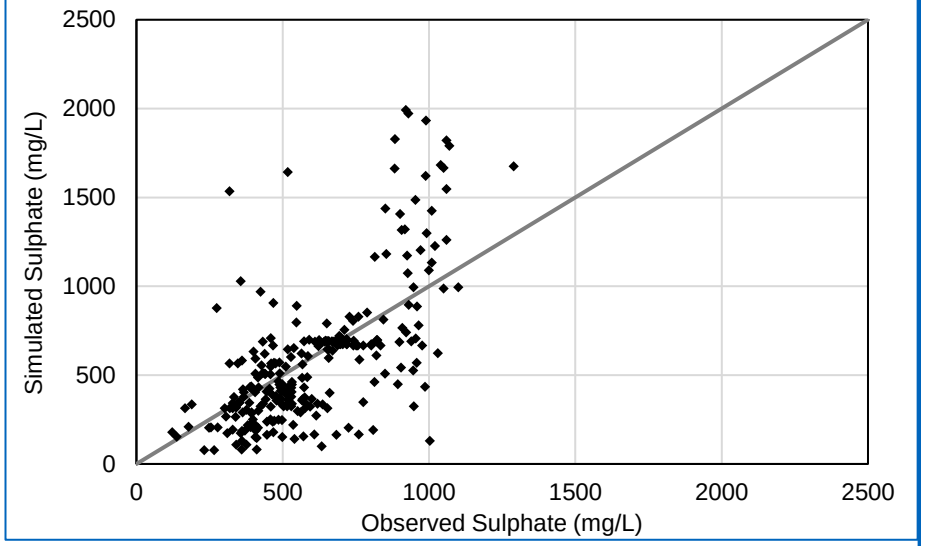
Note: Observed data are monthly averages of sample results

C1-21: Sulphate Calibration Information for Node EV_BC1 - Bodie Creek Sediment Pond Decant (EMS E102685)

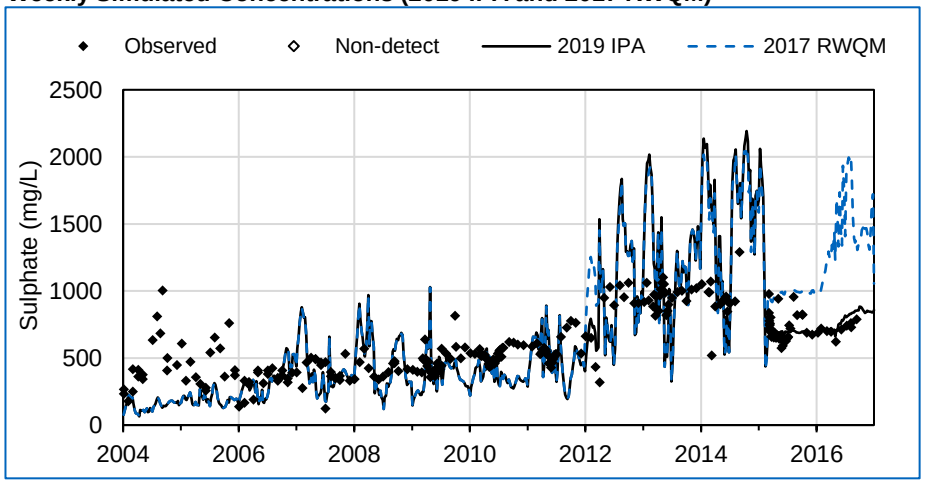
Observed and Simulated Sulphate Data and Calibration Statistics

Statistic	2017 RWQM	2019 IPA	
Model Averaging Period	Weekly	Weekly	Monthly
Calibration Period	2004 to 2016		
First Observed Sample	1/6/2004		
Last Observed Sample	9/14/2016		
Data Points Available for Comparison, n	261	261	144
Non-Detect Count	0	0	0
Observed Mean (mg/L)	599	599	601
Simulated Mean (mg/L)	652	585	595
Bias (mg/L)	54	-13	-5.6
Relative Bias	1.1	0.98	0.99
Error (mg/L)	254	204	216
Percent Error	42%	34%	36%

2019 IPA Simulated vs. Observed Sulphate Concentrations

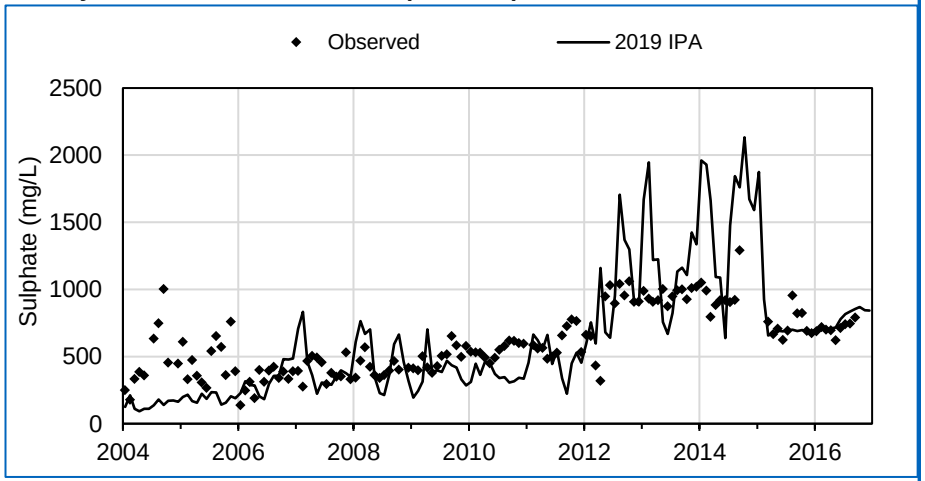


Weekly Simulated Concentrations (2019 IPA and 2017 RWQM)



Note: Observed data are individual sample results

Monthy Simulated Concentrations (2019 IPA)



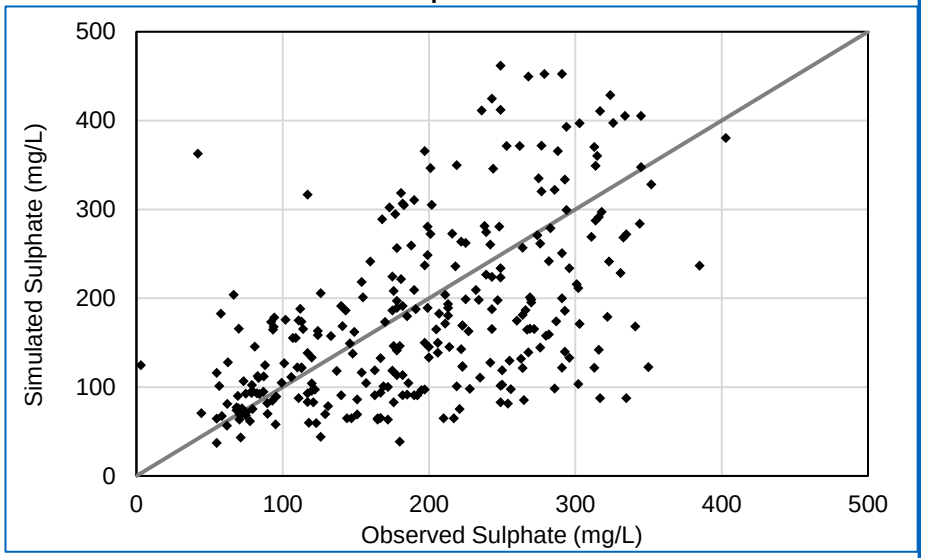
Note: Observed data are monthly averages of sample results

C1-22: Sulphate Calibration Information for Node CM_MC2 - Michel Creek d/s CMO near Andy Goode Creek Junction (EMS E258937)

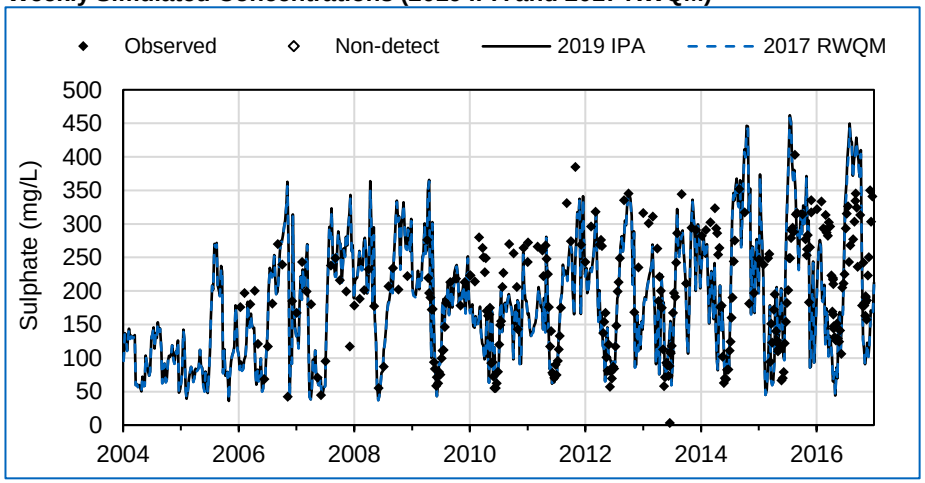
Observed and Simulated Sulphate Data and Calibration Statistics

Statistic	2017 RWQM	2019 IPA	
Model Averaging Period	Weekly	Weekly	Monthly
Calibration Period	2004 to 2016		
First Observed Sample	1/11/2006		
Last Observed Sample	12/21/2016		
Data Points Available for Comparison, n	284	284	127
Non-Detect Count	0	0	0
Observed Mean (mg/L)	195	195	212
Simulated Mean (mg/L)	178	181	199
Bias (mg/L)	-16	-14	-13
Relative Bias	0.92	0.93	0.94
Error (mg/L)	69	70	55
Percent Error	36%	36%	26%

2019 IPA Simulated vs. Observed Sulphate Concentrations

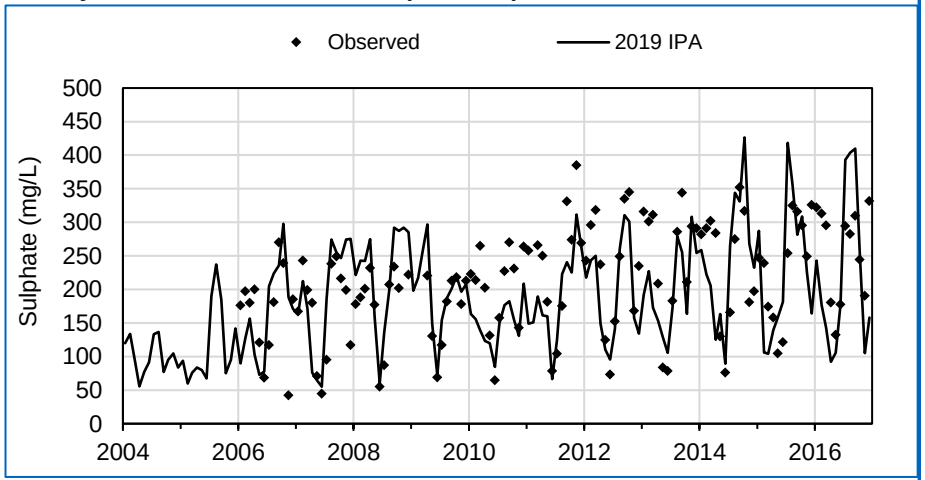


Weekly Simulated Concentrations (2019 IPA and 2017 RWQM)



Note: Observed data are individual sample results

Monthy Simulated Concentrations (2019 IPA)



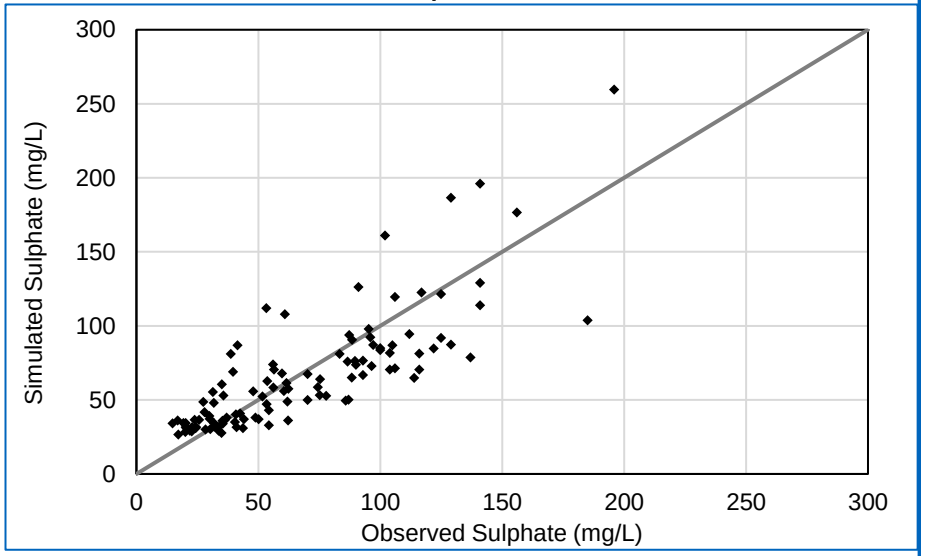
Note: Observed data are monthly averages of sample results

C1-23: Sulphate Calibration Information for Node FR_FR1 - Fording River d/s of Henretta Creek (EMS 0200251)

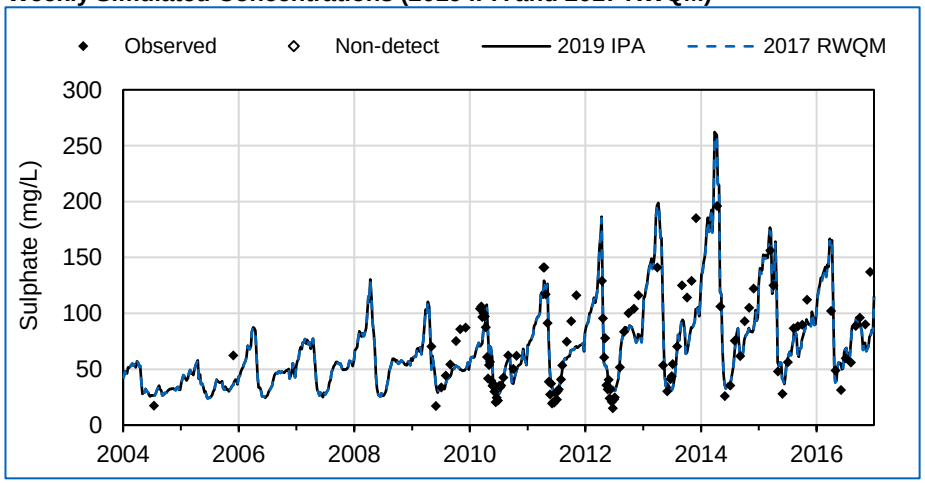
Observed and Simulated Sulphate Data and Calibration Statistics

Statistic	2017 RWQM	2019 IPA	
Model Averaging Period	Weekly	Weekly	Monthly
Calibration Period	2004 to 2016		
First Observed Sample	7/13/2004		
Last Observed Sample	12/7/2016		
Data Points Available for Comparison, n	109	109	71
Non-Detect Count	0	0	0
Observed Mean (mg/L)	68	68	77
Simulated Mean (mg/L)	66	67	71
Bias (mg/L)	-1.7	-1.3	-5.2
Relative Bias	0.98	0.98	0.93
Error (mg/L)	18	18	18
Percent Error	27%	27%	23%

2019 IPA Simulated vs. Observed Sulphate Concentrations

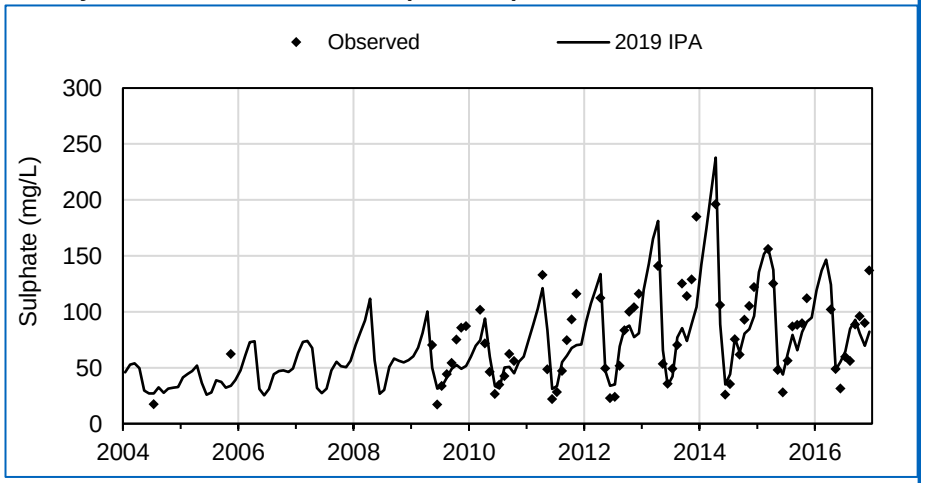


Weekly Simulated Concentrations (2019 IPA and 2017 RWQM)



Note: Observed data are individual sample results

Monthy Simulated Concentrations (2019 IPA)



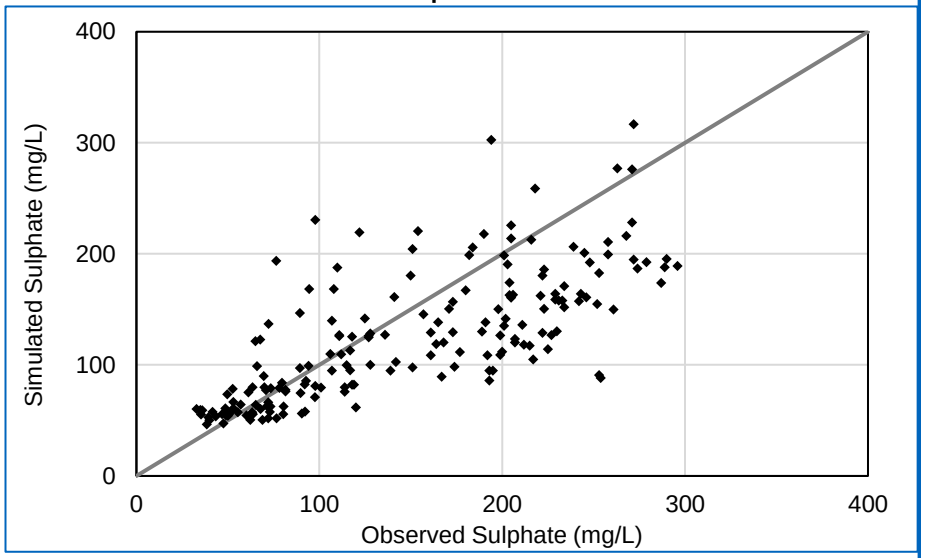
Note: Observed data are monthly averages of sample results

C1-24: Sulphate Calibration Information for Node FR_FR2 - Fording River u/s of Kilmarnock Creek (EMS 0200201)

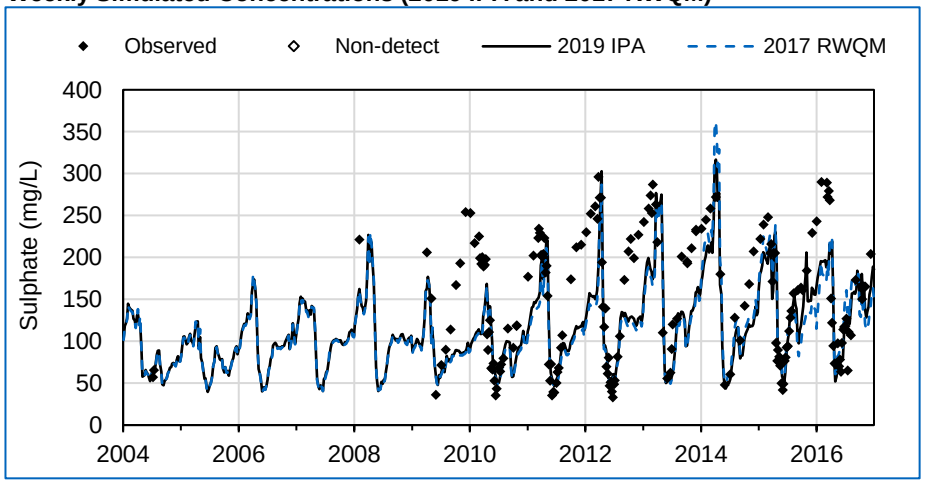
Observed and Simulated Sulphate Data and Calibration Statistics

Statistic	2017 RWQM	2019 IPA	
Model Averaging Period	Weekly	Weekly	Monthly
Calibration Period	2004 to 2016		
First Observed Sample	7/7/2004		
Last Observed Sample	12/12/2016		
Data Points Available for Comparison, n	180	180	91
Non-Detect Count	0	0	0
Observed Mean (mg/L)	148	148	163
Simulated Mean (mg/L)	123	125	129
Bias (mg/L)	-25	-23	-34
Relative Bias	0.83	0.85	0.79
Error (mg/L)	45	42	43
Percent Error	30%	29%	27%

2019 IPA Simulated vs. Observed Sulphate Concentrations

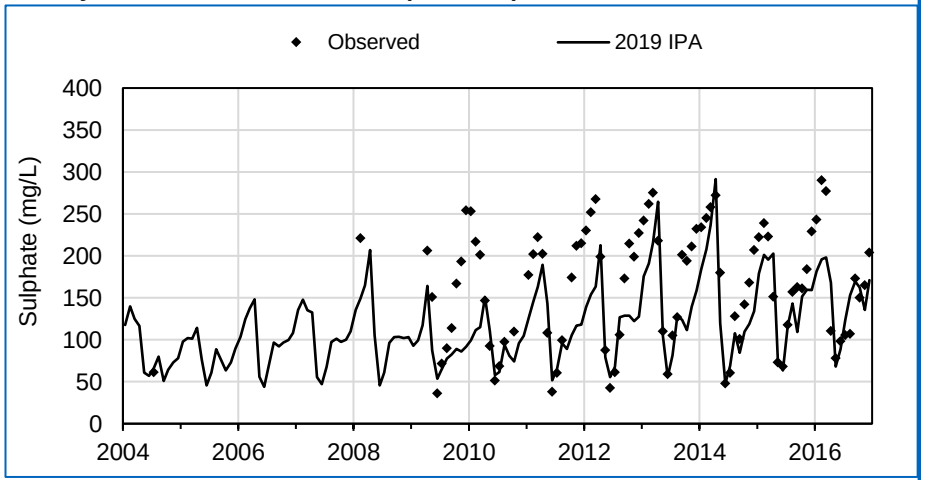


Weekly Simulated Concentrations (2019 IPA and 2017 RWQM)



Note: Observed data are individual sample results

Monthy Simulated Concentrations (2019 IPA)



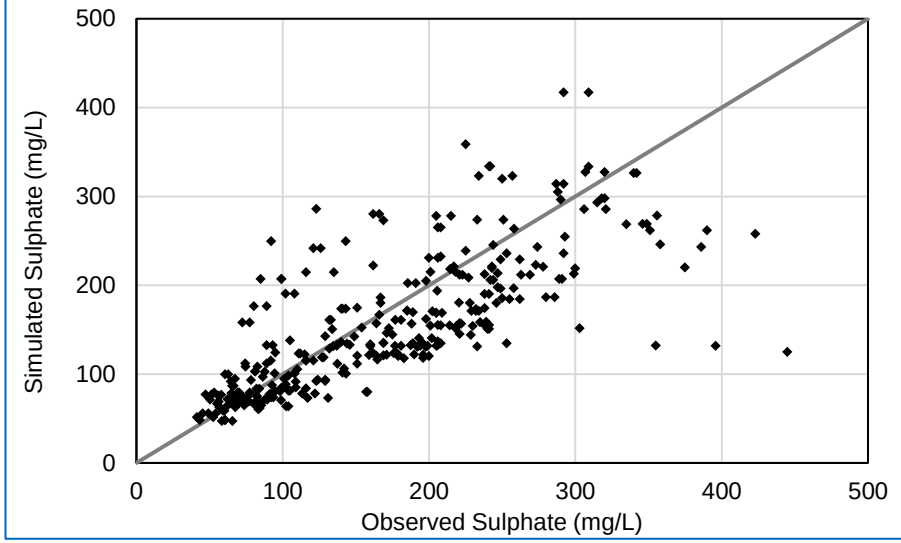
Note: Observed data are monthly averages of sample results

C1-25: Sulphate Calibration Information for Node FR_FR4 - Fording River between Swift and Cataract creeks (EMS 0200311)

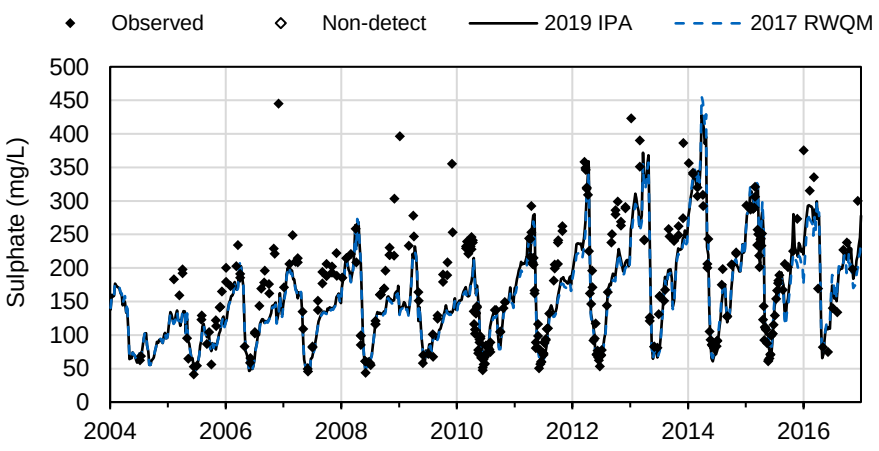
Observed and Simulated Sulphate Data and Calibration Statistics

Statistic	2017 RWQM	2019 IPA	
Model Averaging Period	Weekly	Weekly	Monthly
Calibration Period	2004 to 2016		
First Observed Sample	7/7/2004		
Last Observed Sample	12/12/2016		
Data Points Available for Comparison, n	339	339	131
Non-Detect Count	0	0	0
Observed Mean (mg/L)	168	168	184
Simulated Mean (mg/L)	151	153	160
Bias (mg/L)	-17	-15	-24
Relative Bias	0.9	0.91	0.87
Error (mg/L)	43	42	39
Percent Error	26%	25%	21%

2019 IPA Simulated vs. Observed Sulphate Concentrations

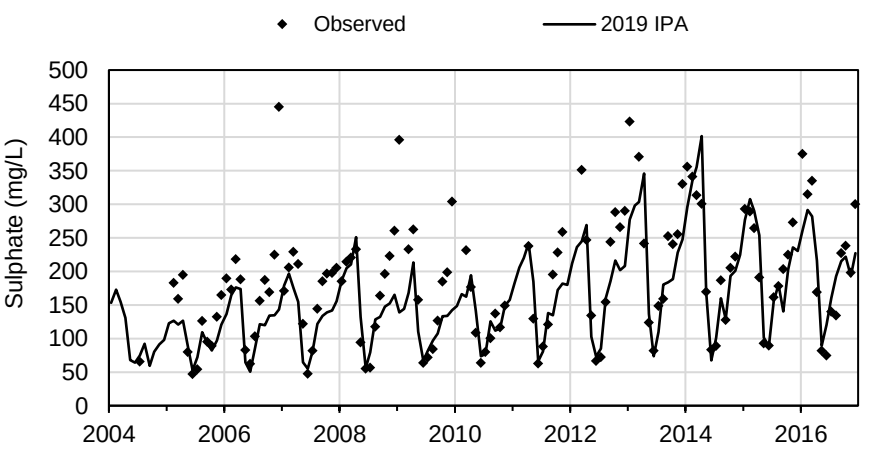


Weekly Simulated Concentrations (2019 IPA and 2017 RWQM)



Note: Observed data are individual sample results

Monthy Simulated Concentrations (2019 IPA)



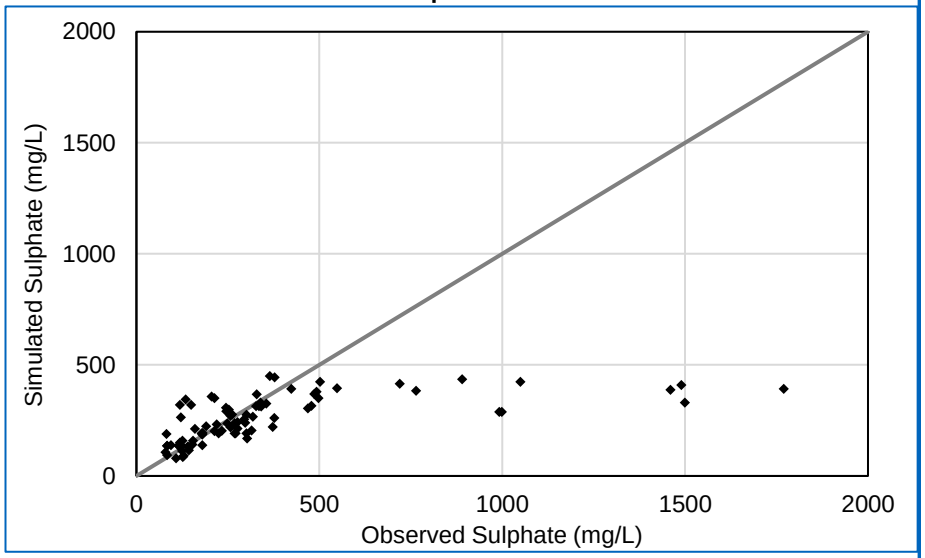
Note: Observed data are monthly averages of sample results

C1-26: Sulphate Calibration Information for Node FR_FRCP1 - FRO Compliance Point - Fording R., 525 m d/s of Cataract Creek (EMS E300071)

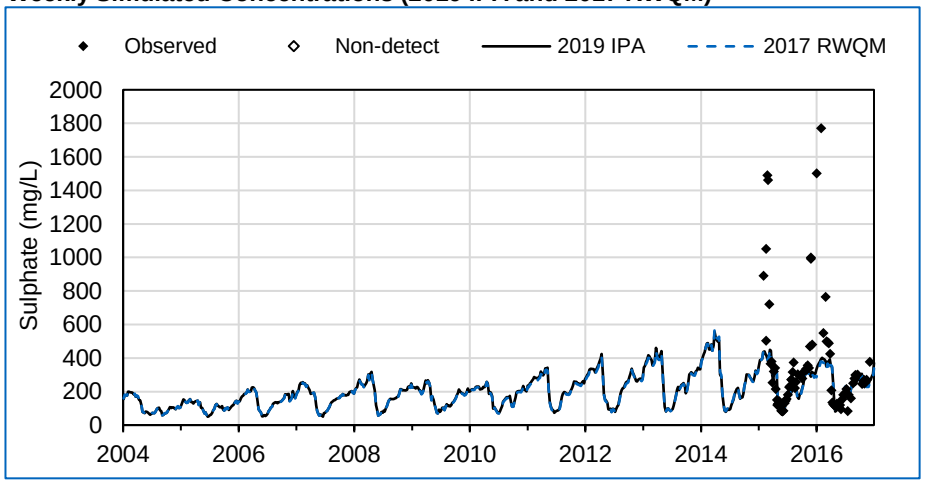
Observed and Simulated Sulphate Data and Calibration Statistics

Statistic	2017 RWQM	2019 IPA	
Model Averaging Period	Weekly	Weekly	Monthly
Calibration Period	2004 to 2016		
First Observed Sample	2/3/2015		
Last Observed Sample	12/6/2016		
Data Points Available for Comparison, n	82	82	23
Non-Detect Count	0	0	0
Observed Mean (mg/L)	359	359	416
Simulated Mean (mg/L)	253	256	263
Bias (mg/L)	-106	-103	-153
Relative Bias	0.71	0.71	0.63
Error (mg/L)	154	150	180
Percent Error	43%	42%	43%

2019 IPA Simulated vs. Observed Sulphate Concentrations

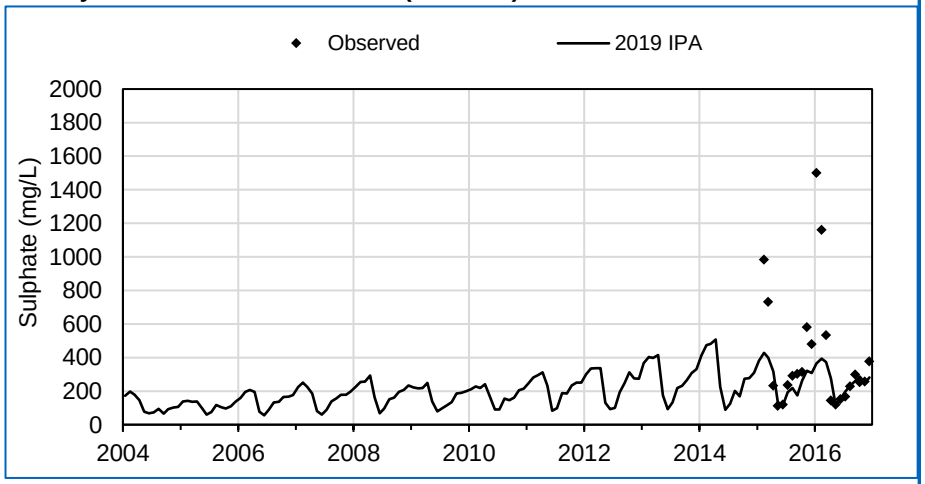


Weekly Simulated Concentrations (2019 IPA and 2017 RWQM)



Note: Observed data are individual sample results

Monthy Simulated Concentrations (2019 IPA)



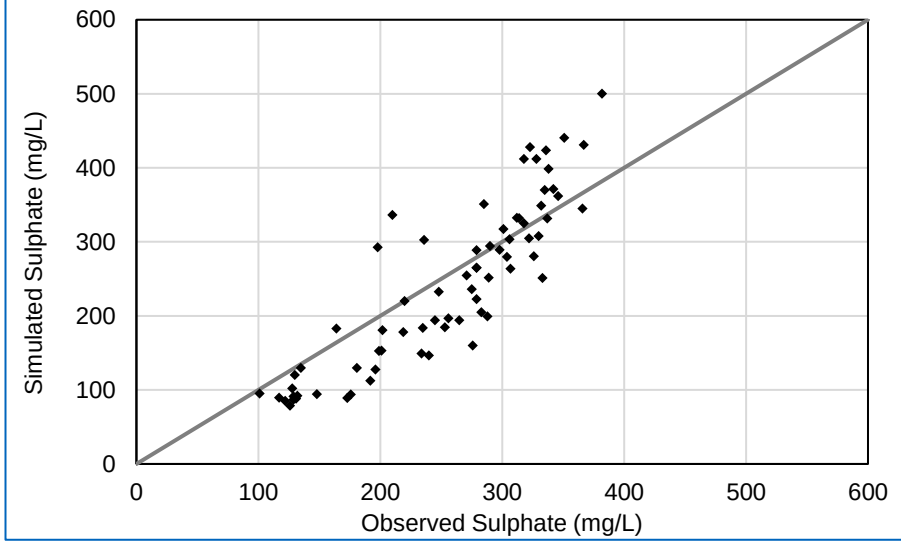
Note: Observed data are monthly averages of sample results

C1-27: Sulphate Calibration Information for Node GH_PC2 - Fording River d/s of Porter Creek (EMS E287431)

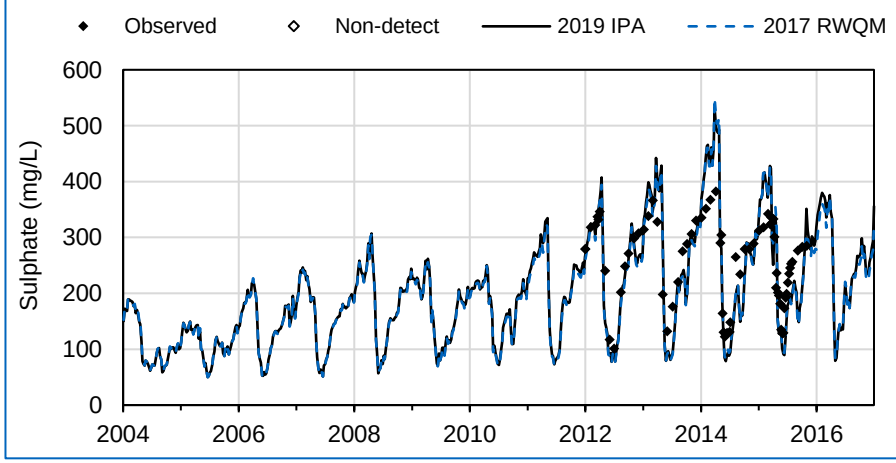
Observed and Simulated Sulphate Data and Calibration Statistics

Statistic	2017 RWQM	2019 IPA	
Model Averaging Period	Weekly	Weekly	Monthly
Calibration Period	2004 to 2016		
First Observed Sample	1/3/2012		
Last Observed Sample	11/2/2015		
Data Points Available for Comparison, n	72	72	47
Non-Detect Count	0	0	0
Observed Mean (mg/L)	253	253	266
Simulated Mean (mg/L)	240	241	261
Bias (mg/L)	-13	-12	-4.7
Relative Bias	0.95	0.95	0.98
Error (mg/L)	46	47	41
Percent Error	18%	18%	15%

2019 IPA Simulated vs. Observed Sulphate Concentrations

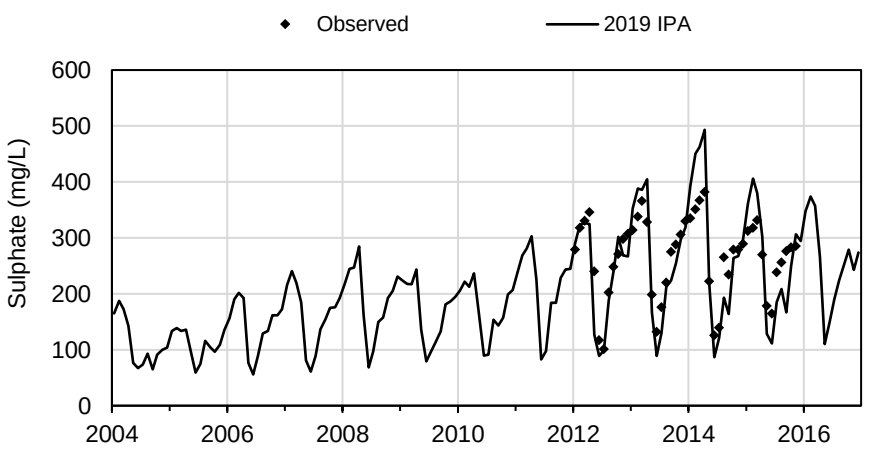


Weekly Simulated Concentrations (2019 IPA and 2017 RWQM)



Note: Observed data are individual sample results

Monthy Simulated Concentrations (2019 IPA)



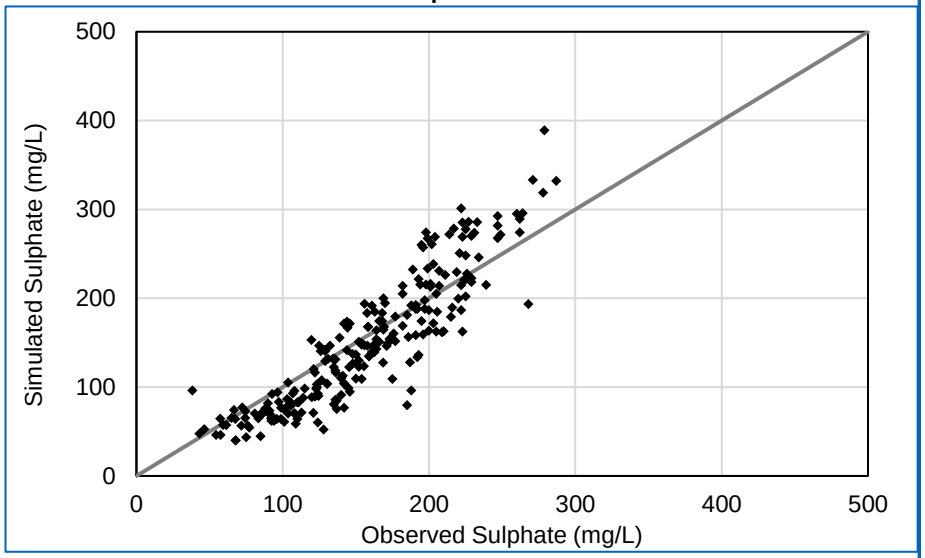
Note: Observed data are monthly averages of sample results

C1-28: Sulphate Calibration Information for Node GH_FR1 - GHO Fording River Compliance Point (EMS 0200378)

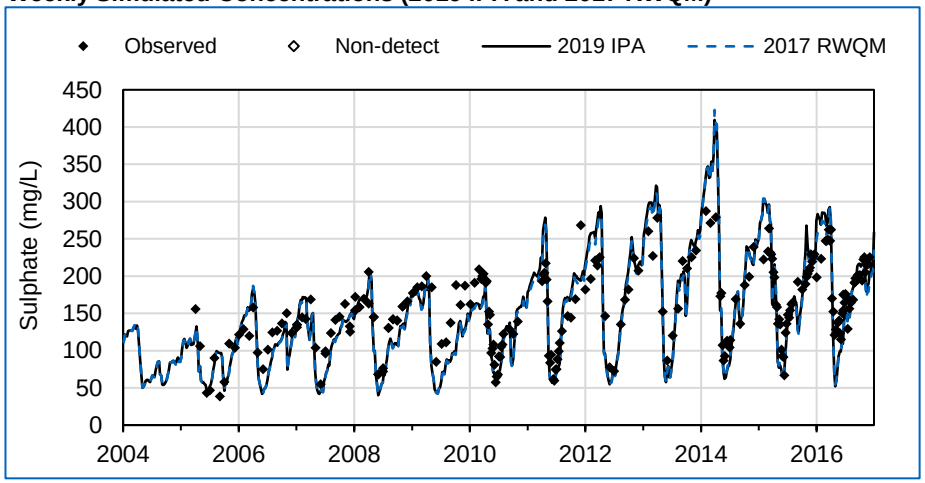
Observed and Simulated Sulphate Data and Calibration Statistics

Statistic	2017 RWQM	2019 IPA	
Model Averaging Period	Weekly	Weekly	Monthly
Calibration Period	2004 to 2016		
First Observed Sample	4/3/2005		
Last Observed Sample	12/6/2016		
Data Points Available for Comparison, n	238	238	133
Non-Detect Count	0	0	0
Observed Mean (mg/L)	157	157	156
Simulated Mean (mg/L)	147	150	153
Bias (mg/L)	-9.1	-6.8	-3.3
Relative Bias	0.94	0.96	0.98
Error (mg/L)	26	27	26
Percent Error	17%	17%	17%

2019 IPA Simulated vs. Observed Sulphate Concentrations

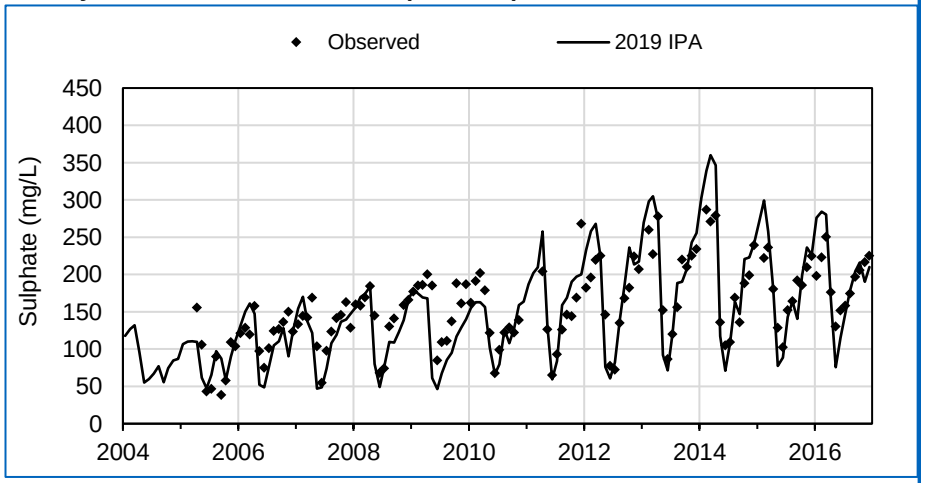


Weekly Simulated Concentrations (2019 IPA and 2017 RWQM)



Note: Observed data are individual sample results

Monthy Simulated Concentrations (2019 IPA)



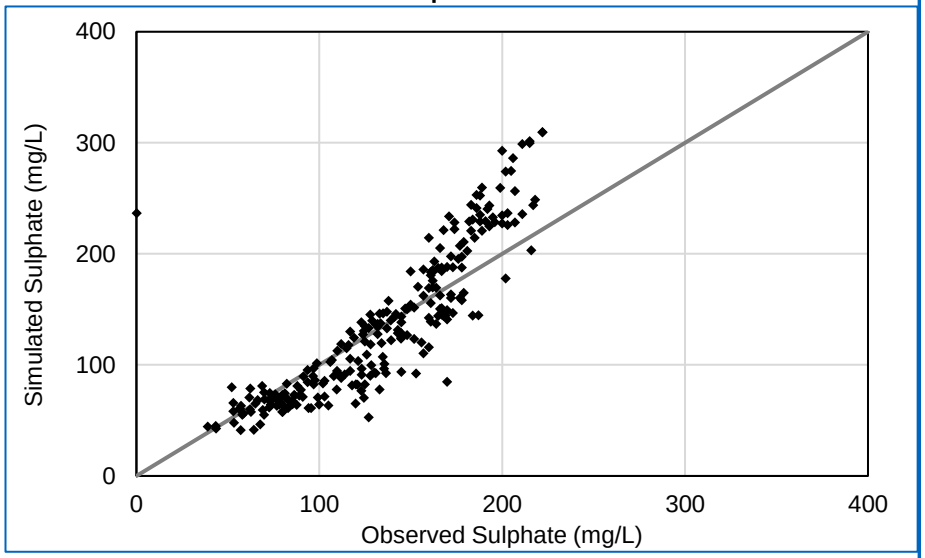
Note: Observed data are monthly averages of sample results

C1-29: Sulphate Calibration Information for Node LC_LC5 - Fording River d/s of Line Creek (EMS 0200028)

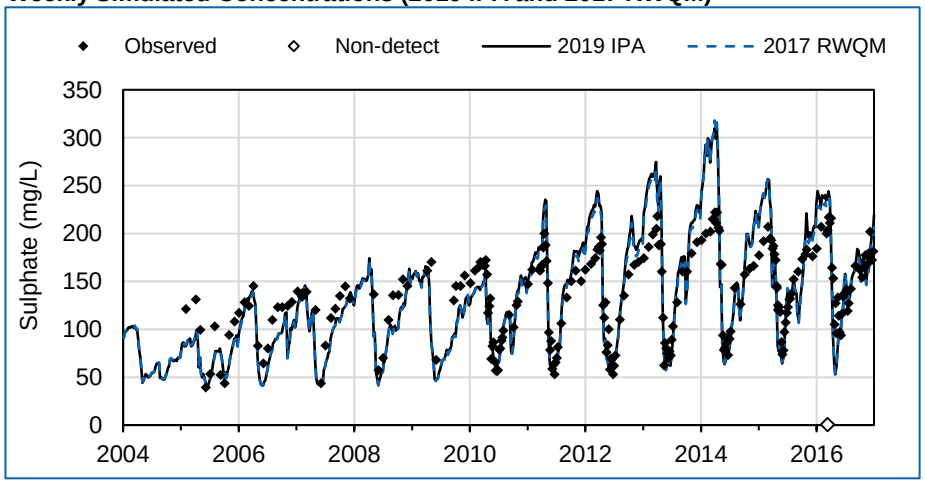
Observed and Simulated Sulphate Data and Calibration Statistics

Statistic	2017 RWQM	2019 IPA	
Model Averaging Period	Weekly	Weekly	Monthly
Calibration Period	2004 to 2016		
First Observed Sample	2/2/2005		
Last Observed Sample	12/28/2016		
Data Points Available for Comparison, n	244	244	131
Non-Detect Count	1	1	0
Observed Mean (mg/L)	134	134	134
Simulated Mean (mg/L)	134	136	137
Bias (mg/L)	0.57	2.2	3.4
Relative Bias	1.0	1.0	1.0
Error (mg/L)	24	25	24
Percent Error	18%	18%	18%

2019 IPA Simulated vs. Observed Sulphate Concentrations

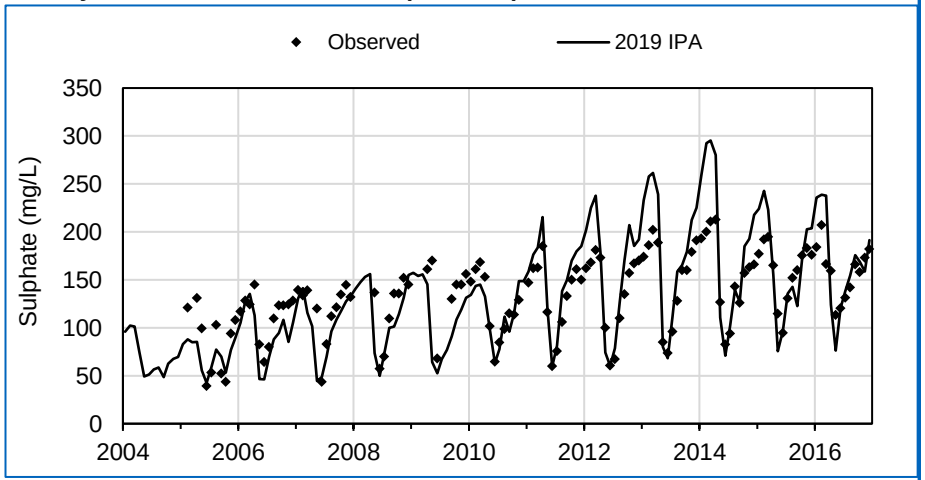


Weekly Simulated Concentrations (2019 IPA and 2017 RWQM)



Note: Observed data are individual sample results

Monthy Simulated Concentrations (2019 IPA)



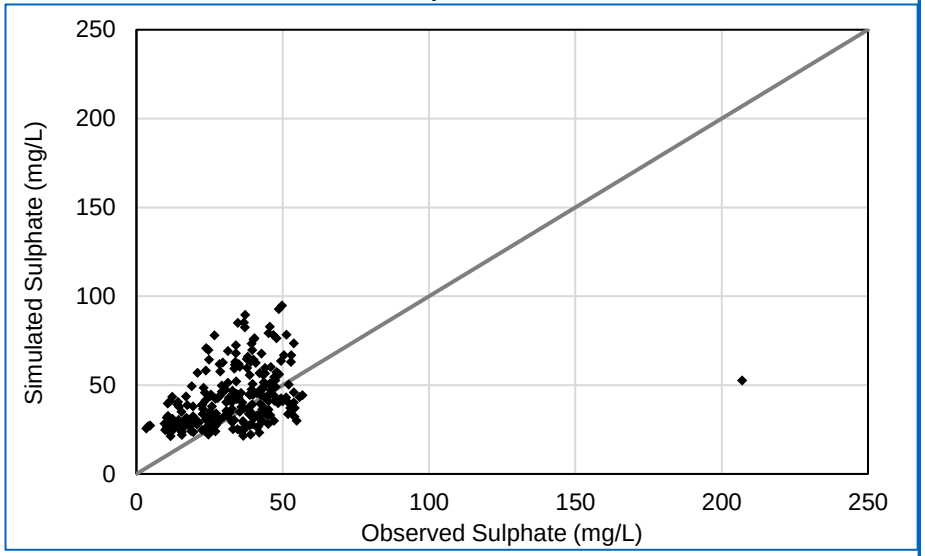
Note: Observed data are monthly averages of sample results

C1-30: Sulphate Calibration Information for Node EV_MC3 - Michel Creek u/s of Erickson Creek (EMS 0200203)

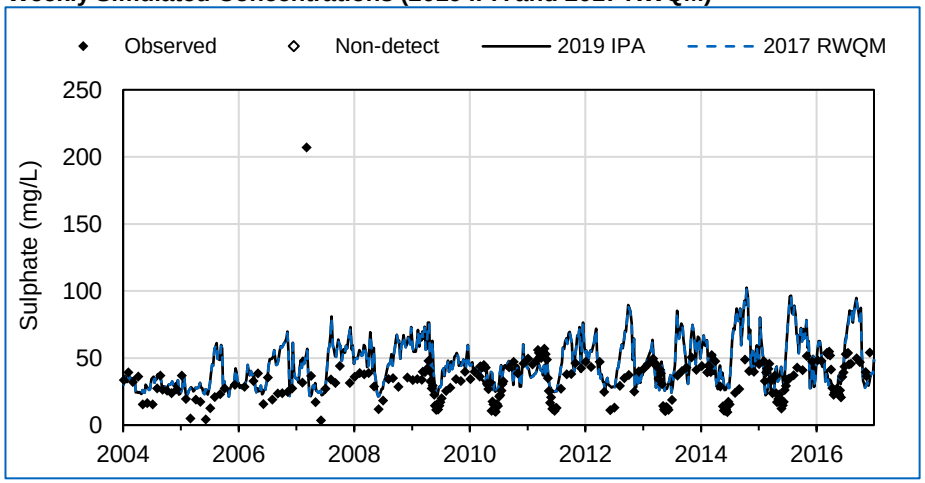
Observed and Simulated Sulphate Data and Calibration Statistics

Statistic	2017 RWQM	2019 IPA	
Model Averaging Period	Weekly	Weekly	Monthly
Calibration Period	2004 to 2016		
First Observed Sample	1/6/2004		
Last Observed Sample	12/6/2016		
Data Points Available for Comparison, n	247	247	149
Non-Detect Count	0	0	0
Observed Mean (mg/L)	33	33	34
Simulated Mean (mg/L)	42	42	45
Bias (mg/L)	9.3	9.7	12
Relative Bias	1.3	1.3	1.3
Error (mg/L)	15	15	17
Percent Error	47%	47%	51%

2019 IPA Simulated vs. Observed Sulphate Concentrations

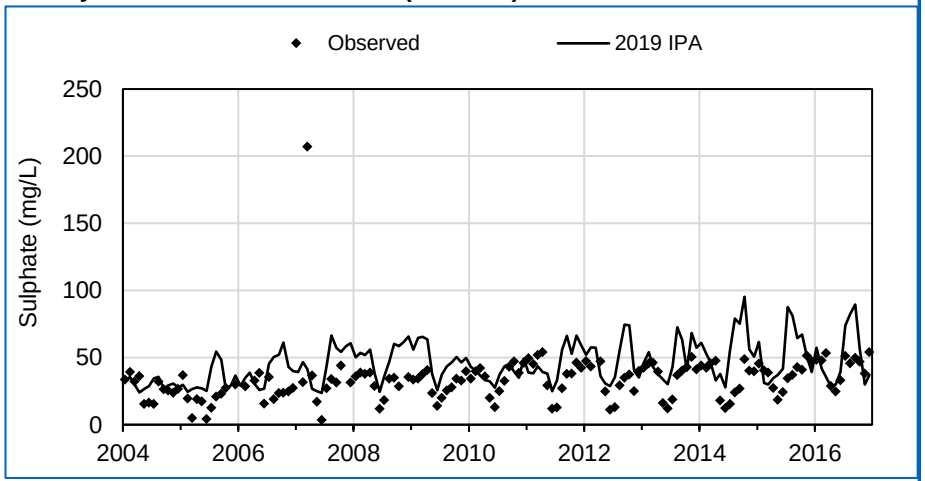


Weekly Simulated Concentrations (2019 IPA and 2017 RWQM)



Note: Observed data are individual sample results

Monthy Simulated Concentrations (2019 IPA)



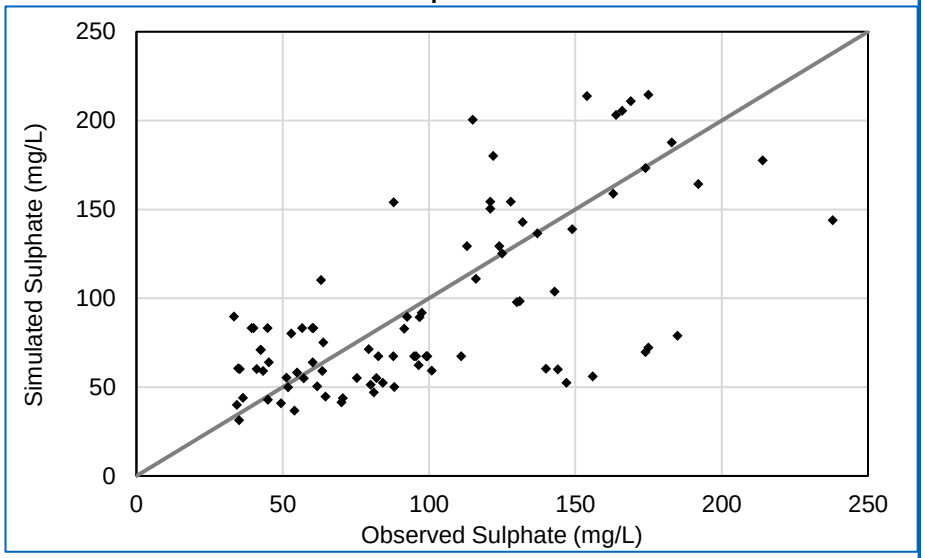
Note: Observed data are monthly averages of sample results

C1-31: Sulphate Calibration Information for Node EV_MC2 - EVO Michel Creek Compliance Point (EMS E300091)

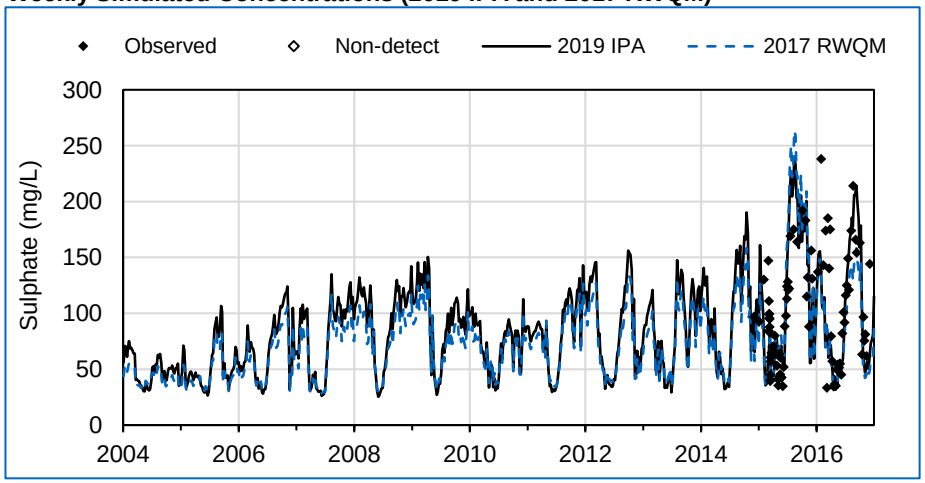
Observed and Simulated Sulphate Data and Calibration Statistics

Statistic	2017 RWQM	2019 IPA	
Model Averaging Period	Weekly	Weekly	Monthly
Calibration Period	2004 to 2016		
First Observed Sample	12/3/2014		
Last Observed Sample	12/5/2016		
Data Points Available for Comparison, n	87	87	25
Non-Detect Count	0	0	0
Observed Mean (mg/L)	99	99	119
Simulated Mean (mg/L)	91	93	110
Bias (mg/L)	-7.5	-5.5	-8.1
Relative Bias	0.92	0.94	0.93
Error (mg/L)	35	30	28
Percent Error	36%	31%	23%

2019 IPA Simulated vs. Observed Sulphate Concentrations

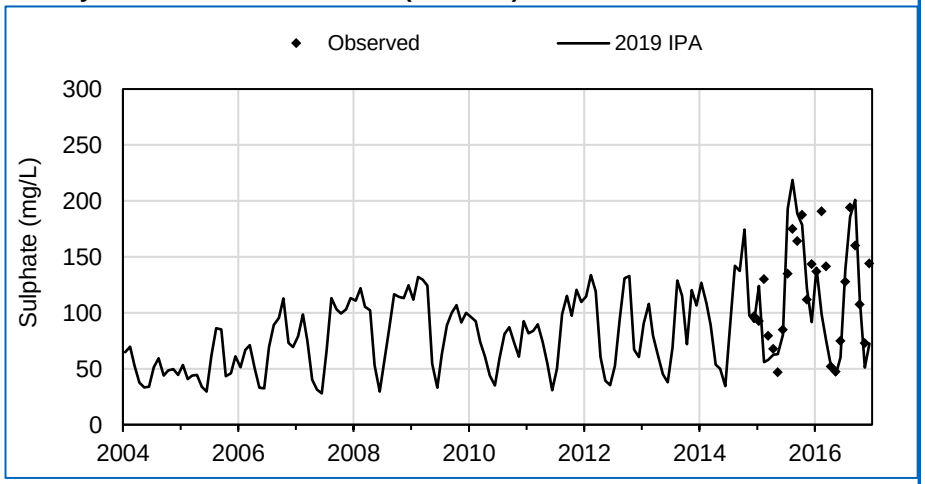


Weekly Simulated Concentrations (2019 IPA and 2017 RWQM)



Note: Observed data are individual sample results

Monthy Simulated Concentrations (2019 IPA)



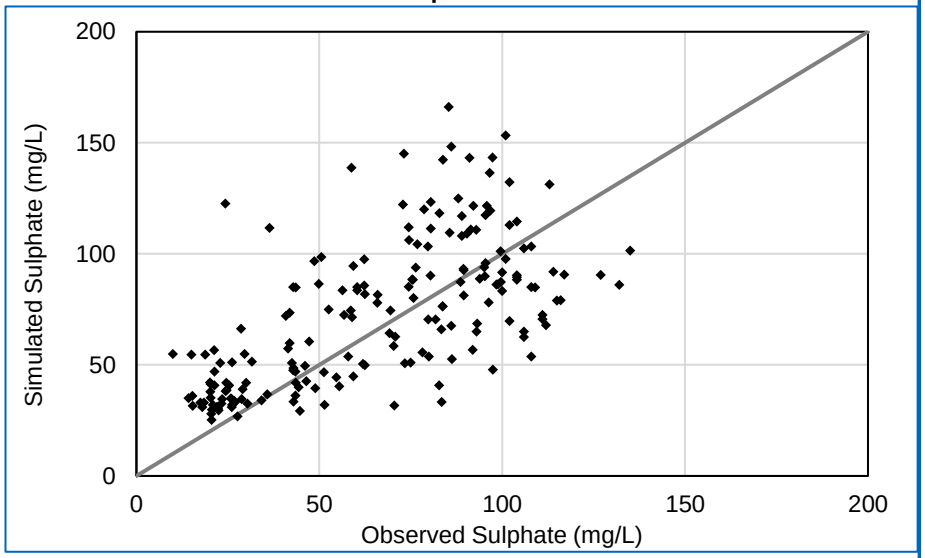
Note: Observed data are monthly averages of sample results

C1-32: Sulphate Calibration Information for Node EV_MC1 - Michel Creek u/s of Highway 43 Bridge (EMS 0200425)

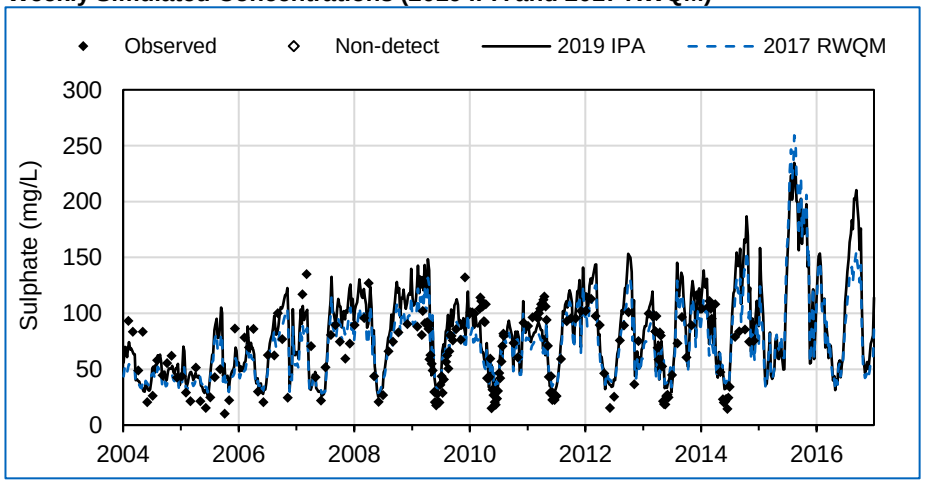
Observed and Simulated Sulphate Data and Calibration Statistics

Statistic	2017 RWQM	2019 IPA	
Model Averaging Period	Weekly	Weekly	Monthly
Calibration Period	2004 to 2016		
First Observed Sample	2/3/2004		
Last Observed Sample	12/3/2014		
Data Points Available for Comparison, n	193	193	123
Non-Detect Count	0	0	0
Observed Mean (mg/L)	65	65	67
Simulated Mean (mg/L)	65	72	77
Bias (mg/L)	0.73	7.7	9.9
Relative Bias	1.0	1.1	1.1
Error (mg/L)	21	22	21
Percent Error	32%	34%	31%

2019 IPA Simulated vs. Observed Sulphate Concentrations

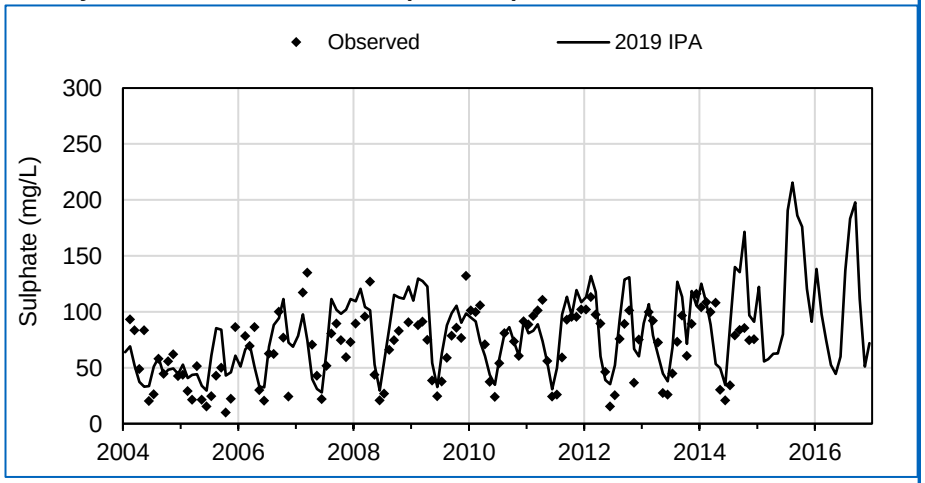


Weekly Simulated Concentrations (2019 IPA and 2017 RWQM)



Note: Observed data are individual sample results

Monthy Simulated Concentrations (2019 IPA)



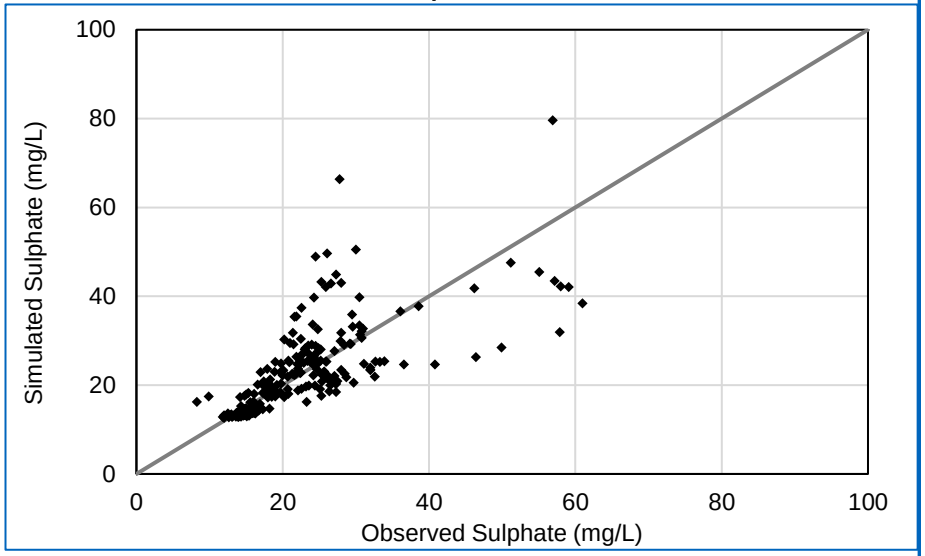
Note: Observed data are monthly averages of sample results

C1-33: Sulphate Calibration Information for Node GH_ER1 - Elk River u/s of Boivin Creek and u/s of Fording River (EMS E206661)

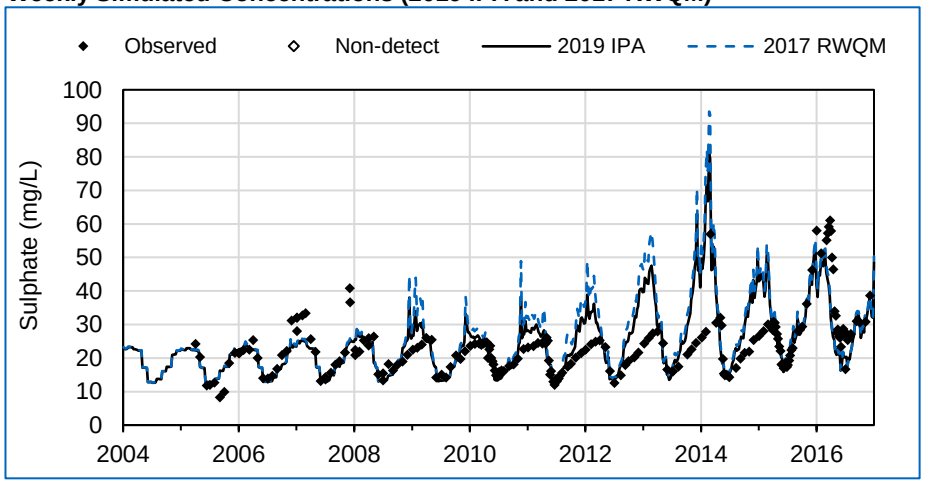
Observed and Simulated Sulphate Data and Calibration Statistics

Statistic	2017 RWQM	2019 IPA	
Model Averaging Period	Weekly	Weekly	Monthly
Calibration Period	2004 to 2016		
First Observed Sample	4/3/2005		
Last Observed Sample	12/7/2016		
Data Points Available for Comparison, n	213	213	139
Non-Detect Count	0	0	0
Observed Mean (mg/L)	23	23	23
Simulated Mean (mg/L)	25	24	25
Bias (mg/L)	2.0	0.49	2.3
Relative Bias	1.1	1.0	1.1
Error (mg/L)	5.7	4.8	5.2
Percent Error	24%	20%	23%

2019 IPA Simulated vs. Observed Sulphate Concentrations

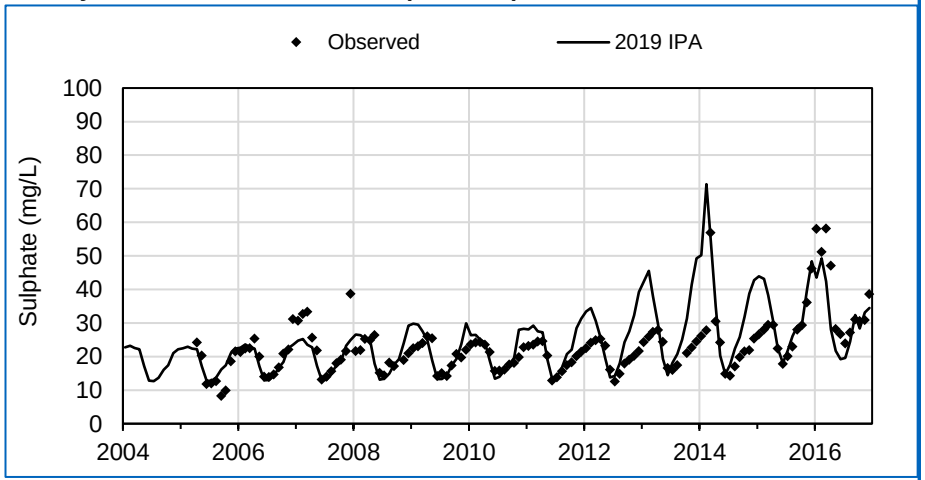


Weekly Simulated Concentrations (2019 IPA and 2017 RWQM)



Note: Observed data are individual sample results

Monthy Simulated Concentrations (2019 IPA)



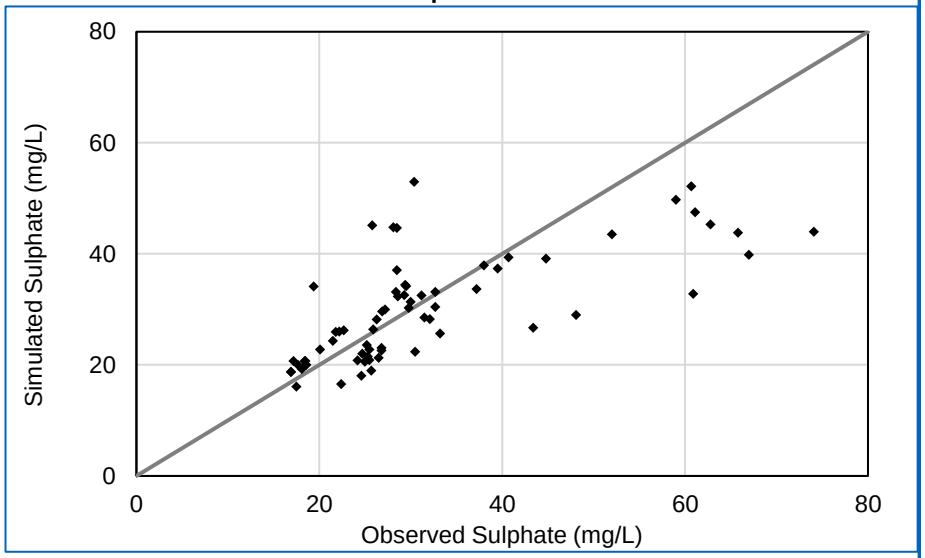
Note: Observed data are monthly averages of sample results

C1-34: Sulphate Calibration Information for Node GH_ERC - GHO Elk River Compliance Point (EMS E300090)

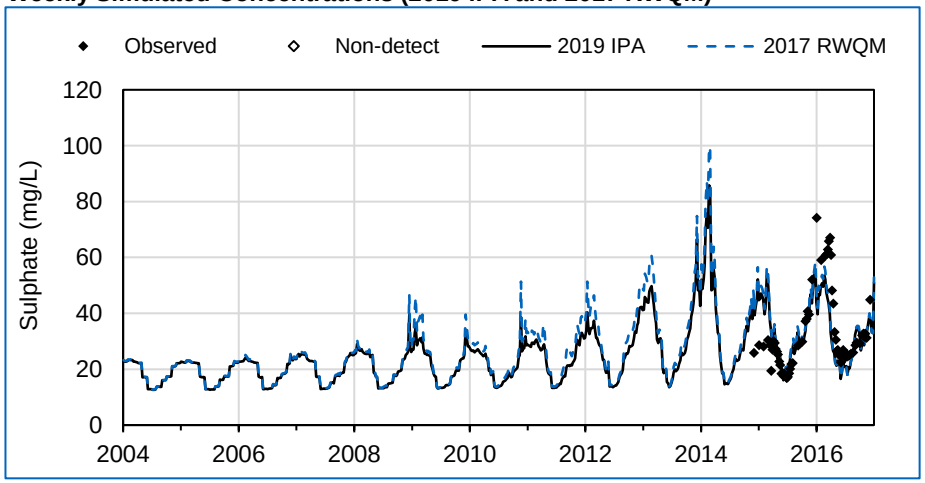
Observed and Simulated Sulphate Data and Calibration Statistics

Statistic	2017 RWQM	2019 IPA	
Model Averaging Period	Weekly	Weekly	Monthly
Calibration Period	2004 to 2016		
First Observed Sample	12/4/2014		
Last Observed Sample	12/7/2016		
Data Points Available for Comparison, n	68	68	25
Non-Detect Count	0	0	0
Observed Mean (mg/L)	32	32	34
Simulated Mean (mg/L)	31	30	34
Bias (mg/L)	-0.84	-2.0	-0.53
Relative Bias	0.97	0.94	0.98
Error (mg/L)	7.0	6.8	7.7
Percent Error	22%	21%	23%

2019 IPA Simulated vs. Observed Sulphate Concentrations

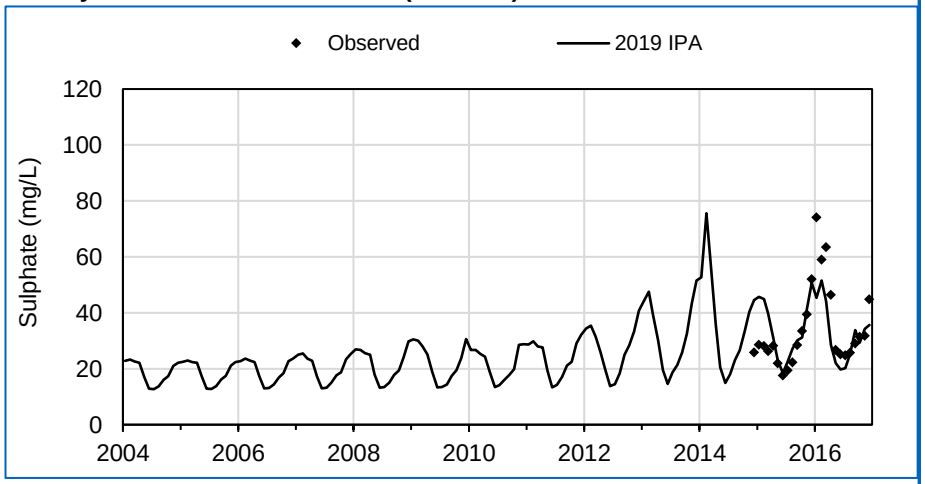


Weekly Simulated Concentrations (2019 IPA and 2017 RWQM)



Note: Observed data are individual sample results

Monthy Simulated Concentrations (2019 IPA)



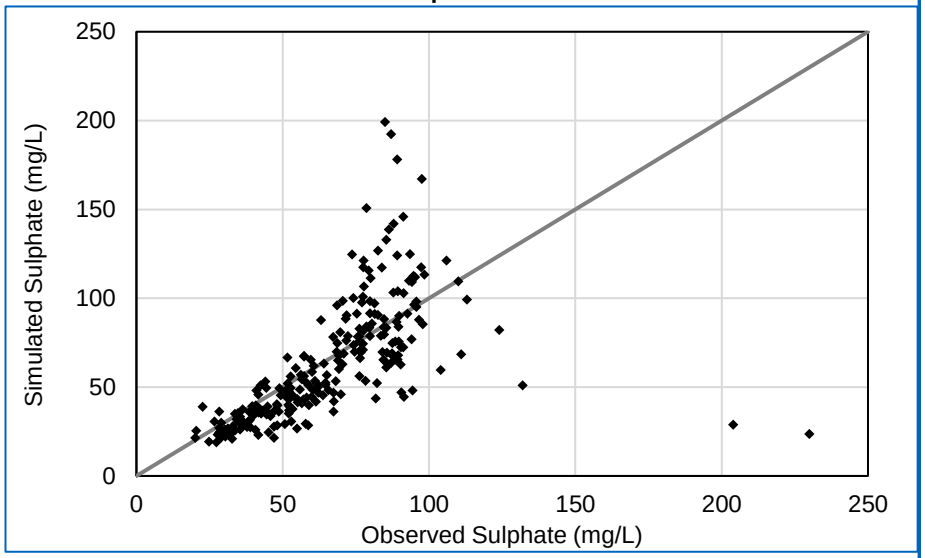
Note: Observed data are monthly averages of sample results

C1-35: Sulphate Calibration Information for Node EV_ER4 - Elk River u/s of Grave Creek (EMS 0200027)

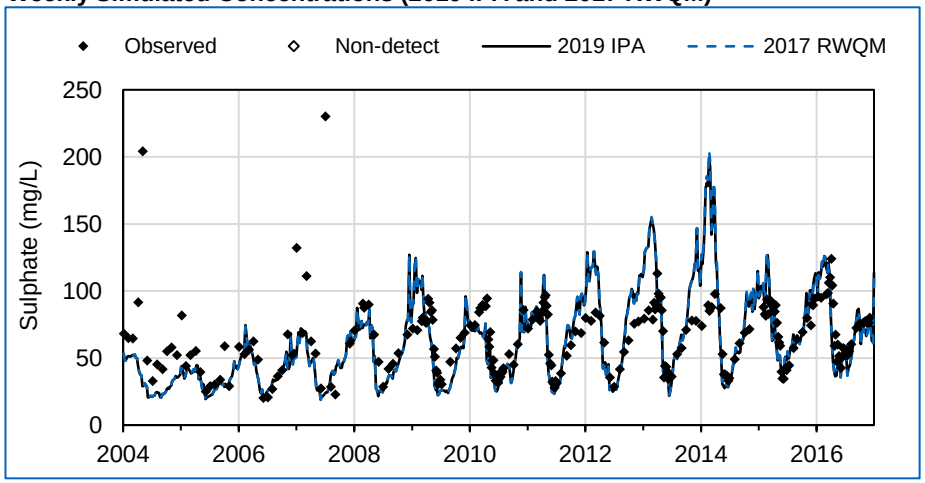
Observed and Simulated Sulphate Data and Calibration Statistics

Statistic	2017 RWQM	2019 IPA	
Model Averaging Period	Weekly	Weekly	Monthly
Calibration Period	2004 to 2016		
First Observed Sample	1/6/2004		
Last Observed Sample	12/6/2016		
Data Points Available for Comparison, n	251	251	149
Non-Detect Count	0	0	0
Observed Mean (mg/L)	65	65	63
Simulated Mean (mg/L)	62	62	62
Bias (mg/L)	-2.7	-3.0	-1.7
Relative Bias	0.96	0.95	0.97
Error (mg/L)	16	16	19
Percent Error	25%	25%	29%

2019 IPA Simulated vs. Observed Sulphate Concentrations

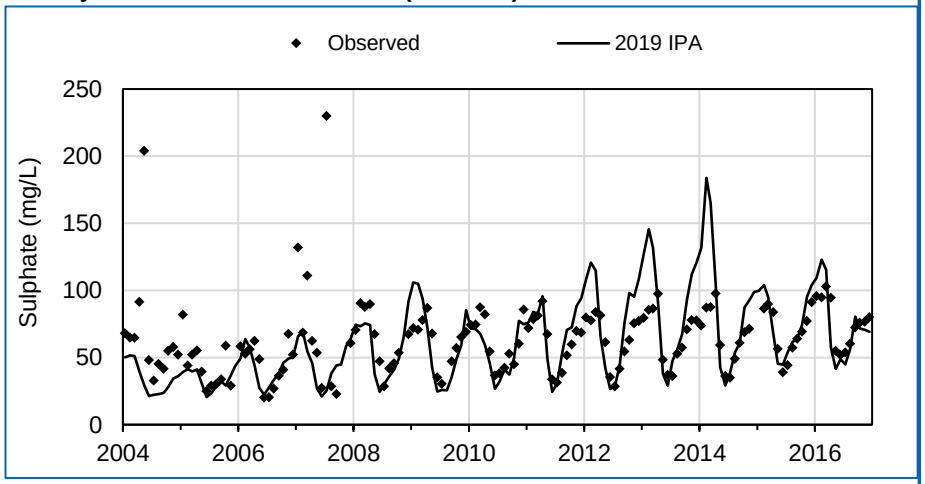


Weekly Simulated Concentrations (2019 IPA and 2017 RWQM)



Note: Observed data are individual sample results

Monthy Simulated Concentrations (2019 IPA)



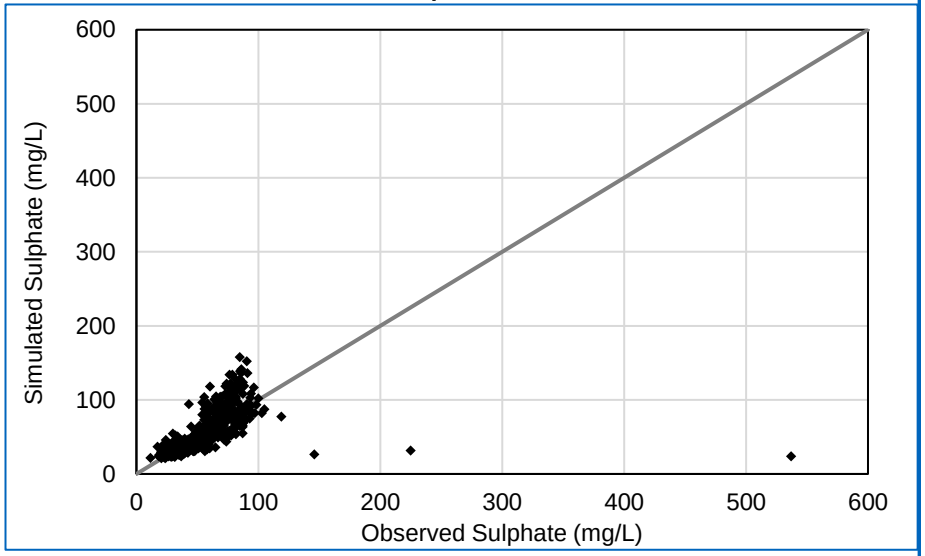
Note: Observed data are monthly averages of sample results

C1-36: Sulphate Calibration Information for Node EV_ER1 - Elk River downstream of Michel Creek (EMS 0200393)

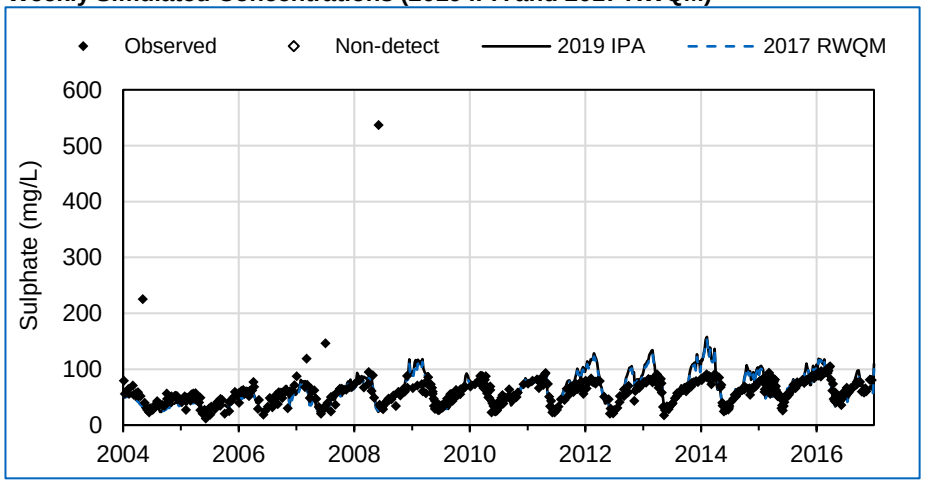
Observed and Simulated Sulphate Data and Calibration Statistics

Statistic	2017 RWQM	2019 IPA	
Model Averaging Period	Weekly	Weekly	Monthly
Calibration Period	2004 to 2016		
First Observed Sample	1/6/2004		
Last Observed Sample	12/18/2016		
Data Points Available for Comparison, n	538	538	156
Non-Detect Count	0	0	0
Observed Mean (mg/L)	59	59	59
Simulated Mean (mg/L)	59	60	63
Bias (mg/L)	-0.071	1.4	3.2
Relative Bias	1.0	1.0	1.1
Error (mg/L)	13	13	13
Percent Error	22%	23%	21%

2019 IPA Simulated vs. Observed Sulphate Concentrations

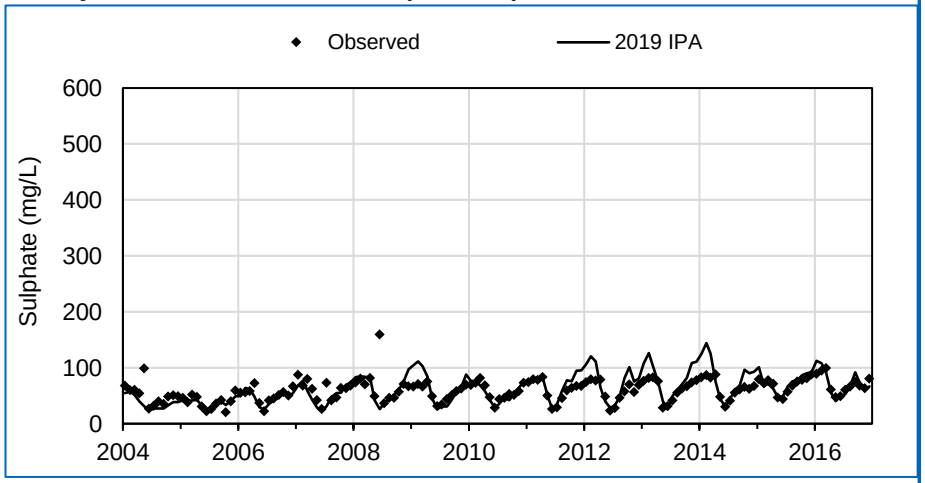


Weekly Simulated Concentrations (2019 IPA and 2017 RWQM)



Note: Observed data are individual sample results

Monthy Simulated Concentrations (2019 IPA)



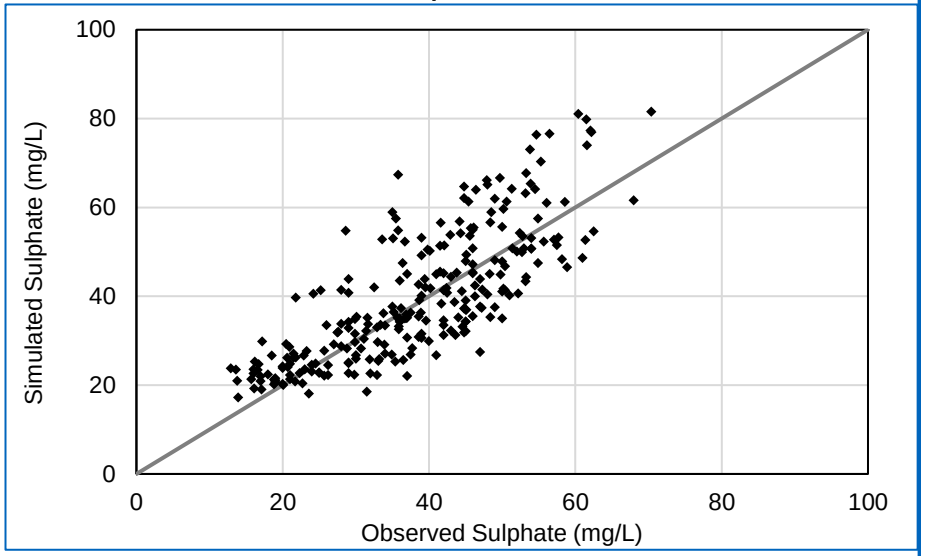
Note: Observed data are monthly averages of sample results

C1-37: Sulphate Calibration Information for Node RG_ELKMOUTH - Elk River at Highway 93 near Elko

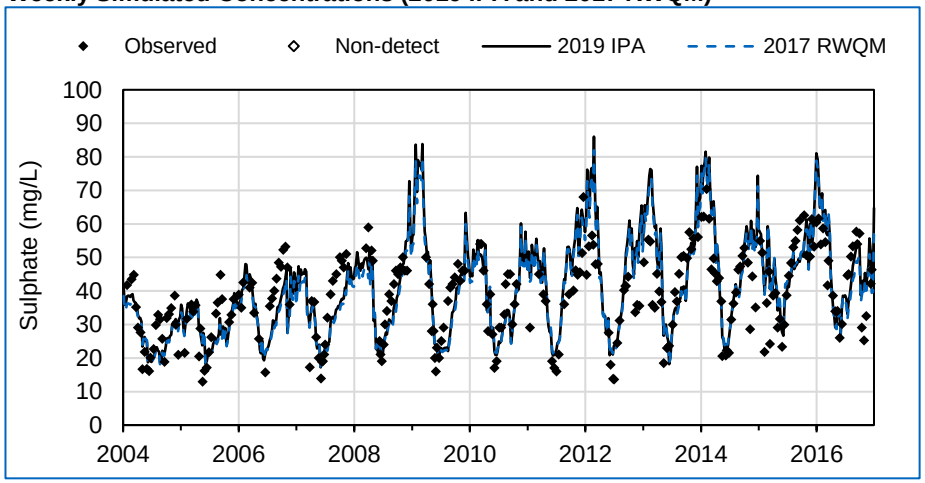
Observed and Simulated Sulphate Data and Calibration Statistics

Statistic	2017 RWQM	2019 IPA	
Model Averaging Period	Weekly	Weekly	Monthly
Calibration Period	2004 to 2016		
First Observed Sample	1/26/2004		
Last Observed Sample	12/18/2016		
Data Points Available for Comparison, n	264	264	134
Non-Detect Count	0	0	0
Observed Mean (mg/L)	38	38	38
Simulated Mean (mg/L)	39	40	40
Bias (mg/L)	0.8	1.7	2.3
Relative Bias	1.0	1.0	1.1
Error (mg/L)	7.3	7.2	7.2
Percent Error	19%	19%	19%

2019 IPA Simulated vs. Observed Sulphate Concentrations

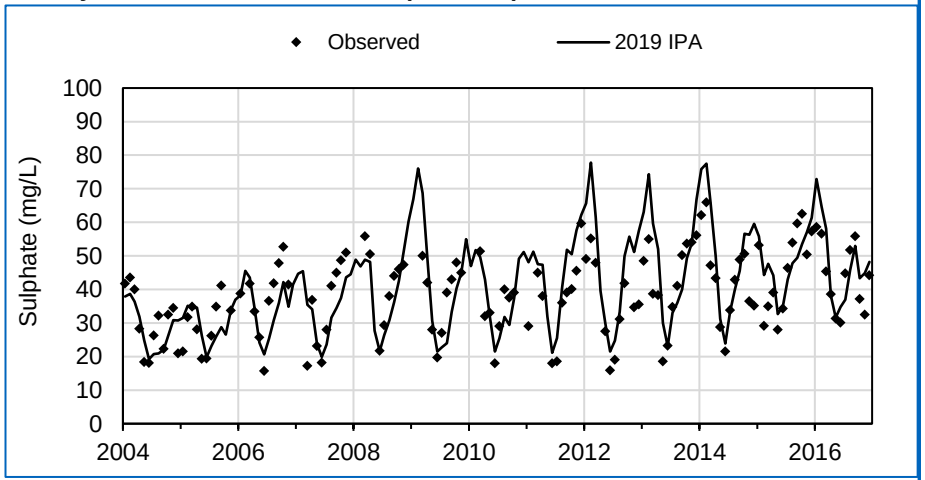


Weekly Simulated Concentrations (2019 IPA and 2017 RWQM)



Note: Observed data are individual sample results

Monthy Simulated Concentrations (2019 IPA)



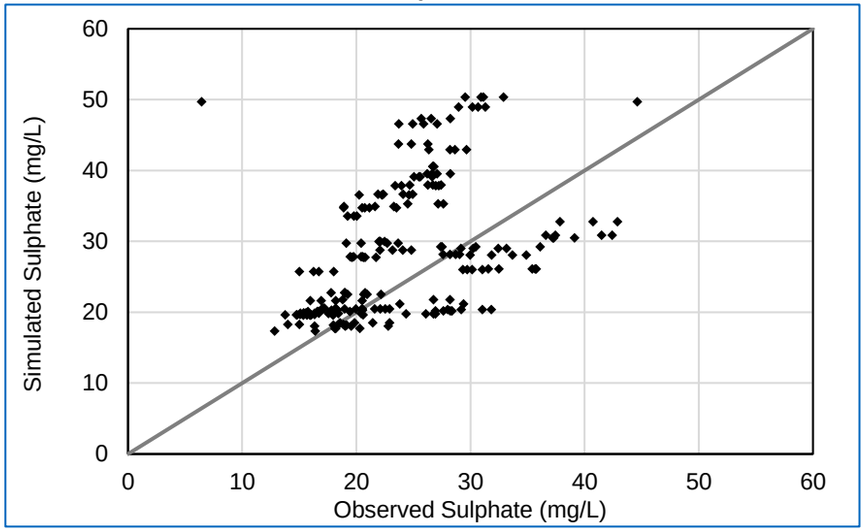
Note: Observed data are monthly averages of sample results

C1-38: Sulphate Calibration Information for Node RG_DSELK - Koocanusa Reservoir (EMS E300230)

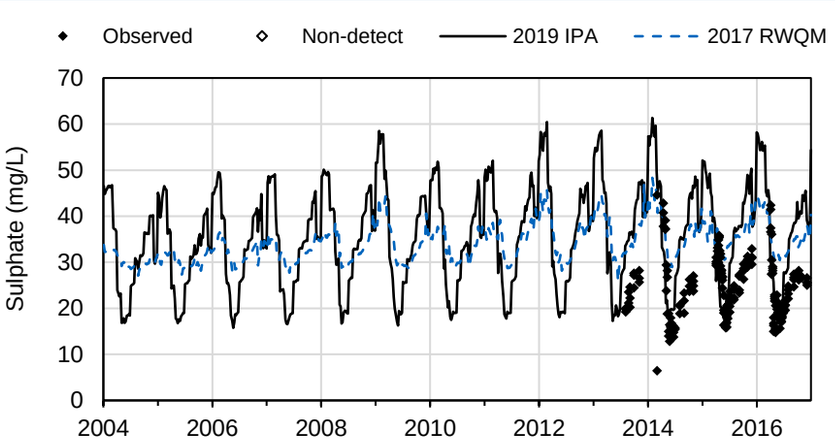
Observed and Simulated Sulphate Data and Calibration Statistics

Statistic	2017 RWQM	2019 IPA	
Model Averaging Period	Weekly	Weekly	Monthly
Calibration Period	2004 to 2016		
First Observed Sample	08/07/2013		
Last Observed Sample	12/06/2016		
Data Points Available for Comparison, n	60	217	31
Non-Detect Count	0	0	0
Observed Mean (mg/L)	24	24	24
Simulated Mean (mg/L)	34	29	34
Bias (mg/L)	9.5	4.7	10
Relative Bias	1.4	1.2	1.4
Error (mg/L)	9.6	7.7	11
Percent Error	40%	32%	46%

2019 IPA Simulated vs. Observed Sulphate Concentrations

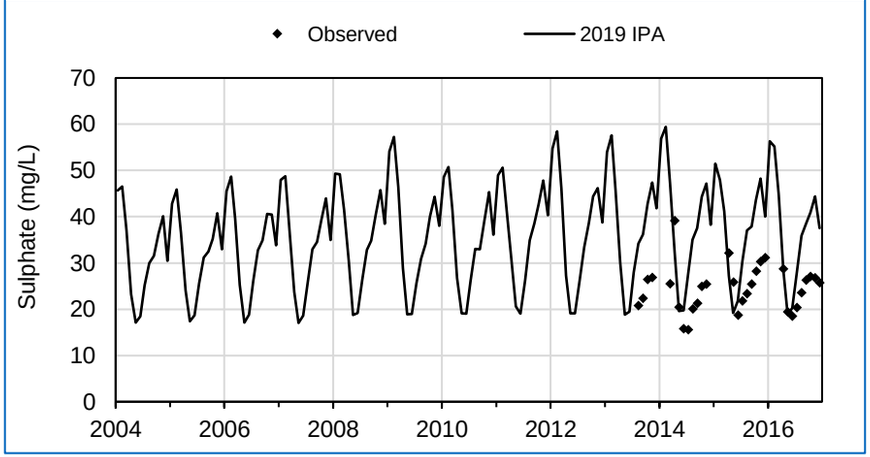


Weekly Simulated Concentrations (2019 IPA and 2017 RWQM)



Note: Observed data are individual sample results

Monthy Simulated Concentrations (2019 IPA)



Note: Observed data are monthly averages of sample results

Note: In the 2017 RWQM Update, projected concentrations in Koocanusa Reservoir were compared to monitored data at RG_DSELK. In the 2019 IPA, the comparison of simulated to monitored data was expanded to include data at the four statiions located downstream of the Elk River: RG_DSELK, RG_GRASMERE, RG_USGOLD and RG_BORDER. Projected concentrations of sulphate in Koocanusa Reservoir were not corrected for model bias.

Figure C-2 Simulated and Observed Sulphate Concentrations in the Elk Valley, 2004 to 2016

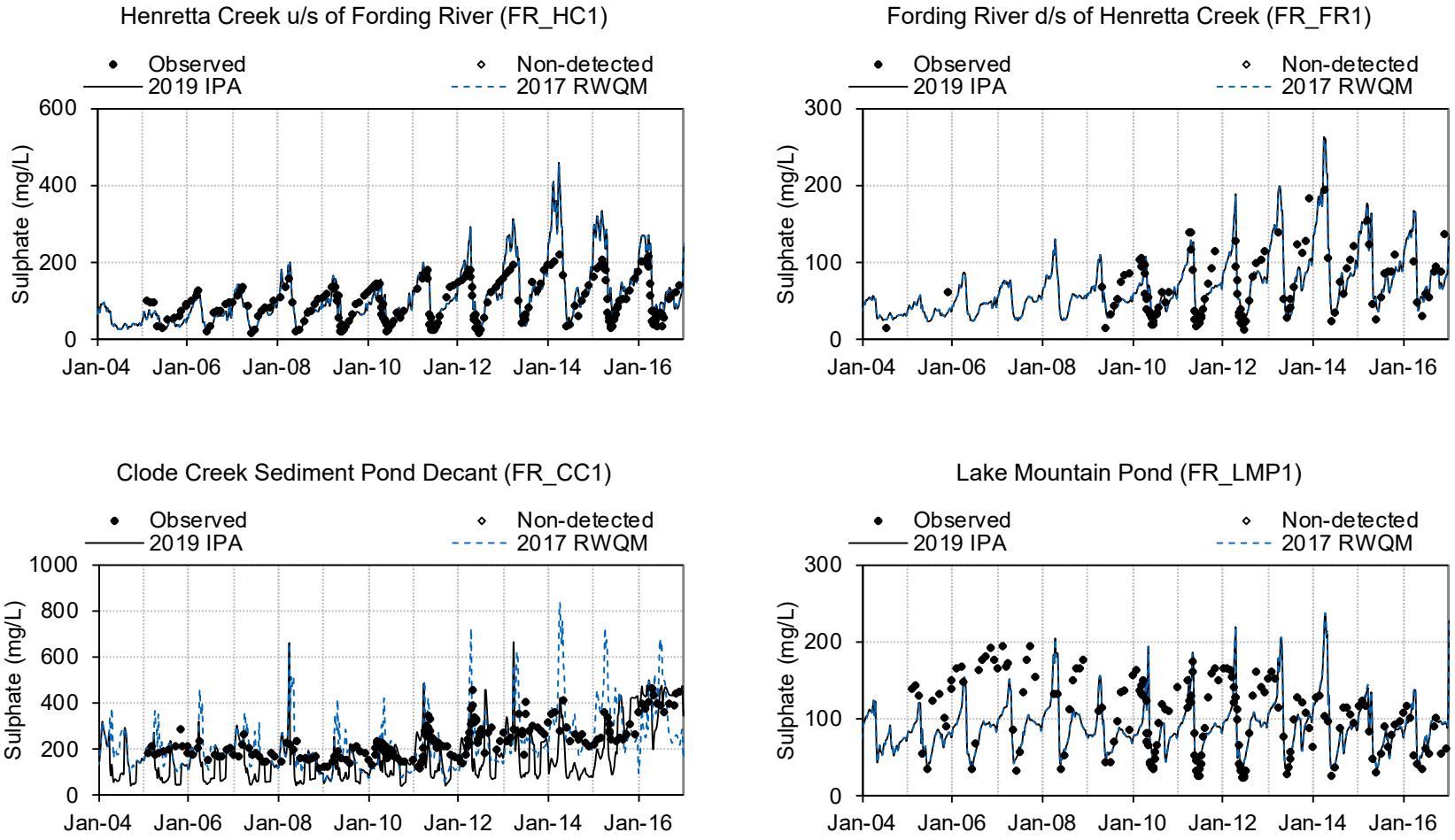
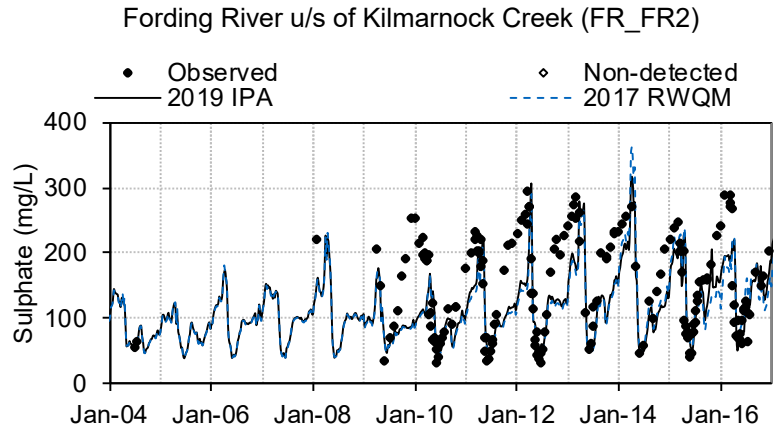
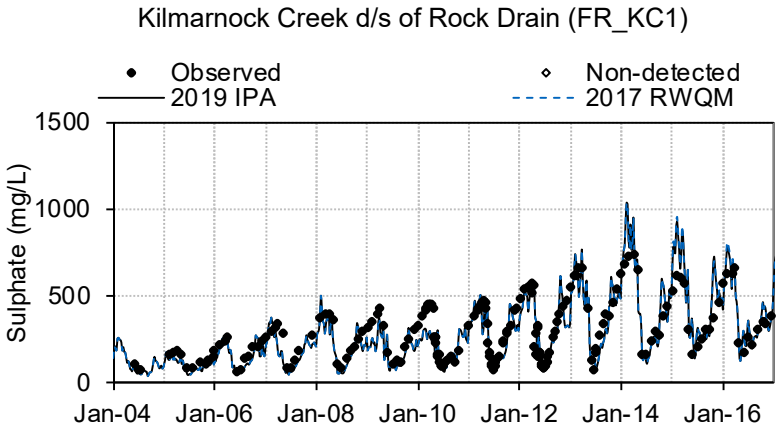
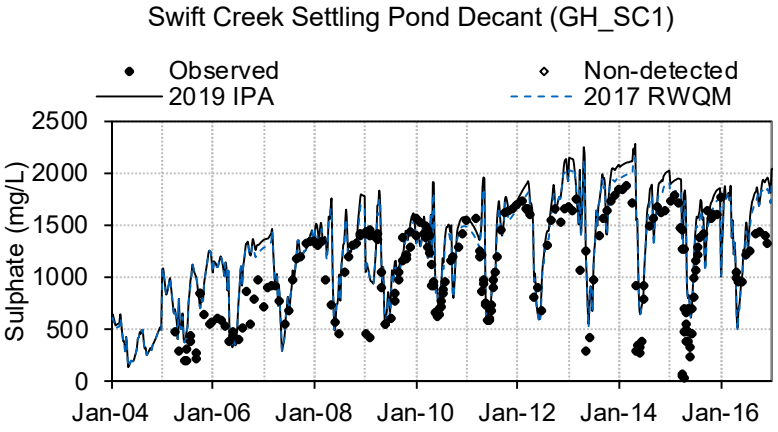


Figure C-2 Simulated and Observed Sulphate Concentrations in the Elk Valley, 2004 to 2016







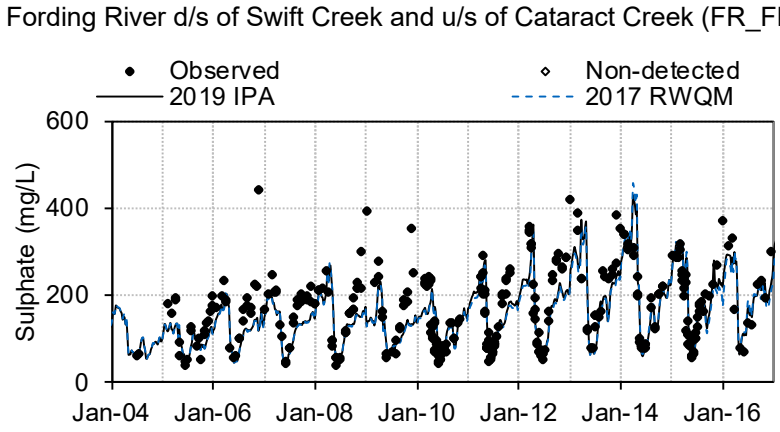
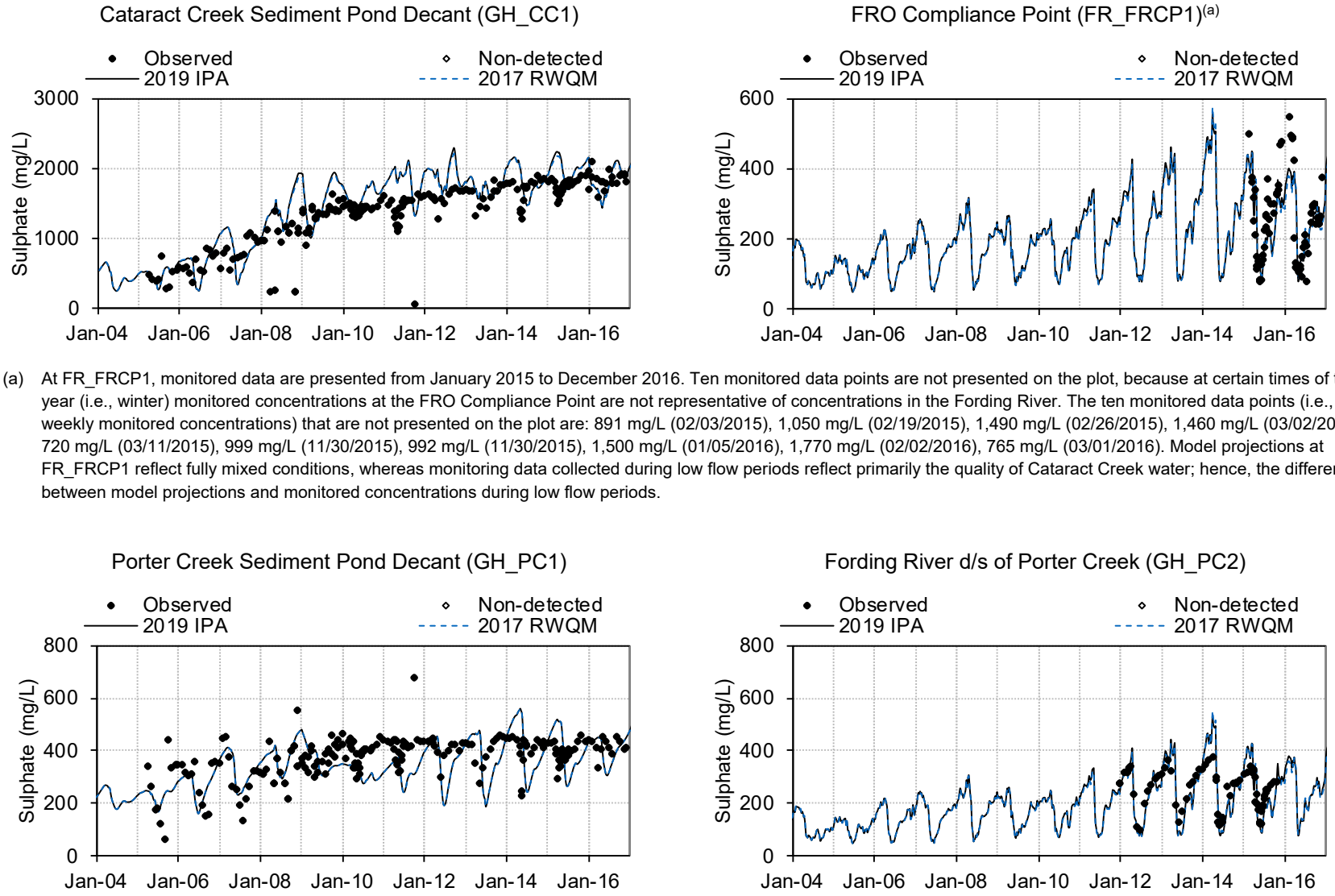
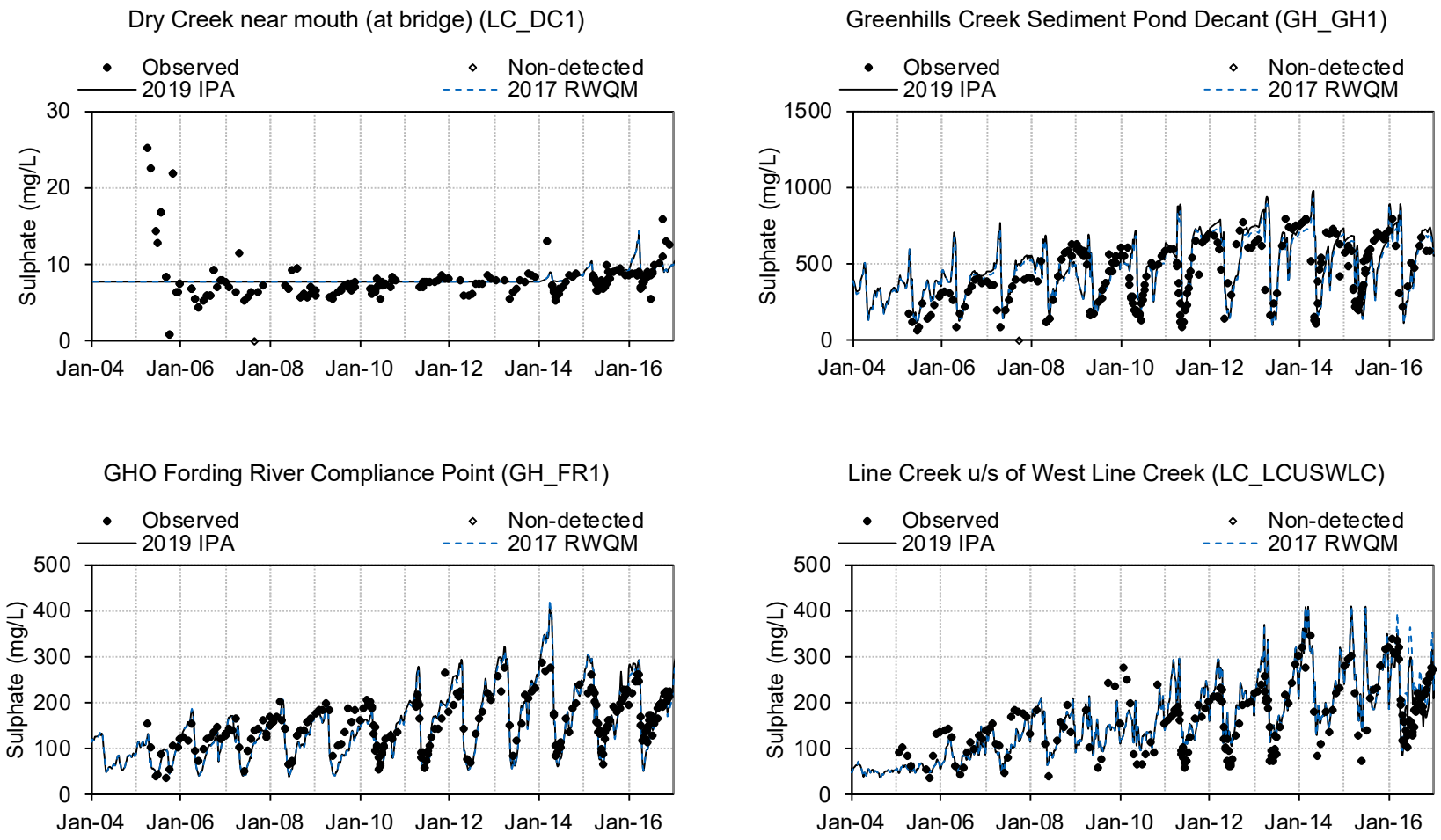


Figure C-2 Simulated and Observed Sulphate Concentrations in the Elk Valley, 2004 to 2016



(a) At FR_FRCP1, monitored data are presented from January 2015 to December 2016. Ten monitored data points are not presented on the plot, because at certain times of the year (i.e., winter) monitored concentrations at the FRO Compliance Point are not representative of concentrations in the Fording River. The ten monitored data points (i.e., weekly monitored concentrations) that are not presented on the plot are: 891 mg/L (02/03/2015), 1,050 mg/L (02/19/2015), 1,490 mg/L (02/26/2015), 1,460 mg/L (03/02/2015), 720 mg/L (03/11/2015), 999 mg/L (11/30/2015), 992 mg/L (11/30/2015), 1,500 mg/L (01/05/2016), 1,770 mg/L (02/02/2016), 765 mg/L (03/01/2016). Model projections at FR_FRCP1 reflect fully mixed conditions, whereas monitoring data collected during low flow periods reflect primarily the quality of Cataract Creek water; hence, the difference between model projections and monitored concentrations during low flow periods.

Figure C-2 Simulated and Observed Sulphate Concentrations in the Elk Valley, 2004 to 2016



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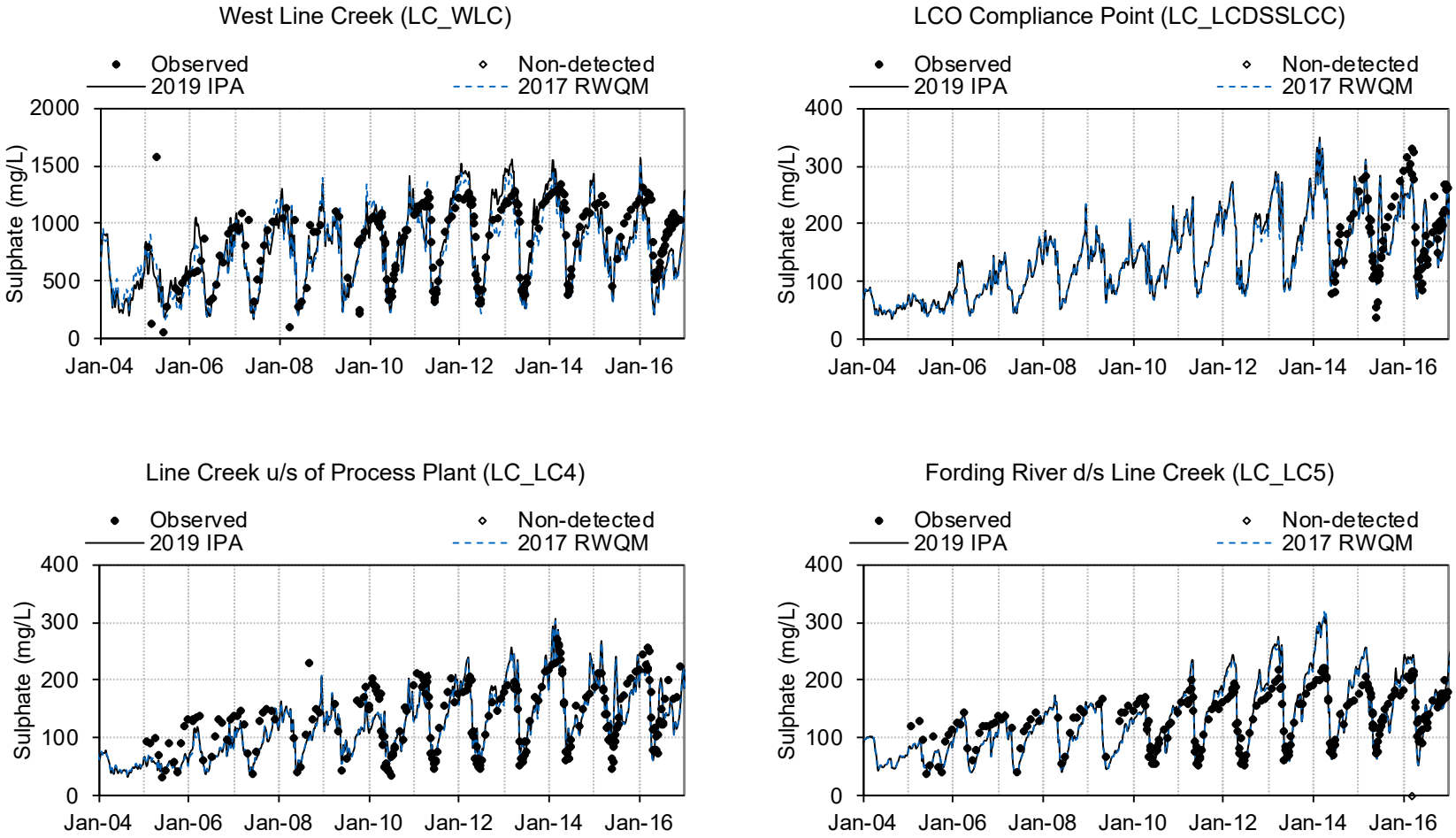

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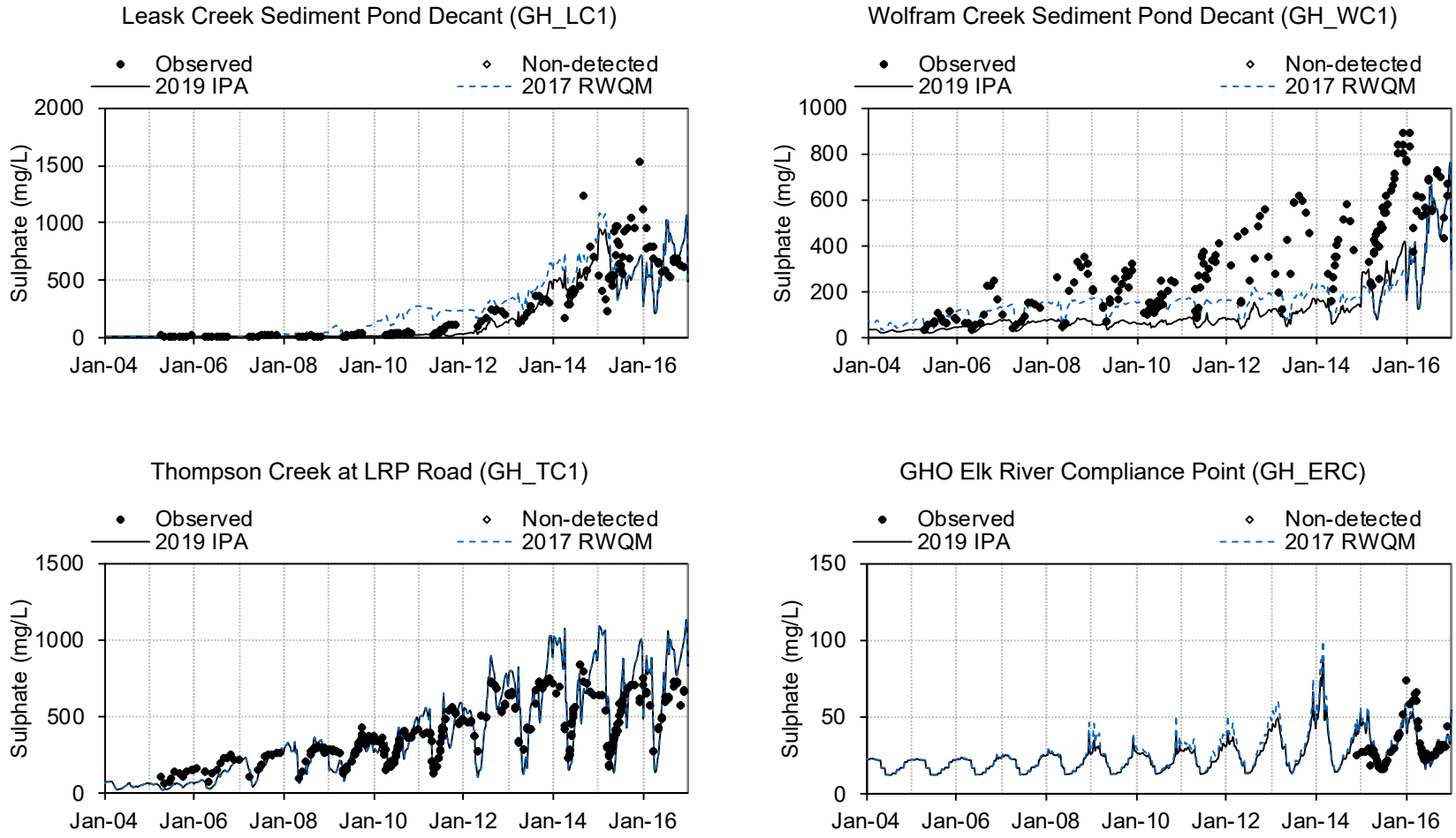

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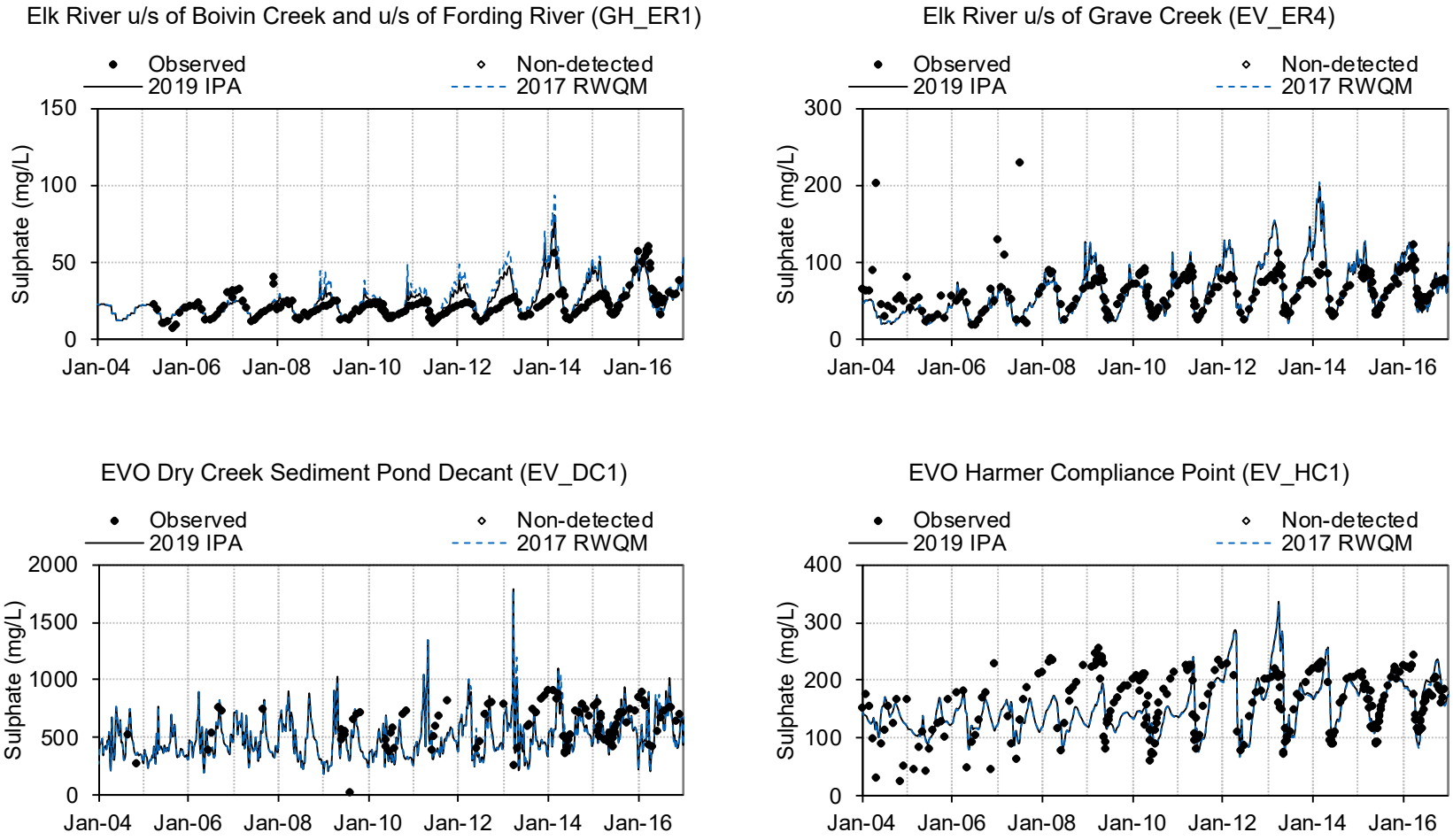


Figure C-2 Simulated and Observed Sulphate Concentrations in the Elk Valley, 2004 to 2016

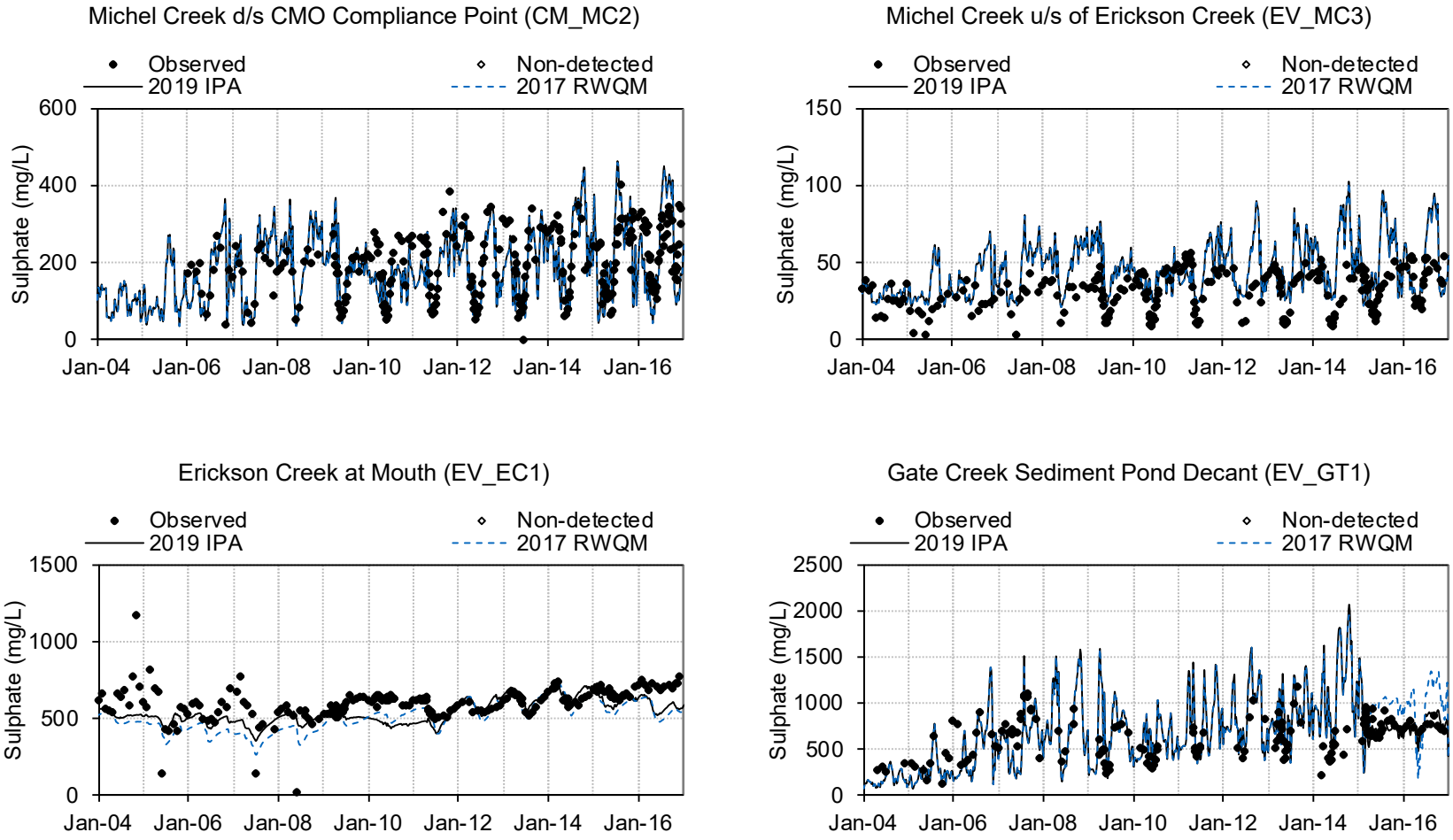


Figure C-2 Simulated and Observed Sulphate Concentrations in the Elk Valley, 2004 to 2016

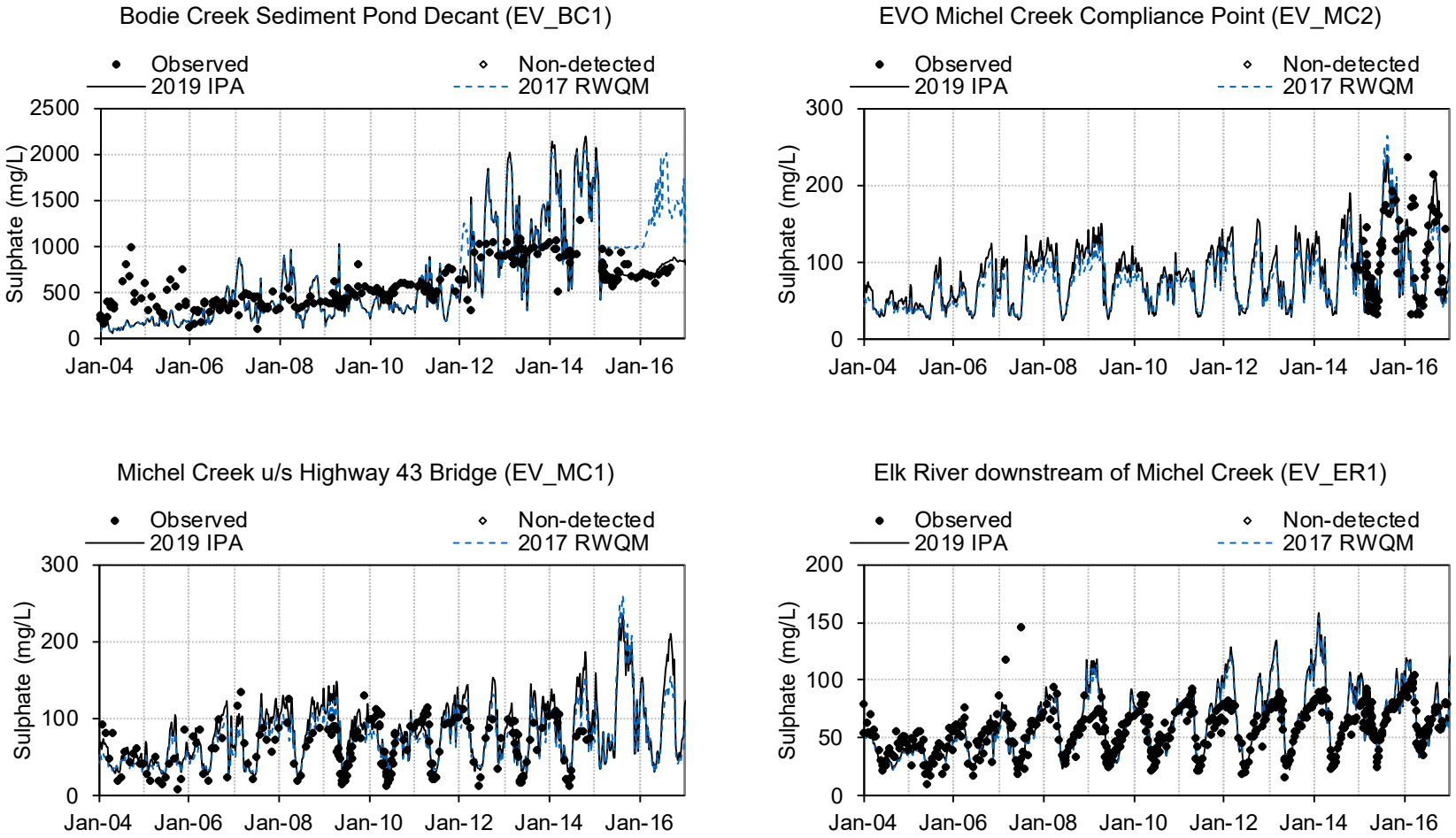
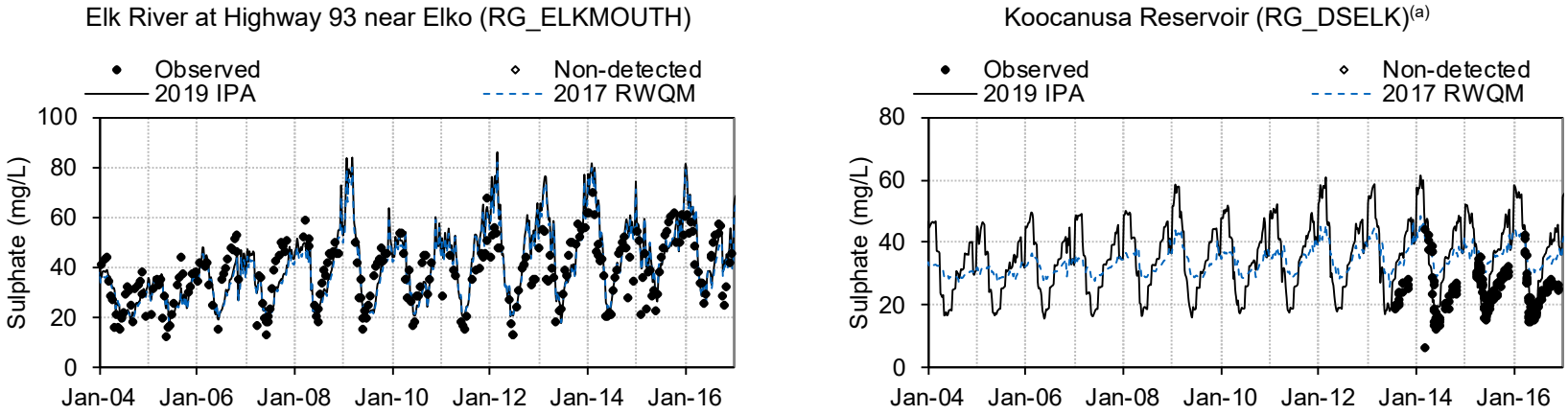


Figure C-2 Simulated and Observed Sulphate Concentrations in the Elk Valley, 2004 to 2016



(a) In the 2017 RWQM Update, projected concentrations in Koocanusa Reservoir were compared to monitored data at RG_DSELK. In the 2019 IPA, the comparison of simulated to monitored data was expanded to include data at the four stations located downstream of the Elk River: RG_DSELK, RG_GRASMERE, RG_USGOLD and RG_BORDER. Projected concentrations of sulphate in Koocanusa Reservoir were not corrected for model bias.