TETRA TECH

TECHNICAL MEMORANDUM

To:	**Nevada Environmental Response Trust**
Cc:	Nevada Division of Environmental Protection United States Environmental Protection Agency
From:	Carl Lenker and Eric Klink
Date:	June 10, 2020
Subject:	**Unit 4 Source Area In-Situ Bioremediation Treatability Study Monthly Progress Report**

At the direction of the Nevada Environmental Response Trust (NERT or Trust), Tetra Tech, Inc. (Tetra Tech) has prepared this memorandum that summarizes Tetra Tech's progress made during April 2020 toward successfully implementing the Unit 4 Source Area In-Situ Bioremediation Treatability Study.

Task Progress Update: April 2020

Task M21 – Unit 4 Source Area In-Situ Bioremediation (ISB) Treatability Study

- Task Leader – Arul Ayyaswami
- Current Status
    - The University of Nevada – Las Vegas (UNLV) completed microcosm and column testing in accordance with the Unit 4 Source Area In-Situ Bioremediation Treatability Study Bench-Scale Work Plan and Treatability Study Modification No. 1. Following completion of the microcosm and column tests on February 28, 2020 (day 554 of the microcosm testing and day 381 of the column testing), the contents of several microcosms and the columns were subsequently analyzed to evaluate and verify biodegradation of the contaminants of potential concern (COPCs). The following is a brief summary of the microcosm and column testing conducted and the analytical results received in April 2020:
        - **Microcosm Testing:** Microcosm testing was performed using primary and replicate microcosms with three intial total dissolved solids (TDS) concentrations (15,200 mg/L, 17,400 mg/L, and 21,000 mg/L). The primary and replicate microcosms contained a combination of molasses, molasses with acetate, mixed microbial cultures, nutrients, and soil and groundwater collected from boring and well locations near the Unit 4 Building. The results of microcosm testing were summarized in previous monthly progress reports and will be discussed in more detail in the Unit 4 Source Area In-Situ Bioremediation Treatability Study Work Plan Addendum. Following completion of the microcosm testing, analyses of the soil and remaining liquid in the microcosms revealed the following:

            (a) Hexavalent chromium, nitrate, and chlorate concentrations for samples from the microcosm soil and remaining liquid were below the detection limits for all the

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microcosms where degradation of COPCs was observed in the liquid phase during ongoing testing.

(b) The average perchlorate concentrations for samples from the remaining liquid in microcosms containing molasses and initial TDS concentrations of 15,200 mg/L, 17,400 mg/L, and 21,000 mg/L were 945 mg/L, 0.001 mg/L, and 0.2 mg/L, respectively. The average perchlorate concentrations for samples from the soil in microcosms containing molasses and initial TDS concentrations of 15,200 mg/L, 17,400 mg/L, and 21,000 mg/L were 915 mg/kg, non-detect (less than 0.04 mg/kg), and 1.3 mg/kg, respectively.

(c) Concentrations of COPCs in samples from the microcosm soil generally correlated with the liquid concentrations, wherein microcosms containing higher liquid concentations also have higher soil concentrations. Therefore, the reduction of COPC concentrations in the liquid phase is a good indicator of biodegradation occuring within the microcosm.

(d) Microbiological testing of the soil remaining in the microcosms revealed that the primary genera present were major components of the microbial culture added to the microcosms, which have also been found in the soil and groundwater collected from the Unit 4 study area. Other microbial species which are reported to degrade nitrate, chlorate, and perchlorate, were also present in the microcosms that used molasses as the carbon substrate.

- **Column Testing:** Column testing consisted of two deep columns (columns A and B, packed with a mixture of sand and soil collected from 95 to 105 feet bgs) and two intermediate columns (columns C and D, packed with a mixture of sand and soil collected from 75 to 85 feet bgs). Column testing was conducted from February 12, 2019 through February 28, 2020. The columns were operated in a recirculation mode during the first 25 days to flush the soil in the columns and obtain consistent effluent concentrations. The columns were subsequently operated under five simulated conditions to evaluate COPC reduction and obtain operational data under flow-through conditions with varying influent concentrations and varying amendments. The simulations were guided by the information gathered from the batch microcosm testing and ongoing column study results. The first four simulations used diluted groundwater with varying amendments to evaluate COPC reduction and operational data with lower COPC concentrations. The final simulation, Simulation Period 5, used undiluted groundwater collected from wells U4-E-01I and U4-E-05D without bioaugmentation. The attached Figures 1 through 8 provide the influent and effluent concentrations of hexavalent chromium, nitrate, chlorate, and perchlorate for the intermediate and deep columns for each simulation period, as well as a description of the simulations. The results were summarized in previous monthly progress reports and each simulation will be discussed in more detail in the Unit 4 Source Area In-Situ Bioremediation Treatability Study Work Plan Addendum. The following provides the primary findings of the column study testing, including the analyses of the column contents following completion of the final simulation:

  (a) The column testing provided evidence that the the use of a combination of molasses, nutrients, and a mixed bacterial culture can reduce the COPCs under flow-through conditions simulating hydrogeologic conditions present within the Unit 4 treatability study area over an extended period of time. The results of Simulation Period 5 indicated that while COPCs began to reduce, the full reduction of the COPCs was not achieved during the simulation period. This result is likely due to the limited contact time available between the microorganisms and contaminants within the relatively

short columns and there insufficient time (i.e., column length) for the microorganisms to reduce all of the COPCs.

(b) Stimulation of microbiological activity using amendments and mixed bactierial cultures can be accomplished with minimal effects to flow rate.

(c) After the microbial community was established, continued bioaugmentation was not required.

(d) Following completion of the column testing, the columns were opened to analyze the contents for microbiological and chemical conditions. The following is a summary of the results:

- Microbiological evaluation revealed that approximately 70% of the bacteria present in the soils from the intermediate column and 50% of the bacteria present in the soils from the deep columns were the phylum proteobacteria. This group represents a wide variety of anaerobic and aerobic microorganisms that are generally capable of adapting quickly to changes in the environment, grow opportunistically when food is available, and have the ability to degrade nitrate and perchlorate.
- Hexavalent chromium was not detected in the soil from the intermediate or deep columns. In the intermediate columns, the average soil concentrations of nitrate, chlorate, and perchlorate were 0.02 µg/kg, 1.7 µg/kg, and 0.4 µg/kg, respectively. In the deep columns, the average soil concentrations of nitrate, chlorate, and perchlorate were 0.013 µg/kg, 1.63 µg/kg, and 0.67 µg/kg, respectively.

- Schedule and Progress Updates
  - Development of the Unit 4 Source Area In-Situ Bioremediation Treatability Study Work Plan Addendum for Phase 2 that is currently anticipated to be submitted early in the Third Quarter of 2020.
- Health and Safety
  - There were no health and safety incidents related to Task M21 during April 2020.
  - Tetra Tech and UNLV have continued to take precautions to address the health and safety concerns associated with COVID-19.

CERTIFICATION

Unit 4 Source Area Bioremediation Treatability Study Monthly Progress Report

Nevada Environmental Response Trust Site
(Former Tronox LLC Site)
Henderson, Nevada

Nevada Environmental Response Trust (NERT) Representative Certification
I certify that this document and all attachments submitted to the Division were prepared at the request of, or under the direction or supervision of NERT. Based on my own involvement and/or my inquiry of the person or persons who manage the systems(s) or those directly responsible for gathering the information or preparing the document, or the immediate supervisor of such person(s), the information submitted and provided herein is, to the best of my knowledge and belief, true, accurate, and complete in all material respects.

Office of the Nevada Environmental Response Trust

Le Petomane XXVII, not individually, but solely in its representative capacity as the Nevada Environmental Response Trust Trustee

Signature: Jay A Steinberg Not Individually, but Solely as President of the Trustee, not individually, but solely in his representative capacity as President of the Nevada Environmental Response Trust Trustee

Name: Jay A. Steinberg, not individually, but solely in his representative capacity as President of the Nevada Environmental Response Trust Trustee

Title: Solely as President and not individually

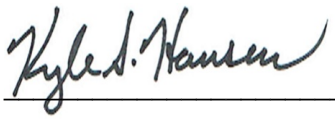
Company: Le Petomane XXVII, Inc., not individually, but solely in its representative capacity as the Nevada Environmental Response Trust Trustee

Date: 6/10/2020

CERTIFICATION

I hereby certify that I am responsible for the services described in this document and for the preparation of this document. The services described in this document have been prepared in a manner consistent with the current standards of the profession, and to the best of my knowledge, comply with all applicable federal, state, and local statutes, regulations, and ordinances. I hereby certify that all laboratory analytical data was generated by a laboratory certified by the NDEP for each constituent and media presented herein.

Description of Services Provided: Prepared Unit 4 Source Area Bioremediation Treatability Study Monthly Progress Report.



June 10, 2020

Kyle Hansen, CEM
Field Operations Manager/Geologist
Tetra Tech, Inc.

Date

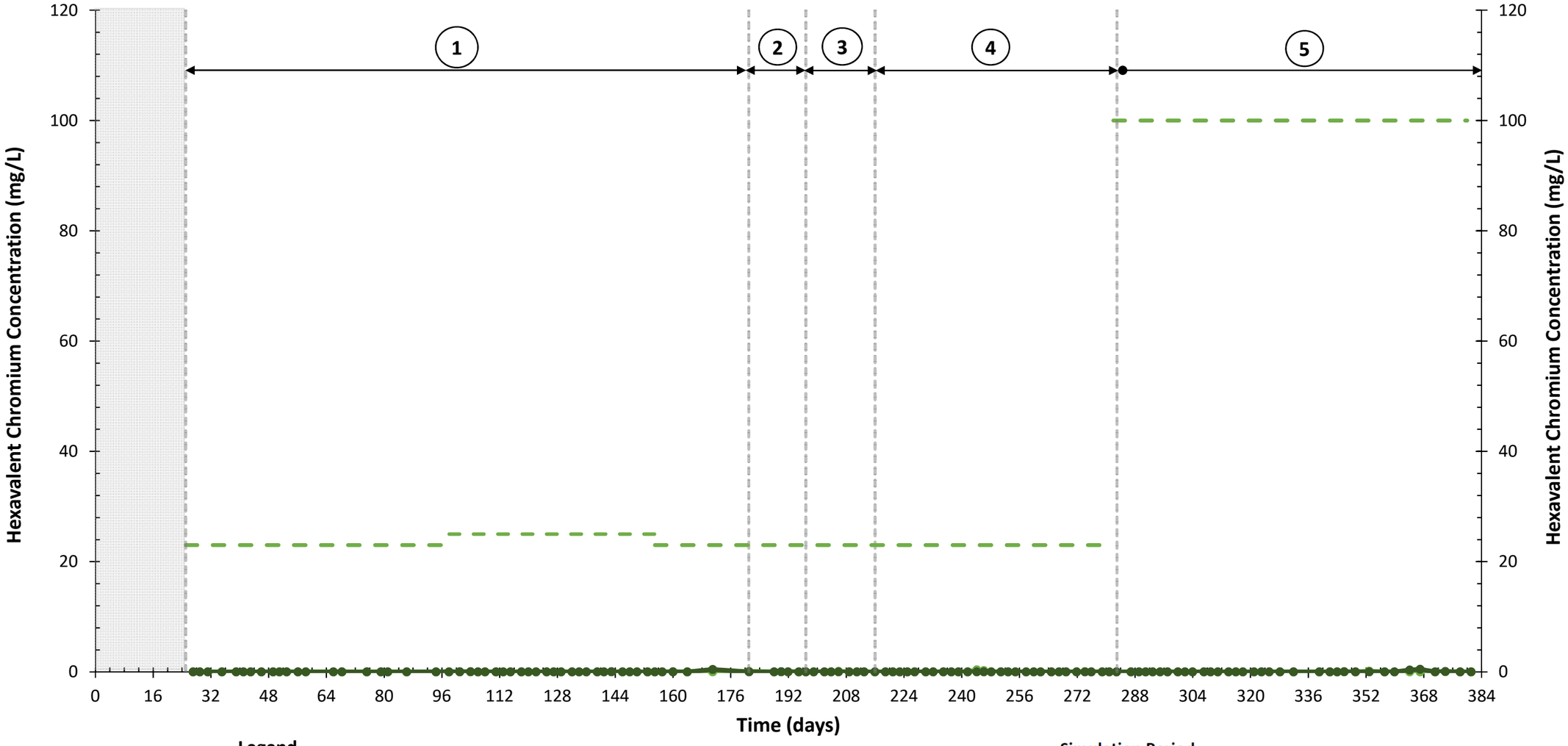
Nevada CEM Certificate Number: 2167
Nevada CEM Expiration Date: September 18, 2020

Figures

Figure 1

Hexavalent Chromium Concentrations for Intermediate Columns

Unit 4 Source Area In-Situ Bioremediation Treatability Study Bench-Scale Testing



Legend

- Effluent Column C
- Effluent Column D
- Influent
- Recirculation Period

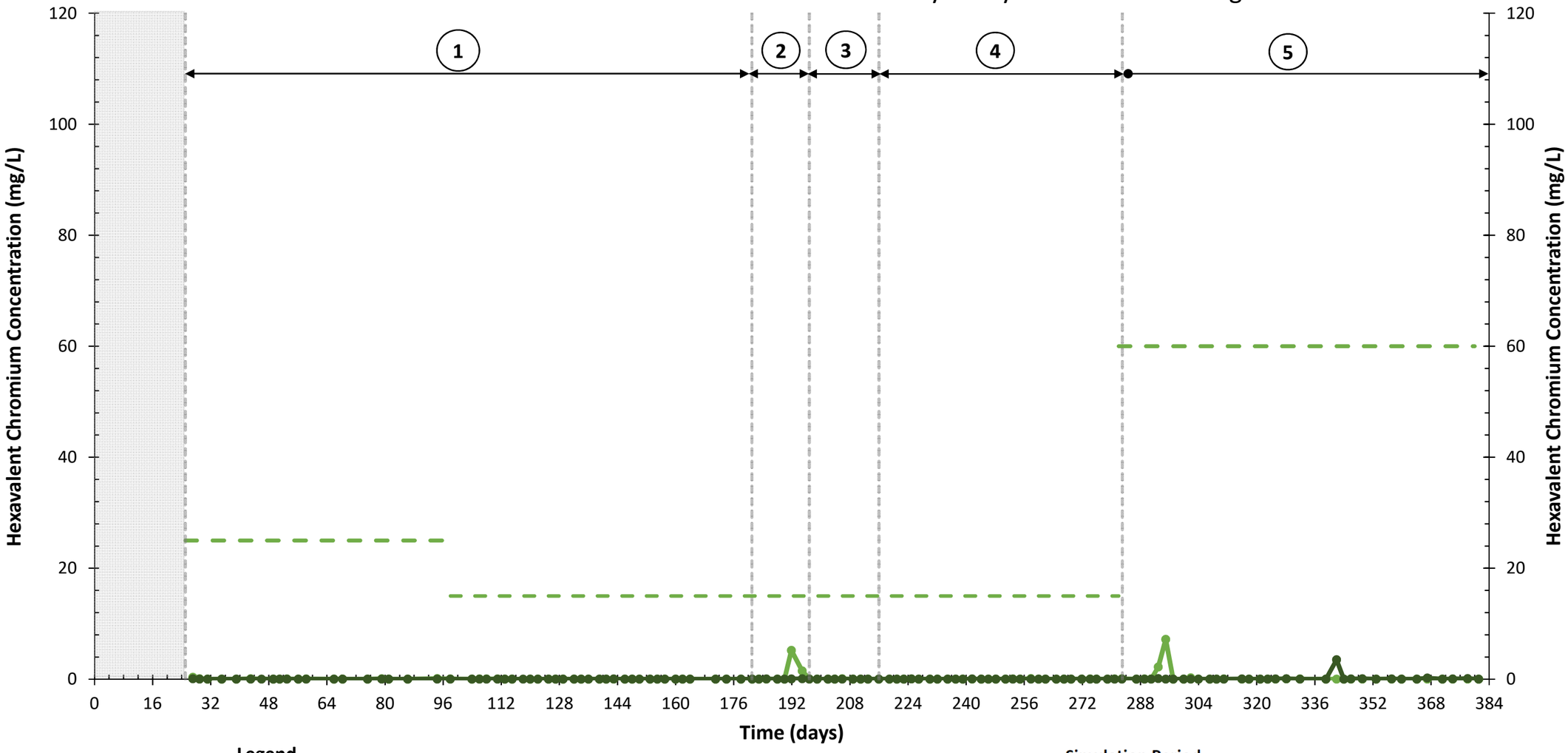
Simulation Period

1. Diluted Groundwater, Molasses, Nutrients, and Mixed Microbial Culture
2. Diluted Groundwater and Nutrients
3. Diluted Groundwater, Reduced Molasses, and Nutrients
4. Diluted Groundwater, Molasses, and Nutrients
5. Undiluted Groundwater, Molasses, and Nutrients

Figure 2

Hexavalent Chromium Concentrations for Deep Columns

Unit 4 Source Area In-Situ Bioremediation Treatability Study Bench-Scale Testing



Legend

- Effluent Column A
- Effluent Column B
- Influent
- Recirculation Period

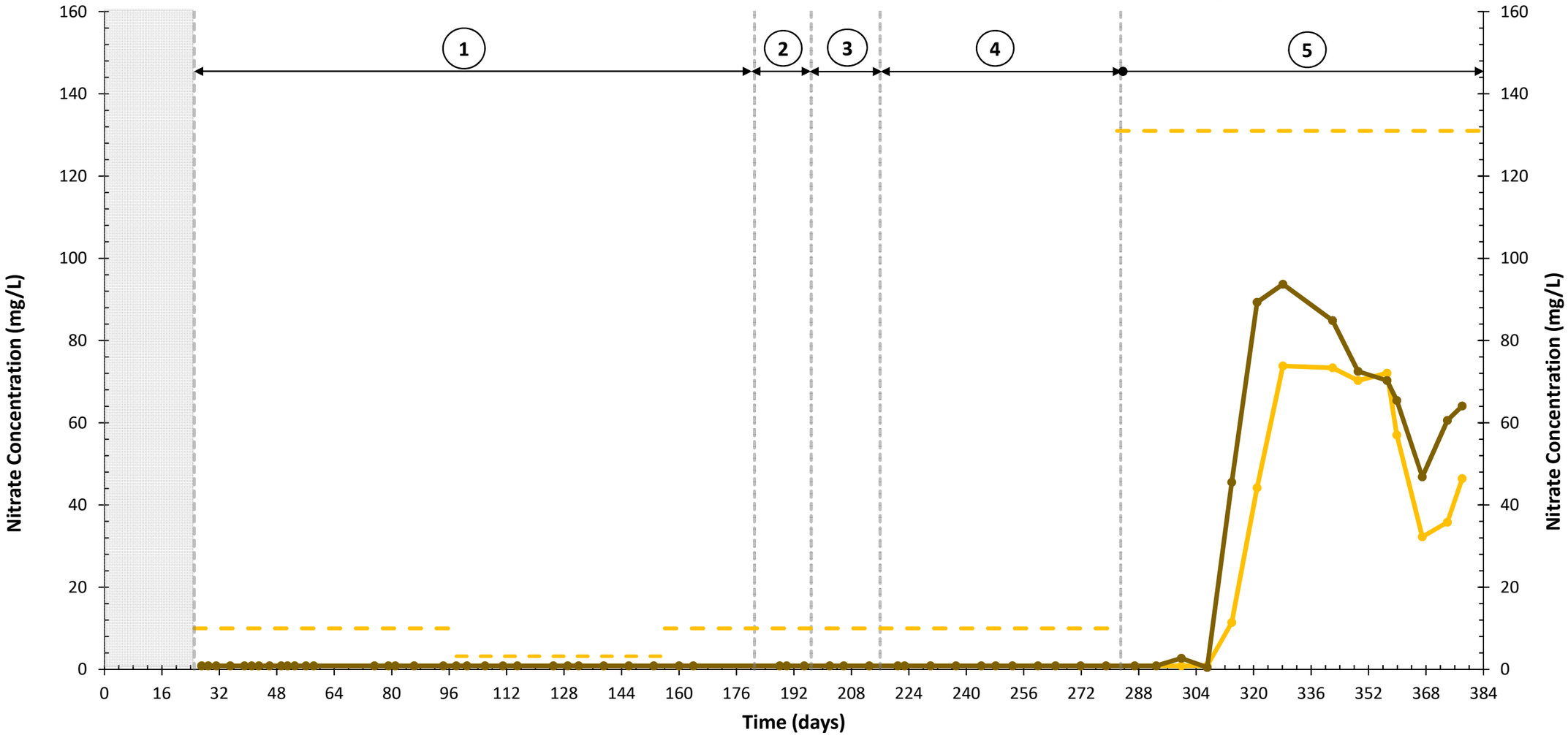
Simulation Period

1. Diluted Groundwater, Molasses, Nutrients, and Mixed Microbial Culture
2. Diluted Groundwater and Nutrients
3. Diluted Groundwater, Reduced Molasses, and Nutrients
4. Diluted Groundwater, Molasses, and Nutrients
5. Undiluted Groundwater, Molasses, and Nutrients

Figure 3

Nitrate Concentrations for Intermediate Columns

Unit 4 Source Area In-Situ Bioremediation Treatability Study Bench-Scale Testing



Legend

- Effluent Column C
- Effluent Column D
- Influent
- Recirculation Period

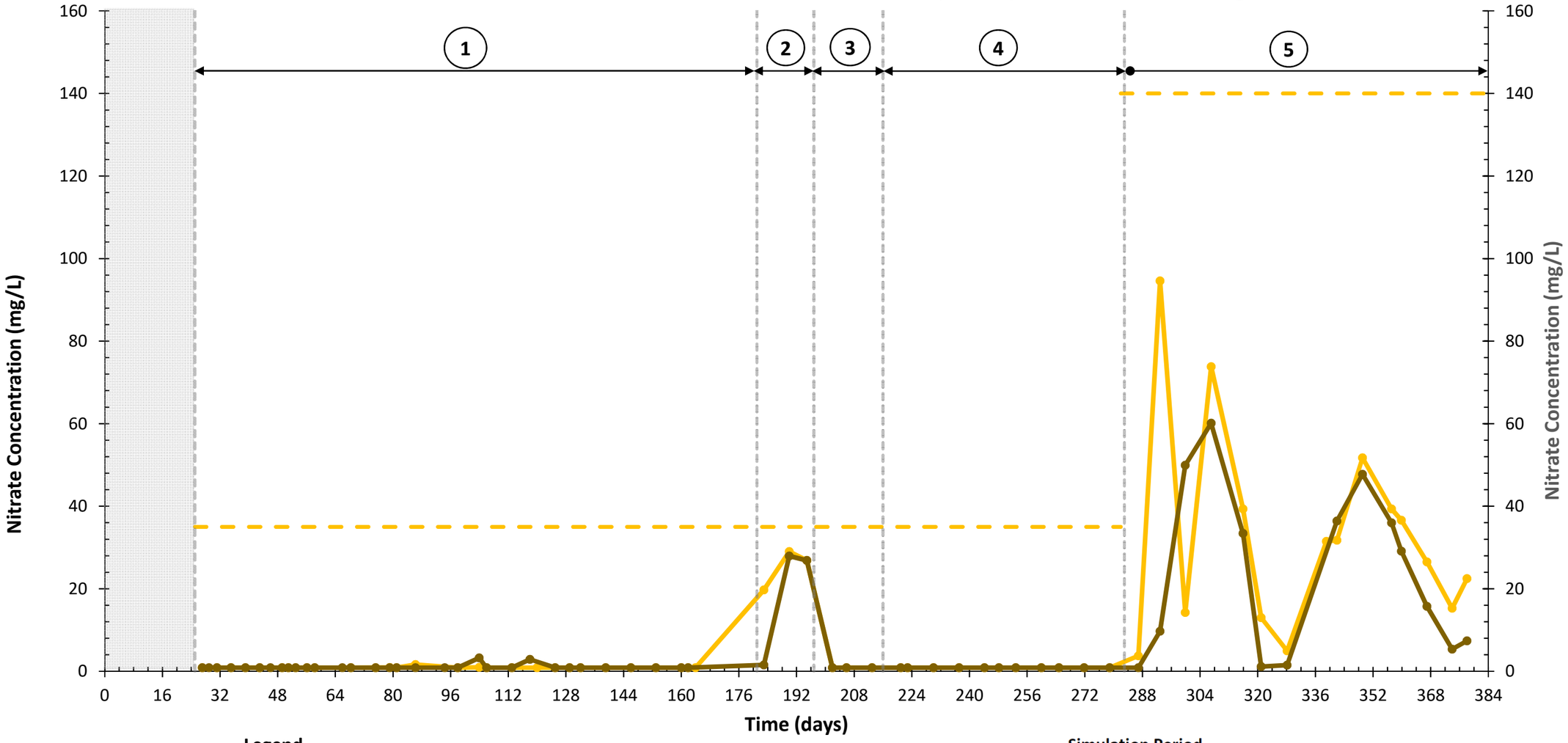
Simulation Period

1. Diluted Groundwater, Molasses, Nutrients, and Mixed Microbial Culture
2. Diluted Groundwater and Nutrients
3. Diluted Groundwater, Reduced Molasses, and Nutrients
4. Diluted Groundwater, Molasses, and Nutrients
5. Undiluted Groundwater, Molasses, and Nutrients

Figure 4

Nitrate Concentrations for Deep Columns

Unit 4 Source Area In-Situ Bioremediation Treatability Study Bench-Scale Testing



Legend

- Effluent Column A
- Effluent Column B
- Influent
- Recirculation Period

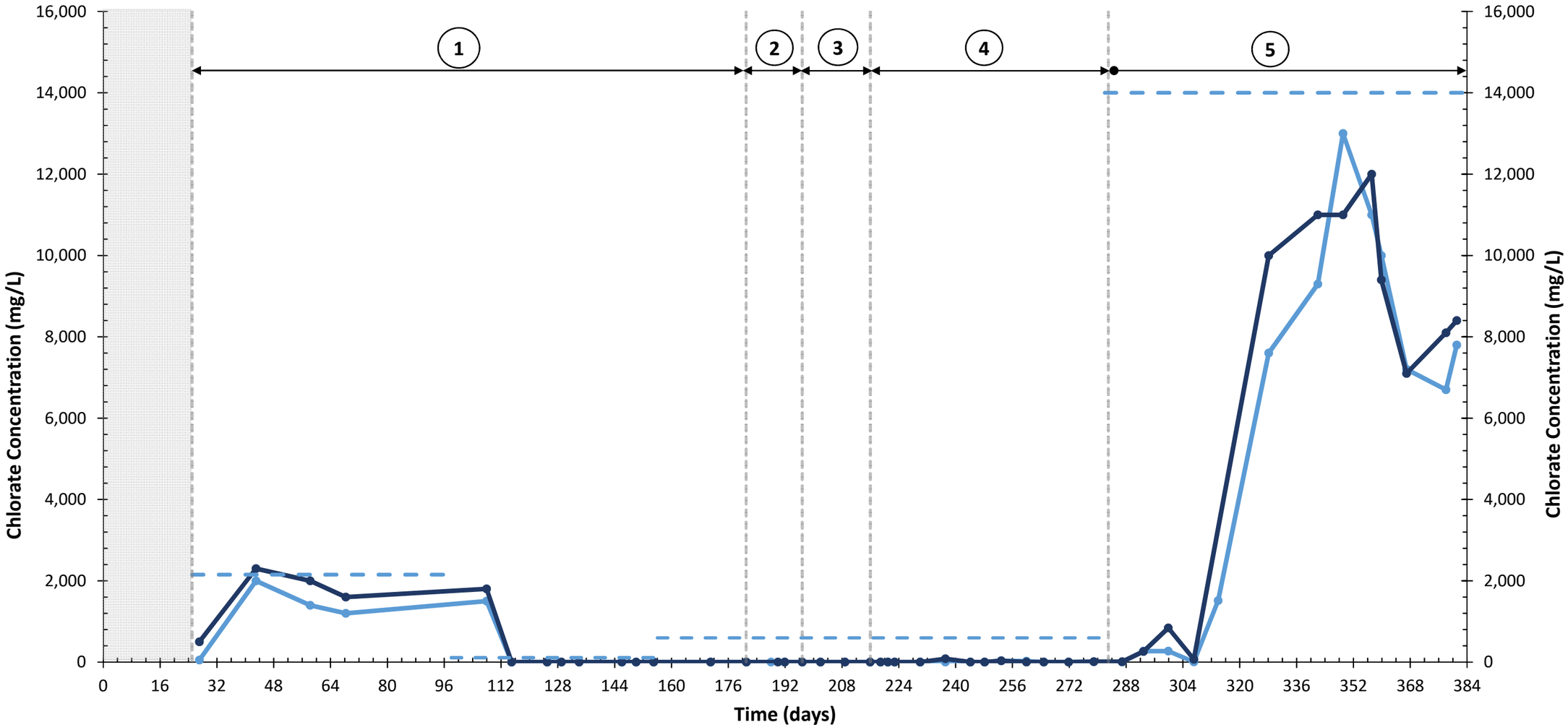
Simulation Period

1. Diluted Groundwater, Molasses, Nutrients, and Mixed Microbial Culture
2. Diluted Groundwater and Nutrients
3. Diluted Groundwater, Reduced Molasses, and Nutrients
4. Diluted Groundwater, Molasses, and Nutrients
5. Undiluted Groundwater, Molasses, and Nutrients

Figure 5

Chlorate Concentrations for Intermediate Columns

Unit 4 Source Area In-Situ Bioremediation Treatability Study Bench-Scale Testing



Legend

- Effluent Column C
- Effluent Column D
- Influent
- Recirculation Period

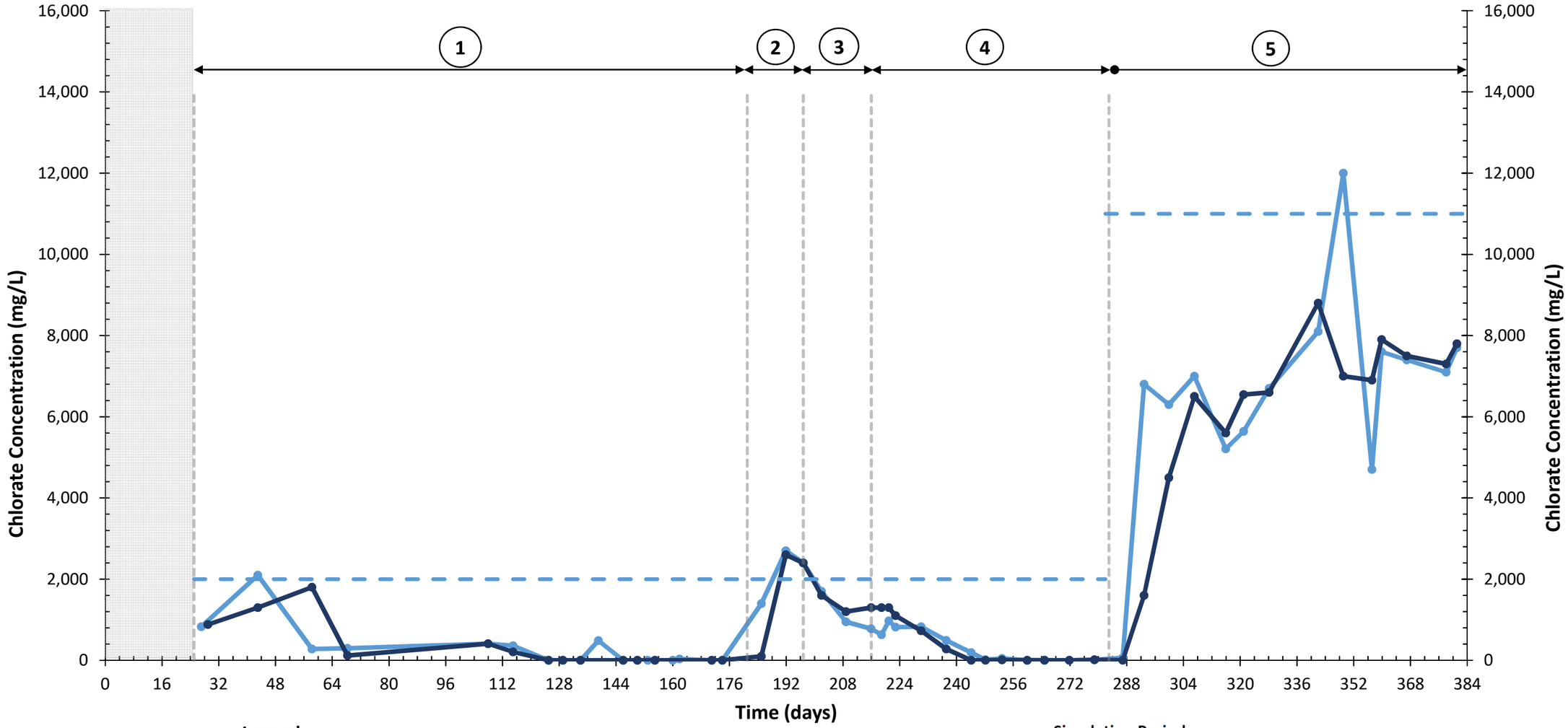
Simulation Period

1. Diluted Groundwater, Molasses, Nutrients, and Mixed Microbial Culture
2. Diluted Groundwater and Nutrients
3. Diluted Groundwater, Reduced Molasses, and Nutrients
4. Diluted Groundwater, Molasses, and Nutrients
5. Undiluted Groundwater, Molasses, and Nutrients

Figure 6

Chlorate Concentration for Deep Columns

Unit 4 Source Area In-Situ Bioremediation Treatability Study Bench-Scale Testing



Legend

- Effluent Column A
- Effluent Column B
- Influent
- Recirculation Period

Simulation Period

1. Diluted Groundwater, Molasses, Nutrients, and Mixed Microbial Culture
2. Diluted Groundwater and Nutrients
3. Diluted Groundwater, Reduced Molasses, and Nutrients
4. Diluted Groundwater, Molasses, and Nutrients
5. Undiluted Groundwater, Molasses, and Nutrients

Figure 7

Perchlorate Concentrations for Intermediate Columns

Unit 4 Source Area In-Situ Bioremediation Treatability Study Bench-Scale Testing

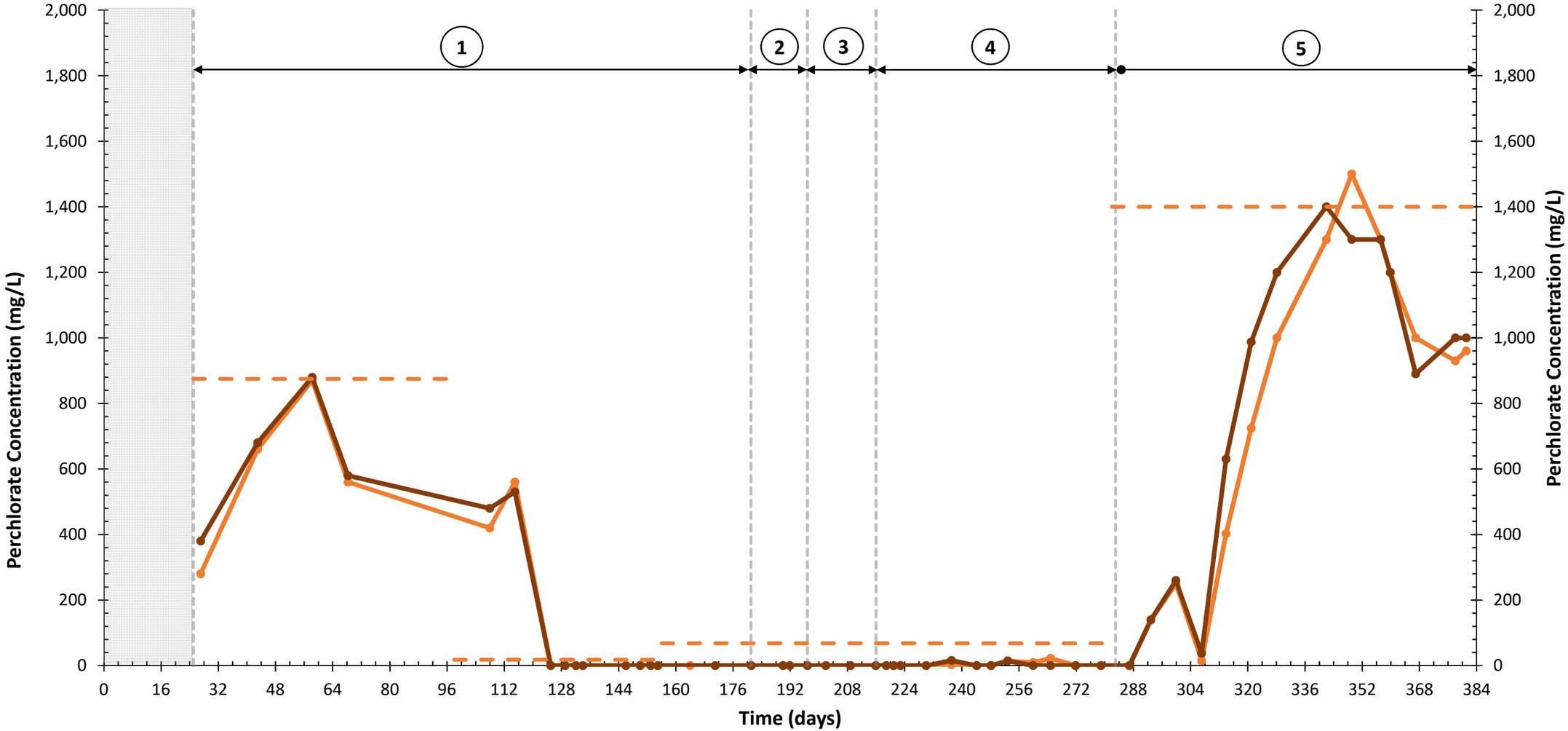
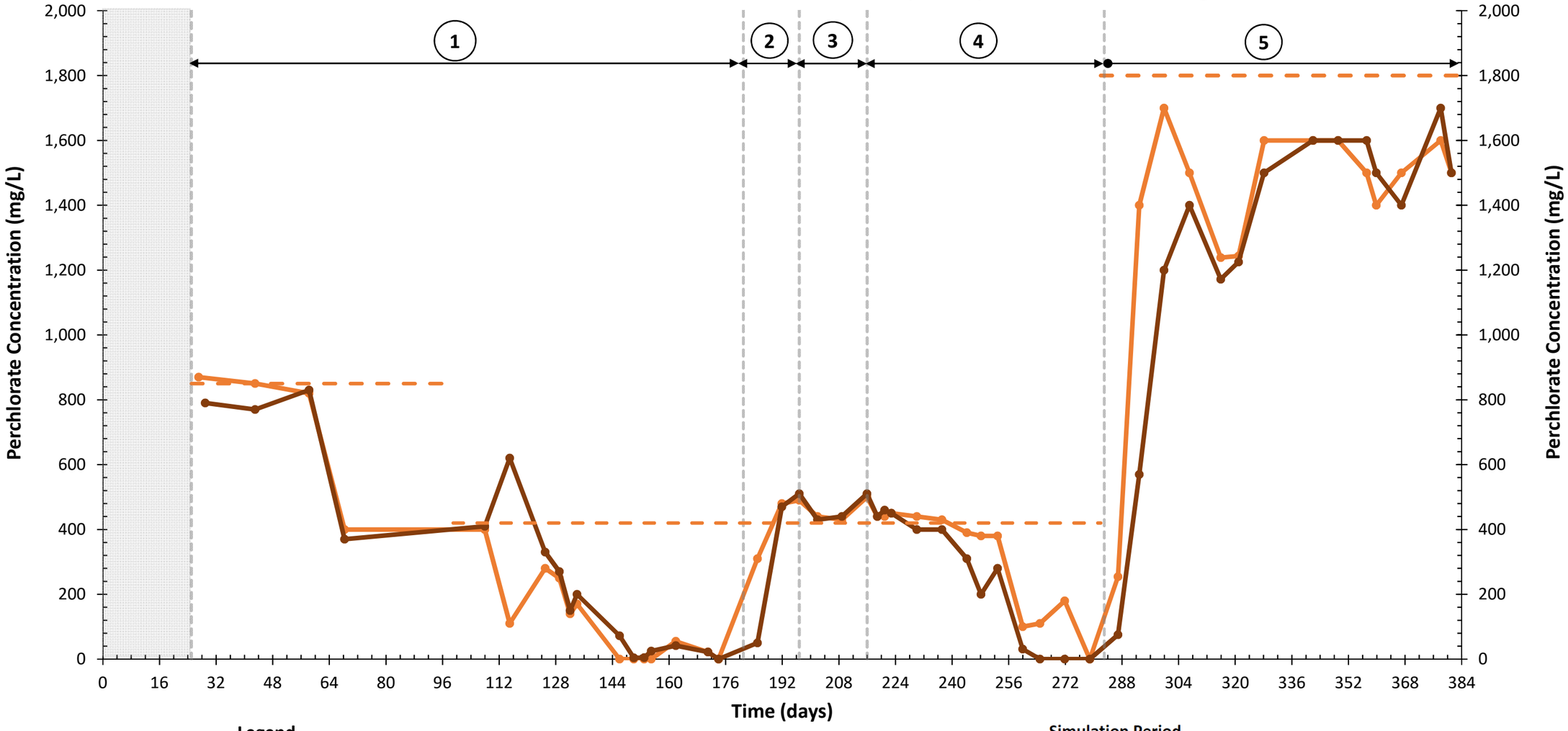


Figure 8

Perchlorate Concentrations for Deep Columns

Unit 4 Source Area In-Situ Bioremdiation Treatability Study Bench-Scale Testing



Legend

- Effluent Column A
- Effluent Column B
- Influent
- Recirculation Period

Simulation Period

1. Diluted Groundwater, Molasses, Nutrients, and Mixed Microbial Culture
2. Diluted Groundwater and Nutrients
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4. Diluted Groundwater, Molasses, and Nutrients
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