APPENDIX H1: ALTERNATIVE GEOTECHNICAL INVESTIGATION PROGRAM

Alternative Geotechnical Investigation Program - Vertical Landfill Expansion (Ayres Associates, October 2022)

WDNR Acceptance of Proposed Alternative Geotechnical Investigation Program for Feasibility Study (January 10, 2023)

Alternative Geotechnical Investigation Program

Vertical Landfill Expansion
Adams County Sanitary Landfill
FID 701040560, License No. 3150

Prepared for:

Adams County Solid Waste Department
Adams County, Wisconsin

October 2022

Alternative Geotechnical Investigation Program

Vertical Landfill Expansion
Adams County Sanitary Landfill
FID 701040560, License No. 3150

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Certifications

"I, Lisa A. Fleming, hereby certify that I am a licensed professional engineer in the State of Wisconsin in accordance with the requirements of ch. A-E 4, Wis. Adm. Code; that this document has been prepared in accordance with the Rules of Professional Conduct in ch. A-E 8, Wis. Adm. Code; and that, to the best of my knowledge, all information contained in this document is correct and the document was prepared in compliance with all applicable requirements in chs. NR 500 to 538, Wis. Adm. Code."

Lisa A. Fleming, PE
Manager – Municipal Services

WISCONSIN LISA A. FLEMING 24918 EAU CLAIRE WI PROFESSIONAL ENGINEER

October 12, 2022
Date

"I, Logan Seipel, hereby certify that I am licensed professional geologist in the State of Wisconsin, in accordance with the requirements of ch. GHSS 2, Wis. Adm. Code; that the preparation of this document has not involved any unprofessional conduct as detailed in ch. GHSS 5, Wis. Adm. Code; and that, to the best of my knowledge, all information contained in this document is correct and the document was prepared in compliance with all applicable requirements in chs. NR 500 to 538, Wis. Adm. Code."

Logan Seipel
Hydrogeologist

WISCONSIN LOGAN C. SEIPEL PG-1424 EAU CLAIRE WI PROFESSIONAL GEOLOGIST

October 12, 2022
Date

Introduction

The purpose of this Alternative Geotechnical Investigation Program (AGIP) is to satisfy the requirements of Ch. NR 512, Wisconsin Administrative Code, for the proposed vertical expansion at Adams County Landfill. The proposed vertical expansion is entirely within the limits of Phases 1 through 6 of the existing landfill that have been approved by the WDNR.

The purpose of the AGIP is to request the WDNR's concurrence that the existing geotechnical data collected at the landfill is sufficient to satisfy the requirements of NR 512 for the proposed vertical expansion.

This AGIP intends to use the historical borings completed as part of the 1986 and 2017 feasibility reports at the site to satisfy NR 512.09 for the vertical expansion. The vertical expansion footprint is approximately 8.3 acres within the permitted limits of waste in Phases 2 through 6 (Sheet 2 of Appendix H). Given the size discrepancy, some of the historical borings and soil samples analyzed for grain size included in this report to satisfy NR 512.09(4)a) are beyond the 300-ft distance from the proposed limits of waste (NR 512.09(1)(a)).

It is Ayres Associates opinion that the subsurface conditions have been sufficiently characterized in the previous feasibility reports. It is not anticipated that further exploration would result in a different outcome of the subsurface analysis due to consistent subsurface conditions as similarly approved by the WDNR in the 2018 Determination of Site Feasibility Letter for the horizontal expansion. There are results identified outside the 300-foot proposed landfill limit that do meet the criteria of the Nr 512.09(4) code. An exemption is requested under NR 512.09 for lack of Atterberg limit results and laboratory hydraulic conductivity per NR 512.09(4(a) and(b).

The plan sheets and figures have been prepared as 22-inch by 34-inch plan sheets and present the information required under NR 512. 11. An exemption is requested under NR 512.11 which indicates that results from the investigation are presented on 24-inch x 36-inch plan sets.

The 2017 Feasibility Report included a geotechnical investigation in compliance with NR 512.09 with the exception of two soil borings which were installed less than the required 25 feet below proposed subbase. An exemption was requested from NR 512.09(1)(b) for the two soil borings and the WDNR granted the exemption in the 2018 Determination of Site Feasibility letter.

General Project Description

Adams County is intending to complete a vertical landfill expansion of the existing Adams County Sanitary Landfill, located in the Town of Strongs Prairie, Wisconsin. The physical/mailing address of the facility is 1420 State Highway 21, Friendship, Wisconsin 53934. The existing landfill began operations in 1989 and is currently filling in phase 5, phase 6 has not been constructed yet. The vertical landfill expansion will not impact waste limits of the existing landfill's 21.9 acres. The expansion will extend the 4H:1V side slopes to a crest of 1073.5' on the top of the landfill. The vertical expansion proposes approximately 224,000 cubic yards (CY) of additional airspace to the existing permitted design capacity of 1,248,200 CY for a total capacity of 1,472,200 CY. The proposed expansion will overlay its waste onto the Phases 2 through 6. The vertical expansion enhances the minimized landfill footprint.

Facility Information – NR 509.05(3)

The following sections present pertinent information regarding the proposed vertical landfill expansion at the Adams County Sanitary Landfill.

Project Title

Vertical Landfill Expansion
Adams County Sanitary Landfill
Adams County, Wisconsin

Landfill Property Owner, Operator, and Primary Contact

Adams County, Wisconsin

Mr. Charlie Kuhn - Director
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Consultant and Primary Contact

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Present Property Owner and Operator

Adams County, Wisconsin

Proposed Landfill Vertical Expansion Location

Legal Location: SW ¼, NE ¼, Section 13, T18N, R5E, Town of Strongs Prairie

Physical Location: 1420 State Highway 21, Friendship, WI 53934

Total Facility Property Area

581 Acres

Total Proposed Landfill Vertical Expansion Limits of Waste Area

21.9 acres

Proposed Landfill Vertical Expansion Lifespan

4 years

Proposed Landfill Vertical Expansion Volume

224,000 CY

Site-Specific Geotechnical Information (NR 512.09,.10,.11)

A geotechnical investigation to determine the physical and subsurface characteristics of the proposed Landfill's location is required per NR 512.09. This data is then used to evaluate the suitability of the proposed location for landfill development. The proposed vertical expansion encompasses approximately

8.3 acres entirely within the footprint of the existing permitted landfill. Ayres proposes using the existing geotechnical data from the previous landfill phases to meet the requirements of NR 512.

A feasibility report submitted by Foth & Van Dyke in 1986 described the site-specific geotechnical investigation conducted for Phases 1 through 4. The 1986 Feasibility Report was approved by the WDNR in 1987. The 2017 Feasibility Report included a full description of geotechnical activities performed for Phases 5 and 6. The 2017 Feasibility Report was approved by the WDNR in 2018. Given that the geotechnical investigations encompassing the entire area of the existing, permitted landfill have all been approved by the WDNR and no additional horizontal expansion is proposed, the following section is largely a summary of the most recent investigation, but also includes pertinent information from the previous (1986) investigation. The reported results of both geotechnical investigations indicate that subsurface conditions at the site are consistent across the previously permitted horizontal extent. Data collected over the course of the 1986 and 2017 investigations for are presented in accordance with NR 512.11 and portrayed in Tables 1-4 and Sheet 1. Data collected from the 2017 Feasibility Report included subsurface data analysis as required by NR 512.10.

Laboratory and field data collected are provided and summarized in the referenced appendices and tables, respectively, of this Section.

Field Investigation

The field investigations were performed as each part of the 1986 and 2017 Feasibility Reports. Field activities performed or documented by Ayres Associates for the 2017 FR included installation of soil borings and monitoring wells, monitoring well development and hydraulic conductivity testing, borehole abandonment, and description of all geologic samples. These activities were conducted under the supervision of a professional geologist. Ayres Associates also conducted groundwater monitoring and provided surveying services. CT Laboratories of Baraboo, Wisconsin, WI Laboratory Certification Number 157066030, performed chemical laboratory analysis of groundwater samples. Professional Service Industries (PSI) of Chippewa Falls, Wisconsin, performed analysis of soil samples for physical properties as well as provided drilling and well installation services. The soil borings and monitoring well locations are shown on Plan Sheet 2 of Appendix H.

Soil Boring Installation

The landfill's existing fill area is approximately 21.9 acres, the proposed fill area is 8.3 acres and per NR 512.09(1) requires the installation of at least 12 soil borings extending 25 feet below the nearest subbase elevation and within 300 feet of the proposed limits of filling. The coarse-grained soil environment within the 300 feet of the proposed limits of filling was previously permitted during the 1986 feasibility and 2017 feasibility. The 1986 and 2017 Feasibility Reports indicate more than 12 borings have been installed per NR 512.09(1) requirements as summarized in Table 1. All soil borings for the 2017 geotechnical investigation were installed to the depth required in NR 512.09(1) with the exceptions for borings B-101 and B-104.The 1986 feasibility details 22 boreholes, with 14 monitoring well installations, all borings meeting the depth requirement of NR 512.09(1) except for MW-18. Soil boring logs are located in Appendix A.

The previously installed boring logs indicate consistent subsurface conditions. Borings adjacent to and surrounding B-101 and B-104 including MW-17, MW-17P, B-13, B-10, MW-16, MW-3, MW-3P, B103, MW-31, and B-106 were installed to the minimum 25-foot depth requirement. It was Ayres Associates opinion that the subsurface conditions were sufficiently characterized by the adjacent wells. Therefore, an exemption requested under NR 512.09 for these two borings was approved by the WDNR in the 2018 Determination of Site Feasibility Letter for the horizontal expansion.

Standard split barrel sampling procedures were used to collect soil samples of the unconsolidated soil at 5-foot intervals. Blow counts, percent recovery, soil structures, mottling, voids, lenses, Munsell color, geologic origin, and Unified Soil Classification System (USCS) classification were recorded on each soil boring log. Soil classification was based on field observations unless a grain size sample was collected, then classification was used from the laboratory. Soil borings were abandoned in accordance with NR 507.08 and NR 141.25. A copy of the boring abandonment forms for the soil borings installed as part of the 2015 investigation are in Appendix A. Abandonment forms for historical borings B-4, B-5, B-10, B-11, B-12, B-13, B-14, B-15, and MW-8 could not be located after extensive search of the Adams County Landfill files, as noted in the 2017 Feasibility Report. Soil samples utilized for this report were collected from the property as part of the investigation for the 2017 Feasibility Report. This report included documentation of the soil sampling and was approved by the department in 2018. Given that documentation and approval, NR 507.07(1)(e) requirement has been met.

The following table summarizes the locational requirements of NR 512.09:

Inside proposed limits of filling	MW-8, 17 B-5[2], 13[2], 15[2]
Inside existing/permitted limits of filling	MW-3[1], 8, 17 B-5[2], 10[2], 12, 13[2], 14, 15[2], 100, 101, 102, 103
Outside proposed vertical limits of filling, within 300 feet	MW-3[1], 16, 18, 19[3,4] B-4, 10[2], 11, 12, 14, 100, 101,102, 103
Outside existing/permitted limits of filling, within 300 feet	MW-1, 2[1], 6, 7, 9, 16, 18, 19[3,4], 20, 21, 29, 30, 31 B-4, 11, 104, 105, 106
Borings that extend 25 feet below nearest subbase	MW-1, 2[1], 3[1], 6, 7, 8, 9, 16, 17, 19[3,4], 20, 21 29, 30, 31 B-4, 5[2], 10[2], 11, 12, 13[2], 14, 15[2], 100, 102, 103, 105, 106
Borings that do not extend 25 feet below nearest subbase	MW-18, B101, B-104
Borings installed that meet NR 512.09 code Require 12 borings for 8.3 acres.	MW-3[1], 8, 16, 17, 19[3,4] B-4, 5[2], 10[2], 11, 12, 13[2], 14, 15[2], 100, 102, 103
Soil physical properties collected near screen	MW-29, 30, 31

[1] Missing Well Development Form
[2] Missing Soil Boring Abandonment Form
[3] Missing Hydraulic Conductivity Value
[4] Missing Grain Size Analysis

Groundwater Monitoring Well Installation

Based on the area of the proposed vertical expansion (8.3 acres) and the coarse-grained soil environment, NR 512.09(2) requires the installation six water table observation wells and two piezometers. Table 2 summarizes the monitoring well information from the wells utilized for vertical expansion. Standard split barrel sampling procedures were used to collect soil samples of the unconsolidated soil at 5-foot intervals. Blow counts, percent recovery, soil structures, mottling, voids, lenses, Munsell color, geologic origin, and USCS classification were recorded on each soil boring log. All monitoring wells were designed, installed, documented, sampled, and developed under the supervision of a professional geologist. The following is a summary of the numbers of wells and piezometers located inside and outside the proposed limits of fill (vertical expansion). MWs 3/3P, 16, 17/17P, 18, and 19/19P were installed for previous 1986 feasibility permitting but lie within 300 feet of the proposed waste fill limits.

Wells within 150 feet of proposed fill limits	MW- 3, 8, 17
Wells within 150 to 300 feet of proposed fill limits	MW-16, 18, 19
Required number of wells installed per NR 512.09	6
Piezometers within 300 feet of fill limits	MW-3P, 17P, 18P, 19P
Required number of piezometers installed per NR 512.09	3
Well nest inside proposed limits of filling	MW-17,17P
Required number of well nest installed per NR 512.09	1

Soil samples were collected for each boring and analyzed for grain size per NR 512.09(4)(a). However, the 1986 feasibility and 2017 feasibility used other samples for Atterberg limits and laboratory hydraulic conductivity outside the 300-foot perimeter of the proposed vertical expansion fill limits. It is Ayres Associates opinion that the subsurface conditions have been sufficiently characterized in the previous feasibility reports. It is not anticipated that further exploration would result in a different outcome of the subsurface analysis due to consistent subsurface conditions as similarly approved by the WDNR in the 2018 Determination of Site Feasibility letter for the horizontal expansion. There are results identified outside the 300-foot proposed landfill limit that do meet the criteria of the Nr 512.09(4) code. An exemption is requested under NR 512.09 for lack of Atterberg limit results and laboratory hydraulic conductivity per NR 512.09(4(a) and(b). Soil samples are known to have also been collected from MW-2, 3, 3P, 16, 17 and 17P according to the feasibility report submitted by Foth & Van Dyke in 1986. However, some soil samples were not taken at the depth of the well screen for the aforementioned wells as required by NR 507.05(1)(d). MW-19 was installed in 1987; no soil sample information was found for MW-19. Appendix B includes historic soil sampling results of the 1986 and 2017 Feasibility Reports.

Monitoring wells installed as part of the 2017 feasibility were developed according to NR 141.21 using various techniques including surging and purging with a bailer, surged and pumped, or pumped only. Following well development of the four wells installed in 2015, a groundwater sample was collected from each well and analyzed for total suspended solids (TSS) as required in NR 507.07. In addition, the supply water from the Adams County Landfill office supply well that was utilized in the construction of MW-30P was analyzed for the parameters required in NR 507.06(1). Results of the TSS analysis are shown on the well development forms in Appendix C, and the laboratory results are in Appendix E. TSS analytical results could not be found for the remaining wells onsite.

A laboratory hydraulic conductivity analysis was completed on two undisturbed soil samples collected in November 2015. In field hydraulic conductivity tests were conducted in January 2016 on the three water table observation wells and one piezometer installed as part of this feasibility. The locations of all wells are shown in Plan Sheet 2 of Appendix H. Well construction reports for monitoring wells and piezometers are in Appendix C.

Laboratory Analysis

According to NR 512.09(4), a minimum of five representative samples shall be collected from each major soil unit and laboratory analyzed for grain size distribution and Atterberg limits (if appropriate for the soil type). Laboratory hydraulic conductivity tests are required on two undisturbed soil samples from each major fine-grained unit. Data collected onsite indicated that there are four major soil units as classified under the USCS. These soil types consist of poorly graded sands (SP), silty sand mixtures (SM), inorganic silts with fine sand (ML), and inorganic clays with medium to low plasticity (CL). There are also lesser amounts of poorly graded sand with silt (SP-SM), poorly graded sand with clay (SP-CL, SC), silty sands with clay and silt (SM-CL), silty clays with very fine sand (CL-ML), clayey silts of low to medium plasticity (MH), and sandy organic silts and clays (OL). Grain size analysis was completed on a total of 19 soil samples in 2017 and all borings and monitoring wells installed during the 1986 feasibility. The samples were collected from depths of 5 feet bgs to 75 feet bgs, all of which were mixtures of CL, ML, and SM soils from various depths.

In addition to the 2017 samples submitted for grain size analysis, two undisturbed Shelby tube samples were collected outside the vertical expansion limits of filling, for laboratory analysis for hydraulic conductivity. In 1986, two Shelby tubes and five remolded samples were collected outside the proposed vertical expansion limits and analyzed for hydraulic conductivity. The historic laboratory soil testing data is in Appendix B. (See geologic cross-sections in Vertical Expansion Feasibility Report soil distribution.)

Field Analysis

Field analysis required by NR 512.09(4)(d), (e), (f) and (g) includes in-situ hydraulic conductivity testing at each monitoring well, groundwater and surface water elevation measurements (monthly for 6 months and quarterly for one year in accordance with NR 512.09[4]), and at least four rounds of baseline groundwater monitoring. Table 5 summarizes the elevation data collected during the 6 months of baseline monitoring. Historic groundwater water elevations are in Appendix F. Groundwater elevation measurements were collected from all monitoring wells onsite.

In field hydraulic conductivity testing was completed at the site for every monitoring well installed as part of the geotechnical investigation. Field hydraulic conductivity values were measured by conducting slug tests on each well; the slug test measures the rate at which groundwater recharges the well screen. The faster the rate of recharge, the higher the hydraulic conductivity value.

The individual well hydraulic conductivity values were used to calculate an average value for the overall aquifer. This average value is an approximation of the actual hydraulic conductivity. Typically, the more wells that are tested, the better the estimate of the aquifer value.

Using the information obtained during the slug test, the hydraulic conductivity was calculated using Waterloo Hydrologic Aquifer Test Pro v. 2013.1 graphical analysis and reporting software. Ayres Associates staff reviewed the monitoring well construction, aquifer conditions (confined or unconfined), and the slug test data and input the information in the software program and a hydraulic conductivity value was calculated.

Hydraulic conductivity values (recovery test only) calculated for the four water table observation wells installed for the geotechnical investigation ranged from 1.1×10^{-2} cm/sec to 4.6×10^{-4} cm/sec as silty sand with ranging composition of silt and clay deposits. Table 4 reports field tested hydraulic conductivity values and summarizes the slug test parameters for the wells installed as part of this geotechnical investigation. Historic slug test procedures and hydraulic conductivity values for the wells installed for Phases 1 through 4 are in Appendix D, if available. Hydraulic conductivity values that are not on the cross sections or in Appendix D could not be located.

Soil and Bedrock Descriptions

General

Tables shown in above present information regarding compliance with NR 512.09 soil boring requirements. The locations of the borings and monitoring wells are shown in Plan Sheet 2 of Appendix H. Geologic cross-sections showing unconsolidated material and groundwater in profile are presented in Appendix H. Copies of the boring logs installed for this expansion and previous phases are all included in Appendix A.

Soil Borings

No soil borings have been conducted during the vertical expansion feasibility report. However historic soil borings have been conducted to reflect the current conditions of the geology onsite.

The soil borings installed in November 2015 (B-100 through B-106 and monitoring wells MW-29 through MW-31) were performed with a truck mounted Diedrich D-120 rotary drilling rig utilizing continuous flight hollow stem augers. Test borings not completed as monitoring wells were abandoned in accordance with NR 141.25. (See Appendix A for these abandonment forms.) Soil samples were obtained by the Standard Penetration Test (SPT) method in accordance with ASTM D-1586 split barrel procedures. A field geologist under direction of a professional geologist visually classified these soil samples in the field. Grain size distributions, geologic origin, and USCS classifications are in Appendix B.

Bedrock Core

Bedrock was not encountered and therefore bedrock cores were not completed.

Soil and Unconsolidated Material

The Natural Resources Conservation Service (NRCS) mapping indicates the surficial soils onsite consists of Plainfield sands, which are formed on outwash plains, stream terraces and ground moraines and are present on 2-12% slopes. The Plainfield sands are described as excessively drained and are classified as low to very low for water runoff. Infiltration rates/soil permeability are high to very high at the site (mapping indicates 6 to 20 inches per hour). Generally, the soils have low natural fertility.

The subsoils of the proposed expansion consist mainly of glaciolacustrine deposits. Glaciolacustrine deposits consist of fine-grained sediments such as fine sands, silt, and clay which were deposited in glacial lakes. These sediments can be deposited in small layers with little variation of grain size.

This geotechnical investigation revealed that the unconsolidated material is at least up to 75 feet thick. Soil boring logs from the 1986 feasibility reveals that the unconsolidated material is at least 100 feet thick. Onsite soils were evaluated through auger cuttings and split barrel samples collected during 2017 subsurface investigations. Soil boring logs indicate that there are 0 to 8 inches of black topsoil (OL). The unconsolidated materials directly underlying the topsoil are described as light brown to dark brown and reddish yellow fine-medium grained silty sands (SM) interbedded with brown silt (ML) and brown clay (CL). Soils onsite were consistently classified as SM (silty sand mixtures), ML (inorganic silts with fine sand), CL (inorganic clay), and CL-ML (inorganic clay with silt) with a 10-foot-thick layer of sand interbedded with clay (SP-SC) encountered in one boring. The clay units varied in thickness (2-5 feet) and were discontinuous at the site. (See geologic cross-sections in Plan Sheets 4-17 for soil distribution.)

Bedrock

Bedrock does not outcrop at the site, and it was not encountered in any of the soil borings on the site from neither the newly installed borings nor the borings installed for the previous feasibility for Phases 1 through 4. Therefore, depth to bedrock is greater than 100 feet bgs. Well logs for private residences in the area indicate bedrock is greater than 109 feet bgs (Adams County 1986 Feasibility Report). The well record for the private water supply well located 1300 feet southwest of the expansion is 124 feet deep and bedrock is encountered at 115 feet bgs. Area mapping indicates that the bedrock in the immediate vicinity of the site consists of Cambrian-age sandstone (Trempealeau, Tunnel City, and Elk Mound Groups) that can range in thickness up to 440 feet and is underlain by Precambrian igneous and metamorphic rock (Devaul and Green, 1971; Mudrey et al., 1982).

A bedrock outcrop (Cottonville Rocks) occurs approximately 1,200 feet east of the proposed site. This outcrop and other outcrops in the County consist of resistant Upper Cambrian Wonewoc sandstone of the Elk Mound Group (Adams County 1986 Feasibility Report).

Hydrogeologic Properties and Functions

General

A total of four new groundwater monitoring wells (three groundwater observation wells and one piezometer) were installed as part of the 2017 feasibility within 300 feet of the proposed limits of waste. Previously existing monitoring well information was utilized as part of the 2017 geotechnical investigation to fulfill the requirements of NR 512.09. See Section 5.2.2 for the previously existing monitoring wells that were used to document conditions in the proposed expansion area. Monitoring well construction, well development forms, and the well information forms (WIF) are in Appendix C. Well construction forms and WIFs that are not attached in Appendix G could not be located for the previously existing wells utilized for the 2017 geotechnical investigation. Monitoring well locations are shown in Plan Sheet 2 of Appendix H.

Regional Hydrogeology

Regional groundwater flow is southwest to Big Roche A Cri Creek, with approximate groundwater surface elevations ranging 910-960 feet msl (Lippelt, 1981). The groundwater table surface occurs at approximately 935-945 feet msl in the vicinity of the site. Infiltrating precipitation can be expected to travel vertically downward through the soils with slight lateral or diagonal movement along the upper surface of the silt and clay layers until it reaches the local groundwater aquifer. The regional water table is generally encountered in one of two aquifers: a glacial aquifer or a sandstone aquifer.

According to the U.S. Department of Agriculture (USDA), the glacial aquifer consists of outwash deposits with well yields as much as 1,000 gallons per minute (gpm) (USDA, 1980). The sand deposits are easily recharged due to their high permeability. Onsite, the deposits are classified as lacustrine. Due to the finer deposits associated with these types of deposits, well yields may be less locally.

The sandstone aquifer consists of fine to coarse grained Cambrian aged sandstone. Well yields from the sandstone aquifer range from 100 to 500 gpm (USDA, 1980). Groundwater in the basin is recharged by precipitation and by induced recharge from surface water bodies.

Regional groundwater elevation and flow information generally correlates to site-specific information measured and/or gathered from the monitoring well network at the site.

Site Specific Hydrogeology

The water table contour maps (Plan Sheets 18 and 19) indicate that the groundwater flows from the expansion area generally to the northwest towards Big Roche A Cri Creek. Depending on surface elevation, groundwater is encountered at approximately 25-45 feet bgs (elevation approximately 935-950 feet msl) within the unconsolidated aquifer. The aquifer is characterized as fine sand of lacustrine origin and laterally extensive throughout the expansion area. No confining layers have been identified and the aquifer is also vertically continuous. Small, alternating lenses of sand/silt layers were noted and typical in a lacustrine environment. Plan sheets 18 and 19 present the groundwater contours for high (September 2019) and low (December 2015) groundwater conditions, respectively. The local water table elevation has historically varied as much as approximately 16 feet over the period of monitoring for the existing landfill site. A significant rise in groundwater elevation over the life of the site has been observed. During the groundwater high conditions (September 2019) and subsequent sampling events, all of the twenty monitoring well screens were submerged. Plan Sheet 19 shows that under the groundwater low conditions (December 2015), only one of the twenty monitoring well screens was submerged and not utilized for determining groundwater contours. Although there is some variation in the direction of groundwater flow between high and low conditions, the overall direction of a west/northwest flow is consistent. Groundwater recharge occurs up gradient and across the expansion area with discharge likely occurring at Big Roche A Cri Creek, the local groundwater discharge point.

Groundwater within the existing footprint travels generally northwesterly beneath the existing landfill and discharges northwest of the site. Table 5-3 presents the groundwater elevation data collected during the 2016 feasibility monitoring. The high elevation for each well measured during the 2016 Feasibility Study is designated in bold text in Table 5-3. Utilizing groundwater elevations measured during the feasibility study on February 25, 2016, from MWs 1, 3, 7, 16, 17, 19, and 30, the groundwater horizontal gradient beneath the entire site ranges from 0.004 to 0.006 feet/feet with only an approximate 9-foot groundwater elevation change across the site. Within the 2016 expansion area, the groundwater horizontal gradient ranges from 0.002 feet/feet to 0.009 feet/feet with an approximate 4-foot groundwater elevation change. The average horizontal gradient is 0.005 feet/feet and the hydraulic conductivity values are 1.4×10^{-3} cm/sec to 2.1×10^{-2} cm/sec as determined by the slug testing completed on the monitoring wells. Utilizing Tables 4.4 and 4.11 of Fetter, 1994, the effective porosity range was determined as 0.02 to 0.15. The horizontal gradient coupled with the groundwater aquifer hydraulic conductivity values measured during the slug testing and effective porosity range equates to a groundwater flow seepage velocity range from 0.13 to 7.80 foot/day. Table 5-4 presents the results of the field hydraulic conductivity testing conducted as part of the geotechnical investigation, while historic hydraulic conductivity data for the existing wells onsite is located in Appendix J. Table 5-5 presents the seepage rate calculations.

Vertical gradients were calculated using elevation measurements collected from the February 25, 2016, sampling round from observation well/single piezometer well nests associated with the proposed expansion. These included well nests MW-2/2P, MW-3/3P, MW-17/17P, MW-19/19P, and MW-30/30P. A review of the values calculated indicate that all five of the well nests show a downward gradient, with the largest gradient in MW-17/17P (0.2124 foot/foot) and an average gradient of 0.1297 foot/foot. These results generally confirm that the site is a groundwater recharge area. Vertical gradients calculated from the EPA vertical gradient calculator for these wells are in Table 5-6.

Horizontal and vertical flow nets were prepared based on the groundwater gradient information and are presented in Plan Sheets 20 and 21. Groundwater elevation data for the horizontal flow net are summarized in Table 5. The flow nets show horizontal and vertical flow direction; however, they are not suitable for quantitative calculations. The flow nets suggest that the high ground to the east is a groundwater recharge area, and that groundwater discharge occurs generally westerly of the site. In general, the flow nets are based on simplified assumptions that the groundwater flow environment is homogenous and isotropic. The flow net is used as a model to generally understand groundwater flow at the site.

Regional Groundwater and Surface Water Quality

Groundwater

Groundwater quality is generally good throughout the Central Wisconsin River Basin although there may be some isolated issues with excessive iron, hardness, and total dissolved solids. In much of the sand plain, groundwater is soft and low in dissolved solids, especially near the Wisconsin River (Devaul and Green, 1971).

In general, total dissolved solids are found in moderate amounts and rarely exceed the recommended limits for drinking water (500 mg/L). The hardness of groundwater in the basin ranges from 18 mg/L to 568 mg/L and becomes softer toward the Wisconsin River. Chloride and sulfate concentrations are well below the recommended limits for drinking water (250 mg/L) (Devaul and Green, 1971).

High nitrate levels cause minor water use issues in the basin. High nitrate levels in groundwater are common in the basin in agricultural areas where manure spreading, agricultural fertilizers, and legume cropping systems are used, as well as in sandy areas where the soil is more permeable (WDNR, 2011).

Surface Water

Surface water quality in the basin is generally good. Most of the dissolved minerals in surface water are the same as those in groundwater, but are usually less concentrated (Devaul and Green, 1971).

The concentration of dissolved solids in the Wisconsin River itself ranges between 85 mg/L to 280 mg/L. Hardness concentrations range from 20 mg/L to 100 mg/L. The lowest concentrations occur slightly after periods of peak flow, whereas highest concentrations occur during times of low flow (Devaul and Green, 1971).

Site Specific Surface Water and Groundwater Quality

Surface Water

There is no surface water in the immediate vicinity of the site. The nearest surface water is Big Roche A Cri Creek, approximately 1 mile to the northwest.

Historic Groundwater Quality

Historic groundwater quality data exists for the existing landfill site starting in 1987, with quarterly data available from approximately 1987 through 1994 and semiannual from 1995 to present. The WDNR reduced the required monitoring frequency to semiannual in 1994. The groundwater monitoring for the current landfill occurs in March and September. Sampling conducted since the May 7, 1995, Plan of Operation approval included twenty-one monitoring wells (MW-1, 1P, 2 2P, 3, 3P, 6, 6P, 7, 7P, 9, 16, 17, 17P, 18, 18P, 19, 19P, 20, 21, and 22). Four additional monitoring wells onsite, associated with the recycling facility (MW-25, 26, 27, and 28), are monitored semi-annually only for groundwater elevation as approved in the 1994 Modification to the Plan of Operation.

The groundwater is encountered in the unconsolidated material of the glacial aquifer across the site. The new wells installed as part of the 2017 feasibility (MW-29, 30, 30P, and 31) have been included as part of the semi-annual monitoring program.

In 1995, the groundwater quality for the landfill monitoring system was evaluated as part of the required Subtitle D groundwater plan modification. The full evaluation is in the August 1994 plan modification, which was approved in May 1995. In general, the plan modification included an evaluation of monitoring data for groundwater quality standard exceedances and calculation of PALs.

PAL values calculated were either approved or modified in a WDNR plan modification approval dated May 7, 1995. PALs were calculated for indicator parameters including filtered alkalinity, filtered chemical oxygen demand (COD), field conductivity at 25° C, and filtered total hardness.

PALs have been calculated, and approved, for the four new monitoring wells in the monitoring program (MW-29, MW-30, MW-30P, and MW-31) for the indicator parameters of alkalinity, field conductivity, and hardness.

A summary of the landfill monitoring data is available on the WDNR GEMS website, and a copy of the May 7, 1995, modification to the Plan of Operation approval including calculated PALs for landfill monitoring is in Appendix G. PAL calculations for the four new monitoring wells and approval of the 2018 Plan of Operations are also in Appendix G.

Baseline Groundwater Quality for the Vertical Expansion

Per the requirements of NR 507.18, baseline groundwater quality must be established. During the Phase 5 and 6 feasibility study, all required rounds of baseline groundwater quality samples were collected at the four new wells (MW-29, 30, 30P, 31) installed as part of the proposed expansion. Baseline parameters that did not appear to be analyzed or reported on the WDNR GEMS database for the previously existing monitoring wells being utilized for the expansion area were also sampled until all required baseline sampling was completed. The samples were analyzed for applicable parameters listed in NR 507.18 Tables 1, 2, and 3. A summary of the inorganic and organic baseline sampling results is in Table 6. All onsite monitoring wells sampling results have been summarized, but it is noted which wells were being utilized as part of the 2016 feasibility monitoring. No baseline sampling was recorded on GEMS for MW-20, MW-21, and MW-22. These wells are associated with the C&D Landfill that was in operation from 1989-2004. These wells are being utilized in this feasibility report only for better site analysis of physical parameters, such as groundwater elevations and flow direction, and subsurface geology descriptions.

No volatile organic compounds (VOCs) were detected as part of the 2016 feasibility sampling. Sporadic detects of low-level VOCs, primarily benzene, have been detected throughout the routine monitoring. Trends have never been established and most likely the VOC detects were from ambient air exhaust from the heavy equipment in operation at the landfill.

In general, the groundwater quality in the Phase 5 and 6 expansion area as reported during the 2016 feasibility study ranges from soft to very hard water. The 2016 hardness results from the four installed wells generally ranged from 80 mg/L to 289 mg/L, with the highest concentrations noted in MW-31. The hardness results from the last eight (8) rounds of semiannual sampling (2018-2021) at the same four wells range from 72.5 to 249 with the highest concentration again in MW-31. Historic sampling of the previously installed wells indicates that hardness over the entire expansion area ranges from as low as 37 mg/L (MW-17P sampled in December 1996) to as high as 835 mg/L (MW-3P sampled in June of 1994).

Testing for pH and conductivity indicated relatively neutral groundwater and low total dissolved solids content. Through the 2016 feasibility study, values of pH ranged from 6.6 to 9.5, with values reaching a low of 6.06 at MW-2 in March 1991. These values were not indicative of any water quality issues. Values of pH from the last 8 rounds of semi-annual sampling (2018-2021) report a low of 6.26 at MW-17P in September of 2018 and 7.9 in September of 2020 in MW-9.

Conductivity during the 2016 feasibility study, which is a relative measure of the dissolved ions present in the groundwater, was generally low, with values from the four newly installed wells ranging from approximately 110 to 417 µΩ/cm. Historic sampling of the previously installed wells indicates that the conductivity over the entire expansion area ranged from as low as 22 µΩ/cm (MW-17 in June 1988) to a high of 1791 µΩ/cm (MW-19 in March 2016). Values of conductivity over the last 8 rounds of semi-annual sampling (2018-2021) range from 107 µΩ/cm (MW-17 in March of 2019) to 1860 µΩ/cm (MW-22 in September 2019). These most recent data do not represent a significant change in the range of values compared to historical results.

The required rounds of baseline monitoring conducted in 2016 detected elevated levels of lead, vanadium, and manganese. A brief discussion of each parameter exceeding a PAL or ES is provided in the following paragraphs.

Manganese

Manganese was detected above the PAL in piezometer MW-30P during the December 17, 2015, sampling round. Historically, groundwater monitoring onsite showed elevated background concentrations of manganese at MW-3P, 6P, 7P, and 18P. Detectable background levels in the Phase 5 and 6 expansion area ranged from 0.0018 mg/L (MW-3) to 0.0292 mg/L (MW-30P) and are within the historic range of detection at the site prior to waste filling. This would indicate that the manganese detects are naturally occurring and represent background water quality.

According to the U.S. Department of Health and Human Services, manganese is a naturally occurring substance found in many types of rock and soil. Manganese concentrations can therefore vary greatly from well to well. Detectable background levels in the expansion area range from 0.0018 mg/L (MW-3) to 0.0292 mg/L (MW-30P). For the most recent baseline sampling, the PAL exceedance of manganese occurred only once during the feasibility baseline water quality testing and does not indicate groundwater quality issues.

Vanadium

Vanadium was detected above the PAL in monitoring well MW-30 during the December 17, 2015, sampling round. Common sources of vanadium in groundwater include dissolution of vanadium-rich rocks (such as mafic and andesitic rocks) and waste streams from industrial processes (Wright and Belitz, 2010). Neither of these sources is a likely source for the detects of vanadium in MW-30; it is located in an up-gradient position of current landfill activities and the soils are lacustrine in nature. Only one exceedance has been detected at this location and it does not represent any pattern of detects indicative of contamination. Subsequent monitoring at this location has resulted in one low level detect of vanadium, but no further PAL exceedances. The exceedance appears to be an anomaly and is not landfill related.

Lead

Lead was detected at levels above a regulatory standard during the 2016 feasibility study at monitoring wells MW-3, MW-3P, MW-17P, MW-30 and MW-31. Only one PAL exceedance was detected at MW-3, MW-3P, and MW-17P. Three PAL exceedances were noted at MW-30, and only one ES exceedance has been noted at MW-31. The following is a discussion on the repetitive exceedances:

> <u>MW-30</u>
> MW-30 is located near the eastern half of the phase 5 and 6 expansion area. There were three detects of lead at MW-30: the first during the December 2015 sampling round, the second during the February 2016 round, and the third during the June 2016 round. All three detects of lead (4.5, 2.6, and 1.8 µg/L respectively) exceeded the PAL of 1.5 µg/L.
>
> <u>MW-31</u>
> MW-31 is located in the southeast corner of the Phase 5 and 6 expansion area. Lead exceeded the ES during the first sampling round at MW-31. Only one lead detect has been noted at MW-31. This detect (97.9 µg/L) exceeds the ES (15 µg/L). Subsequent sampling at this location was no detect for lead. This exceedance at MW-31 appears to be an anomaly as confirmed by the following seven sampling rounds.

According to a study completed by the University of Wisconsin Stevens Point Center for Watershed Science and Education, Adams County Landfill is in a region of Wisconsin where lead in groundwater has been found to be 15 µg/L. In the southern region of Adams County, lead was found in the range of 26-50 µg/L. However, Kevin Masarik, Groundwater Education Specialist, and lead of this study, indicated that these elevated detections of lead are likely a result of lead in the plumbing system of the residences in which the water samples were analyzed from, rather than directly from the groundwater.

As noted above, lead exceeded the PAL at other locations in addition to MW-30 and MW-31 both up and side gradient of the Phase 5 and 6 expansions. Historic sampling of lead from MWs 1, 1P, 2, 2P, 3, 3P, 6, 6P, 7, 7P, 9, 16, 17, 17P, 18, 18P, 19, and 19P from July 1986 to September 1987 indicates that background levels of lead around the site is <5 µg/L (See Table 6 for background and baseline sampling summary).

The groundwater quality evaluation indicated similar quality over most of the Phase 5 and 6 expansion area, with little variation with depth of groundwater and few groundwater exceedances. Based on the eight rounds of the 2016 feasibility data, it appears slightly degraded water quality may be present in the vicinity MW-31. Hardness and conductivity were slightly elevated at MW-31 when compared to other three wells in the Phase 5 and 6 expansion area. The cause for the slight degradation in groundwater quality is not known but appears consistent through the additional rounds of sampling since 2016. The laboratory results from the eight rounds of monitoring associated with the horizontal expansion (Phases 5 and 6) are in Appendix E.

Conclusion and Recommendations

It is Ayres Associates opinion that the subsurface conditions have been sufficiently characterized in the previous feasibility reports. It is not anticipated that further exploration would result in a different outcome of the subsurface analysis due to consistent subsurface conditions as similarly approved by the WDNR in the 2018 Determination of Site Feasibility Letter for the horizontal expansion. Ayres Associates requests approval of this Alternative Geotechnical Investigation Program for the proposed Vertical Expansion at the Adams County Landfill.