EXPERT REPORT

OF

DAVID J. ERICKSON

Community Association for Restoration of the Environment, Inc.

and Center for Food Safety, Inc.,

v.

Cow Palace, LLC

(E.D. Wash. No. CV-13-3016-TOR)

Prepared for:

Law Offices of Charles M. Tebbutt, P.C.
941 Lawrence Street
Eugene, OR 97401

Public Justice
1825 K Street, NW Suite 200
Washington, D.C. 20006

Center for Food Safety, Inc.
303 Sacramento Street, 2nd Floor
San Francisco, CA 94111

This Expert Report contains information designated by Defendant Cow Palace, LLC, as

"CONFIDENTIAL" under the Stipulated Protective Order (ECF No. 82)

INTRODUCTION

1. I, David J. Erickson, have been retained by Plaintiffs in the above-captioned matter to provide expert testimony about the manure management and storage practices of Defendant Cow Palace Dairy, LLC ("Cow Palace" or "Defendant"), including whether these activities have caused contamination of soils and groundwater.

2. I have worked in the in the Hydrogeology/Geology field for 26 years. I am currently the President/Principal Hydrogeologist of Water & Environmental Technologies, PC in Butte, Montana. I have been in this position for over 14 years. I am a registered Professional Geologist in Utah and Wyoming and a Certified Professional Geologist with the American Institute of Professional Geologists. I graduated with a degree in Geological Engineering from Montana Tech.

3. During my 26 years of professional experience, my main focus has been on contaminant hydrogeology: identification of contaminant behavior in the subsurface and remediation of the impacts. I have been responsible for investigation and remediation of many Underground Storage Tank and Hazardous Waste Sites with contaminants including: fuels, solvents, wood treating compounds, metals, pesticides, herbicides, fungicides, and fertilizers.

4. As Project Manager/Principal Hydrogeologist, I have supervised,

designed, installed, and monitored various types of remedial technologies or remedial methods including air stripping, air sparging, vapor extraction, bioventing, bio-cell treatment, biostimulation, Non-Aqueous Phase Liquid (NAPL) recovery, in-situ and ex-situ bioremediation, natural attenuation, barrier wall technology, pump & treat, and excavation & off-site disposal.

5. I have extensive experience working with waste storage impoundments. For instance, I was involved in the hydrogeologic investigation and characterization of groundwater contamination at a Wyoming power facility, where large settling ponds containing coal ash and flue gas desulfurization liquor were leaking, resulting in impacts to groundwater. The investigation included geochemical modeling to identify contaminant fingerprints and a geostatistical model of the alluvium/bedrock contact. After investigating and characterizing the site, I was responsible for the installation of a monitoring system, and, later the development of a groundwater flow and contaminant transport model.

6. During my career, I have looked at over 100 waste lagoons and impoundments. A vast majority have impacted groundwater due to seepage through earthen liners.

7. Water & Environmental Technologies is responsible for installing or operating remedial systems at several locations. Recently, we have installed

or operated:

a. A pumpback system for a major industrial waste pond in Wyoming.

b. A dewatering system for a waste pond in central Wyoming.

c. A capture system for seepage of waste from a waste impoundment and landfill in Utah.

d. A pump and treat system for a leaking pond at a Coal Fired Generator Site in Kemmerer, Wyoming.

e. A free product recovery system to remediate a 250,000 gallon diesel spill at a county shop in Montana.

f. An air sparging/vapor extraction system with oxygen injection for gasoline contamination in Colorado.

g. Installation and optimization of free product recovery by installing interceptor trenches in Wyoming.

h. A multi-million dollar restoration project involving excavation, vapor extraction and multi-phase extraction at a refinery in Sunburst, Montana.

8. I have also completed work on several cases involving nitrate contamination caused by both individual wastewater treatment systems and agricultural activities. These projects include remedial activities at 12

fertilizer distribution facilities and investigation work at both hog and dairy CAFOs. With respect to wastewater treatment and septic discharges, WET has completed an eight-year study of septic system impacts to groundwater and developed a patented treatment system (SepticNET) to remove both nitrate and phosphorous from individual and small community septic discharges.

9. The development of the SepticNET involved several years of sampling and characterizing septic discharges from both individual and community treatment systems, delineating the extent and magnitude of septic impacts to groundwater, and evaluating the hydrogeologic characteristics of multiple areas where nitrate impacts have degraded groundwater above drinking water standards.

10. My curriculum vitae is attached hereto as Exhibit A. It contains a list of my prior work history and activities.

11. I am being compensated at a rate of $175/hour for the time I have spent on this report. This fee is doubled for depositions and trial testimony.

12. I have reviewed numerous documents about Cow Palace, the other "Cluster Dairies" and the Haak Dairy, the Yakima Valley, and resource information for Yakima County. This information includes:

a. The Dairy Nutrient Management Plan ("DNMP") for Cow

Palace, along with all appendices and attached information;

b. Inspection reports prepared by the Washington Department of Agriculture about Cow Palace;

c. Cow Palace's soil sampling information provided to Plaintiffs during discovery, dating from 1998 to the present, including information obtained pursuant to the Administrative Order on Consent ("AOC");

d. Cow Palace's lagoon and manure sampling information provided to Plaintiffs during discovery, including information obtained pursuant to the AOC;

e. Cow Palace's field application summary logs;

f. Cow Palace's hand-written field application logs;

g. Cow Palace's crop yield information, where available;

h. Cow Palace's statements about the Dairy's herd size;

i. Well sampling information for wells sampled by the United States Environmental Protection Agency, including the wells described in the publication titled "Relation Between Nitrate in Water Wells and Potential Sources in the Lower Yakima Valley, Washington" EPA-910-R-13-004 (the "EPA Report");

j. Well installation and sampling information obtained by Cow

Palace and the other Cluster Dairies pursuant to the AOC, including but not limited to Cow Palace's quarterly monitoring reports, the groundwater monitoring well installation report, and well logs from well installation;

k. Residential well sampling information obtained by Cow Palace and the other Cluster Dairies pursuant to the AOC;

l. Documents, records, sampling data, my own personal observations, and other information obtained during Plaintiffs' October 2013 and May 2014 Rule 34 inspections of Cow Palace Dairy and the other Cluster Dairies;

m. Records, sampling data, and other information obtained during Plaintiffs' May 2014 inspection of the now-abandoned manure storage lagoons at the Haak Dairy;

n. Natural Resource Conservation Service Soil Survey Report for Yakima County, Washington;

o. Several studies and reports from the Washington State Department of Ecology, including: Carey, Barbara, Effects of Land Application of Manure on Groundwater at Two Dairies over the Sumas-Blaine Surficial Aquifer, 2002, Washington State Dept. of Ecology Publication No. 02-03-007; Erickson, Denis R., Effects of

Leakage from four Dairy Waste Storage Ponds on Groundwater Quality, Final Report, 1994, Washington State Dept. of Ecology Publication No. 94-109; E.S. Marx, J. Hart and R.G. Stevens, Soil Test Interpretation Guide, Oregon State Extension Service EC 1778. 1999; Vaccaro, J.J., Jones, M.A., Ely, D.M., Key, M.E., Olsen, T.D., Welch, W.B., and Cox, S.E., 2009, Hydrogeologic Framework of the Yakima River Basin Aquifer System, Washington: U.S. Geological Survey Scientific Investigations Report 2009-5152, 106 p.

p. The deposition testimony of Jeff Boivin, Cow Palace employee and manager, and the deposition testimony of Daniel McCarty, a dairy inspector for the Washington State Department of Agriculture.

13. All opinions expressed herein are to a reasonable degree of scientific certainty, unless otherwise specified. I reserve the right to modify or supplement this report based on information obtained by Plaintiffs after the date of this report.

14. Generally, I have been requested by Plaintiffs to render an opinion about whether Cow Palace's manure management and storage practices have resulted in nitrogen, phosphorus, and other contaminants found in cow manure and compounds used in the Dairy such as antibiotics or hormones being leached through the ground and into groundwater. Specifically, I have

been asked to render an opinion about whether Cow Palace's lagoons, pens, composting areas, and other areas at the dairy facility are responsible for the release of nitrogen and other compounds into soils and groundwater. Based on my review of the available information and pertinent literature, I conclude that Cow Palace's manure management and storage practices are one of the primary contributing sources of the nitrogen (in the form of nitrate) contamination observed in the groundwater.

15. Infiltration of wastes and associated contaminants occurs from lagoon seepage, from animal operations and from overapplication of manure to the fields.

16. I have also been asked to render an opinion as to what measures Cow Palace could reasonably take that would reduce nitrogen loading from the Dairy and would remediate the nitrate contamination currently in groundwater. I discuss these options at the end of this report.

SCIENTIFIC AND FACTUAL BACKGROUND

17. The Cow Palace Dairy is a concentrated animal feeding operation or "CAFO" located near 1631 North Liberty Road, Granger, WA 98932. As of 2012, Cow Palace had 7,372 milking cows, 897 dry cows, 243 springers, and 3,095 calves housed at the facility, for a total herd size of 11,607 animals.[1]

[1] COWPAL002097.

According to Cow Palace's DNMP, much of the waste generated from these animals is directed into two settling basins, where solids are settled from the liquid, and then into a series of liquid storage lagoons.[2] Liquid manure from these lagoons is land-applied to Cow Palace's agricultural fields, totaling 533 acres in size per the DNMP.[3]

18. A farm with 2,500 dairy cattle is estimated to create a similar waste load as a city of 411,000 people, due to the large volume of waste produced by an average dairy cow compared with that produced by a person, and due to the fact that human waste is treated before discharge into the environment, whereas waste from CAFOs has no such requirement and, therefore, is not treated, or treated minimally, before reaching the environment.[4] Based on this estimate, the Cow Palace's milking cows produce a similar waste load as a human population of 1,211,957 people (411,000/2500*7372). The additional cows and calves add substantially more waste.

19. Septic discharges from a single family home average approximately 60 gallons per person per day with an average concentration of total nitrogen of 75 ppm, prior to the nitrate attenuation that occurs in the drainfield. The discharge of nitrates and other nutrients to groundwater, if any, occurs

---

[2] COWPAL000010.
[3] COWPAL000005.
[4] EPA Report at 46.

beneath the drainfield and results in a groundwater mixing zone or groundwater impacts within 300-500 feet of the drainfield. Septic systems can cause elevated nitrates in groundwater under specific conditions, such as housing densities less than 1.5 acres/house, locations with poor topsoil for secondary treatment, locations with bedrock aquifers of low permeability, and locations with a shallow groundwater table (i.e., less than 4 feet below ground surface or "bgs").

20. Cow Palace is located in the northern end of the Lower Yakima Valley, and is bounded to the north by basalt hills known as the "Rattlesnake Hills."[5] There are only a handful of agricultural fields located north of Cow Palace Dairy, as is readily apparent based on our site visits or by looking at any aerial photographs of the area, such as those available on Google Maps.[6]

21. There are two main aquifer types in the area. The first is a surficial unconfined to semi-confined alluvial aquifer. This aquifer is composed of highly layered alluvial material with predominantly silt, sand and cobbles and, according to USGS, has a total thickness of up to 500 feet. Based on groundwater monitoring well information provided by the Defendants, the depth to groundwater at Cow Palace ranges from approximately 88 to 185 bgs. However, perched groundwater was encountered during Plaintiffs'

[5] EPA Report at p. 127, Figure 7.
[6] *See also* EPA Report at 46.

May 2014 inspection of a now-decommissioned waste lagoon at depths of approximately 7 and 45 feet bgs at the Haak lagoon. Subsurface lithology at the Cow Palace was observed to be similar to the lithology at the Haak location. Therefore, perched groundwater is likely present beneath the Cow Palace as well. The second aquifer is an extensive basalt aquifer of great thickness underlying the surficial aquifer described above. The basalt aquifer is believed by the USGS to be semi-isolated from the surficial aquifer and stream systems. Natural groundwater flow within the shallower, surficial aquifer generally follows topography, but may be locally influenced by irrigation practices, ponds, lagoons, drains, ditches, and canals.[7] Groundwater in this shallower aquifer generally flows to the south, down the valley, and is used locally for residential water supply and eventually feeds the Yakima River.[8]

22. The Lower Yakima Valley is filled with sediments eroded from nearby highlands, such as the Rattlesnake Hills, and those deposited in the valley bottom by the Yakima River.[9] The alluvial sediments were deposited by area rivers and streams and provide a preferential flowpath horizontally along the depositional direction (*i.e.*, the permeability down the valley (Kx)

---

[7] *Id*. at 7.
[8] Vaccaro, J.J., Jones, M.A., Ely, D.M., Key, M.E., Olsen, T.D., Welch, W.B., and Cox, S.E., 2009, Hydrogeologic Framework of the Yakima River Basin Aquifer System, Washington: U.S. Geological Survey Scientific Investigations Report 2009-5152, 106 p.
[9] *Id*.

is greater than the longitudinal permeability across the valley (Ky) and up to 100 times greater than the vertical permeability (Kz), which is typical of most alluvial systems). This typically results in flow in perched aquifers, especially near lagoons and irrigation ditches, where water is introduced at the surface, infiltrates until reaching a less permeable layer, and flows horizontally until a conduit is found to allow the fluid to migrate vertically. Water wells drilled in this depositional environment can penetrate the perched layer and provide a conduit for contaminant migration into the water table aquifer. As a result, a well that is located along a preferential flow path may capture a substantial portion of its water from a particular surface source, whereas a neighboring well located along a different flow path may exhibit entirely different contaminant characteristics.

23. Shallower wells located in the Lower Yakima Valley are more likely to be contaminated with nitrates than deeper wells, because the sources of the nitrogen loading to the groundwater are man-made and occur on the land's surface. These activities include land-application of solid or liquid manure, transmission of liquids in contact with manure, and storage of manure in unlined, earthen lagoons or composting areas. The EPA Report, along with other earlier studies, document more contaminated wells screened within the shallower aquifer than the deeper, basalt aquifer; in fact,

the highest levels of nitrate generally occur in the shallow alluvial aquifer, especially in the upper portion of the alluvial aquifer.[10]

24. Even the deeper aquifer, although believed by the USGS to be semi-isolated from the surficial aquifer, may be susceptible to impacts from the shallower aquifer when large scale pumping occurs in a preferential vertical flowpath. Appendix A of the EPA Report contains sample data collected from 3 wells completed in the deeper basalt aquifer (EPA Phase 3 well numbers WW-02, WW-07, and WW-09). One of these wells, well WW-02 is a dairy supply well for the Haak Dairy, is completed in the basalt aquifer, and exhibited a groundwater nitrate concentration of 3.12 ppm. Natural background nitrogen concentrations are generally less than 2 ppm in groundwater (caused by fixation of nitrogen gas in the atmosphere and by breakdown of organic matter).[11]

25. Within the approximate property boundary of the Cow Palace, six soil units have been mapped by the NRCS. All six soil units have a silt loam texture with a "well-drained" classification. Three of these soil units (Esquatzel, Shano, and Warden) represent approximately 81 percent of the surface area. These units have a saturated hydraulic conductivity in the

---

[10] *Id*. at 8.
[11] U.S. Geological Survey Circular 1136 Nutrients in the Nation's Waters--Too Much of a Good Thing? By David K. Mueller and Dennis R. Helsel.

range of 1.1 to 4.0 feet per day, which is characterized as "moderately high to high" in their capacity to transmit water. Two of the soil units (Burke and Scoon) represent approximately 19 percent of the surface area and have a saturated hydraulic conductivity less than 0.12 feet per day which is characterized as "very low to moderately low." One of the soil units (Finlay) represents less than 1 percent of the surface area and has a saturated hydraulic conductivity of 4 to 11.9 feet per day, which is characterized as "high."[12]

26. These soil types were confirmed during some of the soil borings taken during the May 2014 site inspection. Soils were collected and analyzed from 57 locations during the May investigation activities, with soil descriptions generally ranging from silt with sand to sand in shallow borings (total depths of 5-10 feet) in agricultural fields and cow pens, and from silt with sand to sandy gravel in deeper borings (total depths of 20-47 feet) near lagoons and compost areas.

27. Manure contains two primary forms of nitrogen: ammonium and organic nitrogen. The organic form of nitrogen is nearly immobile; however, it becomes mobile, and available to crops as fertilizer, through mineralization. Mineralization is the process by which soil microbes

---

[12] EPA Report, Appendix B at B-3.

decompose organic nitrogen into ammonium, which is then available as fertilizer for crops. By tilling manure into the subsurface to depths of 4-5 feet, plant uptake is eliminated and mineralization results in elevated ammonium in the subsurface. The rate of mineralization varies with soil temperature, soil moisture, and the amount of oxygen in the soil. After mineralization, microorganisms within the soil convert ammonium into nitrate. This process, called nitrification, occurs most rapidly when the soil is warm, moist, and well-aerated. Nitrates are the most plant-available form of nitrogen for fertilization purposes, but as described above, are highly mobile and susceptible to leaching loss to groundwater, especially when tilled below the root zone or over applied to the fields.

28. The predominant soils underlying and in the vicinity of Cow Palace Dairy present little potential for any loss of nitrate through denitrification.[13] Denitrification is the conversion of nitrate to nitrogen gas by bacteria. It can only occur in poorly drained, anoxic conditions or organic soils where oxygen is depleted in the root zone. In the absence of denitrification, nitrate moves with the groundwater through natural processes until the groundwater is discharged to surface water, or extracted from a well.

29. Because denitrification is limited in the soils underlying Cow Palace

[13] EPA Report, Appendix B at B-4.

Dairy, any excess nitrate located in the ground where no crops are located will continue to migrate downward with water movement, eventually reaching groundwater.

30. The principle that governs fluid movement in lagoons and the subsurface is known as Darcy's Law. It is the equation that describes how fluid moves through porous media. At its most basic level, Darcy's Law is based on the fact that the amount of fluid movement between two points is directly related to the distance between the points, the pressure or head difference between them, and the permeability or the hydraulic conductivity of the media that the fluid moves through.

31. In equation form, Darcy's Law is typically described as $Q = KIA$, where "Q" is equal to the discharge, or volume of liquid per time unit; "K" is hydraulic conductivity; "A" is the cross sectional area where flow occurs, and "I" is the hydraulic gradient, the change in hydraulic head per unit distance. With knowledge of a few basic hydraulic characteristics, this equation can be used to estimate flux through an aquifer or flow through the liner of a lagoon.

DISCUSSION AND OPINIONS:

COW PALACE'S MANURE STORAGE LAGOONS ARE A MAJOR SOURCE OF THE NITRATE CONTAMINATION OBSERVED IN THE GROUNDWATER

32. I have reviewed the discovery information produced by Cow Palace concerning the Dairy's manure storage facilities, manure management practices, and manure handling practices. I have also twice personally visited the Cow Palace Dairy and have viewed, and in some cases sampled, the lagoons, pens, and manure composting areas.

33. There is significant nitrate contamination observed in the groundwater found beneath and downgradient of Cow Palace Dairy. The area impacted by nitrate encompasses a very large geographic area, indicating a large contaminant source area. The EPA Report and Cow Palace's own monitoring wells show levels of nitrate below the maximum contaminant level ("MCL") in groundwater upgradient from the facility. In fact, there are few upgradient nitrogen sources from Cow Palace Dairy, as water flows down from the Rattlesnake Hills located just north of Cow Palace. There are only a handful of agricultural fields located upgradient from the Dairy, some of which receive dairy manure from at least DeRuyter Dairies.[14] In groundwater downgradient from the facility, nitrate is present at levels that exceed the MCL. The chart below displays the sampling events that have occurred at the Cow Palace facility and at nearby monitoring wells in the past two years.

---

[14] George DeRuyter Transcript at 52:4-53:9 & Ex. 204.

AOC groundwater sampling results at and near Cow Palace Dairies

Well	Well Depth (ft bgs)	Water Table Elevation (ft AMSL) (reported once in well installation rpt)	AOC-upgradient/ AOC-downgradient/ Background	Date	DTW (ft bTOC)	Chloride (mg/l)	Calcium (mg/l)	Nitrate (mg/l)	Phosphorus (mg/l)	Sodium (mg/l)	Sulfate (mg/l)	Magnesium (mg/l)
YVD-02	35	1264.8 ft.	Background	09/24/13	25.09	3.85	20.4	0.41	0.124 J	8.56	5.77	5.89
				03/16/14	unavailable	3.93	90.8	5.3 U	0.06	88.6	66.9	71.7
				06/02/14	unavailable	2.75	62.7	<0.200 U	3.80 J	23.0	3.12	48.7

Well	Well Depth (ft bgs)	Water Table Elevation (ft AMSL) (reported once in well installation rpt)	AOC-upgradient/ AOC-downgradient/ Background	Date	DTW (ft bTOC)	Chloride (mg/l)	Calcium (mg/l)	Nitrate (mg/l)	Phosphorus (mg/l)	Sodium (mg/l)	Sulfate (mg/l)	Magnesium (mg/l)
YVD-03	200.1	931	AOC - upgradient	09/16/13	198.88	14	57.5	4.75	0.890	43.000	70.7	24.3
				12/10/13	190.42	14.3	48.7	5.96	1.020	40.2	54.8 J	20.4
				03/17/14	unavailable	13.3	51.2	4.75	0.23	37.6	38	18.2
				06/02/14	unavailable	10.7	46.40	3.9	0.300 J	36.8	36.0	16.8

Well	Well Depth (ft bgs)	Water Table Elevation (ft AMSL) (reported once in well installation rpt)	AOC-upgradient/ AOC-downgradient/ Background	Date	DTW (ft bTOC)	Chloride (mg/l)	Calcium (mg/l)	Nitrate (mg/l)	Phosphorus (mg/l)	Sodium (mg/l)	Sulfate (mg/l)	Magnesium (mg/l)
YVD-04	245.2	894.9	AOC - upgradient	09/16/13	220.55	14.9	37.4	4.45	0.100 U	49.2	39.1	11.2
				12/10/13	223.5	15.0	38.2	4.64	0.112	49.9	42.2 J	11.7
				03/17/14	unavailable	15.1	37.7	4.03	0.078	47.8	35.2	11.6
				06/02/14	unavailable	14.3	36.8	3.78	0.053 J	50.5	36.2	11.5

Well	Well Depth (ft bgs)	Water Table Elevation (ft AMSL) (reported once in well installation rpt)	AOC-upgradient/ AOC-downgradient/ Background	Date	DTW (ft bTOC)	Chloride (mg/l)	Calcium (mg/l)	Nitrate (mg/l)	Phosphorus (mg/l)	Sodium (mg/l)	Sulfate (mg/l)	Magnesium (mg/l)
YVD-05	182.2	884.3	AOC - downgradient	09/17/13	167.41	10.2	66	4.9	1.62	46.2	76.8	31
				12/11/13	166.39	10.0	41.5	4.36	0.462	45.5	68.4 J	17.0
				03/17/14	unavailable	8.40	33.7	3.3	0.14	43.1	52.7	13.5
				06/01/14	unavailable	8.40	30.8	3.00	0.150 J	43.9	50.5	13.2

Well	Well Depth (ft bgs)	Water Table Elevation (ft AMSL) (reported once in well installation rpt)	AOC-upgradient/ AOC-downgradient/ Background	Date	DTW (ft bTOC)	Chloride (mg/l)	Calcium (mg/l)	Nitrate (mg/l)	Phosphorus (mg/l)	Sodium (mg/l)	Sulfate (mg/l)	Magnesium (mg/l)
DC-01	160	1048.7	AOC - upgradient	01/04/13	150.5			9.8				
				09/24/13	15.47*	44	88.9	11.1	0.123 J	43	223	32.5
				12/11/13	150.49	47.8	91.4	11.5	0.186	41.9	280 J	32.6
				03/17/14	unavailable	48.2	90.5	11.2	0.079	40.2	250	31.4
*appears to be a transposition error				06/02/14	unavailable	41.4	<1.00 J	10	<0.050 J	<0.500 J	224	31.9

Well	Well Depth (ft bgs)	Water Table Elevation (ft AMSL) (reported once in well installation rpt)	AOC-upgradient/ AOC-downgradient/ Background	Date	DTW (ft bTOC)	Chloride (mg/l)	Calcium (mg/l)	Nitrate (mg/l)	Phosphorus (mg/l)	Sodium (mg/l)	Sulfate (mg/l)	Magnesium (mg/l)
YVD-06	169	942.8	Background	09/17/13	110.67	3.13	46	0.51	0.410	17.600	8.140	12.8
				12/09/13	108.21	2.73	31.2 J	0.49 J	0.0600 U	13.0 J	8.53	5.27 J
				3/16/2014*	unavailable	3.470	40.1	0.61	0.13	16.20	8.33	7.59
				06/01/14	unavailable	2.88	37.8	0.51	0.057 J	16.7	7.59	6.50
*labled as "field blank;" duplicate labeled YVD-D1												

Well	Well Depth (ft bgs)	Water Table Elevation (ft AMSL) (reported once in well installation rpt)	AOC-upgradient/ AOC-downgradient/ Background	Date	DTW (ft bTOC)	Chloride (mg/l)	Calcium (mg/l)	Nitrate (mg/l)	Phosphorus (mg/l)	Sodium (mg/l)	Sulfate (mg/l)	Magnesium (mg/l)
YVD-09	122.3	856.8	AOC - downgradient	09/19/13	110.00	96.3 J	107	74.7	0.232 J	189	236	39.3
				12/12/13	109.93	87.2	109	64.4	0.647	176	193	42
				03/19/14	unavailable	104.00 J	109.00	62.40	0.53	173.00	214.00 J	40.80
				06/03/14	unavailable	89.80	113.0	57.1	0.720	193	214	44.5

Well	Well Depth (ft bgs)	Water Table Elevation (ft AMSL) (reported once in well installation rpt)	AOC-upgradient/ AOC-downgradient/ Background	Date	DTW (ft bTOC)	Chloride (mg/l)	Calcium (mg/l)	Nitrate (mg/l)	Phosphorus (mg/l)	Sodium (mg/l)	Sulfate (mg/l)	Magnesium (mg/l)
YVD-10	103.1	867.6	AOC - downgradient	09/17/13	90.23	95.4	216	95	0.148	104	199	51.8
				12/12/13	89.2	91.4	202	86.9	1.4	102	174	55.6
				03/19/14	unavailable	86.80 J	218.00	77.60	0.77	96.80	163.00	54.00
				06/03/14	unavailable	94.3	232 J	86.1	0.800 J	103 J	188	58.6

Well	Well Depth (ft bgs)	Water Table Elevation (ft AMSL) (reported once in well installation rpt)	AOC-upgradient/ AOC-downgradient/ Background	Date	DTW (ft bTOC)	Chloride (mg/l)	Calcium (mg/l)	Nitrate (mg/l)	Phosphorus (mg/l)	Sodium (mg/l)	Sulfate (mg/l)	Magnesium (mg/l)
YVD-14	91	843	AOC - downgradient	09/18/13	77.31	118	260	112	0.100 U	110	213	65.4
				12/12/13	76.97	104	249	105	0.060 U	108	186	85.6
				03/19/14	unavailable	108.00 J	248.00	101.00	0.05 U	102.00	190.00 J	64.50
				06/04/14	unavailable	109	240 J	102	0.078 J	112 J	191	63.2

Well	Well Depth (ft bgs)	Water Table Elevation (ft AMSL) (reported once in well installation rpt)	AOC-upgradient/ AOC-downgradient/ Background	Date	DTW (ft bTOC)	Chloride (mg/l)	Calcium (mg/l)	Nitrate (mg/l)	Phosphorus (mg/l)	Sodium (mg/l)	Sulfate (mg/l)	Magnesium (mg/l)
YVD-15	105.1	849.2	AOC - downgradient	09/17/13	90.16	62.8	125	72.5	0.100 U	127	51.5	51.6
				12/12/13	90.49	120	131	71.2	0.238	114	114	59.4
				03/19/14	unavailable	54.90 J	124.00	47.40	0.22	93.50	44.70	57.90
				06/03/14	unavailable	82.5	138	88.1	0.310	110	39.0	64.7

Well	Well Depth (ft bgs)	Water Table Elevation (ft AMSL) (reported once in well installation rpt)	AOC-upgradient/ AOC-downgradient/ Background	Date	DTW (ft bTOC)	Chloride (mg/l)	Calcium (mg/l)	Nitrate (mg/l)	Phosphorus (mg/l)	Sodium (mg/l)	Sulfate (mg/l)	Magnesium (mg/l)
DC-14	151	906.6	AOC - downgradient	01/03/13	130.61			26				
				09/17/13	131.21	80.2	121	12	0.199	94.9	34.2	32.3
				12/11/13	131.1	64.4	91.2	5.8	0.167	94	33.9 J	23.9
				03/18/14	unavailable	71.8	107	10.6	0.26	87	35.7	28.4
				06/02/14	unavailable	56.1	<0.100 J	6.46	<0.050 J	<0.500 J	24.2	26.3

Well	Well Depth (ft bgs)	Water Table Elevation (ft AMSL) (reported once in well installation rpt)	AOC-upgradient/ AOC-downgradient/ Background	Date	DTW (ft bTOC)	Chloride (mg/l)	Calcium (mg/l)	Nitrate (mg/l)	Phosphorus (mg/l)	Sodium (mg/l)	Sulfate (mg/l)	Magnesium (mg/l)
DC-03	85	838.2	AOC - downgradient	01/02/13	72.4			190				
				09/18/13	72.2	176 J	284	166	0.100 UJ	173	176	73.7
				12/12/13	72.55	172	280	174	0.244	172	176	75
				03/19/14	unavailable	159.00 J	261.00	195.00	0.06	165.00	189.00 J	66.80
				06/04/14	unavailable	201	259 J	234	0.120 J	177 J	214	67.7

Well	Well Depth (ft bgs)	Water Table Elevation (ft AMSL) (reported once in well installation rpt)	AOC-upgradient/ AOC-downgradient/ Background	Date	DTW (ft bTOC)	Chloride (mg/l)	Calcium (mg/l)	Nitrate (mg/l)	Phosphorus (mg/l)	Sodium (mg/l)	Sulfate (mg/l)	Magnesium (mg/l)

DC-03D	116.1	838.3	AOC - downgradient	09/18/13	72.87	56 J	198	46.4	0.100 UJ	62.1	101	44
				12/12/13	73.16	67.9 J	194	38.9	0.0600 U	59.7	99.1	43.3
				03/19/14	unavailable	65.90 J	200.00	42.50	0.05 U	57.50	106.00 J	43.90
				06/03/14	unavailable	65.5	<1.00 J	42.0	<0.050 J	<0.500 J	103	40.9

Well	Well Depth (ft bgs)	Water Table Elevation (ft AMSL) (reported once in well installation rpt)	AOC-upgradient/ AOC-downgradient/ Background	Date	DTW (ft bTOC)	Chloride (mg/l)	Calcium (mg/l)	Nitrate (mg/l)	Phosphorus (mg/l)	Sodium (mg/l)	Sulfate (mg/l)	Magnesium (mg/l)
DC-04	51	844.6	AOC - downgradient	01/03/13	32.68			26				
				09/20/13	32.21	39.4	141	NA	0.100 U	32.1	93.6	25.5
				09/24/13	NL	NA	NA	31.7	NA	NA	NA	NA
				12/12/13	32.6	41.1	148 J	36.7	0.104	31.7	110	28.4
				03/18/14	unavailable	42.00 J	153.00	37.30	0.13	30.40	107.00 J	28.00
				06/03/14	unavailable	36.2	<1.00 J	36.4	<0.050 J	<0.500 J	104	28.9

Well	Well Depth (ft bgs)	Water Table Elevation (ft AMSL) (reported once in well installation rpt)	AOC-upgradient/ AOC-downgradient/ Background	Date	DTW (ft bTOC)	Chloride (mg/l)	Calcium (mg/l)	Nitrate (mg/l)	Phosphorus (mg/l)	Sodium (mg/l)	Sulfate (mg/l)	Magnesium (mg/l)
DC-07	61	845.2	AOC - downgradient	01/03/13	44.11			2.8				
				09/18/13	44.7	30.5	122	4.3	0.100 U	45.7	168	18.4
				12/10/13	44.15	31.0	27.5 J	4.7 J	0.0648	38.4 J	117	11.5 J
				03/16/14	unavailable	26.5	88.4	4.72	0.11	33.5	78.9	15.4
				06/02/14	unavailable	28.2	93.70	<0.800 U	0.120	36.3	105.000	16.500

34. According to its Dairy Nutrient Management Plan or "DNMP," Cow Palace Dairy stores its liquid manure in two settling basins, four waste storage ponds, a "safety debris basin," and several "catch basins," which collect run-off from application fields and cow pens.[15] None of these storage impoundments has any type of geosynthetic liner preventing the downward migration of manure related contaminants. All impoundments are located on an aquifer used for residential drinking water supply and all lagoons have subsurface materials with significant sand, gravel and silt mixtures.

35. Cow Palace does not know whether any of these impoundments were constructed to Natural Resource Conservation Service ("NRCS") 313 standards for manure storage impoundments, with one exception. The current NRCS standard requires waste storage impoundments to be located on soils that have a permeability "that meets all applicable regulation, or the pond shall be lined."[16] The soil permeability requirements are that the wetted surface of a pond shall not exceed 1 X 10-6 cm/s permeability. The 313 standard suggests that a "manure sealing" effect will provide a "liner" that results in a permeability of 1 x 10 -7 cm/s, or an order of magnitude greater protection. The standard notes that, "[i]f the permeability rate

---

[15] COWPAL000012.
[16] WA313-3.

exceeds 1 X 10-6 cm/s, a compacted clay, amended soil liner or synthetic liner is required."[17] Ponds should not be placed in locations above an aquifer that serves as a domestic water supply.[18] If there is no reasonable alternative location, then the standard requires operators to provide "additional measures of safety from pond seepage," such as a clay liner, a flexible membrane liner over a clay liner, or a "geosynthetic clay liner or a flexible membrane liner."[19]

36. The "manure sealing" effect discussed in the NRCS WA313 standard is of questionable merit. While some researchers have found that there is some form of "manure sealing," most also admit that a set of common occurrences have the ability to compromise the effectiveness of the seal. Such occurrences include, for instance, fracture flow through the unsaturated zone beneath the lagoon; disruption of the manure seal during emptying of the lagoon with mechanical excavation; soil with permeability greater than 10-6 cm/s; drying of the exposed subsoil or embankment soil when lagoon levels are low; areas where liquid waste is discharged to the lagoon (i.e., below the outfall of a conveyance pipe or ditch) can be eroded, resulting in damage or removal of a manure seal; gas release from microbial activity in

---

[17] WA313-3.
[18] WA313-8 & Table 5.
[19] WA313-8.

the soil beneath the seal; and repeated freezing and thawing are all conditions that can cause the manure seal to no longer be as effective.[20] Other studies have indicated that improperly sited and constructed lagoons may never fully seal, allowing contaminants to seep into groundwater at rates faster than those stated.[21]

37. From the testimony I have reviewed, the manure "seals" in each of Cow Palace's lagoons frequently dry and crack, and some of Cow Palace's lagoons have been subject to freezing and thawing during the winter months.[22] Additionally, my own personal observations are that the banks of Cow Palace's lagoons have areas that are substantially eroded and impacted by plant and weed growth. These are the types of conditions that impact the effectiveness, if any, of a "manure seal."

38. Current scientific literature indicates that the manure sealing effect can decrease the permeability between one half and one order of magnitude, if the native liner is at least 1x10-6 cm/sec. At this time, only one lagoon appears to meet this standard. As a result, using standard assumptions, a

---

[20] R.J. Nicholson; J. Webb; A. Moore, "A Review of the Environmental Effects of Different Livestock Manure Storage Systems, and Suggested Procedure for assigning Environmental Ratings," Jan. 4, 2004 (http://www.prairieswine.com/pdf/3388.pdf).
[21] *See* Soil Conservation Service, Technical Note: Design and Construction Guidelines for Considering Seepage from Agricultural Waste Storage Ponds and Treatment Lagoons (Sept. 1993) (http//www.epa.gov/region6/6en/w/cafo/tech716.pdf).
[22] Boivin Trans. 155:4-156:11; 164:21-165:4; 174:17-175:7; 183:10-12; 210:2-4; 216:14-217:2.

1x10-5 cm/sec liner on a 1 acre pond with 12 feet of liquid in the pond would leak 4.3 million gallons per year, while a 10-7 cm/sec liner on the same pond would leak 438,000 gallons per year.

39. Even if compliance with the NRCS standard and a one order of magnitude manure seal are assumed, the lagoons will still seep significant amounts of contaminated water into the ground.

40. Cow Palace Dairy's contractor for the Administrative Order on Consent has prepared a "Lagoon Evaluation Method Determination Quality Assurance Project Plan" or "QAPP." In it, Cow Palace proposed to determine whether its lagoons meet the current NRCS WA 313 standard by using a water balance approach detailed in "Protocols for Measuring Dairy Lagoon Seepage Using the Water Balance Method Technical Field Guidance," Luhdorff and Scalmanini, 2012.[23]

41. The purpose of the QAPP is to evaluate whether Cow Palace's proposed "water balance" method will accurately evaluate the amount of leakage from the Dairy's lagoons. To ensure accuracy, Cow Palace intends to compare the results obtained from its water balance test to the calculated seepage rate established in Appendix 10D of the Agricultural Waste

[23] DAIRIES010953.

Management Field Handbook, Part 651 ("AWMFH").[24] For lagoons constructed with soil or clay liners, the AWMFH instructs designers to assume a "seepage rate" of 5,000 gallons per acre, per day – a number that is intended to take into account a one-half order of magnitude reduction in permeability from "manure sealing." In particular, the AWMFH states:

> Some States permit a designer to assume that the initial computed seepage rate will be reduced in the future by an order of magnitude by taking credit for a reduction in permeability resulting from manure sealing. Although the State or local regulations should be used in design for a specific site, the NRCS no longer recommends assuming that manure sealing will result in one order of magnitude reduction. A more conservative assumption described previously allows an initial seepage rate of 5,000 gallons per acre per day, which for the assumed typical site dimensions of 9 feet of liquid and 1 foot thickness of liner, assumes a one half order of magnitude reduction.[25]

42. Thus, NRCS, the drafter of the AWMFH, has abandoned the assumption that a "manure seal" will accomplish an order of magnitude reduction in permeability. Instead, NRCS assumes that a lagoon that impounds nine feet of liquid, with a one-foot clay or soil liner, will seep at a rate of 5,000 gallons per day, per acre. This equates to 5,560,000 gallons of seepage per year from the Cow Palace lagoon system (assumes 400,000 sq. ft. of lagoon surface area per the EPA Report[26], full 4 months per year). The

---

[24] The WA NRCS 313 standard specifically references this Handbook for the design requirements for lagoons.
[25] AWMFH at Appendix 10D-14.
[26] EPA Report at 48.

suggested[27] design standard for seepage from lagoons, the NRCS WA 313 recommended standard for Washington, cautions that lagoons should be constructed with at least clay liners, if not a less permeable type of liner, in areas where an underlying aquifer serves as a domestic water supply. The goal is to have a discharge that is less than 1 x 10-6 cm/sec.[28] This is echoed in the AWFMH, which indicates that a constructed liner may be required if the proposed lagoon is located where the underlying aquifer is a domestic or ecologically vital water supply:

> State or local regulations may prevent locating a waste storage impoundment within a specified distance from such features. Even if the pond bottom and sides are underlain by 2 feet of naturally low permeability soil, if the depth of liquid in the pond is high enough, computed seepage losses may be greater than acceptable. The highest level of investigation and design is required on sites like those described. This will ensure that seepage will not degrade aquifers at shallow depth or aquifers that are of vital importance as domestic water sources.[29]

43. Defendants' QAPP states, in relevant part:

> "The seepage rates measured using the water balance method identified in the Protocols will be evaluated to determine if they provide results of sufficient certainty for comparison with the 4.7 millimeter per day seepage rate requirement. An uncertainty range will be calculated using a 95 percent confidence interval for the Protocols-derived seepage rates. If the uncertainty range is within 25 percent of the seepage rate requirement (+/-1.2 millimeters per day) then the methodology identified in the Protocols will be determined to be sufficient for future lagoon evaluations required under Section

[27] The NRCS standards are only recommendations.
[28] WA313 Standard, Table 5.
[29] AWFMH at 10D-9.

III.F.6 of the AOC SOW."[30]

44. By evaluating the accuracy of its water balance method against this number, Cow Palace has essentially conceded that it reasonably expects to find that its lagoons leak in the neighborhood of 5,000 gallons per day, per acre, or the equivalent of 4.7 mm per day. If the water balance method does not return measurements that are between 3.5 mm and 5.9 mm of seepage per day per acre, then the method is considered inaccurate and cannot be used by the dairies for evaluating the seepage from their lagoons; that is, the results must be in the range of certainty (3.5 mm to 5.9 mm of discharge per day) in order to be validated. This is an admission by Cow Palace that its lagoons leak between 3.5 to 5.9 mm of manure per day, per acre of storage. Given the acreage of lagoons at Cow Palace (approximately 400,000 sq. ft. or 9.2 Acres), that means that Cow Palace leaks over 115,192 gallons of manure contaminated water per day, or over 13,823,000 gallons per year (assuming conservatively that the lagoons are only full 4 months per year), at a minimum using the 3.5 mm/day seepage rate (which itself is likely far lower than the actual seepage rate).

45. The AWMFH instructs that a designer may consider the permeability of *in situ* soils that are to be used for a compacted soil liner bottom in a

[30] DAIRIES010953.

lagoon. According to the Dairy, the soils in the Cow Palace area primarily fall into the ML, SM, and GM group names of the Unified Soil Classification System.[31] Underlying the Dairy, according to the well drilling logs from wells YVD-03, YVD-05, and YVD-06, the soil types are primarily ML, SP, SC, and GP, with YVD-03 having some CL.[32] The AWMFH states that ML, SC, and CL type soils are usually in "Group II," which have an estimated permeability of 5 x 10-6 cm/s to 5 x 10-4 cm/s.[33] Sometimes, ML, SC, and CL type soils can fall into Group III, which have an estimated permeability of between 5 x 10-8 cm/s to 1 x 10-6 cm/s. SP and GP fall into Group I, which are highly permeable, having an estimated permeability of 3 x 10-3 to 2.[34]

46. Based on personal observations during our site visits to the Cow Palace and observations of soil samples collected directly from the bottom of the now-abandoned waste lagoon at the Haak Dairy, it appears that all waste lagoons at Cow Palace were constructed by excavating native soils and perhaps compacting disturbed soils, with two exceptions (Lagoon #4 and

---

[31] DAIRIES016868-870.

[32] YVD-03 (DAIRIES010833-36) (showing ML, SP, SC, and CL type soils until hitting weathered basalt at approximately 185 ft. below ground surface of "bgs"); YVD-05 (DAIRIES010841-843) (showing ML, SP, and GP soil types all the way down to 208 ft. bgs); YVD-06 (DAIRIES010844-846) (showing SP, GP, and ML soil types down to 170 ft. bgs).

[33] AWFMH Table 10D-4 and Table 10D-5.

[34] *Id.*

Catchment Basin Northeast). I observed no evidence of any type of liner in any other lagoon or basin at Cow Palace. As discussed previously, based on soils encountered during Plaintiffs' May 2014 inspection, Cow Palace native soils predominantly range from silt with sand to sand from approximately 0 to 10 feet bgs, and silt with sand to sandy gravel from 10 to 47 feet bgs.

47. The AWMFH goes on to describe how one can calculate the "specific discharge" from a designed lagoon. It uses a mathematical variation of Darcy's law to determine how much a lagoon of specific dimensions and characteristics is expected to discharge. In particular, the AWMFH states that:

> The parameters that affect the seepage from a pond with a natural or constructed clay liner are:
>
> • The size of the pond: The total bottom area and area of the exposed sides of the pond holding the stored waste solids and liquids.
>
> • The thickness of low permeability soil at the excavation limits of the pond: For design, the thickness of the soil at the bottom of the pond is often used because that is where seepage is likely to be highest. In some cases, however, seepage from the sides of the pond may also be an important factor. Seepage from the sides of ponds is best analyzed using finite element flow net programs. In some cases, rather than a single horizon, multiple horizons may be present.
>
> • The depth of liquid in the pond: The depth of liquid at the top of the reservoir when pumping should commence is normally used.
>
> • The coefficient of permeability of the soil forming the bottom

and sides of the pond[.][35]

48. In the following sections, I use the Darcy Equation (Darcy's Law) to calculate the seepage rates from each of Cow Palace's manure storage lagoons. These discharges are calculated using either known values or conservative estimates of the following parameters:

- Permeability of the lagoon liner;
- Hydraulic gradient (head, or pressure drop across the thickness of the liner); and
- Cross-sectional area perpendicular to flow (lagoon bottom)

The equations and calculation broken down in seepage per acre is provided as Exhibit B.

Lagoon 1

49. Lagoon 1 at Cow Palace Dairy is 430 ft. x 280 ft. by 30 ft. deep, with a calculated storage capacity of approximately 18,266,160 gallons, or 56 acre feet.[36] Cow Palace does not possess any information about whether Lagoon 1 can meet the current NRCS WA 313 recommendation standard.[37] Lagoon 1 does not contain any type of geosynthetic liner, but was instead constructed into the ground using a native soil-lined bottom.[38] Cow Palace

---

[35] AWFMH 10D-11.
[36] COWPAL000012; 000038-39.
[37] DAIRIES000910.
[38] Porter Trans. at 35:24-36:6.

does not know the depth of the soil liner, but for the purposes of the calculations below, I assume it is one foot thick and constructed out of native soil.

50. The photos below represent the condition of Lagoon 1 as it was at the time of Plaintiffs' October, 2013 inspection.

Photo: View to northeast of Lagoon 1. Erosion caused by Settling Basins discharging into Lagoon 1 is visible in background.

Photo: View to southwest of Lagoon 1. Dried, cracked, and eroded manure seal is visible in foreground.

51. Visible in the photo is the desiccation of the manure seal and the erosion of the manure down to native soil wherever water is discharged into the lagoons.

52. In order to estimate the seepage from this lagoon, the following assumptions were made: soil permeability 1x10-5 cm/sec, one foot thick soil liner, one order of magnitude manure seal, and an average of 15 feet of liquid in the 30 foot deep pond. Since the pond is much deeper than 15 feet (in fact, Dirk Porter, a decades-long employee with Cow Palace, testified

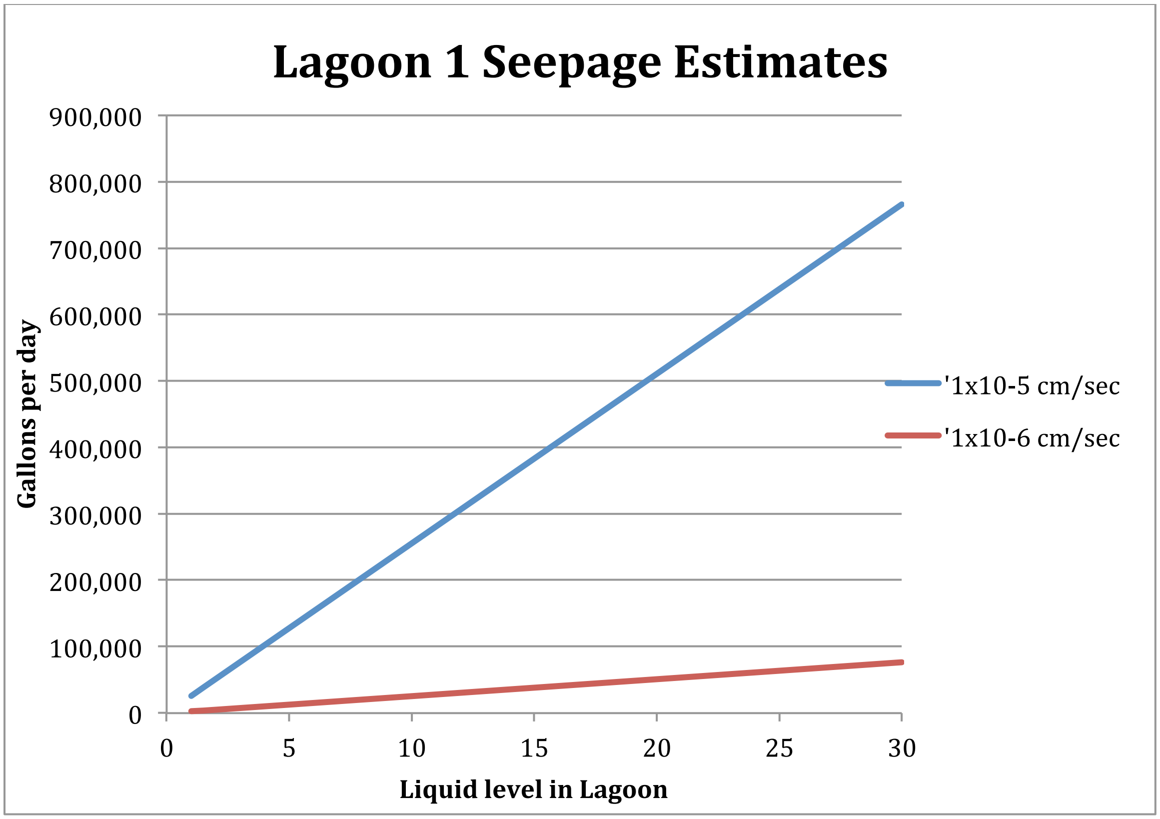
that Lagoon 1 was deepened by the Dairy in 1994 or 1995, making one end of the lagoon 9-10 feet deeper than the other[39]), and the soils in the area and in the pond footprint are sand, gravel and some silt, these assumptions should be conservative. The following table provides a conservative leakage estimate for Lagoon 1:

Q = KiA		
K=	0.000001	cm/sec
i=	15	ft
A=	120400	ft2
Q=	38,298	Gallons/day
	1,148,930	Gallons/month
	13,978,651	Gallons/year

53. There is no question that Lagoon 1 leaks large amounts of liquid manure into the ground. The only variable in the equation that has not been directly tested is the in-place permeability of the soil liner. The other significant variable that changes over time is the depth of liquid in the lagoon which, in this equation, is equal to the head or pressure exerted on the liner. The variable ranges from 0 when the lagoon is empty to 30 feet when the lagoon is full. Since this is the first lagoon in the Cow Palace's manure waste management process, it most likely contains liquid during most of the year. Even assuming that the lagoon has a soil liner that is one foot thick (although there is no information to support this) and varying the

[39] Porter Trans. at 33:3-11.

liner permeability between 1x10-5 cm/sec and 1x10-6 cm/sec while maintaining the lagoon under half full conditions, Lagoon 1 leaks between 38,298 and 383,000 gallons of manure-contaminated water per day, or 4.6 million to 46 million gallons per year, assuming that the pond is half full at least 4 months of the year. Even assuming a liner permeability of 1 x 10-7 cm/sec, Lagoon 1 leaks 3,830 gallons of manure-contaminated water per day, or 460,000 gallons per year, assuming the pond is half full at least 4 months of the year. Given, however, that the soil types in the area are of moderate to high permeability, that Cow Palace has not maintained its manure seal properly, and that Lagoon 1 was dug deeper to one side, the specific discharge amounts are likely on the high end of my calculations. The following graph provides seepage estimates for Lagoon 1 with respect to liquid level changes from 1' to 30' and a range of permeability between 1x10-5 cm/sec and 1x10-6 cm/sec.



54. The lagoon leakage is especially concerning with respect to ground water contamination issues. Once the seepage leaves the bottom of the lagoon it will infiltrate into the subsurface, saturate the underlying soil and continue to migrate in the subsurface until it encounters ground water. Because the leakage occurs below the influence of any plants, there is no chance for the nitrate to attenuate due to plant uptake.

55. Although no samples were collected for analytical testing from Lagoon 1 during our site inspections, reasonable estimates can be made about the chemical nature of its contents using analytical results from lagoons containing similar wastes. A sample collected from Cow Palace

Lagoon 2 in October 2013 exhibited a total nitrogen (sum of organic nitrogen, ammonia, nitrite, and nitrate) concentration of 1,600 ppm. In addition, Table 20 of the EPA report provides analytical results of samples collected from 12 lagoons in the "Dairy Cluster." Total nitrogen concentrations detected in these samples ranged from 290 ppm to 1,800 ppm and averaged 1,180 ppm.

56. The most conservative seepage estimates from this lagoon (3,830 gallons per day) far exceed any estimates of the total septic system discharges for all residents within 3 miles of the Cow Palace.

Settling Basins

57. There are two "Settling Basins" at Cow Palace Dairy. Each has an outside dimension of 200 ft. x 133 ft. by 10 ft. deep, with a calculated storage capacity of approximately 1,521,000 gallons each, for a total of 3,042,000 gallons, or 9.4 acre feet.[40] Cow Palace does not possess any information about whether the Settling Basins can meet the current, or even any prior, NRCS WA 313 standard.[41] The Basins do not contain any type of geosynthetic liner, but rather were constructed into the ground using a native soil-lined bottom.[42] Cow Palace does not know the thickness of the soil

[40] COWPAL000012; 000038.
[41] DAIRIES000910.
[42] ECF No. 133 at 8 (Answer to Second Amended Complaint).

liner, but for the purposes of the calculations below, I assume it is one foot thick. No evidence of a liner was observed during my site visit and it appeared that the edges of the pond were constructed out of native soil.

58. The photos below represent the condition of Settling Basins as they were at the time of Plaintiffs' October, 2013 inspection.

Photo: View to southwest of west Settling Basin. Waste being discharged from collection sump is visible in foreground.

Photo: View to southeast of east Settling Basin. Waste being discharged from collection sump visible on north end of basin.

59. In order to estimate the seepage from this lagoon, the following assumptions were made: soil permeability 1x10-5 cm/sec, 1 foot thick soil liner, 1 order of magnitude manure seal, and an average of 10 feet of liquid in each basin. The Settling basins are the first part of the lagoon process ponds and separate solids by decanting liquids below the upper scum layer, requiring full or near full conditions to operate. Since the pond is 10 feet deep and the soils in the area and in the pond footprint are sand, gravel and some silt, these assumptions should be conservative. The following table

provides a conservative leakage estimate for one of the Settling Basins:

Q = KiA		
K=	0.000001	cm/sec
i=	10	ft
A=	26600	ft2
Q=	5,641	Gallons/day
	169,222	Gallons/month
	2,058,871	Gallons/year

60. There is no question that the settling basins leak liquid manure into the ground. Assuming that the basins have a soil liner that is one foot thick and varying the liner permeability between 1x10-5 cm/sec and 1x10-6 cm/sec while maintaining the basins under full conditions, each Settling Basin leaks between 5,641 and 56,400 gallons of manure-contaminated water per day, or 2 million to 20 million gallons per year, assuming that the ponds are in use year around. Even assuming a liner permeability of 1 x 10-7 cm/sec and half-full conditions year around, each Settling Basin leaks 564 gallons of manure-contaminated water per day, or 200,000 gallons per year, assuming the ponds are in use year around. Given, however, that the soil types in the area are of moderate to high permeability, and that Cow Palace has not maintained its manure seal properly, the specific discharge amounts are likely on the high end of these calculations.

61. The Settling Basin leakage is especially concerning with respect to ground water contamination issues. Once the seepage leaves the bottom of

the lagoon, it will infiltrate the subsurface, saturate the underlying soil and continue to migrate in the subsurface until it encounters ground water. Because the leakage occurs below the influence of any plants, there is no chance for the nitrate to attenuate due to plant uptake.

62. Although no samples were collected for analytical testing from the settling basins during our site inspections, reasonable estimates can be made about the chemical nature of their contents using analytical results from lagoons containing similar wastes. A sample we collected from Cow Palace Lagoon 2 in October 2013 exhibited a total nitrogen concentration (sum of organic nitrogen, ammonia, nitrite, and nitrate) of 1,600 ppm. In addition, table 20 of the EPA report provides analytical results of samples collected from 12 lagoons in the "Dairy Cluster." Total nitrogen concentrations detected in these samples ranged from 290 ppm to 1,800 ppm and averaged 1,180 ppm. The Settling Basins are the first in a series of several waste containment structures at the Cow Palace and are designed to contain manure with more organic solids than subsequent lagoons. Therefore, I believe the estimates of total nitrogen content listed above to be conservative with respect to the actual nitrogen concentrations of the waste contained in the Settling Basins.

Lagoon 2

63. Lagoon 2, or "Pond 2," at Cow Palace Dairy is 300 ft. x 200 ft. by 16 ft. deep (including one foot of freeboard), with a calculated storage capacity of approximately 5,149,980 gallons, or 15.8 acre feet.[43] Cow Palace does not possess any information about whether Lagoon 2 can meet the current, or any prior, NRCS WA 313 standard.[44] Lagoon 2 does not contain any type of geosynthetic liner, but was instead constructed into the ground using a soil lined-bottom.[45] Cow Palace does not know the thickness of the soil liner, but for the purposes of the calculations below, I assume it is one foot thick.

64. The photo below represents the condition of Lagoon 2 as it was at the time of Plaintiffs' October, 2013 inspection.

[43] COWPAL000012; 000038; 000040.
[44] DAIRIES000910.
[45] ECF No. 133 at 8 (Answer to Second Amended Complaint).

Photo: View to the west of Lagoon 2. Dried and cracked manure seal on sloped sides of lagoon is visible on south end of lagoon.

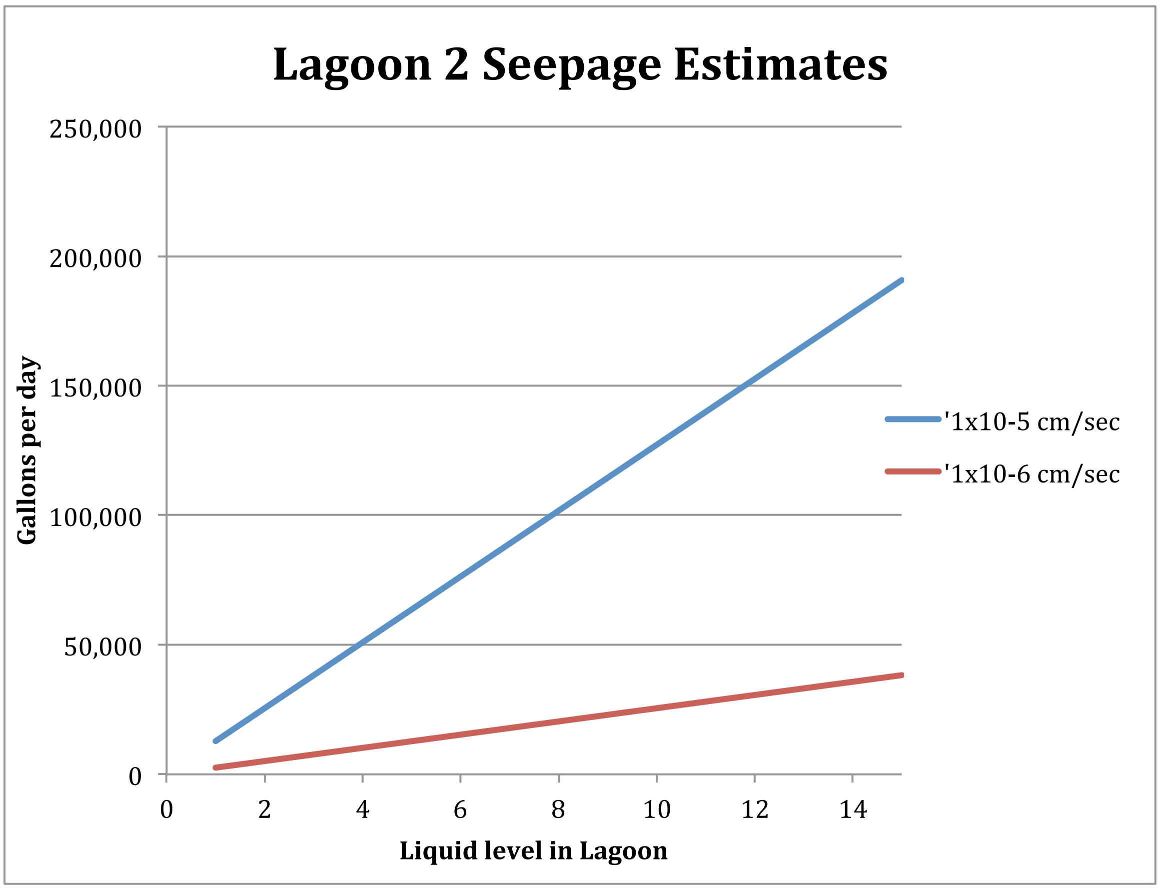
65. In order to estimate the seepage from this lagoon, the following assumptions were made: soil permeability 1x10-5 cm/sec, 1 foot thick soil liner, 1 order of magnitude manure seal, and an average of 8 feet of liquid in the 16 foot deep pond. Since the pond is deeper than 15 feet and the soils in the area and in the pond footprint are sand, gravel and some silt, these assumptions should be conservative. The following table provides a conservative leakage estimates for Lagoon 2:

Q = KiA		
K=	0.000001	cm/sec

i=	7.5	ft
A=	60000	ft2
Q=	9,543	Gallons/day
	286,278	Gallons/month
	3,483,053	Gallons/year

66. There is no question that Lagoon 2 leaks large amounts of liquid manure into the ground. The only variable in the equation that has not been directly tested is the in-place permeability of the liner. The other significant variable that changes over time is the depth of liquid in the lagoon which, in this equation, is equal to the head or pressure exerted on the liner. The variable ranges from 0 when the lagoon is empty to 15 feet when the lagoon is full; however, since this is the second lagoon in the process, it most likely contains liquid during about 6 months per year. Assuming that the lagoon has a soil liner that is one foot thick and varying the liner permeability between 1x10-5 cm/sec and 1x10-6 cm/sec while maintaining the lagoon under half full conditions, Lagoon 2 leaks between 9,543 and 95,400 gallons of manure-contaminated water per day, or 1.7 million to 17 million gallons per year, assuming that the pond is half full at least 6 months of the year. Even assuming a liner permeability of 1 x 10-7 cm/sec and half full 6 months of the year, Lagoon 2 leaks 954 gallons of manure-contaminated water per day, or 170,000 gallons per year. Given, however, that the soil types in the area are of moderate to high permeability, that Cow Palace has

not maintained its manure seal properly, the specific discharge amounts are likely on the high end of my calculations. The following graph provides seepage estimates for Lagoon 2 with respect to liquid level changes from 1' to 15' and a range of permeability between 1x10-5 cm/sec and 1x10-6 cm/sec.



67. The lagoon leakage is especially concerning with respect to ground water contamination issues. Once the seepage leaves the bottom of the lagoon it will infiltrate the subsurface, saturate the underlying soil and continue to migrate in the subsurface until it encounters ground water.

Because the leakage occurs below the influence of any plants, there is no chance for the nitrate to attenuate due to plant uptake.

68. A sample we collected from Cow Palace Lagoon 2 in October 2013 exhibited a total nitrogen (sum of organic nitrogen, ammonia, nitrite, and nitrate) concentration of 1,600 ppm.

Lagoon 3

69. Lagoon 3, or "Pond 3," at Cow Palace Dairy is 225 ft. x 200 ft. by 21 ft. deep (including one foot of freeboard), with a calculated storage capacity of approximately 4,428,160 gallons, or 13.6 acre feet.[46] Cow Palace does not possess any information about whether Lagoon 3 can meet the current, or any prior, NRCS WA 313 standard.[47] Lagoon 3 does not contain any type of geosynthetic liner, but was instead constructed into the ground using a soil-lined bottom. Cow Palace does not know the thickness of the soil liner, but for the purposes of the calculations below, I assume it is one foot thick.

70. In order to estimate the seepage from this lagoon, the following assumptions were made: soil permeability of 1x10-5 cm/sec, 1 foot thick soil liner, 1 order of magnitude manure seal, and an average of 10 feet of liquid in the 21 foot deep pond. Since the pond is much deeper than 10 feet and the soils in the area and in the pond footprint are sand, gravel and some silt,

---

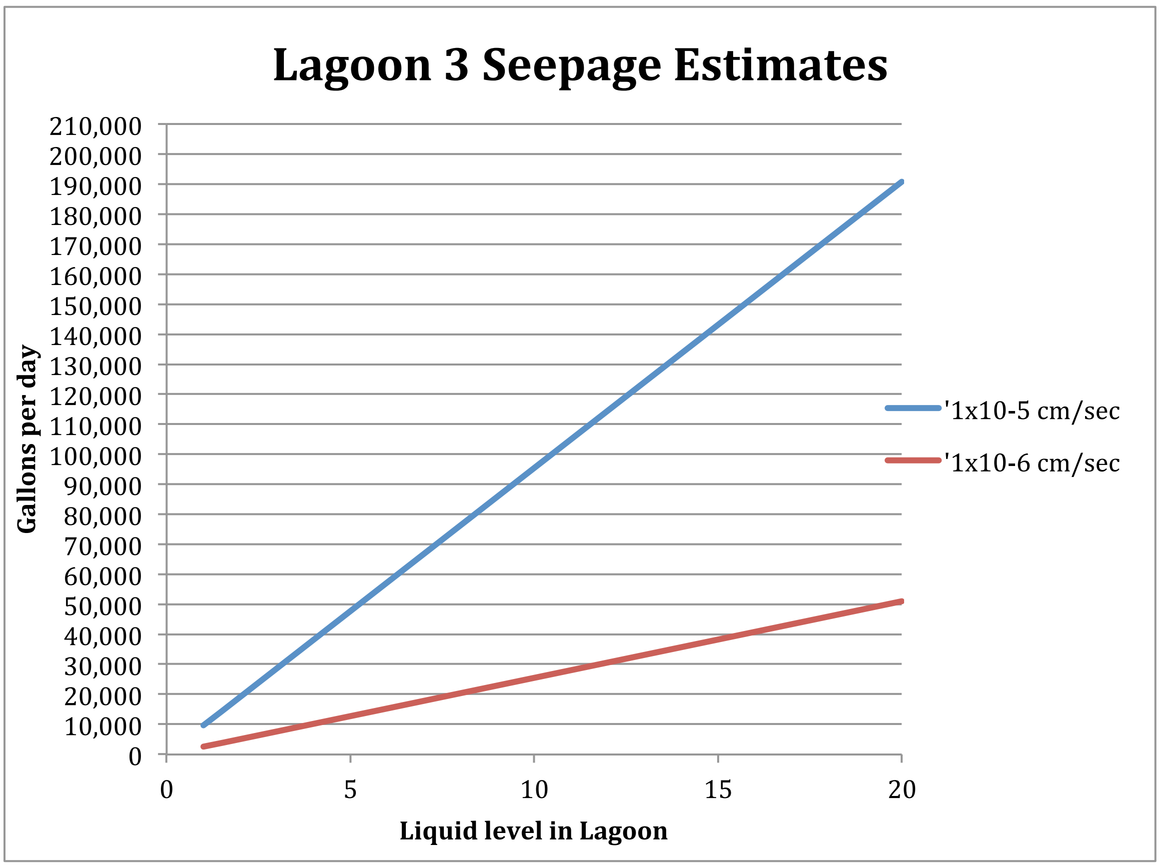
[46] COWPAL000012; 000038; 000041.
[47] DAIRIES000910.

these assumptions should be conservative. The following table provides a conservative leakage estimates for Lagoon 3:

Q = KiA		
K=	0.000001	cm/sec
i=	10	ft
A=	45000	ft2
Q=	9,543	Gallons/day
	286,278	Gallons/month
	3,483,053	Gallons/year

71. There is no question that Lagoon 3 leaks large amounts of liquid manure into the ground. The only variable in the equation that has not been directly tested is the in-place permeability of the liner. The other significant variable that changes over time is the depth of liquid in the lagoon which, in this equation, is equal to the head or pressure exerted on the liner. The variable ranges from 0 when the lagoon is empty to 20 feet when the lagoon is full; however, since this is the third lagoon in the process, it most likely contains liquid about 4 months per year. Assuming that the lagoon has a soil liner that is one foot thick and varying the liner permeability between 1x10-5 cm/sec and 1x10-6 cm/sec while maintaining the lagoon under only half-full conditions, Lagoon 3 leaks between 9,543 and 95,400 gallons of manure-contaminated water per day, or 1.16 million and 11.6 million gallons per year, assuming that the pond is half-full at least 4 months of the year. Even assuming a liner permeability of 1 x 10-7 cm/sec and half-full conditions

four months of the year, Lagoon 3 leaks 954 gallons of manure-contaminated water per day, or 116,000 gallons per year. Given, however, that the soil types in the area are of moderate to high permeability, that Cow Palace has not maintained its manure seal properly, the specific discharge amounts are likely on the high end of my calculations. The following graph provides seepage estimates for Lagoon 3 with respect to liquid level changes from 1' to 20' and a range of permeability between 1x10-5 cm/sec and 1x10-6 cm/sec.



The lagoon leakage is especially concerning with respect to ground water contamination issues. Once the seepage leaves the bottom of the lagoon it will infiltrate the subsurface, saturate the underlying soil and continue to migrate in the subsurface until it encounters ground water. Because the leakage occurs below the influence of any plants, there is no chance for the nitrate to attenuate due to plant uptake.

72. Although no samples were collected for analytical testing from the Lagoon 3 during our site inspections, reasonable estimates can be made about the chemical nature of its contents using analytical results from lagoons containing similar wastes. A sample collected from Cow Palace Lagoon 2 in October 2013 exhibited a total nitrogen (sum of organic nitrogen, ammonia, nitrite, and nitrate) concentration of 1,600 ppm. In addition, table 20 of the EPA report provides analytical results of samples collected from 12 lagoons in the "Dairy Cluster." Total nitrogen concentrations detected in these samples ranged from 290 ppm to 1,800 ppm and averaged 1,180 ppm.

Lagoon 4

73. Lagoon 4, or "Pond 4," at Cow Palace Dairy is 265 ft. x 200 ft. by 14 ft. deep (including one foot of freeboard), with a calculated storage capacity of approximately 3,689,704 gallons, or 11.3 acre feet.[48] Lagoon 4 does not

[48] COWPAL000012; 000038; 000041.

contain any type of geosynthetic liner, but was instead constructed into the ground using a soil-lined bottom.[49]

74. Lagoon 4 was brought into operation at the facility sometime after August, 2004.[50] In designing Lagoon 4, Cow Palace obtained a soil sample of the material used to line Lagoon 4, which was described as "silt with trace sand."[51] The laboratory permeability testing showed that the wall of the constructed lagoon had a permeability of 5.7 X 10-7 cm/sec.[52] Cow Palace's contractor, however, only tested the sides of the earthen lagoon, not the bottom and performed an insufficient number of tests to characterize the liner.[53] In addition, the test was a laboratory analysis of the soil used to line the lagoon, not an actual test of the in-place liner permeability. This is problematic because it does not present a complete picture of the permeability characteristics of the lagoon or significant characterization of the actual permeability of the liner.

75. In order to estimate the seepage from this lagoon, the following assumptions were made: soil permeability 5.7x10-7 cm/sec, 1 foot thick soil liner, both 0.5 and 1 order of magnitude manure seal, and an average of 6.5 feet of liquid in the 14 foot deep pond. Since the pond is much deeper than

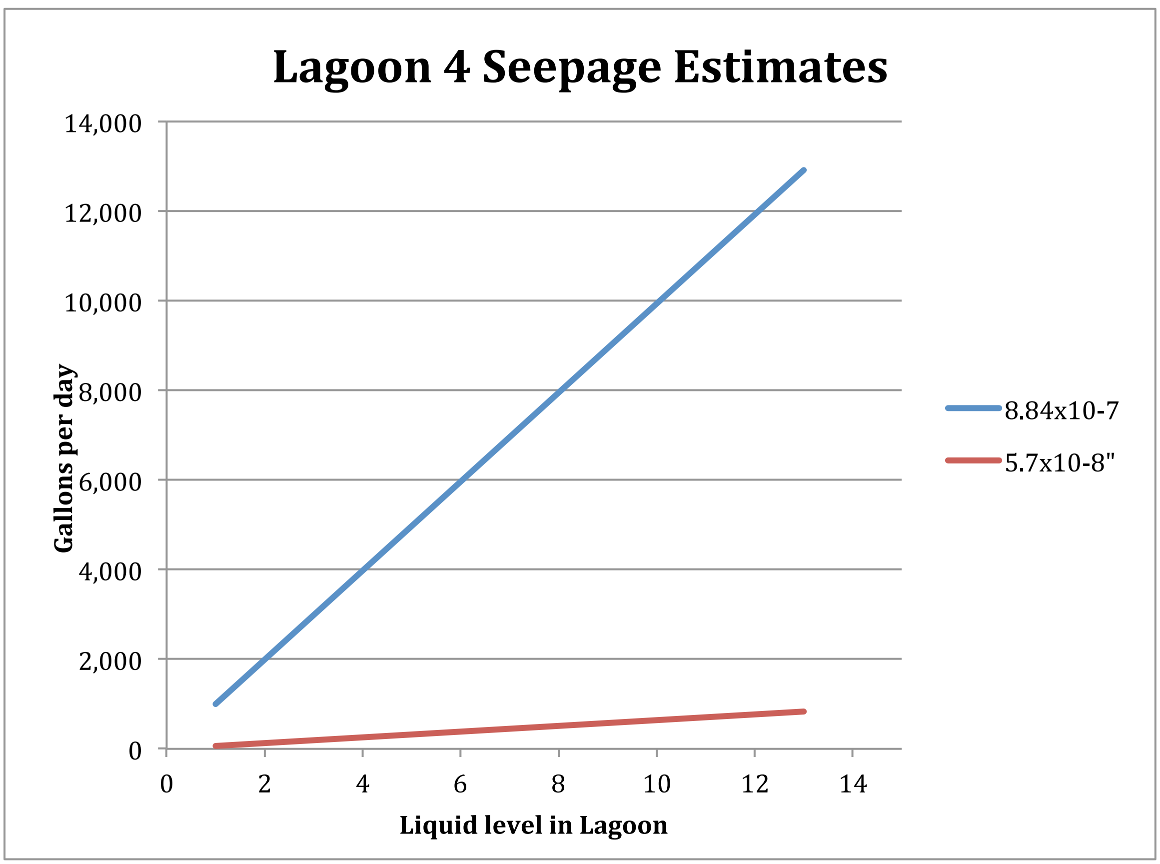
[49] ECF No. 133 at 8 (Answer to Second Amended Complaint).
[50] COWPAL000012.
[51] DAIRIES000921; *see also* DAIRIES000922.
[52] DAIRIES000921.
[53] DAIRIES000931.

6.5 feet and the soils in the area and in the pond footprint are sand, gravel and some silt, these assumptions should be conservative. The following table provides a conservative leakage estimates for Lagoon 4:

Q = KiA		
K=	0.000000057	cm/sec
i=	6.5	ft
A=	53000	ft2
Q=	416	Gallons/day
	12,492	Gallons/month
	151,989	Gallons/year

76. There is no question that Lagoon 4 leaks liquid manure into the ground. One variable in the equation that has not been directly tested is the in-place permeability of the liner with the manure seal, which may decrease the permeability by ½ to 1 order of magnitude. The other significant variable that changes over time is the depth of liquid in the lagoon which, in this equation, is equal to the head or pressure exerted on the liner. The variable ranges from 0 when the lagoon is empty to 13 feet when the lagoon is full; however, since this is the fourth lagoon in the process, it most likely contains liquid during at least 4 months per year. Even assuming that the lagoon has a soil liner that is one foot thick and varying the liner permeability between 5.7x10-8 cm/sec and 8.84x10-7 cm/sec while maintaining the lagoon under half-full conditions, Lagoon 4 leaks between 416 and 6,458 gallons of

manure-contaminated water per day, or 50,600 to 785,000 gallons per year, assuming that the pond is half-full at least 4 months of the year. Given, however, that the soil types in the area are of moderate to high permeability, that Cow Palace has not maintained its manure seal properly, and liquids are likely in the pond more of the year, the specific discharge amounts are likely on the high end of my calculations. The following graph provides seepage estimates for Lagoon 4 with respect to liquid level changes from 1’ to 13’ and a range of permeability between 8.84x10-7 cm/sec and 5.7x10-8 cm/sec.



77. The lagoon leakage is especially concerning with respect to ground

water contamination issues. Once the seepage leaves the bottom of the lagoon it will infiltrate the subsurface, saturate the underlying soil and continue to migrate in the subsurface until it encounters ground water. Because the leakage occurs below the influence of any plants, there is no chance for the nitrate to attenuate due to plant uptake. Based on my observations, I do not believe that there is an effective manure seal on Lagoon 4 that would prevent liquid manure from leaching through the bottom of the lagoon.

78. Although no samples were collected from Lagoon 4 during our site inspections, reasonable estimates can be made about the chemical nature of its contents using analytical results from lagoons containing similar wastes. A sample we collected from Cow Palace Lagoon 2 in October 2013 exhibited a total nitrogen (sum of organic nitrogen, ammonia, nitrite, and nitrate) concentration of 1,600 ppm. In addition, table 20 of the EPA report provides analytical results of samples collected from 12 lagoons in the "Dairy Cluster." Total nitrogen concentrations detected in these samples ranged from 290 ppm to 1,800 ppm and averaged 1,180 ppm.

79. Cow Palace does not use manure that leaks from its lagoons as fertilizer, nor could it.[54] This is reinforced by the fact that the Lagoon's

[54] Cow Palace Revised Response to Plaintiffs' Request for Admission 1.

bottom depth is below crop rooting zones, which I observed during our field sampling to be typically between two- to three-feet below the surface. As such, the manure that leaks from Lagoon 4 has only one final destination: groundwater.

Safety Debris Basin

80. The "Safety Debris Basin" at Cow Palace Dairy is 170 ft. x 200 ft. by 8 ft. deep, with a calculated storage capacity of approximately 2,000,000 gallons.[55] Cow Palace does not possess any information about whether the Safety Debris Basin can meet the current, or any prior, NRCS WA 313 standard.[56] The Safety Debris Basin does not contain any type of geosynthetic liner, but was instead constructed into the ground using a soil-lined bottom. Cow Palace does not know the depth of the soil liner, based on my observation while on site, liner material was not noticeable. The Basin was designed to store manure-contaminated run-off from the Dairy's pens and other areas, as well as run-off from the silage area.[57] Liquid from the Safety Debris Basin is applied to agricultural fields after being pumped into a spray truck or the settling basins.[58]

81. Adjacent to the Safety Debris Basin is another "stormwater catch

[55] COWPAL000012.
[56] DAIRIES000910.
[57] Boivin Trans., 177:16-18; COWPAL000012.
[58] Boivin Trans., 178:24-181:11.

basin," as it was described to me during the October 2013 inspection of Cow Palace Dairy. This stormwater catch basin is not part of the Cow Palace DNMP and not identified as a lagoon for implementation of the AOC, even though the basin had stored manure-contaminated water in the past. I have not seen any information about the construction of this basin or its dimensions, other than the information gained by personal observation.

82. The photographs below depict the condition of the Safety Debris Basin, adjacent storm water catch basin, and surrounding features as they were during Plaintiffs' October 2013 and May 2014 inspections.

Photo: View during October 2013 inspection of drop inlet near Safety

Debris Basin collecting silage leachate. Leachate was being conveyed through a pipe and discharged into Safety Debris Basin.

Photo: View during October 2013 inspection of Safety Debris Basin. A sample of silage leachate being discharged into the basin is being collected at right.

Photo: View to south during May 2014 inspection. Safety Debris Basin visible at left and storm water catch basin at right.

83. There is no question that Safety Debris Basin and the adjacent stormwater catch basin discharge liquid into the ground.

84. My understanding is that Cow Palace does not use liquid that leaks from the Safety Debris Basin and the stormwater catch basin as fertilizer.[59] From my observations, there are no crops in that immediate area that could use the manure as fertilizer, especially considering that the Safety Debris Basin's bottom depth is below crop rooting zones. As such, the manure that leaks from the Safety Debris Basin has only one final destination:

[59] Cow Palace Revised Response to Plaintiffs' Request for Admission 1.

groundwater.

85. My opinions about the Safety Debris Basin are reinforced by sampling accomplished by Plaintiffs during their October 2013 and May 2014 site visits of Cow Palace Dairy. During the 2013 visit, I oversaw the collection of a sample of silage leachate that was being collected from the base of a silage pile into a drop inlet with a grated manhole cover, conveyed in a buried pipe, and discharged into the Basin. The sample contained nitrate at a concentration of 29.5 ppm, ammonia at 574 ppm, and a total nitrogen content of 2,850 ppm. Erosion can occur at pipe discharge locations, especially when liquid falls some distance from the end of the pipe to the discharge point (as depicted in the photographs above), and could potentially compromise any manure seal that would otherwise be present in the basin.

86. During the 2014 visit, I supervised the use of a Geoprobe hydraulic probe to collect soil core samples from the dike between the Safety Debris Basin and the stormwater catch basin. A table of the results is presented below. Although perched groundwater was not encountered in this boring, the lithology was observed to be a highly-layered depositional environment, which is typically commensurate with discrete zones of perched water. Several of the layers at depths up to 18 feet bgs exhibited elevated nitrate concentrations, indicating that contaminated liquid had been in contact with

the subsurface soil.

Sample ID	**Sample Date**	**Depth**	**pH, SU**	**Phosphorus, ppm**	**Nitrate, ppm**	**Ammonium -N, ppm**	**Total Nitrogen, Solid, mg/kg**
CP-SB-04C-8-10	5/22/14	8-10	7.7	38	20.3	1.1	270
CP-SB-04C-10-12	5/22/14	10-12	7.7	5.1	18.2	0.9	887
CP-SB-04C-13-15	5/22/14	13-15	7.8	4.9	14.4	0.8	< 100
CP-SB-04C-15-16	5/22/14	15-16	7.7	5.9	27	1.2	138
CP-SB-04-17.8-18.2	5/19/14	17.8-18.2	7.2	10.7	22	4.4	112
CP-SB-04-19.5-20	5/19/14	19.5-20	8	< 1.4	2.9	2	< 100
CP-SB-04C-20-23	5/22/14	20-23	7.8	< 1.4	7.8	0.5	< 100
CP-SB-04C-27-30	5/22/14	27-30	7.6	2.1	6.1	0.6	< 100
CP-SB-04C-45.5-47	5/22/14	45.5-47	7.8	< 1.4	1.2	7.5	< 100

87. These results support my opinion that the Safety Debris Basin and the stormwater catch basin leak liquid. That nitrates were present deep in the soil shows that these lagoons are leaking liquid manure. Given Plaintiffs' limited investigatory ability, this area requires further characterization.

Catch Basin NW

88. The Catch Basin NW at Cow Palace Dairy is 135 ft. x 242 ft. by 25 ft. deep, with a calculated storage capacity of approximately 3,100,100 gallons, or 9.4 acre feet.[60] The Basin does not contain any type of geosynthetic liner, but was instead constructed into the ground using a soil-lined bottom.

89. The Catch Basin NW is designed to catch stormwater run-off from the cow pens that are located nearby, to collect run-off from the compost area, and to collect runoff and wastewater from the calf barn.[61] The liquid contained in the Basin can be pumped to the settling basins, where it can later be applied to fields.[62]

90. When drilling monitoring well YVD-06 on August 17, 2013, Cow Palace's contractors noticed that there was an "effervescing" in the nearby Catch Basin NW. The bubbling was noticed as the boring was advanced from 100 ft. to 128 ft. bgs, where 20 feet of sandy gravel, a very permeable

---

[60] COWPAL000012.
[61] Boivin Trans. 192:22-193:5.
[62] Boivin Trans. 194:10-195:5.

soil type, was encountered. The bubbling spot in the lagoon was 50 feet north of the edge of the lagoon toward the center of the impoundment. Cow Palace confirmed that the bubbling was only noticed when the air rotary drill was in operation.[63] The air rotary drilling operation uses high pressure, high volume air injection to remove the cuttings from the borehole. The air injection is usually in the range of 900 cubic feet per minute at 300 pounds per square inch. After starting and stopping the air injection, it was verified that the air rotary drill was causing bubbling less than 50 feet away. This bubbling demonstrates that both the subsurface is very permeable with discrete vertical flowpaths and that Catch Basin NW liner was not a significant barrier to fluid migration, likely discharging large amounts of manure liquid to the ground and groundwater. The air injection also finds the path of least resistance through the subsurface material, directly indicating that the subsurface contains preferential flowpaths that can transmit significant quantities of fluid to ground water. At the time, the lagoon was approximately 35 percent full of material.[64] These data further verify our assumption that a majority of the leakage in the lagoons occurs in discrete preferential pathways within the footprint of the lagoon. As a result, a more detailed investigation is required to locate and sample those specific

---

[63] DAIRIES002890.
[64] Boivin Trans. 199:3-5.

migration pathways. Three exploratory borings in the vicinity of over 35 lagoons on four facilities were all that were allowed during our investigation based on the Court Order. This is not a sufficient investigative effort to characterize seepage from the waste handling facilities at this site.

91. Cow Palace drained the lagoon soon thereafter, re-sloping the sides and re-compacting the soil liner.[65] No soil permeability tests or core tests were taken at this time.[66] It is highly suspect why Cow Palace decided not to take or report soil permeability tests for the Catch Basin, considering it had been completely drawn down, re-sloped, and re-compacted, and that it had an obligation under the AOC to demonstrate that its lagoons met the NRCS WA 313 standard. In addition, when we visited the lagoon in the fall of 2013, it had been emptied and a new liner was placed and compacted. Visual observation of the liner and physical inspection (including rubbing some of the material between my fingers to determine silt, sand and clay concentration), indicated it was a fine sand to silt texture, not a compacted clay liner. At that time, waste water from the calf pens was running into a small impoundment in the northwest corner of the lagoon at a rate of 5 to 10 gallons per minute. The small impoundment was less than 10’ by 10’ and 2’ deep. During our two day tour, the flow was fairly constant and the small

[65] Boivin Trans. 198:5-12.
[66] Boivin Trans. 201:5-14.

holding area never overflowed, indicating that infiltration was taking place at a rate roughly equal to the rate of flow into the bermed area minus a small evaporation component.

Photo. View of NW Catchment Basin during October site visit. New liner with significant erosion from infall pipes is shown

Photo. View of NW Catchment Basin. Outfall from calf pens with liquid infiltrating is shown.

92. The photos above represent the condition of the Catch Basin NW as it was at the time of Plaintiffs' October 2013 inspection. As is evident from the photographs, Cow Palace had recently completed re-sloping the sides and compacting the soil liner.

93. There is no question that the Catch Basin NW discharges liquid waste and manure into the ground, especially considering that operation of an air rotary drill 50 feet away provided sufficient air pressure to penetrate the liner of the impoundment, even at 35% capacity. Assuming that the Lagoon has a soil liner that is one foot thick and contains liquid during at least six month per year, the Basin leaks between 8,314 and 83,100 gallons of manure

per day, or between 1.6 million and 16 million gallons/year depending on the specific permeability of the soil. Given, however, that the soil types in the area are of moderate to high permeability, and that Cow Palace has not maintained its manure seal properly, the specific discharge amounts are likely on the high end of my calculations.

94. Given the location of this Basin and the depth of the bottom of the lagoon, once the liquid seeps from the lagoon, there is no opportunity for plant uptake of nutrients. The leakage will migrate through the soil under gravity drainage conditions until it encounters a perched water table or the ground water table where it will contaminate the ground water.

Catch Basin NE

95. The Catch Basin NE at Cow Palace Dairy is 130 ft. x 175 ft. by 8 ft. deep, with a calculated storage capacity of approximately 1,100,000 gallons, or 3.4 acre feet.[67] The Basin does not contain any type of geosynthetic liner, but was instead constructed into the ground using a soil-lined bottom.

96. The Catch Basin NE is designed to catch stormwater run-off from the cow pens that are located nearby, to collect run-off from the truck wash station, and to collect runoff from the silage area.[68] The liquid contained in the Basin can be pumped to the settling basins, where it can later be applied

[67] COWPAL000012.
[68] Boivin Trans. 185:4-7.

to fields.[69]

97. The photos below represent the condition of the Catch Basin NE as it was at the time of Plaintiffs' October 2013 inspection.

Photo. View of NE Catchment Basin. Note erosion from inflow and lack of manure seal.

98. Based on our observations, this basin most likely contains liquid during most of the year. Assuming the basin has 4 feet of liquid, and the manure seal provides a one order of magnitude seal, the following table summarizes the suspected leakage from the basin.

Q = KiA		
K=	0.000001	cm/sec
i=	4	ft
A=	22750	ft2

[69] Boivin Trans. 185:17-25.

Q=	1,930	Gallons/day
	57,892	Gallons/month
	704,351	Gallons/year

There is no question that the Catch Basin NE discharges liquid manure and other liquid wastes into the ground. Assuming that the Basin has a soil liner that is one foot thick, the Lagoon leaks between 1,930 and 19,300 gallons of manure per day, which equates to 704,350 to 7.04 million gallons/year, depending on the specific permeability of the soil. Given, however, that the soil types in the area are of moderate to high permeability, and that Cow Palace has not maintained its manure seal properly, I believe that the specific discharge amounts are likely on the high end of my calculations.

99. The lagoon leakage is especially concerning with respect to ground water contamination issues. Once the seepage leaves the bottom of the lagoon, it will infiltrate the subsurface, saturate the underlying soil and continue to migrate in the subsurface until it encounters ground water. Because the leakage occurs below the influence of any plants, there is no chance for the nitrate to attenuate due to plant uptake.

Stormwater Pumpback Pond / Tailwater Pond / "Tailwater Catching Pond"

100. Cow Palace uses three tailwater recovery ponds located to the south of

the Dairy and to the south of most of its application fields.[70] These ponds are designed to catch run-off from the Dairy's application fields, and contain manure nutrients from manure application runoff.[71] The ponds do not contain any type of geosynthetic liner, but were instead constructed into the ground using a soil-lined bottom.[72]

101. Plaintiffs sampled one of the tailwater recovery ponds during their October Rule 34 inspection of Cow Palace Dairy. The recovery pond that was sampled is located just off Knowles Road, in the southwest corner of one of Cow Palace's application fields. Nitrogen (Ammonia as N) was observed at 90 mg/L; Total Kjeldahl Nitrogen was 128 mg/L; phosphorus was 12 mg/L; calcium was reported at 104 mg/L; magnesium at 51 mg/L; potassium at 257 mg/L; and sodium at 107 mg/L. These results confirm that the tailwater recovery pond contains substantial amounts of manure related nutrients from manure runoff.

102. Plaintiffs also sampled a tailwater recovery pond at the southwest corner of Cow Palace Field 2. That pond had lower concentrations of manure-related contaminants. Given that the pond has no liner, however, these contaminants will contribute, though less than other sources, to the

[70] DAIRIES000915.
[71] Boivin Trans. 218:23-219:11.
[72] Boivin Trans. 225:3-5.

contamination of the groundwater.

103. Cow Palace pumps the water that is recovered in these ponds back into their applications fields once the ponds are approximately two-thirds full. No manure nutrient sampling is conducted before applying liquids from these ponds.[73]

104. The photos below represent the condition of the southwest tailwater recovery pond as it was at the time of Plaintiffs' October, 2013 inspection.

Photo. Tailwater pond adjacent to Liberty

105. There is no question that the tailwater recovery ponds discharge manure-contaminated water into the ground. The concentration of the

[73] Boivin Trans. 222:12-15.

discharge is, of course, dependent on the water quality in the tailwater pond, but the amount of discharge would still occur. There was no evidence of construction of a liner and since the water is runoff from fields, it does not contain the same volume of manure solids as the other process lagoons. As a result, assuming that a manure seal would form is not correct. These ponds appeared to be constructed by placing a berm or dike across the downgradient side of the natural drainage, most likely without any construction of a liner. Assuming that the recovery ponds have a soil liner that is one foot thick that reduce the permeability to 1x10-6 and the ponds contain water during most of the year, then the total pond leakage from these three ponds is between 6,777 and 67,700 gallons per day, or 2.47 million to 24.7 million gallons/year depending on the specific permeability of the soil. Given, however, that the soil types in the area are of moderate to high permeability, and that there are no manure seals on these recovery ponds, the specific discharge amounts are likely on the high end of my calculations.

106. The pond leakage is especially concerning with respect to ground water contamination issues. Once the seepage leaves the bottom of the lagoon, it will infiltrate the subsurface, saturate the underlying soil and continue to migrate in the subsurface until it encounters ground water. Because the leakage occurs below the influence of any plants, there is no

chance for the nitrate to attenuate due to plant uptake.

Haak Dairy Lagoon Cores

107. While there is some range of uncertainty in the calculations outlined *supra*, as stated above, I believe to a reasonable degree of scientific certainty that Cow Palace's lagoons are and have been seeping manure into the ground and groundwater since each came into active operational use. I further believe that the specific discharge rate for each lagoon likely falls into the higher range of my estimates, because of the lagoon construction methods, the permeable soil beneath the lagoons, the lack of an actual liner, the observation of coarse-grained material in the liner footprint, the soil sampling results near the lagoons, and an industry standard that allows significant seepage.

108. The opinions expressed above concerning discharges from Cow Palace's lagoons, basins, and recovery ponds are reinforced by the data results obtained by Plaintiffs' from the Haak Dairy's manure storage lagoon.

Photo. Collecting Geoprobe samples in the Bottom of Haak Lagoon

109. On May 23, 2014, I supervised the use of the Geoprobe hydraulic drill within Haak Dairy's large manure storage lagoon, which had been previously emptied some 7 months earlier in October 2013; mechanically excavated and scraped in November, 2013, which removed any type of "manure seal" that would have been present, and any other remaining solid manure; and then taken out of active service.

110. From my observations, the Haak lagoon that was tested is, most likely, very similar to the lagoons at Cow Palace Dairy, given the age of the facility and the similar manure handling processes. The Haak lagoon has no geosynthetic liners, but rather was constructed into the ground using native soils with no evidence of construction of a soil liner, just like the Cow

Palace impoundments. When investigating the lagoon, areas of a 2-inch thick manure “seal” were visible. Immediately beneath the seal was native soil with no evidence of soil different from the native or mechanical compaction. The native soils in the area are nearly identical to the soils found at Cow Palace; underlying the Haak Dairy, the predominant soils appear to be Warden silt loam,[74] which is also similar to Cow Palace.[75] Accordingly, I believe that a core sampling within the Haak Dairy lagoon provides a good approximation of what one would expect to find if the same tests were conducted in any one of Cow Palace’s lagoons.

111. The photographs below depict the Haak lagoon that was tested as of the date of Plaintiffs’ testing.

[74] HAAK000074-79; HAAK000019-20.
[75] *See, e.g.*, DAIRIES016868-870.

Photo: Side of Haak Lagoon with manure cake and native soil exposed. Note gravel and cobbles.

Photo. Bottom of Haak lagoon with native soil and wire.

112. The analytical results of Plaintiffs' sampling of the Haak Lagoon are contained in the chart below.

Sample ID	Sample Date	Depth	pH, SU	Phosphorus, ppm	Nitrate, ppm	Ammonium-N, ppm	Total Nitrogen/Solid, mg/kg
HD-SB-01-0-1	5/23/2014	0-1	8.1	69.7	94.5	750	1310
HD-SB-01-1-2	5/23/2014	1-2	8.4	12.7	8.4	300	428
HD-SB-01-2-3	5/23/2014	2-3	8.1	8.1	1.4	16	131
HD-SB-01-3-4	5/23/2014	3-4	7.8	6.8	1.5	6.2	124
HD-SB-01-4-5	5/23/2014	4-5	7.4	3.6	0.8	16	< 100
HD-SB-01-5-6	5/23/2014	5-6	7	5.5	1.2	52	163
HD-SB-01-6-7	5/23/2014	6-7	7.2	4.6	1.7	33	172
HD-SB-01-7-8	5/23/2014	7-8	7.1	4.5	1.4	4.9	105
HD-SB-01-8-9	5/23/2014	8-9	7.4	2.5 J	16.1	2.1	115
HD-SB-01-9-10	5/23/2014	9-10	7.6	3	3.7	2.6	< 100
HD-SB-01-10-11	5/23/2014	10-11	7.4	4.5	1.7	1.8	< 100

HD-SB-01-11-12	5/23/2014	11-12	7.4	3.8	1.8	1.3	< 100
HD-SB-01-12-13	5/23/2014	12-13	7.2	4.7	1.6	2.7	< 100
HD-SB-01-13-14	5/23/2014	13-14	7.2	3.8	1.5	1.6	< 100
HD-SB-01-14-15	5/23/2014	14-15	7.6	5.9	1.7	1.5	< 100
HD-SB-01-15-18	5/23/2014	15-18	7.3	4.9	1.6	1.7	< 100
HD-SB-01-18-20	5/23/2014	18-20	7.6	4.9	1.7	1.3	113
HD-SB-01-20-22	5/23/2014	20-22	7.5	5.7	1.9	1.3	< 100
HD-SB-01-22-24	5/23/2014	22-24	7.5	4	2.2	1.5	< 100
HD-SB-01-26-28.5	5/23/2014	26-28.5	7.5	4.7	2.8	1.5	< 100
HD-SB-01-30-32	5/23/2014	30-32	7.2	5	2.3	2.6	< 100

HD-SB-01-34-37	5/23/2014	34-37	7.2	5.2	3.1	2.6	106
HD-SB-01-41-43	5/23/2014	41-43	7.2	3.9	2.1	1.7	< 100
HD-SB-01-43-45	5/23/2014	43-45	7.3	3.6	3.1	3.9	108

113. In total, Plaintiffs probed 45 ft. into the soil below the bottom of the Haak lagoon. Soil samples were collected throughout the soil profile and ground water samples were collected from two perched zones beneath the lagoon. These perched zones are direct evidence of preferential pathways beneath the lagoons that transmit water or seepage from the lagoon into the subsurface, eventually encountering the ground water table.

114. There were substantial concentrations of nitrate, phosphorus, and ammonium in the first foot underlying the Haak Lagoon. Nitrate was observed at 94.5 ppm, phosphorus at 69.7 ppm, and Ammonium at 750 ppm. This is highly indicative that liquid manure was seeping through the bottom of the Haak Lagoon.

115. In the second foot, both phosphorus and nitrate concentrations dropped to 12.7 ppm and 8.4 ppm, respectively. The phosphorus is adsorbed to the soil and only continues to migrate as the capacity of the soil is saturated.

116. More interesting is the conversion from Ammonium to Nitrate that occurs as the liquid seeps into the more oxygen rich soil. Once nitrate is formed, it is both highly soluble and highly mobile in the soil moisture. With a partitioning coefficient near zero, nitrate migrates in the water and is flushed through the soil very quickly with little attenuation. The

concentration of nitrate in the soil is more related to soil moisture conditions than soil absorption capacities.

117. When a permeable flowpath is encountered near the bottom of the lagoon, this leachate is transmitted along that flowpath and migrates deeper into the subsurface. The soil data shows evidence of this migration in the 5-6’ zone, where the ammonium concentration increases.

118. While levels of nitrate and phosphorus drop off after the first two feet, the fact that they are present in the soils underlying the lagoon, and considering that there are no other immediate nitrate or phosphorus sources, demonstrate that the Haak Lagoon, and lagoons of a similar construction, are sources of nitrate contamination. Under unsaturated flow conditions, seepage will find the more permeable sand and gravel zones and a majority of the liquid discharge will migrate in a few locations. Because we did only two borings in the lagoon, finding the preferential flow path in an area that large is somewhat akin to trying to find a needle in a haystack. Further time-consuming assessment would be needed to identify the flow path(s).

119. Overall, the data obtained from the Haak Lagoon boring further supports my conclusions that the lagoons at Cow Palace Dairy are leaking liquid manure into the ground and groundwater, and are therefore an additional source of the nitrate contamination observed in monitoring wells

downgradient.

COW PALACE'S ANIMAL HOLDING PENS ARE ANOTHER SOURCE OF THE NITRATE CONTAMINATION OBSERVED IN THE GROUNDWATER

120. Another source of nitrate loading to groundwater is the Cow Palace's animal holding pens. I have personally observed the pens at Cow Palace twice, in October 2013 and in May 2014. Each time, I observed significant amounts of liquid manure, solid manure, and urine accumulated within the pens. The photographs below fairly depict the pens as I observed them in October 2013 and May 2014.

Photo. View to north-northwest of Cow Palace holding pen. Milking parlor visible in background.

Photo. Note pooled liquid at bottom left.

Photo: View of Cow Palace holding pen during May 2014 inspection. Note saturated manure and soil.

121. I understand from the depositions of Cow Palace's personnel, including Jeff Boivin, that the pens are only scraped during the winter months, and that the manure in the pens is left to accumulate during summer,[76] where the moisture in the manure is susceptible to leaching through the ground.

122. Plaintiffs obtained two borings in Cow Palace's cow confinement pens using the Geoprobe. I personally supervised the drilling of the boring holes with the Geoprobe. The Geoprobe was used to collect the sample because it minimizes the noise level compared to other drilling methods, collects samples quickly, has a small footprint and only cores a small hole

[76] Boivin Trans. 76:7-77:4.

that can be easily sealed with bentonite. The map below depicts the approximate locations where the borings were completed is provided on Figure 1.

123. The results of Plaintiffs' sampling of the cow pens are contained in the table below:

Sample ID	Sample Date	Depth	pH, SU	Phosphorus, ppm	Nitrate, ppm	Ammonium-N, ppm	Total Nitrogen/Solid, mg/kg
CP-SB-10-0-1	5/19/2014	0-1	8.2	82	29.9	60	1060
CP-SB-10-1-2	5/19/2014	1-2	7.8	6.5	94.9	8.5	470
CP-SB-10-2-3	5/19/2014	2-3	7.6	5.5	92.1	0.8	295
CP-SB-10-3-4	5/19/2014	3-4	7.9	18.2	40	1.8	358
CP-SB-10-4-5	5/19/2014	4-5	7.9	9.1	8.5	2.4	153
CP-SB-10-5-6	5/19/2014	5-6	8.2	1.5	4.8	3.4	106
CP-SB-10-6-7	5/19/2014	6-7	8.4	1.9	4.7	2.4	126
CP-SB-10-7-8	5/19/2014	7-8	8.5	3.1	2.9	7.1	161
CP-SB-10-9-10	5/19/2014	9-10	8.5	6.5	5.5	2.2	128
CP-SB-11-0-1	5/20/2014	0-1	7.9	39.2	1.9	29	676
CP-SB-11-1-2	5/20/2014	1-2	8.1	75	1.6	160	1090
CP-SB-11-2-3	5/20/2014	2-3	8.7	25.4	14.2	130	591

124. These results show that cow manure nutrients such as nitrogen and phosphorus have leached through the soils in Cow Palace's pens. The results from the first three feet of the boring CP-SB-10 are most telling. There, nitrate was observed in the 0-1 foot depth at 29.9 ppm; at the 1-2 foot depth at 94.9 ppm, and at the 2-3 foot depth at 92.1 ppm. Four feet down, there was 40 ppm nitrate observed in the soil.

Photo. Geoprobe boring in the Cow Palace Pens.

125. Similar to the lagoons, the data shows an aerobic conversion from ammonium to nitrate in the first 3 feet. The nitrate migrates in soil moisture under unsaturated conditions. When a permeable layer is encountered, the liquid can accumulate and flow along the flowpath to ground water. Since there is no vegetation in the pens, once the conversion to nitrate is complete,

there is very little attenuation of nitrate beneath the pens.

126. These boring results show that Cow Palace's cow pens are a contributing source of the nitrate contamination observed in the groundwater. That excess nitrate and phosphorus were present beneath the pens show that Cow Palace's manure, including nitrate, are being leached through the permeable pen soils, and into the ground where I understand they are unavailable for use as fertilizer by Cow Palace. Since only one boring was completed in the pens, further remedial investigation is required to determine the extent of the loadings from the pens. The results above indicate that further testing is required to determine both the potential flow path and the nutrient load contributed by the holding pens.

COW PALACE'S SILAGE OPERATIONS ARE ANOTHER SOURCE OF THE NITRATE CONTAMINATION OBSERVED IN THE GROUNDWATER

127. During our site visit, leachate runoff from the silage production area was noted. The liquid was allowed to seep out of the silage and infiltrate into the ground. Excess leachate ran into the water collection system and ultimately ended up in the lagoon. A sample of the leachate was collected for laboratory analysis. The results are provided below.

Sample ID	Sample Date	TDS mg/l	pH, SU	Phosphorus, mg/l	Nitrate, mg/l	Ammonium-N, mg/l	Total Kjeldahl Nitrogen, mg/l
CP-Silage-SW	10/30/13	50100	3.9	898	29.5	574	2820

Photo. Silage leachate

128. Given the concentration of nutrients in the acidic leachate from the silage and the fact that this liquid is allowed to run on and into the ground, additional measures should be taken to capture and handle the leachate properly.

Photo. Silage Leachate

COW PALACE'S COMPOSTING OPERATIONS ARE ANOTHER SOURCE OF THE NITRATE CONTAMINATION OBSERVED IN THE GROUNDWATER

129. Another source of nitrate loading to groundwater is Cow Palace's composting area. I have personally observed the composting area at Cow Palace twice, in October 2013 and in May 2014. From my observations, solid manure is composted at Cow Palace on bare soil, without any concrete pads or other less permeable surfaces. The photographs below fairly depict the composting area as I observed it in October 2013 and May 2014.

Photo. Cow Palace compost processing area.

Photo. Soil sample collection in Compost Area.

130. Plaintiffs obtained one boring sample using a Geoprobe from Cow Palace's composting area, CP-SB-12, in May 2014. The map below shows

the approximate location where the boring occurred. The results of Plaintiffs' sampling are depicted in the table below:

Sample ID	Sample Date	Depth	pH, SU	Phosphorus ppm	Nitrate ppm	Ammonium-N, ppm	Total Nitrogen/Solid, mg/kg
CP-SB-12-0-1	5/19/2014	0-1	8.9	330	12.3	100	2170
CP-SB-12-1-2	5/19/2014	1-2	8	270	5.5	70	1680
CP-SB-12-2-3	5/19/2014	2-3	7.6	51.6	1	20	869
CP-SB-12-3-4	5/19/2014	3-4	7.6	59.4	0.9	14	8210
CP-SB-12-4-5	5/19/2014	4-5	7.5	35.3	49.6	4.5	602
CP-SB-12-5-6	5/19/2014	5-6	7.7	20.2	1.6	12	450
CP-SB-12-6-7	5/19/2014	6-7	7.7	26.4	1	100	818
CP-SB-12-7-8	5/19/2014	7-8	8.6	462	0.9	95	2600
CP-SB-12-8-9	5/19/2014	8-9	8.7	1970	6.8	180	5720
CP-SB-12-10-11	5/19/2014	10-11	8	161	1.6	83	1930
CP-SB-12-11-12	5/19/2014	11-12	8.2	65.2	4.2	19	832
CP-SB-12-12-13	5/19/2014	12-13	7.6	5.1	8.4	5.9	276
CP-SB-12-15-16	5/19/2014	15-16	8.1	7.2	5.1	5.2	133
CP-SB-12- 16-17	5/19/2014	16-17	7.9	2.9	2.1	3.5	< 100
CP-SB-12-17-18	5/19/2014	17-18	7.8	1.5	4.3	2.5	< 100

131. These results show that Cow Palace's composting area is another source of nitrate loading to soil and groundwater from the Dairy. Observations in the area indicate both high liquid content in the compost piles and infiltration of any precipitation that falls on the compost area. Subsurface data indicates vertical migration of nitrates, ammonium and phosphorus and accumulation in the 8-9' sample that again indicates the potential for perched zones and migration along preferential pathways. The high nitrate result of 49.6 ppm observed at the 4-5 foot depth, combined with the high ammonium levels observed at the 6-7 foot depth (100 ppm) and the 8-9 foot depth (180 ppm), and the high overall nitrogen content of, e.g., 5720 ppm at 8-9 foot depth are highly indicative of manure leachate infiltrating into the ground from the composting area. The high phosphorus result obtained in the 9-10 foot depth further shows that contamination is seeping through the soil in the composting area. There, phosphorus was observed at 1970 ppm, an exceptionally high number for that deep in the soil. In addition, the high organic nitrogen content indicated a source for continued decomposition and the production of ammonium beneath the composting area.

132. The only present source of the nitrate observed in this boring is the composting area located on the surface. Importantly, because there are no

crops planted in the composting area or nearby that could make use of the nitrate as fertilizer, and given that the soils underlying Cow Palace are not suitable for denitrification, as discussed *supra*, the only destination for the nitrates observed in the soil boring is dissolution into soil moisture, and migration along preferential pathways with a final destination into the area groundwater.

133. In conclusion, these boring results show that Cow Palace's composting area is a source of nitrate loading to groundwater from the Dairy. The excess manure constituents, such as nitrate, ammonium, total nitrogen and phosphorus, observed beneath the composting area demonstrate that Cow Palace's composting operations are causing manure and its associated constituents to leach through the permeable soils. They, thereafter move deeper into the ground where they cannot be used as fertilizer, either by Cow Palace or the recipients of Cow Palace's exported compost. They will eventually reach groundwater with further precipitation and continued moisture addition from the composted material

134. Because we were allowed to complete only one boring in the compost area, further investigation is needed to characterize the extent and magnitude of the soil and ground water impact caused by the compost operation.

COW PALACE'S APPLICATION FIELDS ARE ANOTHER SOURCE OF THE NITRATE CONTAMINATION OBSERVED IN

THE GROUNDWATER

135. Significant sources of nitrate loading to groundwater come from Cow Palace's crop fields. I personally observed the collection of 36 composite soil samples using Geoprobe hydraulic direct-push drill rigs. The samples were collected at approximately 1-foot depth intervals from the ground surface down to 5 feet bgs. The photographs below fairly depict the field areas I observed in May 2014.

136. The map in Exhibit C shows the approximate locations where each boring occurred. Samples from the depth intervals described above were collected from 8 to 10 locations in a section of each crop field and composited together, yielding samples that represent average concentrations in each field section and at each depth interval. I also took a few individual grab samples, which depict just one soil boring in a particular location. These discrete samples were collected and analyzed because of a change in lithology or a change in moisture, as observed by field personnel. In the corners of the pivot-irrigated fields, application of manure from the lagoons is completed manually (as shown in the picture below) by direct discharge of lagoon liquid waste onto the field, as a result one of the borings complete in the corner was analyzed independently of the remainder of the field.

Photo. Manual application of liquid manure at Cow Palace.

Photo. Liquid manure application and tilling.

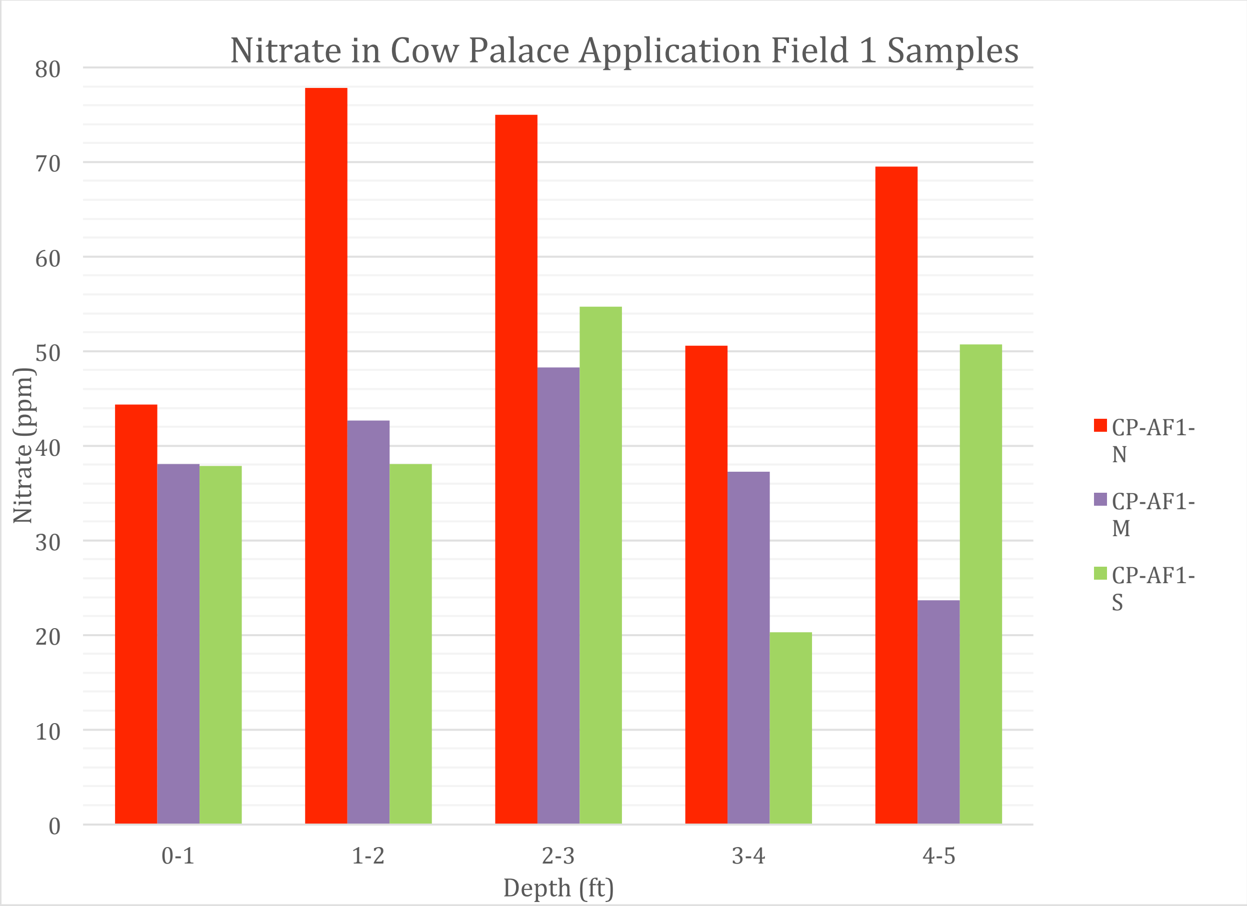
137. The analytical results of Plaintiffs' soil samples from crop fields are summarized in the table below. For clarity, the sample naming scheme is as follows: Cow Palace soil samples collected from application fields are identified with "CP" for Cow Palace, followed by "AF1" or "AF2" for

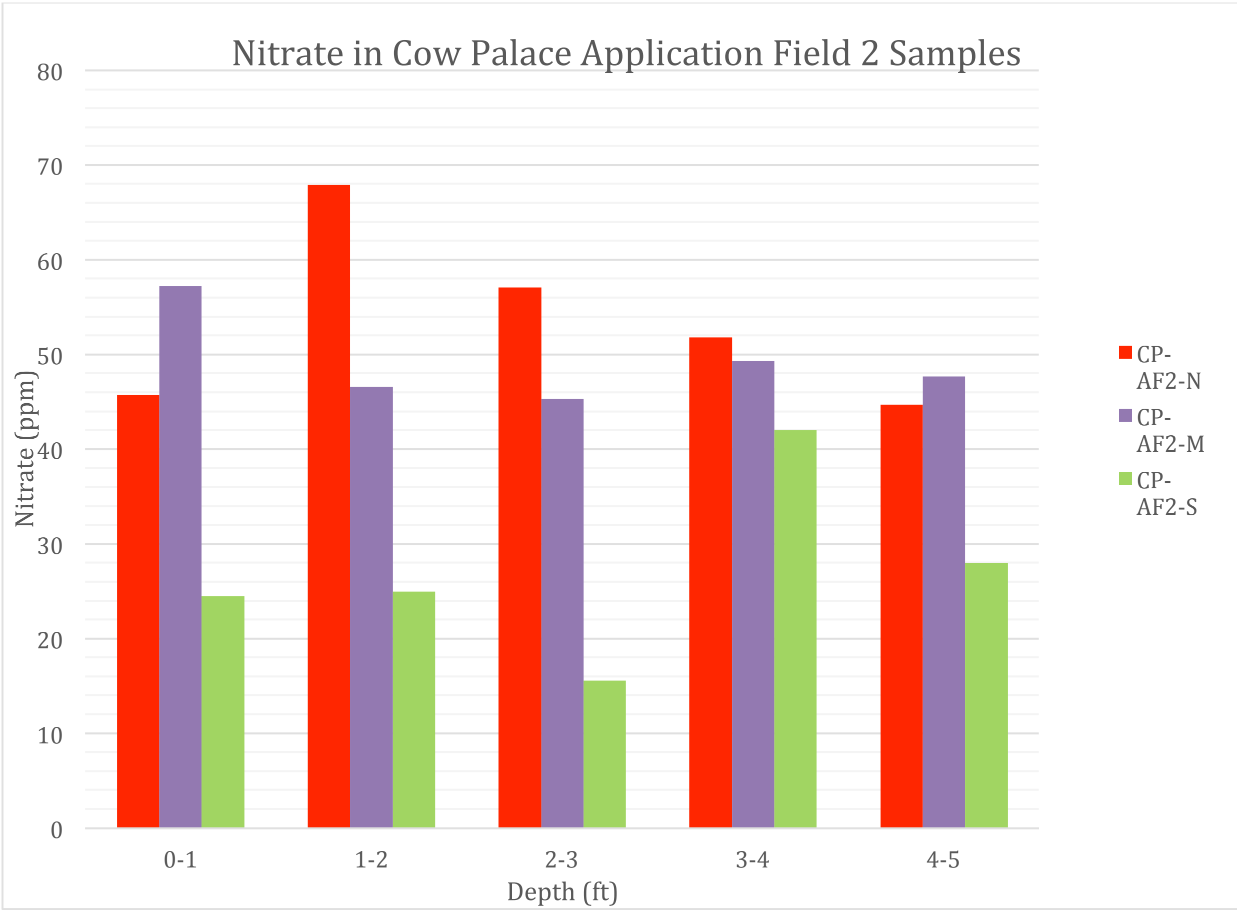
application field number 1 or number 2, followed by a letter identifying which section of the particular field the composite sample was collected ("N" indicates the northern section of the indicated field, "M" indicates the middle section of the indicated field, and "S" indicates the southern section of the indicated field). The final identifier in the sample name contains two numbers indicating the depth below ground from which the sample was collected (ex., 0-1 indicates 0 to 1 foot below the surface). Sample locations were logged in the field using GPS and are shown on Figure 1 in Exhibit C.

Sample ID	**Sample Date**	**Depth**	**pH, SU**	**Phosphorus, ppm**	**Nitrate, ppm**	**Ammonium-N, ppm**	**Total Nitrogen/Solid, mg/kg**
CP-AF1-N-3-4	5/19/2014	3-4	8.3	64.2	50.6	9.3	334
CP-AF1-N-4-5	5/19/2014	4-5	8.3	34.9	69.5	1.4	254
1-CP-AF1-N Grab 3-5ft	5/19/2014	3-5	8	60.6	137	2.2	407
10-CP-AF1-N Grab 3-5ft	5/19/2014	3-5	8.5	45.3	62.3	3.2	233
CP-AF1-M-3-4	5/20/2014	3-4	8.2	64.7	37.3	12	308
CP-AF1-M-4-5	5/20/2014	4-5	8.2	40.7	23.7	11	298
CP-AF1-S-3-4	5/20/2014	3-4	7.8	28.4	20.3	1	251
CP-AF1-S-4-5	5/20/2014	4-5	8.3	41.1	50.7	0.8	165
3-CP-AF1-S Grab 3-5ft	5/20/2014	3-5	8.4	15.4	28.3	0.5	119
5-CP-AF1-S Grab 3-5ft	5/20/2014	3-5	8.4	45.7	38.2	0.6	336
9-CP-AF1-S Grab 3-5ft	5/20/2014	3-5	8	66.6	2.2	36	795
CP-AF2-N-3-4	5/20/2014	3-4	7.9	21.8	51.8	<0.4	238
CP-AF2-N-4-5	5/20/2014	4-5	7.8	18.4	44.7	0.4	274
CP-AF2-M-3-4	5/20/2014	3-4	7.8	19.8	49.3	1.2	<100
CP-AF2-M-4-5	5/20/2014	4-5	7.7	7.9	47.7	1	<100
CP-AF2-S-3-4	5/20/2014	3-4	8.4	62.8	42	0.6	128
CP-AF2-S-4-5	5/20/2014	4-5	7.9	16.5	28	1	<100

138. These analytical results, particularly nitrate concentrations measured in the 3-4 foot and 4-5 foot intervals, which are below any observed roots, indicate that Cow Palace's application fields are a significant source of

nitrate loading to groundwater from the Dairy. The nitrate concentrations measured in samples from 3 to 5 feet deep ranged from 2.2 ppm to 137 ppm, and averaged approximately 46 ppm. The graphs below depict nitrate concentrations in samples collected from the Cow Palace application fields, and Exhibit D contains graphs depicting nitrate, ammonium, and total nitrogen concentrations measured in these fields.





139. The nitrate concentrations observed in these deeper zones are of particular concern when one considers the well-documented moderate to well-drained soils underlying the Cow Palace fields, the fact that irrigated crop fields are a source of recharge to underlying aquifers, and the fact that nitrate is highly mobile and susceptible to leaching loss to groundwater in the absence of attenuating mechanisms such as plant uptake and soil adsorption.

140. Although the Cow Palace was not irrigating the two fields sampled at the time of the Plaintiffs' May 2014 inspection, several soil cores collected

from the fields were observed to be very moist to wet at depths up to 5 feet. Neither the soil moisture at these depths, nor the nitrate dissolved in the soil moisture, are available for plant uptake as no roots were observed at depths greater than 3 feet and rarely 2 feet below the surface. Therefore, with no attenuation mechanisms present, the nitrate present below 2-3 feet deep in the application fields, somewhat dependent on the type of crop planted, has only one destination: groundwater.

141. In conclusion, these boring results show that Cow Palace's application fields are a significant source of nitrate loading to groundwater from the Dairy. The excess manure constituents, such as nitrate, ammonium, total nitrogen and phosphorus, observed beneath crop root zones demonstrate that Cow Palace's field applications are causing manure and manure nutrients to leach through the permeable soils beneath the fields to depths at which they cannot be used as fertilizer. They will eventually reach groundwater through gravity drainage with the driving force of precipitation and irrigation.

COW PALACE SHOULD BE REQUIRED TO TAKE REMEDIAL STEPS TO RECTIFY THE NITRATE CONTAMINATION OF THE GROUNDWATER

142. I have concluded that Cow Palace's lagoons, pens, application fields and composting area are substantial sources of nitrate loading to groundwater from the Dairy. These facilities are typical of 1940-1960 era

chemical manufacturing and industrial operations. In that era, it was believed that discharge to the ground made the problem disappear. Now, with both RCRA and CERCLA investigations, we know that these operations caused significant contamination of soil, ground water and surface water.

143. During my career, I have worked on numerous facilities that have mishandled their waste or failed to recognize the potential impacts from not preventing spills and leaks from entering the subsurface. This facility is handling their waste in a manner that causes impacts to soil, ground water and surface water both from nutrients and from livestock antibiotics and hormones.

144. As I indicated earlier, I am familiar with the RCRA remedial investigation and feasibility study (RI/FS) regulations. I have conducted RI/FS investigations previously in my career, one for a packing plant and one for a dry cleaning operation. I have completed many other projects under RCRA regulation, such as Underground Storage Tank and Landfill investigations and remediation. The type of investigation that should be done at Cow Palace should be similarly robust, planned, thorough and supervised by a third party.

145. We already know, however, that numerous actions should be taken

promptly while a full investigation of the loading contributions are properly assessed in parallel. In order to rectify the current contaminant issues, Cow Palace should be required to synthetically line all of its liquid storage lagoons, impoundments, basins, conveyance infrastructure, and tailwater recovery ponds using proper compaction techniques and current state of the industry liner construction quality assurance/quality control (QA/QC). Based on the calculations conducted above, these storage facilities discharge substantial amounts of liquid manure and its constituents, such as nitrate, ammonium, and phosphorus, into the soil, where they will eventually reach groundwater.

146. The Washington NRCS 313 standard specifically recognizes that synthetically lined lagoons may be necessary where a lagoon is situated over a domestic water supply.[77] An HDPE double-lined lagoon should be constructed according to RCRA landfill requirements cited in 40 C.F.R. § 264.301, but must include a protective soil layer on top of the liner to prevent puncture while cleaning or manually pumping to a haul truck. The double-lined lagoon provides both a higher level of protection than a single liner and leak detection, should a release occur. In addition, a leak detection system should be put into place between the synthetic liners, ensuring that

[77] Natural Resources Conservation Service, Conservation Practice Standard No. 313 (Waste Storage Facility) at 313-8, December 2004.

Cow Palace would be alerted if there were some issue with the integrity of the uppermost liner. This allows the operator to recognize a leak, stop the release and immediately fix the leak without a release to the subsurface.

147. Double-lined waste storage or treatment ponds are the current state of the industry for waste handling operations. We have worked with facilities that have both liquid waste handling and solid waste handling operations on double lined systems.

148. Cow Palace could greatly reduce the discharge by lining the lagoons that have liquids present during the longest period and continue to line these facilities until the waste handling portion is addressed. This should include an assessment of the liquids handling conveyance infrastructure.

149. Second, Cow Palace should be required to compost only on lined pads that collect the leachate generated by the composting operation. The leachate could be used to maintain the proper moisture content for composting, but should not be allowed to enter the subsurface. Commercial compost operations are required to conduct composting and compost handling on concrete surfaces with storm water collection systems. They are also required to maintain the integrity of the concrete through routine crack and joint sealing.

150. Furthermore, Cow Palace should be required to provide to Plaintiffs

all construction plans and specifications for review and approval prior to construction. Cow Palace should also provide all construction QA/QC testing results to Plaintiffs along with access during construction so independent, third-party QA/QC testing may be conducted.

151. Third, as to the confinement pens, Cow Palace should be required to line the pens to limit infiltration; all joints must be watertight; and the design must include provisions to collect runoff from lined areas. Cow Palace must provide Plaintiffs with all construction plans and specifications for review and approval prior to construction. Cow Palace must also provide all construction QA/QC testing results to Plaintiffs, and must provide access during construction so independent, third-party QA/QC testing may be conducted.

152. Finally, Cow Palace must control water balance issues and use irrigation practices that actually follow a realistic nutrient management plan. Data from the application fields clearly show that nutrients are over-applied and have migrated deeper than any possible plant uptake. As a result, large areas contribute high nitrate concentration to the ground water and recent studies show that other compounds, such as livestock antibiotics and hormones can be sourced to ground water from application fields.

153. In conclusion, the Cow Palace Dairy is by far one the largest sources

of nutrients in the area (along with the other Cluster Dairies). Given the current waste handling practices and the volume of liquid and solid waste generated by this facility and the preliminary investigation data generated, to conclude that nitrate impacts to ground water are caused by some other source, such as the few residential septic systems in the area, is irresponsible.

154. Again, the average septic system discharges 60 gallons per person per day with an ammonium concentration between 50 to 75 ppm. In contrast, the EPA estimated that the Cow Palace stores over 40,600,000 gallons of liquid waste and discharges between 4,400 and 23,500 gallons per day, based on very conservative estimates. These numbers do not include the amount of manure and liquid waste over-applied to the application fields.

Dated: September 22, 2014

David J. Erickson PG CPG
President and Hydrogeologist
Water & Environmental Technologies, PC

David J. Erickson, PG, CPG
President/Hydrogeologist
Water & Environmental Technologies, PC
480 East Park, Suite 200
Butte, MT 59701
(406)782-5220
derickson@wet-llc.com

Education

- Bachelor of Science, Geological Engineering, Montana College of Mineral Science & Technology 1988
- Continuing Education Credits – 1990, 1991

Professional History

- *Water & Environmental Technologies*; Butte, MT, President/Hydrogeologist, August 2000 – present
- *Atlatl, Inc*., Butte; MT, Principal Hydrogeologist/Project Manager, May 1994 – August 2000
- *Special Resource Management, Inc.;* Butte, MT, Geological Engineer/Hydrogeologist, 1990-1994
- *Woodward-Clyde Consultants;* Houston, Texas, Staff Geological Engineer/Hydrogeologist, 1989-1990
- *Petroleum Testing Service;* Houston, Texas, Geological Technician, 1988-1989

Representative Experience

Project Manager and Hydrogeologist responsible for the characterization and remediation of a dissolved solvent plume from a county landfill. Remediation consists of in-situ air sparging and a funnel-and-gate capture and in-situ treatment system. The sites complex fractured bedrock and extremely complex ground water flow characteristics required innovative investigation technology to understand the water and contaminant interaction between the bedrock and the alluvial aquifers and ground water and surface water. Project highlights include:

- The use of geophysical method to characterize the bedrock topography and the connection and interaction between aquifers,
- The use of direct push subsurface investigation methods to characterize site conditions and identify contaminant transport pathways,
- Ground water flow and contaminant transport modeling to describe site conditions and test remedial options,
- The installation of source specific remedial methods to control landfill leachate impacts,
- Long term responsibility for all surface water, ground water, remediation, and reporting requirements for the site, and
- Presentation of site characteristics, model results, and site remediation costs in District Court.

Project Hydrogeologist and Lead Expert for the investigation and characterization of geologic, hydrogeologic, and contaminant migration characteristics of solvent and fuel contamination impacting a residential neighborhood. The goal of the investigation work was to determine the source of contamination and identify the responsible party. Geophysical methods (soil conductivity logging) and depth specific profile sampling was used to identify perchloroethylene migration and degradation in multiple production zones within the alluvial aquifer. This subsurface investigation established a connection between historical lagoon leakage and residential supply wells.

Project Manager and Lead Expert conducting a site investigation to assess the impact of historical mining and milling activities on ground water and stream water quality. Dissolved metals concentrations impacting a small town public water supply system prompted a complaint against the Mining Company. Tailings investigations and in stream tracer testing established a direct connection between stream water contamination and spring contamination.

Project Hydrogeologist/Manager for the investigation and remediation of many UST and Hazardous Waste Sites. Contaminants include fuels, solvents, wood treating compounds, metals, pesticides, herbicides, fungicides, and fertilizers.

Project Manager/Hydrogeologist responsible for the design, installation, and monitoring of various types of remedial technologies or remedial methods including (air stripping, air sparging, vapor extraction, bioventing, bio-cell treatment, biostimulation (ORC), NAPL recovery, in-situ & ex-situ bioremediation, natural attenuation, excavation & off-site disposal).

Project Manager responsible for the investigation and remediation of 29 sites in Montana and North Dakota where pesticides, herbicides, fungicides, fuels and fertilizers were spilled.

Project Manager and Hydrogeologist for extensive study and ground water modeling of contaminant effects from ash disposal ponds on an arid Wyoming drainage. The study involved:

- Prediction of contaminant transport,
- Simulation of remedial options,
- Design, installation, optimization and operation of remediation system,
- Permitting of facility expansion,
- Extensive presentations and negotiations with regulatory agencies, and
- Dispute resolution between the facility and potentially effected parties.

Project Engineer responsible for the design and permitting of a double-lined hazardous and non-hazardous repository with leachate collection and ground water relief system.

Project Engineer and Project Manager responsible for the design of ground water monitoring systems and subsurface geological, hydrogeological, and geotechnical investigation.

Project Hydrogeologist studying ground water fluctuations at a RCRA Part B TSD (Hazardous Waste Disposal Facility) in Oregon. Both hydrogeologic and contaminant transport characteristics were very complex.

Project Hydrologist responsible for sediment transport and stream water quality modeling for mine tailing disposal project in Malasia.

Project Hydrogeologist responsible for re-permitting several industrial landfills for large coal-fired electric generating plants in Wyoming. Projects involved investigation of water quality degradation from fly ash disposal activities and characterization of the potential health risks. A statistical evaluation of the water quality was completed to identify potential impacts.

Project Hydrogeologist for evaluation water chemistry changes resulting from the use of wastewater for irrigation at a research farm in Utah.

Project Hydrogeologist for yearly monitoring data analysis at several industrial plants with ponds or landfills in Wyoming and Utah.

Project Hydrogeologist performing final phase of landfill siting study for new RCRA Subtitle D Municipal Solid Waste Landfill

Project Hydrogeologist/Manager for the investigation and remediation of many UST and Hazardous Waste Sites. Contaminants include fuels, solvents, wood treating compounds, metals, pesticides, herbicides, fungicides, and fertilizers.

Project Manager/Hydrogeologist responsible for the design, installation, and monitoring of various types of remedial technologies or remedial methods including (air stripping, air sparging, vapor extraction, bioventing, bio-cell treatment, biostimulation (ORC), NAPL recovery, in-situ & ex-situ bioremediation, natural attenuation, excavation & off-site disposal).

Project Manager responsible for the investigation and remediation of 29 sites in Montana and North Dakota where pesticides, herbicides, fungicides, fuels and fertilizers were spilled.

Expert Witness/Litigation Support Experience

- *Park County v. Burlington Northern Santa Fe Railway Company, Montana Sixth Judicial District Court, Park County, Cause No. DV 97-75, July, 1999.*

- *C&P Packing v. Burlington Northern Santa Fe Railway Company*, Park County, January 2001.
- *Hepp v. Conoco Inc. et. al.*, ADV-2003-14
- *Town of Sunburst v. Texaco et. al.*, CDV-01-179 (a)
- *Town of Superior v. Asarco Incorporated*, US District Court, Missoula Division
- *Aguiar v. Burlington Northern, United States District Court, Great Falls Division*
- *Schammel et. al. v.CR Kendall Corporation, United States District Court, Great Falls Division.*
- *Van Haur v. CR Kendal Corp United States District Court, Great Falls Division*
- *Weiss et. al. v. HCI Dyce Chemical Company, CV-00-123-BLG-JDS*
- *Sieben Livestock Company v. Harp Line Contractors.*
- *Cool Breeze Inc. v. Flying J Inc., Maxim Technologies Inc.*
- *Cause No. ADV-04-984*
- *Friends of the Little Bitterroot v. Commissioners of Flathead County Cause No.: DV-06-560*
- *Mapleton City Corporation v. The Ensign-Bickford Company*, Case No. 020404933
- *Bergren v. BNSF*: CV-03-120-BLG-RFC
- *Devries v. BNSF:* CV-03-121-BLG-RFC
- *Outlook Enterprises v. BNSF*: CV-03-139-BLG-RFC
- *Hallett Minerals v. BNSF* Cause No. CV-03-161-BLG-RFC
- *Ruggles Excavation v. BNSF* Cause No. CV-03-160-BLG-RFC
- *Burley, Nelson, Meridith v. BNSF*
- *Anderson et. al. v. BNSF Cause No. ADV-2008-101*
- *Kerfoot v. Texaco et. al. Cause No BDV-08-1276*
- *City of Livingston et. al. V. BNSF, Cause No. DV07-141*
- *Graham et, al.v. BNSF, Cause No. CV-12-145-M-DVM*

Professional Development

- Hazardous Waste and Geotech Sampling Seminar
- Monitoring Well Installation Seminar
- Analytical Laboratory Seminar (ENSECO)
- Design & Construction of RCRA Final Covers
- Enhanced Bioremediation (EPA)
- Ground Water Pollution & Hydrogeology, Princeton
- Geostatistical Analysis in Hazardous Waste Site Evaluation
- Ground Water Summit 2008
- Montana Water Law Conference 2007
- Landfill Gas Extraction & Ground Water Corrective Measures (presenter)
- National Ground Water Association Annual Conference – heterogeneity
- Environmental Geochemistry of Metals
- Environmental Isotopes in Ground Water Resource and Environmental Contamination
- Environmental Forensics: Methods & Applications
- 2004 NGWA Water & Environmental Law Conference

Certifications
Professional Geologist, Wyoming PG-3101
Professional Geologist, Utah PG-2250
Certified Professional Geologist, American Institute of Professional Geologists, CPG#9402
OSHA 29 CFR 1910.120 Health & Safety
OSHA 29 CFR Certified Waste Site Supervisor
Certified Monitoring Well Constructor

Affiliations
Association of Ground Water Scientists & Engineers
National Ground Water Association
American Institute of Professional Geologist
American Chemical Society
International Society of Environmental Forensics

Awards
Montana Tech Distinguished Alumni Recognition Award, 2003

Seepage from Cow Palace Waste Lagoons

Flow Boundary Conditions

Steady-state flow
Constant hydraulic head (h) of liquid-wastes level in the lagoon for given calculation
(i.e. no change of head in time)
No flow restriction at the bottom of liner (like a "free fall")

Formula used

$q = k(h/d)$
$Q = k(h/d)A$
$h = w+d$

Conversion factors

1 ft	30.48 cm	304.8 mm
1 ft^3	7.48 gal	
1 day	86,400 s	
1 year	365 days	
1 GPY/sqft	0.11 mm/d	
1 Acre	43,546 sqft	

Assumptions & Entry Parameters

Liquid waste is homogenous in vertical and horizontal planes			
Specific gravity of liquid wastes	1	(-)	
Lagoon No. 4 liner			
Hydraulic conductivity (K) equals	1.00E-06	cm/s	
Thickness (d)	2	ft	
Other lagoons			
Hydraulic conductivity (K) of a liner to be installed		cm/s	[independent variable]
Thickness (d) of liner to be installed		ft	[independent variable]
Depth of liquid waste (w)		ft	[independent variable]

Seepage (q) from lined lagoon per unit area (w/o self sealing)

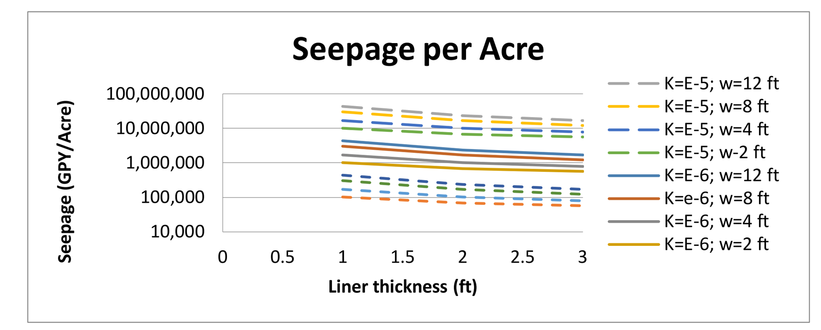
Calculations performed as per:

"Design and Construction Guidelines for Considering Seepage from Agricultural Waste Storage Ponds and Treatment Lagoons", 1993 Soil Conservation Service , U.S. Department of Agriculture

K (cm/s)	w (ft)	d (ft)	Seepage GPY/Acre	Seepage mm/day
		1	43,811,171	112.3
	12	2	23,590,631	60.5
		3	16,850,450	43.2
		1	30,330,811	77.8
	8	2	16,850,450	43.2
1.E-05		3	12,356,997	31.7
		1	16,850,450	43.2
	4	2	10,110,270	25.9
		3	7,863,544	20.2
		1	10,110,270	25.9
	2	2	6,740,180	17.3
		3	5,616,817	14.4

K (cm/s)	w (ft)	d (ft)	Seepage GPY/Acre	Seepage mm/day
		1	4,381,117	11.2
	12	2	2,359,063	6.0
		3	1,685,045	4.3
		1	3,033,081	7.8
	8	2	1,685,045	4.3
1.E-06		3	1,235,700	3.2
		1	1,685,045	4.3
	4	2	1,011,027	2.6
		3	786,354	2.0
		1	1,011,027	2.6
	2	2	674,018	1.7
		3	561,682	1.4

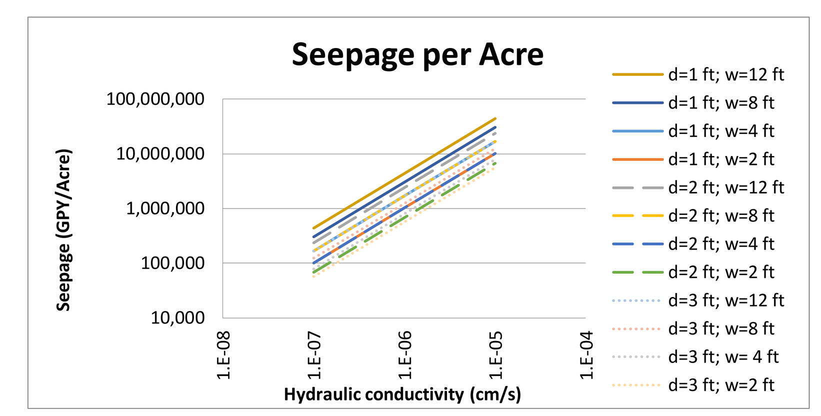
K (cm/s)	w (ft)	d (ft)	Seepage GPY/Acre	Seepage mm/day
		1	438,112	1.12
	12	2	235,906	0.60
		3	168,505	0.43
		1	303,308	0.78
	8	2	168,505	0.43
1.E-07		3	123,570	0.32
		1	168,505	0.43
	4	2	101,103	0.26
		3	78,635	0.20
		1	101,103	0.26
	2	2	67,402	0.17
		3	56,168	0.14



d (ft)	w (ft)	K (cm/s)	Seepage GPY/Acre	Seepage mm/day
		1.E-07	438,112	1.1
	12	1.E-06	4,381,117	11.2
		1.E-05	43,811,171	112.3
		1.E-07	303,308	0.8
	8	1.E-06	3,033,081	7.8
1.0		1.E-05	30,330,811	77.8
		1.E-07	168,505	0.4
	4	1.E-06	1,685,045	4.3
		1.E-05	16,850,450	43.2
		1.E-07	101,103	0.3
	2	1.E-06	1,011,027	2.6
		1.E-05	10,110,270	25.9

d (ft)	w (ft)	K (cm/s)	Seepage GPY/Acre	Seepage mm/day
		1.E-07	235,906	0.6
	12	1.E-06	2,359,063	6.0
		1.E-05	23,590,631	60.5
		1.E-07	168,505	0.4
	8	1.E-06	1,685,045	4.3
2.0		1.E-05	16,850,450	43.2
		1.E-07	101,103	0.3
	4	1.E-06	1,011,027	2.6
		1.E-05	10,110,270	25.9
		1.E-07	67,402	0.2
	2	1.E-06	674,018	1.7
		1.E-05	6,740,180	17.3

d (ft)	w (ft)	K (cm/s)	Seepage GPY/Acre	Seepage mm/day
		1.E-07	168,505	0.4
	12	1.E-06	1,685,045	4.3
		1.E-05	16,850,450	43.2
		1.E-07	123,570	0.3
	8	1.E-06	1,235,700	3.2
3.0		1.E-05	12,356,997	31.7
		1.E-07	78,635	0.2
	4	1.E-06	786,354	2.0
		1.E-05	7,863,544	20.2
		1.E-07	56,168	0.1
	2	1.E-06	561,682	1.4
		1.E-05	5,616,817	14.4

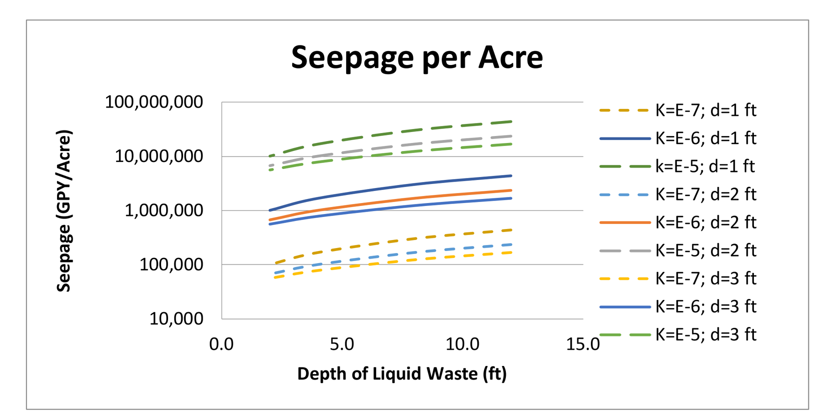


d (ft)	K (cm/s)	w (ft)	Seepage GPY/Acre	Seepage mm/day
		12.0	438,112	1.1
		8.0	303,308	0.8
	1.E-07	4.0	168,505	0.4
		2.0	101,103	0.3
		12.0	4,381,117	11.2
1.0		8.0	3,033,081	7.8
	1.E-06	4.0	1,685,045	4.3
		2.0	1,011,027	2.6
		12.0	43,811,171	112.3
		8.0	30,330,811	77.8
	1.E-05	4.0	16,850,450	43.2
		2.0	10,110,270	25.9

d (ft)	K (cm/s)	w (ft)	Seepage GPY/Acre	Seepage mm/day
		12.0	235,906	0.6
		8.0	168,505	0.4
	1.E-07	4.0	101,103	0.3
		2.0	67,402	0.2
		12.0	2,359,063	6.0
2.0		8.0	1,685,045	4.3
	1.E-06	4.0	1,011,027	2.6
		2.0	674,018	1.7
		12.0	23,590,631	60.5
		8.0	16,850,450	43.2
	1.E-05	4.0	10,110,270	25.9
		2.0	6,740,180	17.3

Brown highlighted cells show seepage from Lagoon 4

d (ft)	K (cm/s)	w (ft)	Seepage GPY/Acre	Seepage mm/day
		12.0	168,505	0.4
		8.0	123,570	0.3
	1.E-07	4.0	78,635	0.2
		2.0	56,168	0.1
		12.0	1,685,045	4.3
3.0		8.0	1,235,700	3.2
	1.E-06	4.0	786,354	2.0
		2.0	561,682	1.4
		12.0	16,850,450	43.2
		8.0	12,356,997	31.7
	1.E-05	4.0	7,863,544	20.2
		2.0	5,616,817	14.4



Seepage (q) from self sealed lagoon per unit area

Flow Boundary Conditions

Same as for the calculations for liners (above)

Calculations performed as per:

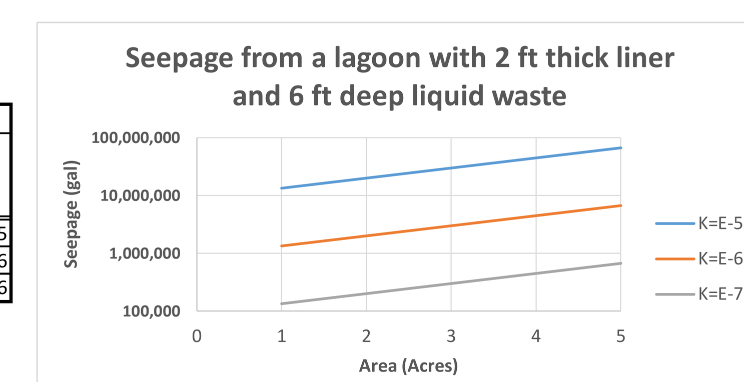
Selected references claiming that Animal Waste Lagoons may self-seal up to K
one order of magnitude lower than the original sediment at the lagoon bottom

Assumptions & Entry Parameters

Hydraulic conductivity (Ks) of a self-sealed layer	cm/s	[independent variable]
Thickness of a self-sealed layer (ds)	ft	[independent variable]
Assumptions are the same as for the calculation for liners (above)		

Seepage from a lagoon with a 2 ft thick liner

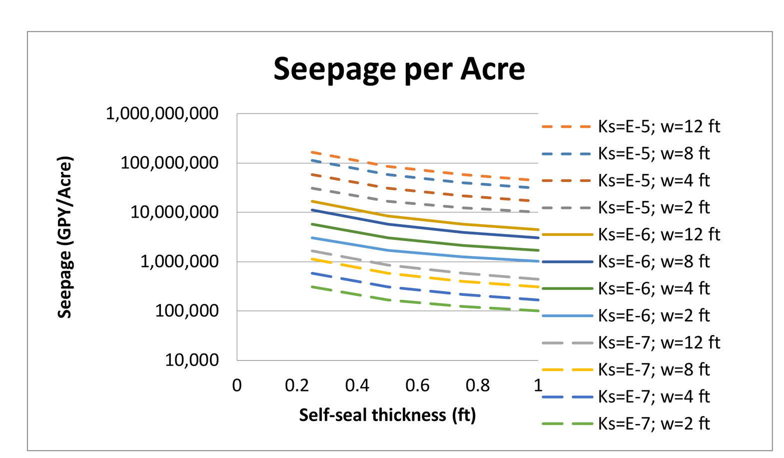
d (ft)	w (ft)	K (cm/s)	Seepage GPY per 1 acre	Seepage GPY per 5 acres	Seepage mm/day
		1.E-07	134,804	674,018	0.35
2.0	6	1.E-06	1,348,036	6,740,180	3.46
		1.E-05	13,480,360	67,401,802	34.56

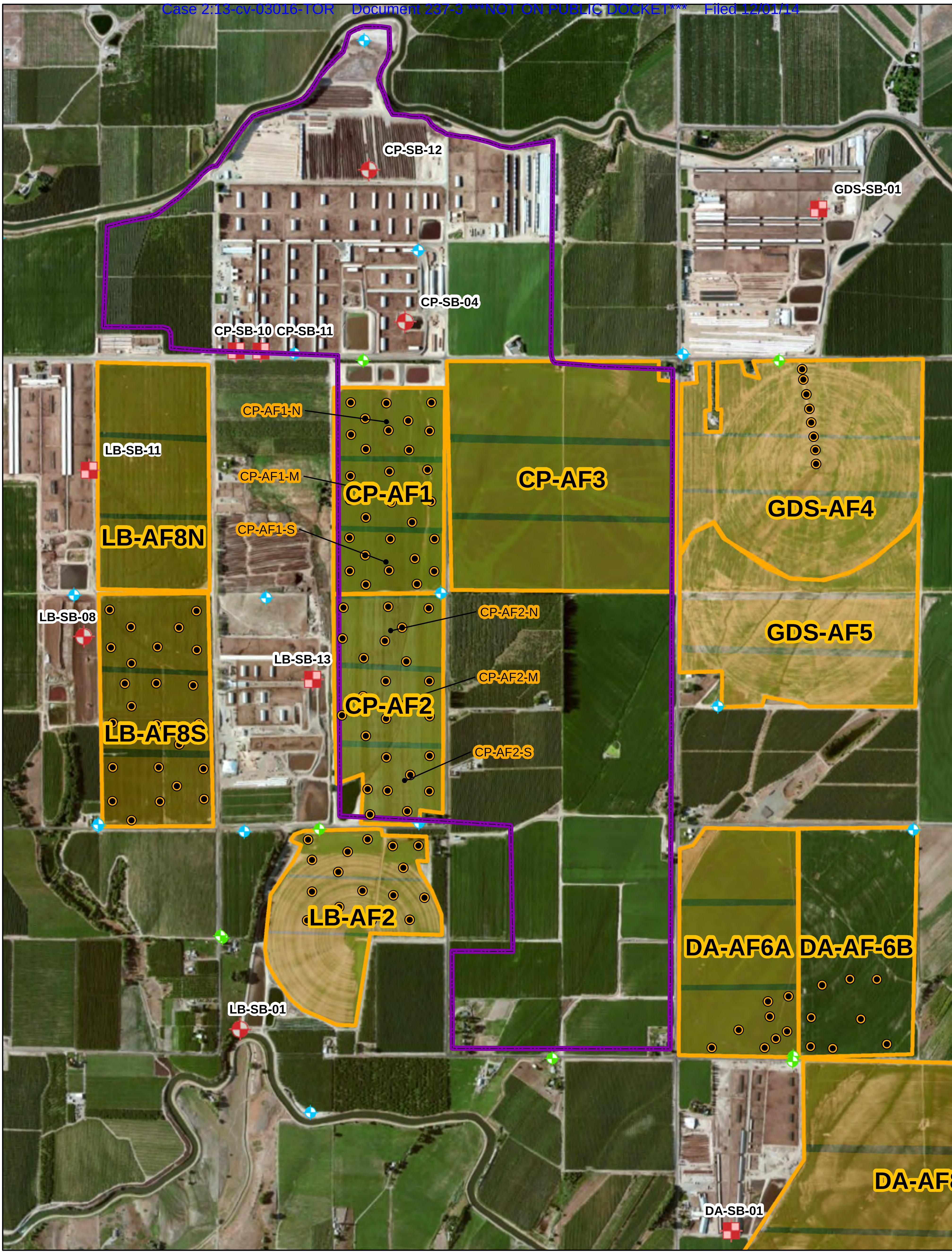


K (cm/s)	w (ft)	ds (ft)	Seepage (GPY/Acre)	Seepage mm/day
		0.25	165,134,414	423.4
		0.5	84,252,252	216.0
	12	0.75	57,291,531	146.9
		1	43,811,171	112.3
		0.25	111,212,973	285.1
		0.5	57,291,531	146.9
	8	0.75	39,317,718	100.8
1.E-05		1	30,330,811	77.8
		0.25	57,291,531	146.9
		0.5	30,330,811	77.8
	4	0.75	21,343,904	54.7
		1	16,850,450	43.2
		0.25	30,330,811	77.8
		0.5	16,850,450	43.2
	2	0.75	12,356,997	31.7
		1	10,110,270	25.9

K (cm/s)	w (ft)	ds (ft)	Seepage GPY/Acre	Seepage mm/day
		0.25	16,513,441	42.3
		0.5	8,425,225	21.6
	12	0.75	5,729,153	14.7
		1	4,381,117	11.2
		0.25	11,121,297	28.5
		0.5	5,729,153	14.7
	8	0.75	3,931,772	10.1
1.E-06		1	3,033,081	7.8
		0.25	5,729,153	14.7
		0.5	3,033,081	7.8
	4	0.75	2,134,390	5.5
		1	1,685,045	4.3
		0.25	3,033,081	7.8
		0.5	1,685,045	4.3
	2	0.75	1,235,700	3.2
		1	1,011,027	2.6

K (cm/s)	w (ft)	ds (ft)	Seepage GPY/Acre	Seepage mm/day
		0.25	1,651,344	4.23
		0.5	842,523	2.16
	12	0.75	572,915	1.47
		1	438,112	1.12
		0.25	1,112,130	2.85
		0.5	572,915	1.47
	8	0.75	393,177	1.01
1.E-07		1	303,308	0.78
		0.25	572,915	1.47
		0.5	303,308	0.78
	4	0.75	213,439	0.55
		1	168,505	0.43
		0.25	303,308	0.78
		0.5	168,505	0.43
	2	0.75	123,570	0.32
		1	101,103	0.26





Legend

- Cow Palace Dairy
- Application Field
- Application Field Composite Area
- Application Field Boring
- Lagoon/Compost/Silage Boring
- Pen Boring
- EPA Well
- Dairy Well

1 Inch = 1500 Feet

0 750 1,500 3,000

N W E S

WATER & ENVIRONMENTAL TECHNOLOGIES, PC

May 2014 Inspection Sample Locations

COW PALACE DAIRY

Job#: CAFOM01

Date: 9/18/2014

FIGURE 1

Path: M:\COW_Palace\May 2014 Inspection Sample Locations.mxd

Cow Palace Dairy, Yakima County, Washington

Surface Water and Lagoon Sample Analytical Results, mg/L

Sample ID	Lab	Date	pH	Solids, Total Suspended TSS @ 105 C	Solids, Total Dissolved TDS @ 180 C	Alkalinity, Total as CaCO3	Chloride	Sulfate	Nitrogen, Ammonia as N	Nitrogen, Kjeldahl, Total as N	Nitrogen, Nitrate as N	Nitrogen, Nitrate + Nitrite as N	Phosphorus, after H2SO4 Hydrolysis	Nitrogen, Nitrite as N	Phosphorus, Orthophosphate as P	Phosphorus, Total as P	Phosphorus, Organic	Phosphorus, Inorganic	Calcium	Magnesium	Potassium	Sodium
Surface Water and Lagoon Contents																						
CP-Catch Basin-SW	EL	10/30/2013	7.3 H	248	236	180	11	5	3.2 D	5.9	0.34	0.47	3.9 D	0.13	1.28 H	4.51	0.63	3.88	38	12.00	24	12
CP-Knowles Rd-SW	EL	10/30/2013	8.3 H	184	1180	1300	98 D	21	90 D	126 D	< 0.01	0.1 D	12 D	0.2	6.42 D	9.9 D	< 0.01	9.9	104	51.00	257	107
CP-R Canal-SW	EL	10/30/2013	8.9 H	19	87	68	4	3	< 0.05	< 0.5	< 0.01	< 0.01	0.03	< 0.01	0.013	0.1	0.07	0.03	14	6.00	1	6
CP-Calf Pen-SW	EL	10/30/2013	7 H	390	350	200	15	21	1.46	13.7	0.4	0.74	3.6	0.33	2.74	4.18	0.54	3.64	44	15.00	20	27
CP-Silage-SW	EL	10/30/2013	3.9 H	590	50100	< 4	990 D	420 D	574 D	2820 D	29.5	29.9 D	966 D	0.37	780 D	898 D	< 0.01	898	1210 D	796.00 D	5090	65
CP-U Storm W-SW	EL	10/30/2013	8.1 H	188	2810	1500	250 D	110 D	61 D	120 D	< 0.01	0.1 D	39 D	0.25	30.3 D	38.2 D	< 0.01	38.2	100	68.00	618	243
CP-L2-SW	EL	10/30/2013	7.6 H	48500	2400	3100	230 D	27 D	330 D	1600 D	< 0.01	0.4 D	358 D	5.9 D	256 D	384 D	26	358	122	49.00	80	26

Notes:
EL indicates Energy Laboratories, Helena, Montana. CAS indicates Cascade Analytical, Wenatchee, WA
H indicates analysis performed past recommended holding time
D indicates reporting limit increased due to sample matrix
J indicates estimated value
-- indicates Not Analyzed

SOIL SAMPLE ANALYTICAL RESULTS

Sample ID	Sample Date	Depth	pH, SU	Phosphorus, ppm	Nitrate, ppm	Ammonium-N, ppm	Total Nitrogen/Solid, mg/kg
COW PALACE							
Application Fields							
CP-AF1-N-0-1	5/19/2014	0-1	8	291	44.4	2	1630
CP-AF1-N-1-2	5/19/2014	1-2	8.3	207	77.8	1.4 J	1150
CP-AF1-N-2-3	5/19/2014	2-3	8.2	118	75	5.3	599
CP-AF1-N-3-4	5/19/2014	3-4	8.3	64.2	50.6	9.3	334
CP-AF1-N-4-5	5/19/2014	4-5	8.3	34.9	69.5	1.4	254
1-CP-AF1-N Grab 3-5ft	5/19/2014	3-5	8	60.6	137	2.2	407
10-CP-AF1-N Grab 3-5ft	5/19/2014	3-5	8.5	45.3	62.3	3.2	233
CP-AF1-M-0-1	5/20/2014	0-1	7.7	352	38.1	1.3	1850
CP-AF1-M-1-2	5/20/2014	1-2	8.1	177	42.7	1	661
CP-AF1-M-2-3	5/20/2014	2-3	8.1	78	48.3	2.8	380
CP-AF1-M-3-4	5/20/2014	3-4	8.2	64.7	37.3	12	308
CP-AF1-M-4-5	5/20/2014	4-5	8.2	40.7	23.7	11	298
8-CP-AF1-M Grab 2-4ft	5/20/2014	2-4	8.2	46.4	48.4	2.8	264
CP-AF1-S-0-1	5/20/2014	0-1	7.8	214	37.9	1.6	1490
CP-AF1-S-1-2	5/20/2014	1-2	8.1	82.6	38.1	0.9	543
CP-AF1-S-2-3	5/20/2014	2-3	8	64.7	54.7	1.1	404
CP-AF1-S-3-4	5/20/2014	3-4	7.8	28.4	20.3	1	251
CP-AF1-S-4-5	5/20/2014	4-5	8.3	41.1	50.7	0.8	165
3-CP-AF1-S Grab 3-5ft	5/20/2014	3-5	8.4	15.4	28.3	0.5	119
5-CP-AF1-S Grab 3-5ft	5/20/2014	3-5	8.4	45.7	38.2	0.6	336
9-CP-AF1-S Grab 3-5ft	5/20/2014	3-5	8	66.6	2.2	36	795
CP-AF2-N-0-1	5/20/2014	0-1	7.9	193	45.7	1.5	1350
CP-AF2-N-1-2	5/20/2014	1-2	8.1	52.3	67.9	0.6	270
CP-AF2-N-2-3	5/20/2014	2-3	7.9	35.8	57.1	0.6	291
CP-AF2-N-3-4	5/20/2014	3-4	7.9	21.8	51.8	< 0.4	238
CP-AF2-N-4-5	5/20/2014	4-5	7.8	18.4	44.7	0.4	274
CP-AF2-M-0-1	5/20/2014	0-1	7.9	173	57.2	1	1230
CP-AF2-M-1-2	5/20/2014	1-2	8.2	42.4	46.6	1.2	237
CP-AF2-M-2-3	5/20/2014	2-3	8.1	29.2	45.3	0.7	< 100
CP-AF2-M-3-4	5/20/2014	3-4	7.8	19.8	49.3	1.2	< 100
CP-AF2-M-4-5	5/20/2014	4-5	7.7	7.9	47.7	1	< 100
CP-AF2-S-0-1	5/20/2014	0-1	7.7	190	24.5	3.2	1430
CP-AF2-S-1-2	5/20/2014	1-2	7.9	69.9	25	0.8	368
CP-AF2-S-2-3	5/20/2014	2-3	7.8	29.8	15.6	0.8	179
CP-AF2-S-3-4	5/20/2014	3-4	8.4	62.8	42	0.6	128
CP-AF2-S-4-5	5/20/2014	4-5	7.9	16.5	28	1	< 100
Storm Water Lagoon Borings							
CP-SB-04C-8-10	5/22/2014	8-10	7.7	38	20.3	1.1	270
CP-SB-04C-10-12	5/22/2014	10-12	7.7	5.1	18.2	0.9	887
CP-SB-04C-13-15	5/22/2014	13-15	7.8	4.9	14.4	0.8	< 100
CP-SB-04C-15-16	5/22/2014	15-16	7.7	5.9	27	1.2	138
CP-SB-04-17.8-18.2	5/19/2014	17.8-18.2	7.2	10.7	22	4.4	112
CP-SB-04-19.5-20	5/19/2014	19.5-20	8	< 1.4	2.9	2	< 100
CP-SB-04C-20-23	5/22/2014	20-23	7.8	< 1.4	7.8	0.5	< 100
CP-SB-04C-27-30	5/22/2014	27-30	7.6	2.1	6.1	0.6	< 100
CP-SB-04C-45.5-47	5/22/2014	45.5-47	7.8	< 1.4	1.2	7.5	< 100

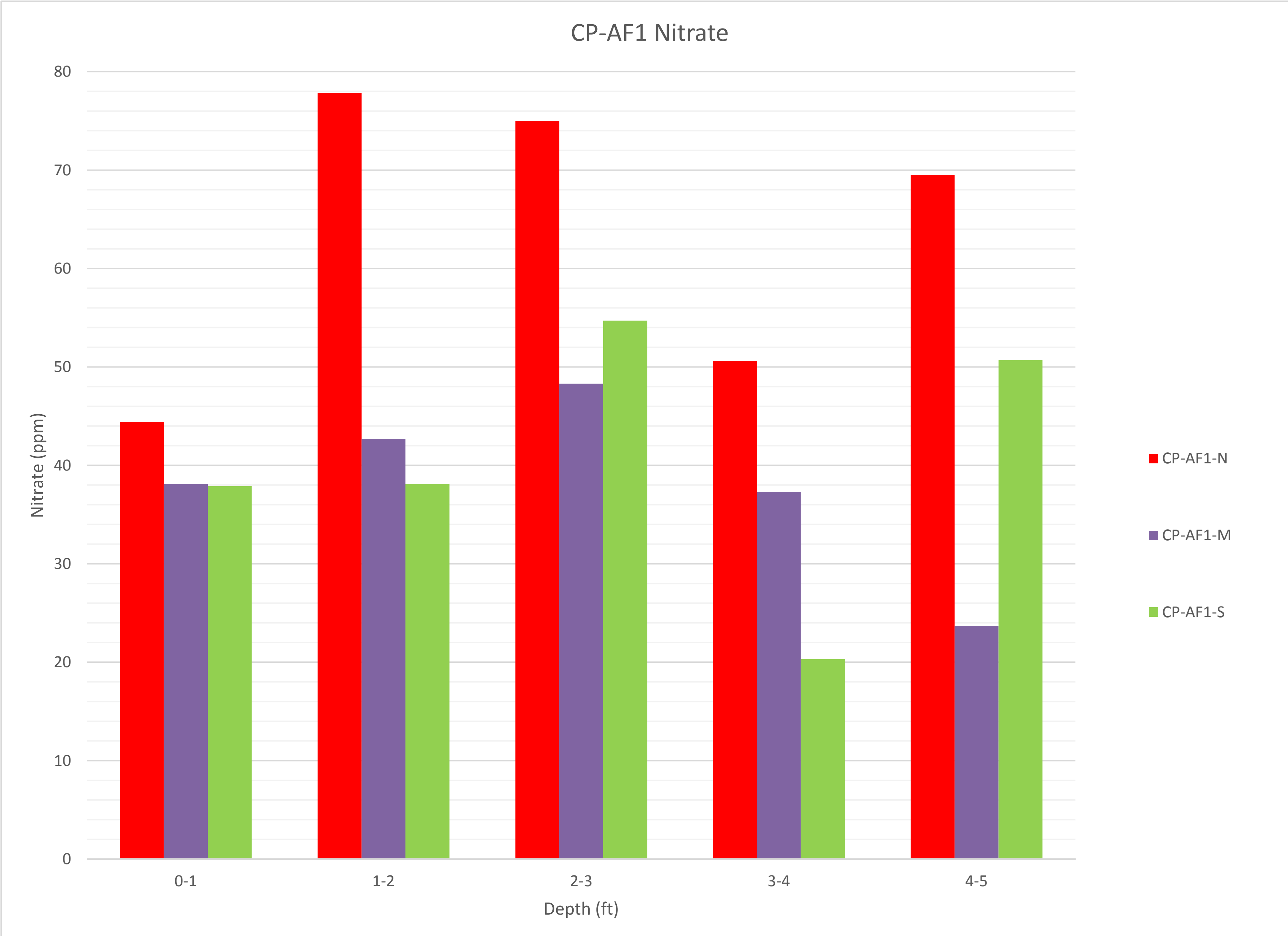
SOIL SAMPLE ANALYTICAL RESULTS

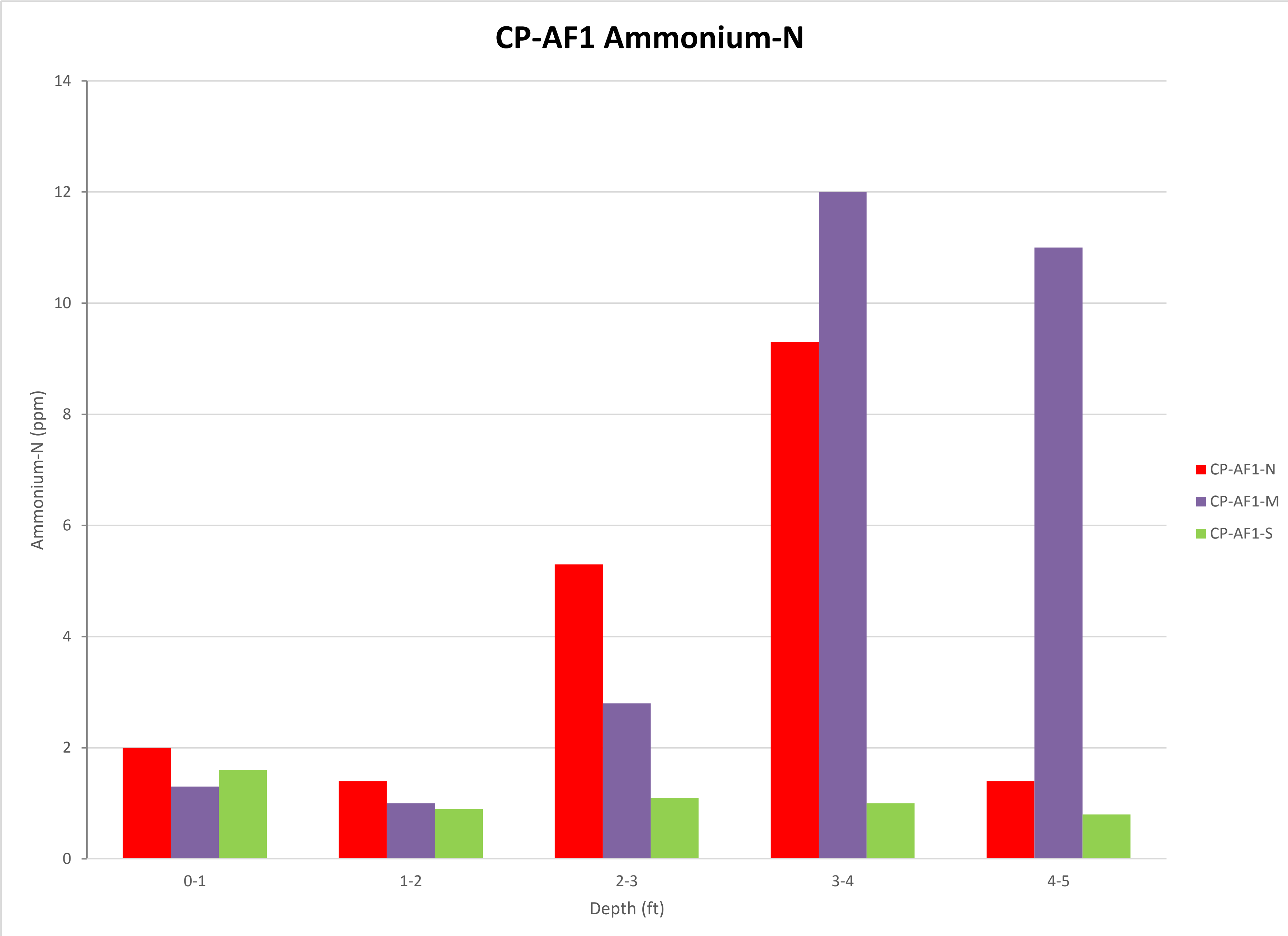
Sample ID	Sample Date	Depth	pH, SU	Phosphorus, ppm	Nitrate, ppm	Ammonium-N, ppm	Total Nitrogen/Solid, mg/kg
Pen Borings							
CP-SB-10-0-1	5/19/2014	0-1	8.2	82	29.9	60	1060
CP-SB-10-1-2	5/19/2014	1-2	7.8	6.5	94.9	8.5	470
CP-SB-10-2-3	5/19/2014	2-3	7.6	5.5	92.1	0.8	295
CP-SB-10-3-4	5/19/2014	3-4	7.9	18.2	40	1.8	358
CP-SB-10-4-5	5/19/2014	4-5	7.9	9.1	8.5	2.4	153
CP-SB-10-5-6	5/19/2014	5-6	8.2	1.5	4.8	3.4	106
CP-SB-10-6-7	5/19/2014	6-7	8.4	1.9	4.7	2.4	126
CP-SB-10-7-8	5/19/2014	7-8	8.5	3.1	2.9	7.1	161
CP-SB-10-9-10	5/19/2014	9-10	8.5	6.5	5.5	2.2	128
CP-SB-11-0-1	5/20/2014	0-1	7.9	39.2	1.9	29	676
CP-SB-11-1-2	5/20/2014	1-2	8.1	75	1.6	160	1090
CP-SB-11-2-3	5/20/2014	2-3	8.7	25.4	14.2	130	591
Compost Boring							
CP-SB-12-0-1	5/19/2014	0-1	8.9	330	12.3	100	2170
CP-SB-12-1-2	5/19/2014	1-2	8	270	5.5	70	1680
CP-SB-12-2-3	5/19/2014	2-3	7.6	51.6	1	20	869
CP-SB-12-3-4	5/19/2014	3-4	7.6	59.4	0.9	14	8210
CP-SB-12-4-5	5/19/2014	4-5	7.5	35.3	49.6	4.5	602
CP-SB-12-5-6	5/19/2014	5-6	7.7	20.2	1.6	12	450
CP-SB-12-6-7	5/19/2014	6-7	7.7	26.4	1	100	818
CP-SB-12-7-8	5/19/2014	7-8	8.6	462	0.9	95	2600
CP-SB-12-8-9	5/19/2014	8-9	8.7	1970	6.8	180	5720
CP-SB-12-10-11	5/19/2014	10-11	8	161	1.6	83	1930
CP-SB-12-11-12	5/19/2014	11-12	8.2	65.2	4.2	19	832
CP-SB-12-12-13	5/19/2014	12-13	7.6	5.1	8.4	5.9	276
CP-SB-12-15-16	5/19/2014	15-16	8.1	7.2	5.1	5.2	133
CP-SB-12-16-17	5/19/2014	16-17	7.9	2.9	2.1	3.5	< 100
CP-SB-12-17-18	5/19/2014	17-18	7.8	1.5	4.3	2.5	< 100

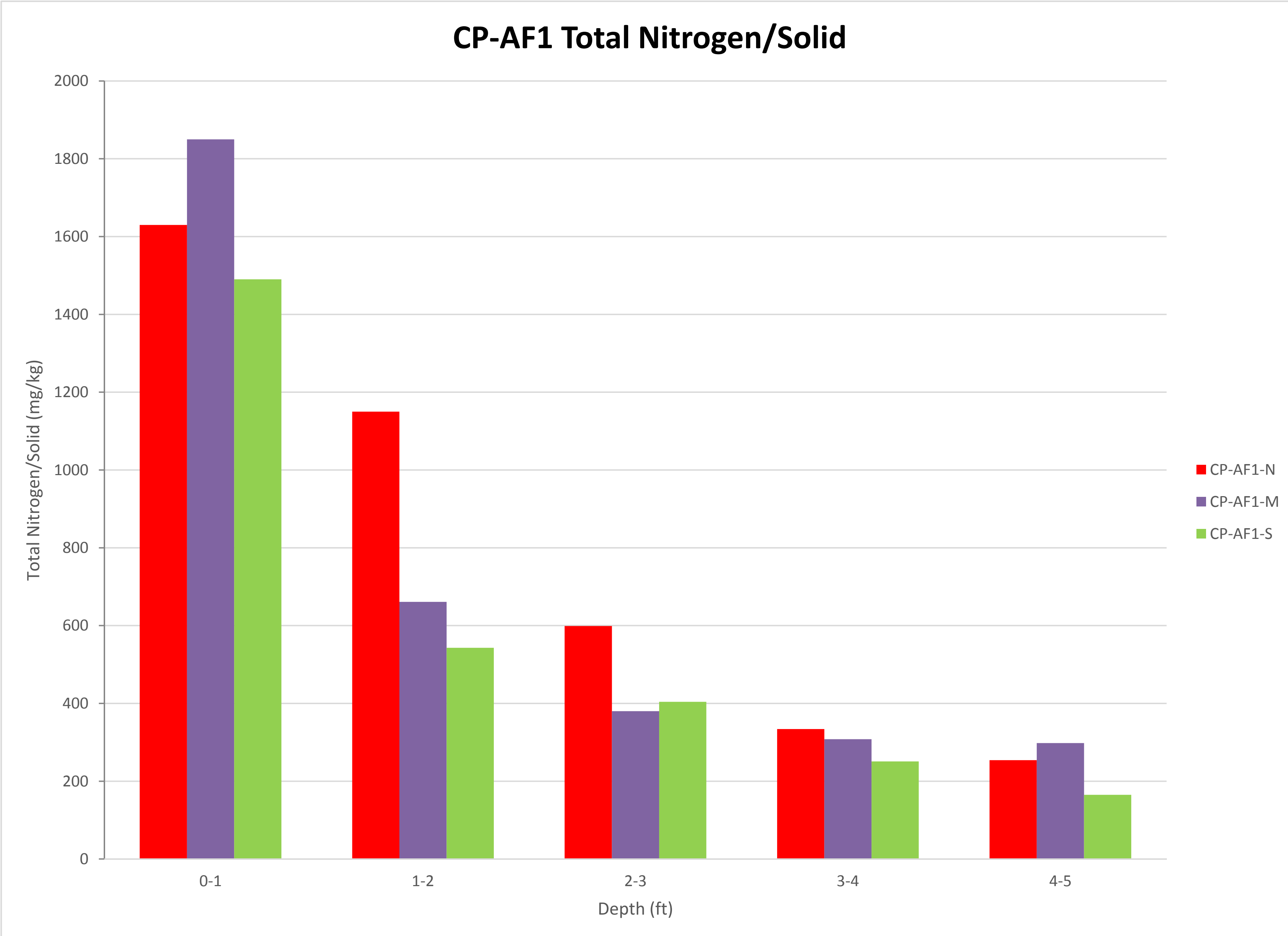
Notes:

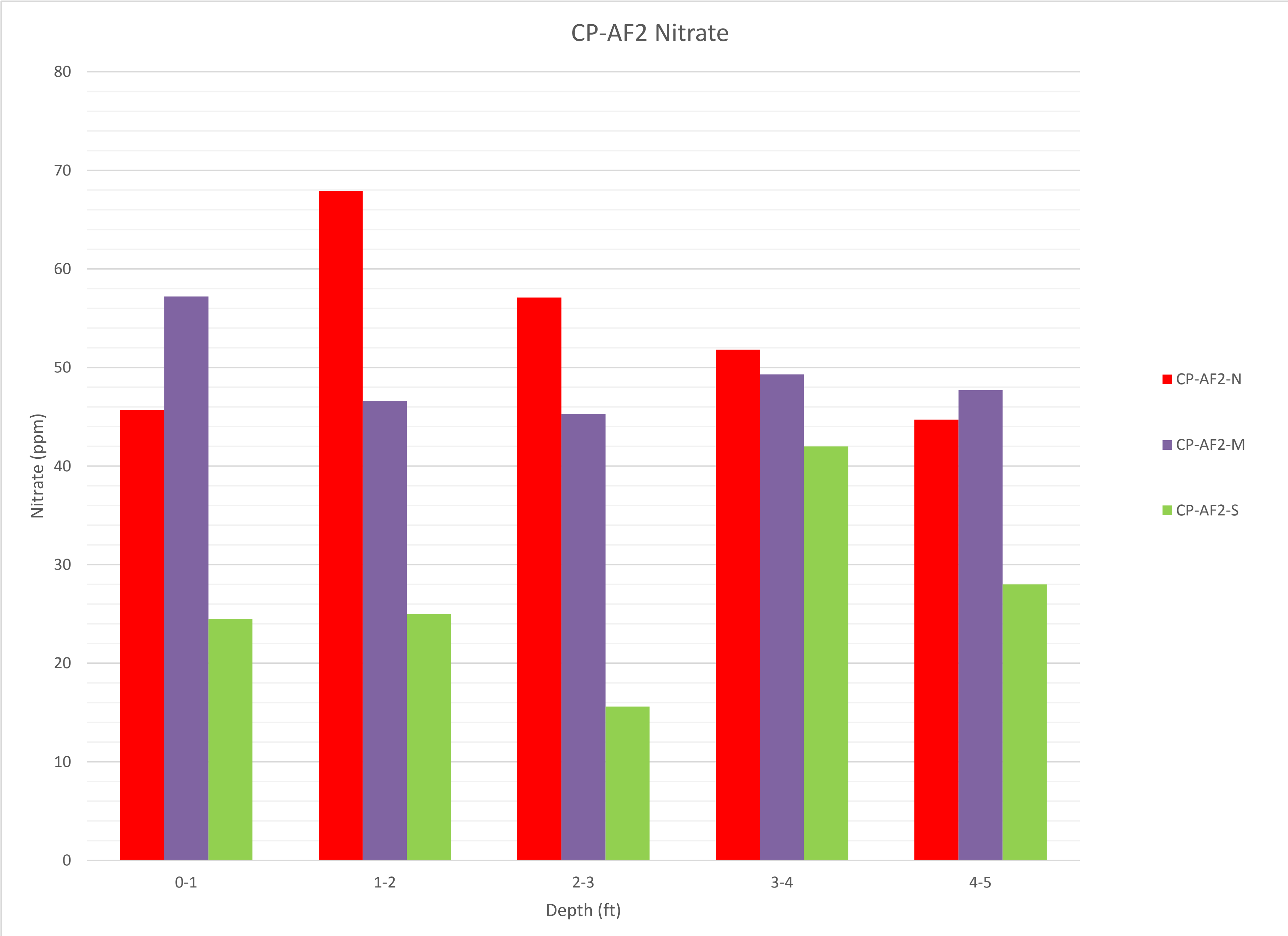
J indicates estimated value

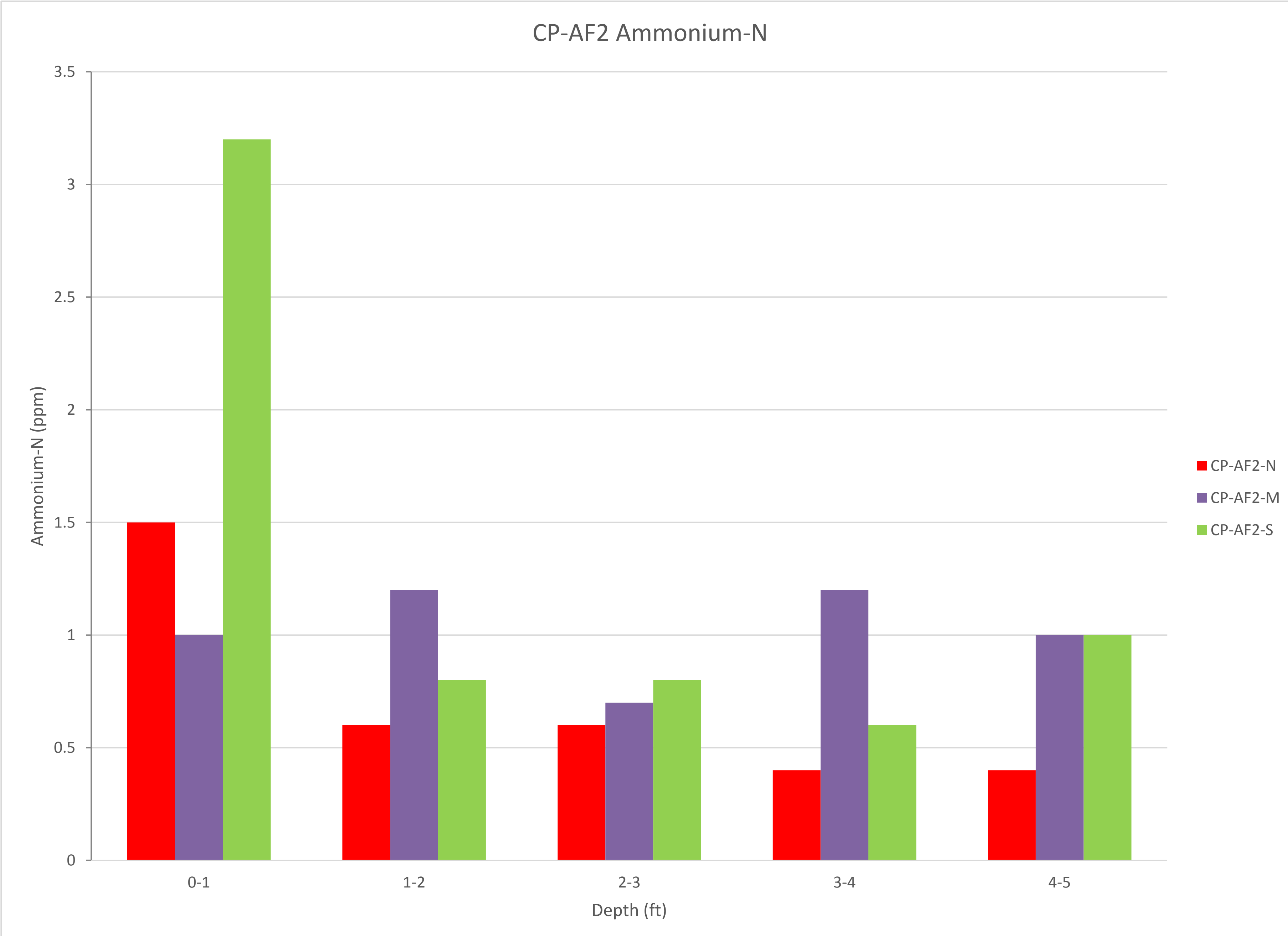
< indicates analyte not detected at indicated reporting limit


CP-AF1 Nitrate
Nitrate (ppm)
80
70
60
50
40
30
20
10
0
0-1
1-2
2-3
3-4
4-5
Depth (ft)
CP-AF1-N
CP-AF1-M
CP-AF1-S


CP-AF1 Ammonium-N
Ammonium-N (ppm)
0
2
4
6
8
10
12
14
0-1
1-2
2-3
3-4
4-5
Depth (ft)
CP-AF1-N
CP-AF1-M
CP-AF1-S


CP-AF1 Total Nitrogen/Solid
Total Nitrogen/Solid (mg/kg)
2000
1800
1600
1400
1200
1000
800
600
400
200
0
0-1
1-2
2-3
3-4
4-5
Depth (ft)
CP-AF1-N
CP-AF1-M
CP-AF1-S


CP-AF2 Nitrate
80
70
60
50
40
30
20
10
0
Nitrate (ppm)
0-1
1-2
2-3
3-4
4-5
Depth (ft)
CP-AF2-N
CP-AF2-M
CP-AF2-S


CP-AF2 Ammonium-N
Ammonium-N (ppm)
0
0.5
1
1.5
2
2.5
3
3.5
0-1
1-2
2-3
3-4
4-5
Depth (ft)
CP-AF2-N
CP-AF2-M
CP-AF2-S


CP-AF2 Total Nitrogen/Solid
Total Nitrogen/Solid (mg/kg)
0
200
400
600
800
1000
1200
1400
1600
0-1
1-2
2-3
3-4
4-5
Depth (ft)
CP-AF2-N
CP-AF2-M
CP-AF2-S

References for Cow Place Docket Project

Canter, L.W., 1996. Nitrates in Groundwater. CRC Lewis Publishers

Cantrell, K.J., R. J. Serne, R.J., and G. V. Last, 2003. Hanford Contaminant Distribution Coefficient

Crohn David, 2004. Nitrogen Mineralization and its Importance in Organic Waste Recycling. In: Proceedings, National Alfalfa Symposium, 13-5 December, 2004, San Diego, CA, UC Cooperative Extension, University of California, Davis 95616.

Database and Users Guide. Pacific Northwest National Laboratory Richland, Washington 99352. U.S. Department of Energy, Contract DE-AC06-76RL01830.

Fetter C.W., 2001. Applied Hydrogeology, Prentice-Hall, Inc.

Ham, J.M. Reddi, L.N. and C.W. Rice, 1999. Animal Waste Lagoon Water Quality Study. Submitted n partial fulfillment of a contract between Kansas State University and the Kansas Water Office, Topeka, KS.

Ham, J.M., 2002. Uncertainty of the Water Balance Techniques for Measuring Seepage from Animal Waste Lagoons. J Environ. Qual. 31:1370-1379.

Huffman, R.L. 2004. Seepage Evaluation of Older Swine Lagoons in North Carolina. American Society of Agricultural Engineers. Vol 47(5) 1507-1512.

Illinois Administrative Cod 506 Livestock Waste Regulations

Kresic, N., 2007. Hydrogeology of Groundwater Modeling. CRC Press.

Miller, D.W., 1980. Waste Disposal Effects on Ground Water. Premier Press, Berkeley, California

Tyner, J. S., and J. Lee. 2004. Influence of seal and liner hydraulic properties on the seepage rate from animal waste holding ponds and lagoons. Trans. ASAE 47(5): 1739-1745.

Tyner, J.S., W. C. Wright, J. Lee, 2006. Lagoon Sealing and Filter Cakes. Transaction of the ASABE. Vol 49(2) 527-531.

US Department of Agriculture, Soil Conservation Service, 1993. Design and Construction Guidelines for Considering Seepage from Agricultural Waste Storage Ponds and Treatment Lagoons; Series Number: 716 (Revision 1)

US Department of Agriculture, Natural Resources Conservation Services, 2009. Part 651 Agricultural Waste Management Field Handbook, Chapter 10 Agricultural Waste Management System Design