Biosparge Remediation System Plan

Agrium US, Inc.
Kenai Nitrogen Operations

Prepared by

Cook Inlet Environmental, Inc.

June 23, 2022

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1.0 Introduction

This plan defines the objectives, design, standards, and procedures for the installation of a biosparge remediation system at the south complex unconfined and semiconfined groundwater aquifer nitrogen plumes at the Agrium Kenai Nitrogen Operations Plant (KNO). KNO is located on the shoreline of Cook Inlet within the North Kenai industrial area as shown on Figure 1.

This plan was prepared by Jene' Worley, Principal Chemist, Cook Inlet Environmental, Inc, 612 Laurel Drive, Kenai, AK 99611 (a third party, Qualified Environmental Professional as defined by 18 AAC.75.333) on behalf of Meghan Teegarden, Senior Environmental Advisor, Agrium US Inc (a Responsible Person).

The plan has been prepared in accordance with the requirements listed in 18 AAC 75.360 for a modified remediation system.

2.0 Objectives

The primary objective of installing a biosparge system at KNO is to accelerate mass removal of ammonia, through naturally occurring aerobic degradation processes, in the southern plume area of the site.

Agrium is undertaking this initiative to supplement its approved corrective action, monitored natural attenuation (MNA). Although MNA continues to be effective at mitigating risk to potential downgradient receptors in Cook Inlet, Agrium has opted to invest in accelerated cleanup of ammonia as a way to reduce the duration of long-term liability at the site overall.

3.0 Site History & Current Regulatory Status

KNO Facility activities are tracked in the Alaska Department of Environmental Conservation (ADEC) contaminated sites database under file number 2323.38.032 and Hazard ID numbers 465 and 1008.

In consultation with, and under approval from the ADEC contaminated sites program, KNO has completed extensive subsurface investigations, hydrogeologic studies, fate and transport modelling, human and ecological risk assessment, conceptual site model development, feasibility studies, an air-sparge pilot study, a remedial action plan, and a long-term groundwater monitoring program which dates back to 1974.

In 2006, ADEC Contaminated sites issued a decision that site characterization is complete, the conceptual site model is sufficiently developed, and that remedial alternatives have been reasonably considered in terms of effectiveness and cost. The decision concluded that effective implementation of monitored natural attenuation (MNA) sufficiently mitigates the risk to downgradient human and ecological receptors at potential exposure points located at the high tide line of Cook Inlet within a reasonable time frame.

Annual groundwater monitoring results collected since 2006, have continuously documented that MNA is working effectively through multiple lines of evidence as follows:

- Exponentially decreasing trends for urea sitewide that correspond with transient increases in microbially mediated urea hydrolysis products, including ammonium and carbonate.
- Upon formation, ammonium and carbonate have shown exponentially decreasing trends which correspond with increases in ammonia nitrification products including nitrite, nitrate, and decreased pH.
- Site wide pH decreases have resulted in groundwater arsenic concentrations that have attenuated to levels that are at or below the marine water quality standard (30 ppb) at the high tide line of Cook Inlet.

While downgradient receptors are currently protected under MNA, Agrium is seeking to proactively invest in mass reduction of residual ammonia in the upgradient portions of southern plume area. This investment is expected to ultimately accelerate the time frame for reaching the default water quality standard of 1 mg/L ammonia-N at the Cook Inlet high tide line, which would in turn reduce the duration of Agrium's long-term liability for the site.

4.0 Biosparge System Design

The biosparge system is designed in accordance with the standard approach outlined in the EPA commissioned Air Sparging Design Paradigm (Battelle 2002). Table 1 summarizes the key design parameters for the air injection system along with the specifications for its components.

Air sparge system components include a compressor, heatless dryer, and receiver tank capable of delivering compressed air at a pressure-dewpoint of -40 degrees C at 120 psi. Instrument air transmission lines will be used to feed two distribution manifolds that will meter and control flow and pressure to each injection well.

Figure 5 shows the construction details of the air injection manifolds. One manifold will inject air into seven sparge wells installed in the unconfined aquifer (UA) wells at screen depths 80 feet below ground surface (BGS). The second manifold will inject air into semi-confined aquifer (SCA) at screen depths 140 feet BGS.

5.0 Well Installations

Figures 2 and 3 are layout maps showing the locations of the new air sparge wells and both new and existing monitoring wells in the UA and SCA. Figure 4 is a cross section of the southern plume area showing the ammonia plume, and the locations, screen depths and lengths of the injection and monitoring wells within the proposed treatment areas.

5.1 Well Placement and Design

Air sparge well locations have been selected in upgradient portions of the unconfined and semi-confined ammonia plumes which exhibit ammonia levels exceeding 300 mg/L.

Air sparge well screen lengths are 5 feet, as specified in the standard recommendations of the EPA Design Paradigm. The Paradigm also notes that the air sparge screen lengths have no effect on air distribution within an aquifer, rather that air distribution is strictly a function of the top of screen depth, and the properties of the aquifer media.

Injection well screen depths were selected based on vertical distributions of ammonia-N. Multi-level sampling completed during site characterization demonstrates that ammonia-N concentrations uniformly distribute over the entire 20-foot thickness of the UA in the upgradient portions of the southern plume. The SCA southern plume similarly exhibits a uniform distribution of ammonia-N along the top 40 feet, but then shows a significant decrease in ammonia-N concentrations at 60 feet below the potentiometric surface. Based on these patterns, which are shown on Figure 4, both air sparge and performance monitoring wells were screened to depths of 80 feet in the UA and 140 feet in the SCA.

New monitoring well locations downgradient of the air sparge wells were selected to allow the establishment of ammonia-N removal trends within the 18-month project operation timeframe. Monitoring wells have been placed downgradient of the air sparge wells at distances outside the radius of influence of the air injection points, but at distances expected to produce preliminary indications of ammonia-N mass removal within 120 days of startup. Groundwater apparent velocities calculated for the UA and SCA are shown on Tables 2 and 3 respectively.

6.0 Well Construction, Development & Surveying

Discovery Drilling Inc. of Anchorage, Alaska was contracted to install the 24 new wells at KNO. A truck mounted, CME Model 850, rotary table drilling rig equipped with 4-inch stainless steel Heisman Well Technology (HWT) tooling was mobilized to the site on May 4, 2022, and drilling was completed on May 29, 2022. All wells were installed and developed in accordance with the ADEC Monitoring Well and Construction Guidance updated November 2008.

Well development consisted of surging and pumping using a portable Grundfos ½ horsepower submersible pump. At least ten casing volumes of water are purged from each well and pumping is continued until water clarity is observed.

The new wells will be surveyed using Real Time Kinematic Global Positioning Satellite (RTK-GPS) with baseline corrections from four on-site control monuments. Base setup will use 1Hz NTRIP corrections from the Soldotna AC23 Caster. This method produces centimeter level accuracy for both horizontal and vertical positioning.

7.0 Groundwater Monitoring

Groundwater monitoring will consist of baseline monitoring and performance monitoring and will be conducted or supervised by a third party Qualified Environmental Professional in accordance with 18 AAC 75.360. Table 4 is a groundwater monitoring schedule.

Monitoring will be conducted in accordance with standards and procedures outlined in the approved KNO Groundwater Sampling and Analysis Plan (SAP) updated through January 2009, and the Quality Assurance Project Plan for APDES and Groundwater Monitoring (QAPP) updated through December 2017.

7.1 Baseline Monitoring

Baseline monitoring will consist of field measured water level, dissolved oxygen, temperature, pH, sampling, and laboratory analysis of urea, ammonia, nitrite, and nitrate. Baseline monitoring will be performed on all thirty-one (31) new and existing wells within the south plume area unconfined and semiconfined aquifers. Baseline monitoring results will be used to designate and finalize the preliminary air sparging and monitoring configurations shown on Figures 2 through 4.

7.2 Performance Monitoring

After startup of the air injection system, performance monitoring will be completed for thirteen (13) designated UA monitoring wells and six (6) designated SCA monitoring wells. Performance monitoring will consist of semi-monthly field measured dissolved oxygen, temperature, ammonia, nitrite, and nitrate, and quarterly sampling and laboratory testing for urea, ammonia, nitrite, and nitrate.

8.0 System Performance Assessment

The system is planned to operate through the end of 2023. At this time, baseline and performance monitoring results will be used to calculate dissolved oxygen transfer rates, ammonia mass removal rates, and degradation product formation rates relative to baseline conditions. Agrium will use this information to assess the system's effectiveness, along with its capital and operating costs to determine if this investment has merit.

9.0 Project Schedule

The following schedule shows the principal project tasks numbered in order of their dependencies, estimated start and end dates, and the current progress status of each.

Task No.	Description	Estimated Start Date	Estimated End Date	Progress Status
1	System Design & Engineering	4/7/22	5/10/22	Complete
2	Procure & Receive Materials & Equipment	5/1/22	6/18/22	Complete
3	Construction	5/4/22	Pending	Stopped, pending regulatory approval.
4	Baseline Monitoring	7/1/22	7/4/22	Pending
5	Startup	7/5/22	7/5/22	Pending
6	Performance Monitoring	7/12/22	12/30/23	Pending
7	Operation & Maintenance	7/5/22	12/30/23	Pending
8	Document Project, Evaluate Data, Optimize Operation, Assess overall effectiveness.	7/5/22	12/30/23	Pending

10.0 Reporting

A report will be submitted to ADEC contaminated sites on or before 12/1/2023, which will include the air injection system and well as-builts, results of baseline and performance monitoring, system operation and maintenance records, and an overall assessment of the performance and effectiveness of the system.

11.0 References

(Battelle 2002) - Air Sparging Design Paradigm, A. Leeson, P. Johnson et.al, Battelle, Columbus, Ohio, August 12, 2002.

Groundwater Sampling and Analysis Plan (SAP), Cook Inlet Environmental Inc., Kenai, Alaska, updated through January 2009.

Quality Assurance Project Plan for APDES and Groundwater Monitoring (QAPP), Cook Inlet Environmental Inc., Kenai, Alaska, updated through December 2017.

Tables

Table 1

Biosparge System Design Basis & Specifications

Agrium KNO

Aquifer characteristics	Design Parameter:	Unconfined Aquifer	Semi-confined Aquifer
Groundwater apparent velocity (K_{sat}) (ft/day):		2	0.146
Aquifer pH range (su):		5.5-9.5	8.0-9.5
Aquifer Temperatures (deg C)		9-12	6-8
Aquifer Thickness (ft):		9-22 feet	75-85 feet
Treatment area (NH_3-N >300 ppm):		65,000 ft^2	36,000 ft^2

Target aerobic nitrification conditions:	Unconfined Aquifer	Semi-confined Aquifer
pH:	7.5-8.0	7.5-9.0
Minimum Temperature (deg C):	7	5
NH_3-N treatement area concentrations (mg/L):	100-865	20-390
Urea-N treatment area concentrations (mg/L):	10-180	10-65
DO Saturation (mg/L):	6.8-8.4	6.8-8.4
Aerobic nitrification rates (λ)($days^{-1}$):	0.6 - 0.7	0.6-0.7

Air sparge well design basis:	Unconfined Aquifer	Semi-confined Aquifer
Well depths (feet below ground):	72-79	140
Well diameters (in):	2	2
Screen length (ft):	5	5
Screen size (in):	0.010	0.010
Screen depth (below water):	15-20	25-30
Well back pressure (psig):	7-10	12-15
Nominal single well airflow (scfm):	6	10
Max single well airflow (scfm):	8	12
Estimated single well radius of influence (ft):	10-22	18-32

Air Compressor Sizing Estimates:	Unconfined Aquifer	Semi-confined Aquifer	Combined Demand (scfm)	IR 30 HP Compressor Supply (scfm)	Atlas 50 HP Compressor Supply (scfm)
Number of air sparge wells (S. Plume):	7	6			
Nominal flow @ 100 psig (scfm)	42	60	102	106 (73% duty)	106 (25% duty)
Max flow @ 100 psig (scfm):	56	72	128	130 (87% duty)	130 (45% duty)
Nominal working pressure (psig):	100	100			
Max working pressure (psig):	125	125			

Table 2
Hydrogeologic Parameters - Unconfined Aquifer
Agrium U.S., Inc. - KNO Plant

S. Plume Sparge Area - Gradients

Location	Gradient (ft/ft)	Test Date
MW-30 to MW-23R	0.0052	2021
MW-28 to MW-29	0.0049	2021
MW-19 to MW-8R	0.0101	2021
Average:	**0.0068**	

Well ID	Hydraulic Conductivity (ft/day)	Test	Test Date
MW-19	15	Distance drawdown	2003
MW-20	5.4	Single well recovery	1992
MW-8	0.8	Single well recovery	1992
MW-5R	1.3	Single well recovery	1992
MW-2	0.6	Single well recovery	1992
MW-3	1.6	Single well recovery	1992
MW-18A	4.3	Single well recovery	1992
MW-11	1.4	Single well recovery	1992
Average:	**3.8**		

Location	Apparent Velocity (K_{sat})(ft/day)	Test	Test Date
MW-30 to MW-23R	0.0069	Calculated	2021
MW-28 to MW-29	0.0066	Calculated	2021
MW-23R to MW-24	2.0	Sodium bromide tracer	2005
MW-19 to MW-8R	0.15	Calculated	2021
Average:	**0.54**		

Table 3

Hydrogeologic Parameters - Semiconfined Aquifer

Agrium U.S., Inc. - KNO Plant

S. Plume Sparge Area Gradients

Well ID	Gradient (dh/dx) (ft/ft)	Test Date	Estimation Method
MW-45 to 46	0.012	2021	Gauging data
MW-46 to 48	0.011	2021	Gauging data
MW-48 to 32	0.026	2021	Gauging data
MW-32 to 35R	0.011	2021	Gauging data
Average:	**0.015**		

SCA Hydraulic Conductivity Estimates

Well ID	Hydraulic Conductivity (K)(ft./day)	Test Date	Estimation Method
TW-2	29	1967	Distance drawdown pumping test.
TW-3	29	1967	Distance drawdown pumping test.
TW-4	26	1967	Distance drawdown pumping test.
MW-46	2.5	2005	ASTM-D2434
MW-46	28	2005	ASTM-D2434
MW-46	0.51	2005	ASTM-D2434
MW-47	1.9	2005	ASTM-D2434
MW-47	3.3	2005	Mean of 3 replicate slug tests.
MW-50	2.0	2005	ASTM-D2434
MW-50	5.0	2005	Mean of 2 replicate slug tests.
MW-50	6.9	2005	ASTM-D2434
MW-51	0.6	2005	ASTM-D2434
MW-51	1.5	2005	Mean of 2 replicate slug tests.
MW-51	11.3	2005	ASTM-D2434
MW-51	0.1	2005	ASTM-D2434
Average:	**9.8**		

S. Plume Sparge Area Apparent Velocities

Well ID	Apparent Velocity (Ksat)(ft/day)
MW-45 to 46	0.115
MW-46 to 48	0.112
MW-48 to 32	0.253
MW-32 to 35R	0.103
Average:	**0.15**

Table 4

Groundwater Monitoring Schedule

Agrium Kenai Nitrogen Operations - Biosparge Project

Well ID	Aquifer	Monitoring
MW-19	UA	B, P
MW-24	UA	B, P
MW-29	UA	B, P
MW-30	UA	B, P
MW-65	UA	B, P
MW-65	UA	B, P
MW-67	UA	B, P
MW-68	UA	B, P
MW-69	UA	B, P
MW-71	UA	B, P
MW-72	UA	B, P
MW-73	UA	B, P
AS-23R	UA	B
AS-60	UA	B
AS-61	UA	B
AS-62	UA	B
AS-63	UA	B
AS-64	UA	B
AS-66	UA	B
MW-46	SCA	B, P
MW-48	SCA	B, P
MW-32	SCA	B, P
MW-33	SCA	B, P
MW-34	SCA	B, P
MW-80	SCA	B, P
MW-82	SCA	B, P
AS- 70	SCA	B
AS-74	SCA	B
AS-75	SCA	B
AS-76	SCA	B
AS-77	SCA	B
AS-81	SCA	B
AS-83	SCA	B

Notes:

UA Unconfined aquifer

SCA Semiconfined aquifer

B Baseline monitoring will consist of a single montoring event prior to startup of the air sparge system. Monitoring will include both field and laboratory measurements of ammonia, nitrate, nitrite, pH, and dissolved oxygen concentrations.

P Performance monitoring will include semi-monthly, field measured ammonia, nitrate, nitrite, pH, and dissolved oxygen, and quarterly sampling and laboratory analysis of ammonia, nitrate, and nitrite.

Figures

VICINITY MAP NOT TO SCALE

NORTH

0 800 1600 Ft.

FIGURE 1

Site Location Map

AGRIUM U.S., INC.
KENAI NITROGEN OPERATIONS PLANT
KENAI, ALASKA

Cook Inlet Environmental Inc.

DATE August 2018
CHKD
DRAWN AC

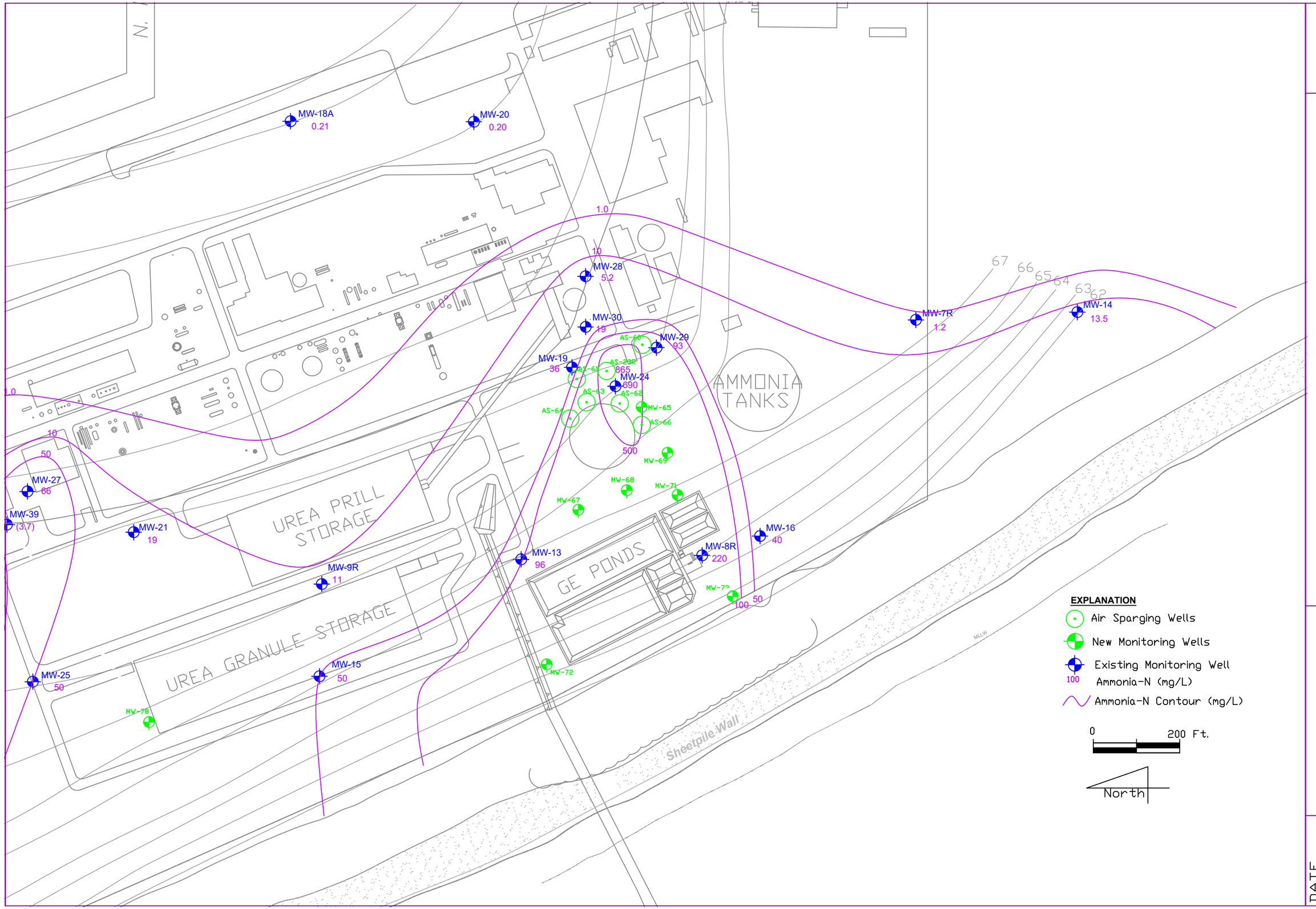

FIGURE 2

well Layout
Unconfined Aquifer

AGRIUM US, INC.
KENAI NITROGEN OPERATIONS PLANT

Cook Inlet Environmental, Inc.

DATE July 2021
CHKD JW
DRAWN LG

A′
MW-18B
0.93
31
30
29
28
27
26
25
24
23
22
21
20
19
18
17
16
15
14
MW-47
1.03
1.0
MW-45-120
0.74
10
MW-46
14.0
AMMONIA
TANKS
MW-48-120
31
AS-75
AS-74
AS-70
100
MW-34
119
AS-77
AS-76
MW-32
390
GE PONDS
AS-83
MW-82
AS-81
MW-80
MW-33
130
MW-35R
15.2
A
UREA PRILL
STORAGE
EA GRANULE STORAGE
MW-79
Sheetpile Wall
MLLW
MW-36R
0.27
MW-37R
0.13
0
200 Ft.
North
EXPLANATION
Semiconfined Sparging Well
Existing Semiconfined Monitoring Well
New Semiconfined Monitoring Well
100 Ammonia-N (mg/L)
Ammonia-N Contour (mg/L)
Potentiometric Surface Contour

FIGURE 3

Well Layout
Semi Confined Aquifer

AGRIUM US, INC.
NITROGEN OPERATIONS PLANT
KENAI NITROGEN OPERATIONS

Cook Inlet Environmental, Inc.

DATE June 2022
CHKD JW
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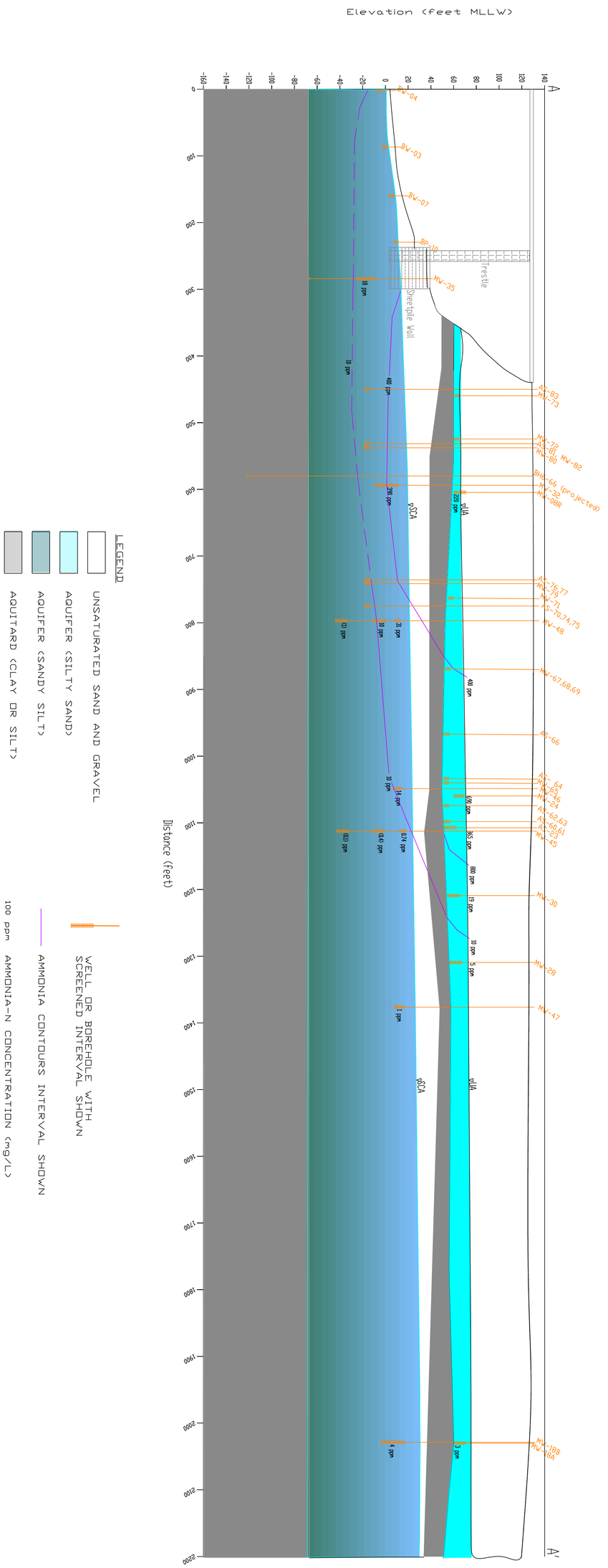

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June 2022
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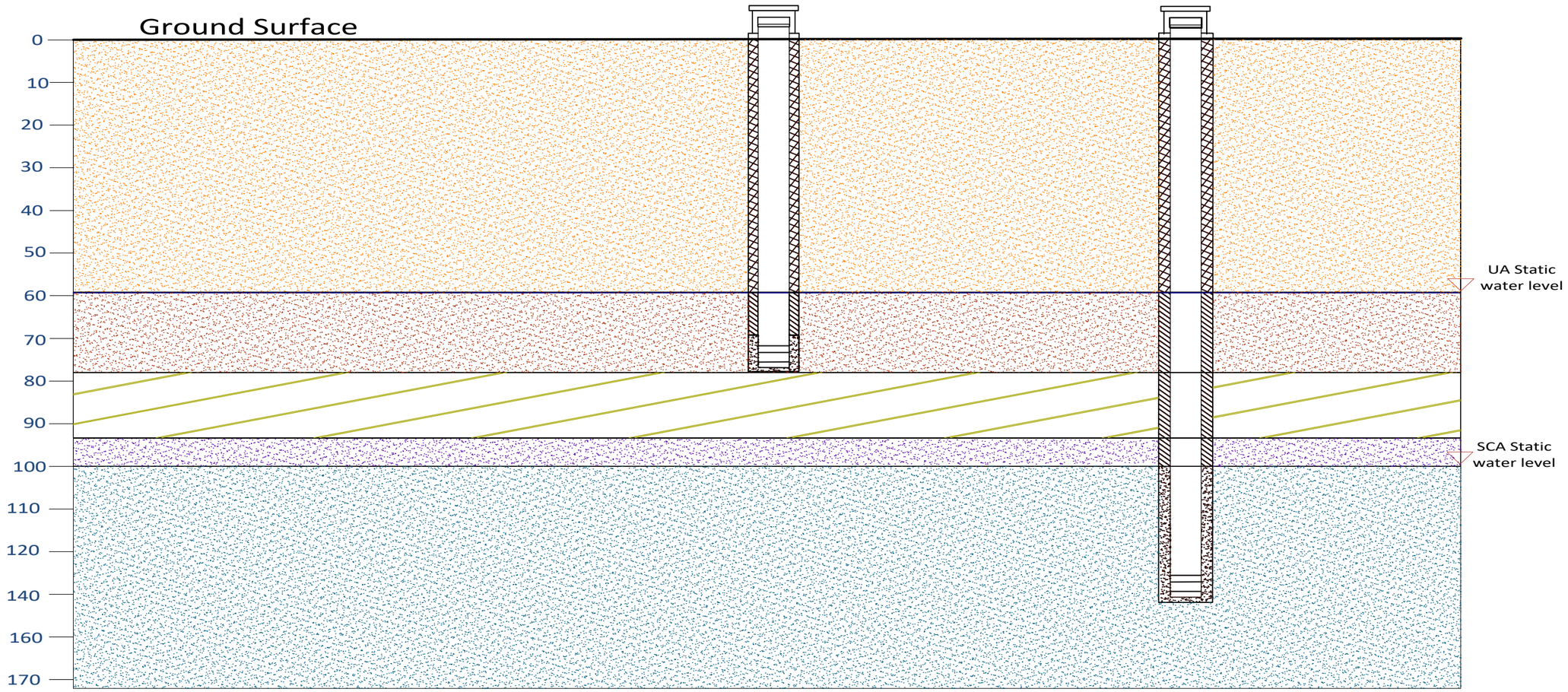
JW
DRAWN
LG

Cook Inlet Environmental, Inc.

Cross Section
South Complex Area

AGRIUM US, INC.
KENAI NITROGEN OPERATIONS PLANT

FIGURE
4



Well Completion

- Volclay Grout
- Hydrated Bentonite (Pel Plug)
- Sand Pack

Lithology

- Vadose Zone (Medium to Coarse Sand and Gravel)
- Unconfined Aquifer (Medium to Course Sand)
- Main Aquitard (Clay)
- SCA Unsaturated (Fine Sand)
- SCA Saturate (Fine Sand w/ Silt)

FIGURE 5

Well Construction Details

AGRIUM US, INC.
KENAI NITROGEN OPERATIONS PLANT

Cook Inlet Environmental, Inc.

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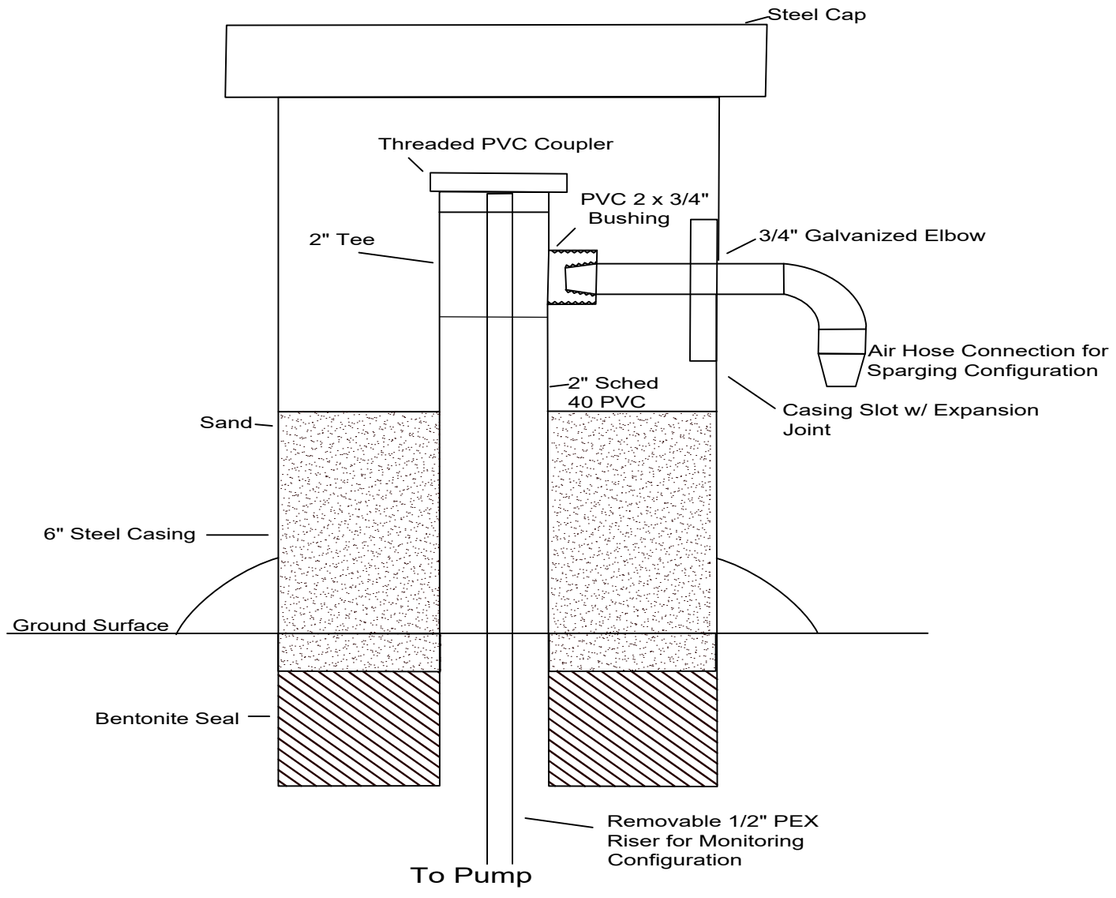
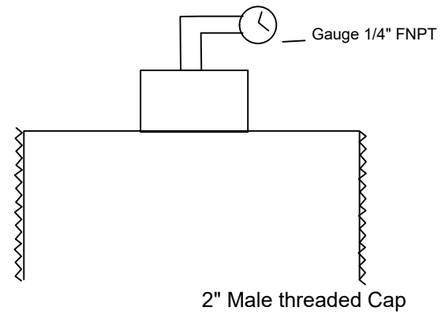
Muli-use Sparge/Monitoring Well Surface Finish



Sparging Cap:

Air Sparge
PVC Cap Details



Monitoring Cap:

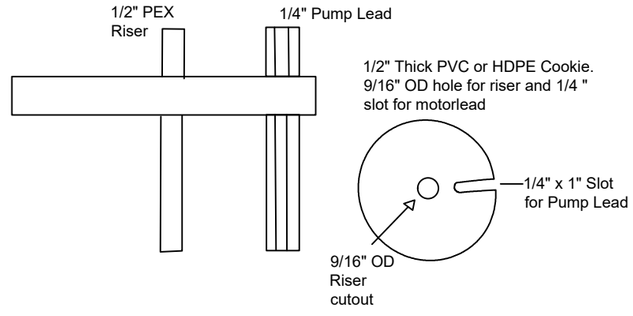


FIGURE 6

Well Head Details

AGRIUM US, INC.
KENAI NITROGEN OPERATIONS PLANT

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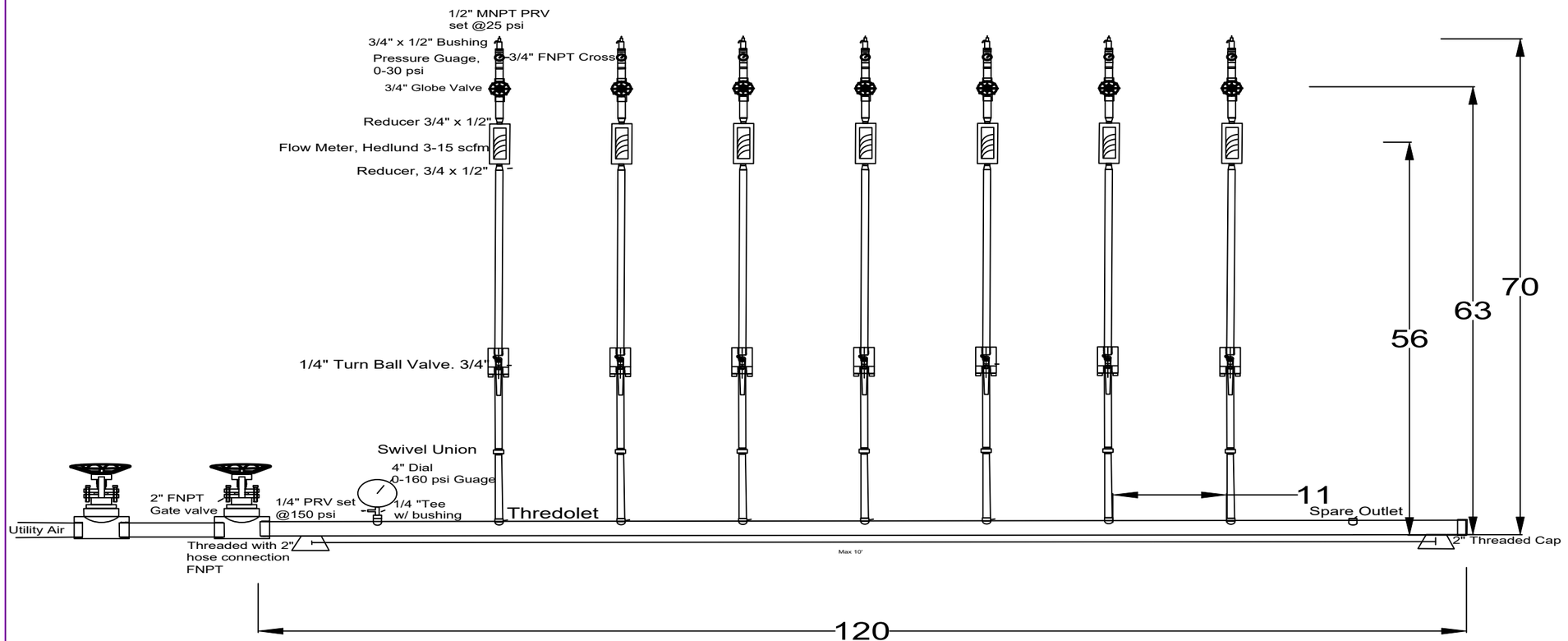
FIGURE 7

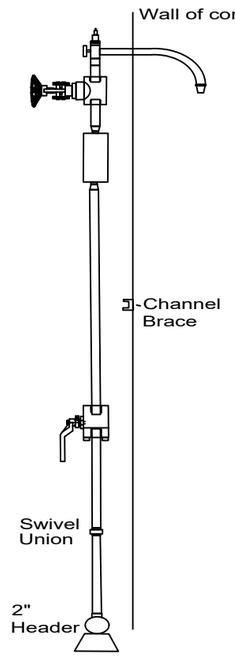
Air Sparge Manifold Details

AGRIUM US, INC.
KENAI NITROGEN OPERATIONS PLANT

Front View



Side View



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