Modelling Nitrate release in the Elk Valley

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Agenda

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- Elk Valley Water Quality Plan
- Modelling Nitrate Release
- Updated Conceptual Model
- Method Adjustments
- Model performance
- What's Next?

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Setting
Elk Valley British Colombia

The Elk Valley is in South Eastern BC

Coal mining has occurred in the Elk Valley since the early 1900's, and open pit coal mining since the 1970s.

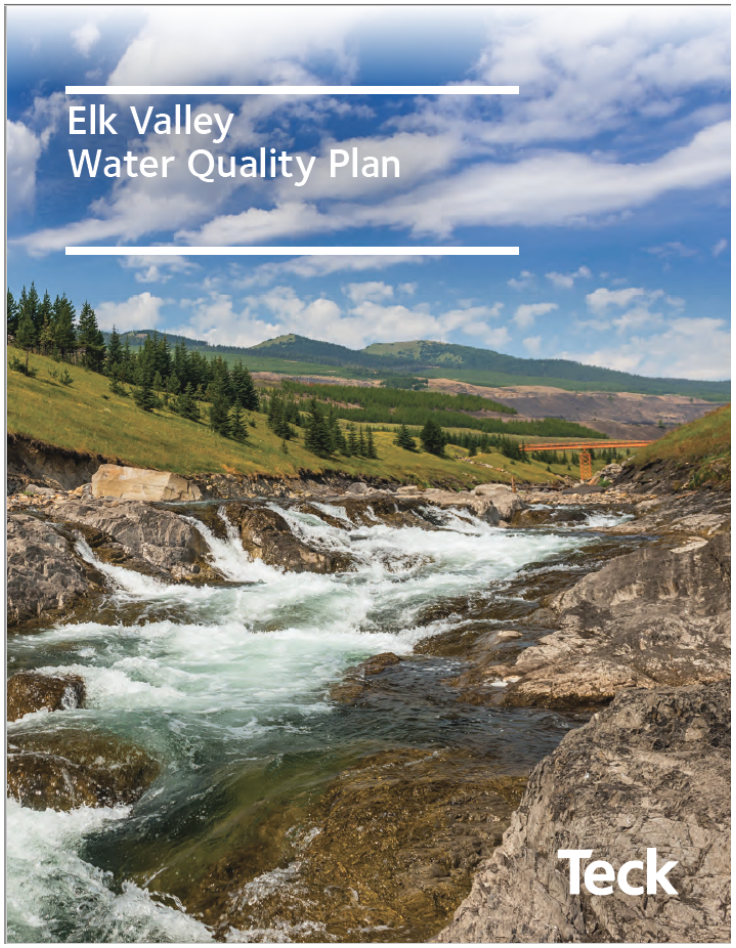
Teck currently operates five open pit steelmaking coal mines in the Elk River drainage.

Image source: 2017 EMC Public report

Elk Valley Water Quality Plan

In 2014, the B.C. Ministry of Environment approved an area based management plan — the Elk Valley Water Quality Plan (EVWQP).

The Plan identified regional water quality targets and a strategy for managing concentrations of selenium, nitrate, sulphate and cadmium in water the Elk Valley.



Regional Water Quality Model

A regional water quality model was developed initially to support Environmental Assessments, and updated in 2014 to support the development of the Elk Valley Water Quality Plan.

The model is used to:

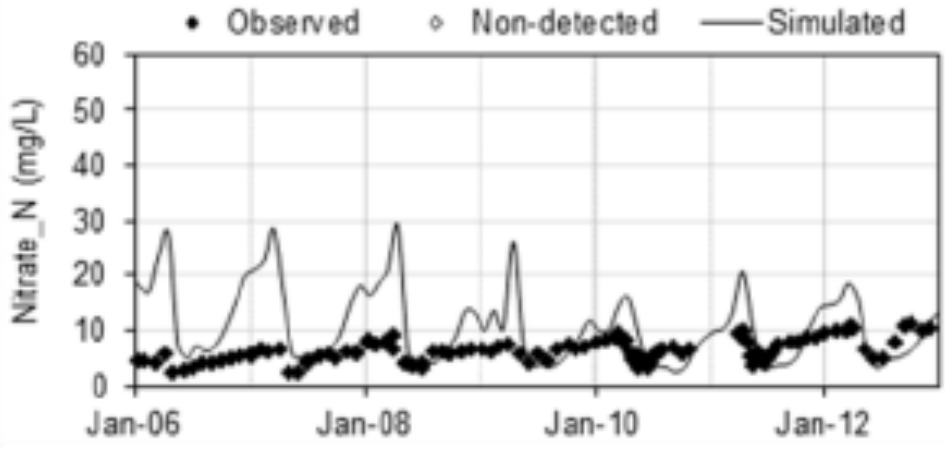
- Estimate the change in water quality in the Elk Valley associated with historical, current and planned future mining from all five operations
- Plan mitigation for selenium, sulphate and nitrate

Modelling Nitrate Release

- Nitrate is a constituent of interest in the Elk Valley and is an important constituent for design of biological treatment plants.

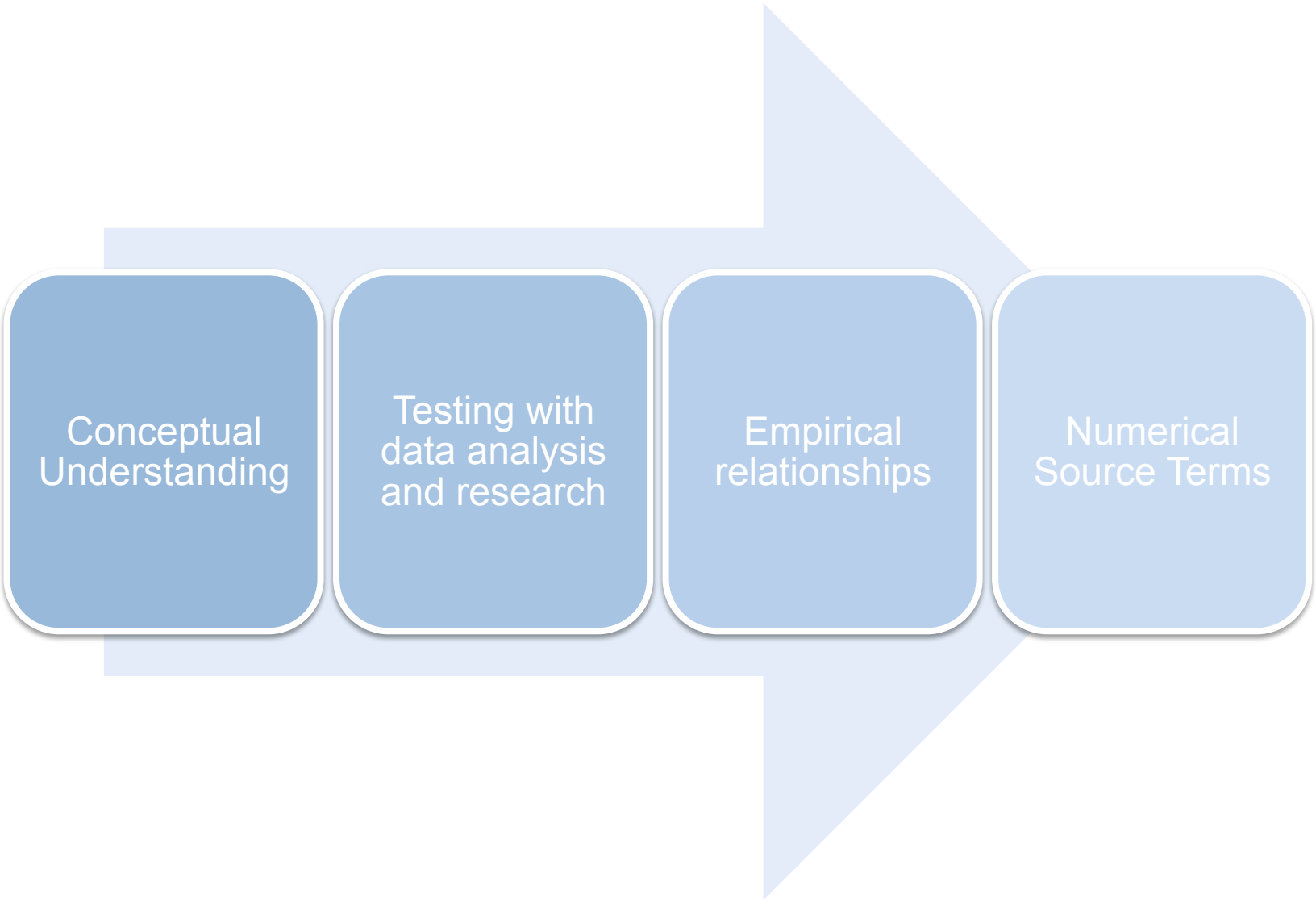
- Originally, the Regional Water Quality model used the published Environment Canada method described by Ferguson and Leask (1988).

- The method calculates nitrate release based on the use of explosives and assumes all explosive residue is washed off of waste rock within a year of being placed.



Source: 2014 EVWQP

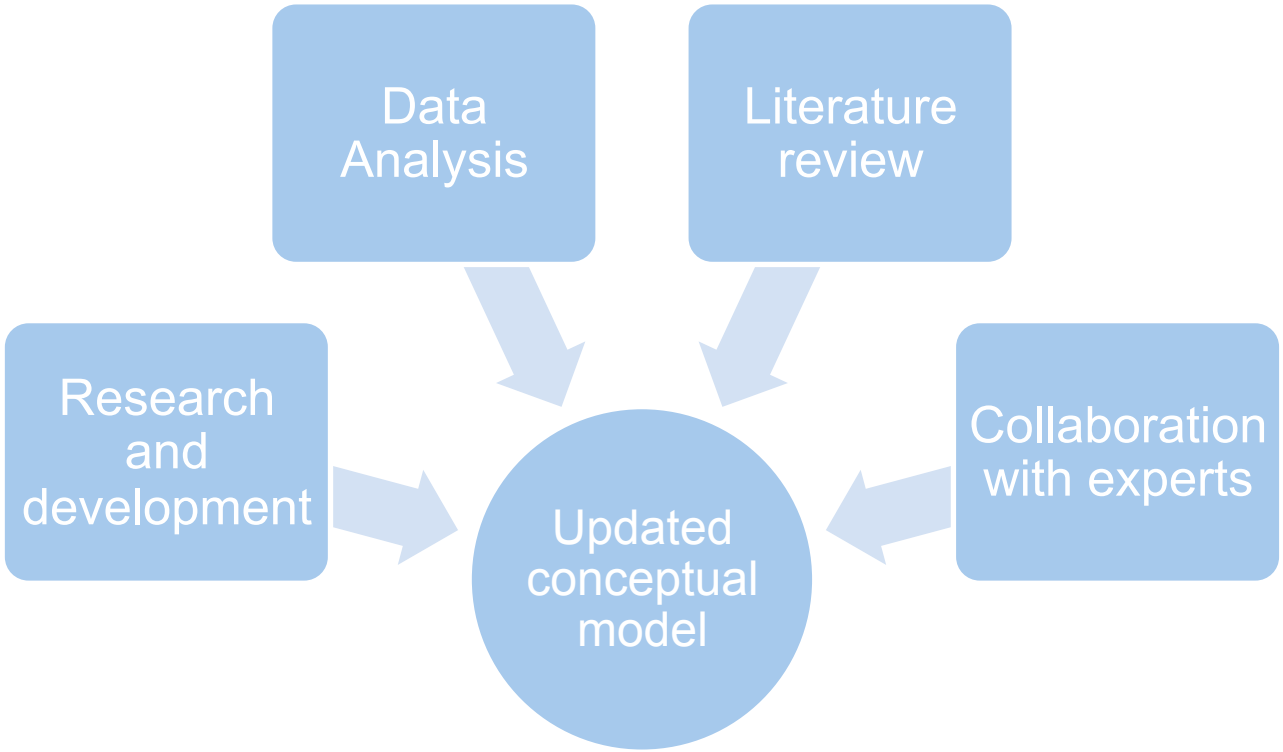
General Model Update Approach



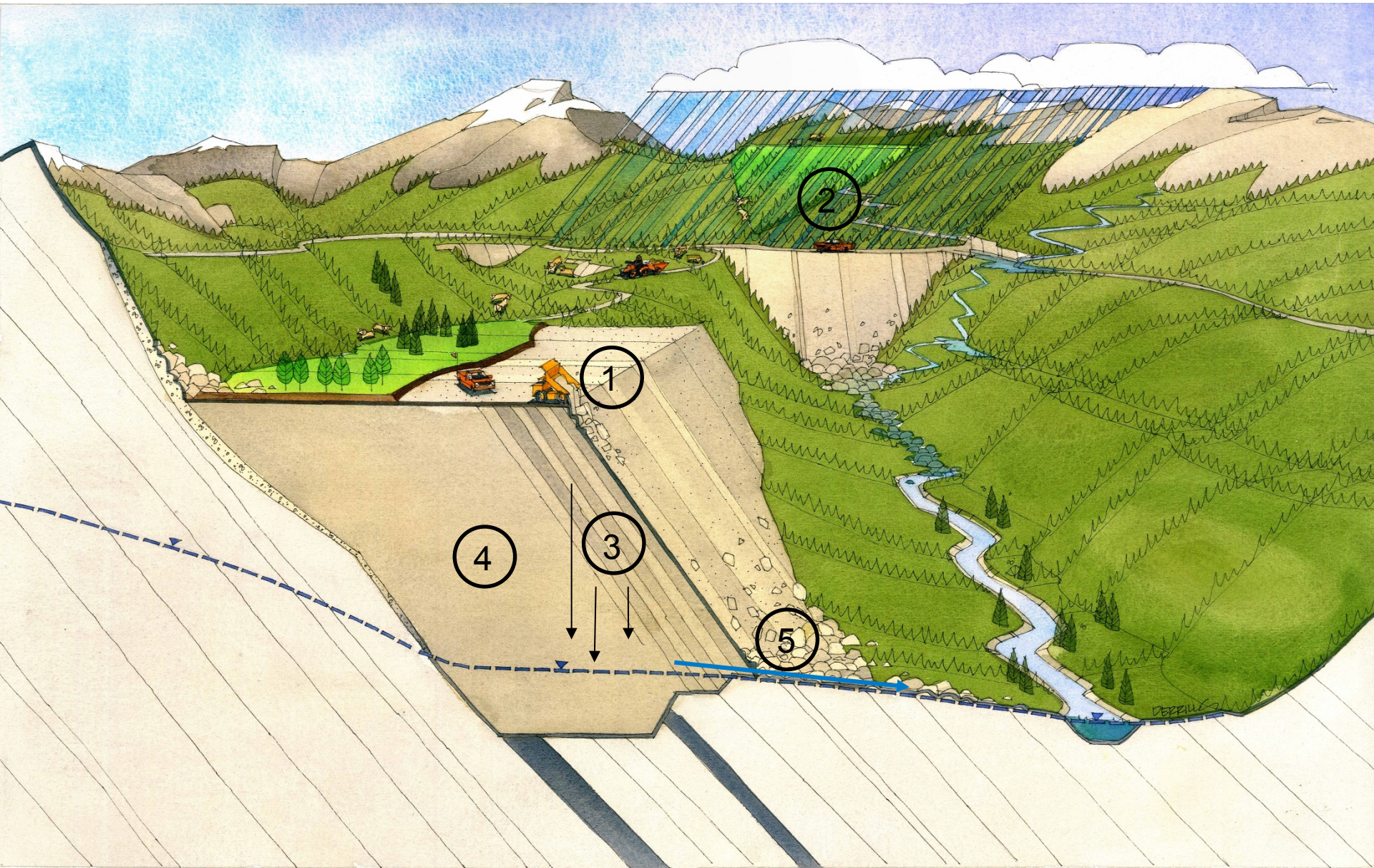
Updated Conceptual Model

Improving model calibration for nitrate was a focal area for the 2017 RWQM update.

Needed a better understanding of waste rock hydrology and how that influences nitrate release

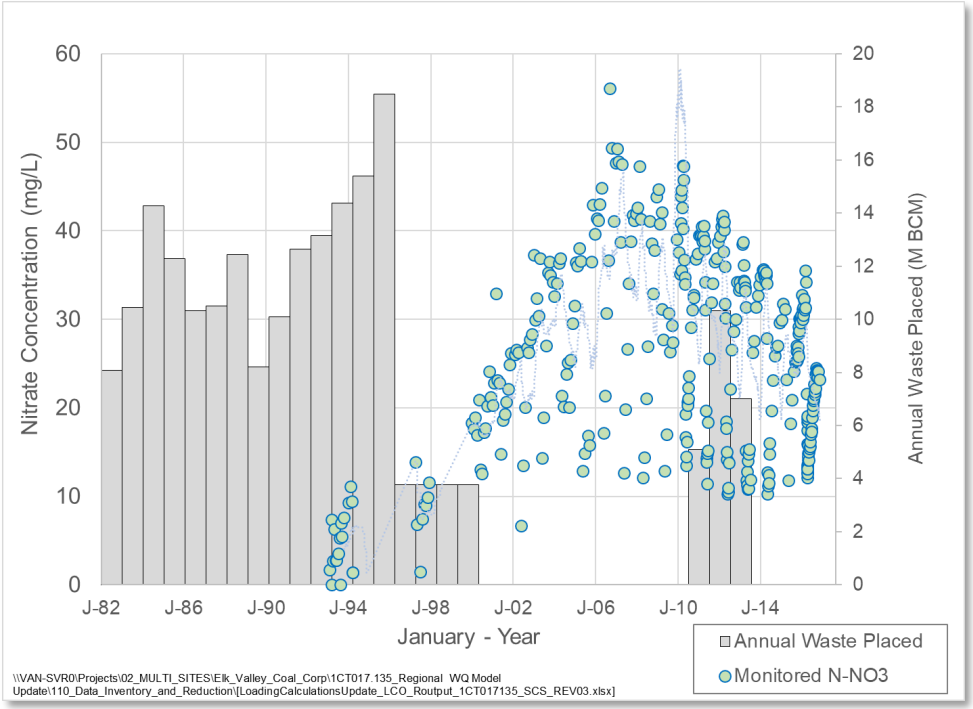


Updated Conceptual Model



Updated Conceptual Model

- The appearance of nitrate downstream of a new waste rock pile occurs several years after the first waste rock placement (initial time delay)
- Nitrate loads coming out of existing waste rock piles are the result of blasting from several years ago
- Concentrations are expected to peak after waste placement has finished
- Concentrations of nitrate will eventually return to low concentrations as nitrate residue is depleted



Nitrate concentration relative to waste placement at WLC (after SRK, 2017)

Updated methodology

Method includes:

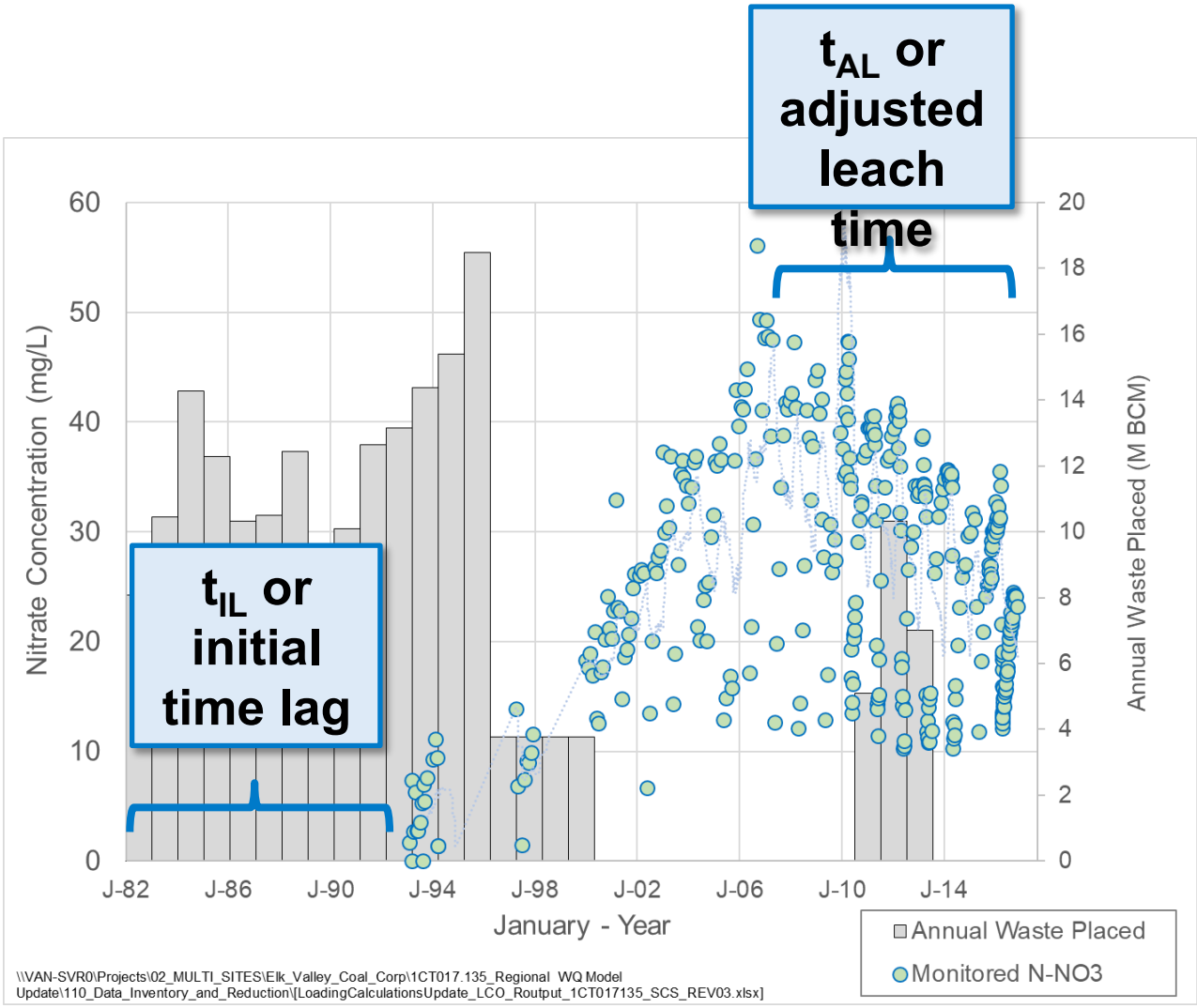
1 Calculate the potential amount of nitrate (as per Ferguson & Leask method)	Potential NO_3-N (kg N/year) = $V(n) \cdot P_f(n) \cdot f_N \cdot f_R$
2 Adjust the initial lag	t_{IL}
3 Adjust the amount leached in a given year	t_{AL}

Where V(n) is volume of waste in year n
$P_f(n)$ is the powder factor
f_N is the fraction of nitrogen (N) in ANFO
f_R is the nitrogen residuals after blasting

Two time adjustments

F&L method assumes 'release' of available nitrate from residuals occurs within a year of that waste placement.

Monitoring data suggests a time lag to the onset of leaching and a less abrupt release



Updated methodology

Method includes:

1. Calculate the potential amount of nitrate (as per Ferguson & Leask method)

   Potential NO_3-N (kg N/year) = $V(n) \cdot P_f(n) \cdot f_N \cdot f_R$

2. Adjust the initial lag

   t_{IL}

   Next few slides focus on the methods used to assess t_{IL}

3. Adjust the amount leached in a given year

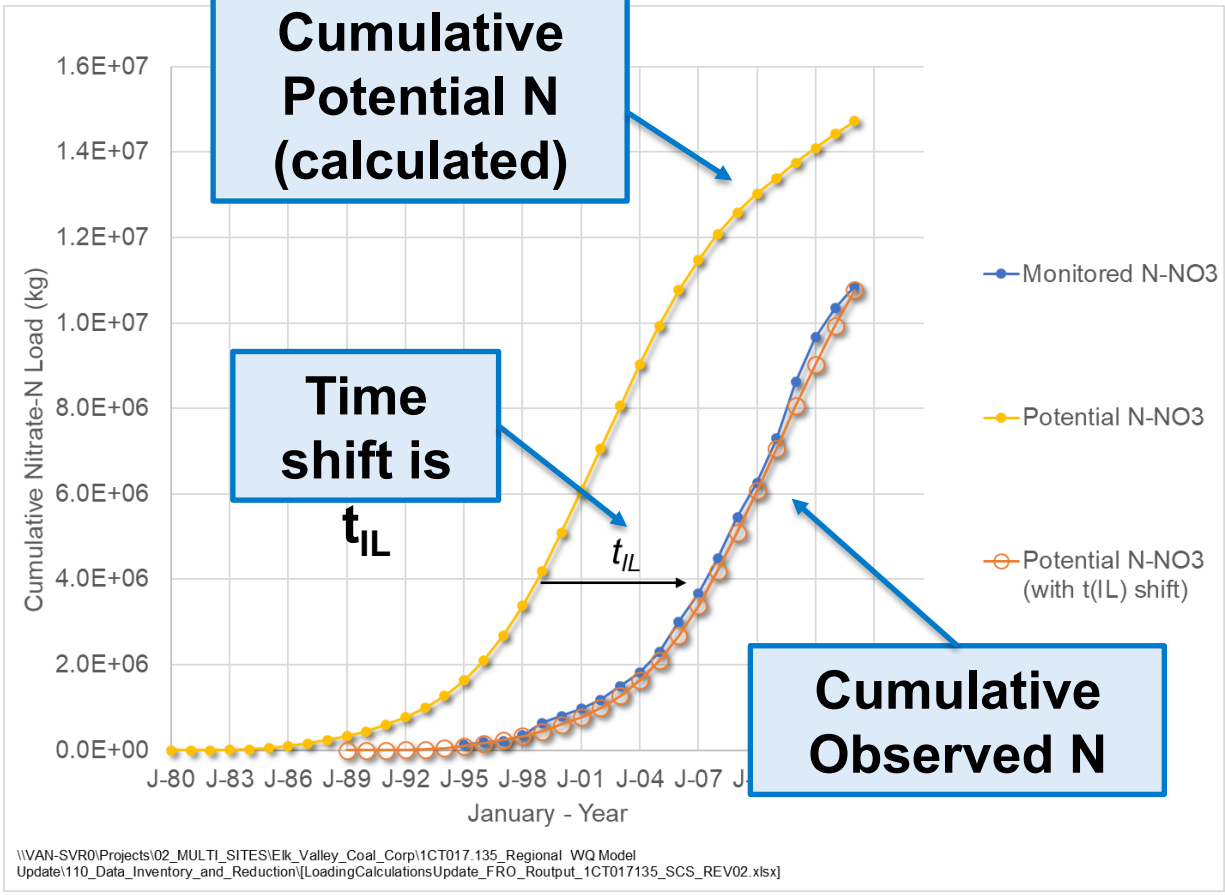
   t_{AL}

   Monitoring data indicates t_{AL} in the Elk Valley may be ~10 yrs

Where V(n) is volume of waste in year n
$P_f(n)$ is the powder factor
f_N is the fraction of nitrogen (N) in ANFO
f_R is the nitrogen residuals after blasting

Estimating Initial Time Lag (t_{IL})

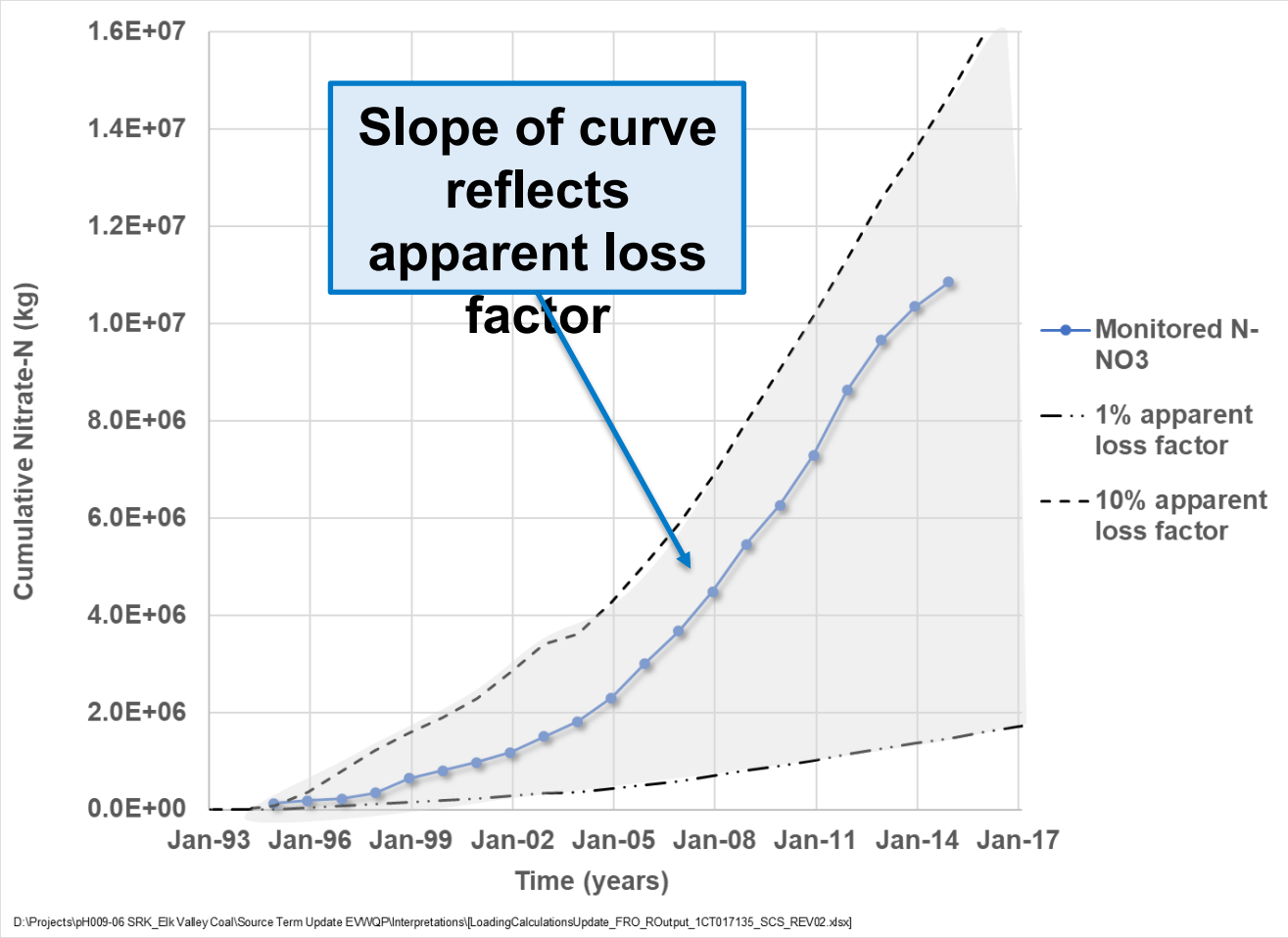
To estimate the t_{IL}, a quasi-Newton method (or variable metric algorithm) was used to shift the cumulative potential nitrate load (from F&L) (on the x axis, or in time) and the slope of the curve to match the monitored nitrate load.



Estimating the slope of the cumulative nitrate load curve

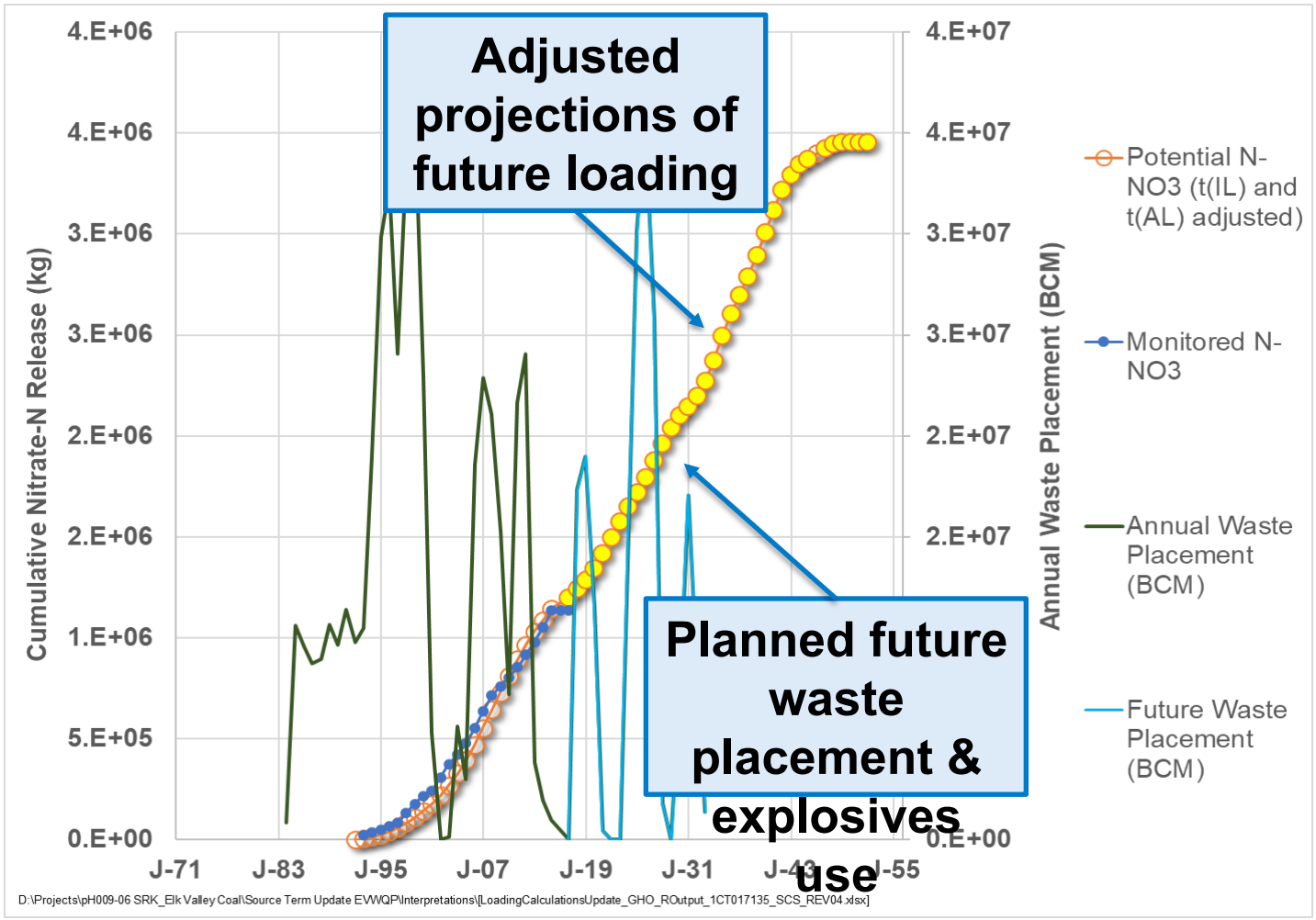
The quasi-Newton method (or variable metric algorithm) also varies the slope of the curve to match the monitored nitrate load.

The slope reflects the apparent loss factor, which is a global factor but encompasses the residuals (or f_R)



Using adjustments to forecast loadings

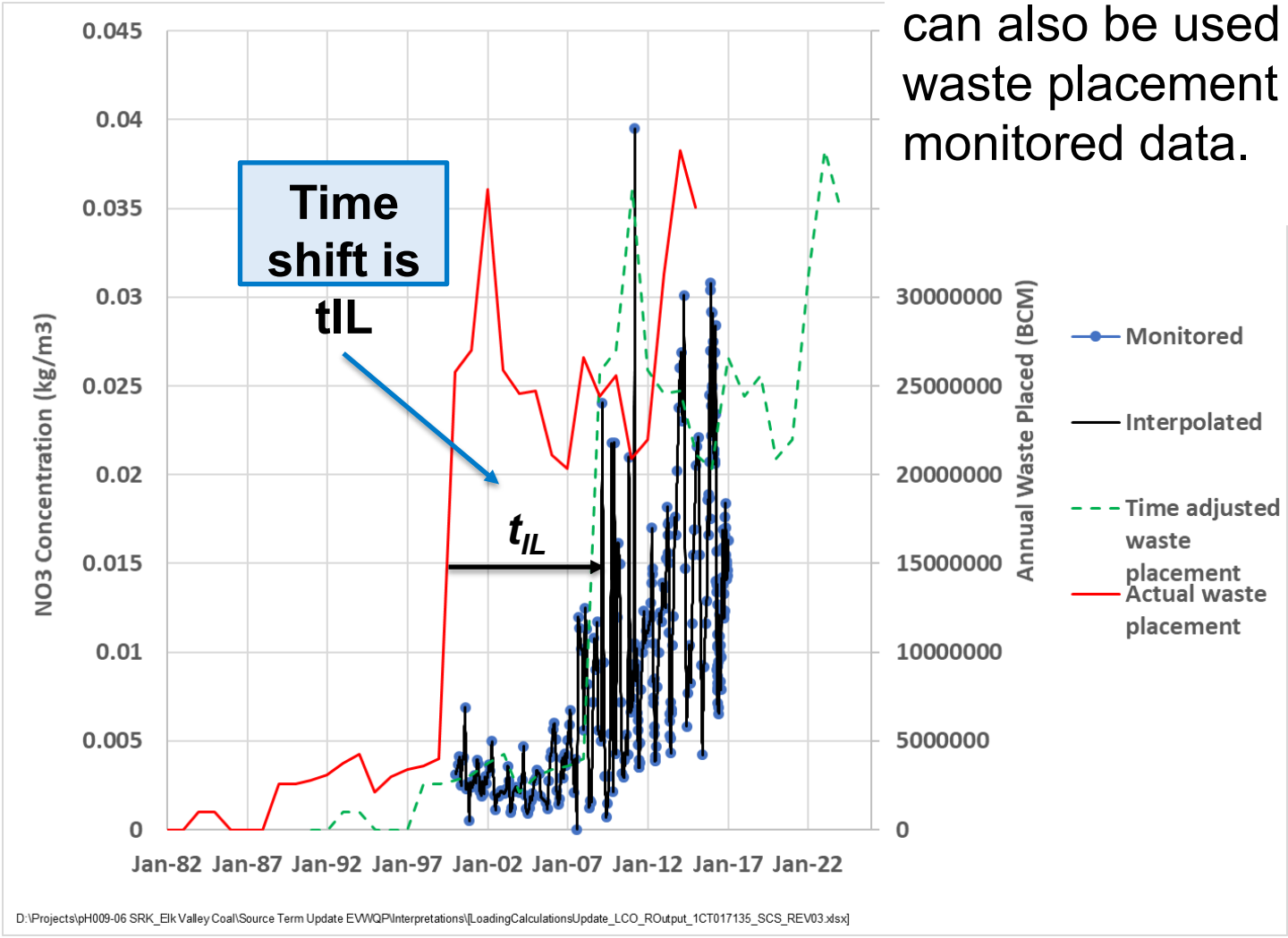
Cumulative NO_3 loadings from waste placed in each year n and continuing to year $n+t_{IL}+t_{AL}$.



Yellow fill indicates predicted future NO_3-N release

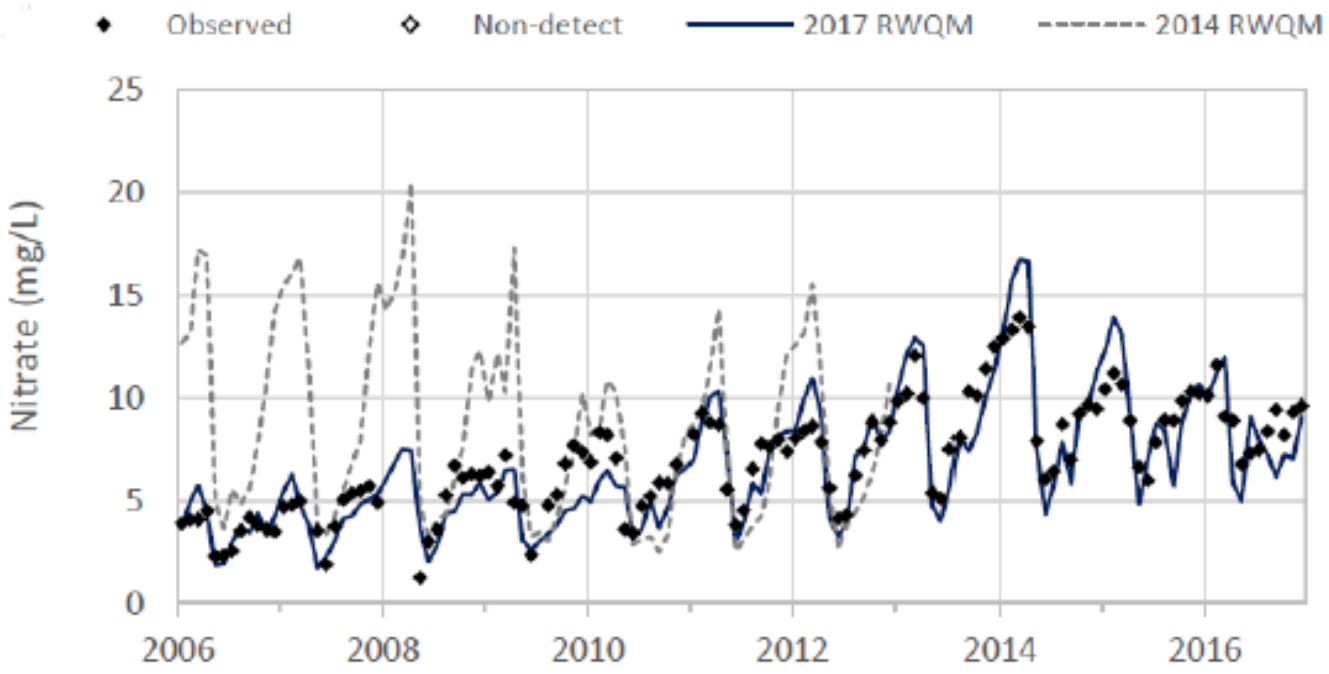
When available data does not support load calculations, concentration trends can be used:

A visual curve-fitting approach can also be used comparing waste placement history to monitored data.



Result: Improved Model Calibration

- Modelled seasonal and long term patterns better match historical monitoring data.
- Model calibration for has improved



Source: Teck 2017 RWQM Update- Overview Report

What's Next?

Teck will continue to refine the conceptual model of constituent release and source terms for nitrate in the Elk Valley using an adaptive management approach.