Technical Remediation Advisory Committee Agenda

Monday, December 9, 2024
6:00 pm
Council Chambers - Hybrid with YouTube Recording
24 Church Street West, Elmira, ON, N3B 2Z6
Chair: Councillor Nathan Cadeau

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    9.3 Screening of Enhanced Technologies for Offsite Groundwater Remediation of the Elmira Drinking Water Aquifer LANXESS Canada Co./Cie Prepared by GHD.

10. Next Meeting - TBD

11. Adjournment

Township of Woolwich
Technical Remediation Advisory Committee (TRAC)
Meeting Minutes

Thursday, Nov 14, 2024
6:18 p.m. – 7:22 p.m.
Hybrid Meeting
Hosted in Council Chambers and on Zoom
24 Church Street West, Elmira

Present from TRAC:	Councillor Nathan Cadeau, TRAC Chair Mayor Sandy Shantz, Councillor Eric Schwindt Tiffany Svensson, Technical Expert *Susan Bryant, TRAC Community Member* Bryan Broomfield, TRAC Community Member Linda Dickson, TRAC Community Member Dr. Sebastian Siebel-Achenbach, TRAC Community Member *Ryan Prosser, TRAC Community Member* Karl Belan, Region of Waterloo
Stakeholders:	*Hadley Stamm, LANXESS Corporation* *Jason Rice, Ministry of the Environment, Conservation and Parks* *Geoff Moroz, Region of Waterloo* *Trevor Heywood, Grand River Conservation Authority*
Present from Staff:	Stacey Bruce, Committee Support Specialist
Regrets:	Eric Hodgins, TRAC Community Member David Hofbauer, TRAC Community Member

**Italics indicate a virtual participant.*

Call to Order at 6:18 P.M.

Land Acknowledgement

Chair Councillor Nathan Cadeau read a Land Acknowledgement.

Disclosures of Pecuniary Interest

No pecuniary interests were declared.

Approval of Previous Minutes

Moved by Dr. Sebastian Siebel-Achenbach
Seconded by Karl Belan

That the Technical Remediation Advisory Committee (TRAC) minutes of June 13, 2024, be adopted as presented.

It was discussed that due to an oversight at the September 12, 2024, meeting, where a motion to adopt the June 13th minutes was mistakenly moved by a non-voting member, the motion was invalid. A new motion was then made to approve these minutes, as they remain in draft form.

…Carried.

Moved by Dr. S. Siebel-Achenbach
Seconded by Susan Bryant

That the Technical Remediation Advisory Committee (TRAC) minutes of Sept 12, 2024, be adopted as presented.

…Carried.

Delegations

None.

Updates

<u>Replacement of On-Site Containment Well PW5 with PW6</u>

LANXESS noted that the well PW6 has been drilled, with electrical work progressing despite subcontractor scheduling challenges. A pre-system startup review (PSSR), a required internal procedure for the chemical plant was noted to be scheduled for next week. It was highlighted that the well is expected to be operational by year-end.

In response to committee questions, it was clarified that electrical work was completed by a contractor in October and involved stringent safety and utility standards due to the chemical plant's requirements. It was also clarified that the well is expected to have performance goals similar to PW5.

<u>Ontario Ministry of the Environment, Conservation and Parks (MECP)</u>

Receipt and Review of LANXESS Proposal to Amend ECA 0831-BX6JGD Biomonitoring Requirements

It was noted that the Ministry received LANXESS' new biomonitoring work plan proposal this month, which has been shared with TRAC. Background was provided, indicating that this follows the Ministry's rejection in April 2024 of LANXESS' November 2023 proposal to eliminate the clam and leech biomonitoring study under Condition 17(2) of the long-term Collection and Treatment System (CTS) ECA for sewage works. The Ministry commented that it had opposed eliminating the study and directed LANXESS to develop and implement a new biomonitoring program. The Ministry is now forming a review team and will work with their Permissions Branch to address next steps and scheduling related to the review of LANXESS' new biomonitoring program submission.

MECP Comments on the LANXESS Elmira 2023 AMR

The Ministry provided an overview of its comments on LANXESS' 2023 Annual Monitoring Report (AMR), required under the CTS sewage works ECA and control orders for groundwater remediation. It was noted that the AMR serves as a performance record to inform the Ministry of remedial operation issues and solutions, facilitating timely collaboration with LANXESS.

It was highlighted that key reporting requirements of the AMRs include groundwater and surface water monitoring, contaminant concentration plume maps, and monitoring data trend evaluations. It was also mentioned that the AMRs are linked to additional reporting, such as sewage works operational data provided in the monthly progress reports and the annual plume stability analysis, which examines long-term groundwater trends and visualizes changes over time. It was clarified that some other environmental monitoring requirements under the control orders are through the annual environmental audit report, although that report focuses on LANXESS' operational compliance aspects rather than remediation work monitoring covered in the AMR.

It was noted that feedback from the Ministry on LANXESS' 2023 AMR has now been communicated to LANXESS in a letter dated November 8, 2024, and shared with TRAC.

It was explained that the Ministry's AMR review requested additional details and data evaluation related to pulse pumping at off-site pumping well E7, specifically focusing on back diffusion. The Ministry also suggested consideration for linking this with additional short-term pulse pumping studies at other pumping wells, discussed during the September 10, 2024, Technical Experts Meeting. It was noted that these other studies are to be evaluated as part of LANXESS' next steps, with a proposed work plan currently being developed by the company.

The Ministry also noted recommending further information being provided in the AMR on residual NAPL (Non-Aqueous Phase Liquid) near the M2 landfill being contained on-site, along with further interpretation of changes in NDMA and chlorobenzene groundwater concentrations at monitoring wells, specifically addressing increases or decreases between years, in alignment with AMR recommendations on refining the groundwater monitoring program.

Additionally, the Ministry commented that they agreed with LANXESS' proposal of no changes to the groundwater monitoring program for 2024, citing no significant data gaps.

Regarding LANXESS' proposed next steps, based on the Aquifer Remedial Evaluation discussed at the September 10, 2024 Technical experts meeting, the Ministry noted LANXESS' plans to evaluate enhanced treatment and remediation technologies for NDMA and chlorobenzene mass removal. Comment was provided that the Ministry suggested that future AMRs include updates on the attenuation status of these compounds in groundwater, based on water quality and other applicable evaluations.

The committee inquired about the timing for LANXESS to fulfill these expectations. It was noted that these expectations are anticipated to be reflected in the 2024 AMR, which is to be submitted to the Ministry by the end of March 2025, allowing time for concerns to be evaluated and addressed by LANXESS. It was noted that monthly progress discussions are held between the Ministry and LANXESS to resolve issues or provide clarifications when requested. It was also emphasized that no compliance instruments have been issued to LANXESS for reporting violations under the ECA.

The Ministry clarified that if significant data gaps or non-compliance issues were identified in the AMR, such as missing key monitoring and reporting requirements specified in the ECA, they could issue a comment response letter for voluntary compliance or a compliance instrument to address a violation. While the current AMR is deemed acceptable with recommendations for improvements in future reports, the Ministry highlighted its ability to use various compliance tools to address any major deficiencies.

A correction to the naming of Shirt Factory Creek in the Ministry's comments on LANXESS' 2023 AMR was noted by the committee.

The committee asked LANXESS for clarification on DNAPLs and their potential off-site presence, referencing Alan Deal's, GHD September 9th TRAC presentation, which stated there was no indication of off-site migration. The committee expressed ongoing uncertainty about the validity of this assessment and suggested that LANXESS provide a more thorough response in the 2024 AMR. It was also noted that draft correspondence from GHD, provided via email on behalf of LANXESS, contains relevant information related to this issue, although it is not directly linked to the AMR. It was explained that it had been suggested to reformat this draft response into a formal letter with a date, signature, and issuer for clarity and official record-keeping. Additionally, it was proposed that LANXESS's technical response be converted into presentation slides to facilitate further discussion at the December 2024 TRAC meeting.

Clarification and supporting evidence in plain language to address this concern was further requested from LANXESS. The question was acknowledged as relevant but deferred to later in the meeting for further discussion.

MECP Creek Floodplain Soil Study

In response to a committee question, the Ministry provided an update on their soil sampling study conducted on some farm properties along Canagagigue Creek. It was explained that the Ministry's soil results will first be shared with the property owners in coordination with Waterloo

Region Public Health and that summary letters for this are expected to be finalized by the end of November 2024. It was noted that the Ministry's technical report for the soil study is anticipated to be available to LANXESS and TRAC in early December 2024 and an update will be provided at the TRAC December meeting.

LANXESS Canada Co.

Canagagigue Creek Human Health & Ecological Risk Assessment (HHERA) Revisions

It was noted that discussions with the Ministry on the Human Health & Ecological Risk Assessment (HHERA) are ongoing, with a meeting scheduled shortly to address comments, work towards consensus, and determine whether additional sampling is needed for approval.

GHD Comments to the Technical Remediation Advisory Committee

It was noted that the committee received technical draft correspondence via email regarding GHD responses to TRAC inquiries on behalf of LANXESS. LANXESS has been asked to reformat this into a formal letter for the TRAC committee. Both the original email and the formalized letter will be circulated before the next meeting to support a more informed discussion.

It was noted that this technical response from GHD requires further clarification, and challenges in summarizing the information comprehensively were acknowledged. The response was described as addressing loose ends from previous investigations, including east-side and former gravel pit work, and a commitment was made to formalize and present it as PowerPoint slides at TRAC's December meeting.

The need to address committee questions, including DNAPL migration concerns, was also recognized. It was noted that preliminary observations indicate high on-site concentrations without evidence of off-site migration, but additional explanation from consulting experts is planned. Apologies were provided for the initial informal draft format, and ongoing efforts to improve the clarity and presentation of the information were noted.

2018 Technology Evaluation Update

It was noted that the 2018 Technical Evaluation has recently been reviewed and finalized after LANXESS addressed minor comments and resolved loose ends from prior investigations. This groundwater evaluation was described to include considerations for NDMA cleanup technologies and proposed pilot studies to test in-situ treatment methods, such as chemical oxidation using Regenesis compounds. As previously noted, these compounds have an effective radius of only 13 meters from potential wells but could be applied in suitable locations with the highest NDMA concentrations, provided access is granted by the landowner and there are no structural impediments, such as existing buildings, restricting entry or operations.

Additionally, it was noted that LANXESS is moving forward with the 2025 Aquifer Remedial Evaluation study and has submitted an internal company funding request for this initiative. It was noted GHD is preparing a work plan for this and that this work requires Ministry approval before implementation. It was further described that this proposed study involves temporarily ceasing pumping at interior off-site wells to stabilize groundwater for sampling. The objective is to better understand NDMA and chlorobenzene levels, as well as other groundwater properties such as oxygen levels and pH, and to conduct in-situ bench testing at a GHD Laboratory in Niagara Falls aimed at evaluating groundwater conditions and different chemical oxidative and natural additive treatment technologies.

In response to committee interest and concerns, it was emphasized that on-site wells and key perimeter wells will continue operating during the proposed study to maintain containment and prevent DNAPL migration or impacts to the Canagagigue Creek. It was further noted that this study is intended to better understand the central and eastern off-site NDMA and chlorobenzene plumes.

At this point Jason Rice left the meeting virtually.

In response to a committee question, it was noted that this temporary study, contingent on Ministry approval, is anticipated to last one to six weeks, with plans for weekly monitoring of well water elevations and concentrations.

It was noted that TRAC has not received the finalized Screening of Enhanced Technologies for Offsite Groundwater Remediation of the Elmira Drinking Water Aquifer to date.

Updated Biological Monitoring Fish Tissues Study Design

At this point Susan Bryant left the meeting virtually.

It was noted that an updated biological monitoring study focused on fish tissue sampling has been submitted to the MECP as an alternative to the clam and leech biomonitoring study. It was described that this proposed plan involves biennial electrofishing at locations previously used in the clam and leech study to assess in-situ compounds in small-bodied fish. This approach was considered logistically simpler and more practical by the committee.

The committee expressed interest in reviewing further details of the study’s design, including tissue sampling, fish quantities, and compositing methods. These details are expected to be provided in a forthcoming plan prepared by GHD on behalf of LANXESS.

Susan Bryant rejoined the meeting virtually.

In clarification to the committee a response was provided that if consistent results from the study show no harm to fish after two to three consecutive sampling events, a request for study relief may be submitted by LANXESS for MECP approval. The committee was also informed that this item will be reviewed further at the December meeting to allow additional time for review and discussion of this document received today.

In response to committee questions, it was discussed that the new fish tissue monitoring study will assess potential impacts on fish tissue, replacing the previous clam and leech study. While not directly comparable, it was noted that the study will use background data from the clam and leech study to evaluate potential sediment or water contamination effects on fish.

Other Business

2028 Order Deadline Remediation Frameworks Discussion

The committee discussed the 2028 control order deadline and the development of the associated alternative remediation framework as a standing discussion item at TRAC meetings.

It was noted that the committee is awaiting LANXESS's draft proposal, which will outline updated remediation objectives and reasonable options for consideration by the committee and the broader community. This process was acknowledged as critical, requiring significant effort and time to move forward collaboratively.

The draft proposal, anticipated by Q3 2025, raised questions about whether this timeline aligns with the committee's expectations. It was emphasized that the proposal is part of broader discussions about the future control order post-2028 and includes potential new technologies for remediation.

The committee sought clarity on LANXESS's work plan and technology evaluation documents, considered first steps in aligning schedules and timelines. It was noted that the ECA process remains distant, requiring extensive coordination with the Ministry to finalize requirements, including evaluating in-situ or alternative methods for enhancing NDMA destruction. It was further emphasized that this assessment depends on scientific studies planned for 2025, with remediation expected to take decades due to the plume's wide and diffuse nature and the extremely low concentration cleanup standard of parts per trillion.

The ECA process was further described as requiring integration of scientific findings and stakeholder engagement, including collaboration with TRAC and the Region of Waterloo, a key stakeholder focused on providing clean drinking water to growing municipalities. It was highlighted that efforts are focused on determining achievable objectives for the new ECA.

It was further noted that LANXESS is updating the 2018 Technical Evaluation study and finalizing a work plan for new remediation technologies, while Arcadis is reviewing the Conceptual Site Model (CSM) on behalf of the company, with submission of the work plan to the Ministry anticipated this December. It was noted that ongoing discussions will continue with the Ministry, the Region, and TRAC regarding the development of the remedial framework, remedial work, and a draft control order, with a target of Q3 2025. The need for further scientific studies in 2025 was emphasized, as key findings are expected to inform the draft control order framework by Q3 2025.

The committee sought clarification and raised concerns about awaiting a draft proposal timeline until Q3 2025, as this could delay the starting point for public and community engagement. The committee expressed a preference for expediting the process to avoid setbacks if scientific findings are unfavorable as this could potentially hinder future planning. It was agreed to expedite the timeline through discussions with the Ministry and involve TRAC members for stakeholder input at a future meeting. The committee also pointed out that a fully developed proposal or draft is not necessarily required to proceed, as high-level discussion points from the company were noted to be sufficient to address the needs of committee members and facilitate progress.

The committee also emphasized the importance of understanding the Ministry's requirements and timelines to align with the priorities of the committee and LANXESS for approval of the ECA process. The legal nature of the ECA document and the challenges in balancing technical, legal and stakeholder requirements was further noted.

A question was raised by the committee regarding how LANXESS and the Ministry plan to communicate updates and progress with stakeholders, particularly the community. The discussion then shifted to broader ongoing strategies for community engagement and the prioritization of immediate logistical updates under other final agenda items.

TRAC Biannual Presentation to Council

The committee discussed preparing their February 2025 presentation to the Township Council. It was highlighted that updates are shared on the committee's EngageWR page to support public involvement and that this page will be transferred to the Social Pinpoint platform in 2025. Additional strategies, such as one-page summaries in local media and townhall or workshop presentations, were suggested to solicit public feedback. It was recommended to wait for a proposed remediation timeline and sufficient relevant information before engaging the public further.

In response to committee concerns about the 2025 remediation study timeline and its impact on proposing a remediation plan before engaging the public, it was clarified that Ministry approval is required prior to commencing any proposed scientific work. It was noted that a work plan is expected to be submitted to the MECP in December, with an estimated three-month review period. It was highlighted that fieldwork is anticipated to begin in Q2 2025, focusing on groundwater sampling to assess changes in oxygen, pH, and contaminant concentrations over several months. Data processing and analysis were also noted to be expected by Q3 2025, with findings potentially available by year-end. While it was emphasized that this timeline is considered realistic, the lengthy process was acknowledged as potentially frustrating to the community and in response disappointment was expressed by the committee.

It was noted that the committee’s upcoming presentation is expected to highlight LANXESS’s 2025 work plan, key outcomes from the recent September 10th Technical Expert Meeting, current initiatives, critical timelines and actions leading to the 2028 control order deadline, reference the 2023 plume stability presentation by Joe Ricker, and proposed project work and timelines. Additionally, it was noted that an introduction of LANXESS’s new plant manager to Council may be coordinated with this presentation. It was emphasized that final presentation approval will be sought from the TRAC committee before it is delivered to Council.

No further discussion occurred around this, but it was suggested that committee members provide input on the upcoming presentation, via email to the Chair and Technical Expert within the next two weeks.

<u>2025 Meeting Schedule</u>

It was noted that a 2025 meeting schedule is being developed in collaboration between LANXESS, TRAC’s Technical Expert, and the Chair to align with key milestones and TRAC’s Terms of Reference. It was also noted that after this, TRAC’s 2025 meeting schedule will be discussed at the committee’s December meeting.

Correspondence

This item was not discussed.

Next Meeting – December 9, 2024

The December TRAC meeting, originally scheduled for December 12, 2024, was rescheduled to Monday, December 9, 2024, to accommodate members' availability. This adjustment was agreed upon to ensure quorum while avoiding conflicts with other commitments.

Adjournment (7:22 P.M.)

Moved by Bryan Broomfield
Seconded by Ryan Prosser

The committee adjourns to meet again on December 9, 2024.

…Carried.

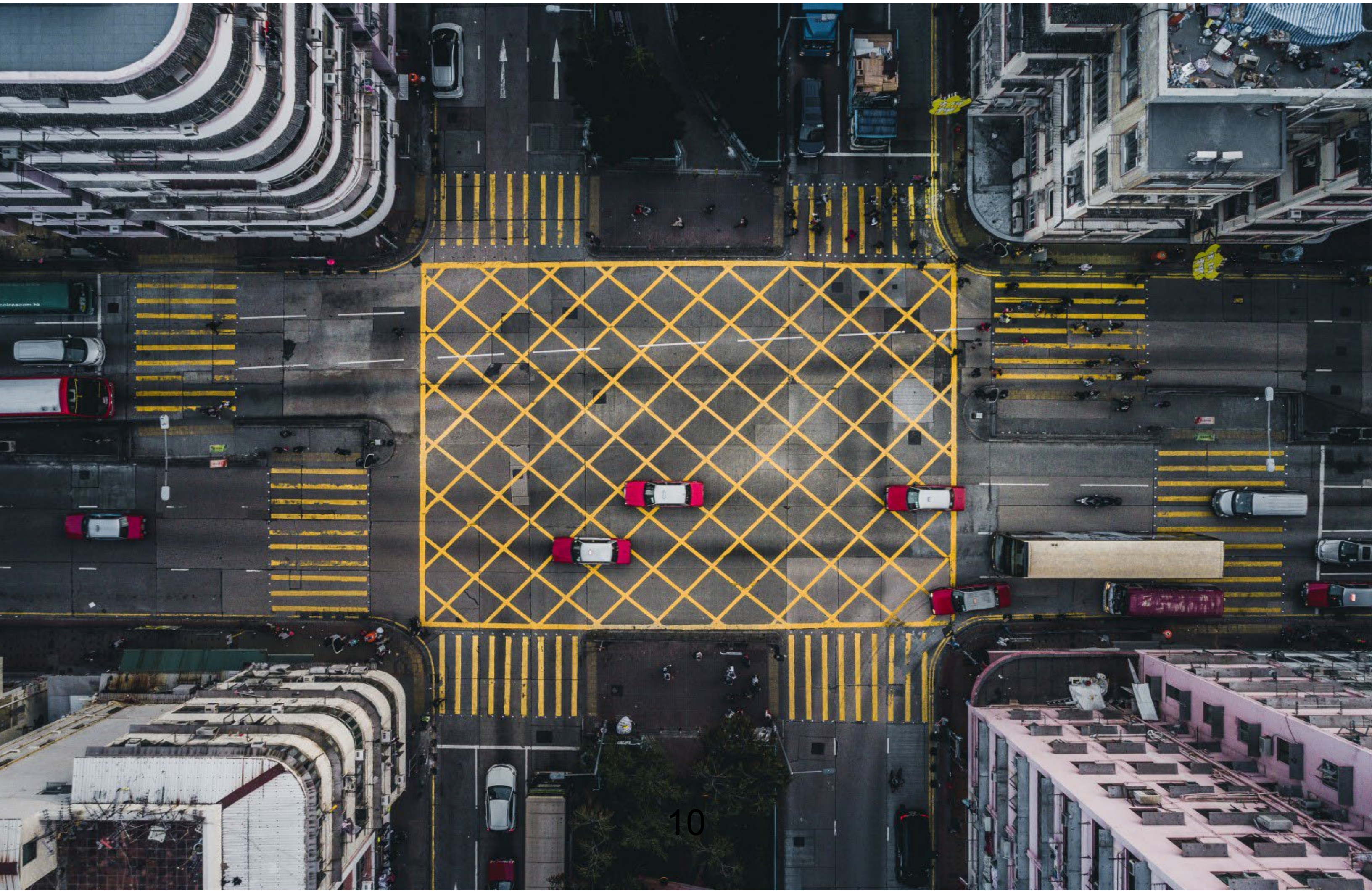
Recorder: Stacey Bruce, Committee Support Specialist

Screening of Enhanced Technologies for Offsite Groundwater Remediation of the Elmira Drinking Water Aquifer

LANXESS Canada Co./Cie.

18 November 2024

→ **The Power of Commitment**



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Our ref: 1119213-55-LTR-65

November 18, 2024

Technical Remediation Advisory Committee
c/o Stacey Bruce
Committee Support Specialist
Clerks Office/Corporate Services
Township of Woolwich
24 Church Street West, P.O. Box 158
Elmira, ON
N3B 2Z6

Screening of Enhanced Technologies for Offsite Groundwater Remediation of the Elmira Drinking Water Aquifer – LANXESS Canada Co./Cie

Dear Ms. Bruce,

Please find attached the Screening of Enhanced Technologies for Offsite Groundwater Remediation of the Elmira Drinking Water Aquifer report (GHD, 2024). This document was compiled in 2018 and submitted as a draft document to the Ministry of Environment, Conservation and Parks (MECP), and the former Woolwich Township Technical Advisory Group (TAG). Comments were received from both parties; however, the report was not finalized. LANXESS completed bench and pilot scale tests and confirmed that implementation of the short list technologies was not favourable at that time.

At the request of the Technical Remediation Advisory Committee (TRAC), the document has been finalized. LANXESS anticipates completing an additional technology screening in 2025 which will provide an update on any additional technology developments since 2018.

Regards

Luis Almeida

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AB/lj/65

Encl.

Copy to: Hadley Stamm, LANXESS
Tiffany Svensson, TRAC
Jason Rice, MECP

Project name	LANXESS Groundwater Remediation
Document title	Screening of Enhanced Technologies for Offsite Groundwater Remediation of the Elmira Drinking Water Aquifer
Project number	11192137-RPT-19
File name	Screening of Enhanced Technologies for Offsite Groundwater Remediation of the Elmira Drinking Water Aquifer

Status Code	**Revision**	**Author**	**Reviewer**		**Approved for issue**		
			Name	**Signature**	**Name**	**Signature**	**Date**
S4	0	Alan Deal	Amy Bugeya	Amy Bugeya	Luis Almeida	Luis Almeida	Nov. 6, 2024

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Appendices

1. Introduction

1.1 Background

LANXESS has recently proposed a strategic management framework to manage the off-site remedial action plan (RAP) for the Elmira Municipal Aquifer (MA) (GHD, 2018). A key feature of this framework is a sequence of elements that involve remediation technology selection and evaluation. The initial element in this sequence is a technology screening process where a list of all groundwater technologies (long list) will be considered and reduced to a short list of technologies for further evaluation. The remediation technologies on the short list will then be comprehensively evaluated in conjunction with treatability studies (as required). The treatability studies will include bench-scale experiments to generate appropriate data for decision-making, and then the most promising remediation technology (or technologies) will be field-tested in a focused pilot-scale trial(s). It is expected that by the time this remediation technology selection and evaluation effort has concluded there will be sufficient data generated from the recent RAP expansion to assess its performance and decide how to proceed as proposed within the strategic management framework.

1.2 Scope

The objective of this technology screening effort is to identify potential *in situ* treatment technologies that could reduce mass significantly in order to satisfy the remedial objectives (ROs). This effort also eliminates *in situ* treatment technologies that do not have the potential to significantly reduce mass of the principal constituents of concern (COC).

In 2017, the Municipal Aquifer Conceptual Site Model (GHD 2017) (CSM) was updated to focus on relevant aspects related to hydrostratigraphy, sources and associated history, COC fate and transport, past remediation efforts, and the COC distribution (GHD, 2017). For the purposes of this technology screening effort, it is assumed the mass distribution of n-nitrosodimethylamine (NDMA) and chlorobenzene in the MA remains unchanged.

2. Constituent Properties and Mass Remaining

NDMA and chlorobenzene are the COCs in the off-Site MA. NDMA is an industrial by-product or waste product of several industrial processes, and chlorobenzene is a colourless, flammable liquid used in chemical manufacturing. The Ontario Drinking Water Quality Standard (ODWQS) for NDMA is 0.009 micrograms per litre (μg/L), and the ODWQS for chlorobenzene is 80 μg/L (MOECC, 2017).

2.1 Relevant Physical-Chemical Properties

Table 1 lists the physical and chemical properties for NDMA and chlorobenzene. NDMA is essentially miscible in water (water soluble) and has a low organic carbon partition coefficient (K_{oc}) which resulted in the spatially extensive plume within the MA system. In contrast, the relatively lower solubility and higher K_{oc} for chlorobenzene resulted in the off-Site chlorobenzene plume being within the limits of the NDMA plume.

The Henry's law coefficient provides a qualitative assessment of the potential removal effectiveness of dissolved compounds during air stripping or sparging. Henry's law is only valid when the partitioning of the dissolved compound has reached equilibrium at an air/water interface. For a dissolved compound to reach this interface it must diffuse through the aqueous phase. Hence the two most influential chemical characteristics are molecular weight and Henry's law coefficient. The low Henry's law coefficient for NDMA of ~10^{-7} atmosphere cubic metre per mole (atm-m^3/mol) indicates that any technology that relies on air/water mass transfer would be limited. In comparison, the Henry's law coefficient for chlorobenzene is 3.58 x 10^{-3} atm-m^3/mol, which suggests that it would be amendable to a technology that relies on air/water mass transfer for mass removal.

Technologies that increase the temperature of a subsurface system attempt to remove mass by either thermal destruction or volatilization. Both NDMA and chlorobenzene have boiling points greater than 100 degrees Celsius (°C) indicating that groundwater would boil before NDMA or chlorobenzene are volatilized.

Table 1 Physical and chemical properties of the COC

Property	NDMA	Chlorobenzene
Formula	$C_2H_6N_2O$	C_6H_5Cl
CAS No.	62-75-9	108-90-7
MW (grams per mole [g/mol])	74.08(1)	112.56(2)
Density (grams per millilitre [g/mL])	1.0059(1)	1.1058(2)
Aqueous Solubility (milligram per litre [mg/L])	1,000,000(1)	466.3(2)
Vapour Pressure at 20°C (millimetre of mercury [mm Hg])	2.7(1)	3.9(2)
Boiling Point (°C)	152-154(1)	132
log K_{ow}	-0.57(1)	2.84(2)
K_{oc}	25.7(3)	224(4)
Henry's Law Constant at 20°C (atm - m^3/mol)	2.63 x 10^{-7}(1) to 1.08 x 10^{-6}	3.58 x 10^{-3}(2)

Notes:

(1) USEPA, January 2014. Technical Fact Sheet – N-Nitrosodimethylamine (NDMA).

(2) USEPA, January 1995. Chlorobenzene Fact Sheet: Support Document, EPA 749-F-95-007a

(3) MOECC, January 2017. Ontario Regulation 169/03, Ontario Drinking Water Quality Standards

USEPA, May 1996. Soil Screening Guidance: Technical Background Document, EPA/540/R-95/128, Office of Solid Waste and Emergency Response, United States Environmental Protection Agency, Washington, D.C.

2.2 Mass Remaining

2.2.1 NDMA Mass Remaining

Extraction well W3, and containment wells E7/E9, have reduced concentrations in the core of the off-Site NDMA plume in the Upper Municipal Aquifer (MU) and the Lower Municipal Aquifer (ML). LANXESS installed replacement well W3R in 2015. While the mass removal rate at E7/E9 has substantially decreased and the NDMA concentrations are approaching the ODWQS of 0.009 µg/L, LANXESS plans to continue operating E7/E9 because it increases the horizontal hydraulic gradient beneath the core of the MA NDMA plume and therefore, the rate of COC migration towards the extraction wells.

The other area where elevated NDMA concentrations persist is in the northwest lobe of the MU plume near monitoring well OW60-26. From 1992 to 2002 NDMA concentrations at OW60-26 increased from 10.07 to 84.22 µg/L. Delineation completed in 2014 reduced the known extent of the northwest NDMA plume in the MU and indicated that elevated NDMA concentrations were limited to within approximately 10 metre (m) of monitoring well OW60-26. In 2015, LANXESS installed a temporary pump in OW60-26 and pumped approximately 8,000 L/day for approximately four months. NDMA concentrations in samples collected from OW60-26 decreased from 42.45 to 20.27 µg/L during this time. This portion of the MU is remote from any extraction wells and the plume appears stagnant. The limited area of the elevated NDMA concentrations suggests that the NDMA mass in the vicinity of OW60-26 is relatively small (less than 100 g).

While the core of the ML NDMA plume near W3 and E7/E9 has been reduced, immediately west of the Site, NDMA concentrations greater than 100 μg/L persist in the ML at monitoring wells CH-44D (147.5 μg/L) and OW61-34 (366.9 μg/L). This portion of the ML is distant from the off-Site Collection and Treatment System (CTS) extraction wells and is in an area where the ML thins (to about 1 m) and eventually pinches out. These plume lobes have been stable since the early 1990s indicating that the groundwater in this area of the ML is not influenced by the off-Site CTS. LANXESS installed new ML extraction wells W8 and W9 near CH-44 and OW61-34, respectively and commissioned them in 2017.

2.2.2 Chlorobenzene Mass Remaining

Extraction wells W3 and W4 have reduced the concentration and extent of the MU chlorobenzene plume. On-Site containment well PW4 has removed most of the plume that was emanating directly from the Site. The remaining off-Site chlorobenzene plume in the MU is between extraction wells W4 and W5B. This portion of the chlorobenzene plume has been relatively stable between approximately 2000, after W5B was commissioned, and 2016. There may be a gap in the existing monitoring well network such that undefined chlorobenzene mass is present in the MA north of this lobe of the chlorobenzene plume. Also, groundwater in this area of the MU appears to be in a stagnation zone created by the competing capture zones generated by extraction wells W4 and W5B. In 2013, LANXESS installed a packer in W4 to prevent it from extracting MU groundwater. Recent eastward migration of the remaining MU chlorobenzene plume towards W5A suggests this has removed the stagnation zone between extraction wells W4 and W5B.

Within the ML, there were two lobes of the chlorobenzene plumes in 1998, one immediately west of the Site and the other farther southwest, beneath central Elmira. Groundwater extraction since 1998 has reduced the extent of the southwest off-Site ML chlorobenzene plume. As with the MU chlorobenzene plume, the remaining portion of the central off-Site ML chlorobenzene plume is within the presumed stagnation zone between extraction wells W4 and W5A. In 2017, LANXESS ceased routine pumping of W4. Continued monitoring will determine if this approach is effective in removing mass associated with the stagnation zone and facilitates extraction of the ML chlorobenzene plume by well W5A. As with the ML NDMA plume immediately west of the Site, elevated chlorobenzene concentrations (2,000 μg/L) also persist. LANXESS began pumping W8 in 2017 to address this lobe of the ML chlorobenzene plume.

As identified in the CSM (GHD 2017), there has been significantly more chlorobenzene mass extracted to date (~3,300 kilogram [kg]) then estimated to be in-place in 1998 (~1300 kg). This inconsistency is supported by the 2015 Check Point Analysis (GHD, 2016) where the simulated chlorobenzene mass removal generally under-predicts the observed mass removal at the majority of extraction wells by a flow-weighted average of ~3.4. NDMA is the most widespread COC in the Municipal Aquifer and has a very low ODWQS (0.009 μg/L) and drives the groundwater remedy. Chlorobenzene concentrations will continue to be reduced as the remedy removes NDMA.

2.3 Characteristics of the Target Treatment Zones

As a result of the RAP reducing COC concentrations in some parts of the MA but not in others, the remaining mass in the off-Site MA has different spatial distributions as described in Section 2.2. For example, the relatively dilute NDMA plume near W3R and dilute chlorobenzene plume between W4 and W5A/B are portions within the MA where mass has been removed and concentrations have been reduced by orders of magnitude. Conversely, there are several relatively small areas, such as near W8 and W9, which feature relatively high concentrations of the COC that the pre-2017 groundwater extraction system has not affected.

Given that the average fraction of organic carbon (f_{oc}) for the MU and ML is 0.24% (GHD 2017), and assuming a porosity of 0.3 and a soil bulk density of 1,855 kilogram per cubic metre (kg/m^3), the ratio of the mass sorbed to the mass of water for a cubic meter of aquifer is 0.38 for NDMA and 3.3 for chlorobenzene.

As described in the CSM (GHD 2017), LANXESS included vertical aquifer sampling (VAS) in groundwater investigations at selected locations to explore potential NDMA or chlorobenzene plume stratification within the MA.

Based on the VAS data, the concentration of NDMA or chlorobenzene was increasing with depth at most of the locations where the MU or MU was sufficiently thick (greater than 15 m). At approximately half the VAS locations, the vertical plume stratification of NDMA or chlorobenzene coincides with the presence of a coarse basal layer of gravel or gravelly sand.

Prior to 1998, diffusion of both NDMA and chlorobenzene occurred from the ML and MU groundwater into adjacent lower hydraulic conductivity material. LANXESS investigated the depth of penetration of COC into the aquitards by collecting soil samples at increasing depths from an aquifer/aquitard contact and analyzing them for NDMA and chlorobenzene. At the location of monitoring well nest CH-47, NDMA had penetrated more than 0.9 m into the adjacent aquitard, and the maximum observed chlorobenzene penetration was 0.6 m into the adjacent aquitard.

While some residual non-aqueous phase liquid (NAPL) exists in the former M-2 landfill, currently beneath the southwest portion of the Site, groundwater contaminated by this residual NAPL is contained beneath the Site and does not contribute to off-Site groundwater COCs (GHD 2017). Based on the data assembled to date, there is no evidence of NAPL presence in the off-Site MA.

In summary, the key features of the treatment target zones are:

- Dissolved and sorbed NDMA and chlorobenzene mass only (no NAPL)
- Co-mingled NDMA and chlorobenzene plumes
- Widespread dilute NDMA plume with concentrations between is 0.009 and approximately 1 μg/L, and chlorobenzene plume with concentrations between is 80.0 and 250 μg/L
- Small areas (less than 2,500 square metres [m^2]) of high concentrations of NDMA (greater than 100 μg/L) and chlorobenzene (between 1,200 and 4,300 μg/L)
- MU and ML composed primarily of sand and gravel with hydraulic conductivity of the order of 10^{-2} to 10^{-1} centimetres per second (cm/s)
- NDMA and chlorobenzene mass present in lower permeability zones adjacent to the ML and MU
- Plume stratification within the MU and ML frequently associated with a coarse basal layer

3. Selection Methodology

The first step of this technology screening process was the identification of all proven *in situ* treatment technologies.

The next step was to complete a preliminary screening of each technology, based on two considerations:

- Is the technology effective to treat NDMA and chlorobenzene?
- Is the technology compatible with treating groundwater in a deep (greater than10 m) confined aquifer system?

Effectiveness - A desktop review of the ability of a treatment technology to reduce the mass of NDMA and chlorobenzene was conducted. Because the NDMA and chlorobenzene plumes are co-mingled, if the technology was deemed ineffective for both COCs, it was removed from further consideration.

Hydrogeological Compatibility - If a particular treatment technology is not appropriate in the MA hydrogeological setting as described by the CSM (GHD 2017) it was removed from further consideration.

Following the preliminary screening, a desktop review was completed based on the available information with respect to the potential application of each technology to the MA. We used the following criteria for the secondary screening of the retained groundwater remediation technologies:

- Timeframe
- Implementability
- Economics
- Adverse Side Effects

The benefits and challenges with implementing each potential treatment technology are discussed with respect to each criterion. Each technology was also qualitatively and comparatively ranked, relative to the other technologies, with each technology achieving one of three ranks (detailed below) based on its feasibility under each criterion.

We also scored each technology separately against the two plume characteristics: the large, dilute plume, and the small area, high concentration plume.

Timeframe - Condition 10.4 of Environmental Compliance Approval (ECA) Number 7483-A45QAW states "…*other remediation measures to achieve Ontario Drinking Water Quality Standards by the year 2028*". We reviewed information with respect to the time required to achieve mass reduction. Any technology that would take many years to be effective would be too inefficient for this application and was ranked "Low" in the secondary screening. "Moderate" and "High" rankings were awarded for relatively shorter time frames.

Implementability - Under this criterion, a technology was assessed in terms of its technical and administrative feasibility. One example of administrative feasibility is that most remediation technologies require installation of infrastructure on private property, which may not be acceptable to the property owner. If the only way to achieve technical feasibility is to increase the amount of infrastructure, then the administrative feasibility is simultaneously reduced. The evaluation of the implementability of the groundwater remediation technologies also considered the depth to COCs and the COC distribution. We also considered the reliability of the technology and the ability to monitor its performance.

If there are significant barriers to successfully implementing the technology under this criterion it was ranked "Difficult", "Moderate" and "Easy" reflect less barriers and challenges.

Cost - The major costs (capital costs and operation and maintenance) associated with implementing each technology were considered. Costs were evaluated qualitatively and relative to each other, and a "Low" cost is favourable, and a "High" cost is not favourable.

Adverse Side Effects - Some technologies can produce undesirable or detrimental effects on groundwater quality. If there is the potential for risk, its magnitude and the adequacy and reliability of any potential controls were also taken into consideration. We ranked the potential for each technology to produce adverse side effects from "Low" through "Moderate" and "High" as this potential increased.

3.1 Potential *In Situ* Groundwater Technologies

The list of *in situ* treatment technologies considered in this screening effort is provided below. The identified technologies have been categorized based on the primary intended mode of mass removal; physical, chemical, biological, or thermal. The Other category was used for those technologies that did not fall squarely into the first four categories. It is acknowledged that many of these technologies have aspects that crossover to other categories. Appendix A contains a brief description of each technology:

Physical

- Soil vacuum extraction (SVE)
- *In situ* air sparging (IAS)
- In-well stripping
- Circulating wells

Chemical

- In situ chemical oxidation (ISCO)
- In situ chemical reduction (ISCR)

Biological

- Bio-sparging
- Bio-venting
- Bio-augmentation
- Bio-stimulation

Thermal

- Electrical resistance heating (ERH)
- Hot air injection
- Hot water injection
- Radio frequency heating (RFH)
- Steam enhanced extraction (SEE)
- Thermal conductive heating (TCH)
- Vitrification

Other

- Monitored Natural Attenuation (MNA)
- Phyto-remediation
- Permeable Reactive Barrier (PRB)
- Funnel and Gate

4. Technology Screening

Appendix A also contains a discussion of the limitations and challenges for application to the MA hydrogeologic conditions. Many of the technologies listed below have limitations that make them unsuitable for application to the MA. Based on the initial screening. we considered the following technologies either ineffective from removing mass of the COC, and/or fundamentally incompatible with the MA:

Physical

- Soil vacuum extraction (SVE)
- *In situ* air sparging (IAS)
- In-well stripping
- Circulating wells

Biological

- Bio-sparging
- Bio-venting

Thermal

- Electrical resistance heating (ERH)
- Hot air injection
- Hot water injection
- Radio frequency heating (RFH)
- Steam enhanced extraction (SEE)

– Thermal conductive heating (TCH)
– Vitrification

Other

– Monitored Natural Attenuation (MNA)
– Phytoremediation
– Permeable Reactive Barriers (PRB)
– Funnel and Gates

Table 4.1 provides the long list of potential treatment technologies and the rational for removing them from further consideration.

A "short-list" of technologies potentially capable of achieving the goals of the RAP was developed. Only those technologies that would be effective in treating the mass of COC present in the MA are considered implementable.

The following technologies were retained for further consideration:

1. *In Situ* Chemical Oxidation (ISCO)
2. *In situ* chemical reduction (ISCR)
3. Bio-augmentation
4. Bio-stimulation
5. Monitored Natural Attenuation (MNA)

MNA processes occurring with the MA are not well known. MNA was not eliminated because it could be effective with respect to NDMA, it is effective for chlorobenzene and it is compatible with conditions in a deep confined aquifer. However, because an active remedy is required to meet remediation goals, we did not include MNA in the secondary screening. It is retained should future condition become more amenable to MNA.

The other four technologies are discussed further in the following subsections. Because this is a high-level screening, and they are similar technologies ISCO and ISCR are discussed together as are bio-augmentation and bio-stimulation.

4.1 *In Situ* Chemical Oxidation and *In Situ* Chemical Reduction

Effectiveness

ISCO is accomplished through the injection of a chemical oxidant that reacts with a dissolved COCs through oxidizing reactions that break the bonds in the compounds. ISCR is similar except the reagent produces reducing reactions. With a few exceptions, these processes generally convert the COCs into nonhazardous or less toxic compounds, primarily carbon dioxide and water. ISCO/ISCR is very effective in converting chlorobenzene into nontoxic compounds. NDMA is considered a "Category 2" organic compound, which is a compound which either exhibits some resistance to degradation by some oxidants or some certain conditions, or if there is uncertainty regarding the effectiveness of ISCO (Siegrist et al, 2011). Studies have been completed that conclude NDMA degradation may occur in reducing conditions in some deep hydrogeologic settings (DoD SERDP 2008, 2009, 2012).

Timeframe

Depending on the oxidant used, the period for ISCO/ISCR reactions can range from a few seconds to weeks, which is compatible with the RAP timeframe. Therefore, the ISCO/ISCR timeframe ranks "High" in the secondary screening, for both the dilute and high concentration portions of the plume

Implementability

The primary restriction with implementing ISCO/ISCR is delivering the oxidant to the COCs in the aquifer so they can come into contact and react. The target in the Elmira MA is an aqueous plume which requires a carefully considered injection strategy. Typically, ISCO/ISCR involves injecting the oxidant, or reducing agent, into the aquifer under pressure via a series of wells. The radius of influence of each well and the size of the target area will determine the number of injection wells required. For example, the MU NDMA plume covered an area of 1,700,000 m^2 in 2017. A plume of this area would require a large number of injection sites. As the amount of infrastructure such as wells increases, the feasibility of ISCO/ISCR decreases.

Administrative challenges include negotiating access to multiple injection sites and ensuring large quantities of hazardous oxidizing chemicals are handled safely.

The large volume of oxidant required, and number of injection sites required for the large dilute plume are the main reasons implementing ISCO/ISCR is scored as “Difficult”. Implementing ISCO/ISCR in a small area, high concentration portion of the plume will be more feasible and is scored as “Moderate.”

Cost

The capital cost to implement ISCO/ISCR is relatively high. The injection wells that target the MA plumes will need to be between approximately 30 m and 100 m deep. Multiple injections may be required to achieve target COC concentrations. Additional training and engineering controls may be required due to potential hazards associated with chemical oxidants.

Because of these factors, we consider the cost of implementing ISCO//ISCR for the dilute plume “High” and the cost to implement ISCO in the high concentration portions of the plume “Moderate”.

Adverse Side Effects

The treatment zones would be within the area that is hydraulically contained by the off-Site CTS. Therefore, in the event the reactions are incomplete, and the goals of the RAP are not achievable, the plume will still be contained.

There are metals in the MA matrix that have the potential to be mobilized during ISCO treatments. If not properly managed, metals such as iron may be precipitated in the aquifer and reduce its permeability.

However, this effect is usually localized to the active treatment zone and may be reversible when redox conditions return to pre-treatment levels. The current off-Site CTS is not designed to reduce metal concentrations prior to discharge to surface waters.

The relative potential for ISCO//ISCR to produce this adverse side effect is “Moderate” for the large dilute plume because it would be wide spread. The relative potential for ISCO//ISCR to produce this adverse side effect is “Low” in the high concentration portions of the plume as activities would be limited to very small parts of the aquifer.

Summary

The following summarizes the secondary screening for ISCO and ISCR

Plume	Effectiveness	Time Frame	Implemetability	Cost	Adverse Effects
Large & Dilute	High	High	Difficult	High	Moderate
Small & High Concentration	High	High	Moderate	Moderate	Low

4.2 Bio-augmentation and Bio-stimulation

Effectiveness

In situ bio-remediation is a treatment process whereby the compounds of concern are metabolized into nonhazardous compounds by naturally occurring microorganisms. The microorganisms utilize the COCs as a source of carbon and energy. Several techniques can be applied to manipulate groundwater conditions in order to enhance naturally occurring biodegradation processes and speed up degradation rates of the COCs. In situ bio-stimulation of groundwater encourages indigenous bacterial populations to metabolize target COCs through the addition of various amendments to the subsurface environment. Bio-augmentation consists of adding exogenous microorganisms to enhance degradation of constituents. While there are differences in the technologies, we are combining them for the purpose of secondary screening. Several aspects of enhanced bioremediation are similar to ISCO. For example, the radius of influence of the injection wells must be sufficient for them to be a feasible means of delivering amendments.

In situ bio-stimulation and bio-augmentation effectiveness is ranked “High” for both the dilute plume and the small area, high concentration portions of the plume.

Timeframe

The time frame for enhancing biodegradation ranges from a few months to many years. The lower end of this time range is compatible with the RAP deadline. Both bioremediation technologies are generally longer than the “High” to “Moderate” time frames for ISCO. Therefore, the bioremediation time frame was ranked “Moderate” for both the large dilute plume and the small area, high concentration portion of the plume.

Implementability

As with ISCO, one restriction with implementing enhanced biodegradation is delivering the enhancing agency to the microbes in the aquifer so they can increase the rate at which they metabolize the COCs. Injection into the aquifer via a series of wells is the typical delivery method. The radius of influence of each well and the size of the target area will determine the number of injection wells required. Because the enhancements take months or years to develop, the natural (or artificially increased) groundwater velocity can aid in dispersion and increase the radius of influence.

Administrative challenges include negotiating access to multiple injection sites.

Monitoring the effectiveness of enhanced biodegradation will depend on the type of enhancement used. For example, if increased oxygen content is the enhancement, the concentrations of dissolved oxygen in groundwater can be monitored. An increase in the concentration of metabolic byproducts is another indication that biologic activity has increased. If additional nutrients are supplied, then monitoring should include these parameters to determine if the nutrients are being consumed. As with most remedial technologies, post remedy monitoring is required because re-bound effects may occur.

If LANXESS implements in situ bioremediation in conjunction with the existing off-Site CTS and it proves ineffective, it should not interfere with the groundwater extraction, but it may have the potential to affect groundwater treatment, if unused simulants are captured by the extraction wells.

The implementation of in situ bio-stimulation and bio-augmentation faces challenges similar to ISCO. Therefore, the implementing in situ bio-stimulation and bio-augmentation for the large dilute plume is considered “Difficult” and implementing ISCO in a small area, high concentration portion of the plume will be more feasible and is scored as “Moderate”.

Cost

The capital cost to implement enhanced biodegradation is relatively high. MA injection wells will need to be relatively deep. Multiple injections may be required to maintain conditions in the MA that promote biodegradation. If the *in situ* biodegradation period extends into years, monitoring costs can become significant.

The cost of implementing ISCO and the cost for implementing in situ bio-remediation will be similar. Accordingly, the cost for in situ bioremediation of the large, dilute plume is “High” and the cost to implement situ bioremediation in the small area, high concentration plume is “Moderate”.

Adverse Side Effects

The zones of enhanced biodegradation would be with in the area that is hydraulically contained by the off-Site CTS. Therefore, in the event the reactions are incomplete and do not achieve ODWQS, the off-Site MA plume will still be contained. Therefore, the potential for adverse side effects is “Low” for both the large, dilute plume and for the small area, high concentration plume.

Summary

The following summarizes the secondary screening for bio-augmentation and bio-stimulation:

Plume	Effectiveness	Time Frame	Implemetability	Cost	Adverse Effects
Large & Dilute	High	Moderate	Difficult	High	Low
Small & High Concentration	High	Moderate	Moderate	Moderate	Low

5. Summary of Selected Technologies for Evaluation

A long list of proven groundwater technologies was developed. We then completed preliminary screening that evaluated the effectiveness of the technologies to treat NDMA and chlorobenzene and their compatibility with hydrogeologic conditions in the MA.

We retained the following technologies for further consideration:

1. *In Situ* Chemical Oxidation
2. *In Situ* Chemical Reduction
3. Bio-augmentation
4. Bio-stimulation

We then completed secondary screening of these technologies via a three-stage ranking of each technology’s effectiveness, the time frame for the technology to be effective, its implementability, the cost, and the potential for it to produce adverse side effects.

No technologies were retained for further evaluation for the large, dilute portions of the NDMA and chlorobenzene plumes. ISCO, in situ bio-stimulation, and in situ bio-augmentation are retained for further evaluation for use in reducing the small area, high concentration portions of the plume.

6. References

Siegrist R, M Crimi,and T Simpkin 2011 In Situ Chemical Oxidation for Groundwater Remediation. Springer Science & Business Media, DoD SERDP. 2009. “Abiotic and Biotic Mechanisms Controlling In Situ Remediation of NDMA.” SERDP Project ER-1421

Table 4.1 Groundwater Treatment Technologies

	Remediation Technology	**Initial Screening Result**	**Rationale**
1	**Physical**		
a)	Soil vacuum extraction (SVE)	Incompatible	MA is confined so not applicable
b)	In situ air sparging (IAS)	Ineffective	NDMA is not volatile, so the technology is ineffective. No means of ensuring all injected gas is collected
c)	In-well stripping	Ineffective	NDMA is not volatile, so the technology is ineffective.
d)	Circulating wells	Ineffective	NDMA is not volatile, so the technology is ineffective.
2	**Chemical**		
a)	In situ chemical oxidation (ISCO)	Retained	Effective in treating NDMA and chlorobenzene and compatible with a deep confined aquifer
b)	In situ chemical reduction (ISCR)	Retained	Effective in treating NDMA and chlorobenzene and compatible with a deep confined aquifer
3	**Biological**		
a)	Bio-sparging	Incompatible	NDMA is not volatile, so the technology is ineffective.
b)	Bio-venting	Incompatible	MA is confined so there is no vadose zone
c)	Bio-augmentation	Retained	Unknown effectiveness in treating NDMA and chlorobenzene and compatible with a deep confined aquifer
d)	Bio-stimulation	Retained	Unknown effectiveness in treating NDMA and chlorobenzene and compatible with a deep confined aquifer
4	**Thermal**		
a)	Electrical resistance heating (ERH)	Incompatible	Insufficient thermal capacity to reach the boiling point of NDMA or chlorobenzene
b)	Hot air injection	Incompatible	Insufficient thermal capacity to reach the boiling point of NDMA or chlorobenzene No means of ensuring injected air is collected
c)	Hot water injection	Incompatible	Insufficient thermal capacity to reach the boiling point of NDMA or chlorobenzene
d)	Radio frequency heating (RFH)	Incompatible	Unproven for deep aquifer systems

e)	Steam enhanced extraction	Ineffective	No means of ensuring that all produced vapours are collected
	(SEE)		
f)	Thermal conductive heating (TCH)	Incompatible	Would need to boil off all water first to reach boiling point of chlorobenzene or NDMA
g)	Vitrification	Incompatible	Elmira MA is too deep
5	**Other**		
a)	Monitored Natural Attenuation (MNA)	Retained	Retained but not included in secondary screening because an active remedy is still required. May be viable in the future
b)	Phyto-remediation	Incompatible	Elmira MA is too deep
c)	Permeable Reactive Barriers (PRBs)	Incompatible	Elmira MA is too deep
d)	Funnel and Gates	Incompatible	Elmira MA is too deep

Appendices

Appendix A

Groundwater Remediation Technologies

Introduction

This Appendix provides a summary of each of the remediation technologies included in the long list of potentially applicable groundwater treatment technologies. The description of the technology is not specific to the Elmira Municipal Aquifer or the constituents of concern (COC) in the MA.

We have reproduced information regarding the remediation technologies included in the Remediation Technologies Screening Matrix and Reference Guide, 4th Edition. The URL is provided for each technology. With the few exceptions that have been noted, it is the source of all technical information provided in this Appendix.

The identified technologies have been categorized based on the primary intended mode of mass removal; physical, chemical, biological, or thermal. The Other category includes technologies that did not rely on physical, chemical, biological, or thermal mechanisms.

Physical

Soil Vapour Extraction (SVE)

https://frtr.gov/matrix2/section4/4-34.html

Soil Vapour Extraction (SVE) is an in situ unsaturated (vadose) zone soil remediation technology in which a vacuum is applied to the soil to induce the controlled flow of air and remove volatile and some semivolatile constituents from the soil. The gas leaving the soil may be treated to recover or destroy the contaminants. Vertical extraction vents are typically used at depths of 1.5 meters (5 feet) or greater and have been successfully applied as deep as 91 meters (300 feet). Horizontal extraction vents (installed in trenches or horizontal borings) can be used as warranted by contaminant zone geometry, drill rig access, or other site-specific factors.

SVE relies on volatilization to transfer the contaminant form the soil to the soil gas and is therefore only effect for treating volatile organic compounds (VOCs) and some fuels.

For the soil surface, geomembrane covers are often placed over soil surface to prevent short circuiting and to increase the radius of influence of the wells. The duration of operation and maintenance for in situ SVE is typically months to years.

In Situ Air Sparging (IAS)

https://frtr.gov/matrix2/section4/4-34.html

Air sparging is an in situ remediation technology in which air is injected through an aquifer. Injected air traverses horizontally and vertically in channels through the soil column, creating an underground stripper that removes contaminants from the soil by volatilization. This injected air helps to flush the contaminants up into the unsaturated zone where an SVE system is usually operated in conjunction with air sparging to remove the vapour phase COCs. This technology is designed to operate at high flow rates that maintain increased contact between ground water and soil and strip more ground water by sparging. Oxygen contained in the air may also enhance biodegradation of contaminants below and above the water table.

The target contaminant groups for air sparging are VOCs and fuels.

Factors that may limit the applicability and effectiveness of the process include:

- Air flow through the saturated zone may not be uniform, which implies that there can be uncontrolled movement of potentially dangerous vapours
- Depth of contaminants and specific site geology must be considered

- Air injection wells must be designed for site-specific conditions
- Soil heterogeneity may cause some zones to be relatively unaffected

Air sparging can be applied through a series of well points and soil vapour extraction could utilize a horizontal perforated pipe system to withdraw air containing contaminant vapours from soil. Typically, the vapour extraction occurs from a central location and the soil air is supplemented by addition of air through well points around the perimeter of the area to be treated. Also, an impermeable liner to eliminate short-circuiting of the system should cover the ground surface.

In-Well Air Stripping

https://frtr.gov/matrix2/section4/4-40.html

In-well air stripping utilizes a well that has been screened at two depths. The lower screen is set in the groundwater saturated zone, and the upper screen is in the vadose zone. Air is injected into the well below the water table, aerating the water and causing it to rise in the well and flow out the upper screen. As this water flows out the upper screen it draws contaminated groundwater in through the lower screen. VOCs vapourize into the air bubbles entrained in the aerated water. When the air bubbles escape out of the water the dissolved COC is reduced. The VOCs enter the vadose zone and are removed from the sub surface by an SVE system. Ground water is never brought to the surface, it percolates back into the saturated zone where it is re-circulated through the in well air stripper.

In well air striping is effective for treating groundwater contaminated with VOCs and some fuels

Circulating Wells

https://frtr.gov/matrix2/section4/4-40.html

Circulating wells (CWs) are designed to create in-situ vertical groundwater circulation cells by drawing groundwater from an aquifer through one screened section of and discharging it through another screened section. CWs utilize either ex situ groundwater treatment, such as air stripping or GAC but the optimum use of CWs is with VOCs where the VOCs can be removed from the groundwater under vacuum either in the well or in an above ground air stripper. Another approach is to amend the extracted groundwater with chemicals that promote destruction of the contaminants. The amended groundwater is then injected into the aquifer where the chemical(s) react with contaminants in the injected water and mix with the native groundwater.

The size of the circulation zone created within the aquifer will depend on the aquifer properties, such as thickness and hydraulic conductivity, the separation between well screen sections, the anisotropy of the aquifer, the groundwater flow velocity and the selected pumping rate. If the width of a plume is larger than the capture zone of a single CW, several CWs are arranged in one line perpendicular to natural groundwater flow. By means of rows of CW wells arranged in series large area plumes can be remediated but the capital costs and access constraints may limit feasibility.

Another important consideration, like most of the groundwater treatment technologies, is how to achieve sufficient penetration of the higher contaminated fine-grained zones, like sandy, silty or clayey layers and lenticular intercalations.

For effective in-well treatment, the contaminants must be adequately soluble and mobile so they can be transported by the circulating ground water.

Chemical

In Situ Chemical Oxidation (ISCO)

https://clu-in.org/techfocus/default.focus/sec/In_Situ_Oxidation/cat/Overview/

Introduction

Chemical oxidation converts hazardous contaminants to non-hazardous or less toxic compounds that are more stable, less mobile, and/or inert. In situ chemical oxidation (ISCO) is accomplished through the injection of a chemical compound that reacts with contaminants in the subsurface to form inert or less hazardous substances through oxidizing reactions. This injection typically utilizes a network of injection wells that can be temporary or permanent. The oxidant typically breaks the carbon bonds in the contaminants converting them into carbon dioxide, chloride and water. In general, the oxidants have been capable of achieving high treatment efficiencies (e.g., >90 percent) for unsaturated aliphatic (e.g., trichloroethylene [TCE]) and aromatic compounds (e.g., benzene), with fast reaction rates.

Each oxidant has advantages and limitations. Some oxidants require a catalyst or other additive to increase their effectiveness. Others require a specific range of pH to be effective. Some oxidants may remain in the subsurface for weeks to months, while others naturally decompose within hours of injection. Once the reaction is complete, some oxidants may produce decomposition products.

The soil oxidant demand (SOD) is a measure of how the naturally occurring materials in soil will affect the performance of some of the oxidants. High SOD will generally increase the cost of cleanup, as more oxidant will be required.

Field applications have clearly affirmed that matching the oxidant and in situ delivery system to the COCs and the site conditions is the key to successful implementation and achieving performance goals.

Permanganate

Permanganate is a non-specific oxidizer of contaminants with low standard oxidation potential and high SOD. It can be used over a wide range of pH values and does not require a catalyst. The reaction stoichiometry of permanganate (typically provided as liquid or solid $KMnO_4$, but also available in Na, Ca, or Mg salts) in natural systems is complex. Due to its multiple valence states and mineral forms, Mn can participate in numerous reactions. The reactions proceed at a somewhat slower rate than other oxidants. Permanganate is most effective when delivered in an aqueous solution and reacts throughout a wide range of pH conditions (5-12).

Permanganate tends to remain in the subsurface for a long time, allowing for more contaminant contact and the potential of reducing rebound. As permanganate oxidizes organic materials, manganese oxide forms as a dark brown to black precipitate.

Potassium permanganate has a much lower solubility than sodium permanganate and generally is applied at lower concentrations. It is inexpensive and readily available commercially. It is also relatively easy and safe to handle compared to peroxide or ozone.

Persulfate

Sodium persulfate ($Na_2S_2O_8$) is an effective oxidant for organic contaminants in soil and groundwater. Persulfate is a strong oxidant with a higher oxidation potential than hydrogen peroxide and a potentially lower SOD than permanganate or peroxide. This ISCO process is chemically complex and can vary in effectiveness, ease of application, and safety profile depending on the activation technology selected.

Persulfate reaction is slow unless placed in the presence of a catalyst, such as ferrous iron. The ferrous iron catalyst will degrade with time and precipitate. Persulfate also can be activated in the presence of base conditions (pH 12). Persulfate activation decreases as the pH falls from 12 but does not stop even at a pH of 8. Groundwater can be made basic by the addition of a strong alkali hydroxide such as potassium or sodium hydroxide.

Hydrogen Peroxide

Oxidation using low concentration solutions of liquid hydrogen peroxide (H_2O_2) in the presence of native or supplemental ferrous iron (Fe^{+2}) produces Fenton's Reagent. In many cases, there may be sufficient iron or other transition metals in the subsurface to eliminate the need to add ferrous sulfate. The reaction yields free hydroxyl radicals (OH^-). These strong, nonspecific oxidants can rapidly degrade a variety of organic compounds to produce carbon dioxide and water. The reactions are extremely rapid. Soil and groundwater often contain an adequate level of iron for sustaining this reaction.

Peroxide oxidation is an exothermic reaction that can generate sufficient heat to boil water. The generation of heat may cause favorable desorption or dissolution of contaminants and their subsequent destruction. Increased mobility may induce contaminants to migrate away from the treatment zone. With its high reaction and decomposition rates, hydrogen peroxide is not likely to address contaminants found in low permeability soil. Because of the fast reaction rate, the area of influence around the injection point is small.

Fenton's Reagent oxidation is most effective under very acidic pH (e.g., pH 2 to 4) and becomes ineffective under moderate to strongly alkaline conditions. This generally requires the injection of an acid to lower the treatment zone pH to between three and five. The reaction oxidizes the ferrous iron to ferric iron and if the subsurface pH is not acidic enough the iron may precipitate, which can result in a loss of permeability in the soil near the injection point.

Because of its reactivity, there are safety concerns with handling catalyzed hydrogen peroxide on the surface, and the potential exists for violent reactions in the subsurface.

Ozone

Ozone gas can oxidize contaminants directly or through the formation of hydroxyl radicals. The oxidation reaction is extremely fast. Due to ozone's high reactivity and instability; it requires closely spaced sparge wells. Ozone is an unstable gas with a half-life of 20 to 30 minutes at 20°C (68°F) and must be produced by an on-site ozone generator. Ozone sparging has the advantage over liquid hydrogen peroxide because the target contaminants transfer faster to air than to water, increasing the speed of degradation.

Compounds which have effectively been treated by ozone sparging are tetrachloroethene (PCE), trichloroethylene (TCE), 1,1,1-trichloroethane (1,1,1-TCA), 1,1-dichloroethyle (1,1-DCE), BTEX, MTBE, and vinyl chloride. Like peroxide, ozone reactions are most effective in systems with acidic pH.

Ozone can be applied as a gas or dissolved in water. As a gas, ozone can degrade a number of chemicals directly and it provides an oxygen-rich environment for contaminants that degrade under aerobic conditions. It also degrades in water to form radical species that are highly reactive and non-specific. Because of its fast reactivity, ozone may not be appropriate for slow diffusion into low-permeability soil as it will be spent before it has the opportunity to diffuse.

Peroxone

http://www.kerfoottech.com/environmental-technology-products-perozone.asp

Peroxone is the injection of peroxide-coated micro bubbles of ozone. Perozone®, is a registered trademarks of Kerfoot Technologies, Inc (KTI). Coating ozone microbubbles with peroxide enhances the destruction of targeted contaminants. KTI also advocates pressure-pulsed injection at low injection rates, on the order of milligrams per minute.

Microbubbles are also touted as being compatible with remediating groundwater in a variety geologic media because of its ability to enter small pore spaces ranging from sands to silty clays to low-permeable fractured bedrock. Another advantage of this technology is the increased surface area afforded by microbubbles results in more contact with the contaminants of concern thereby facilitating more destructive chemical reactions.

Peroxone is effective in the remediation of groundwater contaminated by a variety of contaminants including gas and oil, aromatic ring compounds, halogenated alkenes and alkanes, PAHs, PCBs, pesticides and 1,4 dioxane.

Calcium Peroxide

https://www.solvay.us/en/binaries/IXPER_Soil_Groundwater-236830.pdf

Calcium Peroxide is a fine, very pale yellow, odorless powder that is used for the enhanced natural attenuation of petrochemical and other aerobic biodegradable compounds in soil and groundwater. Calcium peroxide decomposes slowly in contact with water and generates oxygen and heat. The rate of gaseous oxygen generation is controlled by pH and temperature. Enhanced bioremediation is achieved through the extended release of oxygen into the subsurface to supplement the rate limiting oxygen requirement of aerobic microorganisms. Calcium peroxide can also generate hydrogen peroxide, which can then oxidize contaminants.

Calcium peroxide can treat petroleum hydrocarbons and related VOCs such as benzene, toluene, ethylbenzene and xylene and methyl tertiary butyl ether (MTBE). Some halogenated compounds such as vinyl chloride and chlorobenzene can also be treated with calcium peroxide.

ISCO Applicability

The rate and extent of degradation of a target COC are dictated by the properties of the chemical itself and its susceptibility to oxidative degradation. Aquifer conditions such as pH and temperature influence the reaction rate. The oxidants also react with other oxidant-consuming substances such as natural organic matter, reduced minerals and carbonate and other free radical scavengers.

Given the relatively indiscriminate and rapid rate of reaction of the oxidants with reduced substances, the method of delivery and distribution throughout a subsurface region is of paramount importance. Oxidant delivery systems often employ vertical or horizontal injection wells and sparge points with forced advection to rapidly move the oxidant into the subsurface. Permanganate is relatively more stable and relatively more persistent in the subsurface; as a result, it can migrate by diffusive processes.

Potential detrimental oxidation-induced effects include decreased pH, colloid genesis that reduces permeability; mobilization sorbed metals; possible formation of toxic byproducts; evolution of heat and gas; and biological perturbation. Often large quantities of hazardous oxidizing chemicals are required due to the oxidant demand of the target organic chemicals and the unproductive oxidant consumption of the formation. Worker training for the safe handling of process chemicals and proper management of remediation wastes are critical.

In situ chemical oxidation is a viable remediation technology for mass reduction in source areas as well as for plume treatment. The potential benefits of in situ oxidation include the rapid and extensive reactions with various COCs applicable to many bio-recalcitrant organics and subsurface environments. In addition, in situ chemical oxidation can be tailored to a site and implemented with relatively simple, readily available equipment.

In Situ Chemical Reduction (ISCR)

https://clu-in.org/techfocus/default.focus/sec/In_Situ_Chemical_Reduction/cat/Overview/

ISCR involves the placement of a reductant or reductant generating material in the subsurface for the purpose of degrading toxic organic compounds to potentially nontoxic or less toxic compounds. ISCR has a high potential for meeting a variety of remediation goals when it is used on appropriate sites. The chemistry of the contaminant degradation reactions that this technology depends upon is well-documented and established. This technology has shown high potential for achieving mass removal, concentration reduction, mass flux reduction, reduction of source migration potential, and a substantial reduction in toxicity.

ISCR can also be used to immobilize metals such as Cr (VI) by adsorption or precipitation, and degrading non-metallic oxyanions such as nitrate. Common reductants include zero valent iron (ZVI) ferrous iron, sodium dithionite, sulfide salts (calcium polysulfide), and hydrogen sulfide.

Biogeochemical Reductive Dechlorination (BiRD)

https://clu-in.org/download/techfocus/bio/bio-insitubiogeochem-FS.pdf

BiRD is a remediation approach for chlorinated solvents. The approach involves the addition of non-specific sources of sulfur, iron, and organic carbon to stimulate common sulfate-reducing soil bacteria, facilitating the geochemical conversion of native iron minerals into iron sulfides. Iron sulfides have the ability to chemically reduce many chlorinated solvents compounds including PCE, TCE, DCE.

The formation of iron sulfide species and the subsequent transformation of contaminants such as chlorinated solvents occurs through three steps. First is the biological step where the addition of sulfate and carbon source stimulate common sulfate reducing soil bacteria. Next is the geochemical step where : hydrogen sulfide generated from sulfate reducing soil bacteria respiration reacts with native or supplied mineral iron to produce iron sulfide. Finally, an abiotic reaction with the iron sulfide reductively dechlorinates the chlorinated solvent.

The formation of iron sulfide minerals (FeS) does not inhibit or alter aquifer permeability. Typical iron oxides, such as hematite (Fe_2O_3), are actually transformed to iron sulfide minerals rather than precipitating out of solution.

In Situ Redox Manipulation

https://clu-in.org/download/contaminantfocus/dnapl/Treatment_Technologies/DOE-EM-0499.pdf

In situ redox manipulation (ISRM) is a technology based upon the in situ manipulation of natural processes to change the mobility or form of contaminants in the subsurface. ISRM was developed to remediate groundwater that contains chemically reducible metallic and organic contaminants. ISRM creates a permeable treatment zone by injection of chemical reagents and/or microbial nutrients into the subsurface downgradient of the contaminant source. The type of reagent is selected according to its ability to alter the oxidation/reduction state of the groundwater, thereby destroying or immobilizing specific contaminants. Because unconfined aquifers are usually oxidizing environments and many of the contaminants in these aquifers are mobile under oxidizing conditions, appropriate manipulation of the redox potential can result in the immobilization of redox-sensitive inorganic contaminants and the destruction of organic contaminants. This concept requires the presence of natural iron, which can be reduced from its oxidized state in the aquifer sediments to serve as a long-term reducing agent.

A chemical reducing agent such as sodium dithionite is injected into the aquifer through a standard groundwater well. The reducing agent reacts with iron naturally present in the aquifer sediments. Redox sensitive contaminants that migrate through the reduced zone in the aquifer become immobilized (metals) or destroyed (organic solvents). Potential contaminants for treatment with ISRM include: chromate, uranium, technetium, and chlorinated solvents.

ISRM is a passive barrier technique, with no pumping or above-ground treatment required once the treatment zone is installed. For this reason, the operation and maintenance costs after installation are very low. Potential optimal conditions for ISRM include sites where groundwater COCs in the form of redox-sensitive metals, such as chromium, uranium and technetium, inorganic ions, radionuclides, and chlorinated hydrocarbons is dispersed over large areas and is deeper than 30 feet below the surface.

ISRM utilized conventional wells so capital costs are comparable to conventional technologies other than performance monitoring long-term operation and maintenance costs are low. Ideally, the treatment zone remains active in the subsurface, where it is available to treat contaminants that seep slowly from less permeable zones. ISRM minimizes human exposure to contaminants during remediation because neither contaminated groundwater nor matrix material are brought above ground. The barrier is renewable if the original emplacement does not meet performance standards

Zero Valent Iron and Variations

https://cluin.org/contaminantfocus/default.focus/sec/Dense_Nonaqueous_Phase_Liquids_(DNAPLs)/cat/Treatment_Technologies/p/6

The in situ reduction of organic compounds dissolved in groundwater utilizing zero-valent iron (ZVI) has typically relied on the flow of groundwater through a subsurface PRB, however, in situ remediation processes that involve the injection of highly reactive iron powder directly into contaminant zones are also utilized. Injection by direct push rigs has been used successfully to introduce treatment media rapidly to the groundwater or a soil source area. By emplacing the iron powder by means of injection, rather than in the form of a reactive wall, soluble, absorbed-phase, and free-phase halogenated hydrocarbons all can be reduced Note that iron injected as part of a water emulsion can treat only contaminants that are accessible by water and will not treat free-phase hydrophobic contaminants directly.

In order to overcome this limitation, emulsified zero-valent iron (EZVI) is composed of food-grade surfactant, biodegradable vegetable oil, water, and ZVI particles. EZVI forms emulsion particles that contain the ZVI in water surrounded by an oil/liquid membrane. The exterior oil membrane has hydrophobic properties similar to that of DNAPL; therefore, the emulsion is miscible with the DNAPL. Encapsulating the ZVI in a hydrophobic membrane protects the iron from other groundwater constituents that otherwise would exhaust much of the iron's reducing capacity. This approach reduces the mass of EZVI required for treatment relative to unprotected ZVI. EZVI will combine directly with the target contaminants until the oil membrane is consumed by biological activity.

Emulsified oil is not the only substrate that can be injected with ZVI. Depending on the type of contaminant and hydrogeological setting, common substrates such as lactate, molasses, and alcohol can be used. In addition, there are commercially available products that provide a carbon substrate along with ZVI. Pneumatic or hydraulic injection also have been successful in introducing reactants to contaminants in zones of low permeability

In addition to DNAPL remediation, EZVI has been shown to be effective in treating chlorinated alkenes and alkanes.

Biological

Introduction

https://clu-in.org/techfocus/default.focus/sec/Bioremediation/cat/Overview/

Bioremediation uses microorganisms to degrade organic contaminants in groundwater. The microorganisms break down contaminants by using them as an energy source or cometabolizing them with an energy source. Biological remediation technologies attempt to accelerate natural biodegradation process by providing nutrients, electron acceptors, and/or competent degrading microorganisms that may otherwise be limiting the conversion of contaminants organics to innocuous end products. Enhanced biodegradation is a long-term technology, which usually takes years to remediate groundwater.

Short-term risks associated with implementation of bioremediation are low. This technology is easily implementable, and costs are typically moderate, compared with other remediation technologies.

Enhanced biodegradation technology may be effective in detoxifying these compounds and converting them into inert end products such as water, carbon dioxide and low concentrations of chloride and nitrate ions.

As with other in situ remediation processes, the success of biological-based remediation technologies are highly dependent upon Site-specific soil properties and biodegradability of the contaminants. There are several techniques that can be applied to enhance the biodegradation of compounds in groundwater:

Bio-sparging

https://clu-in.org/techfocus/default.focus/sec/Bioremediation/cat/Aerobic_Bioremediation_(Direct)/

Bio-sparging involves the injection of air or oxygen into the saturated zone to stimulate microbial activity. The effectiveness of bio-sparging depends on two primary factors — permeability of the soil and the biodegradability of the contaminants. Soil with higher permeability will allow more air to move through it to reach the microorganisms. Bio-sparging is effective in reducing the concentrations of petroleum COCs dissolved in groundwater. When volatile compounds are present, bio-sparging is often combined with other remedial technologies such as SVE or bioventing.

The remediation process associated with sparging may be physical, biological or both. In the physical process, VOCs are transferred from the aqueous phase to the gaseous phase and removed via the injected air stream. The biological process involves delivery of supplemental oxygen to promote aerobic respiration. Bio-sparging refers to air injection at pressures and flow rates sufficient to deliver supplemental oxygen, but less than those required to volatilize significant

COCs. Evidence indicates properly designed sparging systems significantly enhance both biodegradation and volatilization.

Bio-venting

https://clu-in.org/techfocus/default.focus/sec/Bioremediation/cat/Aerobic_Bioremediation_(Direct)/

Bioventing is similar to bio-sparging except that instead of injecting into the saturated zone, air or oxygen, and nutrients if needed, are injected into the unsaturated zone. Bioventing primarily treats contaminants in the vadose zone or capillary fringe. Oxygen is delivered to the unsaturated zone by forced air movement either through extraction or injection of air to increase oxygen concentrations. Direct air injection is used more commonly to control air flow rates and provide only enough oxygen to sustain microbial activity.

Bioventing has a strong record of treating aerobically degradable contaminants such as fuels, nonhalogenated solvents (e.g., benzene, acetone, toluene, and phenol), lightly halogenated solvents (e.g., 1,2-dichloroethane, dichloromethane, and chlorobenzene), and some semi-volatile organic compounds). To be responsive to bioventing, a site must generally have: low oxygen in soil gas compared to background.

While bioventing is relatively inexpensive, this method can take a few years to clean up a site, depending on contaminant concentrations and site-specific removal.

Bio-augmentation

https://clu-in.org/techfocus/default.focus/sec/Bioremediation/cat/Anaerobic_Bioremediation_(Direct)/

Bioaugmentation, consists of adding exogenous microorganisms to enhance degradation of contaminants. It can be an effective groundwater treatment technology and has been applied successfully to treat chlorinated solvents dissolved in groundwater. This type of bio-augmentation involves the use of mixed anaerobic cultures containing Dehalococcoides sp.(DHC) that can reductively dechlorinate the chlorinated ethenes.

The predominant biodegradation pathway for chlorinated ethenes, such as tetrachloroethene (PCE), under anaerobic conditions is via microbial-mediated reductive dechlorination. Because the chlorinated ethenes are used as electron acceptors during reductive dechlorination, there must be an appropriate source of electrons and a carbon source for microbial growth in order for this process to occur. Incomplete reductive dechlorination often results in an accumulation of cis-1,2-dichloroethene (cDCE) and vinyl chloride, indicating that the carbon source is depleted and/or that microorganisms capable of complete anaerobic reductive dechlorination are not present.

Key design criteria for applying bio-augmentation for remediating contaminated groundwater include identification of a microbial culture, large-scale growth of the culture, injection the culture, and distribution optimization. Challenges in using bio-augmentation as a groundwater remedy include effectively deploying the microbial amendments in the subsurface, achieving a sufficient the rate of growth of these microbial amendments, and uncertainties about the required amendment dosages. Competition by indigenous microorganisms and decay of the bio-augmented culture can also factor into the remediation process.

Bio-stimulatation

https://clu-in.org/techfocus/default.focus/sec/Bioremediation/cat/Anaerobic_Bioremediation_(Direct)/

In situ bioremediation (ISB) of groundwater involves the encouragement of indigenous bacterial populations to metabolize target contaminants through the addition of various amendments (biostimulation) to the subsurface environment. Bacteria perform coupled oxidation/reduction (redox) reactions to live, and bioremediation exploits these reactions to remove contaminants from contaminated groundwater. Bacteria can use different electron acceptors (oxidized compounds) and donors (reduced compounds) and contaminant degradation may occur through direct metabolism, cometabolism, or abiotic transformations that may result from biological activities.

Aerobic Bioremediation

Aerobic bioremediation most commonly takes place in the presence of oxygen and relies on the direct microbial metabolic oxidation of a contaminant. The primary concern when an aerobic bioremediation system is designed is delivery of oxygen, which is the electron acceptor. Aerobic bioremediation is most effective in treating non-halogenated organic compounds. Many reduced contaminants can be aerobically degraded by aerobic bacteria already present in the subsurface environment. Oxygen can be added directly to the subsurface, or chemical oxidants can be applied, which release oxygen as they dissolve or decompose. Oxygen and oxygen-releasing compounds can be delivered to the groundwater via several methods, depending on their physical properties, site hydrogeology, and the desired delivery efficiency. The end products of aerobic respiration are usually carbon dioxide and water.

Anaerobic Oxidative Bioremediation

Anaerobic oxidative bioremediation takes place in the absence of oxygen. It relies on other electron acceptors for direct microbial metabolic oxidation of a contaminant. This approach is often applied at petroleum-contaminated sites where oxygen has already been depleted. Commonly used electron acceptors include nitrate, manganese, iron, sulfate and carbon dioxide.

Anaerobic Reductive Bioremediation

Anaerobic reductive bioremediation takes place in the absence of oxygen. It relies on the presence of biologically available organic carbon, which may be naturally present or added to stimulate activity. The organic carbon is also commonly called an organic substrate or an electron donor source. It creates and sustains anaerobic conditions by consuming oxygen and other electron acceptors during its biodegradation. In many cases, microorganisms use the oxidized contaminants in a respiratory mechanism and are able to derive metabolically useful energy. Anaerobic conditions may be used to degrade highly chlorinated contaminants, such as PCE and TCE to ethene, 1,1,1-trichloroethane (1,1,1-TCA) to ethane, carbon tetrachloride (CT) to methane, or perchlorate to chloride and oxygen. Commonly used electron donors include hydrogen, acetate, corn syrup, lactate, molasses, ethanol, soybean oil, and biomass such as compost or mulch.

Thermal

https://clu-in.org/techfocus/default.focus/sec/Thermal_Treatment%3A_Ex_Situ/cat/Overview/
https://clu-in.org/download/Citizens/a_citizens_guide_to_in_situ_thermal_treatment.pdf

In situ thermal treatment methods either destroy or volatilize organic contaminants in soil and groundwater using heat. Only energy, and in some cases water and air, are added to the subsurface, rather than chemicals or bio-amendments. Thermal treatment is often applied in conjunction with other technologies that collect the now mobilized COC and convey it to the ground surface to be treated using other technologies. It can be particularly useful for mobilizing viscous NAPLs, which do not dissolve readily in groundwater and migrate very slowly, if at all.

In situ thermal treatment methods heat contaminated soil, and sometimes groundwater, to very high temperatures. The heat vapourizes the chemicals and water, changing them into vapours that can move more easily through soil. High temperatures also can destroy some chemicals in the area being heated. In situ thermal treatment methods speed the cleanup of many types of contaminants and are among the few in situ methods that can remediate NAPLs. Depending on operating temperatures, heating may decrease contaminant liquid viscosity, decrease interfacial tension, increase biodegradation rates, increase solubility, and/or increase volatility. Thermal treatment can be used in silty or clayey soil where other cleanup methods do not perform well because of low hydraulic conductivity. They also can reach COCs deep underground or beneath buildings, which would otherwise be difficult or costly to dig up to treat above ground.

A thermal treatment area is usually covered with an impermeable surface cover (such as concrete, asphalt) to keep the heat and steam underground. Such seals also help prevent the release of chemical vapours to the atmosphere.

The following sections summarize some of the different methods and combinations of techniques that can be used to apply heat to contaminated soil and/or groundwater in situ.

Electrical Resistance Heating

Electrical resistance heating (ERH) involves passing electrical current through moisture in the soil between an array of electrodes. As the current flows through the moisture in soil pores, the resistance of the soil produces heat. The power requirements and the geometry of the electrode arrays can be configured based on site conditions. ERH systems can be deployed to any depth and used in both the vadose and saturated zone. The horizontal spacing between electrodes is usually between 14 and 24 feet. The trade-off in distance is between the cost of installing more electrodes and heating the soil more quickly or installing fewer electrodes and heating the soil over a longer time. Soils are heated and volatilization and steam stripping occurs.

SVE-is commonly used to remove the now volatilized contaminants from the subsurface. ERH treatment is not effective for non-volatile compounds such as NDMA.

Hot Air Injection

Injection of hot air can volatilize organic contaminants (e.g., fuel hydrocarbons) in shallow soils. Due to the low heat capacity of air, large volumes of air at high temperatures (and thus high energy usage) are required to heat soils to the levels required for hydrocarbon desorption.

Injection is an *in situ* process that is accomplished through wells or auger injection pathways. Hot air injection increases contaminant mobility and extraction efficiency over ambient-temperature air in soil vapour extraction remediation. Steam is often used in conjunction with hot air to more effectively carry desorbed organics into the vacuum well.

Hot air injection is typically used with bioremediation or other processes, and can be applied to any hydrocarbon contaminants, from light fuels to crude oils and creosotes.

Hot Water Injection

Hot water injection technology was first developed in the petroleum industry and later adapted for the remediation of NAPL-contaminated sites. Field trials of hot water injection have recovered significant quantities of NAPL however, free phase mobile NAPL was still present at each site following significant hot water flushing.

Radio Frequency Heating (RFH)

Radio frequency energy can be directionally focused, tuned in frequency and power to achieve spatial and thermal control for a full range of low to high temperature thermal treatment. Heat is supplied by electrodes and antennae powered by a radio frequency generator. Radio frequency heating (RFH) energy can be applied in dry soil or below the water table from the surface to depth, vertically or horizontally. RFH systems can be operated beneath buildings, around utilities and configured to operate at active facilities with minimal surface expression or interference to site operations RFH is often employed when temperatures higher than steam or hot air injection are desired, usually 150-200 °C.

Steam Enhanced Extraction (SEE)

As with hot water injection, steam injection was first developed by the petroleum industry for enhanced oil recovery. Injection of steam heats the soil and groundwater and enhances the release of contaminants from the soil matrix by decreasing viscosity and accelerating volatilization. Steam injection may also destroy some contaminants. Steam can also be used to warm cold groundwater to improve biodegradation rates.

As steam is injected through a series of wells within and around a source area, the steam zone grows radially around each injection well. The steam front drives the COCs to a system of groundwater pumping wells in the saturated zone and soil vapour extraction wells in the vadose zone. Steam has a higher heat capacity than hot air, providing more efficient means for heating soils, Steam injection utilizes a pressure differential to encourage condensation of the steam and the subsequent desorption and evapouration of volatile hydrocarbons.

Vapours generated in the subsurface by steam injection can be contained and removed using an SVE system.

Thermal Conductive Heating (TCH)

Thermal conduction supplies heat to the soil that causes contaminants to be destroyed or volatilized. Steel wells are used when the COCs are deep. A blanket that covers the ground surface can be used where the contamination is shallow. Typically, an SVE system extracts the volatilized COCs for ex situ treatment.

Vitrification

Vitrification technology uses an electric current to melt contaminated soil at elevated temperatures (1,600 to 2,000ºC 0 to 3,650ºF). Upon cooling, the vitrification product is a chemically stable, leach-resistant, glass and crystalline material similar to obsidian or basalt rock. The high temperature component of the process destroys or removes organic materials. In situ vitrification involves driving electrodes in the soil and melting the soil. As the electrodes progress, the molten mass continues to grow downward and outward until the melt zone reaches the desired depth and width. The process is repeated in square arrays until the desired volume of soil has been vitrified. The process can typically treat up to 1,000 tons of material in one melt setting.

The in situ vitrification process can treat soils saturated with water; however, additional power is used to dry the soil prior to melting which will increase the cost of remediation. Vitrification is more economical to implement when the soil to be vitrified has a low moisture content. When treating contaminated zone groundwater in an aquifer, it may be necessary to lower the water table below the zone of COCs in order to vitrify to the desired depth. Treatment in a water-saturated zone may result in movement of some of the contaminants from the treatment zone to surrounding areas.

Advantages and Limitations

The cleanup time during thermal remediation will depend on several site-specific factors. Remediation time frames will increase where contaminant concentrations are high and/or where the contaminant source is large or deep. The advantages of in situ thermal technologies include its relatively shorter time frame, in some case only weeks or months are required to achieve remedial goals.

Soil heterogeneity may complicate soil heating patterns and groundwater/soil vapour migration. The potential drawbacks of use of in situ thermal technologies include the following:

- Thermal treatment technologies may be difficult to apply near occupied/active sites
- They require more sophisticated design and operation than other remediation technologies
- There is a potential for contaminant to migrate to previously uncontaminated areas
- Post-treatment soil temperatures may remain elevated for prolonged periods of time (months to years)

Others

Monitored Natural Attenuation

https://clu-in.org/techfocus/default.focus/sec/Natural_Attenuation/cat/Overview/

During monitored natural attenuation (MNA) normal subsurface processes, such as dilution, volatilization, biodegradation, adsorption, and chemical reactions with subsurface materials are allowed to reduce contaminant concentrations to acceptable levels.

MNA requires an evaluation of contaminant degradation rates and pathways and predicting contaminant concentration at down gradient receptor points. The primary objective of the evaluation is to demonstrate that natural processes of contaminant degradation will reduce contaminant concentrations below regulatory standards or risk-based levels before potential exposure pathways are completed. In addition, long term monitoring must be conducted throughout the process to confirm that degradation is proceeding at rates consistent with meeting cleanup objectives.

Compared with other remediation technologies, natural attenuation has the following advantages:

- Less generation or transfer of remediation wastes

- Less intrusive as few surface structures are required
- May be applied to all or part of a given site, depending on site conditions and cleanup objectives
- Natural attenuation may be used in conjunction with, or as a follow-up to, other (active) remedial measures
- Target contaminants for natural attenuation are VOCs and SVOCs and fuel hydrocarbons. Fuel and halogenated VOCs are commonly evaluated for natural attenuation

Phytoremediation

https://clu-in.org/techfocus/default.focus/sec/Phytotechnologies/cat/Overview/

Phytoremediation is a set of processes that uses plants to remove, transfer, stabilize and destroy organic/inorganic COCs in ground water, surface water, and leachate. Plants use the following mechanisms to reduce or sequester the COCs; rhizofiltration, phytoextraction, phytotransformation, phytosimulation, or plant-assisted bioremediation and phytostablization.

This technology is applicable to a wide range of contaminants and is most appropriate for sites where large volumes of groundwater contain relatively low concentrations of contaminants. However, since the effectiveness of the phytoremediation treatment is primarily located in the root zone, the treatment is most applicable to sites with relatively shallow COCs in soils or groundwater.

Permeable Reactive Barrier

https://cluin.org/techfocus/default.focus/sec/Permeable_Reactive_Barriers%2C_Permeable_Treatment_Zones%2C_and_Application_of_Zero-Valent_Iron/cat/Overview/

Despite the name, a subsurface permeable reactive barrier (PRB) is not a barrier to groundwater flow. In fact, a PRB is an emplacement of reactive materials in the subsurface designed to intercept a contaminant plume, provide a preferential flow path via the reactive media, and transform the contaminant(s) into environmentally acceptable forms to attain remediation concentration goals at the discharge of the barrier. PRBs are currently being used in full-scale field applications for the treatment of plumes of chlorinated VOCs.

These structures are placed in a strategic location to intercept the flow path of the contaminants. The materials used in these barriers are dependent on the type of contaminants being treated. Some of these materials include ZVI, microorganisms, zeolite, activated carbon, peat, bentonite, limestone and sawdust. As the contaminants pass through the barrier, the treatment processes taking place include degradation, sorption and/or precipitation. The technology is currently restricted to shallow plumes approximately 20 metres deep, or less.

PRBs have the advantage of lower operational costs because little or no energy input is necessary once installed. The reactive zone is limited and as a result PRBs may be easier to design, monitor, maintain, and control than some other systems. Groundwater elevations should be monitoring to confirm the PRM remains permeable and does not clog over time. Down gradient groundwater quality monitoring is also recommended to confirm the permeable barrier remains reactive and is not being consumed during the groundwater remediation.

Funnel and Gates

https://clu-in.org/download/rtdf/prb/reactbar.pdf

Commercial PRBs are currently built in two basic configurations, the funnel and-gate and the continuous PRB. The funnel-and-gate design PRB uses impermeable walls (sheet pilings, slurry walls, etc.) as a “funnel” to direct the contaminant plume to a “gate(s)” containing the reactive media, whereas the continuous PRB completely transects the plume flow path with reactive media. Due to the funnels, the funnel-and-gate design has a greater impact on altering the ground-water flow than does the continuous PRB. In both designs, it is necessary to keep the reactive zone permeability equal to or greater than the permeability of the aquifer to avoid diversion of the flowing waters around the reactive zone.

As with PRBs, funnel and gate systems require some degree of excavation and are limited depths of 20 m or less. Newer techniques for emplacing reactive media, such as the injection of slurries, may increase the depth capability.

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Proposed TRAC Meeting Schedule 2025 and Draft Agenda Items

NO.	DATE(s)	DRAFT AGENDA ITEMS
Council 1	February 4 (CW) OR 18 (C), 2025	As per TRAC Minutes November 14, include December's LANXESS year in review and 2025 work plan presentation to TRAC. Circulate to TRAC mid-January.
TRAC 1	April 10 OR 17, 2025	LANXESS' 2024 AMR summary presentation; MECP update on the review of LANXESS' biomonitoring proposal; LANXESS' evaluation of groundwater remediation technologies; LANXESS' 2025 aquifer remedial evaluation study update and proposal including pilot testing for MECP review and approval, LANXESS' 2024 annual environmental report summary; LANXESS' Monthly Progress Reports (December to March and possibly April); Update on the draft creek HHERA and requested targeted spot removal.
TRAC 2	June 12 OR 19, 2025	OPTIONAL PROGRESS UPDATE – Discussion on public education session including how/when LANXESS' draft revised off-Site Remedial Action Plan (RAP) is reviewed, process for amending Order(s) and ECA(s), MECP and stakeholder roles, objective is to prepare the public for the revised RAP consultation process to replace the existing RAP and regulatory instruments beyond 2028. LANXESS update on HHERA and requested targeted spot removal.
Council 2	August 12 (CW) OR 26 (C), 2025	To be determined based on April and June TRAC meetings and progress made by LANXESS
TRAC 3	September 11 OR 18, 2025	LANXESS progress report on 2025 work plans and field work (ECA biomonitoring, groundwater remediation bench scale testing and pilot testing), and updated groundwater CSM. Update on HHERA and requested targeted spot removal.
TRAC 4	November 13 OR 20, 2025	LANXESS presentation of findings (field, lab and data evaluations for the groundwater remediation bench scale testing and, pilot testing). Update on HHERA and requested targeted spot removal.
TRAC 5	December 11 OR 18, 2025	LANXESS year in review and 2026 work plan presentation; community consultation plan for LANXESS' draft proposal outlining updated off-Site groundwater remediation objectives and reasonable options for consideration by the committee and the broader community. Update on HHERA and requested targeted spot removal.

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Our ref: 11192137-LTR-61

15 November 2024

Ms. Lubna Hussain
Director, West Central Region
Ontario Ministry of the Environment
119 King Street West, 12th floor
Hamilton, ON
L8P 4Y7

LANXESS Canada Co./Cie (LANXESS) Progress Report October 2024

Dear Ms. Hussain

This letter presents a summary of the October 2024 LANXESS Progress Report.

The following noteworthy items regarding the Combined Groundwater Collection and Treatment System (CTS) are discussed in the report text.

The average monthly pumping rates of PW5, W5A, W8, and W9 were less than their Target Average pumping rates during October 2024. PW5 continued operating at a reduced pumping rate in October 2024. PW6 is being installed as a replacement well to maintain the Target Average pumping rate and is on schedule for completion by the end of the year as previously committed to by LANXESS. Despite not meeting the Target Average pumping rate, hydraulic monitoring data indicate PW5 currently generates an effective groundwater capture zone. The pumping rate of W5A was below its Target Average pumping rate in October 2024. The well is unable to maintain its target pumping rate and requires rehabilitation. Due to delays with contractor availability, LANXESS has had to re-schedule rehabilitation of the well; LANXESS is awaiting a future date from their contractor. W8 did not operate in October 2024 due to an instrument failure. The level indicator needs to be replaced. LANXESS will resume pumping as soon as possible. W9 was shut down from October 7 to October 10, 2024 for rehabilitation of the well. W9 was restarted on October 10, 2024 at its Target rate.

During October 2024, the CTS operated within the Effluent Limits and within the Effluent Objectives for all compounds.

Please refer to the detailed information in the Progress Report for further information on these items.

Regards

Luis Almeida

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Project Manager

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AB/kf/61

Encl.

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October 2024

Progress Report
LANXESS Canada Co./Cie
Elmira, Ontario

GHD has prepared this report on behalf of LANXESS Canada Co./Cie (LANXESS) and submitted it to the Ontario Ministry of the Environment, Conservation and Parks (MECP). This report complies with the administrative reporting requirements of the November 4, 1991 Control Order (Control Order), the Amended Environmental Compliance Approval (ECA) No. 0831-BX6JGD (Combined On-Site and Off-Site Groundwater Collection and Treatment Systems [CTS]), and Certificate of Approval (C of A) No. 4-0025-94-976 (E7/E9 Treatment Facility).

Unless otherwise stated, all data included in this report were collected in October 2024.

The Progress Report is organized as follows:

1. Monitoring and Analytical Data

A summary of the LANXESS monitoring programs is provided in Table 1.

A summary of the analytical results for the CTS is presented in Attachment A.

A summary of the analytical results from the monthly September 2024 Environmental Appeal Board (EAB) monitoring of discharges to surface water through storm water outfalls 0200, 0400 and 0800, and the storm water drainage system (SWS), is included in Attachment B. Attachment B is not required under the Control Order but is provided for review. Due to delays with the analytical data, the analytical results from the monthly October EAB monitoring will be provided in the November Progress Report.

A summary of the analytical results for routine quarterly surface water samples collected from Canagagigue Creek (the Creek) in October 2024 is presented in Attachment C.

LANXESS completed the semi-annual Groundwater Elevation Monitoring Program (GEMP) on October 22, 2024. Groundwater elevation contours derived from the GEMP groundwater elevation data are presented in Attachment D.

LANXESS collected groundwater samples for the Upper Municipal Aquifer (MU) Sentry Well Monitoring Program on October 24, 2024 and results are presented in Attachment E.

2. Correspondence, Meetings, and Events

October 15, 2024	September 2024 Progress Report submitted to MECP West Central Region (WCR)

3. CTS Monitoring and Performance

A schematic process flow diagram of the CTS is provided on Figure A.1 (Attachment A).

The October 2024 average pumping rates for the CTS containment wells PW4 and PW5, the CTS extraction wells W3R, W5A, W5B, W6A, W6B, W8 and W9, the Upper Aquifer Containment System (UA CS) wells, and E7, as compared to the target average pumping rates, are listed below, and shown graphically on Figures A.2 and A.3 (Attachment A).

Average Daily Pumping Rates		
October 2024 (Litres/second [L/s])		
Containment and Extraction Wells	**Target Average (1)**	**Average**
On Site Wells		
PW4	2.9	2.9
PW5	1.8	1.0
Upper Aquifer Wells	--	0.6
Off Site Wells		
W3R	18.5	22.4
W5A	4.5	2.6
W5B	4.2	4.3
W6A	0.20	0.36
W6B	0.30	0.43
W8	0.05	0.00
W9	13.6	13.0
E7	23.9	25.7
Yara	--	0.2

Notes:

(1) As wells and treatment system components require periodic downtime for maintenance, the Target Average pumping rate is set at 90% of the set point rate. GHD recommends that LANXESS maintain the target pumping rates greater than or equal to these rates.

With the exceptions discussed below, the containment and extraction wells, including the UA CS wells, are operating as intended.

PW5 continued operating at a reduced pumping rate in October 2024. The well is currently unable to maintain its Target Average pumping rate. PW6 is being installed as a replacement well to maintain the Target Average pumping rate. PW6 is on schedule for completion by the end of the year as previously committed to by LANXESS. The PW5 Target Average pumping rate is an internal operational guideline LANXESS uses when operating extraction/containment wells, which includes a significant safety factor. Despite not meeting the Target Average pumping rate, hydraulic monitoring data indicate PW5 currently generates an effective groundwater capture zone. LANXESS is in the process of connecting new replacement well PW6 to the existing treatment system infrastructure and is working towards bringing the well online. The communication and power lines are scheduled for completion in November 2024.

W5A continued pumping at a reduced rate (between 2.5 L/s and 3.5 L/s) in October 2024 as the well is unable to maintain its target pumping rate (4.5 L/s) and requires rehabilitation. Due to delays with contractor availability, LANXESS has had to re-schedule rehabilitation of the well, which was previously scheduled for the week of October 7, 2024. LANXESS is awaiting a future date from their contractor.

W8 was unable to pump during October 2024 due to an instrument failure. The level indicator needs to be replaced. LANXESS will resume pumping as soon as possible.

W9 was pumping at a reduced rate during the beginning of October 2024. The well pump was running at maximum capacity, therefore, LANXESS believed that the decreased pumping rate was due to an issue with the pump/motor and/or decreased well efficiency. Lotowater Technical Services Inc. (Lotowater), LANXESS' well rehabilitation contractor, completed well rehabilitation between October 7 and October 10, 2024. The well rehabilitation corrected the pumping issue and W9 was restarted on October 10, 2024 at a pumping rate of 15.8 L/s, which is greater than its Target Average pumping rate of 13.6 L/s. Therefore, it is anticipated the well will continue to reach its target pumping rate in subsequent months.

a) Bypass or Upset Conditions

The bypass or upset conditions encountered in the CTS are summarized in Table A.1 (Attachment A).

b) Data Summary and Interpretation

Table A.2 (Attachment A) presents the analytical results for the CTS samples collected in October 2024 and summarizes the effluent pH and temperature. The discharge pH was between 6.94 and 7.07 Standard Units (su), which is within the ECA discharge limit pH range of 5.5 to 9.5 su. The effluent temperature was between 15.1 and 18.8 degrees Celsius (°C), which is less than the discharge limit of 25°C.

The ATS removed ammonia to concentrations that were less than those required by the ECA.

The Combined Discharge Effluent[1] met the Effluent Limits and Effluent Objectives for all indicator parameters in October 2024.

Table A.3 (Attachment A) summarizes the effluent discharge flow rates. The total flow rate of treated groundwater discharged to the Creek via SS+890 was 36.8 L/s. The total flow rate of additional treated groundwater discharged to the Creek via Shirt Factory Creek (at storm water outfall 0800) was 10.9 L/s. The total flow rate of the combined treated groundwater discharged to the Creek (SS+890 discharge plus Shirt Factory Creek discharge) was 47.7 L/s, which was less than the discharge Effluent Limit of 92.2 L/s.

c) Supplementary Data

As part of the ongoing monitoring of on-Site carbon treatment performance, on October 1, 2024, LANXESS collected samples from the carbon tower influent (GCI) and carbon tower effluent (GCE) for volatile organic compound (VOC) and base/neutral and acid extractable compound (BNA) analyses. Table A.4 (Attachment A) presents the GCI and GCE analytical results.

On October 1, 2024, LANXESS collected samples from the influent to and treated effluent from the portable carbon adsorbers installed to pre-treat groundwater from UA CS wells U+500 and U+560. ECA No. 0831-BX6JGD does not require the collection of groundwater samples from UA CS wells; however, LANXESS has been collecting these samples on a voluntary basis to monitor and improve the performance of the on-Site granular activated carbon (GAC) Tower. LANXESS analyzed the samples for VOCs and BNAs. Table A.4 (Attachment A) presents the analytical results for the influent and pre-treated effluent samples from the U+500 and U+560 containment wells.

d) Broad Scan Data

On October 1, 2024, LANXESS collected samples from the groundwater effluent via the SS+890 discharge (GE) and from sampling location SFE, which is the additional groundwater effluent discharge via Shirt Factory Creek. LANXESS analyzed the samples for the ECA broad scan parameters. Table A.5 (Attachment A) presents the broad scan analytical results versus Effluent Limits. All parameters were present in samples of the treated effluent at concentrations that were non-detectable, less than the Effluent Limits, or did not constitute an exceedance as defined by the ECA.

e) Toxicity

LANXESS collected a groundwater sample from the GE SS+890 discharge outfall and a sample from the SFE discharge outfall on October 1, 2024 and submitted the samples for acute toxicity analyses. The

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[1] The Combined Discharge Effluent value was calculated by multiplying the average flow rates by the concentration of the analytes at the SS+890 GE outfall and the additional effluent discharge location via Shirt Factory Creek.

laboratory results indicate that the October 2024 groundwater samples were not acutely toxic to *Daphnia magna* and rainbow trout. The results have been included in Attachment A.

f) Routine Maintenance

Routine maintenance tasks completed on the CTS in October 2024 are summarized in Table A.6 (Attachment A). These activities are completed by LANXESS personnel as part of on-going preventative maintenance and system inspections. These maintenance activities do not typically cause a system bypass or shutdown and are not required by the Control Order or ECA. This information is being provided to demonstrate LANXESS' commitment to proactively maintain the CTS and ensure continued operations.

g) Receiver Water Quality Data

LANXESS collected surface water samples on October 18, 2024. The sampling locations are presented on Figure C.1. This sampling and analysis fulfill the quarterly indicator and broad scan monitoring requirements for the Primary and Secondary Surface Water Quality Monitoring Programs in ECA No. 0831-BX6JGD.

Table C.1 (Attachment C) presents the analytical results for the surface water samples collected in October 2024. Due to instrumentation issues at the analytical laboratory, analytical data for the following parameters has been delayed: 2-mercaptobenzothiazole, benzothiazole, n-nitrosodiphenylamine (SS-110 location only), and 2,4,5-T (all locations apart from SS+925). This data will be provided in the November Progress Report.

Apart from formaldehyde and total phenols, all the parameters analyzed as part of the October 18, 2024 sampling event were either not detected at their reporting detection limit (RDL) or were present at concentrations that were less than the Provincial Water Quality Objectives (PWQOs), Interim PWQOs (IPWQOs), and ECA Schedule E criterion.

The following presents a summary of receiver water quality parameters that were present at concentrations greater than the relevant criteria:

Parameter	PWQO/IPWQO	Schedule E Criterion	Locations	Concentration/ Concentration Range
Formaldehyde	0.8 µg/L	N/A	SS+770 East SS+925	2.0-2.2 µg/L
Total Phenols	0.001 milligrams per litre (mg/L)	N/A	SS-110	0.0534 mg/L
Notes: N/A – No Schedule E Criterion specified in ECA No. 0831-BX6JGD.				

Formaldehyde was detected in the sample collected from surface water monitoring station SS+925 at a concentration of 2.0 micrograms per litre (µg/L), and in the sample collected from surface water monitoring station SS+770 East at a concentration of 2.2 µg/L, which are greater than the IPWQO of 0.8 µg/L. Formaldehyde was not detected (RDL = 2.0 µg/L) in any other surface water samples collected on October 18, 2024, including the sample location adjacent to SS+770 East (SS+770 Centre) and in the sample collected between SS+770 and SS+925 (SS+855). Formaldehyde was also not detected (RD = 2.0 µg/L) in the GE and SFE effluent samples collected in October 2024. Based on the inconsistent reported detection of formaldehyde in the surface water samples collected, and the non-detect GE and SFE effluent discharge sample results, the formaldehyde results are unrelated to operations at the Site and may be attributable to field or laboratory contamination or may be the result of standard variability in sample analysis.

The upstream (SS-110) total phenols concentration on October 18, 2024 was 0.0534 µg/L, indicating that the concentration of total phenols upstream of the Site was greater than the PWQO of 0.001 mg/L. Upstream total phenol concentrations are indicative of discharges upstream of the Site and background surface water quality and are unrelated to operations at the Site.

None of the detected concentrations in the October 2024 surface water samples are defined as an exceedance by ECA No. 0831-BX6JGD.

GHD's statistical analyses completed on the Schedule E parameters from October 2021 to October 2024 are presented in Table C.2. There were no statistically significant differences between the background and downstream parameter concentrations.

Summary of Efforts Made and Results Achieved

During October 2024, the CTS operated within the Effluent Limits and within the Effluent Objectives for all compounds.

4. Groundwater Elevation Monitoring Program

LANXESS and GHD collected groundwater elevation data on October 22, 2024, in conjunction with the semi-annual GEMP. LANXESS and GHD measured groundwater elevations at monitoring wells located on Site to evaluate the effectiveness of the UA CS and the on-Site CTS. GHD also measured groundwater elevations throughout the town of Elmira to evaluate the effectiveness of the off-Site CTS.

Groundwater elevation contours derived from these data are provided in Attachment D.

Surficial Aquifer (SA)

Figure D.1 presents groundwater elevation contours derived from October 22, 2024 groundwater elevations measured in SA monitoring wells. SA groundwater typically flows west, northwest, or southwest towards the swampy area between the SA and Canagagigue Creek. SA groundwater flowed west on October 22, 2024. A hydrogeological investigation completed in April 2019 on the property to the east indicates the SA is absent to the east and south where the ground surface is lower than 356 metres above mean sea level (m AMSL).

Upper Aquifer

In accordance with ECA No. 0831-BX6JGD, LANXESS and GHD completed hydraulic monitoring of the UA CS on October 22, 2024. Figure D.2 provides a map of the key monitoring locations for the UA CS.

Figure D.3 shows the differences between UA_1 groundwater elevations and the corresponding surface water elevations at key monitoring pairs, as measured on October 22, 2024. The difference between the groundwater and surface water indicate the UA CS provided hydraulic containment at the key monitoring pairs on October 22, 2024.

Figures D.4, D.5, and D.6 show the UA_1 groundwater elevation contours for October 22, 2024. Figure D.4 shows UA_1 groundwater elevation contours beneath the entire Site. East of the Creek, UA_1 groundwater elevations were lower than the corresponding surface water elevations which indicates groundwater from the east side of the Site is not discharging to Canagagigue Creek. This is a seasonal condition, as UA_1 groundwater from the east side of the Site typically discharges into the Creek. Beneath the northwest portion of the Site, the dam on the Creek has modified natural UA_1 groundwater flow conditions. Surface water impounded behind the dam recharges UA_1. This causes UA_1 groundwater immediately west and north of the dam to flow southwest, away from the Creek. This flow path typically leads to groundwater discharge south of the dam, but seasonally high surface water elevations in the Creek are preventing this. The UA CS was not designed to contain this portion of the UA_1.

Figures D.5 and D.6 show UA_1 groundwater elevation contours beneath the northern and southern UA CS, respectively, based on data collected on October 22, 2024. Surface water monitoring station SS+450A is in Shirt Factory Creek, a tributary to Canagagigue Creek and the northern limit of the UA CS capture zone. The UA_1 groundwater elevation at UOW+460 (344.74 m AMSL) was lower than the surface water elevation at station SS+450A (344.93 m AMSL) indicating UA_1 groundwater was contained at this location.

Figure D.7 shows the bottom beds of the Upper Aquifer (UA_3) groundwater flow patterns based on the groundwater elevations measured on October 22, 2024. The UA CS provided containment of UA_3 along the southern Site boundary with the Elmira Wastewater Treatment Plant (WWTP). The portion of the UA_3 north of the UA CS capture zone had a relatively low horizontal hydraulic gradient. The zone of static groundwater shown on Figure D.7 did not migrate off Site laterally because the UA_3 pinches out to the west, west of the former Canagagigue Creek flood plain. Therefore, the UA CS contained horizontal UA_3 groundwater flow beneath the Site.

On-Site Containment and Treatment System

When W5B is operating, ECA No. 0831-BX6JGD requires that the MU be contained between monitoring wells OW58-13 and OW58-15, located along the western Site boundary, and monitoring well OW105d, located near the southern Site boundary. The average daily pumping rates for the CTS, Yara extraction system and E7 during the October 22, 2024 GEMP round were as follows:

Containment and Extraction Wells	Target Average Pumping Rate (L/s)	October 22, 2024 Average Pumping Rate (L/s)
PW4	2.9	2.8
PW5	1.8	1.0
W3R	18.5	23.5
W5A	4.5	2.5
W5B	4.2	4.2
W6A	0.20	0.38
W6B	0.30	0.44
W8	0.05	0.00
W9	13.6	15.8
E7	23.9	25.7
Yara	--	0.2

Figure D.8 shows on-Site MU groundwater elevation contours derived from the data collected during the October 22, 2024 GEMP. MU groundwater north of monitoring wells OW58-13 and OW58-15 flowed south-southwest and crossed the Site boundary. There is no requirement to contain this groundwater. South of OW58-13 and OW58-15, the overall flow direction was south to southeast, toward PW4. PW5 captured all on-Site MU groundwater south of PW4. The PW5 capture zone extended south of the southern limit of the compliance boundary at monitoring well OW105d. The flow divide between PW5 and W5B was located west of the WWTP near monitoring well CH-97B and extends northwest.

The MU Sentry Well Monitoring Program provides groundwater quality data to evaluate on-Site MU hydraulic containment along the western Site boundary. GHD completes statistical analyses on the data to identify trends in the concentrations of n-nitrosodimethylamine (NDMA) and chlorobenzene in groundwater samples collected from these wells. Figures E.1 through E.6 present the NDMA and chlorobenzene results for March 2008 through October 2024. Tables E.1 and E.2 provide the MU Sentry Well Monitoring Program results. The following table summarizes the trend analysis results:

Trend Analysis Results		
Monitoring Wells	**NDMA Trends**	**Chlorobenzene Trends**
OW58-13	>50% ND	100% ND
OW165-17	>50% ND	>50% ND
CH-89B	>50% ND	>50% ND
CH-47E	**Decreasing Trend**	**Decreasing Trend**
CH-56B	**Decreasing Trend**	**Decreasing Trend**
CH-97B	>50% ND	>50% ND

GHD did not complete the trend analysis for the OW58-13, OW165-17, CH-89B and CH-97B data sets because the majority of the results were non-detect and the statistical model is not valid for data sets where the constituent of interest was not detected in the majority of the samples. GHD identified statistically significant decreasing trends in NDMA and chlorobenzene concentrations over time in the groundwater samples collected from MU sentry wells CH-47E and CH-56B. The decreasing trends and the persistence of the non-detect results for NDMA and chlorobenzene in the groundwater samples from OW58-13, OW165-17, CH-89B and CH-97B provide an independent line of evidence that the on-Site MU containment wells continue to achieve hydraulic containment of the most heavily impacted groundwater beneath the southwest portion of the Site in 2024.

LANXESS will continue the semi-annual MU Sentry Well Monitoring Program and provide similar trend analyses in future Progress Reports.

Off-Site Municipal Aquifer

Figure D.9 shows groundwater elevation contours for the MU beneath the Elmira area based on the October 22, 2024 groundwater elevation data. E7 provided containment of the southern limit of the off-Site MU NDMA plume. The limits of the off-Site MU NDMA and chlorobenzene plumes were contained on October 22, 2024.

Figure D.10 provides groundwater elevation contours for the Lower Municipal Aquifer (ML) beneath the Elmira area based on data collected on October 22, 2024. Pumping W5A, W6A and W9 produced three distinct capture zones in the off-Site ML. Extraction well W8 was not operating during the October 22, 2024 GEMP round. Groundwater south of E7 flowed north, indicating that pumping E7 contained the southern limit of the ML NDMA plume.

Bedrock Aquifer

Figure D.11 provides Bedrock groundwater elevation contours based on October 22, 2024, groundwater elevation data. Bedrock groundwater flowed west to southwest beneath the Site. The operation of extraction well W5A generated a well-defined capture zone immediately southwest of the Site. Groundwater flow south of E7 is directed north towards E7. E7 contained the limits of the NDMA plume in the Bedrock.

5. Remedial Action Plan

LANXESS has initiated discussions with the MECP.

6. E7 AOP

The average E7 pumping rate (25.7 L/s) was greater than its recommended Target Average pumping rate (23.9 L/s) during October 2024. The influent sample collected on October 8, 2024 contained NDMA at a concentration of 0.02 micrograms per litre (µg/L). NDMA was not detected in the effluent sample collected on October 8, 2024 (RDL = 0.01 µg/L).

7. Environmental Audit

There are no new activities to report for this item in October 2024.

8. Remediation of Former Operating Pond Area

There are no new activities to report for this item in October 2024.

9. Additional Work/Studies

There are no new activities to report for this item in October 2024.

Table 1

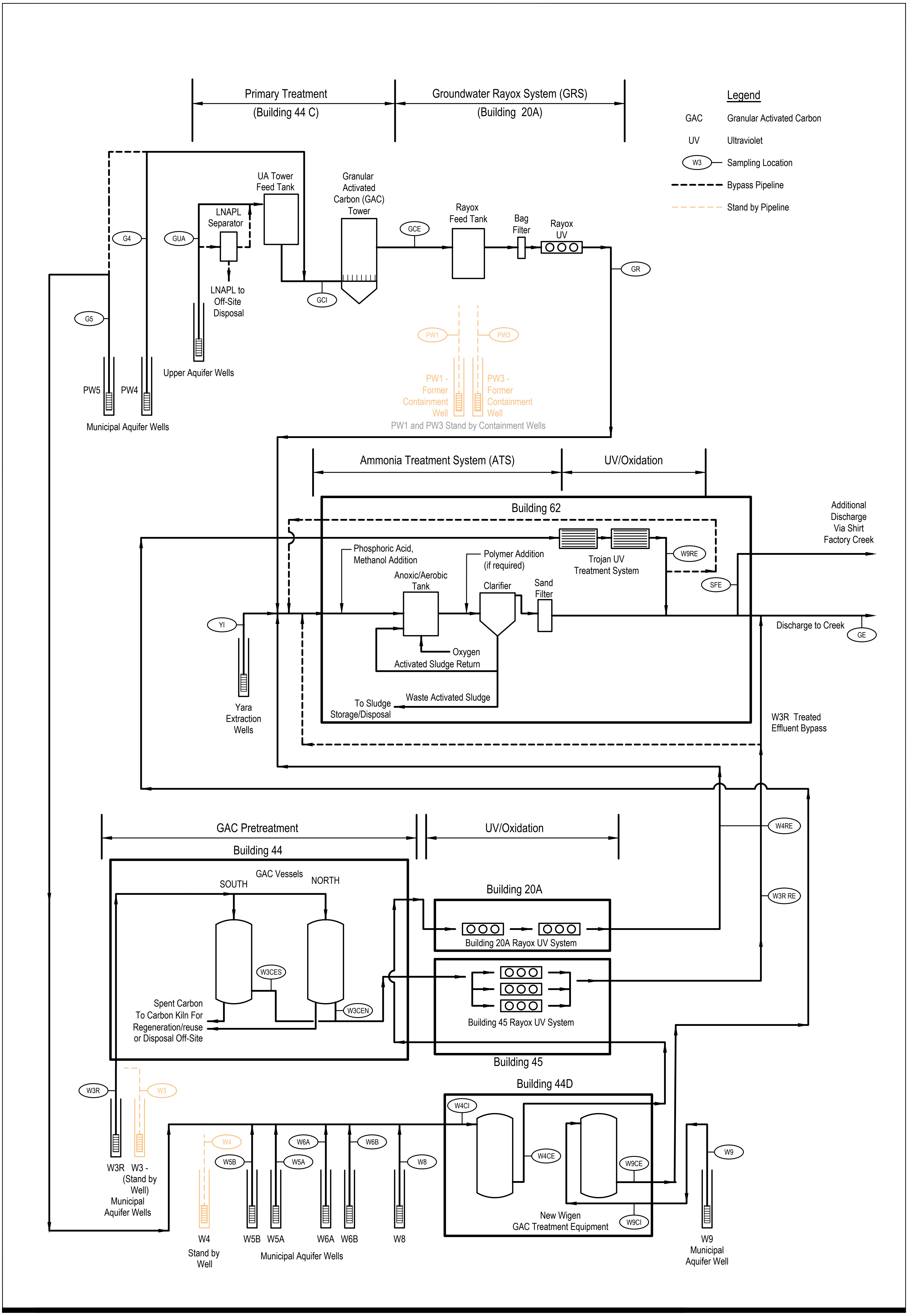
Monitoring Program Summary
LANXESS Canada Co./Cie
Elmira, Ontario

Media and Sampling Program	Parameters	Frequency	October 2024 Results Location
Treatment System			
Off-Site Groundwater Collection and Treatment System (Off-Site CTS) Influent	Offsite Broad Scan (Schedule D)	Annual	-
On-Site Groundwater Collection and Treatment System (On-Site CTS) Influent	Effluent Broad Scan (Schedule C)	Annual	-
Combined On-Site and Off-Site Groundwater Collection and Treatment Systems (CTS) Effluent	Indicator parameters	Monthly	Attachment A
	Effluent Broad Scan (Schedule C)	Quarterly	Attachment A
CTS Effluent - Acute Toxicity	Not applicable	Quarterly	Attachment A
CTS Effluent - Chronic Toxicity	Not applicable	Semi-annual	-
Surface Water			
Environmental Appeal Board (EAB) Sampling	Select VOCs, semi-volatile organic compounds (SVOCs), pesticides, general chemistry	Monthly	Attachment B
Primary Surface Water Quality Monitoring	Indicator parameters	Quarterly	Attachment C
	Effluent Broad Scan (Schedule C)	Quarterly	Attachment C
Secondary Surface Water Quality Monitoring	Indicator parameters	Quarterly	Attachment C
	Effluent Broad Scan (Schedule C)	Quarterly	Attachment C
Upper Aquifer Hydraulic Containment Requirement	Schedule E	As required	-
Receiver Biomonitoring Program – Clams	See Biomonitoring Reports	Biennial (Even Years)	-
Receiver Biomonitoring Program – Benthic		Biennial (Odd Years)	-
Groundwater			
Groundwater Elevation Monitoring Program (GEMP)	Elevation	Semi-annual	Attachment D
Upper Municipal Aquifer (MU) Sentry Well Monitoring Program	n-Nitrosodimethylamine (NDMA), chlorobenzene	Semi-annual	Attachment E
NAPL Monitoring Program (NMP)	Elevation	Annual	-
Creek Bank Groundwater Monitoring Program – Spring Round	NDMA, chlorobenzene	Annual	-
Creek Bank Groundwater Monitoring Program – Summer Round	Selected pesticides and volatile organic compounds (VOCs)	Annual	-
Off-Site Sentry Well Monitoring Program	NDMA +/- chlorobenzene	Annual	-
Off-Site Plume Monitoring Program	NDMA +/- chlorobenzene	Biennial (Odd Years)	-

Attachment A

Analytical Results

Collection and Treatment System



GHD

LANXESS CANADA CO./CIE
ELMIRA, ONTARIO

TREATMENT SYSTEM
PROCESS FLOW SCHEMATIC

Project No. **11192137**
Date **October 2024**

FIGURE A.1

Filename: N:\CA\Waterloo\Projects\662\11192137\Digital_Design\ACAD 2020\Figures\LTR-GEMP2024OCTOBER-DIR061\11192137-GHD-00-00-LTR-EN-D112_WA-GEMP2024OCTOBER-DIR061.dwg
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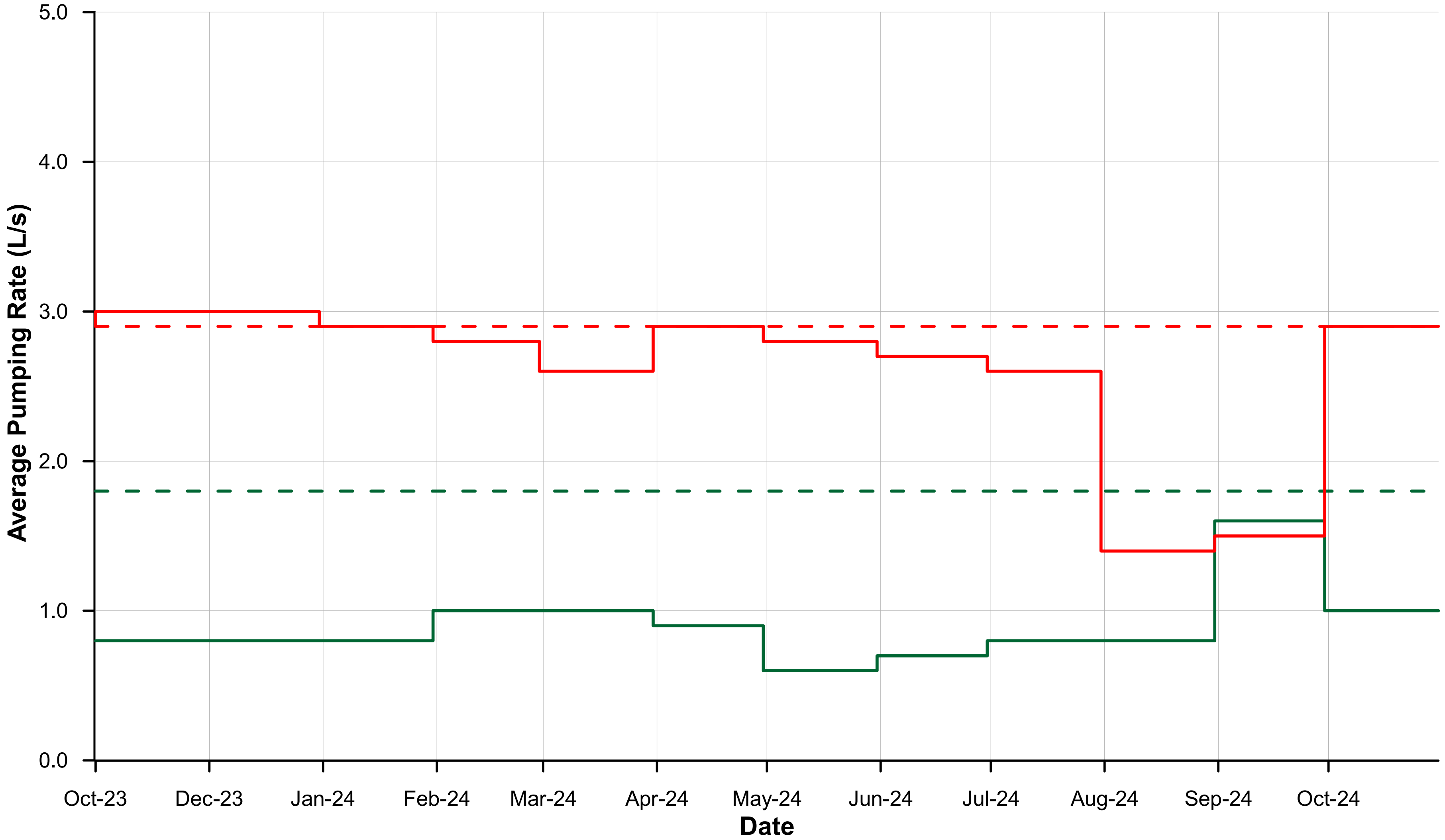

*Note: Target pumping rates were updated based on the average daily pumping rates recommended in the 2015 Model Check Point Analysis (GHD, June 2016). The Target Average pumping rates are 90% of the recommended daily Set Point pumping rates since the wells and treatment system components require periodic downtime for maintenance.

figure A.2
ON-SITE EXTRACTION WELL AVERAGE VS. TARGET PUMPING RATES
LANXESS CANADA CO./CIE
Elmira, Ontario

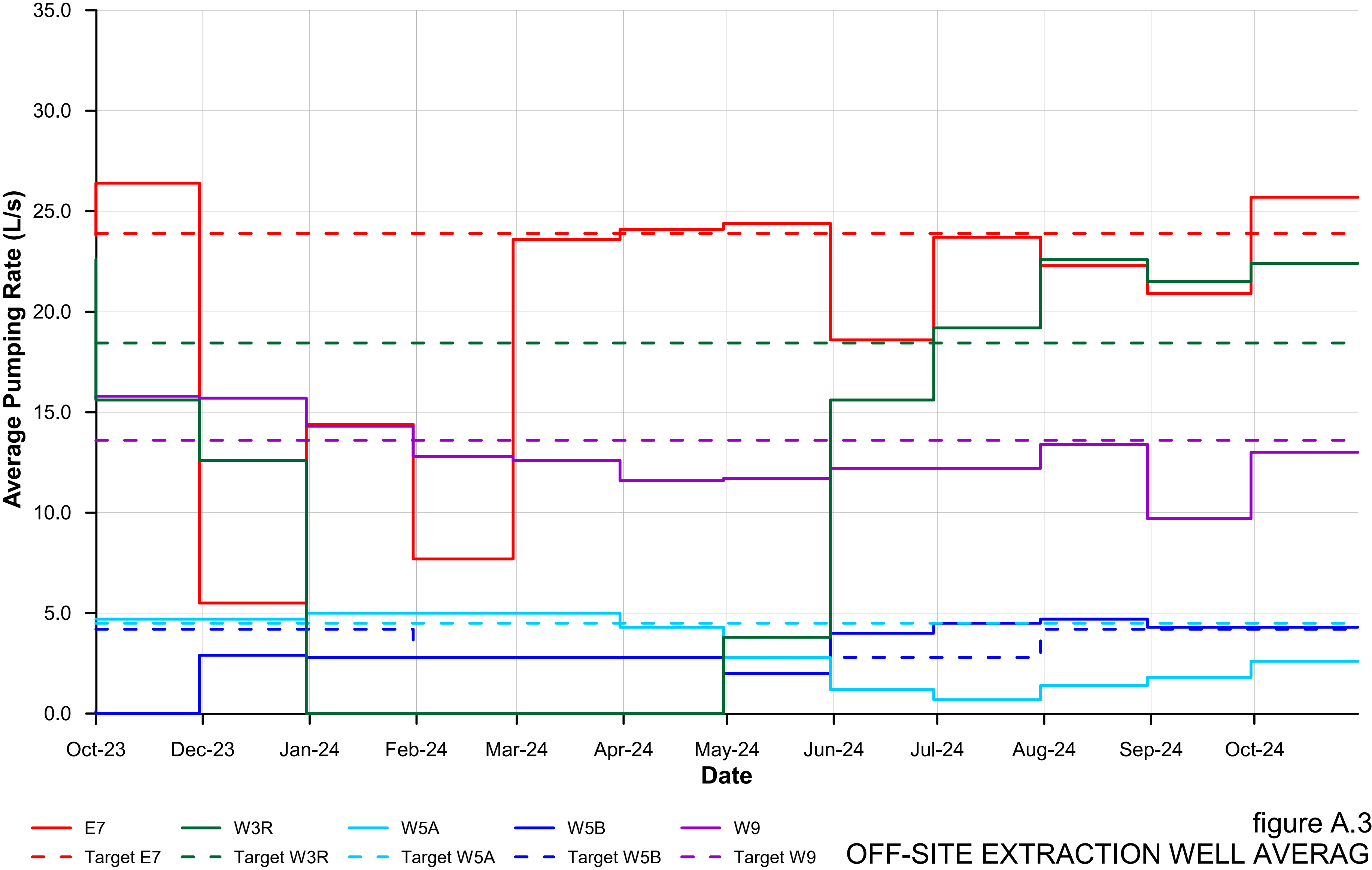

figure A.3a
OFF-SITE EXTRACTION WELL AVERAGE
VS. TARGET PUMPING RATES
LANXESS CANADA CO./CIE
Elmira, Ontario

*Note: Target pumping rates were updated based on the average daily pumping rates recommended in the 2015 Model Check Point Analysis (GHD, June 2016). The Target Average pumping rates are 90% of the recommended daily Set Point pumping rates since the wells and treatment system components require periodic downtime for maintenance.

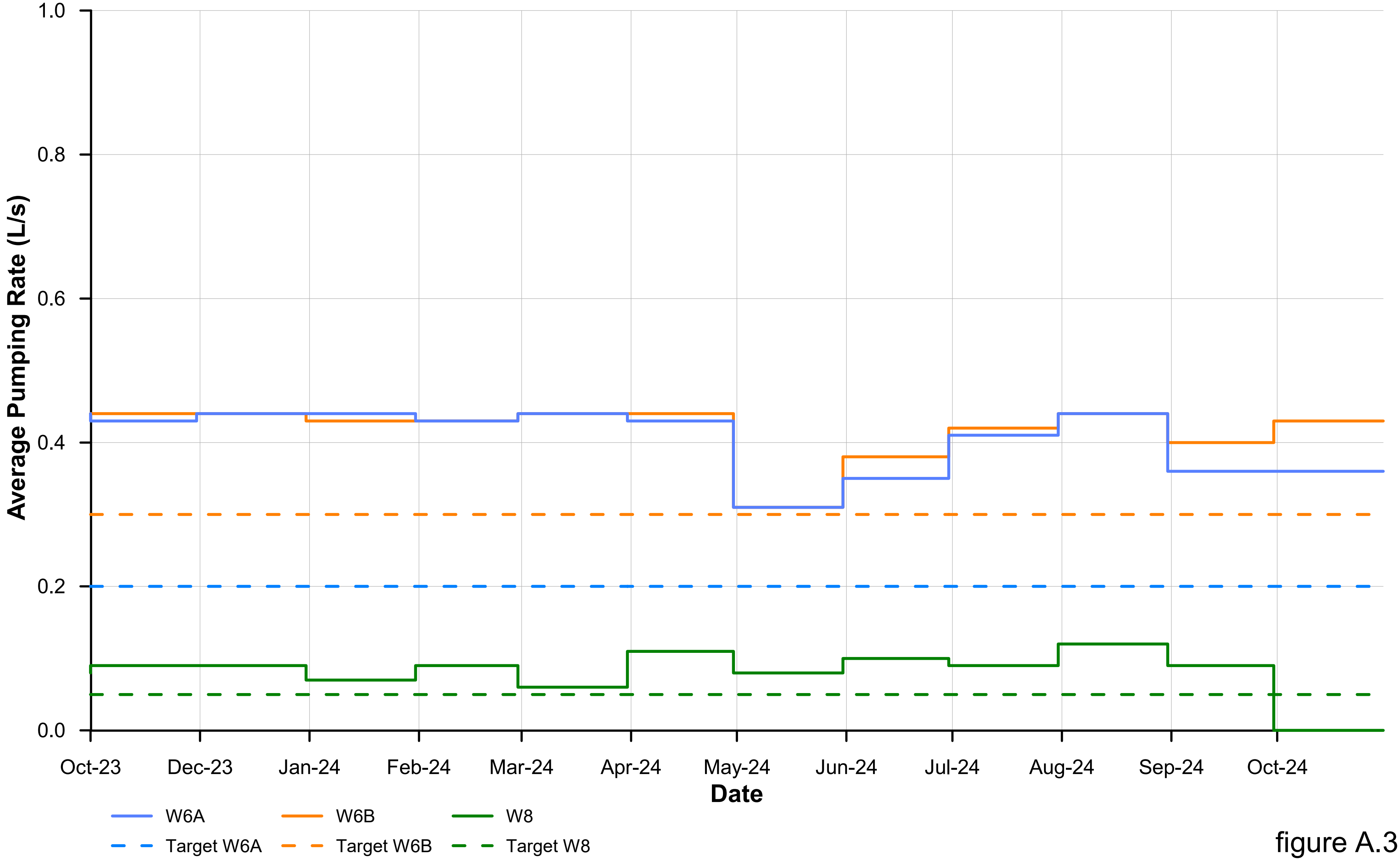

figure A.3b

OFF-SITE EXTRACTION WELL AVERAGE
VS. TARGET PUMPING RATES
LANXESS CANADA CO./CIE
Elmira, Ontario

*Note: Target pumping rates were updated based on the average daily pumping rates recommended in the 2015 Model Check Point Analysis (GHD, June 2016). The Target Average pumping rates are 90% of the recommended daily Set Point pumping rates since the wells and treatment system components require periodic downtime for maintenance.

LANXESS has reduced the W6A and W6B target average pumping rates as a result of reduced well capacity.

Table A.1

Performance - Combined On-Site and Off-Site Groundwater Collection and Treatment System
Bypass/Upset Conditions - October 2024
LANXESS Canada Co./Cie
Elmira, Ontario

ON-SITE GROUNDWATER CONTAINMENT AND TREATMENT SYSTEM

No shutdowns during October 2024

OFF-SITE GROUNDWATER COLLECTION AND TREATMENT SYSTEM

W3R Groundwater Rayox System

October 2	Shut down at 08:00 for scheduled maintenance, and restarted at 11:00
October 4	Shut down at 11:05 due to communication issues, and restarted at 13:35
October 9	Shut down at 02:00 due to communication issues, and restarted at 04:00
October 10	Shut down at 02:30 due to communication issues, and restarted at 11:15
October 11	Shut down at 21:30 due to communication issues, and restarted October 12, 2024 at 03:00
October 17	Shut down at 11:15 to backwash the Building 44D W4 carbon adsorber, and restarted at 14:00
October 24	Shut down at 15:30 due to communication issues, and restarted at 18:45
October 25	Shut down at 02:00 due to communication issues, and restarted at 08:05
October 27	Shut down at 11:45 due to communication issues, and restarted at 14:45
October 31	Shut down at 19:40 due to communication issues, and restarted at 22:25

W5A/W5B/W6A/W6B/W8 Groundwater Rayox System [1]

October 17	Shut down at 11:15 to backwash the Building 44D W4 carbon adsorber, and restarted at 14:00
October 26	Shut down at 16:35 due to flow deviation, and restarted October 27, 2024 at 01:30

W9 Groundwater Trojan UV/Oxidation System

September 30	Shut down at 10:35 due to a critical alarm on the Trojan system, and restarted October 2, 2024 at 12:30
October 7	Shut down at 09:00 for scheduled well rehabilitation, and restarted October 10, 2024 at 10:00

Note:

[1] Groundwater pumped by PW5 is treated in the W5A/W5B/W6A/W6B/W8 Groundwater Rayox System and PW5 is, therefore, shut down when the W4/W5A/W5B/W6A/W6B/W8 system is shut down.

Table A.2

Combined On-Site and Off-Site Groundwater Containment and Treatment System
Analytical Results [1]
October 2024
LANXESS Canada Co./Cie
Elmira, Ontario

Sample Date	Parameter [2] [3]	Untreated Influent										Primary Treatment						Secondary Treatment				Tertiary Treatment		Combined Discharge Effluent[4]	Combined Discharge Effluent		
		W3R	W5A	W5B	W6A	W6B	W9	YI	G4	G5	GUA	W3R CEN	W3R CES	W4 CI	W4 CE	GCI	GCE	W3R RE	W4 RE	W9 RE	GR	SFE	GE		Limit	Adjusted Limit [5]	Objective
1-Oct-24	Ammonia-N (mg/L)																					ND(0.0050)	0.123	0.095	0.84[6]	0.84	0.62
2-Oct-24	Ammonia-N (mg/L)	0.208	0.805	4.06	0.116	0.121		64.7	5.81	1.46	3.46																
15-Oct-24	Ammonia-N (mg/L)						0.185																				
1-Oct-24	Total Phosphorus (mg/L)																					0.468	0.147	0.220	0.5	0.5	--
1-Oct-24	BOD_5 (mg/L)																					ND(2.0)	ND(2.0)	ND(2.0)	15	15	--
1-Oct-24	Total Cyanide (µg/L)																					ND(2)	ND(2)	ND(2)	14	14	ND(5)
1-Oct-24	Formaldehyde (µg/L)																					ND(2.0)	ND(2.0)	ND(2.0)	24	24	ND(5)
1-Oct-24	pH (s.u.)																					6.94	7.07	7.04	5.5 - 9.5	5.5 - 9.5	--
1-Oct-24	Temperature (°C)																					18.8	15.1	15.9	<25	<25	--
1-Oct-24	Chlorobenzene (µg/L)											1.73	0.52	51.4	ND(0.20)	2160	76.4	0.73	ND(0.20)		10.6	ND(0.20)	0.43	0.37	10	9.6	ND(0.5)
2-Oct-24	Chlorobenzene (µg/L)	23.7	118	30.2	ND(0.20)	4.15		0.48	2610	32.2	221																
15-Oct-24	Chlorobenzene (µg/L)						24.7											0.70	ND(0.20)	0.36	9.51	0.30	0.42				
1-Oct-24	Toluene (µg/L)															16.3	1.38					ND(0.20)	ND(0.20)	ND(0.20)	5	4.8	ND(0.4)
1-Oct-24	1,1-Dichloroethane (µg/L)															ND(0.20)	ND(0.20)					ND(0.20)	ND(0.20)	ND(0.20)	10	10	ND(1)
1-Oct-24	g-BHC (Lindane) (µg/L)																					ND(0.0030)	ND(0.0030)	ND(0.0030)	0.14	0.13	ND(0.003)
1-Oct-24	n-Nitrosodimethylamine (NDMA) (µg/L)[7]																	0.01	ND(0.01)		ND(0.01)	ND(0.01)	ND(0.01)	ND(0.01)	0.14	0.13	ND(0.01)
2-Oct-24	NDMA (µg/L)[7]	0.53	0.46	0.08	0.15	0.47		0.03	3.57	0.48	0.34																
7-Oct-24	NDMA (µg/L)[7]																	ND(0.01)									
15-Oct-24	NDMA (µg/L)[7]						2.39											ND(0.01)	ND(0.01)	ND(0.01)	ND(0.01)	ND(0.01)	ND(0.01)				
1-Oct-24	n-Nitrosodiethylamine (NDEA) (µg/L)[7]																	ND(0.06)	ND(0.06)		ND(0.06)	ND(0.06)	ND(0.06)	ND(0.06)	4	4	ND(0.06)
2-Oct-24	NDEA (µg/L)[7]	ND(0.06)	ND(0.06)	ND(0.06)	ND(0.06)	ND(0.06)		ND(0.06)	ND(0.15)	ND(0.06)	ND(0.06)																
7-Oct-24	NDEA (µg/L)[7]																	ND(0.06)									
15-Oct-24	NDEA (µg/L)[7]						ND(0.15)											ND(0.06)	ND(0.06)	ND(0.06)	ND(0.06)	ND(0.06)	ND(0.06)				
1-Oct-24	Nitrosomorpholine (NMOR) (µg/L)[7]																	ND(0.06)	ND(0.06)		ND(0.06)	ND(0.06)	ND(0.06)	ND(0.06)	4	3.9	ND(0.06)
2-Oct-24	NMOR (µg/L)[7]	ND(0.06)	ND(0.06)	ND(0.06)	ND(0.06)	0.11		0.18	ND(0.15)	ND(0.06)	ND(0.06)																
7-Oct-24	NMOR (µg/L)[7]																	ND(0.06)									
15-Oct-24	NMOR (µg/L)[7]						ND(0.15)											ND(0.06)	ND(0.06)	ND(0.06)	ND(0.06)	ND(0.06)	ND(0.06)				
1-Oct-24	Benzothiazole (µg/L)															110	ND(2.0)					ND(2.0)	ND(2.0)	ND(2.0)	4	3.9	ND(2)
1-Oct-24	Carboxin (µg/L)															32.6	0.390					ND(0.100)	ND(0.100)	ND(0.100)	7	6.7	ND(2)

SS+890 Discharge (GE) Flow Rate	36.8 L/s
Shirt Factory Creek Discharge (SFE) Flow Rate	10.9 L/s
Total Combined Discharge Effluent Flow	47.7 L/s

Table A.2

Combined On-Site and Off-Site Groundwater Containment and Treatment System
Analytical Results [1]
October 2024
LANXESS Canada Co./Cie
Elmira, Ontario

Notes:

[1]	All samples analyzed by ALS Canada Ltd. unless otherwise noted.		
[2]	"Parameters" are the parameters identified in ECA No. 0831-BX6JGD.		
[3]	The Sample Locations are coded as follows:		
W3R	Extraction Well W3R Influent.	W5A	Extraction Well W5A Influent.
W6A	Extraction Well W6A Influent.	W6B	Extraction Well W6B Influent.
W9	Extraction Well W9 Influent.	YI	Yara Influent.
G4	Containment Well PW4 Influent.	G5	Containment Well PW5 Influent.
GUA	Upper Aquifer Wells (Combined).		
W3R CEN	W3R North Carbon Adsorber Effluent.	W3R CES	W3R South Carbon Adsorber Effluent.
W4CI	W4 Carbon Adsorber Influent. The influent may include influent from W5A, W5B, W6A, W6B, W8 and PW5.		
W4CE	W4 Carbon Adsorber Effluent. The effluent may include effluent from W5A, W5B, W6A, W6B, W8 and PW5.		
GCI	On-Site Carbon Tower Influent.	GCE	On-Site Carbon Tower Effluent.
W3R RE	Effluent from the W3R UV system.		
W4 RE	Effluent from the W4 UV system prior to treatment through the ATS. The effluent may include effluent from W5A, W5B, W6A, W6B, W8 and PW5.		
W9 RE	Effluent from the W9 Trojan UV/oxidation system.	GR	On-Site Groundwater Rayox Effluent.
SFE	Additional Effluent Discharge via Shirt Factory Creel	GE	Effluent Discharge to Canagaguige Creek.
[4]	The Combined Discharge Effluent value is a calculated value determined by using average flow data from GE Effluent Discharge via SS+880 and Additional Effluent Discharge via Shift Factory Creek and monthly sample results from GE and SFE.		
[5]	Adjusted Effluent Requirements are applicable to monthly average discharge flows greater than 46.0 L/s.		
[6]	Total Ammonia Discharge Effluent Limit value is the greater of: calculated concentration, or 0.84 mg/L (May-October) or 2.4 mg/L (November-April) as per ECA No. 0831-BX6JGD.		
[7]	Samples analyzed by the LANXESS lab, Elmira Ontario.		
ND(RDL)	Not detected at the associated reporting detection limit.		

Table A.3

Combined On-Site and Off-Site Groundwater Collection and Treatment System Flow Rates
October 2024
LANXESS Canada Co./Cie
Elmira, Ontario

Date	On-Site Flow Rate [1] (L/s)	Off-Site Flow Rate [2] (L/s)	ATS Influent Flow Rate [3] (L/s)	W3R Bypass Flow Rate (L/s)	W9 Bypass Flow Rate (L/s)	SS+890 Discharge Flow Rate (L/s)	Shirt Factory Creek Discharge Flow Rate (L/s)	Total Combined Discharge Effluent Flow Rate [4] (L/s)
10/1/2024	3.5	32.8	12.9	23.7	0.0	36.0	0.5	36.5
10/2/2024	3.2	35.9	12.6	20.7	6.1	34.4	4.9	39.3
10/3/2024	3.4	45.4	12.8	23.7	12.6	38.4	10.6	49.1
10/4/2024	3.6	43.5	12.9	21.8	12.6	37.5	9.8	47.3
10/5/2024	3.6	45.4	13.0	23.7	12.6	38.1	11.1	49.2
10/6/2024	3.6	45.4	12.9	23.7	12.6	38.5	10.8	49.2
10/7/2024	3.6	37.7	12.9	23.7	4.9	37.1	4.4	41.5
10/8/2024	3.6	32.8	12.9	23.7	0.0	36.3	0.3	36.6
10/9/2024	3.6	27.1	12.4	18.5	0.0	30.5	0.4	30.9
10/10/2024	3.6	34.8	12.9	15.3	10.4	31.0	7.6	38.6
10/11/2024	3.6	46.1	12.7	21.3	15.8	36.9	12.9	49.8
10/12/2024	3.6	44.9	12.6	20.3	15.8	36.9	11.7	48.6
10/13/2024	3.6	48.2	12.5	23.7	15.8	38.2	13.8	52.0
10/14/2024	3.6	48.1	12.4	23.7	15.8	38.3	13.6	51.8
10/15/2024	3.6	48.0	12.3	23.7	15.8	38.1	13.6	51.7
10/16/2024	3.5	47.9	12.1	23.7	15.8	38.0	13.5	51.6
10/17/2024	3.4	46.2	11.0	23.0	15.8	37.4	12.4	49.7
10/18/2024	3.4	48.0	12.1	23.7	15.8	37.8	13.7	51.5
10/19/2024	3.4	48.0	12.1	23.7	15.8	37.7	13.8	51.5
10/20/2024	3.4	48.0	12.1	23.7	15.8	37.6	14.0	51.5
10/21/2024	3.4	48.0	12.1	23.7	15.8	37.4	14.1	51.5
10/22/2024	3.4	47.8	12.1	23.5	15.8	36.9	14.5	51.4
10/23/2024	3.4	47.8	12.1	23.5	15.8	37.0	14.4	51.3
10/24/2024	3.4	45.4	12.0	21.1	15.8	36.4	12.6	48.9
10/25/2024	3.4	42.1	12.1	17.7	15.8	35.3	10.3	45.6
10/26/2024	3.4	45.1	9.2	23.7	15.8	38.3	10.3	48.6
10/27/2024	3.4	45.5	12.5	20.7	15.8	36.5	12.5	49.0
10/28/2024	3.4	48.7	12.7	23.7	15.8	37.5	14.7	52.2
10/29/2024	3.4	48.5	12.6	23.7	15.8	37.5	14.6	52.1
10/30/2024	3.3	48.5	12.6	23.7	15.8	37.6	14.5	52.0
10/31/2024	3.3	45.8	12.5	20.9	15.8	36.7	12.5	49.2
Average	**3.5**	**44.1**	**12.4**	**22.4**	**13.0**	**36.8**	**10.9**	**47.7**
Minimum	**3.2**	**27.1**	**9.2**	**15.3**	**0.0**	**30.5**	**0.3**	**30.9**
Maximum	**3.6**	**48.7**	**13.0**	**23.7**	**15.8**	**38.5**	**14.7**	**52.2**

Notes:

L/s Litres per second
[1] The ECA requires that the influent flow rate to the on-Site Treatment System be less than 5 L/s.
[2] The ECA requires that the influent flow rate to the off-Site Treatment System be less than 87.2 L/s.
[3] The ECA requires that the influent flow rate to the Ammonia Treatment System be less than 46 L/s.
[4] The ECA requires that the monthly average effluent discharge flow rate be less than 92.2 L/s.

Table A.4

Supplementary Sample Analytical Results
October 2024
LANXESS Canada Co./Cie
Elmira, Ontario

Sample Location:	**UA500I**	**UA500CE**	**UA560I**	**UA560CE**	**GCI**	**GCE**
Sample Date:	**10/1/2024**	**10/1/2024**	**10/1/2024**	**10/1/2024**	**10/1/2024**	**10/1/2024**
Parameter [µg/L]						
Volatile Organic Compounds (VOCs)						
Benzene	14.0	4.99	22.7	ND(0.20)	11.2	0.26
Chlorobenzene	945	106.0	728	ND(0.20)	2160	76.4
1,1-Dichloroethane	ND(0.20)	ND(0.20)	ND(0.20)	ND(0.20)	ND(0.20)	ND(0.20)
Ethylbenzene	81.6	7.94	64.2	ND(0.20)	9.21	0.42
Toluene	2200	567	12500	ND(0.20)	16.3	1.38
m/p-Xylenes [1]	99.0	10.0	156	ND(0.40)	7.05	ND(0.40)
o-Xylene [1]	88.9	8.57	93.4	ND(0.20)	5.50	0.26
Base/Neutral and Acid Extractable Compounds (BNAs)						
Aniline	1170	457	2160	ND(2.0) UJ	49.3	ND(2.0)
Benzothiazole	1330	126	37.0	ND(2.0)	110	ND(2.0)
Carboxin (Oxathiin)	1920	175.0	1900	ND(0.100)	32.6	0.390
2-Chlorophenol	6.98	2.20	ND(0.30)	ND(0.30)	1.38	ND(0.30)
2-Mercaptobenzothiazole	2880	304	22	ND(20)	252	ND(20)
2,4-Dichlorophenol	35.9 J+	6.15 J+	0.35 J+	ND(0.20)	0.50 J+	ND(0.20)
2,6-Dichlorophenol	1.11	0.49	0.24	ND(0.20)	0.26	ND(0.20)
2,4,5-Trichlorophenol	17.7	1.64	ND(0.20)	ND(0.20)	ND(0.20)	ND(0.20)
2,4,6-Trichlorophenol	0.97	0.37	ND(0.20)	ND(0.20)	ND(0.20)	ND(0.20)

Notes:

UA500I	Influent to the installed UA500R portable carbon drum.
UA500CE	Effluent from the installed UA500R portable carbon drum.
UA560I	Influent to the installed UA560 portable carbon drum.
UA560CE	Effluent from the installed UA560 portable carbon drum.
GCI	Carbon Tower Influent.
GCE	Carbon Tower Effluent.
ND(RDL)	Not detected at the associated reporting detection limit.
UJ	The analyte was analyzed for, but was not detected. The reported quantitation limit is approximate and may be inaccurate or imprecise.
J+	The result is an estimated quantity, but the result may be biased high.
[1]	Samples analyzed for m,p-Xylenes and o-Xylene only. No separate analysis for Total Xylenes.

Table A.5

Combined On-Site and Off-Site Groundwater Collection and Treatment System
Effluent Broad Scan Analytical Results
October 2024
LANXESS Canada Co./Cie
Elmira, Ontario

	Sample Station				
Parameter [µg/L unless otherwise noted] [1]	**SFE**	**GE**	**Combined Discharge Effluent [6][7]**	**Effluent Limit [8]**	**Adjusted Limit [9]**
General Chemistry					
Alkalinity ($CaCO_3$) (mg/L)	319	275	285	--	--
Ammonia as N (mg/L)	ND(0.0050)	0.123	0.095	2.4[10]	2.4[10]
Un-ionized Ammonia (mg/L)[2]	ND(0.0010)	ND(0.0010)	ND(0.0010)	--	--
Formaldehyde	ND(2.0)	ND(2.0)	ND(2.0)	24	24
pH (field)	6.94	7.07	7.04	5.5 - 9.5	5.5 - 9.5
Phenols (Total) (mg/L)	0.0018	0.0012	0.0013	--	--
Temperature (field) (°C)	18.8	15.1	15.9	<25	<25
Total Cyanide	ND(2)	ND(2)	ND(2)	14	14
Total Phosphorus (mg/L)	0.468	0.147	0.220	0.5	0.5
Volatile Organic Compounds (VOCs)					
1,1-Dichloroethane	ND(0.20)	ND(0.20)	ND(0.20)	10	10
Benzene	ND(0.20)	ND(0.20)	ND(0.20)	--	--
Chlorobenzene	ND(0.20)	0.43	0.35	10	9.6
Ethylbenzene	ND(0.20)	ND(0.20)	ND(0.20)	--	--
m/p-Xylenes[3]	ND(0.40)	ND(0.40)	ND(0.40)	--	--
o-Xylene[3]	ND(0.20)	ND(0.20)	ND(0.20)	--	--
Toluene	ND(0.20)	ND(0.20)	ND(0.20)	5	4.8
Base/Neutral/Acid Extractables and Nitrosoamines					
2,3,4-Trichlorophenol	ND(0.50)	ND(0.50)	ND(0.50)	--	--
2,4,5-Trichlorophenol	ND(0.20)	ND(0.20)	ND(0.20)	--	--
2,4,6-Trichlorophenol	ND(0.20)	ND(0.20)	ND(0.20)	--	--
2-Chlorophenol	ND(0.30)	ND(0.30)	ND(0.30)	--	--
2-Mercaptobenzothiazole	ND(20)	ND(20)	ND(20)	--	--
2,4-Dichlorophenol	ND(0.20)	ND(0.20)	ND(0.20)	--	--
2,4-Dimethylphenol	ND(0.50)	ND(0.50)	ND(0.50)	--	--
2,6-Dichlorophenol	ND(0.20)	ND(0.20)	ND(0.20)	--	--
Aniline	ND(2.0) UJ	ND(2.0) UJ	ND(2.0)	--	--
Benzothiazole	ND(2.0)	ND(2.0)	ND(2.0)	4	3.9
bis(2-Ethylhexyl)phthalate	ND(0.60)	ND(0.60)	ND(0.60)	--	--
Carboxin (Oxathiin)	ND(0.100)	ND(0.100)	ND(0.100)	7	6.7
Morpholine	ND(1.0)	ND(1.0)	ND(1.0)	--	--
m/p-Cresol[5]	ND(0.50)	ND(0.50)	ND(0.50)	--	--
n-Nitrosodiethylamine (NDEA)[4]	ND(0.06)	ND(0.06)	ND(0.06)	4	4
n-Nitrosodimethylamine (NDMA)	ND(0.01)	ND(0.01)	ND(0.01)	0.14	0.13
n-Nitrosodiphenylamine (NDPhA)	ND(1.0)	ND(1.0)	ND(1.0)	--	--
Nitrosodibutylamine (NDBA)[4]	ND(0.06)	ND(0.06)	ND(0.06)	--	--
Nitrosomorpholine (NMOR)[4]	ND(0.06)	ND(0.06)	ND(0.06)	4	3.9
o-Cresol[6]	ND(0.50)	ND(0.50)	ND(0.50)	--	--
Phenol	ND(0.50)	ND(0.55)	ND(0.54)	--	--
Pesticides and Herbicides					
2,4,5-T	ND(0.050)	ND(0.050)	ND(0.050)	--	--
Lindane (g-BHC)	ND(0.0030)	ND(0.0030)	ND(0.0030)	0.14	0.13
p,p-DDT	ND(0.00040)	ND(0.00040)	ND(0.00040)	--	--

Table A.5

Combined On-Site and Off-Site Groundwater Collection and Treatment System
Effluent Broad Scan Analytical Results
October 2024
LANXESS Canada Co./Cie
Elmira, Ontario

SS+890 Discharge (GE) Flow Rate	36.83 L/s
Shirt Factory Creek Discharge (SFE) Flow Rate	10.91 L/s
Total Combined Discharge Effluent Flow	47.74 L/s

Notes:

ND(RDL)	Not detected at the associated reporting detection limit.
UJ	The analyte was analyzed for, but was not detected. The reported quantitation limit is approximate and may be inaccurate or imprecise.
-	The parameter was not analyzed for.
--	No Effluent Limit value specified in ECA No. 0831-BX6JGD.
[1]	Analyses completed by ALS Canada Ltd. unless otherwise noted.
[2]	Unionized ammonia is a calculated value (station SFE and GE only) based on effluent discharge temperature, pH and total ammonia concentration.
[3]	Samples analyzed for m,p-Xylenes and o-Xylene only. No separate analysis for Total Xylenes.
[4]	Nitrosamine analysis completed by LANXESS Canada Co./Cie.
[5]	Samples analyzed for m,p-Cresols and o-Cresol only. No separate analysis for m-Cresol and p-Cresol following MECP approval (November 21, 1996).
[6]	The Combined Discharge Effluent value is a calculated value determined by using average flow data from GE Effluent Discharge via SS+880 and Additional Effluent Discharge via Shift Factory Creek and monthly sample results from GE and SFE.
[7]	Only Combined Effluent Discharge results are compared to Effluent Limits.
[8]	ECA No. 0831-BX6JGD Effluent Limit.
[9]	Adjusted Effluent Requirements. Applicable to monthly average discharge flows greater than 46.0 L/s.
[10]	Total Ammonia Discharge Effluent Limit value is the greater of: calculated concentration, or 0.84 mg/L (May-October) or 2.4 mg/L (November-April) as per ECA No. 0277 BV2JU5.

Table A.6

Maintenance Summary
On-Site and Off-Site Groundwater Collection and Treatment System
October 2024
LANXESS Canada Co./Cie
Elmira, Ontario

Start Date	Description	Work Type
10/01/2024	Check Bldg. #44C South Gas Fired Wall Unit Heater U/N 8966	External Contractor
10/01/2024	Check Bldg. #44C East-Centre Gas Fired Wall Unit Heater U/N 8968	External Contractor
10/01/2024	Check Bldg. #62 North-West Gas Fired Wall Unit Heater U/N 8972	External Contractor
10/01/2024	Check Bldg. #62 North-East Gas Fired Wall Unit Heater U/N 8973	External Contractor
10/01/2024	Check Bldg. #62 South-West Gas Fired Wall Unit Heater U/N 8974	External Contractor
10/01/2024	Check Bldg. #62 Roof Intake Unit U/N 8637	External Contractor
10/01/2024	Bldg. #45 Rayox Lamps #3, #8, #9 Over Hours	Electrical
10/01/2024	Monthly E7 North Compressor Inspection	General
10/01/2024	Monthly E7 South Compressor Inspection	General
10/02/2024	Top Up Oil in Methanol Truck Unloading Pump	Mechanical
10/07/2024	Bldg. #20 Rayox B Lamps #2, #5, #6 Wipers	Electrical
10/07/2024	Check 62-AIT-901 (62PM-13) - Nitrification Tank pH	Instrumentation
10/07/2024	Check 62-AIT-904 (62-ICP-904) - Nitrification Tank Dissolved O2	Instrumentation
10/07/2024	Check 62-AIT-790 (62PM-26) - Creek Water pH Transmitter	Instrumentation
10/08/2024	Repair Rayox Sludge Removal Drain in Bldg. #20A	Piping
10/08/2024	Repair 44-LT-338 - Backwash Tank Level Transmitter	Instrumentation
10/08/2024	Check/Repair Bldg. #62 Center Sludge Storage Tank Decanting Line	Piping
10/10/2024	Bldg. #20A Rayox Drain Line Leaking	Piping
10/18/2024	Trip and Alarm 20-XS-280 (20TA-11) - Rayox B UV Skid Deviation Control Unit	Instrumentation
10/18/2024	Check 62-LSHH-852 (62TA-04) - Methanol Storage Tank Level High-High Switch	Instrumentation
10/18/2024	Check 62-LSH-861 (62TA-09) - ATS Sand Filter #1 Level Switch	Instrumentation
10/18/2024	Check 62-LSH-862 (62TA-10) - ATS Sand Filter #2 Level Switch	Instrumentation
10/18/2024	Check 62-LSH-863 (62TA-11) - ATS Sand Filter #3 Level Switch	Instrumentation
10/18/2024	Check 62-FSL-915 (62TA-05) - Phosphoric Acid Low Flow Switch	Instrumentation
10/18/2024	Check 20-PSH-325B (20TA-10) - Well W6B Pressure High Switch	Instrumentation
10/18/2024	Check 20-LSH-328 (20TA-12) - W6A/B Sump Level Switch	Instrumentation
10/18/2024	Check 20-XA-245 (20TA-XX) - W3 Well Hut Entry Monitor Switch	Instrumentation
10/18/2024	Check 20-XA-255 (20TA-XX) - W4 Well Hut Entry Monitor Switch	Instrumentation
10/18/2024	Check 20-XA-265 (20TA-XX) - W5 Well Hut Entry Monitor Switch	Instrumentation
10/18/2024	Check 20-XA-326 (20TA-XX) - W6 Well Hut Entry Monitor Switch	Instrumentation
10/18/2024	Check 44-XA-316 (44TA-XX) - W9 Well Hut Entry Monitor Switch	Instrumentation
10/18/2024	Check 20-TSH-246 (20TA-13) - W3 Well Hut Temperature Switch	Instrumentation
10/18/2024	Check 20-TSH-256 (20PM-XX) - W4 Well Hut Temperature Switch	Instrumentation
10/18/2024	Check 20-TSH-266 (20TA-15) - W5 Well Hut Temperature Switch	Instrumentation
10/18/2024	Check 20-TSH-327 (20TA-18) - W6 Well Hut Temperature Switch	Instrumentation
10/18/2024	Check 44-TSH-307 (20TA-16) - W8 Well Hut Temperature Switch	Instrumentation
10/18/2024	Check 44-TSL-317 (20TA17) - W9 Well Hut Temperature Switch	Instrumentation
10/18/2024	Check 44-XS-306 (20TA-08) - W8 Well Hut Entry Monitor Switch	Instrumentation
10/22/2024	W4 North Carbon Adsorber Inlet Leak at Bldg. #44C Mezzanine	Piping
10/28/2024	Bldg. #45 Rayox Will Not Stay Running	Instrumentation
10/30/2024	Check 20-PSH-325A (20TA-09) - W6A/W6B Pressure Switch	Instrumentation
10/31/2024	Check 62-FIT-853 (62PM-17) - Methanol To Splitter Box Flow	Instrumentation
10/31/2024	Check 62-LT-850 (62PM-16) - Methanol Storage Tank Level Transmitter	Instrumentation

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TOXICITY TEST REPORT

Daphnia magna
EPS 1/RM/14

Work Order :	255999
Sample Number :	84247

SAMPLE IDENTIFICATION

Company :	LANXESS Canada Co./Cie	Sampling Date :	2024-10-01
Location :	Elmira ON	Sampling Time :	11:00
Substance :	SFE 100124	Date Received :	2024-10-01
Sampling Method :	Grab	Time Received :	14:00
Sampled By :	A. Norris	Temperature at Receipt :	18 °C
Sample Description :	Clear, colourless	Date Tested :	2024-10-02

Test Method : Reference Method for Determining Acute Lethality of Effluents to *Daphnia magna* . Environment Canada EPS 1/RM/14 (Second Edition, December 2000, with February 2016 amendments).

48-HOUR TEST RESULTS

Substance	Effect	Value
Control	Mean Immobility	0.0 %
	Mean Mortality	0.0 %
100%	Mean Immobility	0.0 %
	Mean Mortality	0.0 %

The results reported relate only to the sample tested and as received.

TEST ORGANISM

Species :	*Daphnia magna*	Time to First Brood :	7.6 days
Organism Batch :	Dm24-18	Average Brood Size :	29.3
Culture Mortality :	4.3% (previous 7 days)		

TEST CONDITIONS

Sample Treatment :	None	Number of Replicates :	3
pH Adjustment :	None	Organisms per Replicate :	10
Pre-aeration Rate :	~30 mL/min/L	Organisms per Test Level :	30
Duration of Pre-Aeration :	0 minutes	Organism Loading Rate :	15.0 mL/organism
Test Aeration :	None	Impaired Control Organisms :	0.0%
Hardness Adjustment :	None	Test Method Deviation(s) :	None

REFERENCE TOXICANT DATA

Toxicant :	Sodium Chloride		
Date Tested :	2024-09-24	LC50 :	6.4 g/L
Organism Batch :	Dm24-18	95% Confidence Limits :	6.2 - 6.6 g/L
Analyst(s) :	JW, CGR, CQ, MK	Historical Mean LC50 :	6.3 g/L
Statistical Method :	Spearman-Kärber	Warning Limits (± 2SD) :	5.9 - 6.7 g/L

COMMENTS

- All test validity criteria as specified in the test method were satisfied.

Approved By : V.Carleton

Victoria (Tori) Carleton
I am approving this document
Nautilus Environmental
2024-10-20 17:37-04:00

Project Manager

Work Order : 255999
Sample Number : 84247

TEST DATA

	pH	Dissolved O_2 (mg/L)	Conductivity (µmhos/cm)	Temperature (°C)	O_2 Saturation (%)*	Hardness (as $CaCO_3$)
Initial Chemistry (100%) :	7.1	8.6	1888	20	100	560 mg/L

0 HOURS

Date & Time : 2024-10-02 10:00
Analyst(s) : MK (CGR)

Concentration (%)	Replicate	Dead	Immobile	pH	Dissolved O_2	Conductivity	Temperature	O_2 Saturation*	Hardness
100	A	0	0	7.1	8.6	1888	20	100	560
100	B	0	0	7.1	8.6	1888	20	100	560
100	C	0	0	7.1	8.6	1888	20	100	560
Control	A	0	0	8.3	8.7	510	21	100	150
Control	B	0	0	8.3	8.7	510	21	100	150
Control	C	0	0	8.3	8.7	510	21	100	150

Notes:

24 HOURS

Date & Time : 2024-10-03 9:40
Analyst(s) : GR (CGR)

Concentration (%)	Replicate	Dead	Immobile	pH	Dissolved O_2	Conductivity	Temperature
100	A	–	0	–	–	–	20
100	B	–	0	–	–	–	20
100	C	–	0	–	–	–	20
Control	A	–	0	–	–	–	20
Control	B	–	0	–	–	–	20
Control	C	–	0	–	–	–	20

Notes:

48 HOURS

Date & Time : 2024-10-04 10:10
Analyst(s) : MK (JGR)

Concentration (%)	Replicate	Dead	Immobile	pH	Dissolved O_2	Conductivity	Temperature
100	A	0	0	8.5	8.6	1876	20
100	B	0	0	8.5	8.6	1867	20
100	C	0	0	8.5	8.6	1847	20
Control	A	0	0	8.3	8.7	521	20
Control	B	0	0	8.3	8.7	519	20
Control	C	0	0	8.3	8.6	518	20

Notes:

Number immobile does not include number dead.

"–" = not measured/not required
* adjusted for temperature and barometric pressure

Test Data Reviewed By : JJ
Date : 2024-10-09

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TOXICITY TEST REPORT
Rainbow Trout
EPS 1/RM/13
Page 1 of 2

Work Order :	255999
Sample Number :	84247

SAMPLE IDENTIFICATION

Company :	LANXESS Canada Co./Cie	Sampling Date :	2024-10-01
Location :	Elmira ON	Sampling Time :	11:00
Substance :	SFE 100124	Date Received :	2024-10-01
Sampling Method :	Grab	Time Received :	14:00
Sampled By :	A. Norris	Temperature at Receipt :	18 °C
Sample Description :	Clear, colourless	Date Tested :	2024-10-02

Test Method(s) : Reference Method for Determining Acute Lethality of Liquid Effluents to Rainbow Trout. Environment Canada, EPS 1/RM/13 (2nd Edition, December 2000, with May 2007, February 2016, and December 2023 amendments).

96-HOUR TEST RESULTS

Substance	Effect	Value
Control	Mean Impairment	0.0 %
	Mean Mortality	0.0 %
100%	Mean Impairment	0.0 %
	Mean Mortality	0.0 %

The results reported relate only to the sample tested and as received.

TEST ORGANISM

Test Organism :	*Oncorhynchus mykiss*	Mean Fork Length :	40.4 mm
Organism Batch :	T24-20	Range of Fork Lengths :	36 - 46 mm
Control Sample Size :	10	Mean Wet Weight :	0.6 g
Cumulative stock mortality rate :	0% (previous 7 days)	Organism Loading Rate :	0.3 g/L
Control organisms showing stress :	0 (at test completion)		

TEST CONDITIONS

Test Type :	Single concentration	Number of Replicates :	1
Sample pH Adjustment :	None	Organisms Per Replicate :	10
Sample Pre-aeration/Aeration Rate :	6.5 ± 1 mL/min/L	Organisms Per Test Level :	10
Duration of Sample Pre-Aeration :	30 minutes	Volume of Sample :	18 L
Control Pre-aeration/Aeration Rate :	6.5 ± 1 mL/min/L	Volume of Control :	18 L
Duration of Control Pre-aeration:	30 minutes	Test Method Deviation(s) :	None

REFERENCE TOXICANT DATA

Toxicant :	Potassium Chloride		
Organism Batch :	T24-20	LC50 :	3381 mg/L
Date Tested :	2024-10-01	95% Confidence Limits :	2880 - 3923 mg/L
Analyst(s) :	AJS, NWP, JGR, GR	Historical Mean LC50 :	3580 mg/L
Statistical Method :	Linear Regression (MLE)	Warning Limits (± 2SD) :	2572 - 4982 mg/L

COMMENTS

- All test validity criteria as specified in the test method were satisfied.

Approved By : V.Carleton

Victoria (Tori) Carleton
I am approving this document
Nautilus Environmental
2024-10-20 17:37-04:00

Project Manager

Work Order : 255999
Sample Number : 84247

TEST DATA

	pH	Dissolved O_2 (mg/L)	Conductivity (µmhos/cm)	Temperature (°C)	O_2 Saturation (%)[3]
Initial Water Chemistry (100%) :	6.8	8.9	1771	15	93
After 30 min pre-aeration :	6.9	9.0	1767	15	95

0 HOURS

Date & Time 2024-10-02 10:05
Analyst(s) : NWP

Concentration	Dead	Impaired	pH	Dissolved O_2	Conductivity	Temperature	O_2 Saturation[3]
100%	0	0	6.9	9.0	1767	15	95
Control	0	0	8.2	9.6	782	15	100

Notes:

24 HOURS

Date & Time 2024-10-03 10:15
Analyst(s) : JGR

Concentration	Dead	Impaired	pH	Dissolved O_2	Conductivity	Temperature
100%	0	0	–	–	–	15
Control	0	0	–	–	–	15

Notes:

48 HOURS

Date & Time 2024-10-04 10:50
Analyst(s) : NWP

Concentration	Dead	Impaired	pH	Dissolved O_2	Conductivity	Temperature
100%	0	0	–	–	–	15
Control	0	0	–	–	–	15

Notes:

72 HOURS

Date & Time 2024-10-05 10:15
Analyst(s) : GR (JW)

Concentration	Dead	Impaired	pH	Dissolved O_2	Conductivity	Temperature
100%	0	0	–	–	–	15
Control	0	0	–	–	–	15

Notes:

96 HOURS

Date & Time 2024-10-06 9:05
Analyst(s) : GR (JW)

Concentration	Dead	Impaired	pH	Dissolved O_2	Conductivity	Temperature
100%	0	0	8.5	9.4	1748	15
Control	0	0	8.4	9.0	736	15

Notes:

"–" = not measured/not required

Number impaired does not include number dead.

[3] adjusted for temperature and barometric pressure

Test Data Reviewed By : JL
Date : 2024-10-08

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TOXICITY TEST REPORT

Daphnia magna
EPS 1/RM/14
Page 1 of 2

Work Order :	255999
Sample Number :	84248

SAMPLE IDENTIFICATION

Company :	LANXESS Canada Co./Cie	Sampling Date :	2024-10-01
Location :	Elmira ON	Sampling Time :	11:30
Substance :	GE 100124	Date Received :	2024-10-01
Sampling Method :	Grab	Time Received :	14:00
Sampled By :	A. Norris	Temperature at Receipt :	18 °C
Sample Description :	Clear, colourless	Date Tested :	2024-10-02

Test Method : Reference Method for Determining Acute Lethality of Effluents to *Daphnia magna* . Environment Canada EPS 1/RM/14 (Second Edition, December 2000, with February 2016 amendments).

48-HOUR TEST RESULTS

Substance	Effect	Value
Control	Mean Immobility	0.0 %
	Mean Mortality	0.0 %
100%	Mean Immobility	0.0 %
	Mean Mortality	0.0 %

The results reported relate only to the sample tested and as received.

TEST ORGANISM

Species :	*Daphnia magna*	Time to First Brood :	7.6 days
Organism Batch :	Dm24-18	Average Brood Size :	29.3
Culture Mortality :	4.3% (previous 7 days)		

TEST CONDITIONS

Sample Treatment :	None	Number of Replicates :	3
pH Adjustment :	None	Organisms per Replicate :	10
Pre-aeration Rate :	~30 mL/min/L	Organisms per Test Level :	30
Duration of Pre-Aeration :	0 minutes	Organism Loading Rate :	15.0 mL/organism
Test Aeration :	None	Impaired Control Organisms :	0.0%
Hardness Adjustment :	None	Test Method Deviation(s) :	None

REFERENCE TOXICANT DATA

Toxicant :	Sodium Chloride		
Date Tested :	2024-09-24	LC50 :	6.4 g/L
Organism Batch :	Dm24-18	95% Confidence Limits :	6.2 - 6.6 g/L
Analyst(s) :	JW, CGR, CQ, MK	Historical Mean LC50 :	6.3 g/L
Statistical Method :	Spearman-Kärber	Warning Limits (± 2SD) :	5.9 - 6.7 g/L

COMMENTS

- All test validity criteria as specified in the test method were satisfied.

Approved By : V. Carleton

Victoria (Tori) Carleton
I am approving this document
Nautilus Environmental
2024-10-20 17:37-04:00

Project Manager

Work Order : 255999
Sample Number : 84248

TEST DATA

	pH	Dissolved O_2 (mg/L)	Conductivity (µmhos/cm)	Temperature (°C)	O_2 Saturation (%)*	Hardness (as $CaCO_3$)
Initial Chemistry (100%) :	7.3	8.5	1441	20	99	590 mg/L

0 HOURS

Date & Time : 2024-10-02 10:10
Analyst(s) : MK (CGR)

Concentration (%)	Replicate	Dead	Immobile	pH	Dissolved O_2	Conductivity	Temperature	O_2 Saturation*	Hardness
100	A	0	0	7.3	8.5	1441	20	99	590
100	B	0	0	7.3	8.5	1441	20	99	590
100	C	0	0	7.3	8.5	1441	20	99	590
Control	A	0	0	8.3	8.7	510	21	100	150
Control	B	0	0	8.3	8.7	510	21	100	150
Control	C	0	0	8.3	8.7	510	21	100	150

Notes:

24 HOURS

Date & Time : 2024-10-03 9:50
Analyst(s) : GR (CGR)

Concentration (%)	Replicate	Dead	Immobile	pH	Dissolved O_2	Conductivity	Temperature
100	A	–	1	–	–	–	20
100	B	–	0	–	–	–	20
100	C	–	0	–	–	–	20
Control	A	–	0	–	–	–	20
Control	B	–	0	–	–	–	20
Control	C	–	0	–	–	–	20

Notes:

48 HOURS

Date & Time : 2024-10-04 10:15
Analyst(s) : MK (JGR)

Concentration (%)	Replicate	Dead	Immobile	pH	Dissolved O_2	Conductivity	Temperature
100	A	0	0	8.4	8.5	1407	20
100	B	0	0	8.4	8.5	1413	20
100	C	0	0	8.4	8.5	1406	20
Control	A	0	0	8.3	8.6	514	20
Control	B	0	0	8.3	8.5	514	20
Control	C	0	0	8.3	8.5	512	20

Notes:

Number immobile does not include number dead.

"–" = not measured/not required
* adjusted for temperature and barometric pressure

Test Data Reviewed By : JJ
Date : 2024-10-09

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TOXICITY TEST REPORT

Rainbow Trout
EPS 1/RM/13
Page 1 of 2

Work Order :	255999
Sample Number :	84248

SAMPLE IDENTIFICATION

Company :	LANXESS Canada Co./Cie	Sampling Date :	2024-10-01
Location :	Elmira ON	Sampling Time :	11:30
Substance :	GE 100124	Date Received :	2024-10-01
Sampling Method :	Grab	Time Received :	14:00
Sampled By :	A. Norris	Temperature at Receipt :	18 °C
Sample Description :	Clear, colourless	Date Tested :	2024-10-02

Test Method(s) : Reference Method for Determining Acute Lethality of Liquid Effluents to Rainbow Trout. Environment Canada, EPS 1/RM/13 (2nd Edition, December 2000, with May 2007, February 2016, and December 2023 amendments).

96-HOUR TEST RESULTS

Substance	Effect	Value
Control	Mean Impairment	0.0 %
	Mean Mortality	0.0 %
100%	Mean Impairment	0.0 %
	Mean Mortality	0.0 %

The results reported relate only to the sample tested and as received.

TEST ORGANISM

Test Organism :	*Oncorhynchus mykiss*	Mean Fork Length :	40.4 mm
Organism Batch :	T24-10	Range of Fork Lengths :	36 - 46 mm
Control Sample Size :	10	Mean Wet Weight :	0.6 g
Cumulative stock mortality rate :	0% (previous 7 days)	Organism Loading Rate :	0.3 g/L
Control organisms showing stress :	0 (at test completion)		

TEST CONDITIONS

Test Type :	Single concentration	Number of Replicates :	1
Sample pH Adjustment :	None	Organisms Per Replicate :	10
Sample Pre-aeration/Aeration Rate :	6.5 ± 1 mL/min/L	Organisms Per Test Level :	10
Duration of Sample Pre-Aeration :	30 minutes	Volume of Sample :	17 L
Control Pre-aeration/Aeration Rate :	6.5 ± 1 mL/min/L	Volume of Control :	18 L
Duration of Control Pre-aeration:	30 minutes	Test Method Deviation(s) :	None

REFERENCE TOXICANT DATA

Toxicant :	Potassium Chloride		
Organism Batch :	T24-20	LC50 :	3381 mg/L
Date Tested :	2024-10-01	95% Confidence Limits :	2880 - 3923 mg/L
Analyst(s) :	AJS, NWP, JGR, GR	Historical Mean LC50 :	3580 mg/L
Statistical Method :	Linear Regression (MLE)	Warning Limits (± 2SD) :	2572 - 4982 mg/L

COMMENTS

- All test validity criteria as specified in the test method were satisfied.

Approved By : V.Carleton

Victoria (Tori) Carleton
I am approving this document
Nautilus Environmental
2024-10-20 17:37-04:00

Project Manager

Work Order : 255999
Sample Number : 84248

TEST DATA

	pH	Dissolved O_2 (mg/L)	Conductivity (µmhos/cm)	Temperature (°C)	O_2 Saturation (%)[3]
Initial Water Chemistry (100%) :	7.0	8.7	1356	15	92
After 30 min pre-aeration :	7.1	9.0	1352	15	95

0 HOURS

Date & Time 2024-10-02 10:05
Analyst(s) : NWP

Concentration	Dead	Impaired	pH	Dissolved O_2	Conductivity	Temperature	O_2 Saturation[3]
100%	0	0	7.1	9.0	1352	15	95
Control	0	0	8.2	9.6	782	15	100

Notes:

24 HOURS

Date & Time 2024-10-03 10:15
Analyst(s) : JGR

Concentration	Dead	Impaired	pH	Dissolved O_2	Conductivity	Temperature
100%	0	0	–	–	–	15
Control	0	0	–	–	–	15

Notes:

48 HOURS

Date & Time 2024-10-04 10:50
Analyst(s) : NWP

Concentration	Dead	Impaired	pH	Dissolved O_2	Conductivity	Temperature
100%	0	0	–	–	–	15
Control	0	0	–	–	–	15

Notes:

72 HOURS

Date & Time 2024-10-05 10:15
Analyst(s) : GR (JW)

Concentration	Dead	Impaired	pH	Dissolved O_2	Conductivity	Temperature
100%	0	0	–	–	–	15
Control	0	0	–	–	–	15

Notes:

96 HOURS

Date & Time 2024-10-06 9:10
Analyst(s) : GR (JW)

Concentration	Dead	Impaired	pH	Dissolved O_2	Conductivity	Temperature
100%	0	0	8.5	9.3	1326	15
Control	0	0	8.4	9.0	736	15

Notes:

"–" = not measured/not required

Number impaired does not include number dead.

[3] adjusted for temperature and barometric pressure

Test Data Reviewed By : JL
Date : 2024-10-08

CHAIN OF CUSTODY RECORD

AQUATOX

AquaTox Work Order No: 255999

P.O. Number:	9000003378
Field Sampler Name (print):	Allan Norris
Signature:	
Affiliation:	LANXESS CANADA
Sample Storage (prior to shipping):	ICE PACK
Custody Relinquished by:	
Date/Time Shipped:	OCT 1/24, 13:00

Shipping Address: AquaTox Testing & Consulting Inc.
B-11 Nicholas Beaver Road
Puslinch, Ontario Canada N0B 2J0

Voice: (519) 763-4412 **Fax:** (519) 763-4419

Client:	LANXESS CANADA CO./CIE 25 ERB ST ELMIRA ON N3B 2J3
Phone:	519 669 1671 x221
Fax:	519 669 3273
Contact:	MICHELLE YANTZI

Sample Identification					Analyses Requested										Sample Method and Volume		
Date Collected (yyyy-mm-dd)	Time Collected (e.g. 14:30, 24 hr clock)	Sample Name	AquaTox Sample Number	Temp on arrival	Rainbow Trout Single Concentration	Rainbow Trout LC50	*Daphnia magna* Single Concentration	*Daphnia magna* LC50	Fathead Minnow Survival & Growth	*Ceriodaphnia dubia* Survival & Reproduction	*Lemna minor* Growth	*Pseudokirchneriella subcapitata* Growth	Other (please specify below)	Grab	Composite	# of Containers and Volume (eg. 2 x 1L, 3 x 10L, etc.)
2024-10-01	11:00	SFE 100124	84247	18°C	✓		✓							✓		1 x 20L
2024-10-01	11:30	GE 100124	84248	18°C	✓		✓							✓		1 x 20L

For Lab Use Only

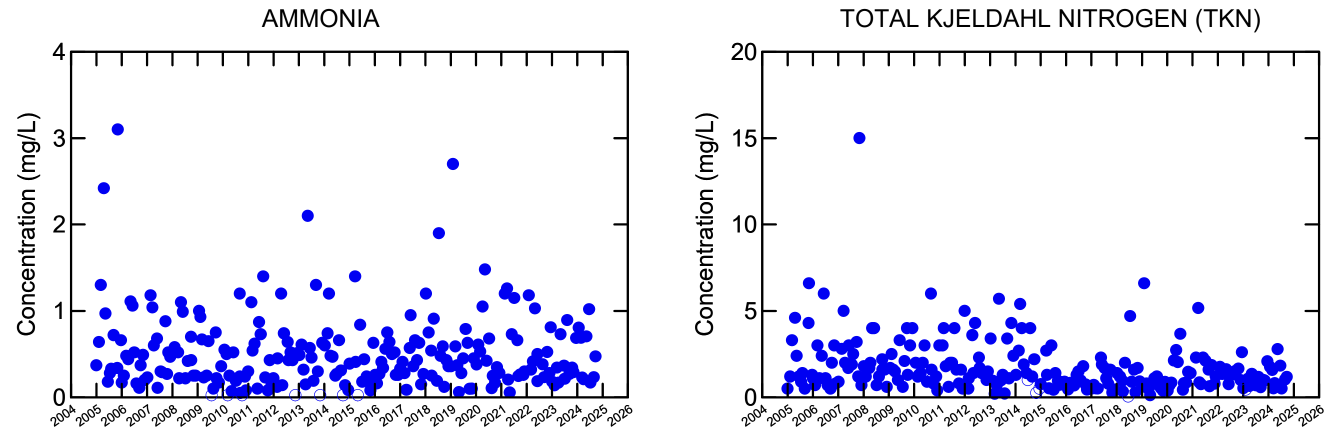
Received By:	JW / MK
Date:	2024-10-01
Time:	14:00
Storage Location:	
Storage Temp.(°C):	

Please list any special requests or instructions:

ACUTE TOXICITY

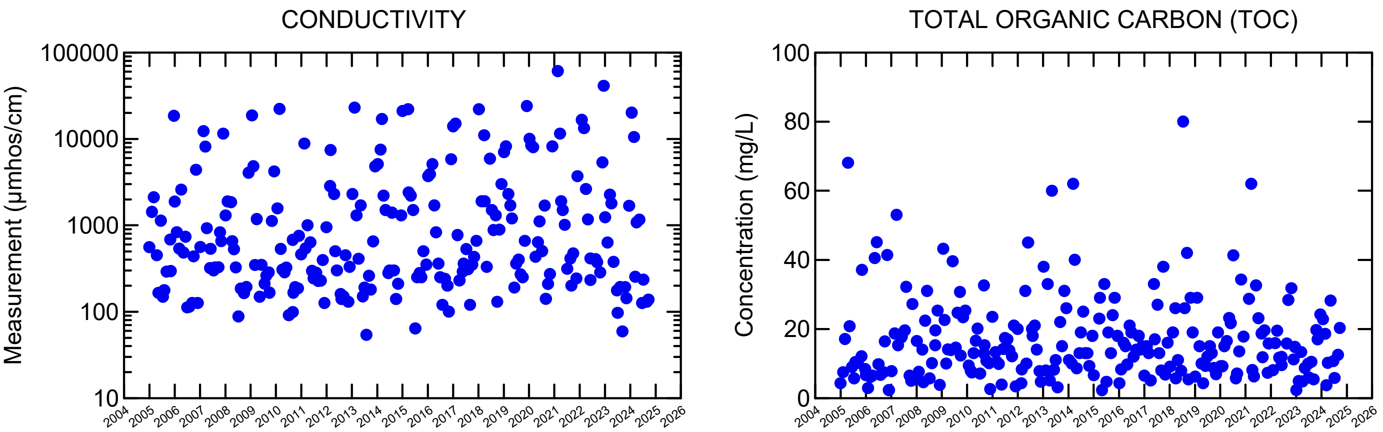
Attachment B

EAB Data



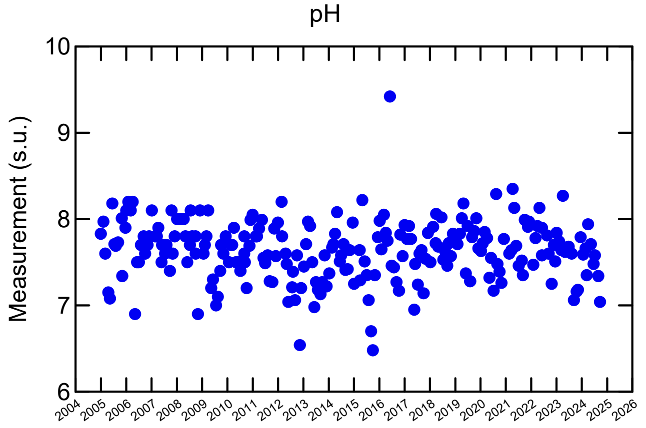
Trend: No Trend Identified

Trend: Decreasing



Trend: No Trend Identified

Trend: No Trend Identified



Trend: No Trend Identified

Legend:

● Detected Result

○ Non-detect
(plotted at one half the detection limit)

Notes:
Any detection limits elevated above target detection limit and/or detected values were not included in the trend analysis.
No Trend: trend analysis did not detect a significant trend above 95 percent confidence.

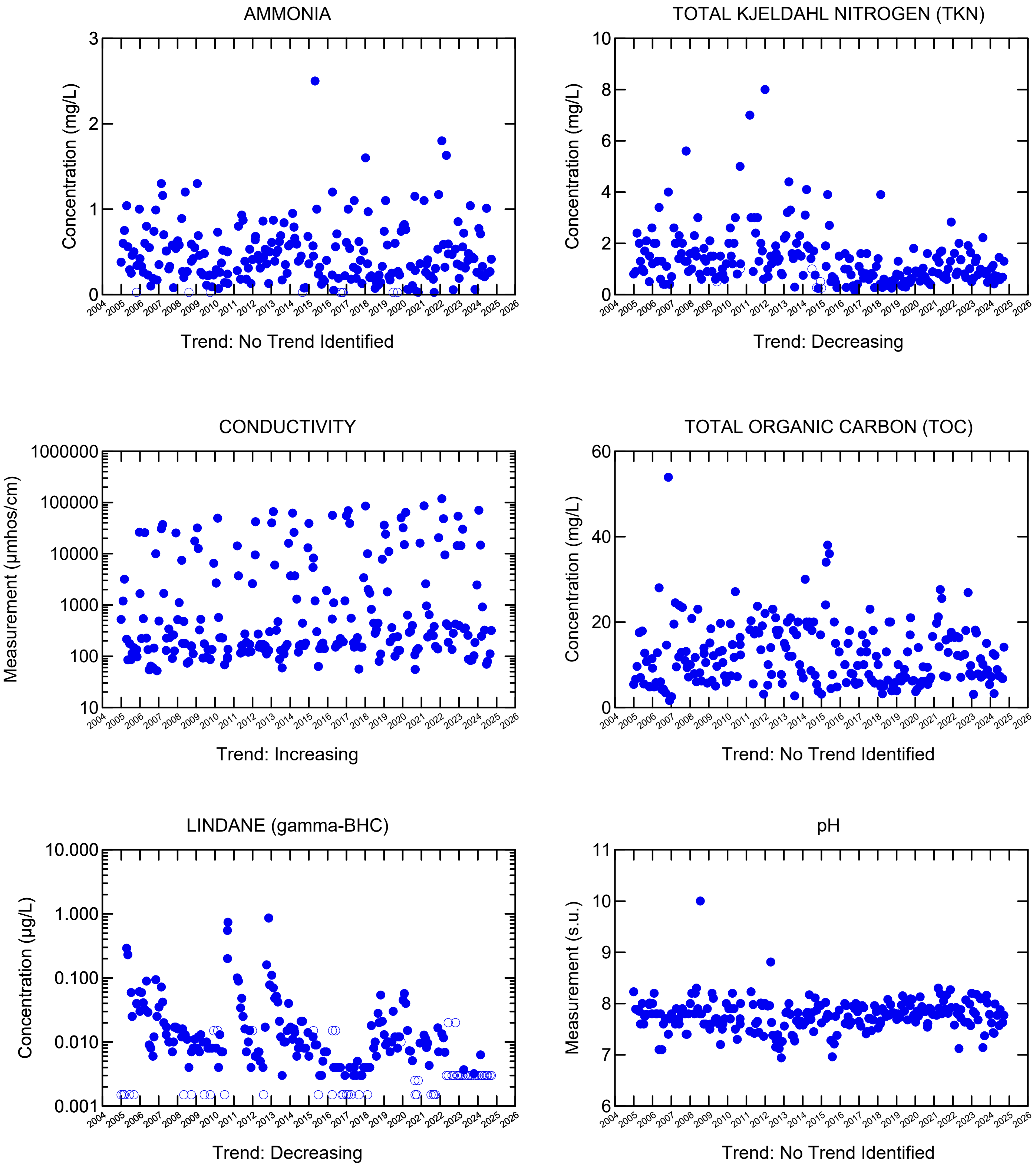
GHD

LANXESS Canada Co./Cie
Elmira, Ontario

ANALYTE CONCENTRATION vs. TIME
STORM WATER OUTFALL 0200

Project No. **11192137-38**
Date: **Oct 25, 2024**

FIGURE B.1



Legend:

- ● Detected Result
- ○ Non-detect (plotted at one half the detection limit)

Notes:

Any detection limits elevated above target detection limit and/or detected values were not included in the trend analysis.

No Trend: trend analysis did not detect a significant trend above 95 percent confidence.

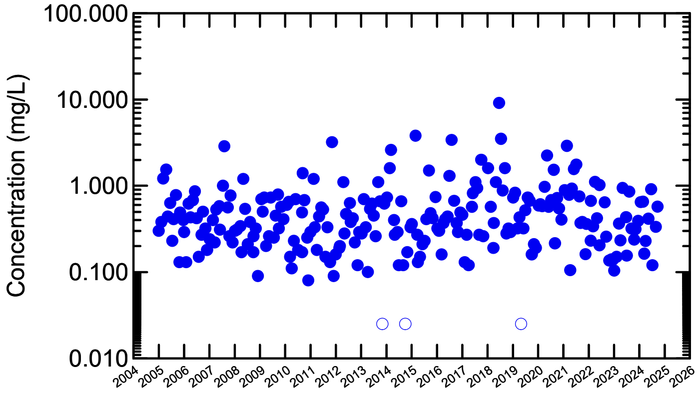
LANXESS Canada Co./Cie
Elmira, Ontario

ANALYTE CONCENTRATION vs. TIME
STORM WATER OUTFALL 0400

Project No. **11192137-38**
Date: **Oct 25, 2024**

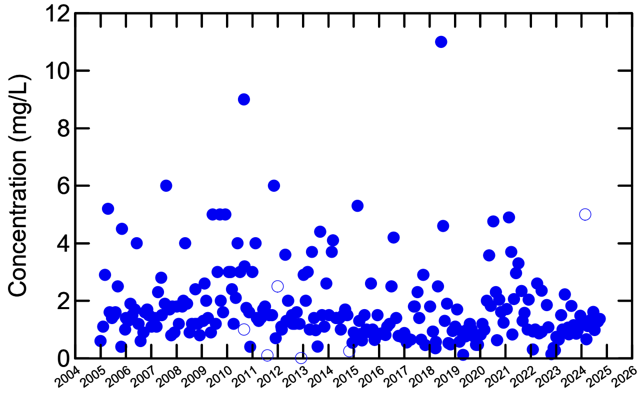
FIGURE B.2

AMMONIA



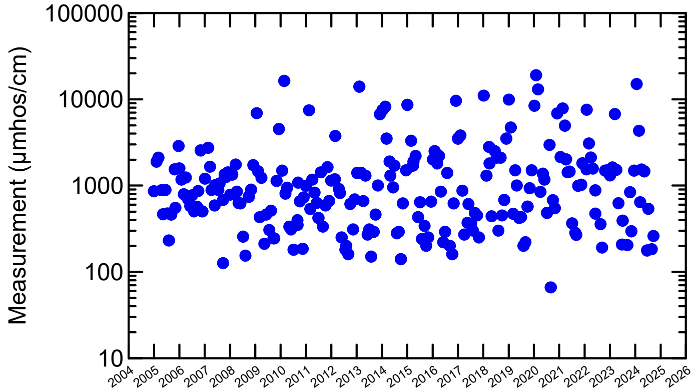
Trend: No Trend Identified

TOTAL KJELDAHL NITROGEN (TKN)



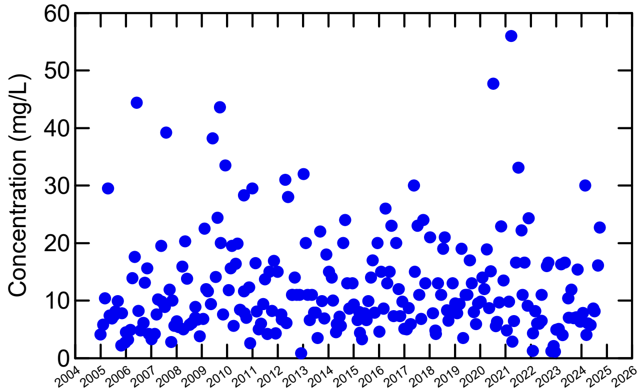
Trend: Decreasing

CONDUCTIVITY



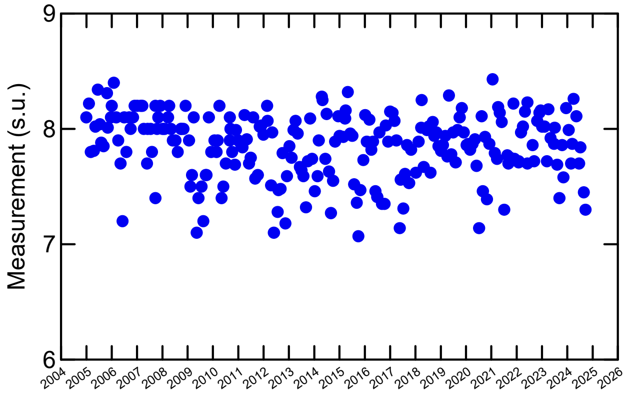
Trend: No Trend Identified

TOTAL ORGANIC CARBON (TOC)



Trend: No Trend Identified

pH



Trend: No Trend Identified

Legend:

● Detected Result

○ Non-detect
(plotted at one half the detection limit)

Notes:

Any detection limits elevated above target detection limit and/or detected values were not included in the trend analysis.

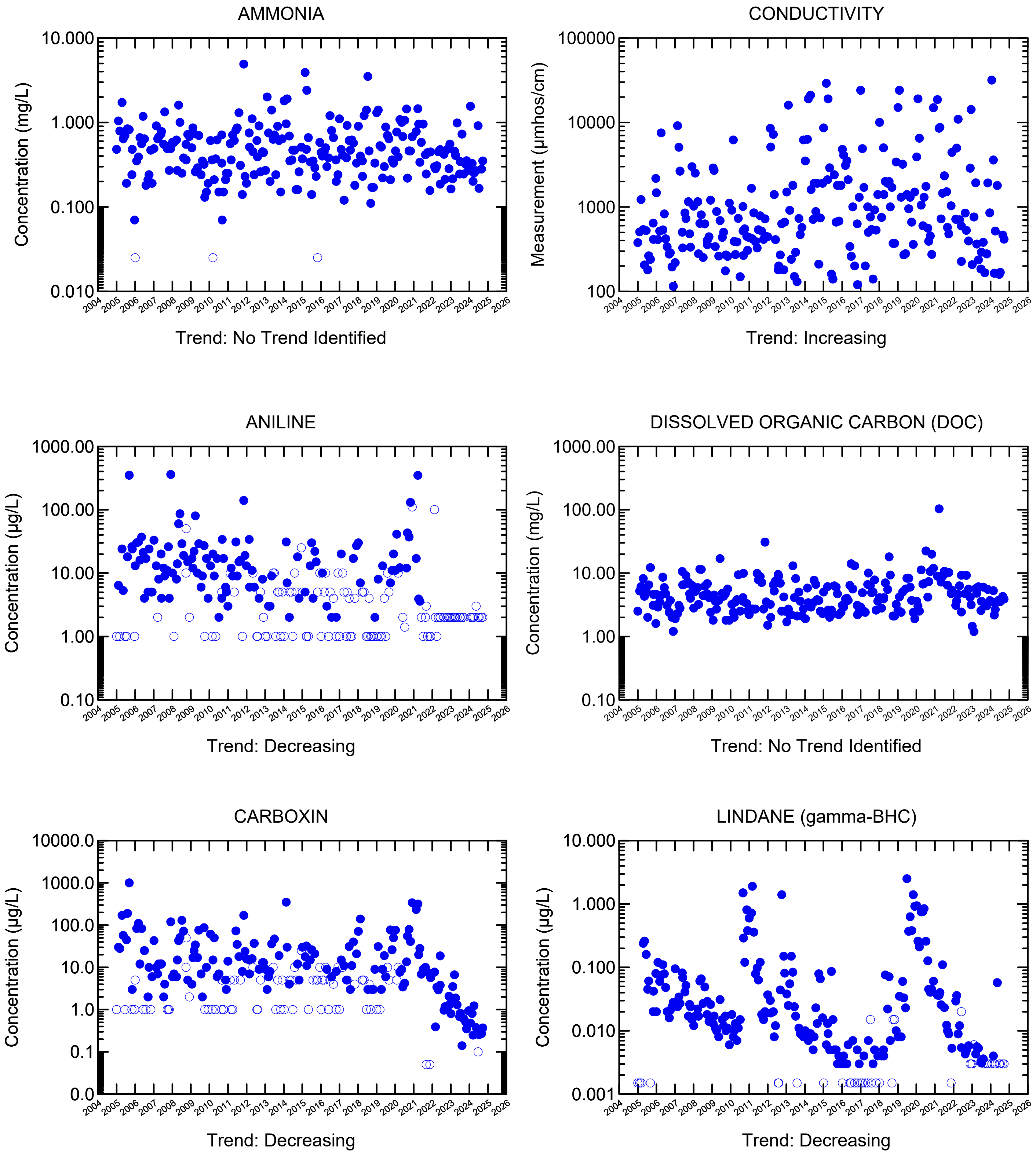
No Trend: trend analysis did not detect a significant trend above 95 percent confidence.

LANXESS Canada Co./Cie
Elmira, Ontario

ANALYTE CONCENTRATION vs. TIME
STORM WATER OUTFALL 0800

Project No. **11192137-38**
Date: **Oct 25, 2024**

FIGURE B.3



Legend:

- ● Detected Result
- ○ Non-detect
  (plotted at one half the detection limit)

Notes:

Any detection limits elevated above target detection limit and/or detected values were not included in the trend analysis.

No Trend: trend analysis did not detect a significant trend above 95 percent confidence.

GHD

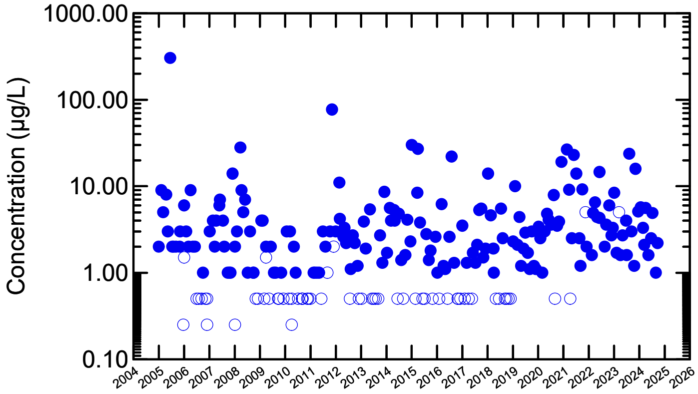
LANXESS Canada Co./Cie
Elmira, Ontario

ANALYTE CONCENTRATION vs. TIME
STORM WATER SEWER

Project No. **11192137-38**
Date: **Oct 25, 2024**

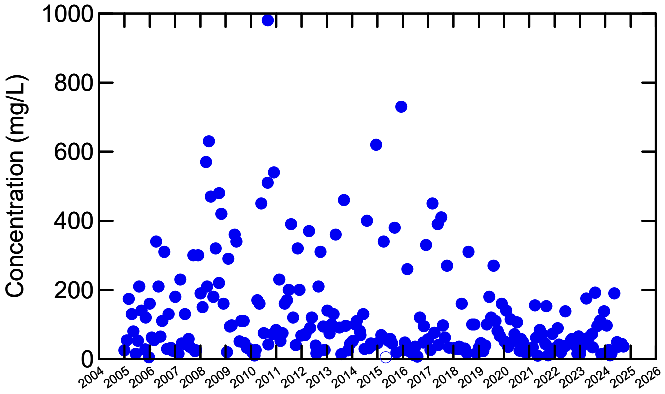
FIGURE B.4

PHENOLICS (TOTAL)



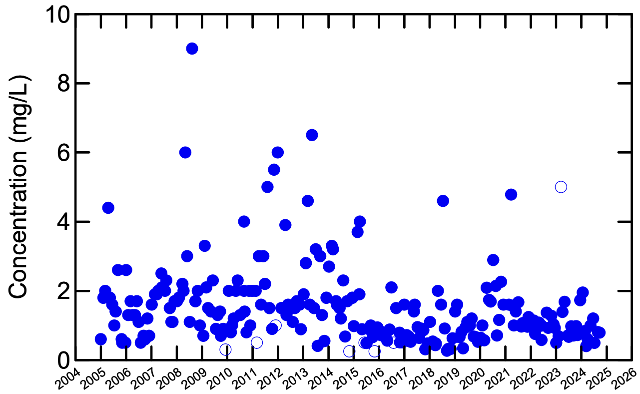
Trend: Increasing

TOTAL SUSPENDED SOLIDS (TSS)



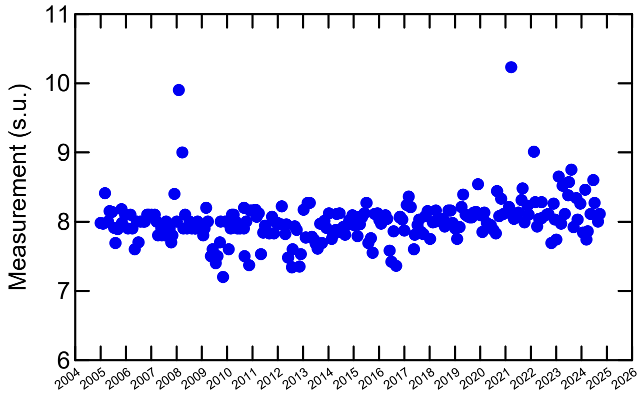
Trend: Decreasing

TOTAL KJELDAHL NITROGEN (TKN)



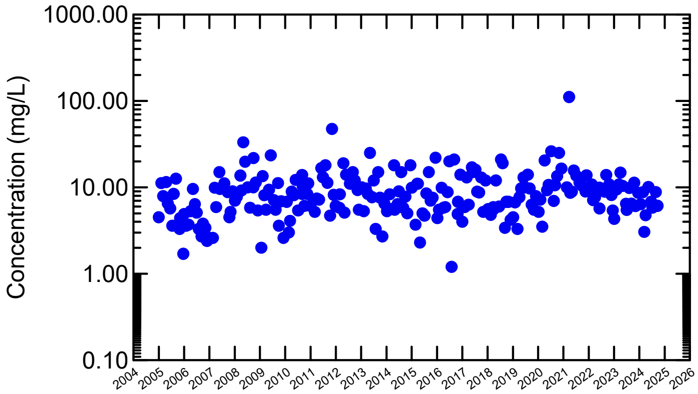
Trend: Decreasing

pH



Trend: Increasing

TOTAL ORGANIC CARBON (TOC)



Trend: Increasing

Legend:

● Detected Result
○ Non-detect
(plotted at one half the detection limit)

Notes:
Any detection limits elevated above target detection limit and/or detected values were not included in the trend analysis.
No Trend: trend analysis did not detect a significant trend above 95 percent confidence.

GHD

LANXESS Canada Co./Cie
Elmira, Ontario

ANALYTE CONCENTRATION vs. TIME
STORM WATER SEWER

Project No. **11192137-38**
Date: **Oct 25, 2024**

FIGURE B.5

Table B.1

Environmental Appeal Board (EAB)
Analytical Results - September 2024
LANXESS Canada Co./Cie
Elmira, Ontario

Sample Location:		**Storm Water Sewer**	**Storm Water Outfall 0200**	**Storm Water Outfall 0400**	**Storm Water Outfall 0800**
Sample ID:		**SWS 092324**	**0200 092324**	**0400 092324**	**0800 092324**
Sample Date:		**9/23/2024**	**9/23/2024**	**9/23/2024**	**9/23/2024**
Parameters	**Units**				
General Chemistry					
Ammonia-N	mg/L	0.350	0.474	0.414	0.572
Conductivity	umhos/cm	415	138	317	260
Cyanide (total)	mg/L	ND(0.0020)	ND(0.0020)	0.0048	ND(0.0020)
Dissolved organic carbon (DOC) (dissolved)	mg/L	3.89	--	--	--
pH, lab	s.u.	8.11	7.04	7.77	7.30
Phenolics (total)	mg/L	0.0022	--	--	--
Sulfide	mg/L	0.033	0.024	ND(0.018)	ND(0.018)
Total kjeldahl nitrogen (TKN)	mg/L	0.791	1.18	1.30	1.37
Total organic carbon (TOC)	mg/L	6.11	20.3	14.1	22.7
Total suspended solids (TSS)	mg/L	36.2	--	--	--
Herbicides					
2,4,5-TP (Silvex)	µg/L	ND(0.500)	ND(1.00)	ND(1.00)	ND(1.00)
2,4-DB	µg/L	ND(0.500)	ND(1.00)	ND(1.00)	ND(1.00)
2,4-Dichlorophenoxyacetic acid (2,4-D)	µg/L	ND(0.500)	ND(1.00)	ND(1.00)	ND(1.00)
Pesticides					
gamma-BHC (lindane)	µg/L	ND(0.0030)	ND(0.0030)	ND(0.0030)	ND(0.0030)
Semi-Volatiles					
2-Mercaptobenzothiazole	µg/L	ND(20)	ND(20)	ND(20)	ND(20)
Aniline	µg/L	ND(2.0)	ND(2.0)	ND(2.0)	ND(2.0)
Benzothiazole	µg/L	ND(2.0)	ND(2.0)	ND(2.0)	ND(2.0)
Carboxin	µg/L	0.368	ND(0.100)	ND(0.100)	ND(0.100)
N-Nitrosodiethylamine	µg/L	ND(0.06)	ND(0.06)	ND(0.06)	ND(0.06)
N-Nitrosodimethylamine	µg/L	ND(0.01)	ND(0.01)	ND(0.01)	ND(0.01)
N-Nitrosodi-n-butylamine	µg/L	ND(0.06)	ND(0.06)	ND(0.06)	ND(0.06)
N-Nitrosodiphenylamine	µg/L	ND(1.0)	ND(1.0)	ND(1.0)	ND(1.0)
N-Nitrosodiphenylamine + Diphenylamine	µg/L	ND(0.40)	ND(0.40)	ND(0.40)	ND(0.40)
Nitrosomorpholine	µg/L	ND(0.06)	ND(0.06)	ND(0.06)	ND(0.06)
Volatiles					
4-Methyl-2-pentanone (Methyl isobutyl ketone) (MIBK)	µg/L	ND(20)	ND(20)	ND(20)	ND(20)
Ethylbenzene	µg/L	ND(0.20)	ND(0.20)	ND(0.20)	ND(0.20)
m&p-Xylenes	µg/L	ND(0.40)	ND(0.40)	ND(0.40)	ND(0.40)
o-Xylene	µg/L	ND(0.20)	ND(0.20)	ND(0.20)	ND(0.20)
Toluene	µg/L	ND(0.20)	0.43	ND(0.20)	0.53
Misc					
Oil and grease	mg/L	ND(5.0)	--	--	--

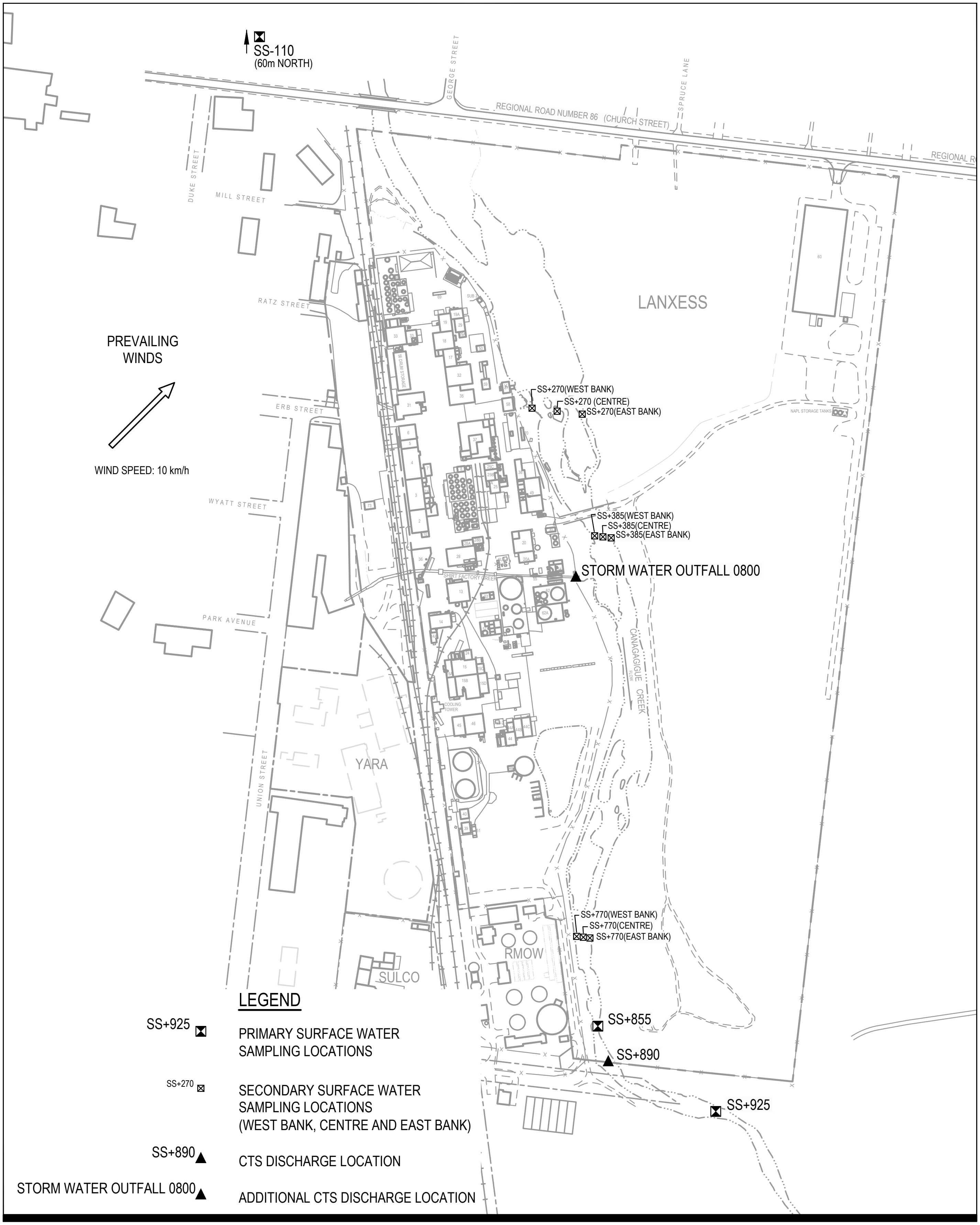
Notes:

ND(RDL)	Not detected at the associated reporting detection limit.
--	The parameter was not analyzed for.

Attachment C

Analytical Results

Surface Water Monitoring Program



LEGEND

SS+925 ☒	PRIMARY SURFACE WATER SAMPLING LOCATIONS
SS+270 ☒	SECONDARY SURFACE WATER SAMPLING LOCATIONS (WEST BANK, CENTRE AND EAST BANK)
SS+890 ▲	CTS DISCHARGE LOCATION
STORM WATER OUTFALL 0800 ▲	ADDITIONAL CTS DISCHARGE LOCATION

0 50 100 150m

Coordinate System:
UTM NAD 27

N

LANXESS CANADA CO./CIE
ELMIRA, ONTARIO

Project No. **11192137**
Date **October 2024**

SURFACE WATER SAMPLING LOCATIONS
OCTOBER 18, 2024

FIGURE C.1

Filename: N:\CA\Waterloo\Projects\662\11192137\Digital_Design\ACAD 2020\Figures\LTR-GEMP2024OCTOBER-DIR061\11192137-GHD-00-00-LTR-EN-D113_WA-GEMP2024OCTOBER-DIR061.dwg
Plot Date: 30 October 2024 4:27 PM

Table C.1

Summary of Detected Compounds in Surface Water
October 2024 [1]
LANXESS Canada Co./Cie
Elmira, Ontario

				Sample Location	SS-110 (Upstream)	SS+270 (West)	SS+270 (Centre)	SS+270 (East)	SS+385 (West)	SS+385 (Centre)	SS+385 (East)	SS+770 (West)	SS+770 (Centre)	SS+770 (East)	SS+855	SS+925
Flow [2] = 340 L/s	Units	PWQO		ECA												
		Status	Value	Schd. E Criteria												
General Chemistry																
Alkalinity	mg/L				179	175	175	176	178	178	179	182	180	181	178/180	190
Ammonia as N	mg/L				0.0798	0.108	0.108	0.0976	0.120	0.0976	0.113	0.119	0.104	0.0893	0.0832/0.102	0.0963
Un-ionized Ammonia	mg/L	PWQO	0.020	0.016	0.0023	0.0024	0.0025	0.0023	0.0018	0.0018	0.0021	ND(0.0010)	ND(0.0010)	ND(0.0010)	ND(0.0010)/ND(0.0010)	ND(0.0010)
Temperature °C (Field)	°C				8.34	8.28	8.29	8.20	8.14	8.10	8.04	7.98	8.01	7.99	7.99	9.21
Conductivity (Field)	µmho/cm				512	509	506	508	509	510	509	551	548	540	543	793
pH (Field)	su	PWQO	6.5-8.5		8.27	8.14	8.17	8.18	7.97	8.07	8.08	7.55	7.60	7.73	7.46	6.79
Dissolved Oxygen (Field)	mg/L	PWQO	>7		12.11	11.40	10.73	11.19	11.15	11.34	11.53	10.80	11.10	10.75	11.35	10.50
Formaldehyde	µg/L	IPWQO	0.8		ND(2.0)	ND(2.0)	ND(2.0)	ND(2.0)	ND(2.0)	ND(2.0)	ND(2.0)	ND(2.0)	ND(2.0)	2.2	ND(2.0)/ND(2.0)	2.0
Total Phenols	mg/L	PWQO	0.001		0.0534	0.0039 U	0.0014 U	0.0061 U	0.0036 U	0.0166 U	0.0015 U	0.0087 U	0.0038 U	0.0024 U	0.0019 U/0.0022 U	0.0053 U
Total Phosphorus	mg/L				0.0912	0.0969	0.104	0.0929	0.0966	0.0978	0.117	0.0966	0.0943	0.111	0.0996/0.0996	0.0992
Remaining 1 General Chemistry Parameter Analyzed					ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Volatile Organic Compounds (VOCs)																
Toluene	µg/L	IPWQO	0.8	1.0	ND(0.20)	ND(0.20)	ND(0.20)	ND(0.20)	ND(0.20)	ND(0.20)	ND(0.20)	ND(0.20)	0.21	0.20	ND(0.20)/ND(0.20)	ND(0.20)
Remaining 7 VOCs Analyzed					ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Base, Neutral and Acid Extractable Compounds (BNAs)																
2-Chlorophenol	µg/L	PWQO	7	7.0	ND(0.30)	ND(0.30)	ND(0.30)	ND(0.30)	ND(0.30)	ND(0.30)	ND(0.30)	ND(0.30) UJ	ND(0.30) UJ	ND(0.30) UJ	ND(0.30) UJ/ND(0.30) UJ	ND(0.30) UJ
2-Mercaptobenzothiazole	µg/L			20	[3]	[3]	[3]	[3]	[3]	[3]	[3]	[3]	[3]	[3]	[3]	[3]
Benzothiazole	µg/L	IPWQO	100	4.0	[3]	[3]	[3]	[3]	[3]	[3]	[3]	[3]	[3]	[3]	[3]	[3]
N-Nitrosodiphenylamine (NDPhA)	µg/L	IPWQO	7		[3]	ND(1.0)	ND(1.0)	ND(1.0)	ND(1.0)	ND(1.0)	ND(1.0)	ND(1.0)	ND(1.0)	ND(1.0)	ND(1.0)/ND(1.0)	ND(1.0)
Phenol	µg/L	IPWQO	5	4.8	ND(0.50)	ND(0.50)	ND(0.50)	ND(0.50)	ND(0.50)	ND(0.55)	ND(0.50)	1.91	ND(0.50)	ND(0.50)	ND(0.50)/ND(0.50)	ND(0.50)
Remaining 16 BNAs Analyzed					ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Pesticides & Herbicides																
2,4,5-T	µg/L				[3]	[3]	[3]	[3]	[3]	[3]	[3]	[3]	[3]	[3]	[3]	ND(0.500)
Remaining 2 Pesticide and Herbicide Analyzed					ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND

Notes:

☐ Concentration greater than associated PWQO/IPWQO and/or Schedule E Criteria.
[1] Samples were collected on October 18, 2024. Winds were from the southwest at 10 km/h.
[2] Flow measurement was obtained from the Grand River Conservation Authority (GRCA) Elmira (Arthur Street) gauge.
[3] Due to instrumentation issues, results for 2-mercaptobenzothiazole, benzothiazole, NDPhA (SS-110 location only), and 2,4,5-T (all locations apart from SS+925) are delayed and will be reported in the November Progress Report.
L/s Litres per second.
RDL Reporting detection limit.
PWQO Provincial Water Quality Objective, MOE, February 1999.
IPWQO Interim Provincial Water Quality Objective, MOE, February 1999.
ND(RDL) Not detected at the associated reporting detection limit.
U The analyte was analyzed for, but was not detected above the level of the reported sample quantitation limit.
UJ The analyte was analyzed for, but was not detected. The reported quantitation limit is approximate and may be inaccurate or imprecise.
178/180 Duplicate sample.

Table C.2

Comparison of Schedule E Parameter Concentrations
at SS+925 and SS-110 Using Statistical Analyses
October 2021 to October 2024
LANXESS Canada Co./Cie
Elmira, Ontario

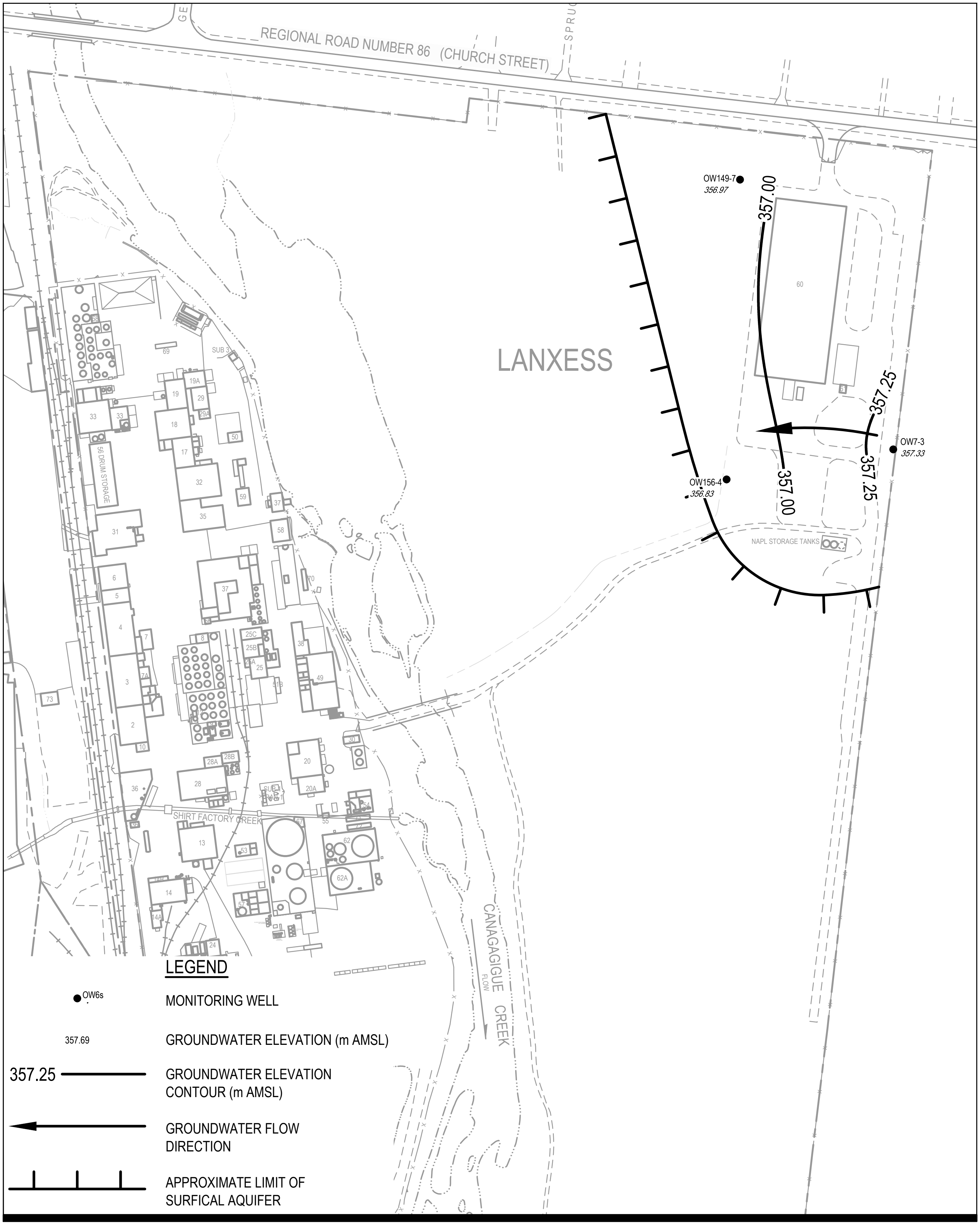
		SS+925					SS-110							
Parameter	**Units**	**Number of Samples**	**Arithmetic Mean (x)**	**Standard Deviation (s_x)**	**w_x (1)**	**t value (t_x) (2)**	**Number of Samples**	**Arithmetic Mean (y)**	**Standard Deviation (s_y)**	**w_y**	**t value (t_y) (2)**	**t* (3)**	**t_c (4) →**	**If t* >t_c, a significant difference is evident (5)**
Un-ionized Ammonia	µg/L	13	0.0009	0.0008	5.15E-08	2.650	13	0.0027	0.0020	2.93E-07	2.650	-3.132	2.650	
Acid Extractables														
2,3,4-Trichlorophenol	µg/L	13	0.2500	0.0000	0.00E+00	2.650	13	0.2500	0.0000	0.00E+00	2.650	(6)	(6)	
2,4,5-Trichlorophenol	µg/L	13	0.2154	0.0658	3.33E-04	2.650	13	0.2154	0.0658	3.33E-04	2.650	0.000	2.650	
2,4,6-Trichlorophenol	µg/L	13	0.2154	0.0658	3.33E-04	2.650	13	0.2154	0.0658	3.33E-04	2.650	0.000	2.650	
2,4-Dichlorophenol	µg/L	13	0.1385	0.0219	3.70E-05	2.650	13	0.1385	0.0219	3.70E-05	2.650	0.000	2.650	
2,6-Dichlorophenol	µg/L	13	0.2154	0.0658	3.33E-04	2.650	13	0.2154	0.0658	3.33E-04	2.650	0.000	2.650	
2-Chlorophenol	µg/L	13	0.1500	0.0000	0.00E+00	2.650	13	0.1500	0.0000	0.00E+00	2.650	(6)	(6)	
Phenol	µg/L	13	0.3412	0.3287	8.31E-03	2.650	13	0.8038	1.9969	3.07E-01	2.650	-0.824	2.650	
m/p-Cresol	µg/L	13	0.2500	0.0000	0.00E+00	2.650	13	0.2500	0.0000	0.00E+00	2.650	(6)	(6)	
o-Cresol	µg/L	13	0.2708	0.0749	4.31E-04	2.650	13	0.2808	0.1109	9.47E-04	2.650	-0.269	2.650	
Base/Neutral Extractables														
2-Mercaptobenzothiazole	µg/L	12	10.0000	0.0000	0.00E+00	2.681	12	10.0000	0.0000	0.00E+00	2.681	(6)	(6)	
Aniline	µg/L	11	1.0000	0.0000	0.00E+00	2.718	10	1.0000	0.0000	0.00E+00	2.764	(6)	(6)	
Benzothiazole	µg/L	12	1.0000	0.0000	0.00E+00	2.681	12	1.0000	0.0000	0.00E+00	2.681	(6)	(6)	
Carboxin	µg/L	13	0.0500	0.0000	0.00E+00	2.650	13	0.0500	0.0000	0.00E+00	2.650	(6)	(6)	
n-Nitrosodimethylamine (NDMA)	µg/L	13	0.0050	0.0000	0.00E+00	2.650	13	0.0050	0.0000	0.00E+00	2.650	(6)	(6)	
Nitrosomorpholine (NMOR)	µg/L	13	0.0300	0.0000	0.00E+00	2.650	13	0.0300	0.0000	0.00E+00	2.650	(6)	(6)	
bis(2-Ethylhexyl)phthalate	µg/L	13	0.4923	0.1754	2.37E-03	2.650	13	0.4923	0.1754	2.37E-03	2.650	0.000	2.650	
Pesticides														
Lindane (gamma-BHC)	µg/L	13	0.0015	0.0000	0.00E+00	2.650	13	0.0015	0.0000	0.00E+00	2.650	(6)	(6)	
Volatile Organic Compounds														
Benzene	µg/L	13	0.1000	0.0000	0.00E+00	2.650	13	0.1000	0.0000	0.00E+00	2.650	(6)	(6)	
Chlorobenzene	µg/L	13	0.1000	0.0000	0.00E+00	2.650	13	0.1000	0.0000	0.00E+00	2.650	(6)	(6)	
Ethylbenzene	µg/L	13	0.1000	0.0000	0.00E+00	2.650	13	0.1000	0.0000	0.00E+00	2.650	(6)	(6)	
Toluene	µg/L	13	0.1000	0.0000	0.00E+00	2.650	13	0.1000	0.0000	0.00E+00	2.650	(6)	(6)	
Trichloroethylene	µg/L	13	0.1000	0.0000	0.00E+00	2.650	13	0.1000	0.0000	0.00E+00	2.650	(6)	(6)	
m,p-Xylenes	µg/L	13	0.2000	0.0000	0.00E+00	2.650	13	0.2000	0.0000	0.00E+00	2.650	(6)	(6)	
o-Xylene	µg/L	13	0.1000	0.0000	0.00E+00	2.650	13	0.1000	0.0000	0.00E+00	2.650	(6)	(6)	

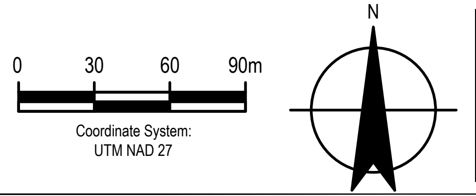
Notes:

(1) w = standard deviation/number of data points
(2) t-value at 99% confidence interval
(3) Difference of means defined as $(x-y)/(w_x+w_y)^{1/2}$
(4) Defined as $(w_x t_x + w_y t_y)/(w_x+w_y)$
(5) The statistical comparison method used was Cochran's Approximation to the Behrens Fisher t-Test (McBean, 1988). The merit of this procedure is that it does not have the restrictive assumptions that the typical t-Test does. In the typical t-Test, the variances of the data sets have to be statistically the same (they are allowed to deviate from one another, but only by an amount that is a function of the size of the data set). Cochran's test removes this assumption, and has been chosen as the method of analysis since the variances of the SS-110 and SS+855 sample sets for parameters such as lindane and toluene, are not similar.
(6) A statistical comparison test was not performed since none of the values were detected above the reporting detection limit for the specified parameter (detection frequency is 100 percent non detect).

Attachment D

Groundwater Elevation Monitoring Program





Coordinate System:
UTM NAD 27

LANXESS CANADA CO./CIE
ELMIRA, ONTARIO

Project No. **11192137**
Date **November 2024**

GROUNDWATER ELEVATION CONTOURS
SURFICIAL AQUIFER
OCTOBER 22, 2024

FIGURE D.1

Filename: N:\CA\Waterloo\Projects\662\11192137\Digital_Design\ACAD 2020\Figures\LTR-GEMP2024OCTOBER-DIR061\11192137-GHD-00-00-LTR-EN-D101_WA-GEMP2024OCTOBER-DIR061.dwg
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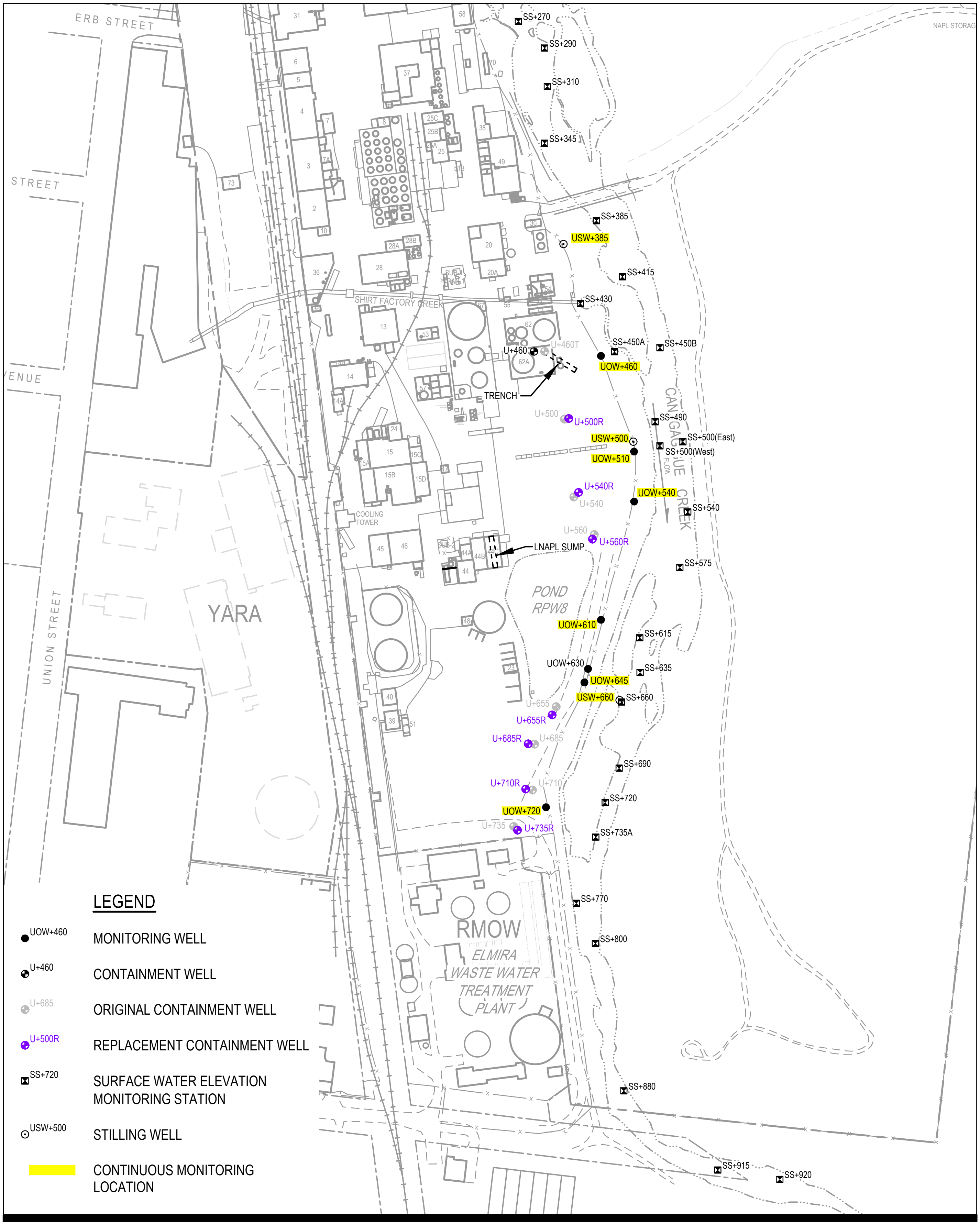

LEGEND

● UOW+460	MONITORING WELL
U+460	CONTAINMENT WELL
U+685	ORIGINAL CONTAINMENT WELL
U+500R	REPLACEMENT CONTAINMENT WELL
☒ SS+720	SURFACE WATER ELEVATION MONITORING STATION
⊙ USW+500	STILLING WELL
🟨	CONTINUOUS MONITORING LOCATION

0 30 60 90m

1:3000

Coordinate System:
UTM NAD 27

N

LANXESS CANADA CO./CIE
ELMIRA, ONTARIO

UPPER AQUIFER
CONTAINMENT SYSTEM

Project No. **11192137**
Date **October 2024**

FIGURE D.2

Filename: N:\CA\Waterloo\Projects\662\11192137\Digital_Design\ACAD 2020\Figures\LTR-GEMP2024OCTOBER-DIR061\11192137-GHD-00-00-LTR-EN-D102_WA-GEMP2024OCTOBER-DIR061.dwg
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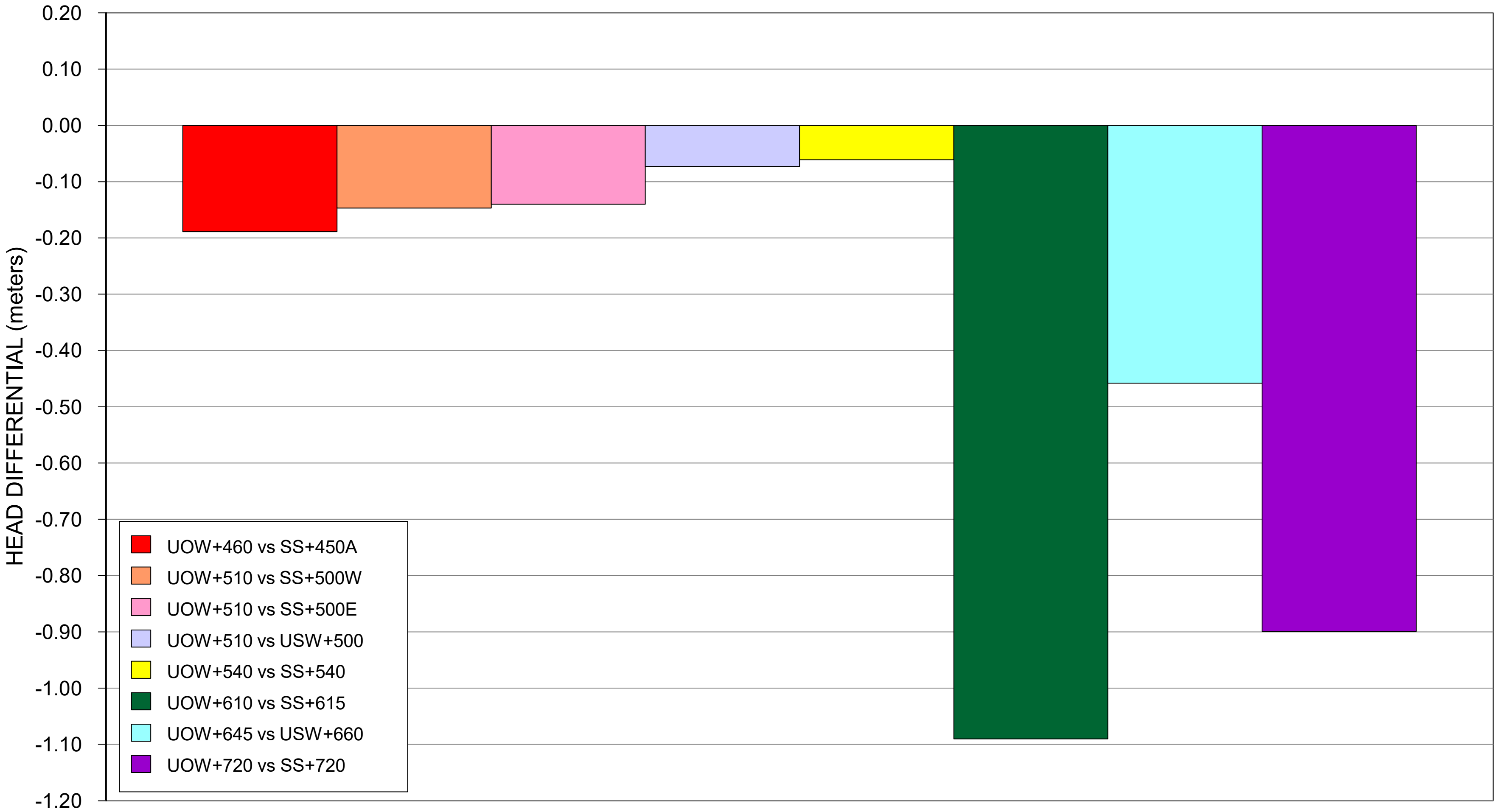


figure D.3

HEAD DIFFERENTIAL AT KEY MONITORING PAIRS - OCTOBER 22, 2024

UPPER AQUIFER CONTAINMENT SYSTEM

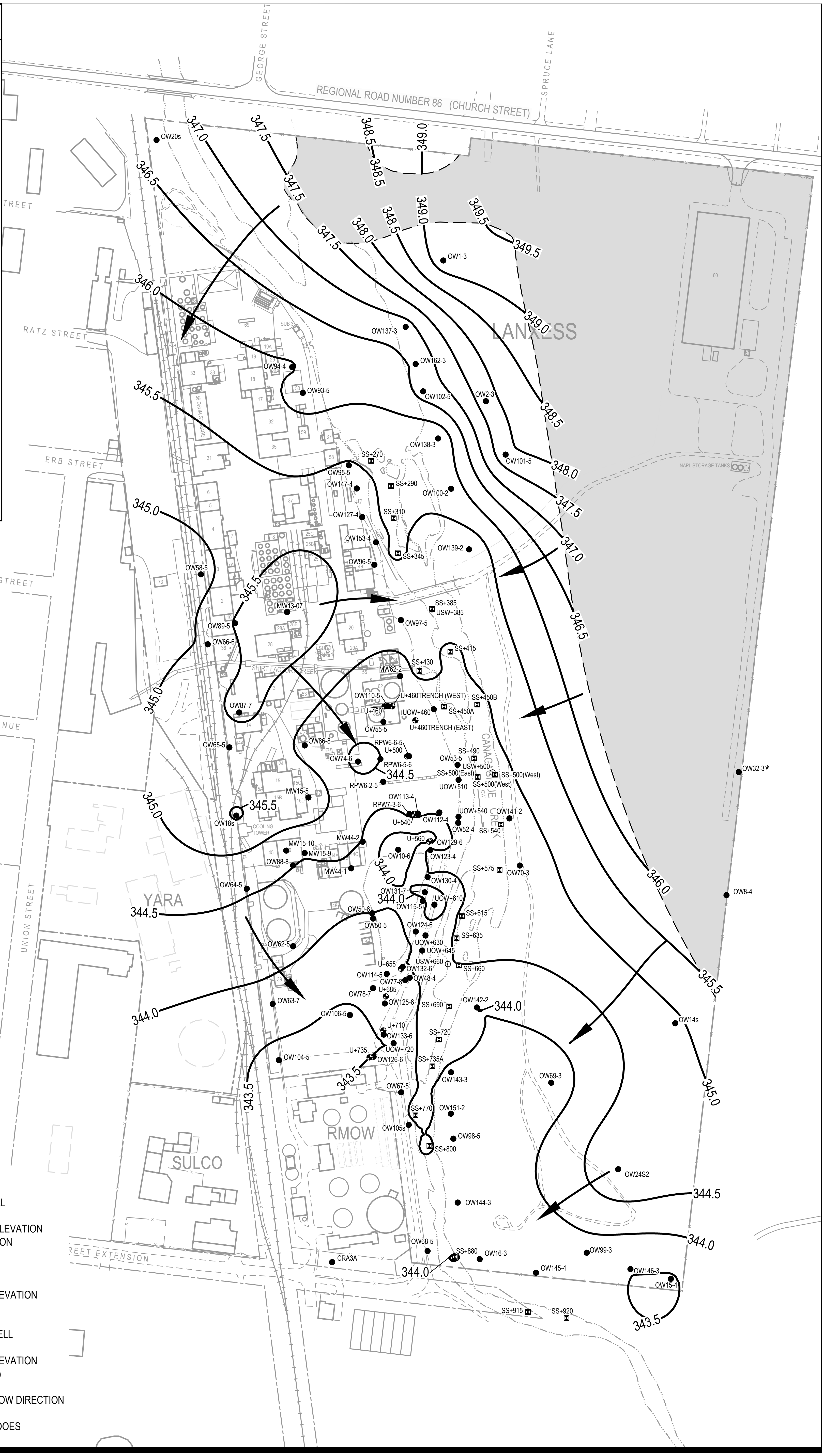
LANXESS CANADA CO./CIE

Elmira, Ontario

GHD

11192137(DIRE061)GIS-OT003 October 28, 2024

WELL ID	UA1 GROUNDWATER ELEVATION (m AMSL)	WELL ID	UA1 GROUNDWATER ELEVATION (m AMSL)
CRA3A	343.99	OW64-5	344.55
MW13-07	345.92	OW65-5	344.99
MW15-10	344.64	OW66-6	345.05
MW15-5	345.39	OW67-5	343.89
MW15-9	344.53	OW68-5	343.97
MW44-1	344.42	OW69-3	343.70
MW44-2	344.49	OW70-3	344.66
MW62-2	344.75	OW74-6	344.37
OW1-3	349.31	OW77-8	343.49
OW10-6	343.48	OW78-7	343.70
OW100-2	345.75	OW8-4	346.44
OW101-5	347.88	OW86-8	344.85
OW102-5	346.72	OW87-7	345.69
OW104-5	343.34	OW88-8	344.51
OW105s	343.88	OW89-5	345.54
OW106-5	343.40	OW93-5	346.24
OW110-5	344.49	OW94-4	345.96
OW112-4	344.55	OW95-5	345.46
OW113-4	344.61	OW96-5	345.40
OW114-5	343.53	OW97-5	345.14
OW115-5	344.24	OW98-5	343.74
OW123-4	344.70	OW99-3	343.84
OW124-6	344.11	RPW6-2-5	344.61
OW125-6	343.68	RPW6-5-6	344.50
OW126-6	343.51	RPW6-6-5	344.63
OW127-4	345.40	RPW7-3-6	344.57
OW129-6	343.69	SS+270	345.57
OW130-4	344.48	SS+290	345.57
OW131-7	343.60	SS+310	345.58
OW132-6	343.97	SS+345	345.56
OW133-6	343.54	SS+385	345.22
OW137-3	346.76	SS+415	344.94
OW138-3	345.52	SS+430	345.13
OW139-2	345.10	SS+450A	344.93
OW141-2	344.78	SS+450B	344.89
OW142-2	343.99	SS+490	344.87
OW143-3	343.84	SS+500(East)	344.86
OW144-3	343.86	SS+500(West)	344.87
OW145-4	343.56	SS+540	344.74
OW146-3	343.52	SS+575	344.85
OW147-4	345.41	SS+615	344.65
OW14s	344.91	SS+635	344.58
OW15-4	343.44	SS+660	344.49
OW151-2	343.85	SS+690	344.47
OW153-4	345.42	SS+720	344.39
OW16-3	343.84	SS+735A	344.20
OW162-3	346.57	SS+770	344.12
OW18s	345.57	SS+800	344.05
OW2-3	347.77	SS+880	344.01
OW20s	346.66	SS+915	344.00
OW24S2	345.02	SS+920	343.80
OW32-3	348.54	UOW+460	344.74
OW48-4	343.90	UOW+510	344.72
OW50-5	343.71	UOW+540	344.68
OW50-6	344.09	UOW+610	343.56
OW52-4	344.74	UOW+630	344.05
OW53-5	344.76	UOW+645	344.03
OW55-5	344.63	UOW+720	343.49
OW58-5	344.82	USW+385	345.23
OW62-5	344.13	USW+500	344.79
OW63-7	343.85	USW+660	344.49



LEGEND

● OW153-4	MONITORING WELL
⊕ U+460	CONTAINMENT WELL
⊠ SS+310	SURFACE WATER ELEVATION MONITORING STATION
⊙ USW+385	STILLING WELL
345.68	GROUNDWATER ELEVATION (m AMSL)
*	UA MONITORING WELL
345.0 ——	GROUNDWATER ELEVATION CONTOUR (m AMSL)
←——	GROUNDWATER FLOW DIRECTION
▨	AREA WHERE UA1 DOES NOT EXIST

0 30 60 90m

Coordinate System:
UTM NAD 27

N

LANXESS CANADA CO./CIE
ELMIRA, ONTARIO

GHD

GROUNDWATER ELEVATION CONTOURS
UA1 - OCTOBER 22, 2024

Project No. **11192137**
Date **November 2024**

FIGURE D.4

Filename: N:\CA\Waterloo\Projects\662\11192137\Digital_Design\ACAD 2020\Figures\LTR-GEMP2024OCTOBER-DIR061\11192137-GHD-00-00-LTR-EN-D104_WA-GEMP2024OCTOBER-DIR061.dwg
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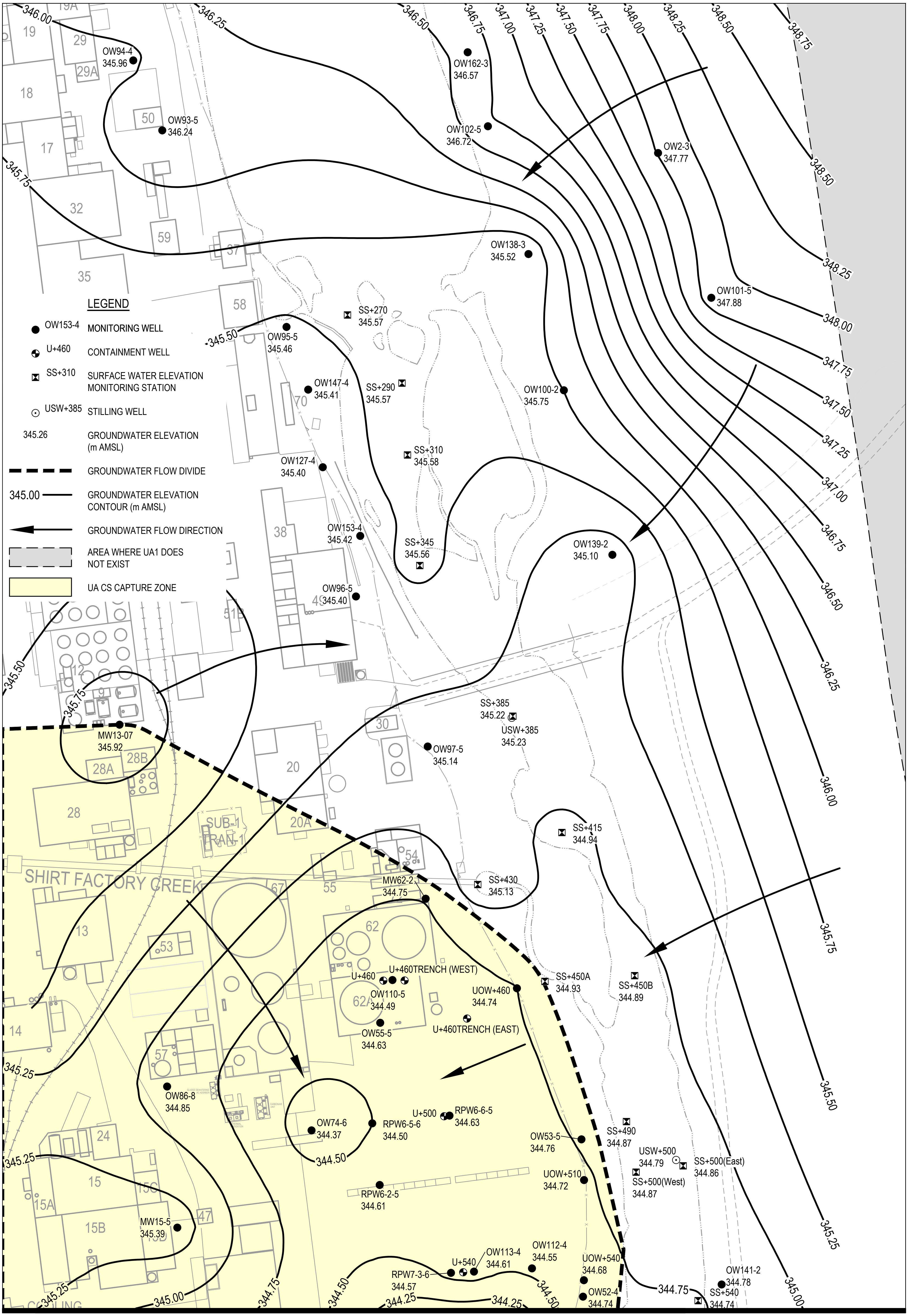

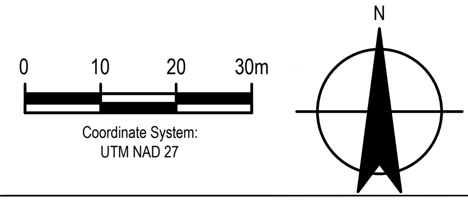

LANXESS CANADA CO./CIE
ELMIRA, ONTARIO

Project No. 11192137
Date November 2024

GHD

GROUNDWATER ELEVATION CONTOURS
UA1 - OCTOBER 22, 2024

FIGURE D.5

Filename: N:\CA\Waterloo\Projects\662\11192137\Digital_Design\ACAD 2020\Figures\LTR-GEMP2024OCTOBER-DIR061\11192137-GHD-00-00-LTR-EN-D105_WA-GEMP2024OCTOBER-DIR061.dwg
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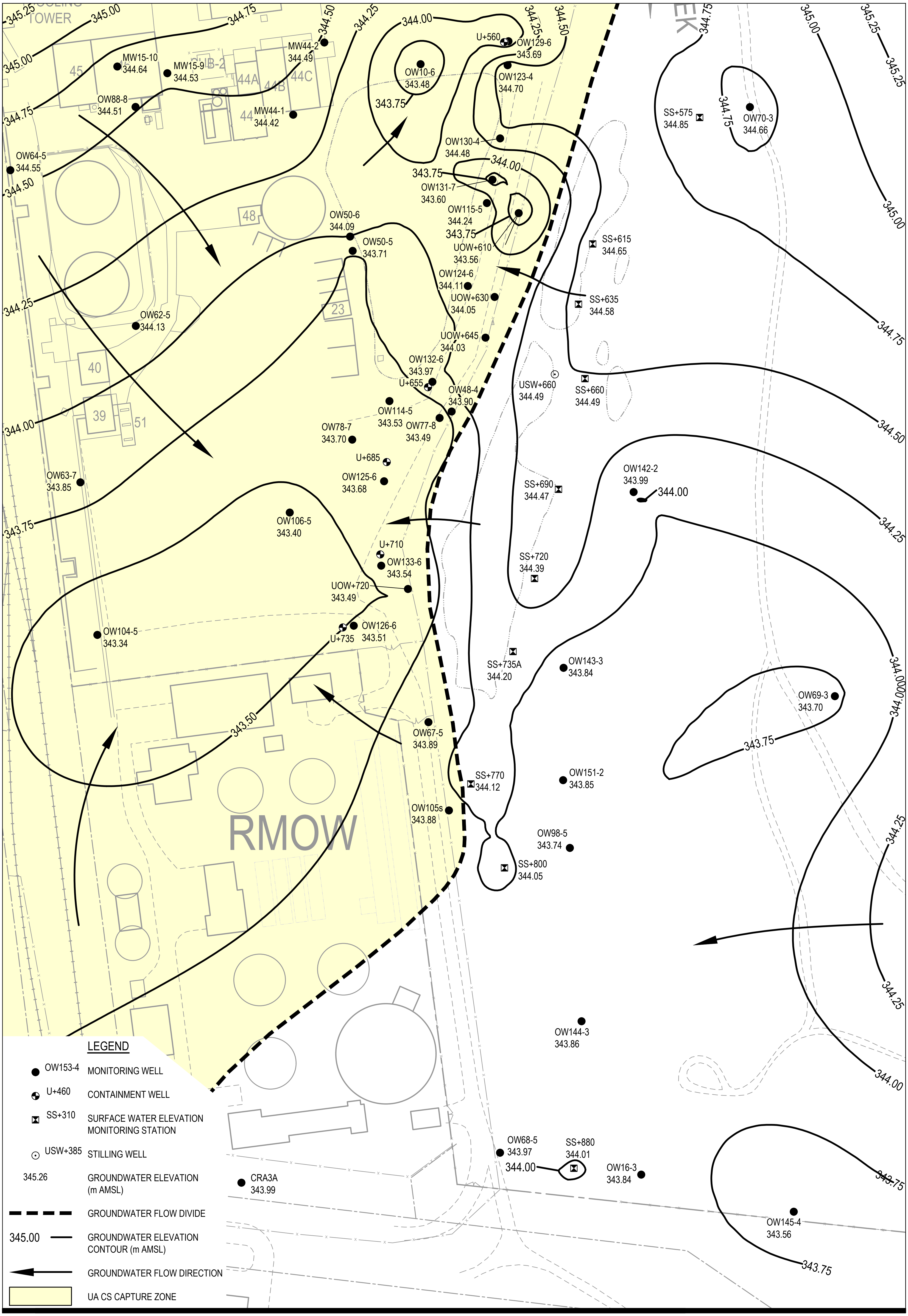
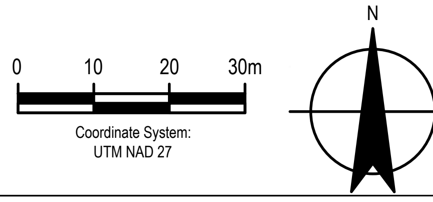


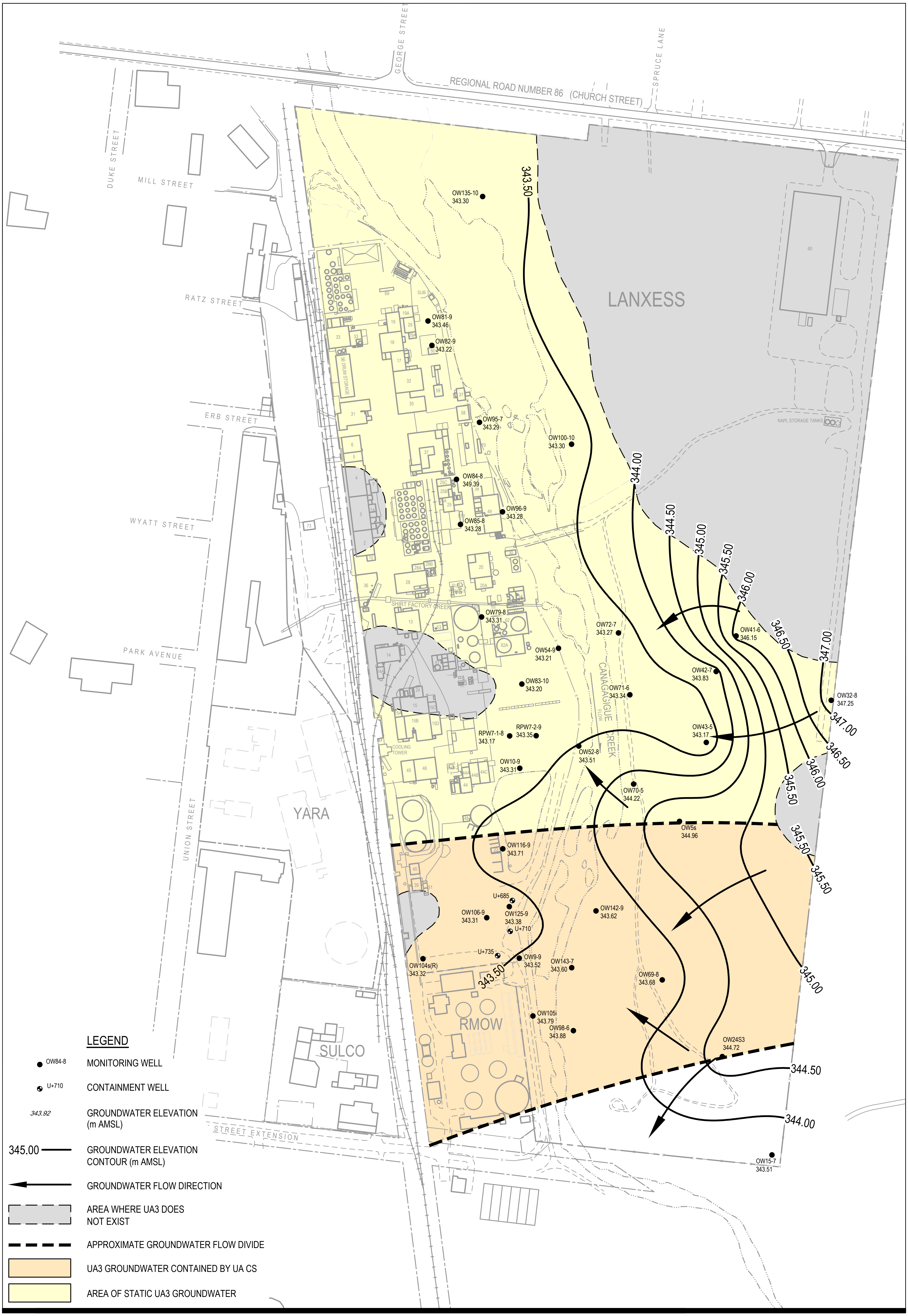


LANXESS CANADA CO./CIE
ELMIRA, ONTARIO

Project No. **11192137**
Date **November 2024**

GROUNDWATER ELEVATION CONTOURS
UA1 - OCTOBER 22, 2024

FIGURE D.6



LANXESS CANADA CO./CIE
ELMIRA, ONTARIO

Project No. **11192137**
Date **November 2024**

GHD

GROUNDWATER ELEVATION CONTOURS
UA3 - OCTOBER 22, 2024

FIGURE D.7

Filename: N:\CA\Waterloo\Projects\662\11192137\Digital_Design\ACAD 2020\Figures\LTR-GEMP2024OCTOBER-DIR061\11192137-GHD-00-00-LTR-EN-D107_WA-GEMP2024OCTOBER-DIR061.dwg
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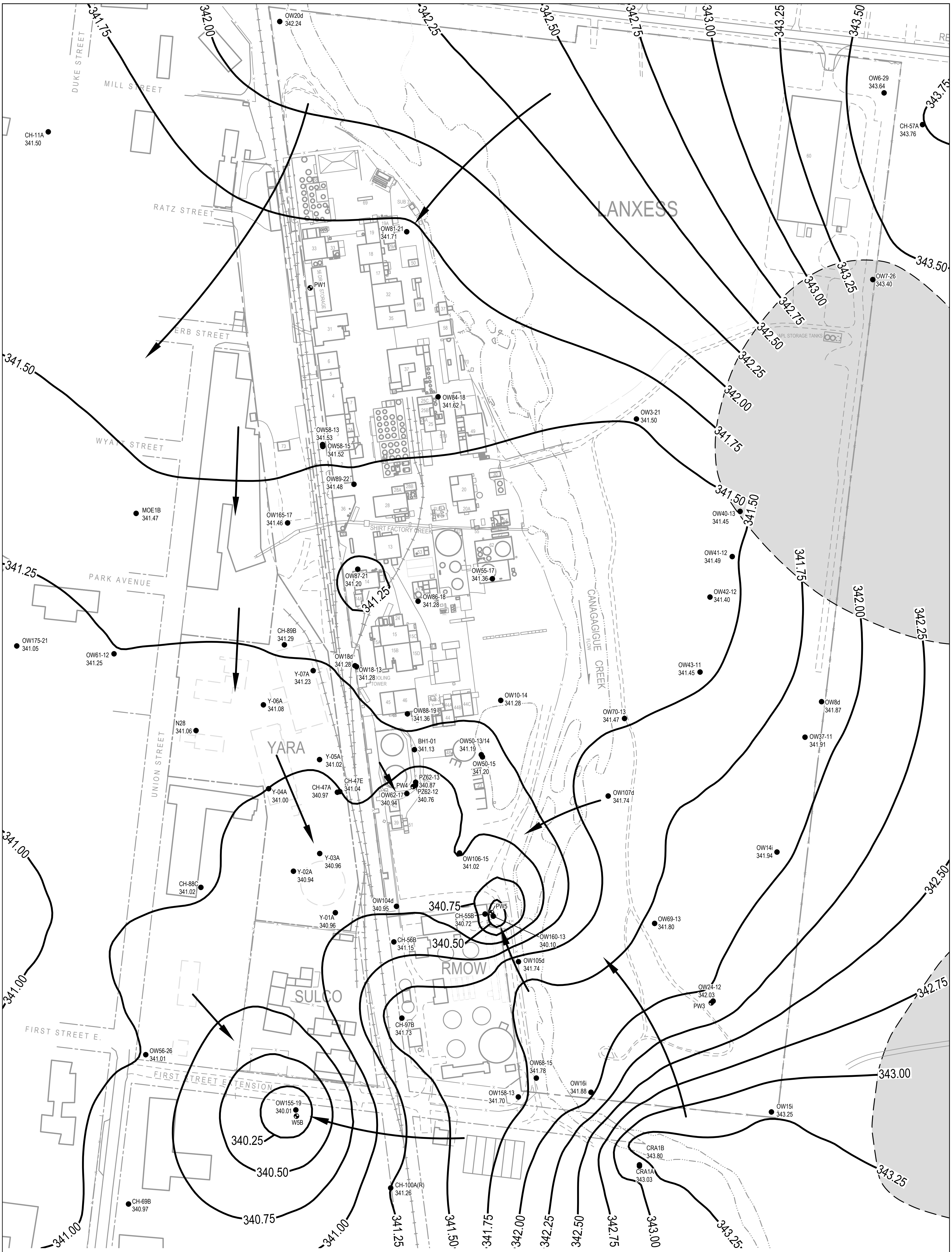


LEGEND

● OW153-4	MONITORING WELL
⊗ PW1	EXTRACTION/CONTAINMENT WELL
344.10	GROUNDWATER ELEVATION (m AMSL)
*	UA3/MU TRANSITION WELL, GROUNDWATER ELEVATION NOT UTILIZED TO CONSTRUCT CONTOURS
▨	APPROXIMATE AREA WHERE UPPER MUNICIPAL AQUIFER DOES NOT EXIST
344.40 ───	0.25m GROUNDWATER ELEVATION CONTOUR (m AMSL)
◄───	GROUNDWATER FLOW DIRECTION

0 30 60 90m

Coordinate System:
UTM NAD 27

N

LANXESS CANADA CO./CIE
ELMIRA, ONTARIO

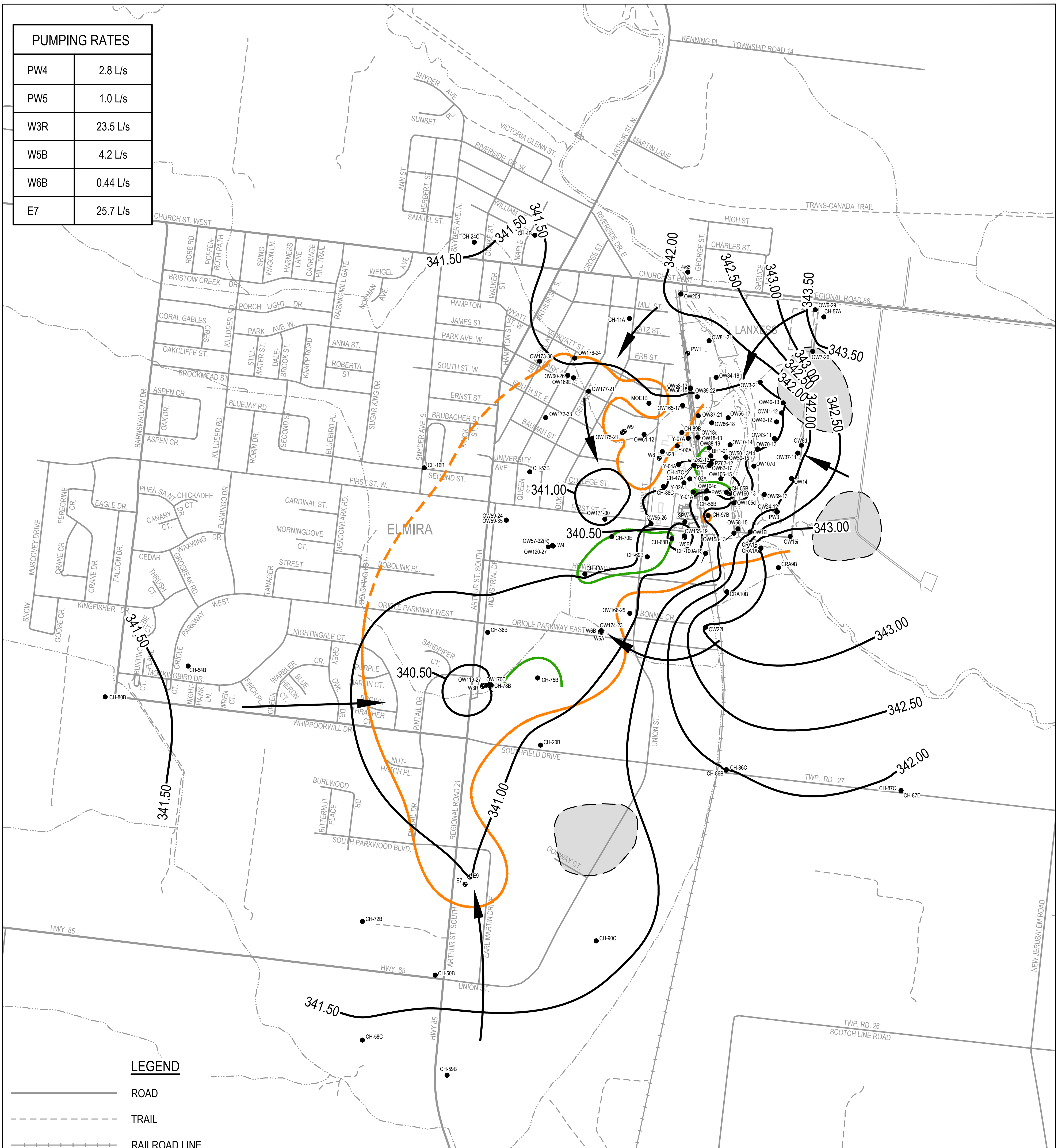
GROUNDWATER ELEVATION CONTOURS
UPPER MUNICIPAL AQUIFER
OCTOBER 22, 2024

Project No. **11192137**
Date **November 2024**

FIGURE D.8

Filename: N:\CA\Waterloo\Projects\662\11192137\Digital_Design\ACAD 2020\Figures\LTR-GEMP2024OCTOBER-DIR061\11192137-GHD-00-00-LTR-EN-D108_WA-GEMP2024OCTOBER-DIR061.dwg
Plot Date: 04 November 2024 9:56 AM

PUMPING RATES	
PW4	2.8 L/s
PW5	1.0 L/s
W3R	23.5 L/s
W5B	4.2 L/s
W6B	0.44 L/s
E7	25.7 L/s



LEGEND

ROAD

TRAIL

RAILROAD LINE

RIVER OR STREAM

APPROXIMATE AREA WHERE UPPER MUNICIPAL AQUIFER DOES NOT EXIST

343.50 GROUNDWATER ELEVATION CONTOUR (m AMSL)

FLOW DIRECTION

W4 EXTRACTION/CONTAINMENT WELL

OW60-26 MONITORING WELL

341.78 GROUNDWATER ELEVATION (m AMSL)

* GROUNDWATER ELEVATION NOT UTILIZED TO CONSTRUCT CONTOURS

2023 NDMA CONCENTRATION CONTOUR (0.009 ug/L)

APROXIMATE 2023 NDMA CONCENTRATION CONTOUR (0.009 ug/L)

2023 CHLOROBENZENE CONCENTRATION CONTOUR (80 ug/L)

WELL ID	MU GROUNDWATER ELEVATION (m AMSL)	WELL ID	MU GROUNDWATER ELEVATION (m AMSL)	WELL ID	MU GROUNDWATER ELEVATION (m AMSL)
4/65	342.03	CRA10B	342.44	OW40-13	341.45
BH1-01	341.13	CRA1A	343.03	OW41-12	341.49
CH-100A(R)	341.26	CRA1B	343.8	OW42-12	341.4
CH-101A	341.34	CRA9A	343.19	OW43-11	341.45
CH-11A	341.5	E9	341	OW50-13/14	341.19
CH-16B	341.32	MOE1B	341.47	OW50-15	341.2
CH-20B	341.19	N28	341.06	OW55-17	341.36
CH-24C	341.52	OW10-14	341.28	OW56-26	341.01
CH-30B	341.41	OW104d	340.95	OW57-32(R)	341.06
CH-32B	341.83	OW105d	341.74	OW58-13	341.53
CH-33B	341.57	OW106-15	341.02	OW58-15	341.52
CH-38B	340.91	OW107d	341.74	OW59-24	341.21
CH-43A	341.03	OW119-27	340.18	OW59-35	341.14
CH-47A	340.97	OW120-27	341.15	OW60-26	341.33
CH-47E	341.04	OW14i	341.94	OW61-12	341.25
CH-4B	341.47	OW155-19	340.01	OW62-17	340.94
CH-50B	341.44	OW158-13	341.7	OW6-29	343.64
CH-53B	341.04	OW15i	343.25	OW68-15	341.78
CH-54B	341.48	OW160-13	340.1	OW69-13	341.8
CH-55B	340.72	OW165-17	341.46	OW70-13	341.47
CH-56S	341.15	OW166-25	340.86	OW7-26	343.4
CH-57A	343.76	OW169E	341.08	OW81-21	341.71
CH-58C	341.52	OW16i	341.88	OW84-18	341.62
CH-59B	341.63	OW170C	340.4	OW86-18	341.28
CH-69B	340.97	OW171-30	340.95	OW87-21	341.2
CH-70E	341.13	OW172-33	341.2	OW88-19	341.36
CH-72B	341.39	OW173-30	341.44	OW89-22	341.48
CH-75B	340.6	OW174-23	340.63	OW8d	341.87
CH-78B	340.59	OW175-21	341.05	PZ62-12	340.76
CH-80B	341.54	OW176-24	341.65	PZ62-13	340.87
CH-86B	341.83	OW177-21	341.44	SPW	340.96
CH-86C	342.1	OW18-13	341.28	Y-01A	340.94
CH-87C	341.64	OW18d	341.28	Y-02A	340.96
CH-87D	341.88	OW20d	342.24	Y-03A	341
CH-88C	341.02	OW22i	343.07	Y-04A	341.02
CH-89B	341.29	OW24-12	342.03	Y-06A	341.08
CH-90C	341.46	OW3-21	341.5	Y-07A	341.23
CH-97B	341.73	OW37-11	341.91		

0 150 300 450m

Coordinate System:
UTM NAD 27

N

GHD

LANXESS CANADA CO./CIE
ELMIRA, ONTARIO

GROUNDWATER ELEVATION CONTOURS
UPPER MUNICIPAL AQUIFER
OCTOBER 22, 2024

Project No. **11192137**
Date **November 2024**

FIGURE D.9

Filename: N:\CA\Waterloo\Projects\662\11192137\Digital_Design\ACAD 2020\Figures\LTR-GEMP2024OCTOBER-DIR061\11192137-GHD-00-00-LTR-EN-D109_WA-GEMP2024OCTOBER-DIR061.dwg
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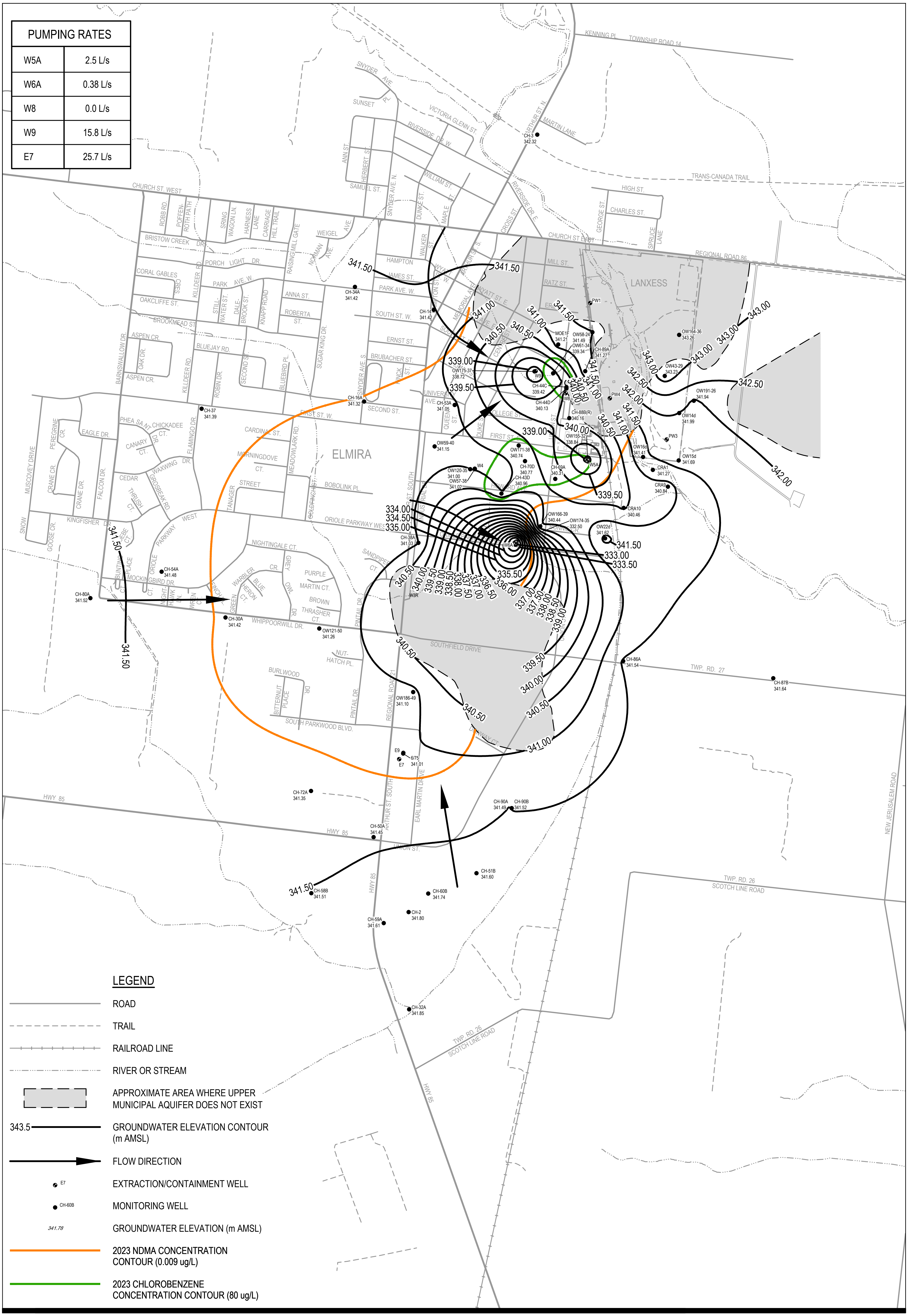
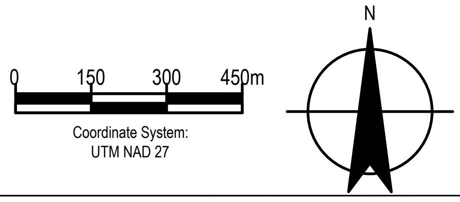


PUMPING RATES	
W5A	2.5 L/s
W6A	0.38 L/s
W8	0.0 L/s
W9	15.8 L/s
E7	25.7 L/s

LEGEND

- ROAD
- TRAIL
- RAILROAD LINE
- RIVER OR STREAM
- ▨ APPROXIMATE AREA WHERE UPPER MUNICIPAL AQUIFER DOES NOT EXIST
- 343.5 GROUNDWATER ELEVATION CONTOUR (m AMSL)
- FLOW DIRECTION
- E7 EXTRACTION/CONTAINMENT WELL
- CH-60B MONITORING WELL
- 341.78 GROUNDWATER ELEVATION (m AMSL)
- 2023 NDMA CONCENTRATION CONTOUR (0.009 ug/L)
- 2023 CHLOROBENZENE CONCENTRATION CONTOUR (80 ug/L)



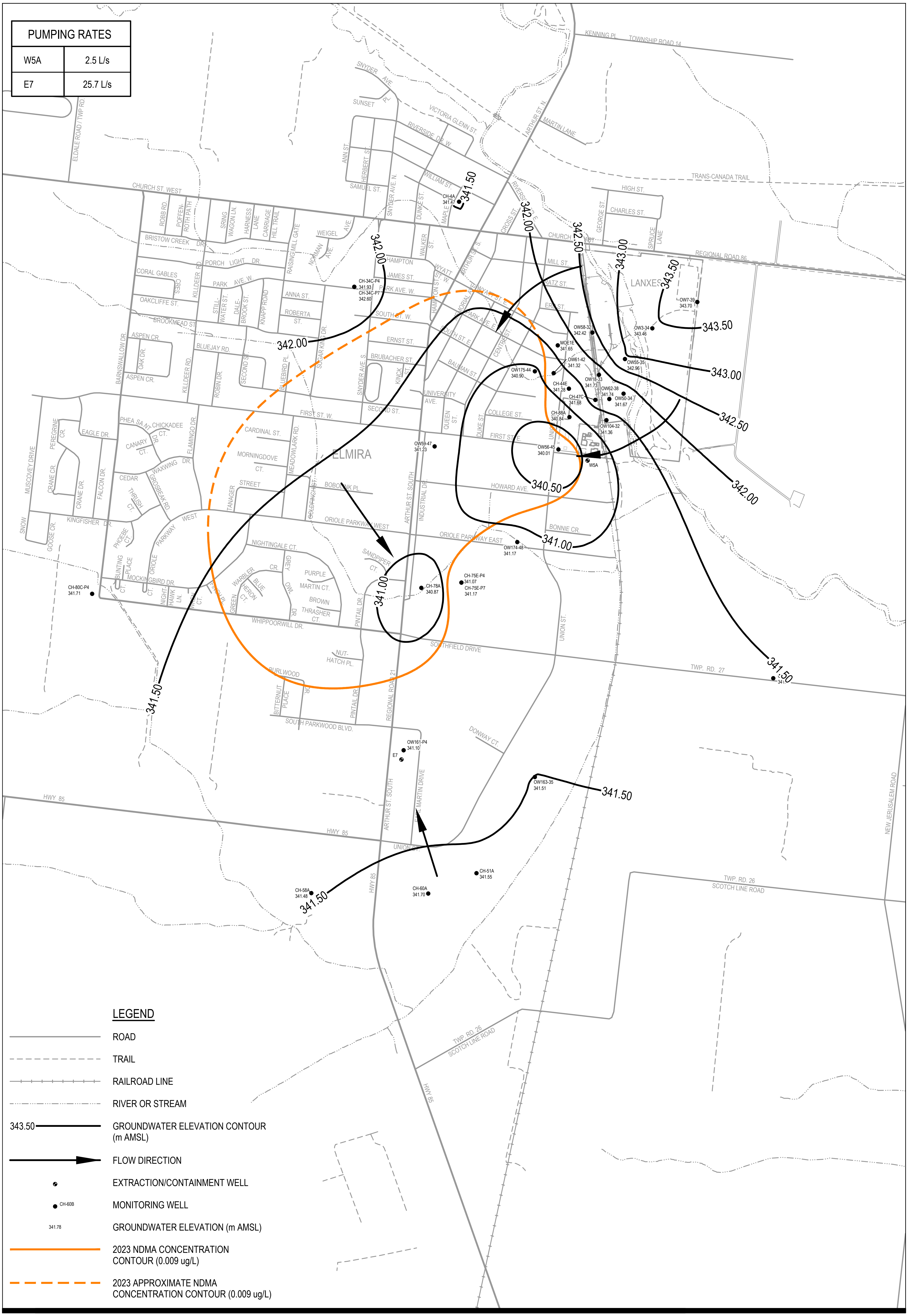
LANXESS CANADA CO./CIE
ELMIRA, ONTARIO

Project No. **11192137**
Date **November 2024**

GHD

GROUNDWATER ELEVATION CONTOURS LOWER MUNICIPAL AQUIFER OCTOBER 22, 2024

FIGURE D.10



PUMPING RATES	
W5A	2.5 L/s
E7	25.7 L/s

0 150 300 450m

Coordinate System:
UTM NAD 27

N

LANXESS CANADA CO./CIE
ELMIRA, ONTARIO

GROUNDWATER ELEVATION CONTOURS
BEDROCK AQUIFER
OCTOBER 22, 2024

Project No. **11192137**
Date **November 2024**

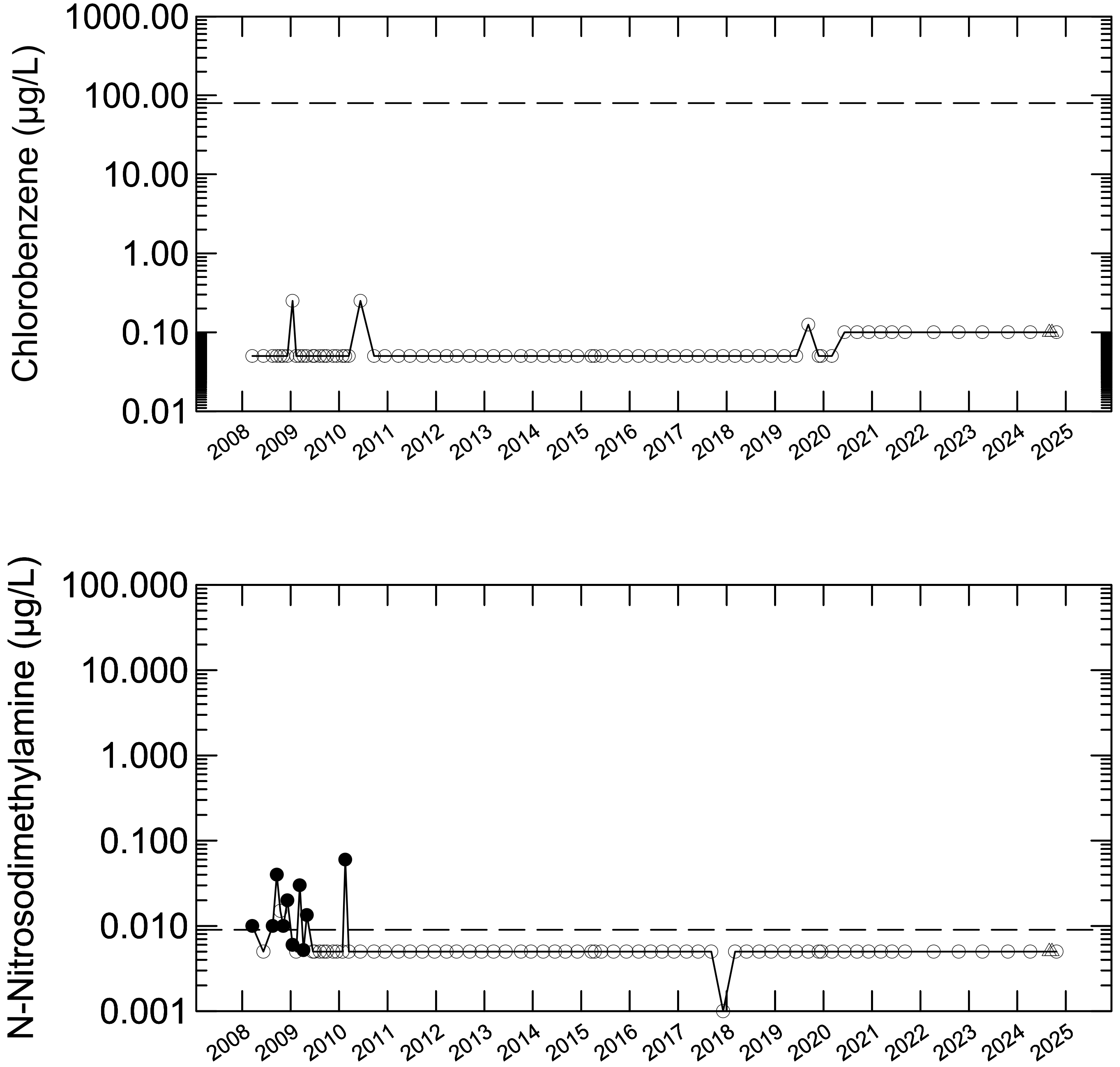
FIGURE D.11

Filename: N:\CA\Waterloo\Projects\662\11192137\Digital_Design\ACAD 2020\Figures\LTR-GEMP2024OCTOBER-DIR061\11192137-GHD-00-00-LTR-EN-D111_WA-GEMP2024OCTOBER-DIR061.dwg
Plot Date: 04 November 2024 2:21 PM

Attachment E

Analytical Results

MU Sentry Well Monitoring Program



Legend:

- ● Detected Result
- ○ Non-detect
- △ Monthly sample, due to loss of containment
- — — Ontario Drinking Water Standard

Note:

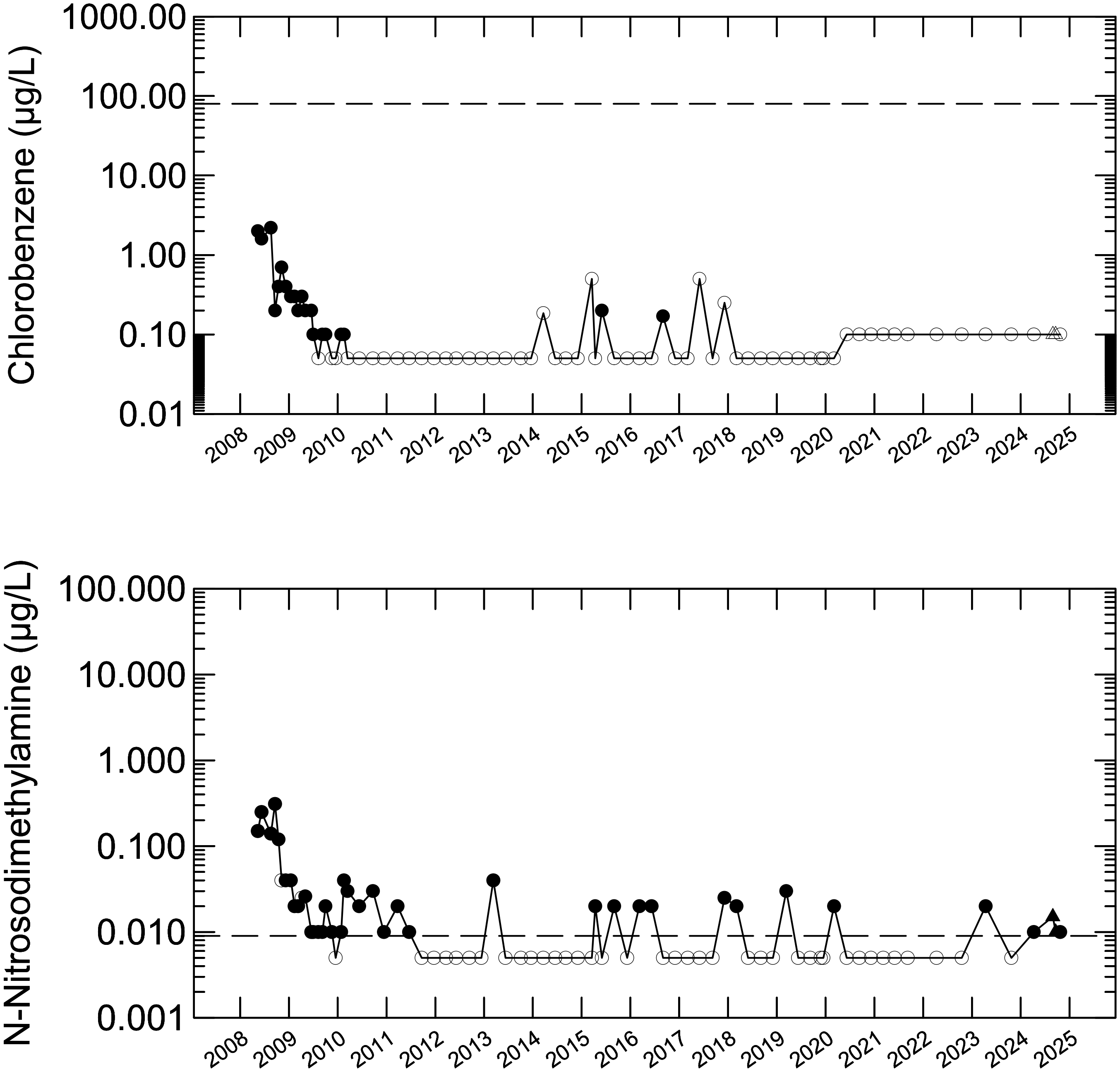
Non-detects are shown as one half the laboratory detection limit

Evaluation of Groundwater Analytical Data
Lanxess Canada Co./Cie
Elmira, Ontario

Project No. **11192137**
Date: **Nov 1, 2024**

MU SENTRY WELL OW58-13

FIGURE E.1



Legend:

- ● Detected Result
- ○ Non-detect
- ▲ Monthly sample, due to loss of containment
- — — Ontario Drinking Water Standard

Note:

Non-detects are shown as one half the laboratory detection limit

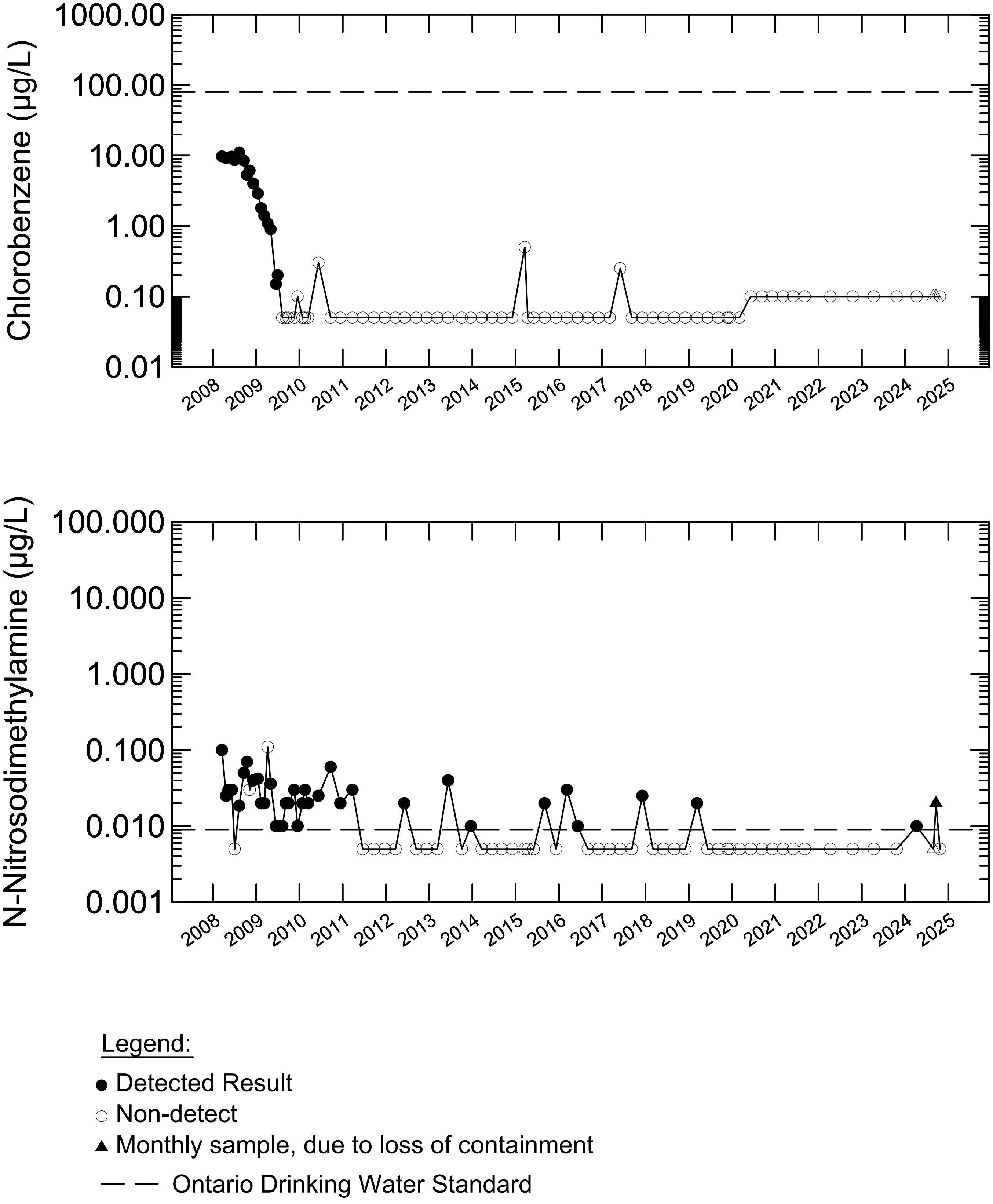
GHD

Evaluation of Groundwater Analytical Data
Lanxess Canada Co./Cie
Elmira, Ontario

Project No. **11192137**
Date: **Nov 1, 2024**

MU SENTRY WELL OW165-17

FIGURE E.2



Note:

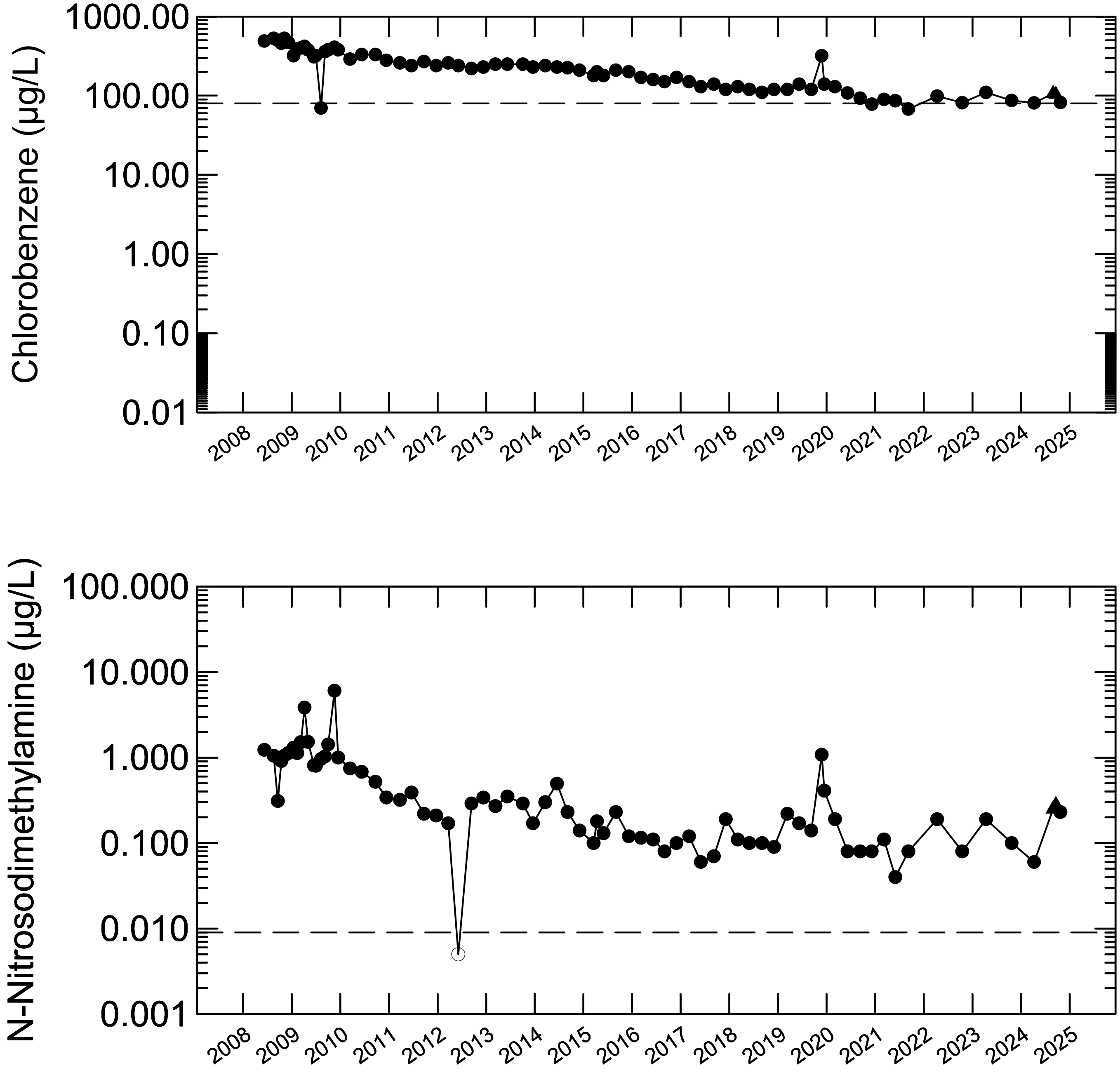
Non-detects are shown as one half the laboratory detection limit

Evaluation of Groundwater Analytical Data
Lanxess Canada Co./Cie
Elmira, Ontario

Project No. **11192137**
Date: **Nov 1, 2024**

MU SENTRY WELL CH-89B

FIGURE E.3



Legend:

- ● Detected Result
- ○ Non-detect
- ▲ Monthly sample, due to loss of containment
- — — Ontario Drinking Water Standard

Note:

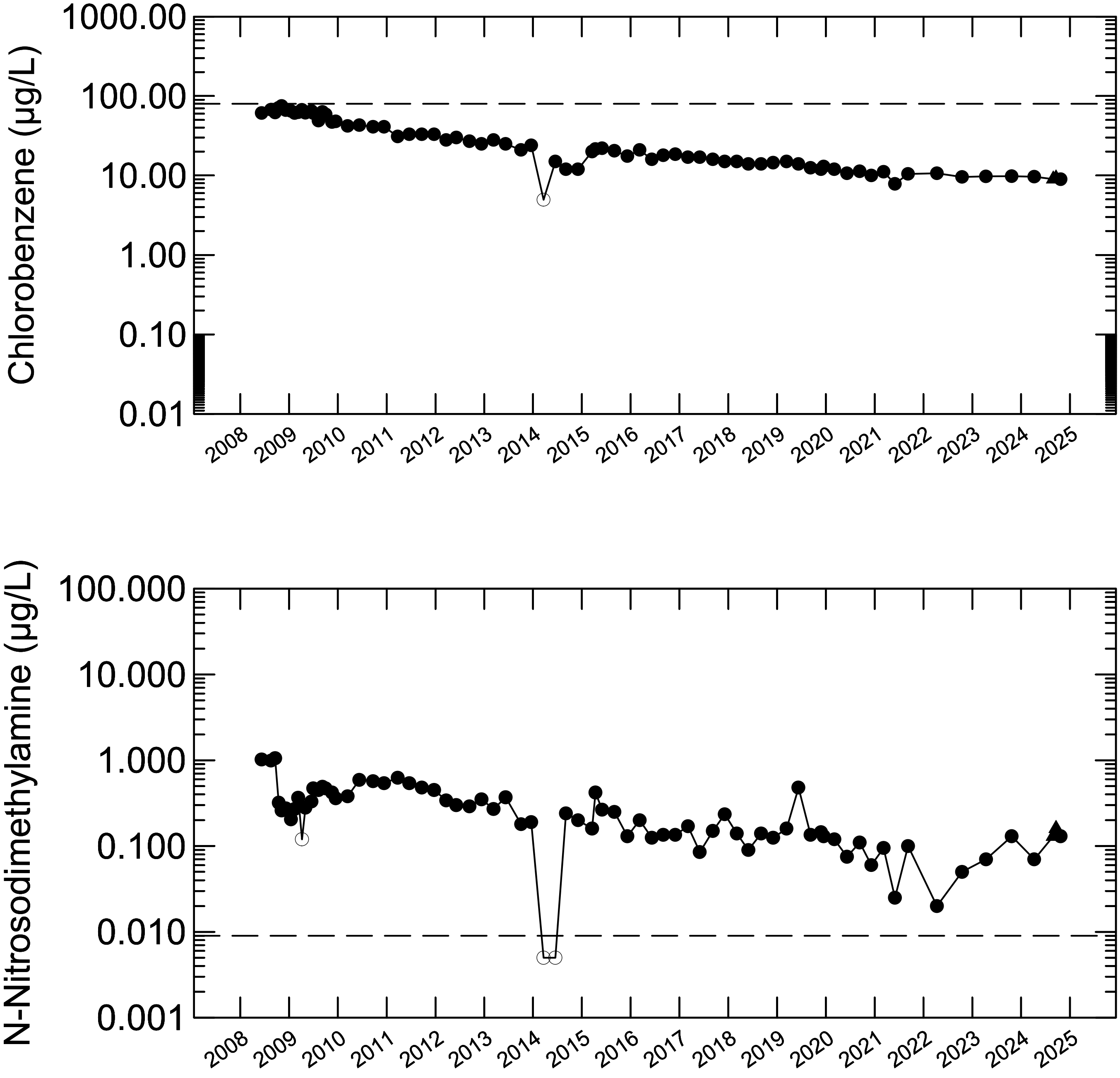
Non-detects are shown as one half the laboratory detection limit

Evaluation of Groundwater Analytical Data
Lanxess Canada Co./Cie
Elmira, Ontario

Project No. **11192137**
Date: **Nov 1, 2024**

MU SENTRY WELL CH-47E

FIGURE E.4



Legend:

● Detected Result

○ Non-detect

▲ Monthly sample, due to loss of containment

— — Ontario Drinking Water Standard

Note:

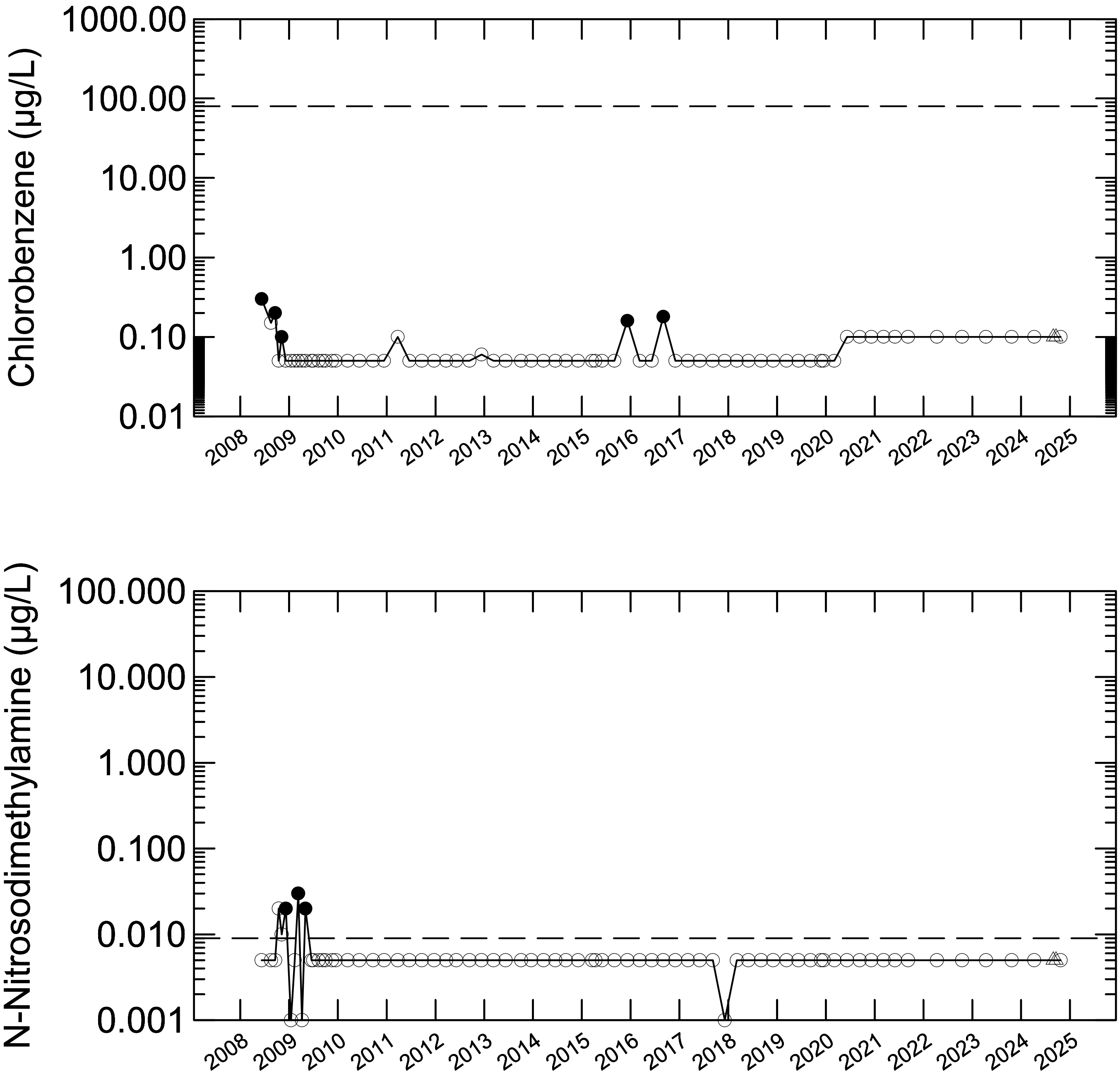
Non-detects are shown as one half the laboratory detection limit

Evaluation of Groundwater Analytical Data
Lanxess Canada Co./Cie
Elmira, Ontario

Project No. **11192137**
Date: **Nov 1, 2024**

MU SENTRY WELL CH-56B

FIGURE E.5



Legend:

● Detected Result

○ Non-detect

△ Monthly sample, due to loss of containment

— — Ontario Drinking Water Standard

Note:

Non-detects are shown as one half the laboratory detection limit

Evaluation of Groundwater Analytical Data
Lanxess Canada Co./Cie
Elmira, Ontario

Project No. **11192137**
Date: **Nov 1, 2024**

MU SENTRY WELL CH-97B

FIGURE E.6

Table E.1

Sentry Well Analytical Results - Chlorobenzene
LANXESS Canada Co./Cie
Elmira, Ontario

	Sample Location[1][2]					
	OW58-13	**OW165-17**	**CH-89B**	**CH-47E**	**CH-56B**	**CH-97B**
Aquifer Designation	**MU**	**MU**	**MU**	**MU**	**MU**	**MU**
Sample Date						
6-Mar-17	ND (0.1)	ND (0.1)	ND (0.1)	150	17 / 17	ND (0.1)
2-Jun-17	ND (0.1)	ND (1.0)	ND (0.5)	130	17 / 17	ND (0.1)
8-Sep-17	ND (0.1)	ND (0.1)	ND (0.1)	140	16 / 16	ND (0.1)
6-Dec-17	ND (0.1)	ND (0.5)	ND (0.1)	120	15 / 15	ND (0.1)
6-Mar-18	ND (0.1)	ND (0.1)	ND (0.1)	130	15 / 15	ND (0.1)
1-Jun-18	ND (0.1)	ND (0.1)	ND (0.1)	120	14 / 14	ND (0.1)
4-Sep-18	ND (0.1)	ND (0.1)	ND (0.1)	110	14 / 14	ND (0.1)
3-Dec-18	ND (0.1)	ND (0.1)	ND (0.1)	120	14 / 15	ND (0.1)
13-Mar-19	ND (0.1)	ND (0.1)	ND (0.1)	120	15 / 15	ND (0.1)
10-Jun-19	ND (0.1)	ND (0.1)	ND (0.1)	140	14 / 14	ND (0.1)
9-Sep-19	ND (0.25)	ND (0.1)	ND (0.1)	120	13 / 12	ND (0.1)
26-Nov-19	ND (0.1)	ND (0.1)	ND (0.1)	320	12 / 12	ND (0.1)
16-Dec-19	ND (0.1)	ND (0.1)	ND (0.1)	140	13 / 13	ND (0.1)
15-Jan-20	--	--	--	140 / 140	--	--
5-Mar-20	ND (0.1)	ND (0.1)	ND (0.1)	130	12 / 12	ND (0.1)
8-Jun-20	ND (0.2)	ND (0.2)	ND (0.2)	108	10.5 / 10.8	ND (0.2)
11-Sep-20	ND (0.2)	ND (0.2)	ND (0.2)	92.7	11.3 / 11.2	ND (0.2)
7-Dec-20	ND (0.2)	ND (0.2)	ND (0.2)	78.0	10.2 / 9.82	ND (0.2)
9-Mar-21	ND (0.2)	ND (0.2)	ND (0.2)	89.7	11.0 / 11.3	ND (0.2)
2-Jun-21	ND (0.2)	ND (0.2)	ND (0.2)	86.3	7.97 / 7.75	ND (0.2)
8-Sep-21	ND (0.2)	ND (0.2)	ND (0.2)	67.8	9.88 / 11.1	ND (0.2)
12-Apr-22	ND (0.2)	ND (0.2)	ND (0.2)	98.8	10.7 / 10.6	ND (0.2)
17-Oct-22	ND (0.2)	ND (0.2)	ND (0.2)	81.4	9.52 / 9.66	ND (0.2)
14-Apr-23	ND (0.2)	ND (0.2)	ND (0.2)	110	9.74 / 9.76	ND (0.2)
23-Oct-23	ND (0.2)	ND (0.2)	ND (0.2)	87.0	9.82 / 9.77	ND (0.2)
9-Apr-24	ND (0.2)	ND (0.2)	ND (0.2)	80.9	9.76 / 9.55	ND (0.2)
29-Aug-24	ND (0.2)	ND (0.2)	ND (0.2)	107	9.03 / 9.00	ND (0.2)
19-Sep-24	ND (0.2)	ND (0.2)	ND (0.2)	104	9.26 / 9.38	ND (0.2)
24-Oct-24	ND (0.2)	ND (0.2)	ND (0.2)	82.0	8.80 / 9.16	ND (0.2)

Notes:

9.8 / 9.7	Result / Duplicate Result
ND(RDL)	Not detected (ND) at the associated reporting detection limit (RDL).
[1]	From March 2008 until March 2020, samples analysed by Bureau Veritas (formerly Maxxam Analytics Inc.) unless otherwise noted. From June 2020 onward, samples analyzed by ALS Canada Ltd, unless otherwise noted.
[2]	Sample results are in micrograms per litre (µg/L) unless otherwise noted.
--	The parameter was not analyzed for.

Table E.2

Sentry Well Analytical Results - NDMA
LANXESS Canada Co./Cie
Elmira, Ontario

	Sample Location[1][2]					
	OW58-13	OW165-17	CH-89B	CH-47E	CH-56B	CH-97B
Aquifer Designation	MU	MU	MU	MU	MU	MU
Sample Date						
6-Mar-17	ND (0.01)	ND (0.01)	ND (0.01)	0.12	0.19 / 0.15	ND (0.01)
2-Jun-17	ND (0.01)	ND (0.01)	ND (0.01)	0.06	0.08 / 0.09	ND (0.01)
8-Sep-17	ND (0.01)	ND (0.01)	ND (0.01)	0.07	0.10 J / 0.20 J	ND (0.01)
6-Dec-17	ND (0.002)[4]	0.025[4]	0.025[4]	0.19[4]	0.23[4] / 0.24[4]	ND (0.002)[4]
6-Mar-18	ND (0.01)	0.02	ND (0.01)	0.11	0.14 / 0.14	ND (0.01)
1-Jun-18	ND (0.01)	ND (0.01)	ND (0.01)	0.10	0.09 / 0.09	ND (0.01)
4-Sep-18	ND (0.01)	ND (0.01)	ND (0.01)	0.10	0.12 / 0.16	ND (0.01)
3-Dec-18	ND (0.01)	ND (0.01)	ND (0.01)	0.09	0.13 / 0.12	ND (0.01)
13-Mar-19	ND (0.01)	0.03	0.02	0.22	0.18 / 0.14	ND (0.01)
10-Jun-19	ND (0.01)	ND (0.01)	ND (0.01)	0.17	0.15 J / 0.81 J	ND (0.01)
9-Sep-19	ND (0.01)	ND (0.01)	ND (0.01)	0.14	0.14 / 0.13	ND (0.01)
26-Nov-19	ND (0.01)	ND (0.01)	ND (0.01)	1.08	0.14 / 0.15	ND (0.01)
16-Dec-19	ND (0.01)	ND (0.01)	ND (0.01)	0.41	0.12 / 0.14	ND (0.01)
15-Jan-20	--	--	--	0.36 / 0.36	--	--
5-Mar-20	ND (0.01)	0.02	ND (0.01)	0.19	0.12 / 0.12	ND (0.01)
8-Jun-20	ND (0.01)	ND (0.01)	ND (0.01)	0.08	0.08 / 0.07	ND (0.01)
11-Sep-20	ND (0.01)	ND (0.01)	ND (0.01)	0.08	0.11 / 0.11	ND (0.01)
7-Dec-20	ND (0.01)	ND (0.01)	ND (0.01)	0.08	0.06 / 0.06	ND (0.01)
9-Mar-21	ND (0.01)	ND (0.01)	ND (0.01)	0.11	0.09 / 0.10	ND (0.01)
2-Jun-21	ND (0.01)	ND (0.01)	ND (0.01)	0.04	0.03 / 0.02	ND (0.01)
8-Sep-21	ND (0.01)	ND (0.01)	ND (0.01)	0.08	0.10 / 0.10	ND (0.01)
12-Apr-22	ND (0.01)	ND (0.01)	ND (0.01)	0.19	0.02 / 0.02	ND (0.01)
17-Oct-22	ND (0.01)	ND (0.01)	ND (0.01)	0.08	0.05 / 0.05	ND (0.01)
14-Apr-23	ND (0.01)	0.02	ND (0.01)	0.19	0.08 / 0.06	ND (0.01)
23-Oct-23	ND (0.01)	ND (0.01)	ND (0.01)	0.10	0.13 / 0.13	ND (0.01)
9-Apr-24	ND (0.01)	0.01	0.01	0.06	0.07 / 0.07	ND (0.01)
29-Aug-24	ND (0.01)	0.0151[5]	ND (0.01)	0.25	0.14 / 0.12	ND (0.01)
19-Sep-24	ND (0.01)	0.01	0.02	0.28	0.16 / 0.16	ND (0.01)
24-Oct-24	ND (0.01)	0.01	ND (0.01)	0.23	0.13 / 0.13	ND (0.01)

Notes:

9.8 / 9.7	Result / Duplicate Result.
0.03 | 0.042	Result | Split Sample Result (different laboratories reporting).
ND(RDL)	Not detected (ND) at the associated reporting detection limit (RDL).
[1]	Samples analyzed by LANXESS Technology Centre, Ontario, unless otherwise noted.
[2]	Sample results are in micrograms per litre (µg/L) unless otherwise noted.
[3]	Split samples analyzed by Bureau Veritas (formerly Maxxam Analytics Inc.)
[4]	Samples analyzed by Bureau Veritas (formerly Maxxam Analytics Inc.)
[5]	Sample analyzed by ALS Canada Ltd.
--	The parameter was not analyzed for.
J	Estimated concentration.

While I have only briefly examined to date TRAC Question 1 and 4, I can advise you for your own information that Mr. Almeida's answers are woefully inaccurate.

His map is very poor as are his comments that the Gap area is topographically high which is nonsensical , inaccurate and likely intentionally disingenuous. It is unfortunate that Sebastian (& Tiffany) continue to reference "the Gap area" as either symbolic or significant to the major issue of massive liquid wastes flowing onto the Stroh property from Uniroyal Chemical's east side ponds (RPE 1-5). The gravity flowing toxic liquid wastes crossed the property line from Uniroyal to the Stroh farm (west to east) for almost the entire length of the Uniroyal site with the notable exception being the southern end of "the Gap area" whose surface elevation begins to rise as it meets the very large, diagonal, north-west to south-east ridge of high land that is mostly on Uniroyal's property with a very little on the Stroh property. Luis is just having fun by pretending to think that "the Gap area" only consists of the high ground at the southern end of the Gap area. Obviously liquid wastes flow downhill via gravity and it is typical for example of Uniroyal/Chemtura to sample soils on the higher ground and then pompously declare that gosh we didn't find any evidence of migrating liquid wastes here.

The sampling on the Stroh farm has been minimal, shallow and totally bogus and unacceptable and Lanxess gratefully thanks the MECP for their service to the cause of sham cleanup.