NORFOLK SOUTHERN

**Norfolk Southern Corporation**
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**Christopher M. Hunsicker, P.E.**
North Regional Manager
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April 14, 2024

Ralph Dollhopf
On-Scene Coordinator
United States Environmental Protection Agency
Transmitted by e-mail

Re: Stream Mitigation Measures Work Plan – Complete Package
NSRC East Palestine, OH Derailment

Dear Mr. Dollhopf,

Per your request, Norfolk Southern Railroad Company (NSRC) has prepared the attached Sediment Mitigation Measures Work Plan – Modified (Version 5) to provide all components under a single transmittal. This package includes the following components:

- Sediment Mitigation Measures Work Plan – Modified
  - Attachment A – Mitigation and Containment Tactics (submitted March 11, 2024)
  - Attachment B – Decision Tree for Ongoing Operations During Culvert Work (submitted March 11, 2024)
  - Attachment C – Surface Water Guidelines from Ohio (submitted March 11, 2024)
  - Attachment D – Attenuation Review (submitted April 8, 2024)
  - Attachment E – Culvert 1 Mitigation Options Plan (submitted March 25, 2024)
  - Attachment F – Field Adjustments per SR1 Finding Letter (submitted April 11, 2024)
  - Attachment G – Sulphur Run Mitigation Field Walk and Recommended Tactics Tracking Sheet (submitted April 11, 2024)

A redline strike-out version of the plan text has been provided to indicate changes made since the March 11, 2024 submittal to incorporate Attachments D through G, along with a clean and complete plan.

Should you have any questions regarding this information, please contact me at 412-445-4456 at your earliest convenience.

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Enclosures:
Sediment Mitigation Measures Work Plan – Modified

**Norfolk Southern Railway Company**

# Sediment Mitigation Measures Work Plan – Modified

## East Palestine Train Derailment

## Columbiana County, Ohio

**Prepared in response to USEPA's Administrative Order pursuant to Section 311 of the Clean Water Act – Docket No. CWA-1321-5-24-001**

Rev. 5

April 13, 2024
(modified March 1, 2024 by USEPA)

# Sediment Mitigation Measures Work Plan

**East Palestine Train Derailment**
**Columbiana County, Ohio**

**Prepared in response to USEPA's Administrative Order pursuant to Section 311 of the Clean Water Act – Docket No. CWA-1321-5-24-001**

Rev. 5
April 13, 2024

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# Version Control

| Revision No. | Date Issued | Page No. | Description |
|---|---|---|---|
| 0 | January 5, 2024 | --- | Initial Plan |
| 1 | February 5, 2024 | All | Revisions based on January 26, 2024 (written) and February 5, 2024 (verbal) comments from USEPA |
| 2 | March 1, 2024 | All | Revisions by USEPA |
| 3 | March 6, 2024 | All | Minor formatting changes and updates (figure name, references, and number updates) |
| 4 | March 11, 2024 | Figures and Attachments | Edits to notes in Figures 5-16 and re-name Attachment A |
| 5 | April 13, 2024 | Attachments | Adding Attachments F and G; Incorporating all approved attachments |

# Contents



# Tables



# Figures

# Attachments

# 1 Introduction

This Sediment Mitigation Measures Work Plan (Plan) was developed on behalf of Norfolk Southern Railway Company (NSRC) by Arcadis U.S., Inc. (Arcadis) and subsequently modified by the United States Environmental Protection Agency (EPA) in response to the February 3, 2023, derailment in East Palestine, Ohio. This Plan was prepared in accordance with the EPA Administrative Order (Docket No. CWA-1321-5-24-001) which was issued pursuant to Section 311 of the Clean Water Act (CWA), and which became effective on October 18, 2023 (CWA Order). This Plan identifies sediment mitigation measures to be implemented as required by Paragraph 57 of the CWA Order. The waterbodies targeted for action are those described in subparagraphs 51 (a) and (b) of the CWA Order (see Figure 1):

- Sulphur Run from its confluence with Leslie Run to 1,000 feet upstream beyond the confluence with the Unnamed Tributary of Sulphur Run (located just north of the railroad tracks), which is commonly called the North Ditch (referred to in this Plan as the Sulphur Run area)
- Leslie Run from its confluence with Bull Run to 1,000 feet upstream past the confluence with Sulphur Run (referred to in this Plan as the Leslie Run area)

The purpose of this Plan is to describe mitigation measures to address impacts attributed to the derailment in the waterbody areas. Section 2 provides a summary of relevant investigation and cleaning events completed to date. Section 3 describes mitigation measures including iterative procedures and end points. Section 4 provides a schedule for implementation of mitigation actions. Section 5 lists references cited throughout this Plan.

# 2 Summary of Work in the Sulphur Run and Leslie Run Areas

## 2.1 Investigation Efforts

Several investigation efforts have been performed since the derailment to assess the presence of chemicals of potential concern (COPCs) in environmental media over time. The COPC list (see Table 1) was provided by the EPA and represents what was on the train, what was subsequently detected in surface water and sediment after the derailment, and what is potentially toxic to human health. Associated degradation products and combustion products were also considered. In addition, EPA provided ecological screening levels (ESLs) and human health screening levels (HHSLs) to allow evaluation of the potential for contaminated media to serve as ongoing sources and threats to the environment and human health. EPA is using HHSLs to establish whether the discharged oil and any CWA hazardous substances discharged continue to pose a substantial threat to public health or welfare. Table 1 presents the identified COPCs, ESLs, and HHSLs. The COPCs are presented in four categories to aid in the understanding of the sources of impacts to the waterbodies: the analytes identified in the EPA-approved *Appendix D – Main Line Interim Soil Removal Plan* (Arcadis 2023a), polycyclic aromatic hydrocarbons[1] (PAHs), semi-volatile organic compounds (SVOCs), and volatile organic compounds (VOCs).

NSRC carried out investigation events in the waterbodies in February, March, May, July/August, and November/December 2023 in accordance with the following Work Plans:

- *Sediment Sampling Work Plan* (Arcadis 2023b)
- *Qualitative Stream Sediment Assessment Sampling and Analysis Plan and Quality Assurance Project Plan* (EnviroScience 2023a)
- *Sediment Quality Assurance Project Plan* (QAPP, Arcadis 2023c) and *Appendix H1 Sulphur Run Characterization Work Plan* (Arcadis 2023d)
- *Sediment Quality Assurance Project Plan* (Arcadis 2023e) and *Appendix H2 Leslie Run and Downstream Creeks Characterization Work Plan* (Arcadis 2023f)[2]
- *Comprehensive Sheen and Sediment Investigation Work Plan – Sulphur Run and Leslie Run* (Arcadis and EnviroScience 2023) and the associated QAPP (Arcadis 2023g)

The May-August 2023 investigations were performed under EPA's Unilateral Administrative Order for Removal Actions CERCLA Docket No. V-W-23-C-004. Investigation efforts included qualitative stream (sheen) assessments, sediment probing, and sampling with analytical testing for COPCs in sediment, sheen, and pore water. The field efforts, field and analytical data, and resulting data evaluation and conclusions are provided in the *Sediment Investigation Summary Report* (Arcadis 2023h).

The November/December 2023 investigation work conducted under the CWA Order included a qualitative stream (sheen) assessment along the entire length of the waterbodies, as well as the collection of sediment and sheen samples for analytical testing for the COPCs listed in Table 1. Figures 2 through 19 illustrate the

[1] PAHs are a subset of SVOCs and include 1-methylnaphthalene, 2-methylnaphthalene, acenaphthene, acenaphthylene, anthracene, benzo[a]anthracene, benzo[a]pyrene, benzo[b]fluoranthene, benzo[g,h,i]perylene, benzo[k]fluoranthene, chrysene, fluoranthene, fluorene, indeno[1,2,3-cd]pyrene, naphthalene, phenanthrene, and pyrene. The SVOC category in Table 1 includes only non-PAH SVOCs.

[2] The *Appendix H1 Sulphur Run Characterization Work Plan* and associated QAPP (Arcadis 2023f and Arcadis 2023e) and the *Appendix H2 Leslie Run and Downstream Creeks Sediment Characterization Work Plan* and associated QAPP (Arcadis 2023f and Arcadis 2023g) replaced the Sediment Sampling Work Plan included as Appendix H to the March 2023 Removal Work Plan (Arcadis 2023d).

November/December 2023 sampling locations in the Sulphur Run and Leslie Run areas. The results from the qualitative sheen assessment were provided in the *Qualitative Sheen Assessment Summary Report* (EnviroScience 2023b). The full report of all final and validated data required under Paragraph 56 of the CWA Order – the *Comprehensive Sheen and Sediment Investigation Report – Sulphur Run and Leslie Run* – was submitted on January 19, 2024 (Arcadis 2024).

In July/August 2023, NSRC also completed an aquatic biocriteria and stream assessment as well as a native freshwater mussel assessment.

- *Aquatic Biocriteria Plan of East Palestine Streams: Sulphur Run, Leslie Run, Bull Creek, North Fork Little Beaver Creek, and Little Beaver Creek 2023* (EnviroScience 2023c) – this work was approved by and completed under the direction of the Ohio Environmental Protection Agency (Ohio EPA).
- *Native Mussel Resources Assessment Workplan for the Little Beaver Creek Watershed of Ohio and Pennsylvania* (EnviroScience 2023d) – this work was approved by and completed under the direction of the Ohio Department of Natural Resources and the US Fish and Wildlife Service.

In addition, actions to characterize and address sediment within five culverts along Sulphur Run – as required in Paragraphs 59, 60, and 61 of the CWA Order – are documented under separate work plans and summary reports and are not described herein (Arcadis 2023i and 2023j).

## 2.2 Stream Washing Efforts

Past stream washing efforts to remediate impacts to the sediments included the entire stretch of Sulphur Run from the derailment site to the confluence of Leslie Run, and within Leslie Run from the confluence to approximately 1,800 feet downstream, ending just south of the East Palestine Wastewater Treatment Plant.

Stream washing was completed in segments of approximately 200 to 500 feet in length, and sheen and sediment capture devices were established downstream of the wash area.

- Capture devices included soft booms, hard booms, and turbidity curtains. A vacuum truck was staged at the capture devices to skim and recover sheen, product, and/or sediments produced from the washing activities.
- The length of each segment was determined based upon access points for personnel and equipment.
- The upstream extent of a segment was defined by the downstream extent of the previously completed segment, with the capture devices from the previously completed segment remaining in place during the washing of the next segment.

Washing within a segment was completed using a high-volume low-pressure pumping tactic that pulled stream water from the immediate upstream segment to wash the stream banks and bottom. During the washing, crews also agitated the sediments using hand tools and manual manipulation, and debris was removed for disposal.

Stream washing continued in this manner moving from the upstream start point in Sulphur Run to the downstream extent established in Leslie Run. Once crews reached the final targeted segment in Leslie Run, they began again from the first segment.

An additional tactic was used to achieve more agitation of stream sediments. While washing using the high-volume, low-pressure pumping tactic continued on the stream banks, air knifing using a high-pressure air wand was used to remediate the stream bottom.

# 3 Mitigation Measures

Under this Plan, NSRC will implement the mitigation tactics (such as those described in Section 3.1) followed by stream re-assessments (as described in Section 3.2) to mitigate impacts to sediments identified during the November/December 2023 stream assessment (EnviroScience 2023b, Arcadis 2024). The tactics will be applied in an iterative fashion and as such are expected to be flexible and adaptable. Refer to Attachments A and F for descriptions of procedures for removal tactics such as focused digging, excavation, etc.

## 3.1 Sediment Mitigation

Areas within both Sulphur Run and Leslie Run requiring mitigation are shown on Figure 1. Areas of the affected streams that have observed sheen scores of 2 and 3 from the Qualitative Sheen Assessment and chemical exceedances in sediment of human health screening levels will be targeted. Areas of confounding sources of contamination in Sulphur Run are depicted in Figures 5 & 7 by red hatches.

A stakeholder group consisting of NSRC, EPA, Ohio (OEPA), and as applicable their consultants, will assess each of the targeted areas in the field to select and determine mitigation tactics. Mitigation tactics will be specific for each targeted area and will include consideration of aggressive removal tactics such as focused digging, excavation, etc. Once a targeted area is assessed by the stakeholder group, NSRC will propose a mitigation tactic for each targeted area, which may vary from one target area to the next. The EPA Operations Chief will determine and document the tactic(s) to be employed following consideration of stakeholder input.

Following implementation of mitigation tactics and an equilibration period of at least 12 hours, each targeted area will undergo a focused qualitative sheen re-assessment to determine the effectiveness of the tactic employed. This process will be repeated until a sheen score of 0 or 1 is achieved in that area. When the stakeholder group has determined that only no sheen or light sheen (0 or 1 score) conditions remain, the initial tactical objective will be considered to have been met and the tactic is considered effective. Teams will employ an iterative approach to addressing sheen scores of 2s and 3s in Leslie and Sulphur Run which includes assessment of each area and re-assessment after tactics are employed. During this process, tactics may change and new tactics not previously employed may be developed. Adjustments to tactics resulting from initial mitigation efforts in Sulphur Run are described in Attachment F.

### 3.1.1 Sulphur Run

- Perform sediment mitigation using tactics in targeted areas with documented sheen scores of 2 and 3 (medium and heavy sheens) and target areas with exceedances of HHSLs in sediment (Figure 20, based on analytical results from the November/December 2023 field work). As shown on Figures 5-10, and 20 there are 14 targeted areas. Selection of tactics to be employed in each targeted area will follow the process discussed above.
    - A field walk was conducted March 11-12, 2024 in Sulphur Run. The field walk was attended by representatives of NSRC, EPA, OEPA and their consultants, as appliable. Observations and proposed mitigation tactics for each mitigation area in Sulphur Run developed during the field walk and subsequent adjustments resulting from SR1 are presented in Attachment G.
- See Figures 5 through 10 for visual detail of the areas for sediment mitigation. Figures 2-4 present data in the upstream portion of the Sulphur Run area (upstream of the railroad crossing) for reference.
- Mitigation in Sulphur Run shall also include sections within Culvert 1 where qualitative assessment sheen scores of 2 and 3 were identified (Arcadis 2023j). The mitigation tactics employed for Culvert 1 will be evaluated by the stakeholder group and determined by the EPA Operations Chief. Refer to Attachment E (subject to separate approval by EPA) for tactical options. Pre-mitigation briefs with the Agencies (EPA

and OEPA) and OSHA will be conducted to discuss and resolve safety concerns relating to culvert work.

- Specific areas within the flow path of oil discharged during the derailment that are known to have confounding sources of contamination will be addressed. These areas include the portion of the creek adjacent to the former Leake Oil gas station (see Figure 5) and areas with an unknown black product/liquid unrelated to the derailment that surfaced during air knifing activities in March 2023 (see Figure 7).

### 3.1.2 Leslie Run

- Based on a review of information collected during the November/December Qualitative Sheen Assessment, the locations in Leslie Run with heavy sheens appear to be directly related to creek features that may be trapping / retaining the sheens, such as large rocks, log jams, or downed trees. The sediment mitigation efforts are designed to address these obstructions to eliminate sheens, while keeping the actions focused to reduce impacts to the creek habitat and ecosystem, which have already shown signs of significant ecological recovery. Tactics to be employed in each targeted area will follow the stakeholder assessment process discussed above in Section 3.1.
- Target areas include those identified to contain sheen scores of 2 and 3 (medium and heavy sheens) and target areas with exceedances of HHSLs in sediment (Figure 21, based on analytical results from the November/December 2023 field work).
- See Figures 11-16 for visual detail of the 31 areas identified for stream mitigation in Leslie Run. Figures 17-19 present data for the remainder of the Leslie Run Area for reference.

### 3.1.3 Iterative Mitigation Cycle

Mitigation will be an iterative process until the initial tactical objective is attained. After tactics are completed for a designated area, crews will wait at least 12 hours to allow the targeted area to recover to a normal state (reduction in turbidity, etc.), after which sediment agitation efforts (following qualitative re-assessment procedures) will be employed to determine the observed level of sheen score for the area and assess the effectiveness of the cleanup. If the stakeholder group determines that a sheen score of 0 (none) or 1 (light) is present, then the targeted area will be considered as having achieved the initial tactical objective. Assessment crews will agitate throughout the targeted area for assessment, including the specific location which scored as a 2 or 3 during the November 2023 Qualitative Assessment. The observations of sheen related to achieving initial tactical objectives for sediment mitigation will be documented on a field log form. Note that sediment mitigation crews may encounter conditions different from those observed during the November 2023 stream assessment. In Sulphur Run and Leslie Run, if crews are unable to generate medium or heavy sheens at the targeted areas, this condition will be documented. Crews will then step out up to 25 feet upstream and downstream to check for medium or heavy sheens. Conditions will be documented. If no medium or heavy sheens are observed, conditions will be documented, and the target area left at least 12 hours. When crews return, if they are still unable to generate medium or heavy sheens at the targeted areas, this condition will be documented and sediment mitigation in that particular area will not be performed. This decision (as relevant) on the second visit will be confirmed in the field with Agencies' representatives.

### 3.1.4 Containment

During sediment mitigation activities at each targeted area, necessary containment and recovery controls will be employed. These containment and recovery controls shall be specified and implemented for each mitigation tactic in Attachment A which is employed. Refer to Attachment A for an array of containment and recovery controls. Additional requirements for containment are described in Attachment F.

### 3.1.5 Safety

All work will be completed in accordance with the approved Health and Safety Plan for the site (Arcadis 2023k) and the existing Job Hazard Analysis (JHA) developed for stream washing (HEPACO 2023). This JHA will be reviewed and updated prior to the start of work, as specific measures will need to be included to address the hazards associated with working in cold conditions. If, during this review or when tactics are determined, new tasks requiring JHAs are identified, relevant JHAs will be developed for review after a safety assessment and prior to implementing those work activities.

Worker air sampling will be performed during stream washing using personal air sampling badges for butyl acrylate and vinyl chloride, as well as real-time monitoring for VOC. In the community, handheld air monitoring will be conducted for total VOCs during stream washing activities. Additionally, air sampling will be performed at four to six locations in the community immediately surrounding the work area using co-located evacuated canisters and badges, which provide data on a panel of 75 VOCs, including vinyl chloride and butyl acrylate. Air sampling methods that will be used for air sampling and their associated detection limits are listed in Table 3.5 of the Air Sampling and Analysis Plan (CTEH 2023). For consistency with the air monitoring work completed during the actions taken in the culverts on Sulphur Run, the team will follow the relevant elements of the Decision Tree for Ongoing Operations During Culvert Work (Attachment B).

## 3.2 Re-Assessments

### 3.2.1 Qualitative Sheen Re-Assessment

An initial comprehensive qualitative sheen re-assessment will be performed following completion of the sediment mitigation efforts outlined in Section 3.1. Iterations of re-assessment at quarterly frequencies or other frequencies determined by the Agencies for final natural attenuation monitoring will continue until EPA has determined that all mitigation endpoints have been successfully achieved.

The qualitative re-assessment of sheens will be conducted in the following areas:

- In Sulphur Run from its confluence with Leslie Run to 1,000 feet upstream beyond the confluence with the Unnamed Tributary of Sulphur Run (located just north of the railroad tracks), which is commonly called the North Ditch (see Figure 5 for the upstream demarcation).
- In Leslie Run from its confluence with Bull Run to 1,000 feet upstream beyond the confluence with Sulphur Run (see Figure 16 for the downstream demarcation / start of the qualitative re-assessment).

Work will be carried out using methods consistent with previous surveys conducted in these streams in March, May, and November 2023. The field team will walk the length of the stream channel identified for each waterbody and record observations at a frequency of every 25 feet. All work will be completed in accordance with the relevant EPA-approved work plan and quality assurance project plan (EnviroScience 2023a), and all observation logs and associated documentation will be provided to EPA consistent with Section 3.4.

### 3.2.2 Surface Water, Sediment, and Biologic Sampling

Surface water sampling will be conducted at the locations listed in Attachment C, which also shows endpoint criteria. Surface water samples will be collected after the qualitative sheen re-assessments described above in Section 3.2. Sediment samples will be collected at all locations sampled in November/December 2023 (Arcadis 2024, Figures 2-19) for the parameters in Table 1 and after tactics are complete, concurrent with surface water samples. The need for additional biocriteria monitoring by NSRC in Leslie Run will be determined by the Agencies following review of post-derailment biomonitoring. Surface water, sediment, and biologic sampling will be conducted consistent with the existing and/or updated technical procedures and quality assurance project plan(s) for the site.

## 3.3 End Points

Removal work will be deemed complete when three field conditions are met: (1) no sheen is observed by NRSC field crews and Agencies' representatives in Sulphur Run and Leslie Run, (2) attainment of surface water quality criteria for the designated use as promulgated by OEPA; and (3) when exceedances of human health screening levels for oil and CWA hazardous substances discharged by NSRC have been mitigated such that the contamination no longer presents a substantial threat to public health and welfare.

Refer to Attachment C for surface water criteria. Results (scores) of the Qualitative Sheen Re-Assessment (Section 3.2.1) will determine if the criterion for sheen is met. Refer to Table 1 for human health screening levels.

Attachment D, which is under development and subject to separate approval by EPA, will include an evidence-based, literature-referenced discussion of natural breakdown processes of petroleum lube oil, petro oil NEC, and constituents in the environment. The discussion will be related to the conditions in Sulphur and Leslie Run and is necessary for any potential consideration of natural attenuation as a final mitigation tactic to meet sheen removal endpoints.

For areas with confounding sources of contamination, endpoints will be achieved when efforts have been made including consideration of aggressive tactics, implementation of engineering controls designed and installed to prevent recontamination to the extent practical, and the number of iterations performed (remove-assess-remove-reassess) to achieve the initial tactical objective equals the maximum performed in any other area of the creeks.

Following mitigation at any given targeted location, the stakeholder group will return no earlier than 12 hours later to assess the location and determine whether the initial tactical objective has been achieved (see Section 3.1). Mitigation will continue at that location until it is achieved. After mitigation tactics are complete in Sulphur Run and Leslie Run, the re-assessments described above in Section 3.2 will be conducted to determine if end points described in this section have been reached. If they have not, additional mitigation will be planned and conducted.

## 3.4 Data Submittal

The field teams will document qualitative findings, photographs, and agreements reached in the field. Relevant field data (e.g., qualitative sheen values, coordinates, field observations, sample descriptions, photographs, etc.) will be provided to EPA via the existing EPTD ArcGIS Online (AGO) shared account and NS SharePoint file sharing service, unless an alternate solution is approved by EPA.

### 3.4.1 Qualitative Data

NS will collect data, review to assure accuracy and transmit data to EPA using AGO and SharePoint under the following timelines:

- Qualitative field data (Location IDs; dates/times; coordinates; other observation or information as relevant, like sheen scores) shall be provided via GIS Service to AGO no later than 48 hours following collection of the information.
- Summaries (e.g., tables) of qualitative data shall be uploaded to NS SharePoint and emailed no later than 48 hours following collection of the information.

For collection of any samples for laboratory analysis, those data will be transmitted as follows.

### 3.4.2 Analytical Data

NS will collect field samples for laboratory analysis and transmit to EPA consistent with existing EPTD data transmission methods:

- Sample Location data
  - Via AGO shared Group - Sample Name, Location name, date, time, and coordinates shall be shared with EPA via existing EPTD AGO group no later than 48 hours from collection.
  - Via analytical data electronic data deliverables (EDD) - Sample coordinates shall be provided with all finalized analytical data EDDs.
- Preliminary analytical data
  - Shall be transmitted to EPA within 24 hours of receipt from the laboratory.
  - Data format shall be consistent with the EPTD electronic data deliverable format emailed to R5_data@epa.gov, R5_ENVL@epa.gov, and others per the relevant directive.
- Final data to EPA EQUIS
  - Final data shall be uploaded to EPA's EPTD EQUIS project within 24 hours.
  - Data format shall be consistent with the EPTD EQUIS format already in-use.
- NS SCRIBE
  - Analytical data shall be uploaded to EPA SCRIBE.net within 24 hours, consistent with existing EPTD procedures.

### 3.4.3 Reporting

NSRC will submit a report within 30 days from completion of the re-assessments discussed in Section 3.2. The report will at minimum summarize mitigation tactics employed for target areas including Culvert 1, validated analytical data, and qualitative data. Qualitative sheen assessment results collected over time will be overlain on a map of the creeks to graphically illustrate changes in sheen scores over time (i.e., March, May, and November events). All sediment data will be compared to HHSLs to determine if exceedances of these screening levels have been mitigated. If applicable, the report will also delineate areas where natural attenuation is proposed as a final mitigation tactic to meet sheen removal endpoints. Following the final re-assessments (Section 3.2), NSRC will submit a comprehensive report consistent with Paragraph 64 of the CWA 311 Order within 60 days after completing all mitigation and sampling required under this plan.

# 4 Schedule

Mitigation and qualitative stream re-assessments are expected to be completed by June 30, 2024. Work, beginning with the supporting activities described below, will start upon EPA approval of this Plan and EPA's explicit direction to proceed.

The timing and duration of supporting activities and mitigation work is as follows:

- **Tactics Selection for Target Areas and Safety Review by Stakeholders.** Refer to Section 3.1. This effort is anticipated to take 1-2 weeks.
- **Secure Access Agreements, Complete Health and Safety Reviews, Confirm Logistical Arrangements.** Access to adjacent properties will be required to complete the mitigation measures. Access agreements were in place with property owners for the November/December 2023 sampling, and these agreements will be reviewed and extended if needed. In addition, this time will be used to confirm locations for secondary containment and vacuum/suction collection equipment, and review/update the stream washing health and safety JHA. This effort is anticipated to take 1-2 weeks.
- **Conduct Sediment Mitigation in Sulphur Run.** It is anticipated that the sediment mitigation in Sulphur Run will take a total of 3-4 weeks to complete. The start date for sediment mitigation will be provided to EPA after required property access is confirmed, logistical details are finalized, and health and safety planning is complete and approved, but will not begin later than April 1, 2024.
- **Conduct Sediment Mitigation Work in Leslie Run.** After the stream mitigation efforts in Sulphur Run are complete, work in Leslie Run will begin. The targeted stream mitigation in Leslie Run is expected to take 2-3 weeks to complete. Mitigation completion is targeted for June 30, 2024.
- **Conduct Re-Assessment in Sulphur Run and Leslie Run.** After the sediment mitigation efforts in Sulphur Run and Leslie Run are complete, NSRC will coordinate with EPA to determine a start date for the qualitative stream assessment and sampling. The timing of the qualitative stream assessment is dependent on conditions in the field – specifically, the creeks must be at base flow levels. The re-assessment is estimated to take about 2 weeks to complete. Re-assessment will also include surface water sampling at locations listed in Attachment C and sediment sampling at locations sampled in November/December 2023, is expected to take 2-3 weeks to complete.
- **Review and Share Results.** Qualitative sheen re-assessment results will be collected on an ongoing basis and overlain on a map of the creeks to graphically illustrate changes in sheen scores over time (i.e., March 2023, May 2023, November 2023, and Spring 2024 events). Quantitative data will be shared as described in Section 3.4. Note that NSRC will communicate routinely with EPA regarding mitigation measures progress, data evaluation status and findings, and any potential additional measures that may be needed throughout implementation of this Plan.

# 5 References

Arcadis. 2023a. Appendix D – Main Line Interim Soil Removal Plan. Rev. 4.2, May 16.

Arcadis. 2023b. Sediment Sampling Work Plan. February 21. Plan included in Appendix H of the March 2023 Removal Work Plan.

Arcadis. 2023c. East Palestine Trail Derailment Site Sediment Quality Assurance Project Plan. Rev 4. July 21.

Arcadis. 2023d. Appendix H1 – Sulphur Run Characterization Work Plan. Rev 2. July 11.

Arcadis. 2023e. East Palestine Trail Derailment Site Sediment Quality Assurance Project Plan – Appendix H2. Rev 3. August 8.

Arcadis. 2023f. Appendix H2 – Leslie Run and Downstream Creeks Characterization Work Plan. Rev 2. July 31.

Arcadis. 2023g. Comprehensive Sheen and Sediment Investigation Work Plan Quality Assurance Project Plan. Rev 2. November.

Arcadis. 2023h. Sediment Investigation Summary Report. December 8.

Arcadis. 2023i. Sulphur Run Culvert Sediment Removal Plan. November 8.

Arcadis. 2023j. Culvert Sediment Removal Report. December 21.

Arcadis. 2023k. East Palestine Train Derailment Site Health and Safety Plan. Rev 3.2. July 23.

Arcadis. 2024. Comprehensive Sheen and Sediment Investigation Report – Sulphur Run and Leslie Run. January 19.

Arcadis and Environmental Standards, Inc. 2024a. Comprehensive Sheen and Sediment Investigation Work Plan – Sulphur Run and Leslie Run. Addendum No. 1. Rev 1. January 19.

Arcadis and Environmental Standards, Inc. 2024b. Comprehensive Sheen and Sediment Investigation Work Plan Quality Assurance Project Plan. Addendum No. 1. Rev 1. January 19.

Arcadis and EnviroScience. 2023. Comprehensive Sheen and Sediment Investigation Work Plan – Sulphur Run and Leslie Run. Rev 2. November 3.

CTEH. 2023. CTEH Air Sampling and Analysis Plan. Rev 3.1. October 18.

CTEH. 2023b. CTEH Surface Water Sampling and Analysis Plan. Rev.4.3 June 28.

EnviroScience. 2023a. East Palestine, Ohio – Qualitative Stream Sediment Assessment Sampling and Analysis Plan and Quality Assurance Project Plan. March 15.

EnviroScience. 2023b. Qualitative Sheen Assessment Summary Report. December 11.

EnviroScience. 2023c. Aquatic Biocriteria Plan of East Palestine Streams: Sulphur Run, Leslie Run, Bull Creek, North Fork Little Beaver Creek, and Little Beaver Creek 2023

EnviroScience. 2023d. Native Mussel Resources Assessment Workplan for the Little Beaver Creek Watershed of Ohio and Pennsylvania

EnviroScience. 2023e. East Palestine, Ohio – Leslie Run & Sulphur Run Operating Tactic. Version 2.0. July 6.

HEPACO. 2023. Job Hazard Analysis: Creek Washing – Using Trash Pump and Adjustable Spray Nozzle. May.

Ohio EPA. 2023. Water Quality in Leslie Run and Sulphur Run. Ohio Environmental Protection Agency, Division of Surface Water, October 2023. Accessed online at https://epa.ohio.gov/static/Portals/47/citizen/StreamUpdate.pdf

EPA. 2018. Region 4 Ecological Risk Assessment Supplemental Guidance. Interim Drhttps://www.epa.gov/sites/default/files/201803/documents/era_regional_supplemental_guidance_report - march-2018_update.pdfaft. March.

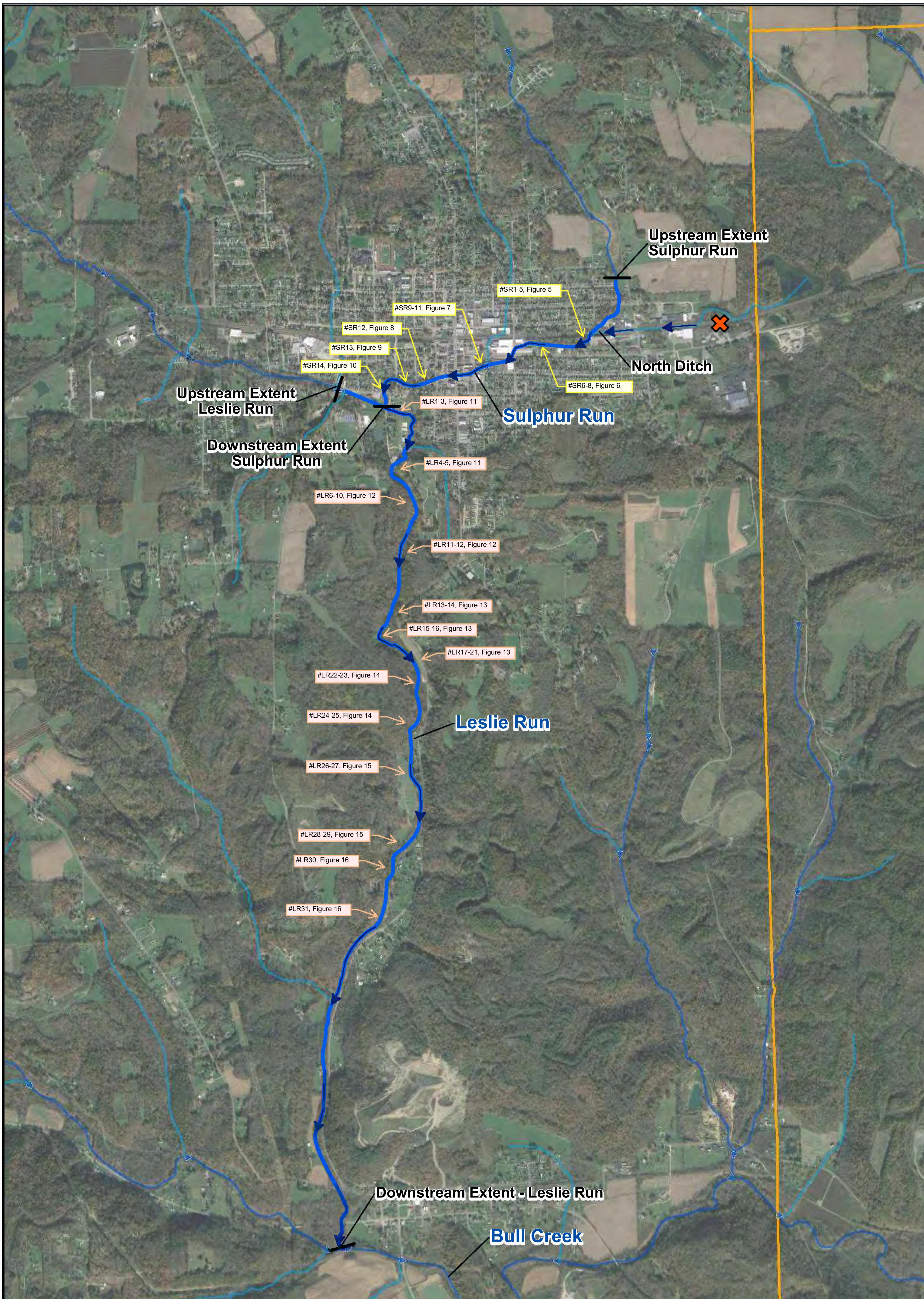
# Tables

**Table 1: Analyte List and Screening Levels**
**Sediment Mitigation Measures Work Plan**
**East Palestine Train Derailment Site, East Palestine, Ohio**

| Analytes[1] | CAS# | Screening Levels[2] | | |
|---|---|---|---|---|
| | | Units | Ecological (ESL) | Human Health (HHSL) |
| **Appendix D** | | | | |
| 2-Butoxyethanol | 111-76-2 | mg/kg | 0.765 | 7660 |
| 2-Ethylhexyl acrylate | 103-11-7 | mg/kg | 0.053 | 3.9 |
| Benzene | 71-43-2 | mg/kg | 0.01 | 76.6 |
| Diethylene glycol | 111-46-6 | mg/kg | -- | -- |
| Ethylene glycol | 107-21-1 | mg/kg | 42.389 | 61300 |
| Vinyl chloride | 75-01-4 | mg/kg | 0.14 | 0.111 |
| n-Butyl acrylate | 141-32-2 | mg/kg | 0.159 | 4.4 |
| **PAHs** | | | | |
| 1-Methylnaphthalene | 90-12-0 | mg/kg | 0.141 | 199 |
| 2-Methylnaphthalene | 91-57-6 | mg/kg | 0.0202 | 278 |
| Acenaphthene | 83-32-9 | mg/kg | 0.0067 | 4160 |
| Acenaphthylene | 208-96-8 | mg/kg | 0.00587 | 4160 |
| Anthracene | 120-12-7 | mg/kg | 0.027 | 20800 |
| Benzo[a]anthracene | 56-55-3 | mg/kg | 0.0317 | 23.2 |
| Benzo[a]pyrene | 50-32-8 | mg/kg | 0.0319 | 2.33 |
| Benzo[b]fluoranthene | 205-99-2 | mg/kg | 0.0272 | 23.3 |
| Benzo[g,h,i]perylene | 191-24-2 | mg/kg | 0.17 | 2080 |
| Benzo[k]fluoranthene | 207-08-9 | mg/kg | 0.0272 | 233 |
| Chrysene | 218-01-9 | mg/kg | 0.0571 | 2330 |
| Fluoranthene | 206-44-0 | mg/kg | 0.06423 | 2780 |
| Fluorene | 86-73-7 | mg/kg | 0.019 | 2780 |
| Indeno[1,2,3-cd]pyrene | 193-39-5 | mg/kg | 0.017 | 23.3 |
| Naphthalene | 91-20-3 | mg/kg | 0.03275 | 42 |
| Phenanthrene | 85-01-8 | mg/kg | 0.0419 | -- |
| Pyrene | 129-00-0 | mg/kg | 0.053 | 2080 |
| **SVOCs** | | | | |
| 2,4-Dinitrophenol | 51-28-5 | mg/kg | 0.223 | 153 |
| 2,6-Dinitrotoluene | 606-20-2 | mg/kg | 0.296 | 4.45 |
| 2-Nitrophenoll | 88-75-5 | mg/kg | 0.168 | -- |
| 4,6-Dinitro-2-methylphenol | 534-52-1 | mg/kg | 1.477 | 6.13 |
| 4-Nitrophenol | 100-02-7 | mg/kg | 0.153 | -- |
| Benzoic acid | 65-85-0 | mg/kg | 0.019 | 306000 |
| Benzyl alcohol | 100-51-6 | mg/kg | 0.0037 | 7660 |
| Isophorone | 78-59-1 | mg/kg | 0.876 | 6990 |
| Nitrobenzene | 98-95-3 | mg/kg | 0.407 | 225 |
| Phenol | 108-95-2 | mg/kg | 0.175 | 23000 |
| m & p-Cresol | 106-44-5 | mg/kg | 0.26 | 1530 |
| **VOCs** | | | | |
| 1,2,4-Trimethylbenzene | 95-63-6 | mg/kg | 0.097 | 905 |
| 2-Butanone | 78-93-3 | mg/kg | 7.604 | 61800 |
| 2-Hexanone | 591-78-6 | mg/kg | 0.045 | 498 |
| 4-Methyl-2-pentanone | 108-10-1 | mg/kg | 0.073 | 267000 |
| Acetone | 67-64-1 | mg/kg | 0.065 | 105000 |
| Carbon disulfide | 75-15-0 | mg/kg | 0.0078 | 4340 |
| Ethylbenzene | 100-41-4 | mg/kg | 0.175 | 383 |
| Methyl acrylate | 96-33-3 | mg/kg | 0.003 | 1170 |
| Styrene | 100-42-5 | mg/kg | 0.126 | 18000 |
| Toluene | 108-88-3 | mg/kg | 0.01 | 8900 |
| m&p-Xylene | 179601-23-1 | mg/kg | 0.0046 | 3850 |
| o-Xylene | 95-47-6 | mg/kg | 0.103 | 4410 |

Notes:
1. Listed analytes identify the chemicals of potential concern (COPCs). The COPCs are categorized by Soil Removal Plan Appendix analytes (Arcadis 2023h), polycyclic aromatic hydrocarbons (PAHs), semi-volatile organic compounds (SVOCs), and volatile organic compounds (VOCs). The SVOC category includes only non-PAH SVOCs.
2. Ecological screening levels (ESLs) and human health screening levels (HHSL) are provided for each COPC in milligrams per kilogram (mg/kg) as applicable (-- indicates not available).

# Figures




Legend

Incident Location

Ohio/Pennsylvania State Line

Investigation Extent

Flow Path from Derailment

NHD Flowlines

Other Creek/Run Channels/Unnamed Tributaries

Sediment Mitigation Area

Sulphur Run

Leslie Run

Map Date: 10/30/2023

Service Layer Credits:

0 0.5

Miles

NORFOLK SOUTHERN
EAST PALESTINE, OHIO

CREEK FLOW PATH AND
SEDIMENT MITIGATION AREAS

ARCADIS

FIGURE

1

Document Path: T:_ENV\NorfolkSouthern\EastPalestine_Feb5_2023\MXD\SedimentSampling\Report Figures\Figure 1-1_Investigation Extent.mxd


Sheen Results
Pie Quadrants

Appendix D, SVOC, PAH, VOC

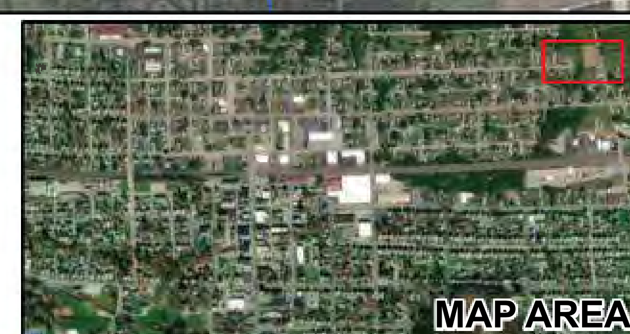
No

Yes

One or more of the analytes in the four COPC groups were detected

November 2023 Qualitative Sheen Observations

- Score 0
- Score 1
- Score 2
- Score 3




Map Date: 1/19/2024

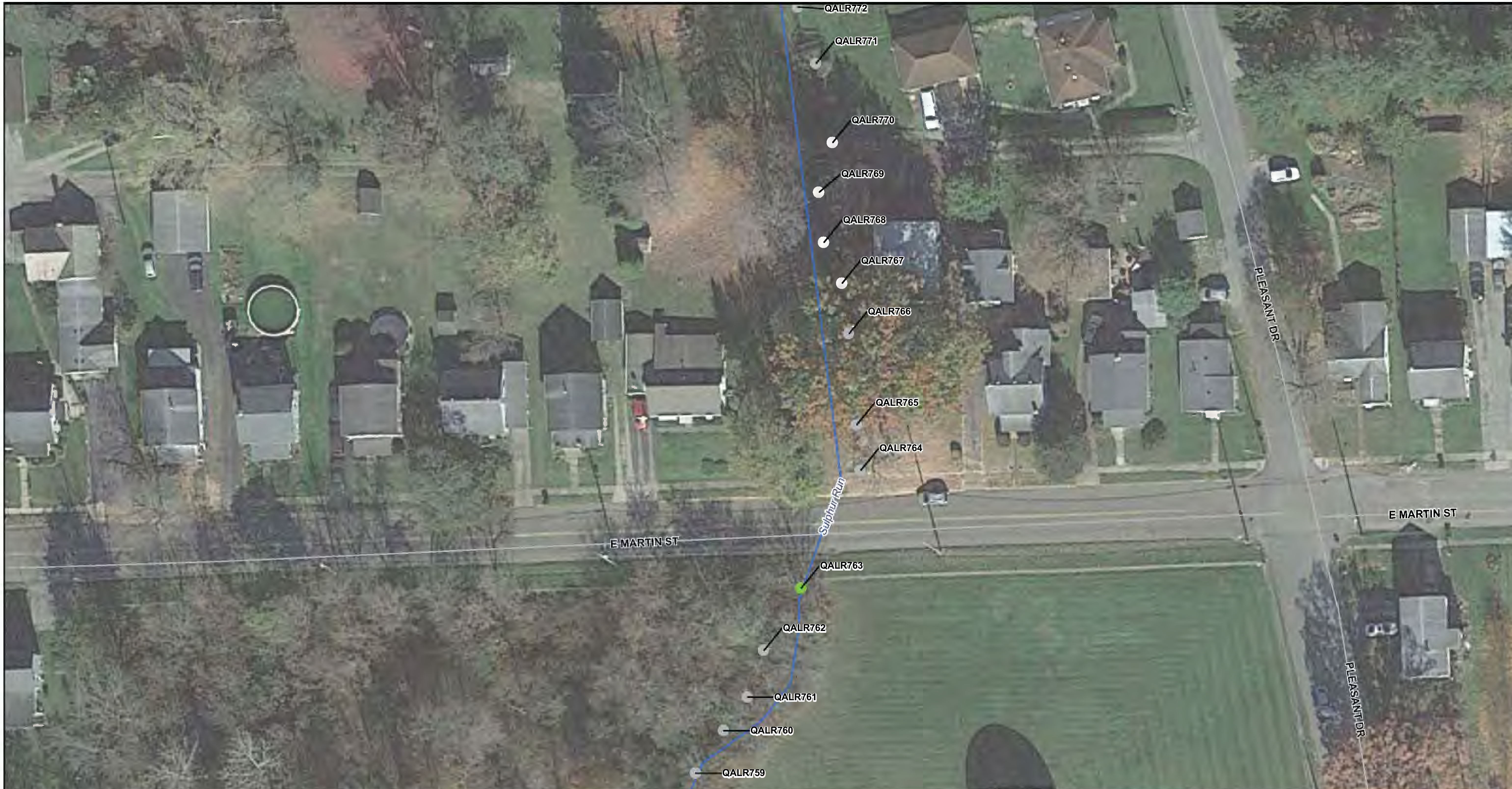
0 40 80
Feet

NORFOLK SOUTHERN
EAST PALESTINE, OHIO

**SULPHUR RUN - DETAIL 1**

ARCADIS

FIGURE
2




Sheen Results
Pie Quadrants

Appendix D / SVOC / PAH / VOC

No
Yes
One or more of the analytes in the four COPC groups were detected

November 2023 Qualitative Sheen Observations
- Score 0
- Score 1
- Score 2
- Score 3


Map Date: 1/19/2024

0 40 80
Feet

NORFOLK SOUTHERN
EAST PALESTINE, OHIO

**SULPHUR RUN - DETAIL 2**

ARCADIS

FIGURE
3


Sheen Results
Pie Quadrants

Appendix D — SVOC
PAH — VOC

No
Yes

One or more of the analytes in the four COPC groups were detected

November 2023 Qualitative Sheen Observations

- Score 0
- Score 1
- Score 2
- Score 3


Map Date: 1/19/2024

0 40 80
Feet

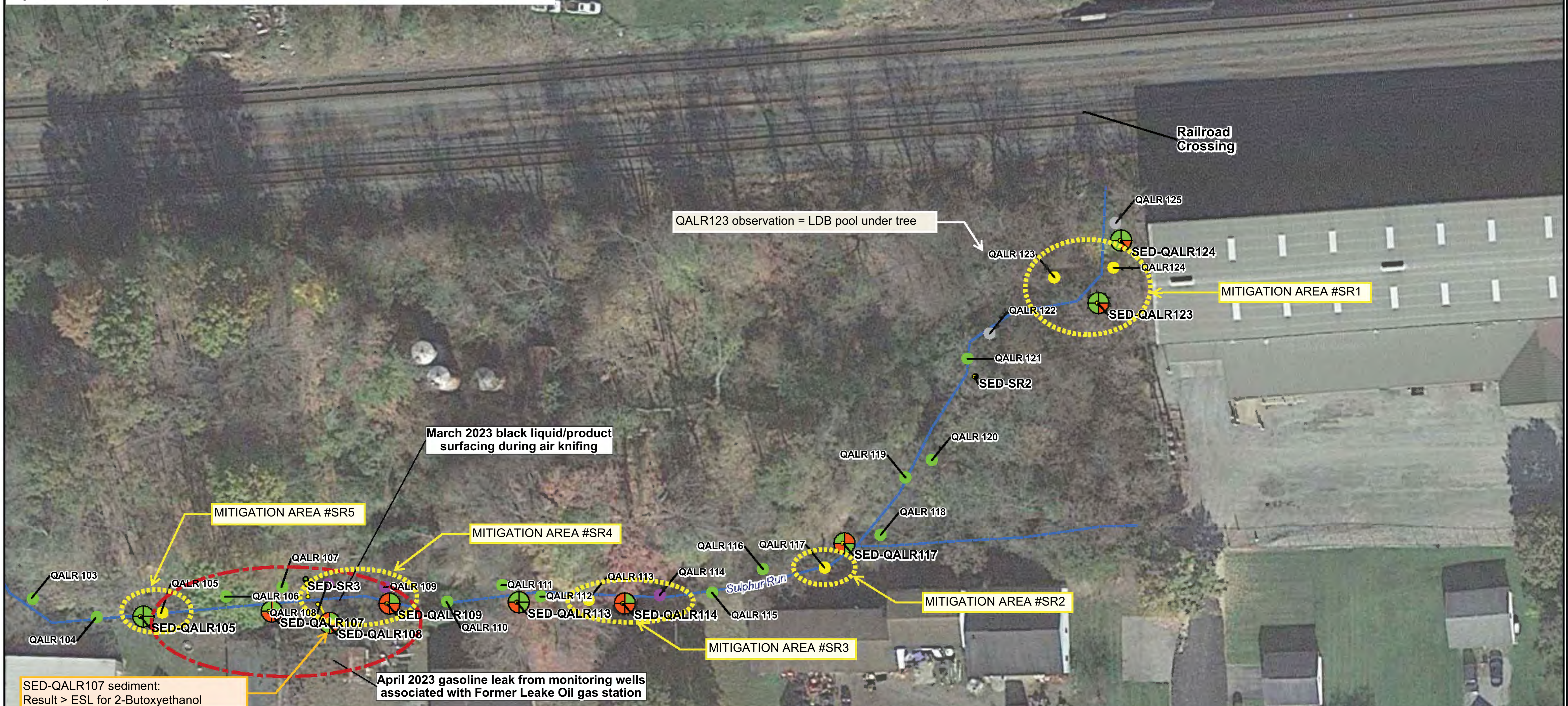
NORFOLK SOUTHERN
EAST PALESTINE, OHIO

**SULPHUR RUN - DETAIL 3**

ARCADIS

FIGURE
4

Notes:
1. Targeted locations for stream mitigation identified with dashed yellow lines, additional details provided in yellow text boxes.
2. Information on legacy sources to the creek provided in white text boxes with approximate creek area identified with dark red dashed lines.
3. Context from November/December 2023 qualitative stream (sheen) assessment that informs targeted locations provided in tan text boxes.




Sheen Results
Pie Quadrants

PIE QUADRANTS

Appendix D | SVOC
PAH | VOC

No
Yes
—One or more of the analytes in the four COPC groups were detected

November 2023 Qualitative Sheen Observations
- Score 0
- Score 1
- Score 2
- Score 3


Map Date: 1/19/2024

0 40 80
Feet

N

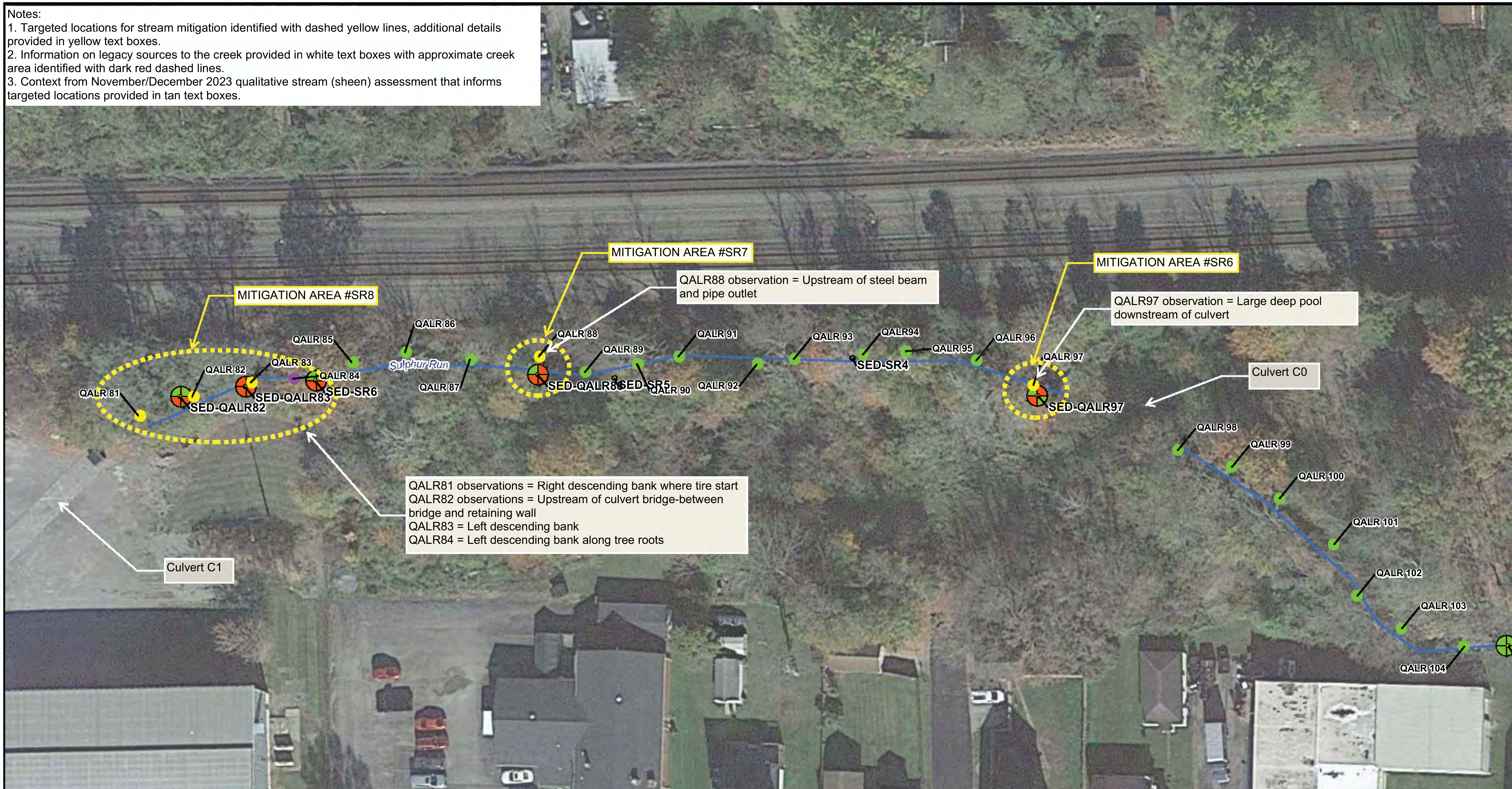
NORFOLK SOUTHERN
EAST PALESTINE, OHIO

**SULPHUR RUN - DETAIL 4**

ARCADIS

FIGURE
5

Notes:
1. Targeted locations for stream mitigation identified with dashed yellow lines, additional details provided in yellow text boxes.
2. Information on legacy sources to the creek provided in white text boxes with approximate creek area identified with dark red dashed lines.
3. Context from November/December 2023 qualitative stream (sheen) assessment that informs targeted locations provided in tan text boxes.




Sheen Results
Pie Quadrants

Appendix D | SVOC
PAH | VOC

No
Yes

November 2023 Qualitative Sheen Observations
- Score 0
- Score 1
- Score 2
- Score 3

One or more of the analytes in the four COPC groups were detected


Map Date: 1/19/2024

N

0 40 80
Feet

NORFOLK SOUTHERN
EAST PALESTINE, OHIO

**SULPHUR RUN - DETAIL 5**

ARCADIS

FIGURE
6

Document Path: T:_ENV\NorfolkSouthern\EastPalestine_Feb5_2023\MXD\SedimentSampling\Report Figures\App_H_Report\Corridor_Scores\Corridor_Scores_Detections\Corridor_Scores_Detections.aprx

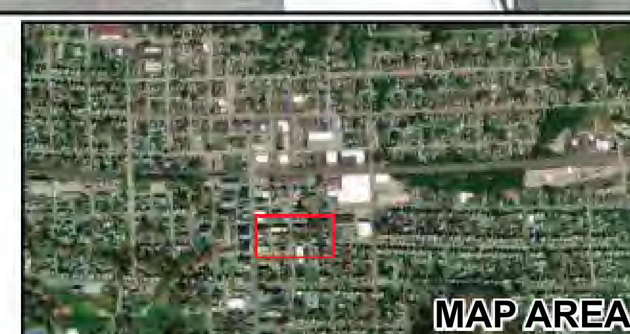
Notes:
1. Targeted locations for stream mitigation identified with dashed yellow lines, additional details provided in yellow text boxes.
2. Information on legacy sources to the creek provided in white text boxes with approximate creek area identified with dark red dashed lines.
3. Context from November/December 2023 qualitative stream (sheen) assessment that informs targeted locations provided in tan text boxes.


**Sheen Results**
PIE QUADRANTS
Pie Quadrants

Appendix D | SVOC
PAH | VOC

No
Yes
One or more of the analytes in the four COPC groups were detected

**November 2023 Qualitative Sheen Observations**
- Score 0
- Score 1
- Score 2
- Score 3




Map Date: 1/19/2024

0 40 80
Feet

NORFOLK SOUTHERN
EAST PALESTINE, OHIO

**SULPHUR RUN - DETAIL 6**

ARCADIS

FIGURE
7

Notes:
1. Targeted locations for stream mitigation identified with dashed yellow lines, additional details provided in yellow text boxes.
2. Information on legacy sources to the creek provided in white text boxes with approximate creek area identified with dark red dashed lines.
3. Context from November/December 2023 qualitative stream (sheen) assessment that informs targeted locations provided in tan text boxes.

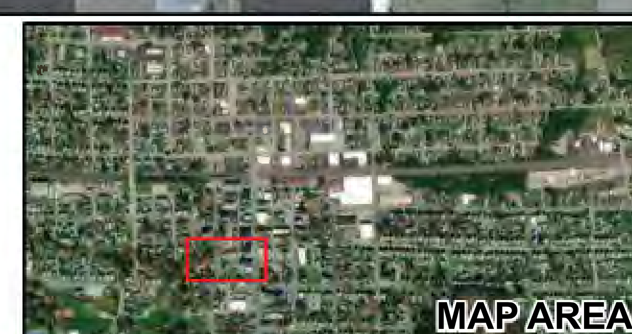

Sheen Results
Pie Quadrants

Appendix D | SVOC
PAH | VOC

No
Yes — One or more of the analytes in the four COPC groups were detected

November 2023 Qualitative Sheen Observations

- Score 0
- Score 1
- Score 2
- Score 3




Map Date: 1/19/2024

N

0 40 80
Feet

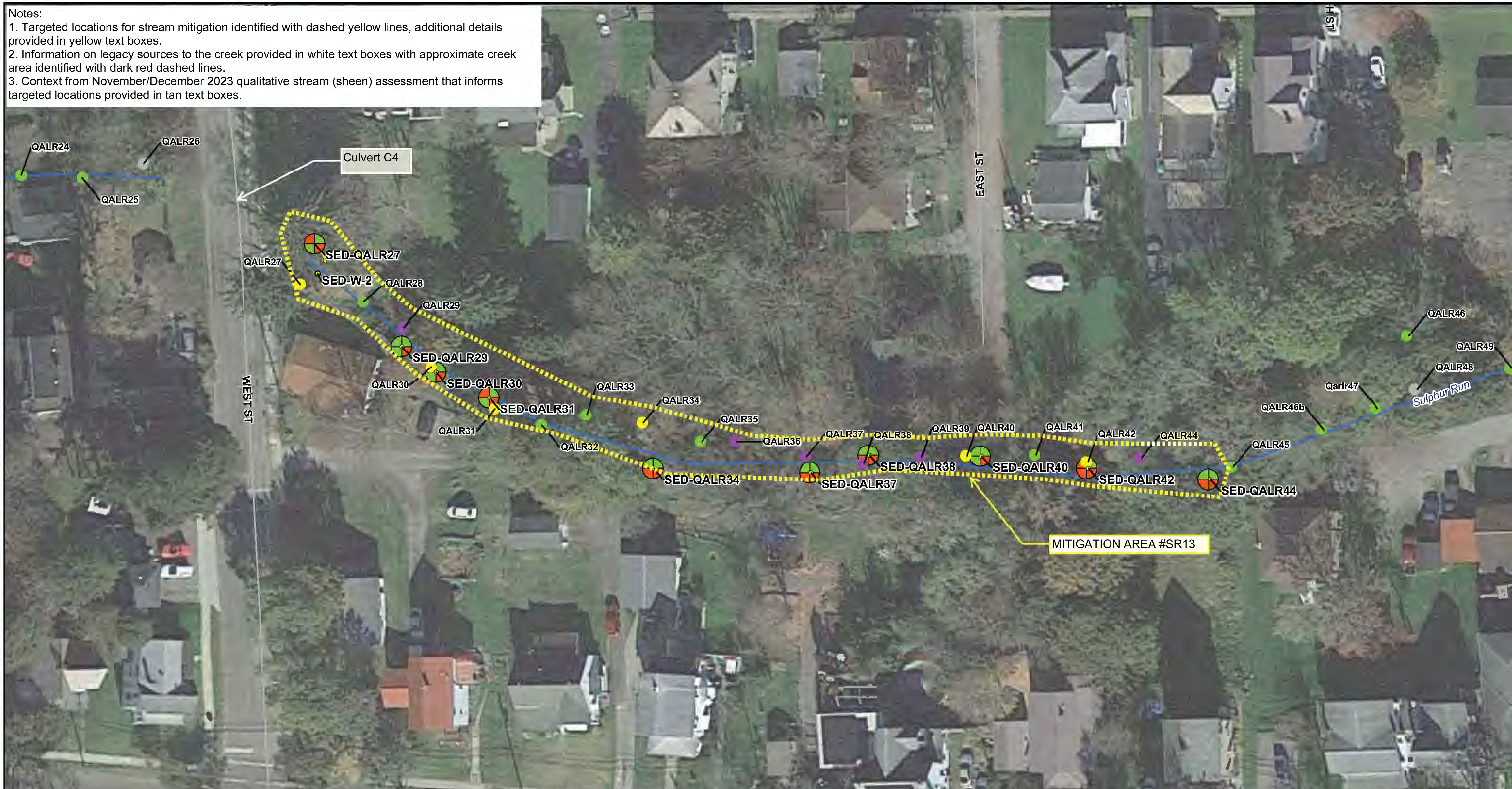
NORFOLK SOUTHERN
EAST PALESTINE, OHIO

**SULPHUR RUN - DETAIL 7**

ARCADIS

FIGURE
8

Notes:
1. Targeted locations for stream mitigation identified with dashed yellow lines, additional details provided in yellow text boxes.
2. Information on legacy sources to the creek provided in white text boxes with approximate creek area identified with dark red dashed lines.
3. Context from November/December 2023 qualitative stream (sheen) assessment that informs targeted locations provided in tan text boxes.




Sheen Results
Pie Quadrants

PIE QUADRANTS

Appendix D | SVOC
PAH | VOC

No
Yes

One or more of the analytes in the four COPC groups were detected

November 2023 Qualitative Sheen Observations
- Score 0
- Score 1
- Score 2
- Score 3


Map Date: 1/19/2024

0 40 80
Feet

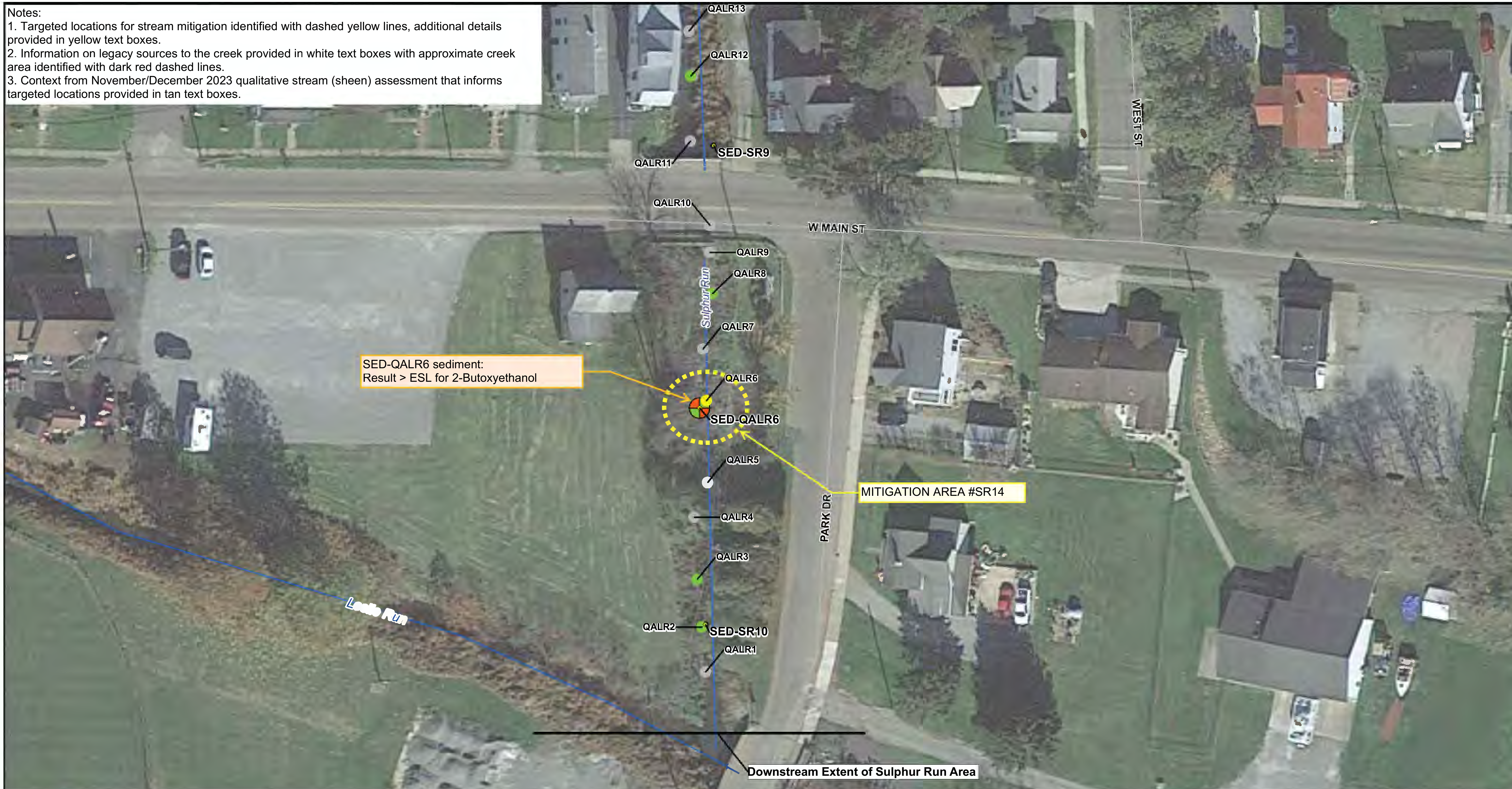
NORFOLK SOUTHERN
EAST PALESTINE, OHIO

**SULPHUR RUN - DETAIL 8**

ARCADIS

FIGURE
9

Notes:
1. Targeted locations for stream mitigation identified with dashed yellow lines, additional details provided in yellow text boxes.
2. Information on legacy sources to the creek provided in white text boxes with approximate creek area identified with dark red dashed lines.
3. Context from November/December 2023 qualitative stream (sheen) assessment that informs targeted locations provided in tan text boxes.




Sheen Results
Pie Quadrants

Appendix D / SVOC / PAH / VOC

No
Yes
One or more of the analytes in the four COPC groups were detected

November 2023 Qualitative Sheen Observations
- Score 0
- Score 1
- Score 2
- Score 3


Map Date: 1/19/2024

0 40 80
Feet

NORFOLK SOUTHERN
EAST PALESTINE, OHIO

**SULPHUR RUN - DETAIL 9**

ARCADIS

FIGURE
10


Notes:
1. Targeted locations for stream mitigation identified with dashed yellow lines, additional details provided in yellow text boxes.
2. Context from November/December 2023 qualitative stream (sheen) assessment that informs targeted locations provided in tan text boxes.

Sheen Results
PIE QUADRANTS
Pie Quadrants

Appendix D | SVOC
PAH | VOC

No
Yes

One or more of the analytes in the four COPC groups were detected

November 2023 Qualitative Sheen Observations
- Score 0
- Score 1
- Score 2
- Score 3

Map Date: 1/19/2024

0 — 250
Feet

NORFOLK SOUTHERN
EAST PALESTINE, OHIO

**LESLIE RUN - DETAIL 1**

ARCADIS

FIGURE
11


Notes:
1. Targeted locations for stream mitigation identified with dashed yellow lines, additional details provided in yellow text boxes.
2. Context from November/December 2023 qualitative stream (sheen) assessment that informs targeted locations provided in tan text boxes.

Sheen Results
PIE QUADRANTS
Pie Quadrants

Appendix D | SVOC
PAH | VOC

No
Yes

One or more of the analytes in the four COPC groups were detected

November 2023 Qualitative Sheen Observations
- Score 0
- Score 1
- Score 2
- Score 3

Map Date: 1/19/2024

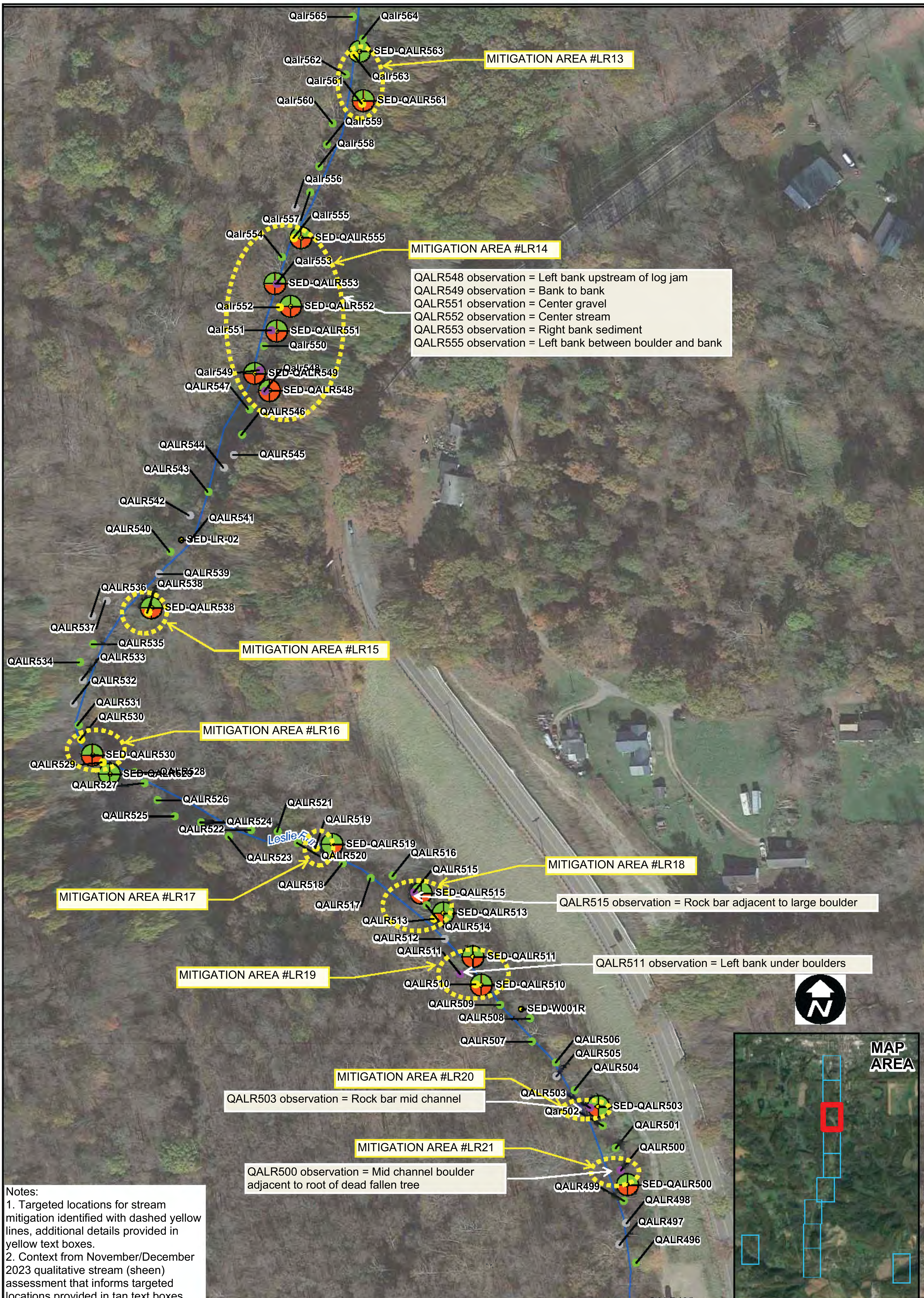
0 250
Feet

NORFOLK SOUTHERN
EAST PALESTINE, OHIO

**LESLIE RUN - DETAIL 2**

ARCADIS

FIGURE
12




Notes:
1. Targeted locations for stream mitigation identified with dashed yellow lines, additional details provided in yellow text boxes.
2. Context from November/December 2023 qualitative stream (sheen) assessment that informs targeted locations provided in tan text boxes.

Sheen Results
PIE QUADRANTS
Pie Quadrants

Appendix D | SVOC
PAH | VOC

No
Yes

One or more of the analytes in the four COPC groups were detected

November 2023 Qualitative Sheen Observations
- Score 0
- Score 1
- Score 2
- Score 3

Map Date: 1/19/2024

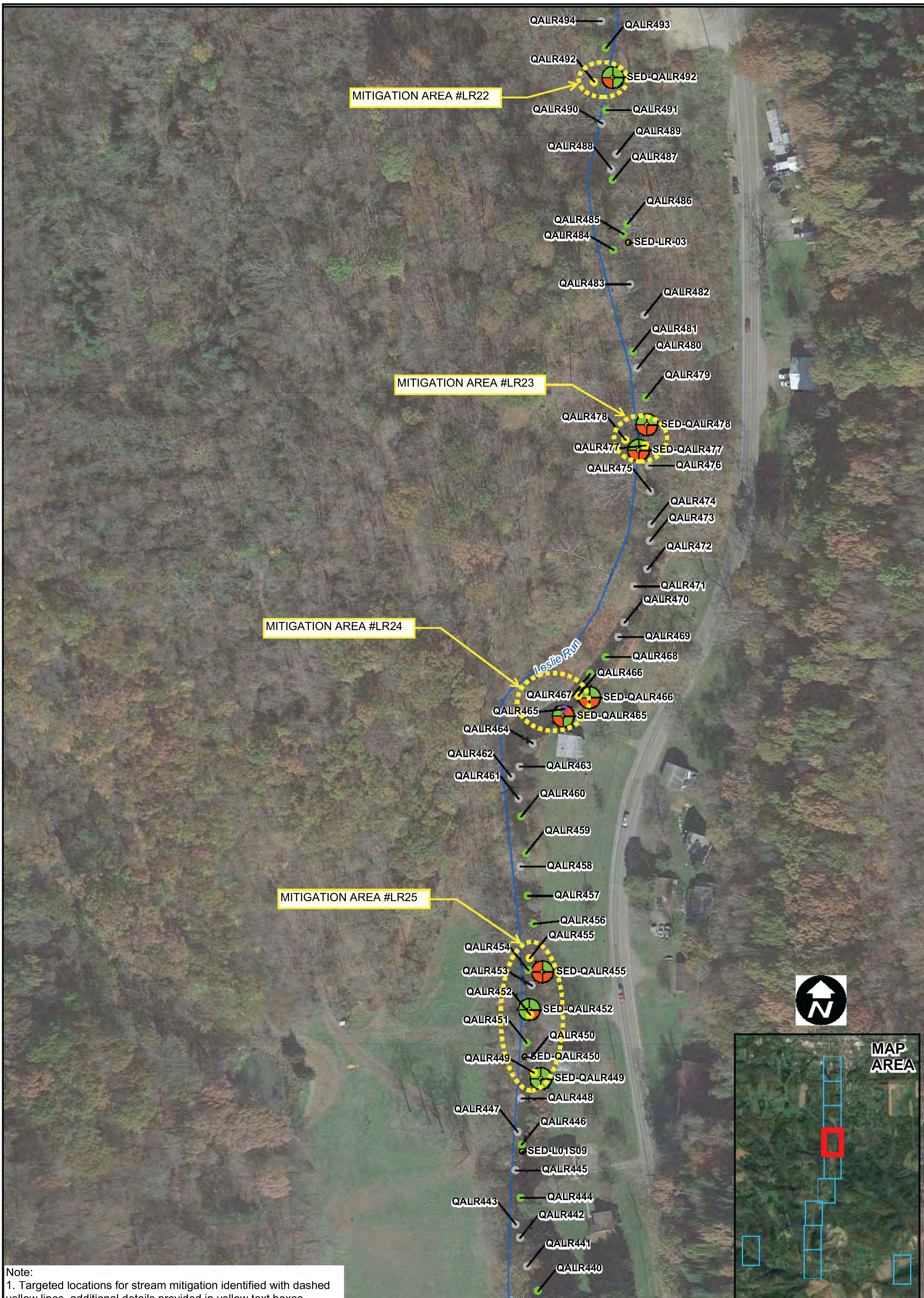
0 — 250 Feet

NORFOLK SOUTHERN
EAST PALESTINE, OHIO

**LESLIE RUN - DETAIL 3**

ARCADIS

FIGURE
13




Note:
1. Targeted locations for stream mitigation identified with dashed yellow lines, additional details provided in yellow text boxes.

Sheen Results
PIE QUADRANTS
Pie Quadrants
Appendix D SVOC
PAH VOC
No
Yes
—One or more of the analytes in the four COPC groups were detected

November 2023 Qualitative Sheen Observations
- Score 0
- Score 1
- Score 2
- Score 3

Map Date: 1/19/2024

0 250
Feet

NORFOLK SOUTHERN
EAST PALESTINE, OHIO

**LESLIE RUN - DETAIL 4**

ARCADIS

FIGURE
**14**


Note:
1. Targeted locations for stream mitigation identified with dashed yellow lines, additional details provided in yellow text boxes.

Sheen Results
PIE QUADRANTS
Pie Quadrants

Appendix D | SVOC
PAH | VOC

No
Yes

One or more of the analytes in the four COPC groups were detected

November 2023 Qualitative Sheen Observations
- Score 0
- Score 1
- Score 2
- Score 3

Map Date: 1/19/2024

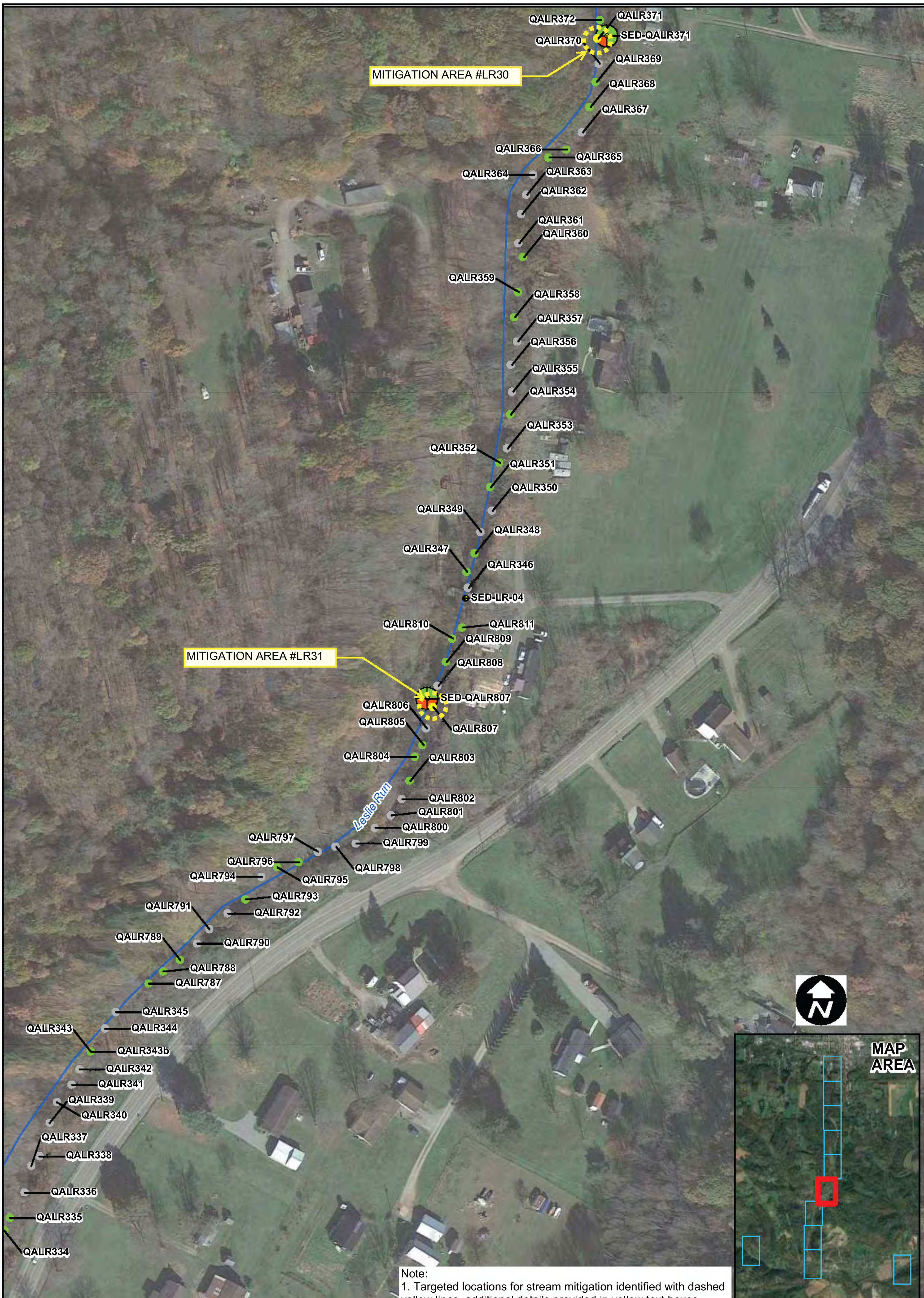
0 250
Feet

NORFOLK SOUTHERN
EAST PALESTINE, OHIO

**LESLIE RUN - DETAIL 5**

ARCADIS

FIGURE
15




Sheen Results
PIE QUADRANTS
Pie Quadrants

Appendix D | SVOC
PAH | VOC

No
Yes
One or more of the analytes in the four COPC groups were detected

November 2023 Qualitative Sheen Observations
- Score 0
- Score 1
- Score 2
- Score 3

**Map Date: 1/19/2024**

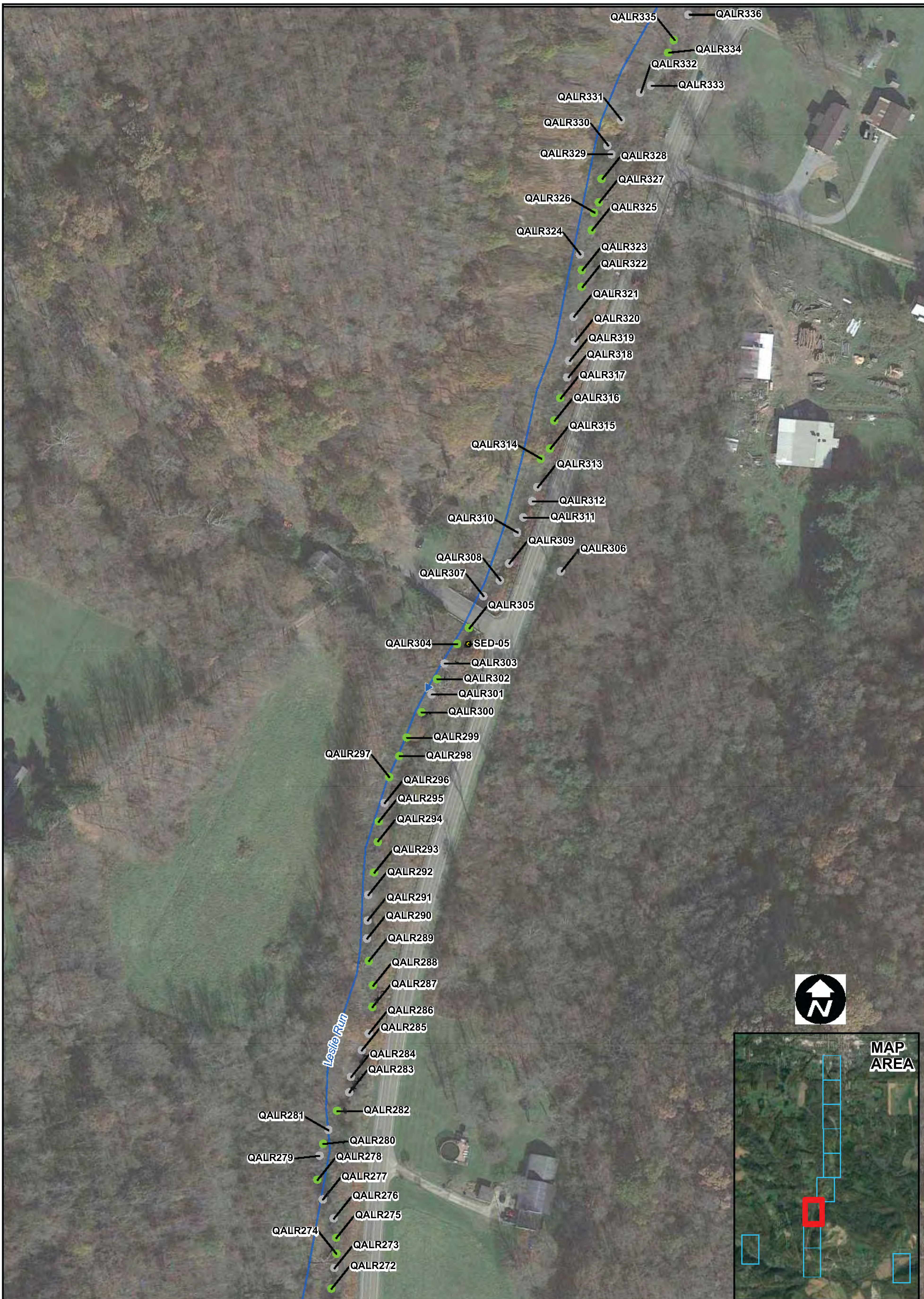
0 250
Feet

NORFOLK SOUTHERN
EAST PALESTINE, OHIO

## LESLIE RUN - DETAIL 6

ARCADIS

FIGURE
16




Sheen Results
PIE QUADRANTS
Pie Quadrants

Appendix D | SVOC
PAH | VOC

No
Yes

One or more of the analytes in the four COPC groups were detected

November 2023 Qualitative Sheen Observations

- Score 0
- Score 1
- Score 2
- Score 3

Map Date: 1/19/2024

0 250
Feet

NORFOLK SOUTHERN
EAST PALESTINE, OHIO

**LESLIE RUN - DETAIL 7**

ARCADIS

FIGURE
17


Sheen Results
PIE QUADRANTS
Pie Quadrants

Appendix D | SVOC
PAH | VOC

No
Yes

One or more of the analytes in the four COPC groups were detected

November 2023 Qualitative Sheen Observations

- Score 0
- Score 1
- Score 2
- Score 3

Map Date: 1/19/2024

0 250
Feet

NORFOLK SOUTHERN
EAST PALESTINE, OHIO

**LESLIE RUN - DETAIL 8**

ARCADIS

FIGURE
18


Sheen Results
PIE QUADRANTS
Pie Quadrants

Appendix D | SVOC
PAH | VOC

No
Yes

—One or more of the analytes in the four COPC groups were detected

November 2023 Qualitative Sheen Observations

- Score 0
- Score 1
- Score 2
- Score 3

Map Date: 1/19/2024

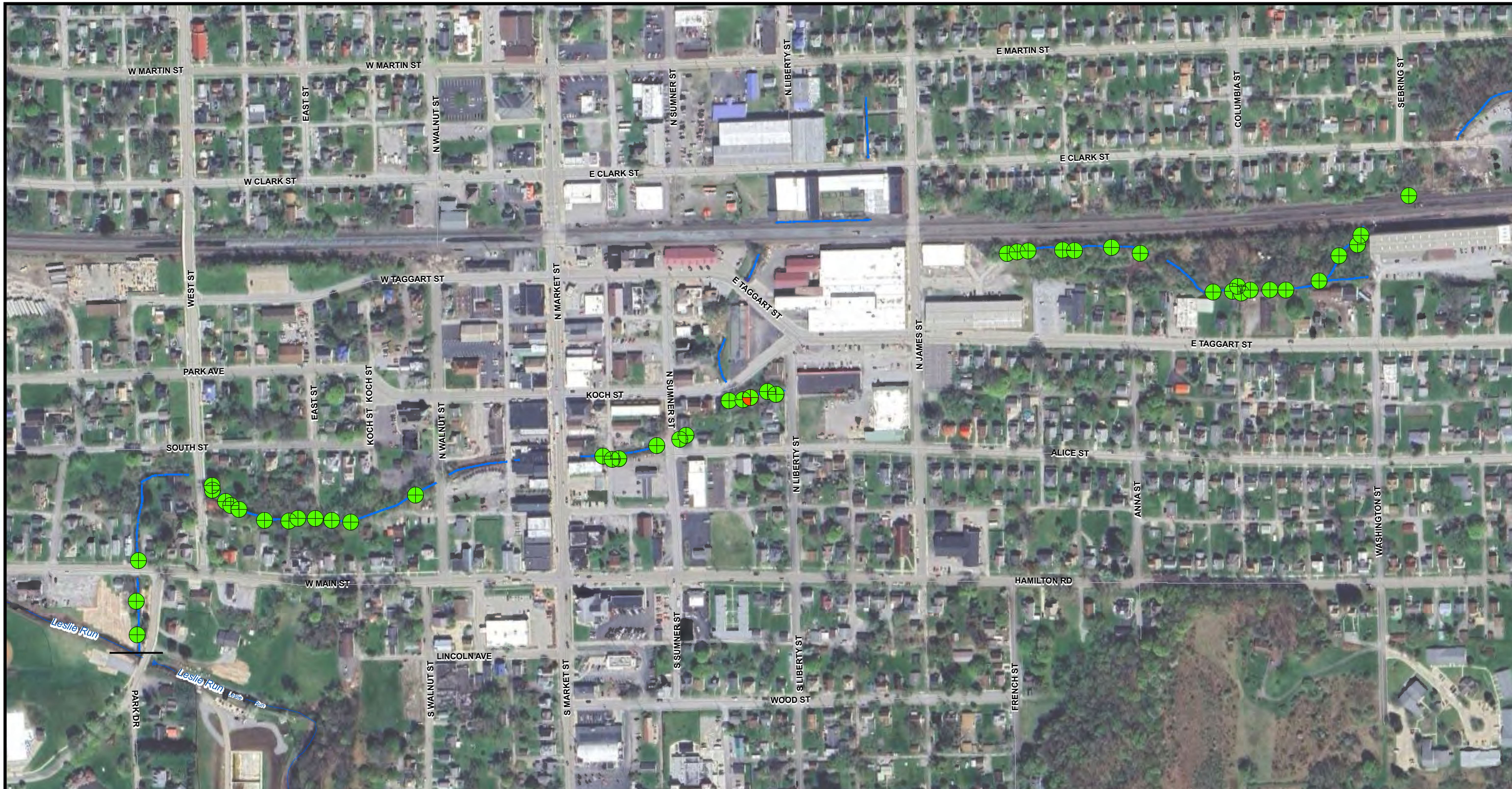
0 — 300
Feet

NORFOLK SOUTHERN
EAST PALESTINE, OHIO

**LESLIE RUN - DETAIL 9**

ARCADIS

FIGURE
**19**




Legend

Sulphur Run

PIE QUADRANTS

Derailment

SVOC

PAH

VOC

No

Yes

One or more of the analytes in the four COPC groups exceed the Human Health Screening Level (HHSL)

Map Date: 3/5/2024

0 280 560

Feet

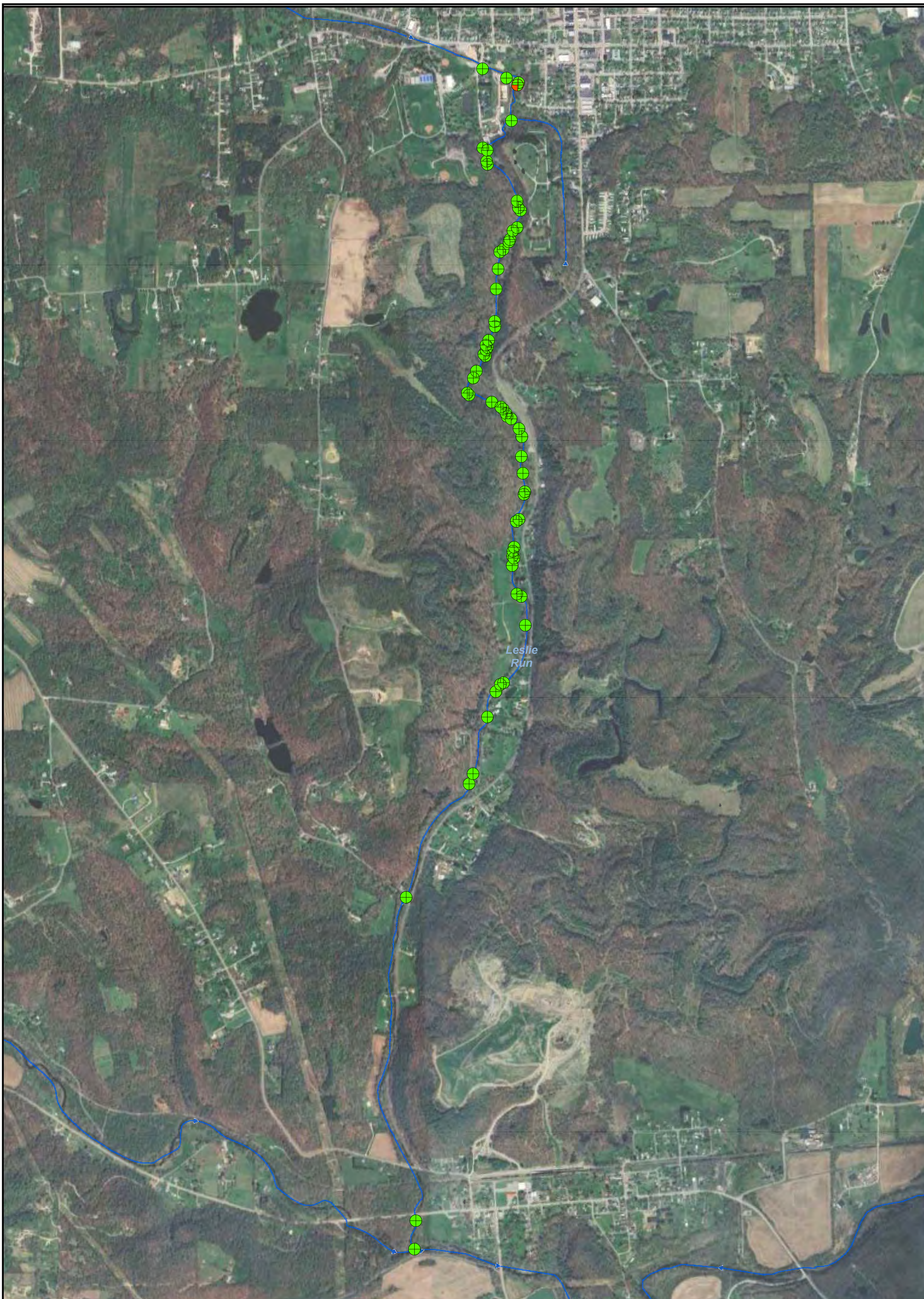
NORFOLK SOUTHERN
EAST PALESTINE, OHIO

**SULPHUR RUN SEDIMENT SAMPLE LOCATIONS AND HUMAN HEALTH SCREENING LEVELS**

ARCADIS

FIGURE

20




PIE QUADRANTS

Derailment | SVOC
PAH | VOC

No
Yes

One or more of the analytes in the four COPC groups exceed the Human Health Screening Level (HHSL)

Map Date: 3/5/2024

NORFOLK SOUTHERN
EAST PALESTINE, OHIO

**LESLIE RUN SEDIMENT SAMPLE LOCATIONS AND HUMAN HEALTH SCREENING LEVELS**

ARCADIS

FIGURE 21

# Attachment A

Mitigation and Containment Tactics - Leslie Run & Sulphur Run

# Attachment A

## Sources for Mitigation and Containment Tactics – Leslie and Sulphur Run

1) Exxon Mobile “Oil Spill Response Field Manual”, revised 2014.
https://corporate.exxonmobil.com/-/media/global/files/risk-management-and-safety/oil-spill-response-field-manual_2014.pdf

2) NOAA Hazardous Materials Response and Assessment Division and American Petroleum Institute “Options for Minimizing Environmental Impacts of Freshwater Spill Response”, September 1994
Options for Minimizing Environmental Impacts of Freshwater Spill Response (noaa.gov)

3) Environment Canada. EN4-84/2008E-PDF “Guidelines for Selecting Shoreline Treatment Endpoints for Oil Spill Response”, October 2007. G.A. Sergey (Environment Canada) and E.H. Owens (Polaris Applied Sciences, Inc.,)
SergyEndpointsJan29.indd (publications.gc.ca)

4) Environment and Climate Change Canada. Cat. No. : En14-321/2018E-PDF (Online) “Shoreline Cleanup Assessment Technique (SCAT) Manual, Third Edition”
En14-321-2018-eng.pdf (publications.gc.ca)

5) Upper Mississippi River Basin Association, “Inland Response Tactics Manual”, July 2013. Available on U.S. EPA Region 5 RRT website at:
Tactics Manual (rrt5.org)

# EAST PALESTINE, OHIO
# LESLIE RUN & SULFUR RUN
# OPERATING TACTIC

Version 2.0

Prepared for:

Norfolk Southern Railway Company
East Palestine, Ohio

**Project No.:** 17465
**Date:** 07/06/2023

Prepared by:

EnviroScience
Excellence In Any Environment

5070 Stow Rd.
Stow, OH 44224
800-940-4025
www.EnviroScienceInc.com

# TABLE OF CONTENTS

# 1.0 PURPOSE

This operating tactic was developed in response to the train derailment in East Palestine, Ohio, and subsequent release of products to surface waters. The purpose of this document is to detail the tactic that will be used to reduce or remove sheen and product from potentially impacted sediments in Leslie Run and Sulfur Run.

# 2.0 LESLIE RUN CLEAN-UP TACTIC

## 2.1. LOCATION

This clean-up tactic was developed using information from the approved March 29, 2023, and May 24, 2023, *Qualitative Stream Sediment Assessment Samling Summary Report* which identified and categorized impacted sediments from the upstream extent of Sulphur Run to the confluence with Leslie Run and Leslie Run downstream to the confluence with Bull Run. The priority areas for work crews are those areas categorized as a 3 in the qualitative assessment within Sulphur Run and Leslie Run to the confluence of Bull Run.

### 2.1.1. Stream Access

Much of Leslie Run and Sulfur Run is privately owned, which will require access agreements to allow work crews access to the property that will have clean-up activities. The East Palestine Wastewater Treatment (EP WWTP) facility has already granted access to their property. Considering this, this tactic should be initiated in the vicinity of the WWTP and proceed downstream. For Sulfur Run, clean-up activities will be conducted in areas where previous access has been granted.

## 2.2. STREAMBED CLEAN-UP TACTIC

Crews will utilize a portable 2–3-inch water trash pump to spray water to agitate the areas of impacted sediment to release entrained product from the stream bed. The water pump will draw creek water and be sprayed via an adjustable nozzle at the appropriate areas. Crews may use steel rakes or other hand tools to improve the sediment cleaning through manual agitation. This procedure will be completed in 20-yard sections with containment on the downstream end of the 20-yard stream reach. Containment includes a section of 6-inch creek boom positioned to contain potential product. Additionally, sheen absorbing boom such as MYCELX products Sheendevil / Verismat or equivalent will be placed in front of creek boom to collect released product. Additionally, a portable vacuum unit will also be staged within the working area to collect gross sheen or product not collected by absorbent material. The portable vacuum unit may be a drum vacuum, trailer vacuum or vacuum truck depending on access to the area where work is being completed.

For Leslie Run, a secondary containment point will be installed in Leslie Run downstream of the work areas to collect material that may bypass the primary containment and collection point. The secondary containment will be where a vacuum truck can be safely staged to collect potential product and will include areas on downstream end of the WWTP property, the pull off across from 5558 OH-170 and Carbon Hill Road Bridge. Vacuum recovery of material that accumulates at the secondary containment will occur. Crews will work in a downstream progression to prevent recontamination of areas previously cleaned.

For Sulfur Run, clean-up activities will be conducted at three locations. Anna St. to large culvert behind the CeramSource, Inc. property, Sumner St. to Market St., and along Park Dr., from Main St. to Sulfur Run confluence with Leslie Run. Secondary containment and a vacuum truck will be staged at each location to collect potential product.

The process may likely be paused intermittently to allow for suspended material to settle, improving visibility and to prevent large sediment loading to downstream locations. Special attention will be made to turnover larger substrate (i.e., flat substrate larger than a basketball) that sheen is potentially entrained underneath. Crews will also regulate washing pressure to not erode stream banks during progress.

This tactic will temporarily disturb stream sediments and instream habitat. However, Leslie Run is a high gradient stream where bed load and substrates will redeposit and re-stabilize after high flow events. It is understood that although there will be temporary habitat disturbance, this tactic will reduce recovery time for aquatic biota.

Additionally, in areas upstream of the EP WWTP outfall, air knifing may be utilized in finer sediment to potentially mobilize product into the water column for collection and reduce sedimentation mobilizing downstream. The process will be limited as finer sediment types are limited downstream of the EP WWTP.

The areas washed will be marked and outlined using a submeter accurate dGPS unit. This information will be downloaded into an ArcView Mapping System for further evaluation.

The cleanup will have direct oversight of aquatic biologists or equivalent personnel from NS and Ohio EPA and or USEPA to guide the cleanup to enhance efficiency, avoid ecological sensitive areas, monitor sediment and water turbidity conditions, ensure the overall progress with the cleanup, and avoid unnecessary harm to the aquatic ecosystem.

# 3.0 FIELD VARIANCES

Every effort will be made to follow the Leslie Run and Sulfur Run remedial procedure as presented. However, as conditions in the field may change, it may become necessary to implement minor modifications to clean-up procedures. If deviations are deemed appropriate and necessary by field personnel, the project manager will notify Operations, and verbal approval will be obtained before implementing any necessary changes. Any modifications to the approved procedure will be documented in digital field forms or field notebooks.

# 4.0 REPORTING

All data collected as part of the Leslie Run and Sulfur Run procedure will be summarized as described in the Qualitative Stream Sediment Assessment Sampling and Analysis Plan and will be submitted with a summary report to be utilized during future quantitative assessment efforts. These reports will be discussed with the Environmental Unit and used to inform additional tactics, future assessment, and remedial efforts specifically to Leslie Run sediments.

# 5.0 HEALTH AND SAFETY

## 5.1. HEALTH AND SAFETY PLAN

Crews will follow the East Palestine Site Specific *Health Safety and Environment Plan, Hazards, and Risk Minimization Policies* (HASP) to ensure employees will be provided with a safe work environment.

In addition to guidelines covered in the HASP, all personnel must adhere to all federal, state, and local safety laws and regulations.

### 5.1.1. Daily Safety Briefing

Anticipated Hazard Assessment (AHA), also known as Hazard Identification or Job Safety Analysis, is the term given to identifying risks to health and safety during field work and documenting the control measures taken to manage those risks. AHA forms are to be completed prior to field work and discussed during each daily safety briefing. Once safety briefings are concluded, all members of the team are required to sign the daily AHA. At any time if conditions change, all work must stop and the AHA must be amended and reviewed to address the change.

This task should be shared among the entire field crew, giving all members of the team the opportunity to address specific safety issues, cover topics of concern, and to maintain a more dynamically safe work environment. All employees are given the responsibility and authority to stop work when employees believe that a situation exists that places them, their coworker(s), contracted personnel, or the public at risk or in danger. The project manager is responsible for keeping records of all safety briefings held.

# Attachment B

Decision Tree for Ongoing Operations During Culvert Work

## DECISION TREE FOR ONGOING OPERATIONS DURING CULVERT WORK

This decision tree outlines the collaborative efforts related to air monitoring and sampling in work and community areas and associated communications as it pertains to culvert characterization and cleanup activities. This decision tree and its associated actions will be implemented in accordance with the CTEH Air SAP and QAPP, which also outlines the instrumentation that will be used during culvert characterization and instrument detection limits. This decision tree and its associated actions will also be implemented in accordance with the EPA START's HAPSITE plans and protocols.

**Key Analytes**

- Vinyl chloride:
    - Community screening value: 20 ppb
        - Basis: Agency for Toxic Substances and Disease Registry (ATSDR) Minimal Risk Level (MRL) for intermediate inhalation
    - Occupational exposure guideline: 1 ppm
        - Basis: American Conference of Governmental Industrial Hygienists (ACGIH) time-weighted average Threshold Limit Value (TLV-TWA) and Occupational Safety and Health Administration (OSHA) Permissible Exposure Limit (PEL)
- Butyl acrylate:
    - Community screening value: 20 ppb
        - Basis: Michigan Department of Natural Resources and Environment 24-hour average Initial Threshold Screening Level (ITSL)
    - Occupational exposure guideline: 2 ppm
        - Basis: American Conference of Governmental Industrial Hygienists (ACGIH) time-weighted average Threshold Limit Value (TLV-TWA)

**Provisions to be Enacted**

- Prior to cleanup activities, robot-assisted air monitoring will be conducted within the culverts to characterize atmospheric conditions inside culverts.
    - Robot-assisted air monitoring will be conducted for total VOCs, butyl acrylate, and vinyl chloride. In addition, a badge will be positioned on the robot for laboratory analysis of butyl acrylate and vinyl chloride. Air monitoring instrumentation to be used, detection limits, and associated actions are listed in Table 4.7 of the CTEH Air SAP v3.1, and air sampling methods to be used and associated detection limits are listed in Table 3.5 of the CTEH Air SAP v3.1.
    - *Note: Results of surface water and sediment sampling conducted both upstream and downstream of the culverts do not indicate the presence of butyl acrylate or vinyl chloride in surface waters or sediments. Therefore, butyl acrylate and vinyl chloride are not expected to be released from the sediment during culvert work.*
- During cleanup activities, the following provisions will be enacted in work areas:
    - Handheld air monitoring will be conducted within the culverts for total VOCs and other analytes as indicated by job hazard analysis (JHA) for confined space entry (e.g., oxygen, % LEL, hydrogen sulfide) and in the work area surrounding the culverts for total VOCs,

butyl acrylate, and vinyl chloride. Instrumentation to be used, detection limits, and associated actions for air monitoring in the work area surrounding the culverts are listed in Table 4.5 of the CTEH Air SAP v3.1.
    - The presence and character of any odors will be documented during handheld air monitoring.
    - Personal air samples for butyl acrylate and vinyl chloride will be collected on workers conducting operations within the culverts. Methods to be used and method detection limits are listed in Table 3.5 of the CTEH Air SAP v3.1.
- During cleanup activities, the following provisions will be enacted in community areas immediately surrounding the culvert work areas:
    - Handheld air monitoring will be conducted in community areas for total VOCs. The presence and character of any odors will be documented during handheld air monitoring. Instrumentation to be used, detection limits, and associated actions are listed in Table 4.6 of the CTEH Air SAP v3.1.
    - Air sampling will be conducted (4-6 locations) in the community surrounding the culvert work area using both canisters and stationary badges, for a panel of 75 VOCs, including vinyl chloride and butyl acrylate. Methods to be used and method detection limits are listed in Table 3.5 and Section 3.2.1 of the CTEH Air SAP v3.1.
    - The EPA START's HAPSITE will be available during culvert work activities and will follow the methods and actions outlined in the EPA START's HAPSITE plans and protocols.
        - If detections of butyl acrylate or odors consistent with butyl acrylate are observed within the culvert or in the work area surrounding the culvert, CTEH personnel will inform the EPA Operations Section Chief. At the direction of EPA Operations, the EPA START's HAPSITE will evaluate air quality in accordance with the EPA START's HAPSITE plans and protocols. These actions may include collecting grab samples for butyl acrylate and vinyl chloride at the nearest downwind community receptors.
    - Odor reports will continue to be investigated by Community Strike Teams, who immediately respond to the area of the odor report and conduct outdoor air monitoring using handheld instruments, deploy an air sample for butyl acrylate, and characterize and document odors in the area.
        - In addition, CTEH personnel will inform the EPA Operations Section Chief. At the direction of EPA Operations, the EPA START's HAPSITE will evaluate air quality in accordance with the EPA START's HAPSITE plans and protocols. These actions may include collecting a grab sample for butyl acrylate and vinyl chloride in the area of the odor report. Before the end of the work day, the EPA START's HAPSITE operators may evaluate site conditions and consider returning to the area where the odor was reported to collect a follow-up grab sample for butyl acrylate and vinyl chloride.

**Decision Criteria**

- VOC concentrations in community areas during handheld air monitoring continue to be below action levels, as outlined in the CTEH Air SAP and QAPP, or if above action levels, actions continue to be taken in accordance with the CTEH Air SAP and QAPP.

- Odor documentations during handheld air monitoring continue to show no detectable odors consistent with butyl acrylate in community areas. If odors consistent with butyl acrylate are observed in community areas, Community Strike Teams will continue to investigate the odors (see Provisions to be Enacted section above for further details).
- Concentrations of VOCs, vinyl chloride, and butyl acrylate in work areas during robot-assisted and handheld air monitoring continue to be below action levels, as outlined in the CTEH Air SAP and QAPP, or if above action levels, actions continue to be taken in accordance with the CTEH Air SAP and QAPP.
- In response to detections of butyl acrylate or odors consistent with butyl acrylate in the work area, CTEH personnel will inform the EPA Operations Section Chief. At the direction of EPA Operations, the EPA START's HAPSITE will evaluate air quality in accordance with the EPA START's HAPSITE plans and protocols. These actions may include collecting grab samples for butyl acrylate and vinyl chloride at the nearest downwind community receptors.
    - *Note: Based on surface water and sediment data, butyl acrylate is not expected to be released from the sediment during culvert work. Previous creek operations (i.e., air knifing, creek agitation and washing) did not rely on mobile laboratories, HAPSITE, or MINICAMS; rather, air characterization during previous creek operations was addressed using the other data streams outlined herein (e.g., handheld air monitoring, worker personal air sampling).*
- Air sampling results along the work area perimeter continue to show no detections of vinyl chloride or butyl acrylate that exceed the community screening values of 20 ppb.
- Investigation of odors reported by community members continues to show no detections of butyl acrylate in air samples.

**Decision Tree**

- The hours of culvert operations will be communicated to the CTEH Project Manager and the EPA Operations and Air Operations groups, including operators of the EPA START's HAPSITE.
- If butyl acrylate is detected (i.e., any detection above the instrument's limit of detection), or if odors consistent with butyl acrylate are detected, within the culvert or in the work area surrounding the culvert, CTEH personnel will inform the EPA Operations Section Chief. At the direction of EPA Operations, the EPA START's HAPSITE will evaluate air quality in accordance with the EPA START's HAPSITE plans and protocols. These actions may include collecting a grab sample for butyl acrylate and vinyl chloride at the nearest downwind community receptor, based on prevailing wind direction.
    - The identity and types of operations occurring will be identified, and site and environmental conditions (i.e., wind direction, temperature) will be examined. The nature of the detection or odor will be evaluated (i.e., an instantaneous peak measurement or consistently elevated measurements) to determine the trend of the measurements.
    - Real-time air monitoring using handheld instruments will continue within the culvert, in the work area, and in nearby community areas (including around the work area perimeter) to characterize the area, including documentation of any odors.
    - If it is determined that EPA START's HAPSITE will collect an initial grab sample, and if the initial grab sample yields a concentration of butyl acrylate or vinyl chloride below the

community screening value (20 ppb), the EPA START's HAPSITE operators may consider discontinuing monitoring at the receptor and returning to its standby location, and work operations will continue.

- If it is determined that EPA START's HAPSITE will collect an initial grab sample, and if the initial grab sample yields a concentration of butyl acrylate or vinyl chloride above the community screening value (20 ppb), the EPA START's HAPSITE operators may consider returning to the same downwind location and collecting three follow-up grab samples at 15-minute intervals to evaluate the average concentration over a one-hour period.
  - Engineering and/or administrative controls will be considered on a case-by-case basis, considering the site and environmental conditions within and around each culvert. Engineering and/or administrative controls may include the use of fans, air scrubbers, or temporarily shifting work to a different area (e.g., upwind). If fans or air scrubbers are utilized, handheld air monitoring and air sampling locations will be positioned to encompass locations downwind of the engineering control.
  - If it is determined that EPA START's HAPSITE will collect three follow-up grab samples at 15-minute intervals, and if the one-hour average concentration of butyl acrylate or vinyl chloride is below the community screening value (20 ppb as a one-hour average), the EPA START's HAPSITE operators may consider discontinuing monitoring at the receptor and returning to its standby location, and work operations will continue.
  - If it is determined that EPA START's HAPSITE will collect three follow-up grab samples at 15-minute intervals, and if the one-hour average concentration of butyl acrylate or vinyl chloride is above the community screening value (20 ppb as a one-hour average), the EPA Operations Section Chief will be notified, and work (or specific activities resulting in elevated readings) may be temporarily stopped until concentrations in grab samples return to below 20 ppb. Engineering and/or administrative controls will be considered on a case-by-case basis. In addition, Unified Command may evaluate the need to engage a community outreach team to discuss potential avenues for communication with downwind receptors (e.g., distribution of flyers or other information via website, use of hotlines to answer questions).

# Attachment C

Surface Water Guidelines from Ohio EPA

**Attachment C**

**Monitoring and Stream Water Quality Requirements**

Stream sampling will monitor water quality within the local watersheds. Confirmation of compliance with Ohio Water Quality Standards for oil is necessary to ensure oil discharged by NSRC no longer remains in Sulphur Run and Leslie Run in harmful quantities.

Ohio Water Quality Standards, located in Ohio Administrative Code Chapter (OAC) 3745, consist of numeric criteria, narrative criteria, and biological criteria. These criteria have been developed to be protective of human health and the environment. Specific parameters have been identified to enable tracking of the restoration efforts related to the train derailment, they are discussed below.

**Chemical Criteria Applicable to Sulphur and Leslie Run**

Water quality parameters and applicable Ohio criteria are contained in Table 1. The parameters and sites are consistent with the SWSAP stream monitoring program. In addition to the parameters in Table 1, Ohio has a water quality standard for the parameter “Oil and Grease”. The limit for Oil and Grease is a maximum of 10 mg/l (OAC 3745-1-37). The criteria also include the following language: *Surface waters shall be free from floating oils and shall at no time produce a visible sheen or color film. Levels of oils or petrochemicals in the sediment or on the banks of a watercourse which cause deleterious effects on the biota will not be permitted*.

**Narrative Criteria Applicable to Sulphur and Leslie Run**

Ohio water quality standards also contain a list of narrative criteria, the “free froms”, located in OAC 3741-1-04. Specific to the plan is the following:

> *(B) Free from floating debris, oil, scum and other floating materials entering the waters as a result of human activity in amounts sufficient to be unsightly or cause degradation.*

**Biologic Criteria Applicable to Leslie Run**

A final component of Ohio water quality standards which is applicable is the State’s biological criteria. This standard employs a series of tiered use designations using ecological communities (fish and macroinvertebrates) to determine compliance with appropriate biocriteria. Leslie Run has a use designation of both warmwater habitat in the upper reaches and coldwater habitat in the lower reaches. Sulphur Run (listed in Ohio as “Unnamed tributary”) has a use designation of Limited Resource Water; biocriteria are not applicable to this use designation. Biocriteria monitoring was done in 2023 by NS through an approved State of Ohio study plan. OEPA will conduct biocriteria monitoring in 2024 at River Mile 0.1 and 3.3 in Leslie Run. The need for additional biocriteria monitoring in Leslie Run is pending results of post-derailment biomonitoring. Additional monitoring, if criteria are unmet, will be conducted in accordance with prior plans (EnviroScience 2023c).

**Locations**

Surface water monitoring locations are a subset of those originally approved in the Surface Water Sampling and Analysis Plan (SWSAP). Sampling shall continue at stations **W002** and **W010** in Sulphur Run and at stations **W001**, **W004**, **W005,** and **W009** in Leslie Run. Figures 1 and 2 below contain a map and site description as presented in the SWSAP.

*Figure 1- Sampling locations map*

**Figure 1.3 Active Surface Water Sampling Locations**

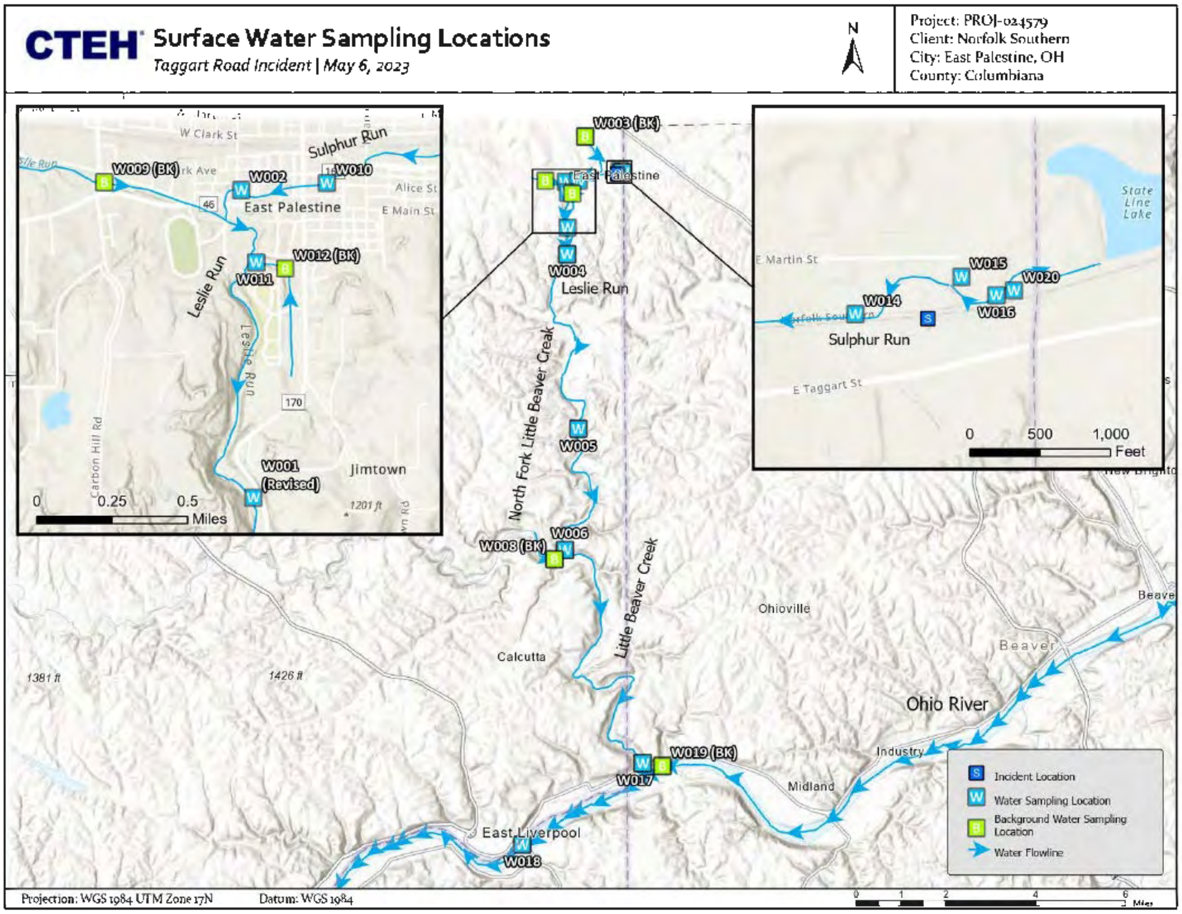


*Figure 2 - Narrative description of sampling locations*



**Table 1.3 Active Surface Water Sampling Locations**

| WATERBODY | LOCATION CODE | LATITUDE | LONGITUDE | LOCATION DESCRIPTION |
|---|---|---|---|---|
| Leslie Run | W001 (Revised)[1] | 40.8187 | -80.5433 | Leslie Run South of East Palestine City Park |
| Sulphur Run | W002 | 40.8334 | -80.5438 | Sulphur Run - culvert under West St, between South St and Meadow Ln |
| Sulphur Run | W003 (BK) | 40.8483 | -80.5347 | Sulphur Run at Concord Rd. Upstream of incident site |
| Leslie Run | W004 | 40.8102 | -80.5430 | Leslie Run at Big Valley Raceway |
| North Fork Little Beaver Creek | W005 | 40.7538 | -80.5389 | North Fork Little Beaver Creek approximately 10 yards north of Pancake Clarkson Rd bridge |
| North Fork Little Beaver Creek | W006 | 40.7152 | -80.5444 | North Fork Little Beaver Creek, approximately 20 yards north of crossing of Main St. bridge. |
| Little Beaver Creek | W007 | 40.6756 | -80.5416 | Little Beaver Creek, at intersection of Grimm Bridge Rd and Beaver Creek Camp Rd |
| Little Beaver Creek | W008 (BK) | 40.7040 | -80.5530 | Little Beaver Creek on Old Fredericktown Rd, west of Jackson St bridge |
| Leslie Run | W009 (BK) | 40.8335 | -80.5524 | U/S Leslie Creek at Brookdale Ave |
| Sulphur Run | W010 | 40.8339 | -80.5396 | NW corner of intersection of Alice St and Sumner St. |
| Leslie Run | W011 | 40.8300 | -80.5427 | Approximately 10 yards east of Leslie run and the tributary convergence. Southwest of Leake St. |
| Tributary of Leslie Run | W012 (BK) | 40.8302 | -80.5410 | Upstream Leslie Run tributary, at bend. South of Leake St. |
| Sulphur Run | W013 | 40.8350 | -80.5356 | 100 ft east of intersection of N Pleasant Dr and incident railroad tracks; Inactive since March, 9 2023 due to excavation activities |
| Drainage ditch | W014 | 40.8358 | -80.4996 | Approximately 20 yd SE of Brave Industries |
| Ohio State Line Lake overflow | W015 | 40.8367 | -80.5207 | Swamp south of cornfield, approximately 50 yds south of road |
| Ohio State Line Lake overflow | W016 | 40.8365 | -80.5201 | Swamp approximately 10yd west of earthen dam near water pumps |
| Little Beaver Creek | W017 | 40.6355 | -80.5454 | Ohioville Borough Boat Ramp |
| Ohio River | W018 | 40.6208 | -80.5648 | Along Ohio River, downstream of river and at mouth of two channels, West of Jennings Randolph Bridge 30 yards away |
| Ohio River | W019 (BK) | 40.6459 | -80.5058 | Approximately 0.5 miles upstream of Little Beaver Creek entrance into the Ohio River |
| Ohio State Line Lake overflow | W020 | 40.8366 | -80.5198 | Upstream of Dam northeast of incident site on state line |

(BK) indicates background sampling locations.

[1] W001 (Original) was sampled on February 4, 2023 and was located approximately 10 yards downstream of the Park Drive Bridge (40.8321, -80.5444). W001 was relocated to "W001 (Revised)" due to the installation of an aeration station.

*Table 1 - Ohio water quality criteria*

| Contaminant of Concern | Notes | CAS | Ohio EPA WQS IMZM (µg/L) | Ohio EPA WQS OMZM (µg/L) | Ohio EPA WQS OMZA (µg/L) | Ohio EPA Human Health (µg/L) |
|---|---|---|---|---|---|---|
| 1,2,4-Trimethylbenzene | | 95-63-6 | 280 | 140 | 15 | |
| 1-Methylnapthalene | | 90-12-0 | | | | |
| 2,4-Dinitrophenol | | 51-28-5 | | | | 300 |
| 2,6-Dinitrotoluene | | 606-20-2 | 1500 | 730 | 81 | |
| 2-Butoxyethanol | | 111-76-2 | | | | |
| 2-Ethyhexyl acrylate | | 103-11-7 | | | | |
| 2-Hexanone | | 591-78-6 | | | | |
| 2-Methylnapthalene | | 91-57-6 | | | | |
| 2-Nitrophenol | | 88-75-5 | 1300 | 650 | 73 | |
| 3 & 4-Methylphenol | Ohio WQS for 3-Methylphenol | 108-39-4 | 1100 | 560 | 62 | |
| 3 & 4-Methylphenol | Ohio WQS for 4-Methylphenol | 106-44-5 | 960 | 480 | 53 | |
| 4,6-Dinitro-2-methylphenol | | 534-52-1 | | | | |
| 4-Nitrophenol | | 100-02-7 | | | | |
| Acenapthene | | 83-32-9 | 38 | 19 | 15 | 90 |
| Acenapthylene | | 208-96-8 | ID | ID | ID | |
| Acetone | | 67-64-1 | | | | |
| Anthacene | | 120-12-7 | 0.35 | 0.18 | 0.02 | 400 |
| Benzene | | 71-43-2 | 1400 | 700 | 160 | 160 |
| Benzo(A)anthracene | | 56-55-3 | ID | ID | ID | 0.013 |
| Benzo(A)pyrene | | 50-32-8 | ID | ID | ID | 0.0013 |
| Benzo(B)fluoranthene | | 205-99-2 | ID | ID | ID | 0.013 |
| Benzo(g,h,i)perylene | | 191-24-2 | ID | ID | ID | |
| Benzo(K)fluoranthene | | 207-08-9 | ID | ID | ID | 0.13 |
| Benzoic acid | | 65-85-0 | | | | |
| Benzyl alcohol | | 100-51-6 | | | | |
| Carbon disulfide | | 75-15-0 | 260 | 130 | 15 | |
| Chrysene | | 218-01-9 | ID | ID | ID | 1.3 |
| Diethylene Glycol | | 111-46-6 | | | | |
| Ethylbenzene | | 100-41-4 | 1100 | 550 | 61 | 130 |
| Ethylene Glycol | | 107-21-1 | 2600000 | 1300000 | 140000 | |
| Ethylene glycol monobutyl ether | 2-Butoxyethanol | 111-76-2 | | | | |
| Fluoranthene | | 206-44-0 | 7.4 | 3.7 | 0.8 | 20 |
| Fluorene | | 86-73-7 | 220 | 110 | 19 | 70 |
| Indeno(1,2,3-C,D)pyrene | | 193-39-5 | ID | ID | ID | 0.013 |
| Isophorone | | 78-59-1 | 15000 | 7500 | 920 | 18000 |
| Methyl acrylate | | 96-33-3 | | | | |
| Methyl ethyl ketone (MEK) | 2-Butanone | 78-93-3 | 400000 | 200000 | 22000 | |
| Methyl isobutyl ketone (MBK) | | 108-10-1 | | | | |
| Napthalene | | 91-20-3 | 340 | 170 | 21 | |
| n-Butyl Acrylate | | 141-32-2 | | | | |
| Nitrobenzene | | 98-95-3 | 4000 | 2000 | 380 | 600 |
| Phenanthrene | | 85-01-8 | 61 | 31 | 2.3 | |
| Phenol (wwh,ewh) | | 108-95-2 | 9400 | 4700 | 400 | 300000 |
| Phenol (lrw) | | 108-95-2 | 9400 | 4700 | N/A | 300000 |
| Phenol (cwh) | | 108-95-2 | 9400 | 4600 | 160 | 300000 |
| Pyrene | | 129-00-0 | 83 | 42 | 4.6 | 30 |
| Styrene | | 100-42-5 | 570 | 290 | 32 | |
| Toluene | | 108-88-3 | 1100 | 560 | 62 | 520 |
| Vinyl Chloride | Chloroethene | 75-01-4 | 17000 | 8400 | 930 | 16 |
| o-xylene / m+p-xylene | Ohio uses Xylenes (sum of m-, o-, and p-xylene) | 1330-20-7 | 480 | 240 | 27 | |
| IMZM = Inside Mixing Zone Maximum, OMZM = Outside Mixing Zone Maximum, OMZA = Outside Mixing Zone Average, wwh = warmwater habitat, ewh = exceptional warmwater habitat, cwh = coldwater habitat, lrw = limited resource waters | | | | | | |

# Attachment D

Attenuation Review

# Attachment D.

Review of the natural breakdown of petroleum lube oil and constituents in the environment.

### Key Outcomes of the Review

- This document discusses the mechanisms for natural environmental breakdown and degradation of the specific 'petroleum lube oil' material (i.e., YUBASE6 mineral base oil) that was released to Sulphur Run and Leslie Run during the derailment.
- According to the SDS provided by the distributor for YUBASE6, the material is a clear, colorless liquid that is not considered hazardous and has no known significant effects upon inhalation, skin contact, or ingestion. The released mineral base oil has no significant aquatic toxicity to algae, invertebrates, or fish.
- The residual released mineral base oil in Sulphur Run and Leslie Run is expected to naturally attenuate by two key mechanisms:
  - The primary attenuation driver is biodegradation with the aid of a healthy natural sediment microbial community.
  - The more recalcitrant components of the released mineral base oil have a moderate to high potential for further secondary degradation by photooxidation of sheens in the presence of direct sunlight and normal aqueous levels of dissolved organic matter.
- In addition, a healthy mixed community of petroleum-acclimatized fungal species indigenous to Sulphur and Leslie Runs may be capable of generating biological surfactants that have been reported to aid in the dissolution/solubilization of the more recalcitrant components of the released mineral base oil, which will reduce sheen generation.
- Results of recent forensic sampling of sediments and sheens in Sulphur Run and Leslie Run are expected to support assessment of what other products are present in the creeks and whether observed sheens are related to the released mineral base oil or other legacy/ongoing sources. This paper does not discuss the attenuation of these other sources, which may also be contributing to sheen.

## 1. Introduction

This Attachment D to the Sediment Mitigation Measures Work Plan has been prepared at the request of the United States Environmental Protection Agency (EPA) to discuss attenuation mechanisms that may be present for petroleum lubricating oil within waterways in and near the site of the February 2023 derailment in East Palestine, Ohio. This Attachment is intended to fulfill the following requirement stated in EPA's March 1, 2024 letter approving, with modifications, the Sediment Mitigation Measures Work Plan:

> *This document shall include a thorough, evidence-based, literature-referenced discussion of the natural breakdown of petroleum lube oil, petro oil NEC, and constituents in the environment. The review and discussion are to be related to the physical, chemical, and biological conditions in Sulphur and Leslie Run and is intended to inform consideration of final sheen mitigation steps.*

The product identified on the shipment consist as 'petro oil NEC' was fully recovered during derailment clean-up operations. As such, it is not considered to be present within waterways in and near the derailment site and was not considered in the following discussion. This Attachment includes a description of the specific 'petroleum lube oil' material released (i.e., YUBASE6 mineral base oil), stream conditions prior to the derailment, anticipated fate and transport of the released material, attenuation and biodegradation mechanisms, and inferred conclusions regarding long-term conditions.

## 2. Description of Released Petroleum Material

### Terminology and Overview of Refinement Process

Mineral base oils, also referred to as mineral oil or white oil, are produced from the undistilled residuals remaining after atmospheric distillation of a crude oil. These residuals are passed through vacuum distillation to select the fraction that boils between about 300 °C and 600 °C. This distillate fraction is also referred to as the C17 to C45 Fraction, which refers to the behavior of the refined material in standard oil testing procedures relative to the performance of normal alkane hydrocarbon benchmark compounds containing between 17 and 45 carbons. This vacuum distillate fraction is further processed – typically by solvent extraction, solvent dewaxing, and/or hydrofinishing – to remove aromatic compounds, paraffins (i.e., straight chain alkanes), and polar compounds such as resins and asphaltenes. The remaining base oil is primarily composed of isoparaffins (i.e., isoalkanes, branched alkanes) and naphthenes (i.e., cyclic alkanes, alicyclic alkanes). [Stout et al. 2002]

The removal of aromatics during the refining process significantly reduces the polyaromatic hydrocarbon (PAH) content, which results in a significant reduction in toxicity and carcinogenicity compared to crude oil. Interest in standardizing an approach to assessing the carcinogenic potential of mineral oil and therefore assessing the effectiveness of the refining process for the various mineral base oils traded in commodity markets resulted in the development of a standardized test, referred to as IP346, to independently assess the aromatic content of oils produced by refineries. The reported value of an IP346 test represents the weight percentage of aromatic content in a finished mineral oil. A value below 3% w/w has been demonstrated to correlate with a sufficiently low aromatic content to allow the product to be deemed non-carcinogenic. [Carrillo et al. 2019]

### YUBASE6 Physical and Chemical Properties

YUBASE6 is described by the producer in their provided safety data sheet (SDS) as a hydrotreated heavy paraffinic petroleum distillate with CAS# 64742-54-7 (SK Enmove 2023). It is alternatively described by the producer as a base oil or mineral oil. It is herein referred to as a mineral base oil. Table 1 (see next page) lists selected chemical and physical properties of the product relevant for the following discussion.

PubChem describes the product with CAS# 64742-54-7 as a horticultural spray oil used as insecticides and/or larvicides on crops, aquatic areas (mosquito larvicide/pupacide), and other areas (animal, commercial, industrial, medical, and residential premises). In mosquito larvicide/pupacide uses, the oil is not directly toxic, but stops larval development by creating a physical barrier over standing water and puddles, preventing oxygen from reaching larvae and pupae. It is also used in the chemical, fuel, lubricant blending, and petroleum refining industries as a diluent, intermediate, lubricant, and additive.

***Table 1.*** *Summary of physical and chemical properties for YUBASE6, as cited in the product SDS*

| Property | YUBASE6 |
|---|---|
| CAS# | 64742-54-7 |
| Physical state | Liquid |
| Color | Clear, colorless |
| Odor | Mineral oil (slight) |
| Boiling point | 380 °C to 550 °C |
| Relative density | 0.842 g/mL (15 °C) |
| Partition coefficient (Log $K_{OW}$, n-octanol/water) | 3.9 to 6 |
| Viscosity | 36 $mm^2/s$ (40 °C) |
| Chemical stability | The product is stable. |
| IP346 (DMSO extract) | typical 0.2%, max 0.5%, not a carcinogen |
| LC50 Inhalation, dusts and mists | Rat: >5.53 mg/L (4 hr) |
| LD50 Dermal | Rat: >5.53 mg/L (4 hr) |
| LD50 Oral | Rat: >5,000 mg/kg |
| Acute EC50 | Daphnia: >100 mg/L (48 hr) |
| Acute IC50 | Algae: >100 mg/L (72 hr) |
| Acute LC50 | Fish: >100 mg/L (96 hr) |

To address the potential for natural attenuation of this product, it is necessary to understand its composition according to the following four petroleum compound classes: paraffins, isoparaffins, naphthenes, aromatics.[i] This information is not provided in the SDS but may be estimated based on the information that is provided in the SDS along with published studies of mineral base oil composition and degradability relative to its viscosity and density. Haus et al. [2001] studied 32 unformulated mineral base oils, obtained from Mobil Oil Corporation, for 'paraffinic' composition according to viscosity. Note that the authors use the term paraffinic here to refer to both paraffins and isoparaffins. Most of the oils were deparaffinized[ii], so the 'paraffinic' compositions of the final refined oils will be primarily isoparaffins (i.e., isoalkanes). The base oil that most closely matches YUBASE6 mineral oil had the characteristics summarized in Table 2 (see next page). Where available, the YUBASE6 mineral oil characteristics are also provided.

[i] **Paraffins** are straight chain hydrocarbons (i.e., the carbon atoms are arranged in a linear chain) – they may also be referred to as normal alkanes or n-alkanes. **Isoparaffins** are hydrocarbons consisting of linear chains of carbons with one or more branches in the chains – they may also be referred to as isoalkanes. **Naphthenes** are hydrocarbons containing one or more rings of carbons where all carbons are joined by single bonds – they may also be referred to as cyclo alkanes or alicyclic alkanes. **Aromatics** are hydrocarbons containing one or more benzene rings (i.e., rings of six carbons), each containing alternating double and single bonds between the carbons.

[ii] The deparaffinizing step in mineral base oil refining removes true paraffins (i.e., n-alkanes). Normal paraffins have a waxy nature. In a mineral base oil they are undesirable because they affect technical performance of a lubricant at low temperatures. Removal of n-alkanes during refining by a process referred to as dewaxing or deparaffinizing is necessary to obtain a high-quality mineral oil lubricant. [Carrillo et al. 2019]

***Table 2.*** *Chemical and physical properties of the mineral base oil cited by Haus et al. [2001] with highest similarity to YUBASE6, along with the corresponding properties of YUBASE6 from the provided SDS (where available).*

| Property | Mineral Base Oil Similar to YUBASE6 | YUBASE6 |
|---|---|---|
| Kinematic Viscosity (40 °C) | 31.58 $mm^2/s$ | 36 $mm^2/s$ |
| Viscosity Index | 106.8 | -- |
| Pour Point | -9 °C | -- |
| Flash Point | 213 °C | 230 °C |
| Refractive Index | 1.4554 | -- |
| Density | 0.887 | 0.842 $g/cm^3$ |
| Primary Biodegradability | 56% | -- |
| % Paraffinic | 67% | -- |
| % Aromatic | 1% | 0.2%, max 0.5% |
| % Naphthenic | 32% | -- |
| Total Aromatics (mmol/kg) | 144.8 | -- |
| Total Polars (mmol/kg) | 13.45 | -- |

In 2003, Haus et al. demonstrated a strong negative correlation (r = -0.929) between primary biodegradability[iii] and the log-transformed kinematic viscosities of mineral base oils as shown in Figure 1 (at right), which visually represents the strength of the correlation. In the Haus et al. studies, Primary Biodegradability (B) was evaluated using the CEC L-33-A-93 test.[iv] Given the provided linear correlation equation [B = 104.55-(32.72 • log(KV))], the % Primary Biodegradability of YUBASE6 mineral base oil may be estimated at 54%. This value correlates well with the primary biodegradability of the mineral base oil reported by Haus et al. [2001] described above, having other properties consistent with YUBASE6 mineral base oil. [Haus et al. 2003]

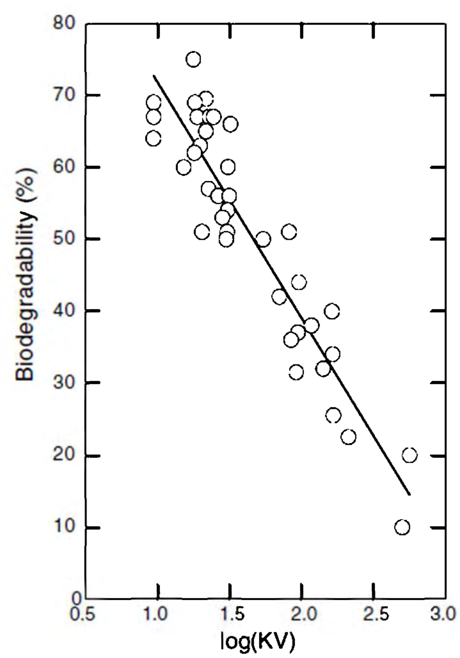



***Figure 1 (at right).*** *Primary Biodegradability % vs Kinematic Viscosities. Reproduced from Haus et al. 2003.*

[iii] The European Chemical Agency defines primary degradation as ‘The structural change (transformation) of a chemical substance by microorganisms, resulting in the loss of the original chemical identity.’ In simple terms, it is the loss of the parent molecule. [Prosser et al. 2016]

[iv] The CEC L-33-A-93 test evaluates primary biodegradability by measuring the loss of lubricant due to microbial degradation, assessed by measuring the infrared absorbance at 2950 $cm^{-1}$ (CH2–CH3 band) in solvent extracts before and after incubation for 21 days with an inoculum of coarse-filtered secondary (final) sewage treatment plant effluent. It is applicable to unused lubricating base oils free from any additives [CEC 1995, Carrillo et al. 2019]

## YUBASE 6 Toxicity

The toxicity of YUBASE6 as reported in the supplier-provided SDS is consistent with literature reports for similar mineral base oils. The effectiveness and applicability of the IP346 test for determination of carcinogenic potential is reviewed in detail by Carrillo et al. [2019]. Dalbey et al. [2014] provides a comprehensive overview of general toxicity of twelve mineral base oils from a range of refinery grades, referred to by the authors as 'lubricating oil base stocks' or LOBs. Aromatic content percentages for the twelve oils (ARC wt%, which correlates with IPC346 wt%), ranged from 0.1% to 20%. The mineral base oil reported that most closely relates to YUBASE6 was CAS# 64742-65-0; a solvent-dewaxed heavy paraffinic distillate with ARC wt% 0.17. In the study, the authors distinguish between two general classes of mineral base oils: Sufficiently Refined and Insufficiently Refined. Sufficiently Refined mineral base oils are defined as those with levels of aromatic compounds not considered carcinogenic. The oils in the study considered as 'Sufficiently Refined' had IP346 values of 0.53% or below. YUBASE6, having a typical IP346 value of 0.2% and a maximum of 0.5%, is classified as 'Sufficiently Refined' relative to the Dalbey et al. [2014] study. The more highly refined mineral oils used for food-contact applications, pharmaceuticals, laxatives, body lotions, baby oils, cosmetics, or direct food additives were not evaluated in this study. The authors' conclusions as related to Sufficiently Refined mineral base oils were as follows:

- Experimental no observed adverse effect levels (NOAELs) for systemic toxicity and developmental toxicity with repeated dermal exposures to sufficiently refined LOBs were 1,000 to 2,000 milligrams per kilogram per day (mg/kg/d) and typically were the highest doses tested.
- Sufficiently Refined mineral base oils are likely to have little, if any, effects on reproductive parameters.
- Sufficiently Refined mineral base oils as currently marketed would not be considered hazardous, although testing or a thorough knowledge of refining history is needed to verify this designation. Note, the testing noted here refers to a product-specific IP346 evaluation. The IP346 result for YUBASE6 is presented in the supplier-provided SDS, as described above.

## 3. Information on Prior Stream Conditions

Stream conditions at the time of the release are summarized in other documents, including the Conceptual Site Model (Arcadis 2024). In summary, Sulphur Run downgradient of the derailment location consists of an urbanized/developed waterway, impacted by surrounding property use and drainage. The creek is classified by Ohio Environmental Protection Agency (OEPA) as a Limited Resource Water, the lowest use designation OEPA assigns to waterways of the state (OEPA 2022). Streambed conditions within Sulphur Run range from concrete and disturbed/reworked materials to sand, sediment, and gravel. There are five segments that are culverted under both businesses and residential structures (Arcadis 2023). Leslie Run, which Sulphur Run joins southwest of the derailment site, is a higher energy creek consisting of a more natural streambed setting, dominated by alluvial/fluvial sediment, including sand, gravel, and silt. Observations of sediment conditions have been documented in field logs generated throughout the sampling conducted under the EPA-issued Clean Water Act Order.

Both creeks fall within the Little Beaver Creek watershed. In their 2022 Water Quality Assessment, OEPA rated the Leslie Run-Bull Run watershed as "impaired" and "not supporting." The causes of the impairment are listed as "historical" and due to *E. coli*. The source of the data is indicated as 2001 (OEPA 2022). OEPA has a 2024 version of the report under development. Similarly, USEPA's 2022 assessment of the watershed ranked the entire area as "impaired." Historical sediment sampling data provided by OEPA is included in the Sediment Investigation Summary Report (Arcadis 2023). In addition, the October 2023 OEPA Fact Sheet indicates that in 1985, Sulphur Run and Leslie Run "were severely impacted by land uses and discharges from several sources, including the Village wastewater treatment plant (WWTP)."

In addition to the historical impacts, there have been other inputs to Sulphur Run and Leslie Run since the February 2023 derailment that have impacted the creeks, caused degradation of water quality, and contribute to the presence of sheens. These are detailed in the Sediment Investigation Summary Report (Arcadis 2023), and include:

- As a result of an investigation into high lower explosive limit (LEL) readings recorded during air knifing operations in Sulphur Run on March 31, 2023, OEPA discovered gasoline leaking from a former Leake Oil gas station just to the south of Sulphur Run on Taggert Street. OEPA investigated and found gasoline in several monitoring wells on the Leake Oil property, some of which contained more than one foot of gasoline. This location continues to be an active source of gasoline / petroleum to the creek. The property is now under a trust and will be managed by OEPA.
- A June 1, 2023 unauthorized discharge of industrial soap with colorants (2-Butoxyethanol) into Sulphur Run that caused excessive foaming, discoloration, and other conditions which created a nuisance and resulted in a buildup of foam within the creeks and had the potential to negatively impact aquatic organisms. OEPA issued a Notice of Violation (2306EPA0000898-V001) for violations of water pollution and water quality standards.
- Discoveries of an oil substance (on June 1, 2023) and a terracotta pipe containing oily liquid and sediments saturated with an oily substance (August 25, 2023) originating from existing industrial operations near Sulphur Run.
- A January 28, 2024 gasoline release documented by OEPA that impacted storm water catch basins that discharge into Sulphur Run.
- A fish kill in Leslie Run on August 7, 2023 that occurred as part of work to replace the Park Avenue bridge when a contractor for the Ohio Department of Transportation dropped the old bridge into the creek.

## 4. Anticipated Fate and Transport of Released Material

Oil released to the waterways during and shortly after the derailment is subject to a complex series of forces at both large scales (e.g., movement with overall hydrologic gradients and surface water flow) and small scales (e.g., capillary pressures that act on small amounts of oil within the pore space of sediment). Terminology and processes related to released oil, sheens, and transport are summarized in general terms in National Oceanographic and Atmospheric Administration (NOAA) documentation (NOAA 2016) and in Appendix E of the Interstate Technology and Regulatory Council (ITRC) LNAPL-3 Guidance Document (ITRC 2018).

The interactions between large-scale and small-scale forces, combined with the changing environmental setting and lack of a single, consistent steady-state flow condition, mean that mathematical modeling approaches are not suited to describing the complex fate and transport of oil in the environment. Nonetheless, the main processes that are involved in oil movement in the environment at both large and small scales are well-understood. These include:

### Movement of oil on the water surface and formation of sheens.

An expression known as the spreading coefficient describes the tendency of a fluid (e.g., oil) to spread at the interface between two other fluids (e.g., air and water) [Blunt et al. 1995; Keller et al. 1997]. In general, petroleum products tend to have a positive spreading coefficient at air-water interfaces, and interfacial tension forces will tend to lead to oil spreading to a thin layer; however, this spreading behavior may be limited by surface water movement, currents, and other environmental forces with which the capillary forces of interfacial tension interact. The observation of sheens on waterways in areas with documented hydrocarbon impacts is generally an indication that the materials present exhibit a positive spreading coefficient.

### Movement of oil into pore spaces in sediment and soil.

In response to either hydraulic gradients, capillary forces, or both, oil can enter pore spaces in a porous medium such as soil or sediment. These behaviors can be complex in a three-phase system, with oil forming an intermediate-wetting phase between water (the wetting phase, tending to have strong contact with the surrounding medium) and air (the non-wetting phase, tending to have less contact with the surrounding medium). Spreading forces can lead to oil forming thin layers in the three-phase system, between air and water within pore space. These systems have been studied in a laboratory-scale [see, for example, Wilson et al. 1990 and Keller et al. 1997]. Oil under these systems can exhibit very low residual saturations, meaning that spreading forces over time and rising/falling air-water interfaces can be capable of converting most oil within the pore space into sheen and making it amenable to degradation by methods described below (see Section 6).

Dynamics within a two-phase oil and water system, such as exists below the water table, are also well understood; oil typically exists as a non-wetting phase in this system, and a number of relative permeability models exist to describe relative permeability of a soil medium to oil based on soil properties, fluid properties, and pore conditions. The mobility of oil in the pore space in this condition is generally lower than that associated with a three-phase system, and is controlled by hydraulic gradients, viscosity, and oil saturation (i.e., the percentage of pore space occupied by oil). In instances where soil structures are disturbed via erosional effects or scouring, oil may also leave porous media to form sheens or surficial layers. Controls and mechanisms for movement of oil as a non-wetting phase in a two-phase system, including the entry pressure necessary for oil to enter new pore spaces and displace water from pores, are described by Charbeneau [2000], Corey [1986], and Wilson et al. [1990].

## 5. Overall Conceptual Understanding

Oil within porous media in or near Sulphur or Leslie Runs will likely be present within a wide range of both two-phase and three-phase systems over time. Oil is also likely to be stable and immobile during some conditions (e.g., when submerged and not subject to strong hydraulic gradients) and mobile at a small scale (e.g., via spreading over an air-water interface when a rising or falling water level passes through the porous medium) during others. This range of conditions is expected to provide a mechanism for areas of oil stored in pore space to be gradually depleted over time, with small amounts of oil mass converted to sheens. These sheens would then be subject to photo-oxidation or biodegradation, as discussed in the following section. Additional depletion may occur through other mechanisms, such as direct biodegradation and/or dissolution.

Overall, the combined effects of the mechanisms described above are expected to lead to gradual depletion of a mostly stable, finite volume of oil within porous media within and adjacent to the waterways. Mechanisms for attenuation of oil are well-understood and described in the following section.

## 6. Anticipated Attenuation Mechanisms

Several mechanisms have been long-recognized as potentially significant for the degradation of petroleum crude oils and refined products to the environment. Each of these is evaluated relative to both the conditions in Sulphur and Leslie Runs and the characteristics of the released mineral base oil.

### Evaporation

Evaporative losses of petroleum products are largely dependent on the substance's vapor pressure. Vapor pressure is in turn dependent on temperature. Because refined petroleum products are composed of thousands of individual constituents, it is impractical to attempt to define vapor pressures for them. Molecular weight and boiling point are sometimes used as proxies for vapor pressure, with higher evaporative losses seen with substances having molecular weights <150 amu and boiling points <175 °C. To understand vapor pressure of petroleum products, it is instructive to consider the properties of representative constituents. For example, n-pentane evaporates readily (5 carbons, MW = 72 g/mol; BP = 35 °C; $VP_{25°C}$ = 69 kPa), n-decane evaporates slowly (10 carbons, MW = 142 g/mol; BP = 174 °C; $VP_{25°C}$ = 0.2 kPa), and n-pentadecane (15 carbons, MW = 212 g/mol; BP = 271 °C; $VP_{25°C}$ = 0.0007 kPa) has little if any evaporative loss at room temperature.[v] [Stout et al., 2002]

Table 3 summarizes the above in reference to common petroleum products. In general terms, compounds like pentane (C5) and decane (C10) are representative of the evaporation characteristics for gasoline (of which they are components), and pentadecane (C15), which is a component of diesel, has low evaporative loss. Diesel fuels in general have lower evaporation than gasoline. In terms of evaporation, mineral oils are more similar to vegetable oils used for cooking (i.e., minimal to no evaporation).

***Table 3.*** *Overview of carbon ranges and boiling point ranges for representative petroleum products. [Stout et al., 2002; Wang et al., 2006]*

| Petroleum Product | Typical carbon range | Typical BP range | Evaporation Potential |
|---|---|---|---|
| Gasoline | n-C4 to n-C15 | 40°C to 180°C | Fast to moderate |
| Diesel (#2) | n-C8 to n-C28 | 125°C to 380°C | Moderate to low |
| Lubricating Oils | n-C17 to n-C45 | 300°C to 600°C | Low to none |
| YUBASE6 | Not available | 380°C to 550°C | |

In Sulphur and Leslie Run waterways, residual YUBASE6 is expected to be either associated with sediments in the creeks or present as surface sheens, and appreciable evaporative loss is expected to occur only from surface sheens. The boiling point range (380°C to 550°C) and vapor pressure (≤0.1 kPa) cited in the product SDS suggest this oil will have vapor pressures less than n-decane and possibly similar to pentadecane. Therefore, minimal to no degradative loss due to evaporation at this location and any such losses will be dependent on its ability to form a surface sheen.

## Dissolution/Solubilization

The terms dissolution and solubilization are typically used interchangeably when discussing the tendency for a petroleum product to dissolve into water. It is also referred to as degradation by water washing. Dissolution is considered a degradation route in that it can, under the right conditions, result in the progressive loss of hydrocarbon mass from a source location. Dissolution has the potential to provide a ready degradation route if YUBASE6 is present in creek sediments in Sulphur and Leslie Runs, as water continually passes through the creeks year-round and the amount of YUBASE6 present is fixed. It is however dependent on the tendency for the oil to dissolve into the water. [Stout et al. 2002]

As petroleum products are mixtures of thousands of individual hydrocarbon compounds, petroleum dissolution into water must be thought of in terms of the solubilities of the individual compounds rather than the product as a whole. It must also be considered as the relative preference for individual petroleum compounds to solubilize in the water versus in the petroleum mixture. [Stout et al. 2002]

Table 4 (see next page) presents water solubilities of some representative aliphatic hydrocarbons (i.e. paraffins, isoparaffins and naphthenes). Aromatic compounds, while generally more water soluble than aliphatic hydrocarbons with the same number of carbons, are not considered here as YUBASE6 does not have sufficient aromatic content to produce a meaningful loss in hydrocarbon content through their dissolution.

[v] Chemical and physical properties are from PubChem (https://pubchem.ncbi.nlm.nih.gov/)

***Table 4.*** *Aqueous solubilities of hydrocarbons with equivalent carbon numbers but from different petroleum classes.*

| | **Aqueous Solubilities at 25 °C (mg/L)[vi]** | | |
|---|---|---|---|
| **# Carbons** | **Paraffins** | **Isoparaffins** | **Naphthenes** |
| 6 | n-hexane, 10 | 3-methylpetane, 18 | cyclohexane, 55 |
| 10 | n-decane, 0.05 | 2,6-dimethyloctane, 1.0 | decalin, 0.9 |
| 15 | n-pentadecane, 0.002 | farnesane, 0.004 | drimane, 0.04 |
| 20 | eicosane, 0.002 | phytane, 0.00002 | pimarane, 0.0009 |

Table 4 (above) highlights some generalizations noted by Stout et al. [2002] and Lafargue and Barker [1998].

- Hydrocarbons with fewer carbons have higher water solubilities than heavier hydrocarbons in the same class.
- For hydrocarbons with the same number of carbons, alkylation or cyclization generally results in higher water solubility.
- Items 1 and 2 point to the fact that water solubility increases with compound polarity.
- The trends tend to break down for hydrocarbons with more than 15 carbons.

The work of Lafargue and Barker [1988] addresses the above-noted uncertainties between component solubility and hydrocarbon mass loss on water washing of petroleum products through a series of laboratory studies and comparison to field examples. For hydrocarbon fractions greater than C15, water washing had limited to no effect on aliphatic hydrocarbons (paraffins, isoprenoids, and naphthenes). This is consistent with the water solubilities shown in Table 4 for C20 compounds in that aqueous solubilities at this carbon number are all very low. YUBASE6 is expected to contain primarily aliphatic hydrocarbons with carbon numbers ≥C20. For this reason, dissolution on its own is not expected to be a significant contributor to hydrocarbon mass loss.

Al-Otibi et al. [2022] have recently demonstrated good success in applying a series of fungal (yeast) cultures in aqueous solutions, which were isolated from oil-reservoir soils in Saudi Arabia, for dissolution and solubilization of recalcitrant crude and used oils, through biosurfactants production. The biosurfactants caused the collapse of oil droplets within the system within 15 days, with cultures grown with crude and used oils producing superior biosurfactant effects than those grown in diesel and kerosene. The biosurfactants caused oily contaminants to become more water soluble. Once solubilized, this would limit the oil's ability to sheen and enable it to disperse in the water flow to complete secondary biodegradation and mineralization.

Although the science around fungal biosurfactant generation to aid in recalcitrant petroleum biodegradation is a newly-emerging science, the findings highlight the importance of a healthy, diverse microbial community to optimize attenuation of mineral base oil hydrocarbon mass and sheening.

## Biodegradation

As Stout et al. [2002] have noted, there are indigenous microbial populations in most environments (soil, sediment, water) that are capable of degrading petroleum as long as they are provided favorable conditions, including nutrients, an energy source, oxygen, water, appropriate pH, and temperature. Oxygen dissolved in surface or sub-surface water is sufficient to maintain degradation so long as it is

[vi] Paraffins solubilities from Lafargue and Barker, 1988; other solubilities are from PubChem (https://pubchem.ncbi.nlm.nih.gov/) or predicted using the US Environmental Protection Agency's EPISuite™ (https://www.epa.gov/tsca-screening-tools/epi-suitetm-estimation-program-interface).

regularly replenished. The presence of separate phase petroleum pools is regarded as problematic as such environments are toxic to petroleum-degrading microbes. The currently-proposed stream mitigation program is expected to largely address this potential issue. Among the aliphatic hydrocarbons, straight chain hydrocarbons (i.e., paraffins, n-alkanes) are the most susceptible to biodegradation, branched (isoprenoids / isoparaffins) and cyclic (naphthenic, alicyclic) hydrocarbons are significantly less biodegradable due to steric hindrance effects that limit the access of bacterial enzymes to the carbon-carbon bonds. However, even these more recalcitrant hydrocarbons will degrade as the availability of paraffins is reduced. Aromatics degradation is typically initiated later than for paraffins, and somewhat in parallel with isoparaffins. Again, if aromatics are absent, naphthene degradation is expected to begin sooner.

Because YUBASE6 is expected to contain little if any paraffin and very small amounts of aromatic compounds, its biodegradation is expected to begin as soon as conditions are otherwise favorable. This is in contrast to the case of a typical heavy petroleum product release where isoparaffins and naphthenes degradation is delayed until paraffins and aromatics degradation is well underway. As described by Wang and Christensen [2006], the biodegradation of petroleum in the environment depends on the composition of the local microbial community. Indigenous bacteria and other microorganisms are often the best adapted and most effective at degrading oil as they are acclimatized to the conditions of the area. Given the long history of urban and industrial impacts – particularly in Sulphur Run – and evidence of the presence of legacy petroleum impacts in the area, the local microbial community may already be well adapted for petroleum constituent degradation.

Hernandez-Adame et al. [2021] note the importance of the synergistic participation of microbial consortia including fungi, for optimal degradation of hydrocarbons. This is particularly important where two removal stages are considered. In the first fast stage (primary degradation), the hydrocarbons that are easily degraded are consumed, and the second slower stage addresses the more recalcitrant petroleum components. For mineral base oils like YUBASE6, based on the characteristics inferred from the producer SDS, the first/primary degradation stage is expected to reduce ~54% of the hydrocarbon mass, (see Section 2, Description of Released Petroleum Material) with the remaining more recalcitrant component consisting primarily of naphthenic (cyclic/alicyclic) saturated hydrocarbons. Prenafeta-Boldú et al. [2019] have noted that fungal communities have shown promising results for degradation of recalcitrant alicyclic hydrocarbons, including the bicyclic monoterpene α-pinene. Al-Otibi et al. [2022] have also reported good results with a variety of candida (yeast) fungal strains for the degradation of crude oil and used oil isolated from oil-reservoir soils in Saudi Arabia. The recognition of the importance of fungal communities in the degradation of the more recalcitrant components of hydrocarbons is an emerging topic in petroleum release remediation. Although controlled studies demonstrating effectiveness at complex release sites have not yet been published to the authors' knowledge, this emerging science highlights the importance of maintaining a healthy, petroleum-acclimatized community of indigenous microbes from a variety of taxa and species to achieve optimal bioremediation following a heavy oil release. Further, limiting disruption to those fungal communities is important for supporting the biodegradation processes.

Given appropriate conditions of temperature, oxygenation, water chemistry, and microbial community composition, the aqueous environments present in Sulphur and Leslie Runs are expected to biodegrade petroleum products to smaller more polar compounds such as alcohols, phenols, aldehydes, epoxides, diols, and carboxylic acid. Of note, volatile and semivolatile constituents comprised of the above compound classes have been monitored in surface water samples in Sulphur and Leslie Runs since February 2023. Approximately 99.5% of volatile and semivolatile analyses have been "not-detected" in surface water since August 2023 (i.e., 292 positive results out of 51,985 total results).

### Emulsification

Emulsification is typically defined as the process by which fine water droplets are dispersed into an oil. This may occur either in a surface sheen within the water column, or an oil pocket in the benthic zone. Typically wave or water flow energy is required to initiate the formation of an oil-water emulsion at a petroleum release site. Although some emulsions can be problematic for natural attenuation by slowing the rate of microbial degradation in stable emulsions, some newer dispersants are reported to accelerate biodegradation, even beyond what would have been expected from just the increased surface area of the finely dispersed oil droplets. [Hubbe et al. 2013] However, asphaltenes at >3% w/w in the oil are required to stabilize petroleum oil-water emulsions. Mineral base oil is unlikely to form emulsions at aquatic release sites as asphaltenes are removed during the refining process. [Dalbey et al., 2014, Haus et al., 2003] Any emulsions formed are expected to be unstable and break down to separate water and oil phases within minutes to hours. Emulsification is not expected to be a significant contributor to mineral base oil environmental degradation. [Wang and Christensen, 2006; Fingas and Fieldhouse, 2003; Silva et al., 2022]

## Dispersion

Oil dispersion is best understood as the opposite of emulsification. Whereas emulsification involves the entrainment of small water droplets within an oil product, dispersion involves the entrainment of small oil droplets within a water column. Some authors refer to both processes as emulsions, distinguished as either oil-in-water (O/W) emulsions or water-in-oil (W/O) emulsions. [Hubbe et al. 2013] The process of oil, sheen, or slick dispersion may be through either natural processes or artificial processes with the addition of dispersant chemicals. Natural processes involve the entrainment of small droplets of oil within a water column through wave or water flow energy. Oil droplets <20 micrometers (µm) in diameter can be stable in a water column for long periods, thus allowing for the required biological degradation processes to proceed to completion. Like emulsions, the process of natural dispersion into stable dispersions is also dependent on the presence of asphaltenes in the oil; therefore, natural dispersion is unlikely be a significant contributor to mineral base oil environmental biodegradation. [Wang and Christensen 2006; Péquin et al. 2022; Hubbe et al. 2013] Wave or water flow energy, or other physical processes, are likely to form non-stable dispersions if creek-base materials containing entrained YUBASE6 product are disturbed. These are expected to collapse into surface sheens in a time-frame of seconds to minutes once the energy dissipates. [Wang and Christensen 2006] While this process cannot in itself be considered as a form of natural attenuation, it would support photooxidation as a process for ultimate removal of remaining product from the creek system. This is discussed further below.

## Sedimentation

Sedimentation refers to processes whereby oil is permanently deposited on the bottom of a water body. Once sedimented it will be progressively covered by other sediments and biodegradation will either shift to anaerobic processes and/or be significantly slowed. In a related process, oil-mineral aggregates (OMA), also referred to as oil-particulate aggregates (OPA), can form when oil contacts fine mineral particles (such as suspended clay particles) and water. Unlike sedimentation, OMA formations have been observed to facilitate natural oil removal and enhance biodegradation. [Owens and Lee 2003; Wang and Christensen 2006] The processes have been reported as equally effective in marine and freshwater environments and remedial options to facilitate the process have been investigated [USGS 2015]. These have been correlated with the removal of oil stranded within sediments (via sedimentation) through both natural recovery (natural attenuation) and active remediation through the addition of suspended particulate matter (e.g. clay minerals) in the presence of turbulent water flow. The relatively stable OPAs are more easily dispersed in the water column, reducing the presence of free oil and making the oil more available for biodegradation. It is reported to be equally effective for both light and heavy oils. Caution is warranted however, because while regarded as an effective self-cleansing process in even low-energy intertidal environments, naturally formed OPAs can lengthen and complicate oil spill cleanup in lowland rivers with gentle gradients.

“Modeling the transport and fate of OPAs in riverine systems requires integration of hydrodynamic, sediment transport, and contaminant fate and transport models (Dollhopf and others, 2014; Niu and others, 2010, 2011), while employing some of the same guidelines used for developing conceptual and mathematical models of fate and transport of contaminated sediment at hazardous waste sites (U.S. Environmental Protection Agency, 2005).” [USGS 2015]

Like dispersion and emulsification, OMA/OPA formation is also dependent on asphaltenes in the released oil. Thus, the role of OPA in mineral base oil releases cannot be adequately understood from studies of released crude oils. [Gustitus et al. 2017]

### Photooxidation

Photooxidation can contribute significantly to degradation of petroleum oils released to aqueous systems. Its effectiveness is dependent on the thickness of the sheen/slick and the sun-incidence with thinner sheens oxidizing more readily. Petroleum photooxidation yields a similar suite of more polar degradation products as for biodegradation, including alcohols, ketones, aldehydes, and acids. As for biodegradation, these are more water soluble than oils and therefore more readily biodegraded themselves than the oil they originated from. [Wang and Christensen, 2006]

Because YUBASE6 is unlikely to undergo sedimentation, any pockets of free product remaining after physical mitigation efforts conclude are expected to persist as such if trapped by overlying impervious materials. Therefore natural creek-base disturbances may release minor sheening following physical mitigation efforts. Such natural disturbances may be due to gas ebullition from the subsurface, micro or macro fauna or flora activities, or storm water pulses, for example. This process is expected to support the eventual full removal of any remaining YUBASE6 from the creek system as the free product will remain lighter than water rather than transforming into a solid permanent deposit in the creek bed.

For photooxidation specific to mineral base oil products, the work of Shankar et al. [2020] is instructive. The group studied photooxidation of lubricating oil sheens on seawater during 96 hours of natural photooxidation. During this time, they observed that a wide range of polar degradation products were formed and moved from the sheen into the water column, including carboxylic acids, esters, anhydrides, phenols, aldehydes, and ketones. Degradation was observed within the first three hours of photooxidation. Most of the compounds observed at 3 hours continued to increase until 48 hours, after which they decreased, suggesting further photooxidation of the dissolved photoproducts. As the carbon-carbon bonds in aliphatic hydrocarbons are resistant to direct photooxidation, the mechanism underlying the degradation of the oil and formation of the polar degradation products likely involved indirect photooxidation. The authors theorized that natural organic matter in the water was first oxidized, generating reactive oxygen which then served as the primary oxidant causing the degradation of the aliphatic oil components.

With reference to the environments of Sulphur and Leslie Runs, it is expected that minor sheening resulting from biodegradation-resistant remnants of YUBASE6 in the creek systems will also readily photodegrade in areas receiving direct sunlight for a few hours per day with ecologically relevant levels of natural organic matter in dissolved in the water. A healthy ecosystem of sediment microbes and native invertebrates along with other flora and fauna is expected to provide sufficient dissolved matter to support indirect photooxidation of sheens.

### Anticipated extent of natural YUBASE6 environmental attenuation

On release to the environment, degradation rates of petroleum materials can vary widely, not only between different types of materials but also between locations for the same materials. Stout et al., [2002] identified the significant contributors to variable degradation rates for a single release as follows:

- Release conditions: rate, volume, and composition
- Depth: surface, subsurface, water contact or depth to groundwater
- Soil conditions: moisture, oxygen, microbial populations, stratigraphy

Further confounding the issue is the potential presence of pre-existing petroleum impacts. Degradation rates can be very different, either faster or slower, at sites with co-mingled petroleum impacts compared to a release in a pristine environment.

Given the foregoing, attempts to assign degradation rates to specific releases are subject to much uncertainty. As such, there may be little value in assigning either a relative or absolute projected rate of degradation to a specific petroleum release. [Stout et al., 2002]

These limitations and uncertainties extend to efforts to predict chemical half-life as a component of an environmental risk assessment. To date, models to predict chemical persistence have been limited to predictions for individual compounds. The physical and chemical variability found in petroleum hydrocarbons present challenges that make predictive model development unfeasible for crude oils and refined petroleum products. Models predicting environmental persistence for individual constituents of a petroleum product are used as proxy in such cases. [Prosser et al., 2016]

The EPA developed a suite of six models (the Biodegradation Probability Program: BIOWIN) to address this challenge. These models were viewed as somewhat limited for broad applicability to petroleum hydrocarbons and an updated model (BIOHCWin) has since been proposed to predict the biodegradation half-life of individual petroleum product constituents. Prosser et al. [2016] evaluated the utility of BIOHCWin for predicting the biodegradation half-lives of petroleum hydrocarbon constituents in freshwater and seawater relative to empirical data from over 50 recent studies. Of note, the EPA considers a constituent to be persistent if its half-life in freshwater is >40 days. Overall, the predictive power was stronger for freshwater than seawater and 96% of freshwater predictions correlated well with the empirical data; correctly predicting constituent persistence relative to the empirical data. Among the misclassified constituents most were predicted conservatively, i.e. predicted half-lives suggested the constituent would be persistent when the empirical data showed it was not. Of note, naphthenic (i.e. cyclic aliphatic) constituents were included among the conservatively misclassified constituents. [Prosser et al., 2016]

Of the 489 constituents evaluated in freshwater, 125 were either isoparaffins or naphthenes, which form the majority of the constituents in mineral base oil. None were experimentally determined to be persistent (i.e. biodegradation half-lives were all <40 days) but eight were predicted to be persistent (two isoparaffins and six naphthenes). By comparison, of the 27 paraffins included, none were either predicted or observed to be persistent. In general, BIOHCWin appears to be conservative in general in predicting biodegradation half-lives for isoparaffins and naphthenes. Experimentally determined half-lives were found to be less than the predicted half-lives for 70% of these constituents. Experimentally determined half-lives were found to be on average 10 days less than what was predicted.

In summary, attempts to predict rate or extent of attenuation for remnants of YUBASE6 in Sulphur and Leslie Runs subsequent to physical mitigation efforts are expected to be of limited value and from a technical standpoint, there is no defensible basis for assigning either a relative or absolute projected rate of attenuation from either the available scientific literature or available models.

While quantification of a degradation rate in traditional terms may not be practical for petroleum product releases, the presence of well-understood degradation mechanisms can nonetheless provide confidence that degradation is occurring. This document has identified three potential drivers of YUBASE6 natural attenuation in Sulphur and Leslie Runs. These are summarized here, along with an assessment of their expected relative influence and probabilities.

- Primary attenuation driver: Biodegradation – high probability to approximately 54% mineral base oil TPH mass reduction
- Secondary attenuation driver: Photooxidation – high probability for YUBASE6 sheens, ideally suited for minor sheening, supported by dissolved organic matter produced by a healthy creek ecosystem and natural physical dispersion mechanisms.
- Tertiary attenuation driver: Biosurfactant formation and solubilization – lower probability, unproven emerging remedial pathway, dependent on appropriate and healthy fungal communities.

The rate of natural attenuation observed will be dependent on how well the natural environments in Sulphur and Leslie Runs support these processes.

## 7. Anticipated Effects of Attenuation

Over time, the attenuation mechanisms described above are expected to lead to the following within areas of oil-impacted sediment:

A reduction in overall remaining mass of the released oil in the environment.
Because the volume of YUBASE6 initially released is finite, and new YUBASE6 is not being added to the system, the biodegradation mechanisms described above will decrease the overall total mass of the released mineral base oil by converting its constituents to end products, including carbon dioxide and water.

A reduction in the oil saturation within pore space of sediment and soil.
As the overall mass of oil decreases, the percentage of pore space occupied by oil in a given volume of impacted sediment or soil will decrease. Redistribution of oil during stabilization and equilibration will also tend to decrease the percentage of pore space occupied by oil. This percentage, referred to as oil saturation, is a key influence on oil mobility in a two-phase system (specifically on the relative permeability of a porous medium to oil).

An increase in the viscosity of the remaining oil.
Generally, the more readily evaporated, dissolved, or biodegradable compounds in a petroleum mixture are the lighter, lower-molecular weight compounds within the mixture. As the lighter compounds degrade and attenuate, the remaining compounds in the mixture will be relatively higher-molecular-weight and the viscosity of the mixture will tend to increase.

The combined effects of the above processes, which each reflect straightforward physical changes, lead to an overall lower degree of oil mobility in the environment. A reduction in the finite amount of oil mass present necessarily limits the degree to which oil can travel in porous media, and the reduction in pore space saturation and increase in oil viscosity will both tend to decrease the relative permeability of a porous medium to oil and reduce oil mobility. These conditions will limit the ability of oil to migrate into previously unimpacted areas, especially in a two-phase system, and generally tend to stabilize oil in places where attenuation mechanisms such as biodegradation will gradually contribute to further mass reductions.

## 8. Summary and Potential Next Steps

The released mineral base oil is a clear, colorless liquid that is not expected to have significant toxicity to humans or ecological receptors, and is expected to naturally attenuate over time. Biodegradation, which could occur either in porous media or in association with sheens present on waterways, and supported by dispersion and/or dissolution, is expected to be a dominant mechanism for attenuation, leading to conversion of hydrocarbon constituents to carbon dioxide and water. Photo-oxidation is also expected to be an important mechanism for attenuation of this oil, especially following sheen formation. In addition, a healthy mixed community of petroleum-acclimatized fungal species indigenous to Sulphur and Leslie Runs may be capable of generating biological surfactants that have been reported to aid in the dissolution/solubilization of the more recalcitrant components of the released mineral base oil, which will reduce sheen generation.

Results of recent forensic sampling of sediments and sheens in Sulphur Run and Leslie Run are expected to support assessment of what products other than the YUBASE6 mineral base oil are present in the creeks and whether observed sheens are related to the released mineral base oil or other legacy/ongoing sources. The forensic data will help establish this linkage – as has been used previously in a similar petroleum release [USGS 2015] – and establish if YUBASE6 is attenuating as anticipated at this site.

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# Attachment E

Culvert 1 Mitigation

Norfolk Southern Railway Company

East Palestine, Ohio Derailment

# Attachment E: Culvert C1 Mitigation Options Plan

**Columbiana County**

**East Palestine, Ohio**

March 2024

# Contents



# Tables



# Figures



# Appendices

# Acronyms and Abbreviations

| | |
|---|---|
| Arcadis | Arcadis U.S., Inc. |
| JSAs | Job Safety Analyses |
| JHAs | Job Hazard Analyses |
| NSRC | Norfolk Southern Railway Company |
| OSHA | Occupational Safety and Health Administration |
| PE | Professional Engineer |
| USEPA | United States Environmental Protection Agency |

# 1 Introduction

Arcadis U.S., Inc. (Arcadis) prepared this Culvert C1 Mitigation Options Plan (Plan), on behalf of Norfolk Southern Railway Company (NSRC), in response to direction provided by the United States Environmental Protection Agency (USEPA) in their March 1, 2024 approval with modifications letter for the Sediment Mitigation Measures Work Plan (Arcadis 2024). This Plan is Attachment E to that document. The purpose of this Plan is to describe mitigation measures associated with cleaning locations in Culvert C1 where qualitative sheen assessment scores of 2 and 3 have been documented as well as measures that will be implemented to address potential occupational health and safety challenges during the work.

## 1.1 Background

Culvert cleaning activities associated with the Clean Water Act Order were initiated in November 2023 to address sediment within five culverts, identified as C0, C1, C2, C3, and C4, located along Sulphur Run within the Village of East Palestine, Ohio. Refer to Figure 1 for the locations of the culverts. Culvert cleaning activities were conducted in accordance with the Sulphur Run Culvert Sediment Removal Plan (Arcadis 2023a; Removal Plan). The Removal Plan included a pre-cleaning investigation, utilizing drone and robotic equipment, to assess working conditions in the culverts and facilitate development of a cleaning plan prior to the start of work. Pre-cleaning investigation work in Culvert C1 was completed from November 11 through 15, 2023.

After initial assessment of the pre-cleaning investigation information collected from Culvert C1 and a subsequent field review, USEPA and Occupational Safety and Health Administration (OSHA) concerns regarding occupational safety caused USEPA to suspend plans to clean Culvert C1 until further evaluation of cleanup approaches and associated safety protocols have been completed. These concerns included the duration the workers would be required to be in the culvert, working in water in very cold temperatures, and stream ingress and egress. To address these concerns, a supplemental field investigation was performed to refine the scope of work within the culvert in the interest of worker safety. Addendum 1 to the Removal Plan was developed by Arcadis on behalf of NSRC and approved by the USEPA on December 18, 2023 with modifications (Arcadis 2023b). The addendum consisted of a supplemental field investigation, conducted by entering Culvert C1, to perform the following:

- A sheen assessment to determine areas where sheen is present within the sediments and debris within the culvert;
- Evaluation of the culvert bottom to verify the presence or absence of a constructed structural bottom; and
- Measurement of sediment depth.

The findings from the supplemental field investigation – which was completed on December 19, 2023 – are summarized in the Culvert Sediment Removal Report (Arcadis 2023c).

USEPA approved the Culvert Sediment Removal Report via letter dated February 8, 2024, and directed that the plan for Culvert C1 cleaning activities be presented in the Sediment Mitigation Measures Work Plan. USEPA provided additional detail on next steps for Culvert C1 in their March 1, 2024 approval with modifications letter for the Sediment Mitigation Measures Work Plan. Following receipt of the March 1, 2024 letter, NSRC and Arcadis representatives met with agency representatives, including OSHA, to review the proposed tactics that will be implemented to mitigate the health and safety-related concerns associated with Culvert C1 cleaning activities.

### 1.1.1 Previous Culvert Cleaning Operations

In response to observations of sheen at the outlet of Culvert C1, jet washing operations were undertaken by NSRC within Culvert C1 in March 2023 over period of approximately four days. This work was conducted from the exterior of the culvert only (i.e., from a manhole at the corner of Taggart and James Street, the inlet, and the outlet) by extending the jet washing hose into the culvert. Jet washing was conducted in approximately two halves (i.e., upstream and downstream of the manhole), with each half taking approximately two days to clean. Daily cleaning activities were halted when sheen was no longer observed at the outlet. Containment was established at the outlet of the culvert, where sheen observations were made.

## 1.2 Current Culvert Conditions

Existing conditions in Culvert C1 have been assessed on several occasions by robotic and drone equipment and separately by NSRC and agency representatives via person-entry. The robotic and drone investigations provided detailed imagery, Lidar survey data, and air monitoring data of the interior of the Culvert C1. NSRC and agency inspections included the performance of the Supplemental Sheen Assessment and inspection of culvert bottom conditions, wall and ceiling condition, and sediment depth. This information proved to be very useful in assessing the potential hazards and developing cleaning plans. Additional existing condition culvert information is presented in the Culvert Sediment Removal Report (Arcadis 2023c). Table 1, below, summarizes the key culvert conditions that were confirmed during these investigations and presents Culvert C1 data in 50-foot-long segments beginning at the culvert outlet moving upstream.

**Table 1. Culvert C1 Supplemental Assessment**

| Site Name | Distance From Downstream (feet) | Culvert Width (feet) | Sediment Depth (inches) | Estimated Sediment Volume (cubic yards) | Sheen Category [a] | Stream Morphology | Bottom Conditions | Material Type |
|---|---|---|---|---|---|---|---|---|
| Outlet | 0 | 15 | -- | -- | -- | -- | -- | -- |
| C1-50 | 50 | 15 | -- [b] | -- [b] | 1 | Riffle | No bottom | Sediment mixed with cobble/gravel |
| C1-100 | 100 | 10 | -- [b] | -- [b] | 2 | Riffle | No bottom | Sediment mixed with cobble/gravel |
| C1-150 | 150 | 10 | -- [b] | -- [b] | 1 | Riffle | No bottom | Sediment mixed with cobble/gravel |
| C1-200 | 200 | 10 | -- [b] | -- [b] | 3 | Riffle | No bottom | Sediment mixed with cobble/gravel |
| C1-220 | 220 | 10 | -- [b] | -- [b] | 3 | Riffle | Transition to corrugated pipe | Sediment mixed with cobble/gravel |
| C1-250 | 250 | 10 | 1 | 1 | 0 | Pool | Corrugated pipe | Minimal sediment between ribs |
| C1-300 | 300 | 10 | 1.5 | 2 | 0 | Pool | Corrugated pipe | Sediment and gravel |
| C1-350 | 350 | 10 | 2 | 3 | 3 | Pool | Corrugated pipe | Minimal sediment between ribs |
| C1-400 | 400 | 10 | 2 | 3 | 2 | Pool | Corrugated pipe | Fine sediment, little rock |
| C1-450 | 450 | 10 | 4 | 6 | 1 | Pool | Concrete bottom | Sandy sediment |
| C1-500 | 500 | 10 | 4 | 6 | 0 | Pool | Concrete bottom | No sediment |
| C1-550 | 550 | 10 | 0 | 0 | 0 | Riffle | Concrete bottom | No sediment |
| C1-600 | 600 | 10 | 0 | 0 | 0 | Riffle | Concrete bottom | No sediment |
| C1-650 | 650 | 10 | 0 | 0 | 0 | Riffle | Concrete bottom | No sediment |
| C1-700 | 700 | 10 | 0 | 0 | 0 | Riffle | Concrete bottom | No sediment |
| C1-750 | 750 | 10 | 0 | 0 | 0 | Pool | Concrete bottom | No sediment |
| C1-800 | 800 | 10 | 0 | 0 | 0 | Pool | Concrete bottom | No sediment |
| Inlet | 818 | -- | -- | -- | -- | -- | -- | -- |
| | | | Total (CY) | 22 | | | | |

**Notes:**
a Scores are based on the following criteria:
0 = No sheen
1 = Light sheen; assigned when a small presence of string-sheen is observed, and the majority of the stream bed area/culvert bottom does not produce sheen during disturbance
2 = Medium sheen assigned when there is a step-down in the presence of sheen stream/culvert-wide, with basketball-sized bubbles and no odor
3 = Heavy sheen assigned when there is a stream/culvert-wide prevalence of sheen or larger amounts of sheen produced with odor upon disturbance
b Estimated sediment depth/volume has not been determined. Structural bottom was not identified, despite pot holing more than 2 feet deep.

# 2 Proposed Mitigation Plan

This section describes mitigation efforts that will be undertaken to address sheen in Culvert C1 as well as the health and safety concerns associated with performing this work.

The following outlines the measures/tactics that will be implemented to minimize the potential health and safety-related hazards associated with performing cleaning activities within Culvert C1. Culvert C1 health and safety hazards include, but are not limited to, the following:

- Limited access;
- Work in water;
- Slips, trips, and falls;
- Lifting heavy objects;
- Atmospheric conditions;
- Culvert deterioration;
- Low light;
- Culvert ingress/egress along existing stream bank; and
- Equipment noise.

The health and safety hazards were previously addressed in the project-specific Job Safety/Job Hazard Analyses (JSAs or JHAs) prepared for the earlier efforts. The JSAs or JHAs that apply to the proposed field effort include the following: JSA - Culvert Cleaning 1381-HME, CSR Preplan for Culvert Cleaning Operations (entry plan), JSA For Culvert Sediment and Sheen Sampling, Culvert Manual Entry & Assessment JHA Update 2 (Air), and the Sulphur Run Creek Washing JHA. Note that the Culvert Cleaning and Creek Washing JHAs have been recently updated and are currently under review. Work will not begin until they are fully approved.

The mitigation tactics described below will be implemented during the work.

## 2.1 Mitigation Tactic #1 – OSHA Representation During Work

As an added level of health and safety precaution, OSHA has indicated they will have staff available to oversee work throughout performance of the Culvert C1 cleaning. OSHA will be an integral team member - alongside USEPA, Ohio Environmental Protection Agency, Coast Guard, and NSRC representatives - constantly assessing the real-time conditions to facilitate safe performance of the work.

## 2.2 Mitigation Tactic #2 – Structural Engineer’s Inspection

A structural engineer, licensed as a Professional Engineer (PE) in the state of Ohio, conducted a visual inspection of Culvert C1 to assess its condition. The inspection was conducted by walking the length of the work areas within the culvert. This inspection included the following:

- Visual assessment of the condition of all visible concrete and corrugated metal surfaces;
- Identification of any structurally significant cracks, spalling, rusting, or similar visual indicators;
- Sounding a selection of concrete surfaces to determine potential presence of areas with surface delamination;
- Photographing existing conditions, including documenting any areas of concern; and
- Identification of any other signs of structural distress.

The results of the inspection were summarized in a memorandum prepared by the PE, dated March 22, 2024 (Appendix 2). The PE's conclusion was that there were no structural issues regarding the condition of the culvert that should prohibit work within the culvert. The PE identified, within the concrete sections of culvert, areas along the ceiling that were delaminating in select locations, areas with surface cracks, and portions of the southern wall with some undermining. The PE noted that the delamination and surface cracks are a maintenance issue and not a structural concern. Further, he noted that there was no indication of movement or stress on the culvert walls due to the undermining. The PE recommended that within the culvert section where there is no structural bottom, cleaning measures should be conducted in a manner that will not lead to significant material removal from the bottom section of the culvert. Therefore, in the vicinity of the culvert wall foundation, in sections with no structural bottom, stream washing will be conducted to lightly agitate the substrate and not result in significant movement of material from these areas as recommended by the PE. In addition, areas of ceiling delamination and surface cracking will be monitored for any changed conditions. A JHA will be developed and approved by USEPA Safety prior to the start of work, which describes the associated protocol for implementation of the PE's recommendation.

Note that the Village of East Palestine representatives were contacted by NSRC and they confirmed that they are not aware of any structural issues associated with Culvert C1.

## 2.3 Mitigation Tactic #3 – Revised Cleaning Methods

The sheen analysis, performed in accordance with Addendum 1 to the Removal Plan, sectioned the culvert into 17 work areas. The results of the sheen assessment indicated that there were four sections out of 17 that exhibited enough sheen production to warrant cleaning activities (i.e., those sections with a sheen assessment score of 2 or 3) as summarized in Table 1. Refer to Figure 2, attached, which shows the locations of the sections of culvert with a sheen assessment of 2 or 3. A transition from the concrete culvert to the corrugated metal pipe culvert occurs in one of the sections that exhibited sheen. Therefore, of the four sections identified as producing a sheen score of 2 or 3, approximately 1.75 sections were bottomless concrete culvert and 2.25 sections were identified within the corrugated metal pipe sections that have a structural bottom.

Proposed cleaning methods were evaluated and modified to minimize cleaning duration and stress on the workers. Bottomless culvert section cleaning methods were modified to be consistent with stream washing techniques being conducted outside the culverts. Cleaning methods within culvert sections that have a structural bottom will utilize vacuum extraction with modifications.

Alternative mechanized means for sediment removal were considered. A feasibility study of these alternatives is provided in Appendix 1 to this Plan. In addition, jet washing from the exterior of the culvert was considered as an alternative to stream washing inside the culvert. However, due to the large cross-sectional area, inability to clean isolated sections of the culvert without potentially impacting downstream areas, and remote cleaning operation jet washing is not as effective for targeted mitigation of sheen. Revised cleaning methods are further described below.

### 2.3.1 Stream Washing

For those portions of the culvert with no structural bottom, mitigation will include stream washing consistent with procedures identified in Attachment A to the Sediment Mitigation Measures Work Plan. Stream washing will be completed with containment installed at the downstream end of the section to be cleaned to not impact the immediate downstream section. Bottom materials within the culvert will be agitated and released sheens and sediment will be captured by the downstream containment, which will include petroleum fence, skimming sweep, petroleum fence, soft boom, and hard boom (listed in order upstream to downstream). Fences/absorbent boom will be disposed after completion of mitigation. Washing will continue until a sheen score of 0 or 1 is observed. The washed section will be allowed to equilibrate for at least 12 hours and then another qualitative sheen assessment will be performed to determine the effectiveness of the tactic employed. This process will be performed and repeated consistent with the protocol described in Section 3.1 of the Sediment Mitigation Measures Work Plan to determine when the mitigation objective is achieved.

### 2.3.2 Vacuum Extraction

In the sections of corrugated metal pipe, which has a corrugated bottom, workers will utilize a 4-inch diameter vacuum hose to remove the material in a manner similar to the cleaning activities conducted at the other culverts. This is a very effective way to remove the material from between the corrugations of the culvert, where much of the sediment is located. However, to minimize the time spent in the culvert and the potential for injury due to lifting sandbags, the sandbag berms and diversion piping will be replaced with a foam-constructed diversion berm. A foam diversion is considerably more manageable to deploy and relocate as the work progresses through the culvert in comparison to the sandbag berms and diversion piping. Containment will also be installed at the downstream end of the work area, to not re-impact clean downstream sections of the culvert. Containment will be installed in a similar manner for the stream washing techniques described above to capture any sheen that might be generated while sediments are being removed.

## 2.4 Mitigation Tactic #4 – Liberty Street and T&M Hardware & Rental Parking Lot Closures

As shown on Figure 2, the sections of Culvert C1 where cleaning will take place cross beneath Liberty Street and the parking lot for T&M Hardware located in in the strip mall at the corner of Taggart and Liberty Streets.  NSRC will coordinate with representatives from the Village of East Palestine and T&M Hardware to plan for a temporary closure of these locations to eliminate loading on the culvert by vehicular traffic during the performance of culvert cleaning activities. Appropriate traffic controls (e.g., flaggers, signage) will be coordinated by NSRC's contractor during street and parking lot closures.

# 3 Schedule

It is anticipated that by implementing the measures proposed above, performance of the cleaning activities within Culvert C1 will take between 5 to 8 days, which may have otherwise taken weeks to complete by other means. Work will be initiated immediately following the approval of this Plan and is tentatively scheduled to begin the week of March 25, 2024.

# 4 Summary

Extensive investigative efforts (i.e., robotic reconnaissance, multi-disciplinary team inspections, and sheen identification) have been put forth to develop this Plan to minimize the time workers will need to be in the culvert by limiting work to sheen generating sections of the culvert. In addition, occupation of the culvert is further minimized by use of foam-constructed diversions and absorbent booms to reduce the manual placement of sandbag berms and their relocation as work progresses. Consideration was given to alternative mechanized cleaning methods, but it is believed that the selected approach – which includes stream washing and vacuum extraction – can be conducted safely and is the most efficient manner to complete this work available at this time.

The multi-firm/agency team has worked through how to address the potential challenges and have put in place added safety features (i.e., prefabricated stairs for stream ingress/egress, air monitoring, rescue plans, lighting, bypass lock-out/tag-out, etc.). In addition, this work will be conducted in a time of year with warmer temperatures than previous culvert cleaning activities.

# 5 References

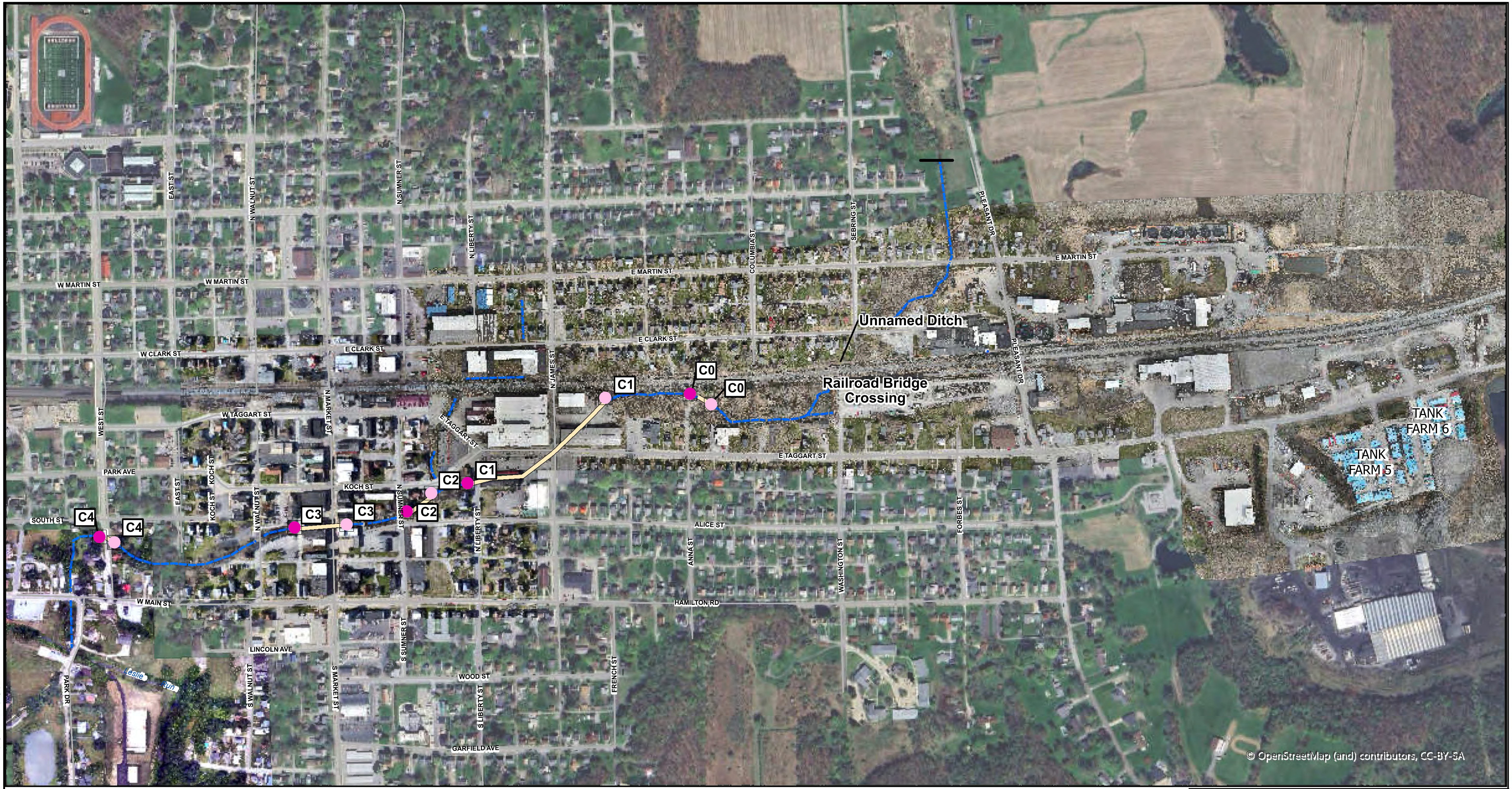
Arcadis. 2023a. Sulphur Run Culvert Sediment Removal Plan. November 8.

Arcadis. 2023b. Addendum 1 to the Sulphur Run Culvert Sediment Removal Plan. December 18.

Arcadis. 2023c. Culvert Sediment Removal Report. December 21.

Arcadis. 2024. Sediment Mitigation Measures Work Plan. March 11.

# Figures




Legend
- Start of Culvert
- End of Culvert
- Sulphur Run
- Culvert Alignment

Map Date: 3/17/2024

Drone flight aerial date: 03/13/2024

0 450 900 Feet

NORFOLK SOUTHERN
EAST PALESTINE, OHIO
CULVERT C1 MITIGATION OPTIONS PLAN

**SULPHUR RUN CULVERTS**

ARCADIS

FIGURE 1

Document Path: T:_ENV\NorfolkSouthern\EastPalestine_Feb5_2023\ArcPro\SedimentSampling\SedimentSampling.aprx


Legend

Qualitative Sheen Observations

- Score 0
- Score 1
- Score 2
- Score 3

Map Date: 3/14/2024

Drone image onsite dated: 03/13/2023

0 100 200
Feet

NORFOLK SOUTHERN
EAST PALESTINE, OHIO
CULVERT C1 MITIGATION OPTIONS PLAN

**CULVERT C1**
**SHEEN ASSESSMENT**

ARCADIS

FIGURE
2

# Appendix 1

## Evaluation of Mechanized Removal Methods

# 1 Objective

The objective of this evaluation is to assess the feasibility of alternative methods of mechanized sediment removal against the current practice of vacuum extraction by entering the culvert. These methods were identified given their potential to decrease the amount of time workers spend in the culvert and improve worker safety (e.g., minimizing lifting).

## 1.1 Description of Alternatives

The following sections describe the alternatives that were considered for potential use.

### 1.1.1 Vacuum Extraction with Culvert Entry

***Image 1 – Photo showing vacuum truck and cleaning hose extending into culvert.***

Vacuum extraction with culvert entry, which is the current practice, has been evaluated and the proposed approach for going forward has been modified. This modification consists of installing a stream diversion for flow around the immediate work area utilizing a foam-constructed curb – similar to those used for secondary containment berms. This foam diversion is easily relocatable and avoids having to carry-in sandbags for stream diversion. At the downstream end of the work area within the culvert, absorbents will be installed to provide sheen containment. Once these work area controls are in place, vacuum extraction of sediments may be performed using a 4-inch diameter vacuum hose. The hose is attached to a vacuum truck and can extend as far as 400 feet while remaining effective at removing sediment. Removed sediment and water is then collected in the vacuum truck and transported to a dewatering roll-off container in preparation for disposal.

**Advantages**

This method was used extensively in previous culvert cleaning and was shown to be very effective at removing sediment, especially from within pipe corrugations. This option also allows for easy set up and dismantling at the beginning and end of a workday, which pairs well with the limited amount of sediment that is expected to be removed - minimizing the worker's time in the culvert. Ingress and egress to the stream and culvert by the workers would be accomplished with prefabricated stairs placed on the stream bank.

**Limitations**

The limitations of this application are the size of the rocks and debris that the vacuum hose can remove, although this has been accommodated elsewhere by washing in-place and/or limited manual removal, which requires a minimum of two workers in the culvert at a time. In addition, the vacuum truck is loud and somewhat disruptive to nearby residences and businesses.

### 1.1.2 Robotic Vacuum

The robotic vacuum is a form of vacuum extraction that utilizes a robot-mounted vacuum hose. This alternative would still require worker entry to deploy stream diversion or containment, requiring the construction of a bypass system which would require workers in the culvert. Workers may also have to enter the culvert to vacuum areas that the robot could not effectively capture or remove any obstructions.

**Advantages**

This application could be effective at targeting the minimal amount of sediment which lies mostly in the culvert corrugations and could be controlled by a remote from the exterior of the culvert. This alternative also reduces the strain on the worker, as it would complete a portion of the manual labor. The robotic vacuum is a zero emission/electric tool.

**Limitations**

***Image 2 – Photo showing robotic vacuum equipment.***

The limitations of the robotic vacuum include unit availability, limited travel distance, limitations on the debris it can remove, and maneuverability around obstructions or into tight corners. As noted above, this option would still require workers to enter the culvert to visually confirm that cleaning has been completed, capture any missed areas, remove stuck robot, and setup and remove diversions and containment. These activities would require approximately the same amount of time workers are in the culvert as vacuum extraction with culvert entry. Reduction of worker time in the culvert will not be significant as there is a minimal amount of sediment to be removed, but the time for the robot to remove that sediment will be much longer than a worker due to nature of using robotics. Ingress and egress are also more challenging than typical vacuum extraction in that the robot would likely have to be lifted into stream as the bank may be challenging to maneuver.

### 1.1.3 Battery Operated Loaders

The battery-operated loader is a form of extraction that utilizes a remote-control loader to transport sediment out of the culvert. However, it would still require manual labor to remove sediment from pipe corrugations as scooping with the loader would be ineffective. This alternative could be used in-place of wheelbarrows to transport removed sediment but would require workers to shovel sediment from within the corrugations into the bucket.

**Advantages**

This application can be remote controlled, is electric/zero emission, and reduces the manual labor strain on the workers in the culverts. The payload it could remove is equal to or larger than a wheelbarrow that workers may use.

**Limitations**

The limitations for this option include ingress and egress from the stream, as the equipment would have to be lifted down into the stream. The equipment will not be effective at removing sediment from the culvert corrugations, has a limited travel distance of 300 feet, and potential to damage the culvert. Workers would also have to enter the culvert to install diversions and containment or a bypass to facilitate a safe water level for operation and enter the culvert to remove any obstructions not removeable by the loader. This would require similar or more time spent in the culvert by workers in support of this option compared to vacuum extraction with culvert entry. In addition, removing the sediment from the culvert with the loader would take longer than vacuuming it out due to the need to load the bucket, travel time in and out of the culvert, and limited amount of sediment to be removed.

***Image 3 – Photo showing battery operated loader.***

## 1.1.4 Conveyors

The conveyor is a form of extraction that utilizes a conveyor belt to mechanically move sediment that has been loaded onto it by a worker. This alternative would require worker entry for loading and to deploy diversions and containment.

**Advantages**

This application can reduce the strain on workers removing the material from the culvert and there is a large payload conveyance if needed.

**Limitations**

This option still requires workers to enter the culvert to install and load the conveyor belt and install bypass and containment controls. The equipment would have to stay in place for the duration of the work. Aside from not needing this level of sediment conveyance given the limited volume of sediment anticipated to be removed, ingress and egress of the equipment would be impractical on a daily basis and it may get damaged or obstruct flow during a storm event. The labor in the culvert to set up the equipment would also be significant. Further, powering such a system must be considered and its presence may obstruct worker movement within the culvert.

***Image 4 – Photo showing a conveyor system. Temporary conveyor system fabrication may vary.***

# 2 Alternative Comparison

To evaluate the alternatives, a set of performance metrics and a comparison rating system was developed, which is presented in Table 1 below. The rating system is scaled from 1 to 3, with 1 being the least optimal and 3 being optimal. As shown in Table 1, the Vacuum Extraction with Culvert Entry alternative scored the highest, followed by the Robotic Vacuum, Battery Operated Loaders, and Conveyors, respectively. The efficiency, ease of setup, and access make vacuum extraction with culvert entry the preferred alternative.

**Table 1: Alternatives Comparison**

| Criteria Considered | Alternatives | | | |
|---|---|---|---|---|
| | Vacuum Extraction with Culvert Entry | Robotic Vacuum | Battery Operated Loaders | Conveyors |
| **Amount of time workers spend in culvert** | 1 | 1 | 1 | 1 |
| **Effectiveness to remove sediment from corrugations** | 3 | 2 | 1 | 1 |
| **Stream ingress and egress** | 3 | 2 | 2 | 1 |
| **Availability of equipment** | 3 | 1 | 1 | 2 |
| **Ability to target work areas** | 3 | 2 | 1 | 1 |
| **Strain of lifting on workers** | 2 | 2 | 2 | 1 |
| **Reducing risk for slips, trips, and falls** | 2 | 2 | 2 | 1 |
| **Minimizing disturbance to the surrounding community** | 2 | 3 | 2 | 1 |
| **TOTAL** | **19** | **15** | **12** | **9** |

Notes:
1 – Least Optimal
2 – Satisfactory
3 – Optimal

# 3 Conclusion

Alternative methods of mechanized means to remove sediment were compared to the current practice of vacuum extraction by culvert entry. The most feasible option with all criteria considered is removal of materials from Culvert C1 by vacuum extraction with culvert entry. While the other alternatives demonstrated some advantages, even the remote alternatives will still require entry to the culvert. The remote alternatives also add a level of complexity innate to working with robotic equipment. Vacuum extraction with culvert entry is generally the safest option for worker’s ingress and egress, easiest to implement and the most efficient means to perform the cleaning.

# Appendix 2

**Structural Assessment of Culvert C1**

**Structural Assessment of Culvert C1**
**East Palestine, Ohio Derailment**
**March 22, 2024**

## Introduction

Arcadis U.S., Inc. (Arcadis), prepared a Mitigation Options Plan for Culvert C1 in March 2024 (See the Culvert C1 Mitigation Options Plan (Plan), which is Attachment E to the Sediment Mitigation Measures Work Plan[1]). Per Section 2.2 of the Plan, a "Structural Engineer's Inspection" was proposed to assess the condition of the culvert prior to proceeding with mitigation efforts. A structural assessment was performed by Michael Bucek, Arcadis Senior Structural Engineer and Ohio PE, the morning of Wednesday, March 20, 2024 per the Plan. This technical memorandum has been prepared following the field inspection for that assessment.

## Background

See the Plan for background information.

## Culvert Inspection & Structural Assessment

The structural assessment was performed beginning at the outlet of Culvert C1. The initial 50 feet of structure consists of a corrugated metal pipe running below North Liberty street (see Image 1). No yielding or other deformation of the pipe surface was observed. Surface rust was present near the waterline, but no apparent structural section loss was noted.

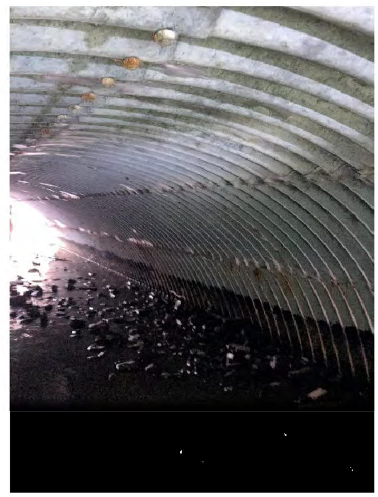


**Image 1 - Corrugated Pipe**

Beyond the initial pipe section, the culvert transitions into a concrete box culvert without a structural base (similar to the arch section). Numerous form ties were present along the walls, with some locations observed to have very minor spalling at the concrete interface. Several areas were observed to have surface cracking, although all cracks appeared to be tight with no measurable gap width. Efflorescence was observed in the roof structure at some locations; typically occurring at what appears to be construction joints between concrete segments. Some roof areas were observed to have delamination of the concrete cover over the reinforcing strands. The reinforcing in these areas appeared to be in acceptable condition with minor to no loss of structural capacity. Additionally, the protective encasement around several steel beams was observed to have partially failed with surface rust developing on the exposed steel beam underneath (see Image 2). The purpose of these beams was unclear. Their location was below an existing structure. It is possible they were originally installed to provide additional capacity due to a surcharge loading from the structure above. The partially failed encasement does not appear to have any structural function, instead it is likely intended to help protect the beams from corrosion.

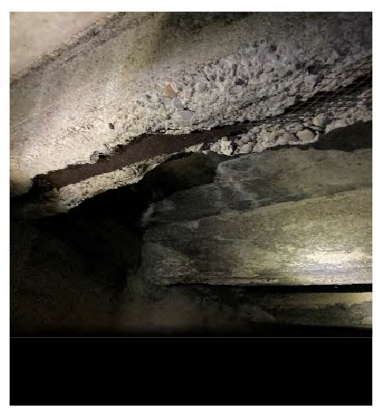


**Image 2 – Steel Beam Encasement**

[1] Arcadis. 2024a. Sediment Mitigation Measures Work Plan. East Palestine Train Derailment. March 11.

The culvert base in this section consisted of soft sediments mixed with gravel and other debris. Several areas, especially along the southern wall, were observed to have undermined a portion of the wall foundation (see Image 3). No movement of the foundation appeared to have occurred, nor was there any sign of distress in the culvert wall. Any significant movement of the foundation would most likely lead to readily observed cracks and spalls of the wall and/or ceiling, none of which were observed.

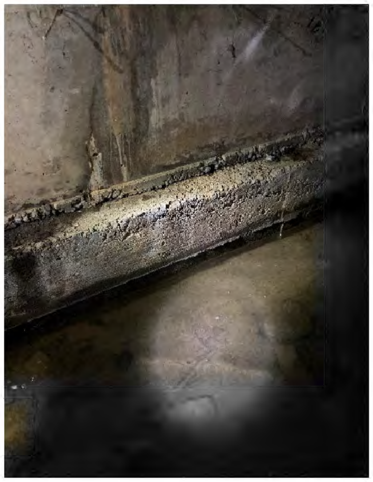


**Image 3 – Scour at the Foundation**

At approximately 220 feet into the culvert, the culvert transitions back to a corrugated metal pipe. Based on available record documentation, this portion of the culvert was recently (within the past ~15 years) replaced. This portion of the culvert was in good condition with little to no visible signs of wear or damage. However, at the transition area around roughly 210 feet, the remains of an original bottom slab structure remain with significant sediment build-up and some undermining of the remaining bottom (see Image 4). Once again, no visual indications of overstress or other damage to the culvert walls or ceiling structure were observed.

**Image 4 – Culvert Transition**

At approximately 450 feet into the culvert, the culvert transitions to a concrete box culvert with a concrete bottom. This profile continues upstream to the end of the culvert. Similar to the other concrete portion of the culvert, this area was in fair condition with limited locations of surface spalling, non-expanding cracking, and efflorescence at cracks and joints. Due to the concrete bottom, no scouring or undermining was observed.

## Conclusion

Structurally, no significant areas of concern were identified during the visual assessment of Culvert C1. Expected “wear and tear” was observed, but no damage or deformation that could lead to concerns of reduced structural performance. No signs of movement or other distress were noted. While some potential maintenance issues have been identified (scour, beam protection), these issues should not prevent remediation efforts from proceeding. However, remediation efforts should not include actions (i.e., significant material removal from bottomless sections) that may worsen these conditions.

Michael D. Bucek, Senior Structural Engineer (PE – OH, et.al.)

# Attachment F

## Field Adjustments per SR1 Findings

**NORFOLK SOUTHERN**

**Norfolk Southern Corporation**
650 West Peachtree Street NW
Atlanta, GA 30308

**Daniel Hunt, P.G.**
Senior Manager
Environmental Remediation

April 11, 2024

Ralph Dollhopf
On-Scene Coordinator
United States Environmental Protection Agency
Transmitted by e-mail

Re: Stream Mitigation Measures Work Plan – Modified (March 11, 2024) – Field Adjustments per SR1 Findings (Revision 1)
NSRC East Palestine, OH Derailment

Dear Mr. Dollhopf,

Per your request, Norfolk Southern Railroad Company (NSRC) has prepared this letter documenting our strategy for addressing the breach of containment during the first day of sediment mitigation measures in Sulphur Run (March 25, 2024). Pursuant to the United States Environmental Protection Agency (USEPA) directive dated March 27, 2024, this letter documents NSRC's modified strategy for sheen containment and collection tactics that will be deployed upon sediment mitigation restart. This letter also serves as a request for sediment mitigation restart upon USEPA approval of these modifications.

During the first day of sediment mitigation in Sulphur Run, the containment system established per the approved tactics was breached. Mitigation was being performed downstream of the railroad crossing of Sulphur Run at the time of the breach (upstream portion of SR1). Mitigation then included stream washing using two pump/hose setups and the containment system included a petroleum fence, skimming sweep, petroleum fence, soft boom, and hard boom (listed in order of upstream to downstream). The containment system was modified to control the sheen release through the addition of another downstream boom upon the observance of breakthrough. The estimated duration of the containment breach was less than an hour.

Based on the findings from the first day of mitigation efforts, adjustments to the tactics are required to ensure proper containment of sheen and prevent future breakthrough. The Modifications to Sheen Collection Methods and Modifications to Containment described below were successfully tested in the field on March 29, 2024. The test was witnessed by a team consisting of Arcadis, EnviroScience, Stantec, NS Ops, OEPA, and USEPA. During the test, a small amount of sheen was produced in the work area and monitored as it approached the primary containment and collection point. The sheen was successfully contained at the primary point and removed via the vac truck. No sheen was observed in any of the downstream backup points. Mitigation adjustment details and supporting rationale are provided below.

### Modifications to Sheen Collection Methods

Based on observations during the first day of stream mitigation, sheen collection methods have been modified as follows:

1. Mechanical removal will be the primary recovery method to collect the sheens at all mitigation areas. A vac truck is the preferred piece of equipment for mechanical removal. A tow-behind vacuum trailer coupled with a four-wheel drive truck (vac trailer) may also be used for potential sheen collection in more difficult areas to access. However, a more portable setup (e.g., a drum vac or vac attached to 5-gallon bucket) will be used to collect the sheens if use of a vac truck or tow-behind vacuum trailer/four-wheel drive truck is not possible due to limited access.
2. Absorbents will still be used to collect sheens in combination with the mechanical removal. Modifications have been made to the containment setups, detailed below, to increase absorbent contact time to collect the sheen.

## Modifications to Containment

The location and components of the containment zones are paramount to ensuring the proper conditions for sheen to coalesce for collection. Moving forward, every mitigation area will be accompanied by, at a minimum and in this order moving from upstream to downstream, a primary containment and collection point, a primary backup zone, a secondary containment and collection point, two (2) secondary backup points, and a tertiary containment and collection point. Absorbents will be used to collect sheens in combination with the mechanical removal as determined needed in the field during operations and as directed by USEPA. These absorbents may include the use of pom-poms, peat moss booms and pillows, Spilltrain oil shammy roll, and/or rubberizer (will be containerized). Absorbents will be changed as needed. Modifications and additions to the containment zones are detailed below and a schematic is provided as Figure 1. The locations and setups for each containment will be discussed with USEPA for each mitigation area as noted under the Quality Control and Communication Plan section below.

1. *Primary Containment and Collection Point*
    - A portable underflow dam will be set up downstream of each mitigation area. This will slow the water flow to allow for mechanical removal of the sheen through use of the selected method (i.e., vac truck, vac trailer, or drum vac) and increase contact time for absorbent effectiveness. An absorbent boom will be set up directly upstream of the dam to absorb any sheen that collects against the dam wall. A sheen curtain will be placed directly upstream of the absorbent boom to assist in removing any sheen potentially traveling in the water column. Next, a hard boom will be set up upstream of the sheen curtain and this boom will be appropriately angled to direct the sheen to the location along the shoreline established for mechanical collection. Another absorbent will be placed upstream of the hard boom.
2. *Primary Backup Zone*
    - Hard boom and/or absorbents will be placed downstream between the primary and secondary containment and collection point setups upon observation of breakthrough. The intention of this zone is to control sheen using hard boom and capture sheen using absorbents before it reaches the secondary containment and collection point. The location of the hard boom and/or absorbents within this zone will be determined in the field.
3. *Secondary Containment and Collection Point*
    - A second mechanical removal setup (i.e., vac truck, vac trailer, or drum vac) with hard boom and absorbents will be established and positioned downstream of the primary containment and the primary backup zone. This will be a redundant and contingent collection location if sheen breaches the primary and primary backup containments. Personnel will be present and ready to implement this setup during all mitigation activities.
4. *Secondary Backup Points*
    - At least two setups that consist of hard boom and absorbents will be established downstream of the secondary containment and collection point. Locations for these setups will be chosen so that mechanical removal is possible should high volumes of sheen make it to these containments.
5. *Tertiary Containment and Collection Point*
    - A tertiary containment location will be identified downstream of the secondary containment and the secondary backup points. This will be a second redundant and contingent collection location if sheen breaches the secondary and secondary backup containments. A portable underflow dam, hard boom and absorbents, and sheen curtain will be staged at this location for deployment as needed. Personnel and mechanical sheen removal equipment will not be present continuously at this location, but personnel and equipment will be available to react quickly in the event sheen breaches the primary and primary backup containments.

## Quality Control and Communication Plan

All containments will be installed from downstream to upstream, starting with the secondary backup points. Supplies will be staged at the tertiary point during containment installation as well. This will ensure that crews working within the stream channel will be working upstream of redundant containment setups as much as possible. For each mitigation area, the location for each containment setup will be determined in the field and, once installed, all containment system setups will be reviewed and verified by Arcadis, EnviroScience, Stantec and USEPA. Mitigation will not commence until there is a concurrence that the containment and collection methods are satisfactorily in place at the right locations for each mitigation area. Upon completion of installation, all containment setups, including the secondary backup points, will be monitored continuously until work is complete.

During mitigation, all personnel have stop work authority if sheen is observed breaching any containment. All monitoring personnel will be equipped with a two-way radio to ensure quick and effective communication during operations.

If higher flows (e.g., rain events or releases from the bypass pumping/pond) are anticipated after mitigation work is complete for the day, containment systems will be maintained in place for 2 hours after mitigation is completed and then removed. Impacts from the bypass releases have the greatest impact in the upstream portions of Sulphur Run. Containments will be left in place overnight during low flow or dry conditions. If sheen is observed downstream of the secondary backup point for any reason while mitigation activities are being performed, an immediate notification will be made to USEPA, OEPA, a representative of the City of East Palestine, and Columbiana County Emergency Management Agency (CCEMA).

### Staffing and Third-Party Oversight

Oversight staff will include an oversight team and separate third-party oversight. An NSRC employee will also be present on site in East Palestine during stream mitigation.

The oversight team will include, at a minimum, four full-time oversight personnel consisting of Arcadis and EnviroScience. One team of two people will be responsible for monitoring the secondary and tertiary patrol zones for the presence of sheen from mitigation efforts. The secondary patrol zones will be routinely monitored (e.g., every few hours) and the tertiary patrol zone will be monitored at least once per day. One person will be responsible for monitoring the primary patrol zone, and one person will be tasked with observing/documenting sheen assessment and mitigation efforts. Refer to Figure 1 for the extent of each patrol zone. The person monitoring the primary patrol zone will focus their attention on the primary containment setup. If any sheens are observed to be downstream of that setup or moving around that setup, that person will immediately call for a stop work and use the radio to alert the team monitoring the secondary patrol zone of the breach and coordinate placement of hard booms/absorbents within the primary backup zone. Monitoring teams will also generally assess the creek for the presence of sheen in each patrol zone.

Third-party oversight will be provided by Stantec. Third-party oversight will include one person to monitor and verify the setup and operation during all mitigation work.

### Rain or High Flow Events and Associated Actions

Mitigation activities will be suspended or not initiated in the event of heavy rain or high flow events. Heavy precipitation is defined as one-inch of rainfall within a 24-hour period, more than 0.3 inches of rain in any one-hour period, or any flash flood advisory, warning, or watch issued by the National Weather Service (NWS) for Columbiana County (Ohio) or Beaver County (Pennsylvania). High flow events will be determined on a case-by-case basis for each targeted area prior to work beginning each day. This determination will be made by the field teams conducting and overseeing the mitigation activities. This will provide the flexibility needed as different areas and setup configurations may have different high flow levels that require a stop work to be implemented.

If higher flows (i.e., rain events or releases from the bypass pumping/pond) are anticipated after mitigation work is complete for the day, containment systems will be maintained in place for 2 hours after mitigation is completed and then removed. Impacts from the bypass releases have the greatest impact in the upstream portions of Sulphur Run. Containments will be left in place overnight during low flow or dry conditions.

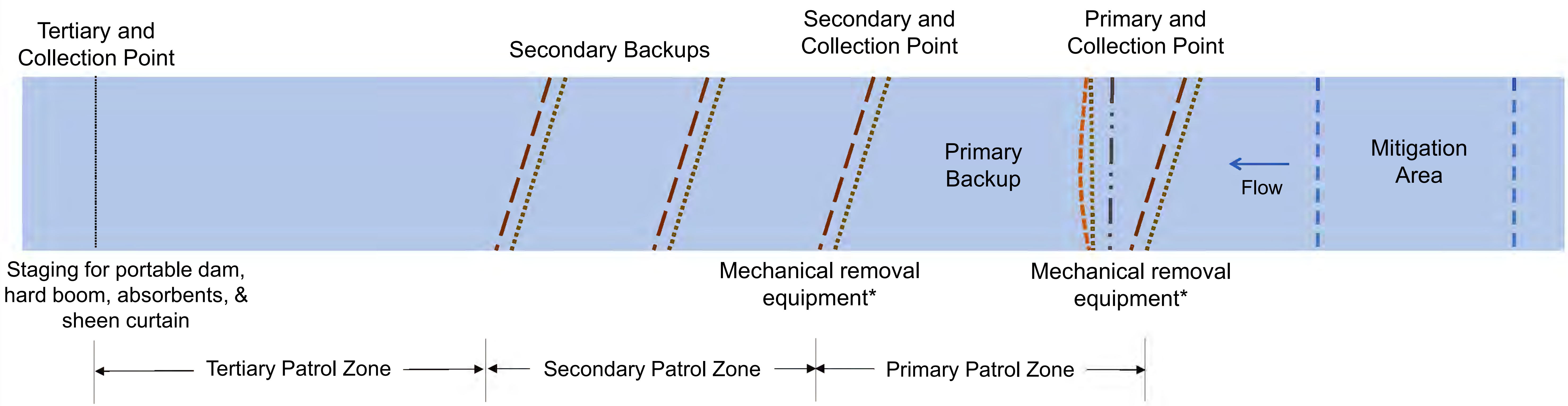
In addition, if a period of heavy precipitation occurs, NSRC oversight team representatives (one member of the oversight team and the third-party oversight) will conduct a visual stream observation in conjunction with USEPA to assess for the presence of any sheen downstream from containment or any damage to containment structures. Observations will be made from shore at locations agreed upon by USEPA. Fourteen locations are currently identified for observation through April 3, 2024 per discussions with USEPA; additional locations may be added – the 14 locations are illustrated on Figure 2.

Should you have any questions regarding this information, please contact me at 404-273-4472 at your earliest convenience.

**Daniel Hunt, P.G.**
Senior Manager Environmental Remediation
**404-273-4472**
**Daniel.Hunt@nscorp.com**

**NORFOLK SOUTHERN**
650 West Peachtree Street NW
Atlanta, GA 30308

Enclosures:
Figure 1: Mitigation Area Containment Setup Schematic
Figure 2: Sheen Observation Points




Legend:
- Hard boom
- Absorbent
- Portable dam
- Sheen curtain
- Mitigation area boundary

*Note: Mechanical removal equipment includes vac truck, vac trailer, or drum vac pending access.

**Schematic Not to Scale**

NORFOLK SOUTHERN
EAST PALESTINE, OHIO

**MITIGATION AREA CONTAINMENT SETUP SCHEMATIC**

ARCADIS

FIGURE 1


Legend

Sulphur Run

Observation Point

Map Date: 3/5/2024

0 280 560

Feet

NORFOLK SOUTHERN
EAST PALESTINE, OHIO

**SHEEN OBSERVATION POINTS**

ARCADIS

FIGURE

2

# Attachment G

**Sulphur Run Field Walk and Recommended Tactics Tracking Sheet**

| Sulphur Run Field Walk<br><br>Updated: April 11, 2024 | | | Individuals Present<br>Document agency decision makers: | Ohio EPA - Bill Zawiski; USEPA - Chris Gazzetti; Mannik Smith Group - Dan Capone; TetraTech - Greg Powell and Mason Amin; HEPACO - Josh Herdt and Kevin Tolliver; EnviroScience - John Crandall and Dan Schweitzer; Project Navigator - Matt Jackson; Arcadis - Rick Adams, Sarah Hill, Frank Menarde, Seth Zellhart, Tim Fisher, and Mike Higgins; USCG - Taylor Charles and Taylor Steinbach; CTEH - Kavon Salehi; NS - Dan Hunt; AEG - Kyle Gibuy; and PVE - Gregory Palmer | |
|---|---|---|---|---|---|
| **Creek** | **Mitigation Area** | **Sample IDs (only ES Nov23 sheen scores of 2 or 3)** | **Tactics Recommended during Site Walk (see notes 1-3)**<br>- include initial tactic + planned escalation steps, as appropriate - | **Other Notes**<br>- identify bank conditions, potential impacts on slope stability, debris, tactic considerations, etc. - | **Containment Plan - updated per Field Adjustments per SR1 Findings Letter (Rev 1, April 11, 2024)**<br>- specify type and location of equipment, mitigation areas covered, etc. - |
| Sulphur | SR1 | QALR123 | Perform qualitative sheen assessment to confirm Scores of 2 and 3. Use mini-excavator to move boulders along west bank just downstream of railroad crossing to exposure underlying sediment/soil for removal likely through hand excavation with shovels (use of mini-excavator for removal to be considered/evaluated). Consider removing other sediments that generate sheen through hand excavation with shovels. Conduct stream washing of entire area using pump/hose and sediment agitation with mechanical sheen collection supplemented with absorbents as needed. Focus washing along shorelines and sediment deposits. Historic Sheen Score 3 areas will be washed regardless of Sheen Score produced during initial mitigation assessment. | Logs and stumps in the area are potential traps for sediment. They will be removed from the stream if possible and disposed or moved around to release sediment if they cannot be removed. Oil stained/impacted debris will be removed for disposal if necessary for sheen mitigation. | Every mitigation area will be accompanied by, at a minimum and in this order moving from upstream to downstream, a primary containment and collection point, a primary backup zone, a secondary containment and collection point, two secondary backup points, and a tertiary containment and collection point.<br>1. Primary Containment and Collection Point<br>• A portable underflow dam will be set up downstream of each mitigation area. An absorbent boom will be set up directly upstream of the dam to absorb any sheen that collects against the dam wall. A sheen curtain will be placed directly upstream of the absorbent boom to assist in removing any sheen potentially traveling in the water column. Next, a hard boom will be set up upstream of the sheen curtain and this boom will be appropriately angled to direct the sheen to the location along the shoreline established for mechanical collection. Another absorbent will be placed upstream of the hard boom.<br>2. Primary Backup Zone<br>• Hard boom and/or absorbents will be placed downstream between the primary and secondary containment and collection point setups upon observation of breakthrough. The location of the hard boom and/or absorbents within this zone will be determined in the field.<br>3. Secondary Containment and Collection Point<br>• A second mechanical removal setup (i.e., vac truck, vac trailer, or drum vac) with hard boom and absorbents will be established and positioned downstream of the primary containment and the primary backup zone. Personnel will be present and ready to implement this setup during all mitigation activities.<br>4. Secondary Backup Points<br>• At least two setups that consist of hard boom and absorbents will be established downstream of the secondary containment and collection point. Locations for these setups will be chosen so that mechanical removal is possible should high volumes of sheen make it to these containments.<br>5. Tertiary Containment and Collection Point<br>• A tertiary containment location will be identified downstream of the secondary containment and the secondary backup points. A portable underflow dam, hard boom and absorbents, and sheen curtain will be staged at this location for deployment as needed. |
| Sulphur | SR1 | QALR124 | | | |
| Sulphur | SR2 | QALR117 | Perform qualitative sheen assessment to confirm Score of 2. Consider removing sediments that generate sheen through hand excavation with shovels. Conduct stream washing of entire area using pump/hose and sediment agitation with mechanical sheen collection supplemented with absorbents as needed. Debris present and will be washed and returned to creek. | Debris present in stream and along north bank. Debris includes steel bar, bricks, and concrete blocks. Oil stained/impacted debris will be removed for disposal if necessary for sheen mitigation. | |
| Sulphur | SR3 | QALR113 | Perform qualitative sheen assessment to confirm areas with Scores of 2 or 3. Focused removal through digging with shovel at QALR114. Removed sediment to be placed in 5-gallon buckets for transport/disposal. After focused removal conduct stream washing of entire area using pump/hose and sediment agitation with mechanical sheen collection supplemented with absorbents as needed. | | |
| Sulphur | SR3 | QALR114 | | | |
| Sulphur | SR4 | QALR108 | Perform qualitative sheen assessment to confirm areas with Scores of 2 or 3. Consider removing sediments that generate sheen through hand excavation with shovels. Conduct stream washing along north shore only - avoid disturbing south shore and current wooden structures in place. Stream washing will be performed using pump/hose and limited sediment agitation with mechanical sheen collection supplemented with absorbents as needed. Install and maintain booms along both shores of creek to mitigate ongoing source from land impacts until remedial decision on funding/path forward for adjacent property determined by OEPA. | Adjacent to former Leake Oil properties (now under state of OH/land bank ownership). Land impacts on south shore and possibly north shore. Grant application submitted for funding to remediate the areas through OH, decision on funding anticipated in the next few months. Bill Z. (Ohio EPA) to request investigation/data reports if available for property. | |
| Sulphur | SR4 | QALR109 | | | |
| Sulphur | SR4 | SED-SR3 | | | |

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|---|---|---|---|---|---|
| **Creek** | **Mitigation Area** | **Sample IDs (only ES Nov23 sheen scores of 2 or 3)** | **Tactics Recommended during Site Walk (see notes 1-3)**<br>- include initial tactic + planned escalation steps, as appropriate - | **Other Notes**<br>- identify bank conditions, potential impacts on slope stability, debris, tactic considerations, etc. - | **Containment Plan - updated per Field Adjustments per SR1 Findings Letter (Rev 1, April 11, 2024)**<br>- specify type and location of equipment, mitigation areas covered, etc. - |
| Sulphur | SR5 | QALR105 | Perform qualitative sheen assessment to confirm Score of 2. Focused sediment removal through digging with shovel. Removed sediment to be placed in 5-gallon buckets for transport/disposal. After focused removal conduct stream washing of entire area using pump/hose and sediment agitation with mechanical sheen collection supplemented with absorbents as needed. Rocks will be flipped/washed. | Numerous tile blocks along bank and across the stream. Oil stained/impacted debris will be removed for disposal if necessary for sheen mitigation. | curtain will be staged at this location for deployment as needed. Personnel and mechanical sheen removal equipment will not be present continuously at this location, but personnel and equipment will be available to react quickly in the event sheen breaches the primary and primary backup containments.<br><br>All containments will be installed from downstream to upstream, starting with the secondary backup points. This will ensure that crews working within the stream channel will be working upstream of redundant containment setups as much as possible. |
| Sulphur | SR6 | QALR97 | Perform qualitative sheen assessment to confirm Score of 2. Consider removing sediments that generate sheen through hand excavation with shovels. Conduct stream washing of entire area using pump/hose and sediment agitation with mechanical sheen collection supplemented with absorbents as needed. | Sheen observed in an area with a deeper pool/water depths just downstream of culvert. | |
| Sulphur | SR7 | QALR88 | Perform qualitative sheen assessment to confirm Score of 2. Consider removing sediments that generate sheen through hand excavation with shovels. Conduct stream washing of entire area using pump/hose and sediment agitation with mechanical sheen collection supplemented with absorbents as needed. Focus spray on steel beam imbedded across stream bottom. | Sheen appears trapped behind steel beam in stream. Check sediments on upstream side of beam for possible removal. | |
| Sulphur<br>Sulphur<br>Sulphur<br>Sulphur | SR8<br>SR8<br>SR8<br>SR8 | QALR81<br>QALR82<br>QALR83<br>QALR84 / SED-SR6 | Perform qualitative sheen assessment to confirm areas with Scores of 2 or 3. Focused removal through digging with shovel around tree stump at QALR84. Removed sediment to be placed in 5-gallon buckets for transport/disposal. Following focused removal at QALR 81-84, conduct stream washing of entire area using pump/hose and sediment agitation with mechanical sheen collection supplemented with absorbents as needed. Washing will use an attachment to focus spray on/in tree root at QALR84. | Tires in/along bank at QALR81. Permission to remove fence on property along south bank to access stream. | |
| Sulphur<br>Sulphur<br>Sulphur<br>Sulphur | SR9<br>SR9<br>SR9<br>SR9 | QALR75<br>QALR76<br>QALR78<br>QALR79 | Perform qualitative sheen assessment to confirm areas with Scores of 2. Consider removing sediments that generate sheen through hand excavation with shovels. Conduct stream washing of entire area using pump/hose and sediment agitation with mechanical sheen collection supplemented with absorbents as needed. Areas where contamination trapped below debris and boulders – need to be prepared to overturn and/or move objects to remove or wash sediments beneath. | Possible targeted removal of sediment at QALR76. Oil stained/impacted debris will be removed for disposal if necessary for sheen mitigation. | |
| Sulphur | SR10 | QALR785 | Perform qualitative sheen assessment to confirm areas with Scores of 2 or 3. Rock observed at QALR785 and QALR786. Focused removal through digging with shovel at QALR785 especially under rock as | Rock along northern shore and mid channel. Oil stained/impacted debris will be removed for disposal if necessary for sheen mitigation. | |

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| Sulphur | SR10 | QALR786 | possible. Removed sediment to be placed in 5-gallon buckets for transport/disposal. Following focused removal at QALR786, Conduct stream washing of entire area using pump/hose and sediment agitation with mechanical sheen collection supplemented with absorbents as needed. Rocks will be flipped/washed. | | |
| Sulphur | SR11 | QALR65 | Perform qualitative sheen assessment to confirm areas with Score of 3. QALR66 sheen trapped under large rock. QALR65 sheen trapped between large rock and bank. Focused sediment removal through digging with shovel especially under rocks as possible. Removed sediment to be placed in 5-gallon buckets for transport/disposal. Following focused removal, Conduct stream washing of entire area using pump/hose and sediment agitation with mechanical sheen collection supplemented with absorbents as needed. Rocks will be flipped/washed. | Sheen identified under large rocks. Oil stained/impacted debris will be removed for disposal if necessary for sheen mitigation. | |
| Sulphur | SR11 | QALR66 | | | |
| Sulphur | SR12 | QALR51 | Perform qualitative sheen assessment to confirm Score of 3. Focused sediment removal through digging with shovel. Removed sediment to be placed in 5-gallon buckets for transport/disposal. Conduct stream washing following focused removal using pump/hose and sediment agitation with mechanical sheen collection supplemented with absorbents as needed. Rocks will be flipped/washed. | Oil stained/impacted debris will be removed for disposal if necessary for sheen mitigation. | |
| Sulphur | SR13 | QALR27 | Perform qualitative sheen assessment to confirm areas with Scores of 2 or 3. Focused removal through digging with shovel around tree stumps at QALR29, QALR36, QALR37, QALR39, and QALR44. Tree stumps observed to trap the sheens and coincide with Scores of 3. Removed sediment to be placed in 5-gallon buckets for transport/disposal. Following focused removal, conduct stream washing of entire area using pump/hose and sediment agitation with mechanical sheen collection supplemented with absorbents as needed. Longer mitigation area will be segmented and washed in ~50ft sections. Washing will use an attachment to focus spray on/in tree roots. | Mitigation area access available only from north shore. Sheens trapped within tree/roots along the shoreline. It is anticipated that this area will take multiple days to complete due to its length. The re-assessment in the most upstream segment will be performed ~12 hours after completion of that particular segment to allow crew to return to upstream segment if needed before the work in the overall area is completed. | |
| Sulphur | SR13 | SED-W-2 | | | |
| Sulphur | SR13 | QALR29 | | | |
| Sulphur | SR13 | QALR30 | | | |
| Sulphur | SR13 | QALR31 | | | |
| Sulphur | SR13 | QALR34 | | | |
| Sulphur | SR13 | QALR36 | | | |
| Sulphur | SR13 | QALR37 | | | |
| Sulphur | SR13 | QALR38 | | | |
| Sulphur | SR13 | QALR39 | | | |
| Sulphur | SR13 | QALR40 | | | |
| Sulphur | SR13 | QALR42 | | | |
| Sulphur | SR13 | QALR44 | | | |

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| Sulphur | SR14 | QALR6 | Perform qualitative sheen assessment to confirm area with Score of 2. Consider removing sediments that generate sheen through hand excavation with shovels. Removed sediment to be placed in 5-gallon buckets for transport/disposal. Following focused removal, conduct stream washing of entire area using pump/hose and sediment agitation with mechanical sheen collection supplemented with absorbents as needed. | Most accessible mitigation area in Sulphur Run. Recent field observations indicated little to no sheens identified (generally Scored as 0 and 1). | |

General notes:

1. Qualitative stream assessment to be re-performed for length of Sulphur Run to confirm no additional areas identified with Scores of 2 or 3. If additional areas identified, mitigation measures will be determined in the field.
2. Focused removal limited to sediment only, no digging into the banks. Team will always be prepared to try removal at locations with Score of 3. Removal will start with a shovel, other hand-held equipment to be evaluated if needed based on stream bottom conditions.
3. Stream washing process: Pool will be created upstream of mitigation area and water will be drawn using a 2-inch trash pump/hose. Hose will be fitted with attachments to focus spray when needed (e.g., around trees roots). Mechanical removal will be the primary recovery method to collect the sheens at all mitigation areas. A vac truck is the preferred piece of equipment for mechanical removal - other options include a vac trailer or drum vac pending access considerations. Absorbents (e.g., pom-poms, peat moss booms and pillows, shammy roll, etc. ) will be used to collect sheens in combination with the mechanical removal as determined needed. Absorbents will be changed as needed.
4. Field tactics may be changed based upon observations from prework qualitative assessment and agreement amongst the stakeholder group.