Appendices B through T

Nitrogen Dynamics at a Manured Grass Field Overlying the Sumas-Blaine Aquifer in Whatcom County

March 2014

Supplement to Publication No. 14-03-001

Publication and Contact Information

These appendices are available on the Department of Ecology's website as a supplement to https://fortress.wa.gov/ecy/publications/SummaryPages/1403001.html

For more information contact:

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Environmental Assessment Program
P.O. Box 47600, Olympia, WA 98504-7600
Phone: (360) 407-6764

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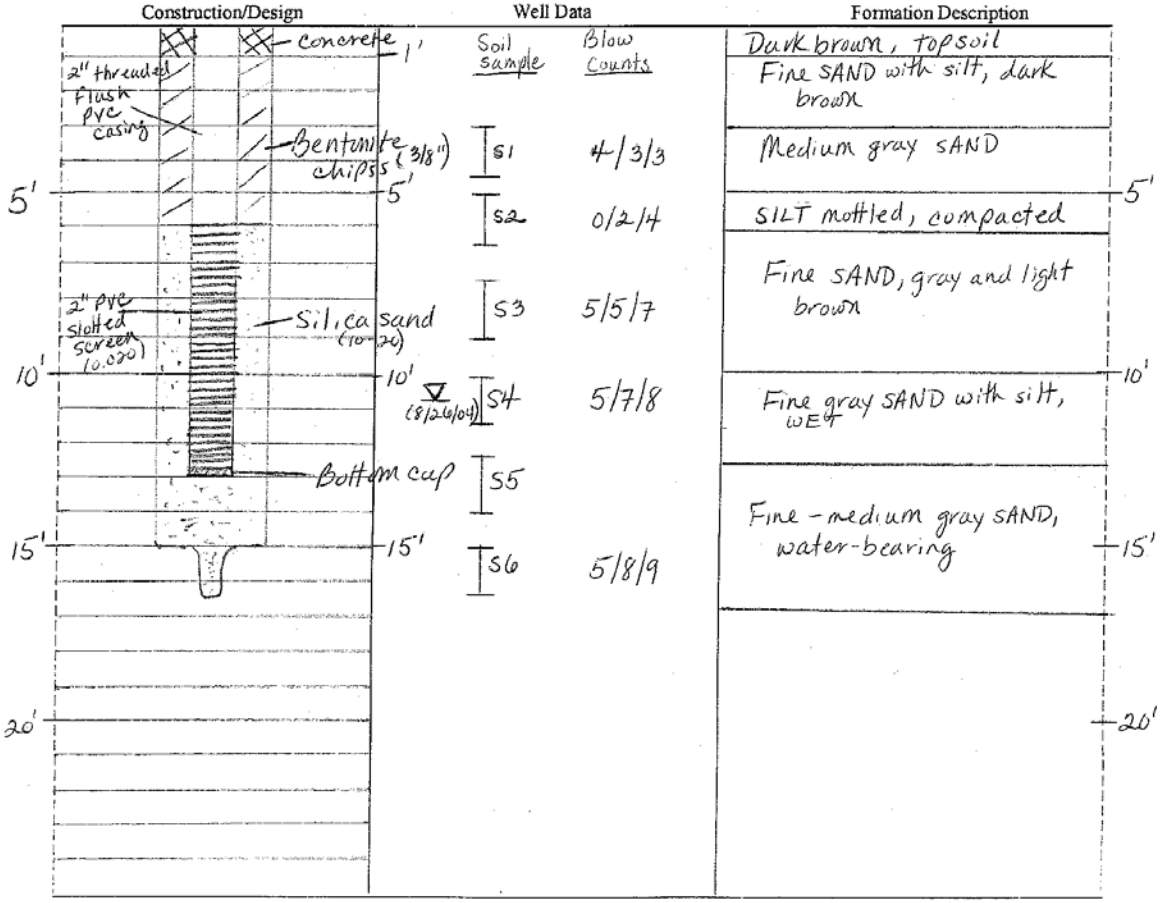
Geologic Log

Unique Ecology Well ID Tag No AKG-721
Site Address H St. Rd.
City Lynden County: Whatcom
Location ___1/4-1/4 ___1/4 Sec___ Twn___ R___ EWM or WWM circle one
Lat/Long (s, t, r Lat Deg 48 Lat Min/Sec 59/583
Long Deg 122 Long Min/Sec 30/356
Cased or Uncased Diameter 2" Static Level 10.7'
Date 8/25/04
Driller Holt Drilling, Milton, WA
Hydrogeologist Barbara Carey, Ecology

Drilling Method: Hollow-stem auger
Ground surface elevation: 130.00'
(from USGS 1:24,000 map)



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Geologic Log

Unique Ecology Well ID Tag No AKG-722

Site Address H St. Rd.

City Lynden County: whatcom

Location ___1/4- 1/4 ___1/4 Sec___ Twn___ R___ EWM or WWM (circle one)

Lat/Long (s, t, r Lat Deg_____ Lat Min/Sec _____

Long Deg _____ Long Min/Sec _____

Cased or Uncased Diameter _____ Static Level 8.4'

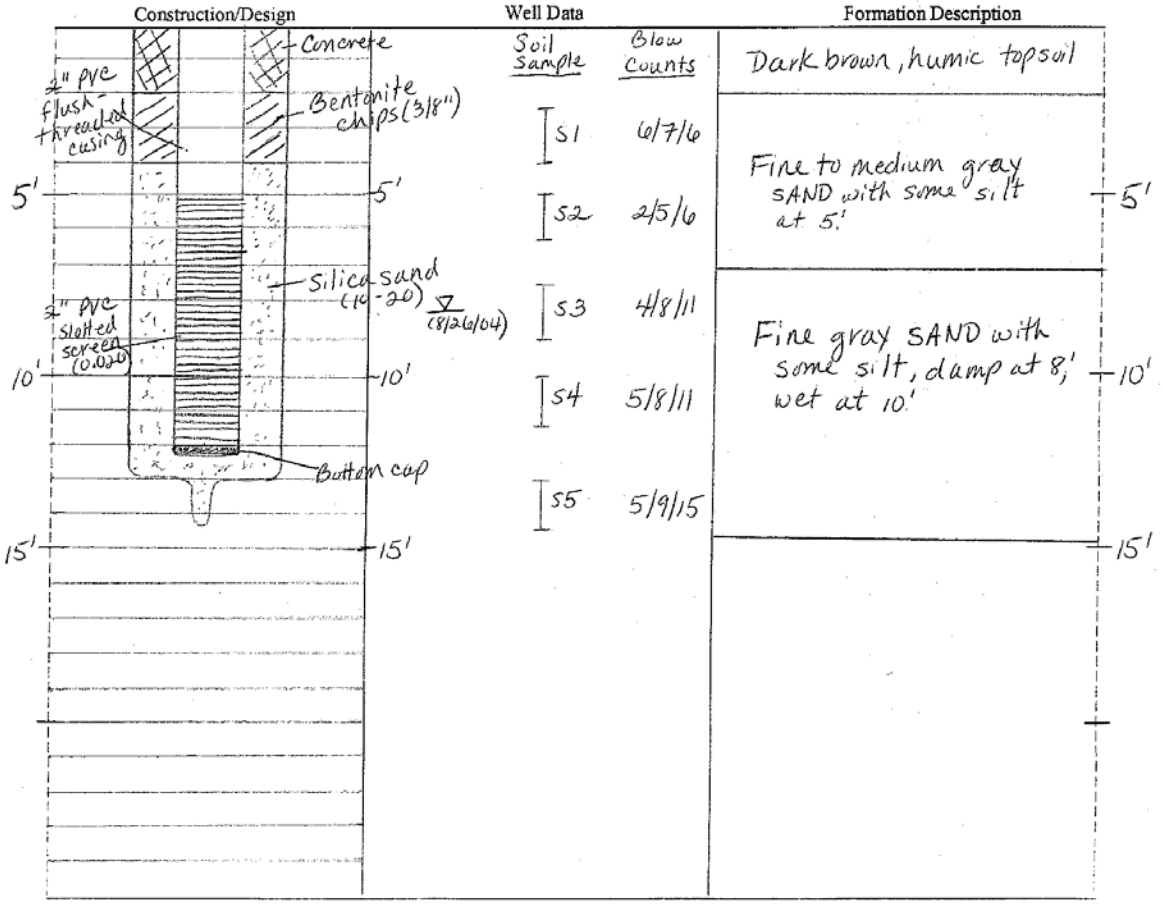
Date 8/25/04

Driller Holt Drilling, Milton, WA

Hydrogeologist Barbara Carey, Ecology

Drilling Method: Hollow-stem auger

Ground Surface Elevation: 126.80' (from USGS 1:24,000 map, relative to AKG-721)



ECY 050-12 (Rev 2 01)

Geologic Log

Unique Ecology Well ID Tag No AKG-723

Site Address H St. Rd.

City Lynden County: Whatcom

Location ___1/4-1/4 ___1/4 Sec___ Twn___ R___ EWM or WWM (circle one)

Lat/Long (s, t, r Lat Deg 48 Lat Min/Sec 59/465

Long Deg 122 Long Min/Sec 30/365

Cased or Uncased Diameter _____ Static Level 9.7'

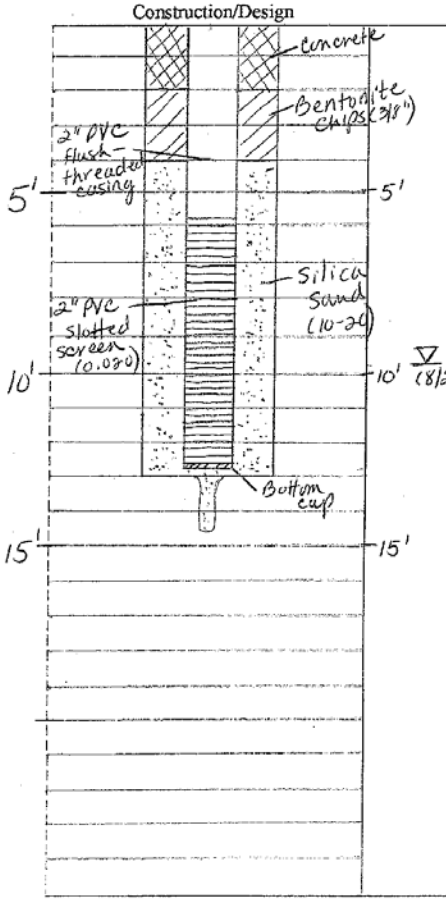
Date 8/25/04

Driller Holt Drilling, Milton, WA

Hydrogeologist Barbara Carey, Ecology

Drilling Method: Hollow-stem auger

Ground surface elevation: 126.84' (From USGS 1:24,000 map, relative to AKG-721.)



Well Data: Soil Sample	Blow Counts	Formation Description
		Topsoil
S1	1/3/4	Gray SILT with some sand, orange mottling, compacted
S2	1/1/1	Fine brown SAND
		Medium to fine SAND, gray + black
S3	1/1/3	Fine to medium SAND, brown + gray, damp at 8.5'
S4	2/3/9	Medium to fine SAND, gray + black, some orange staining about 10-10.5' WET
S5	5/10/14	

▽ (8/26/04)

ECY 050-12 (Rev 2-01)

Geologic Log

Unique Ecology Well ID Tag No AKG- 724

Site Address H St. Rd.

City Lynden County: Whatcom

Location ___1/4- 1/4 ___1/4 Sec.___ Twn.___ R.___ EWM or WWM *circle one*

Lat/Long (s, t, r Lat Deg 48 Lat Min/Sec 59/447

Long Deg 122 Long Min/Sec 30/303

Cased or Uncased Diameter 2" Static Level 8.25'

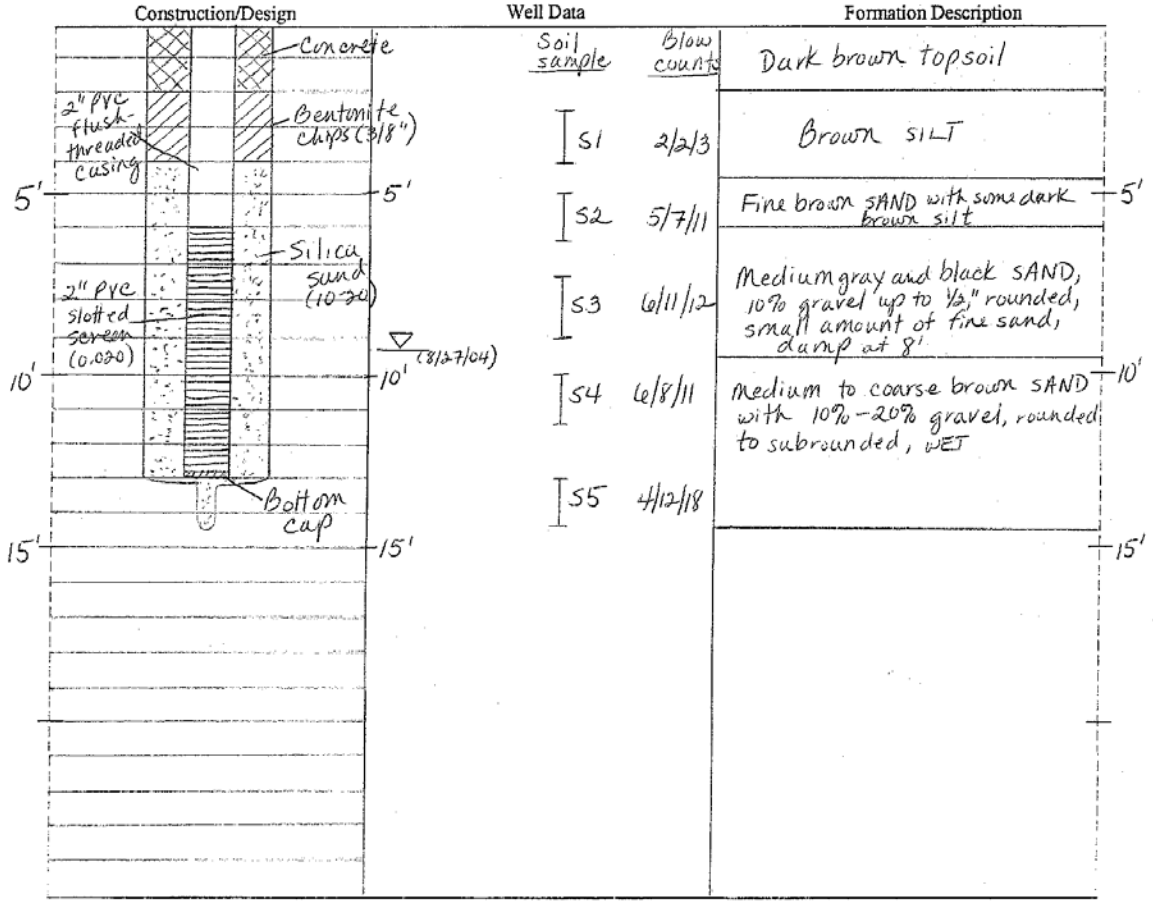
Date 8/26/04

Driller Holt Drilling

Hydrogeologist Barbara Carey

Drilling Method: Hollow Stem Auger

Ground Surface Elevation: 12497' (From USGS 1:24,000 map, relative to AKG-721.)



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Geologic Log

Unique Ecology Well ID Tag No AKG-725

Site Address H St. Rd.

City Lynden County: whatcom

Location ___1/4-1/4 ___1/4 Sec.___ Twn___ R___ EWM or WWM circle one

Lat/Long (s, t, r Lat Deg 48 Lat Min/Sec 59/512

Long Deg 122 Long Min/Sec 30/364

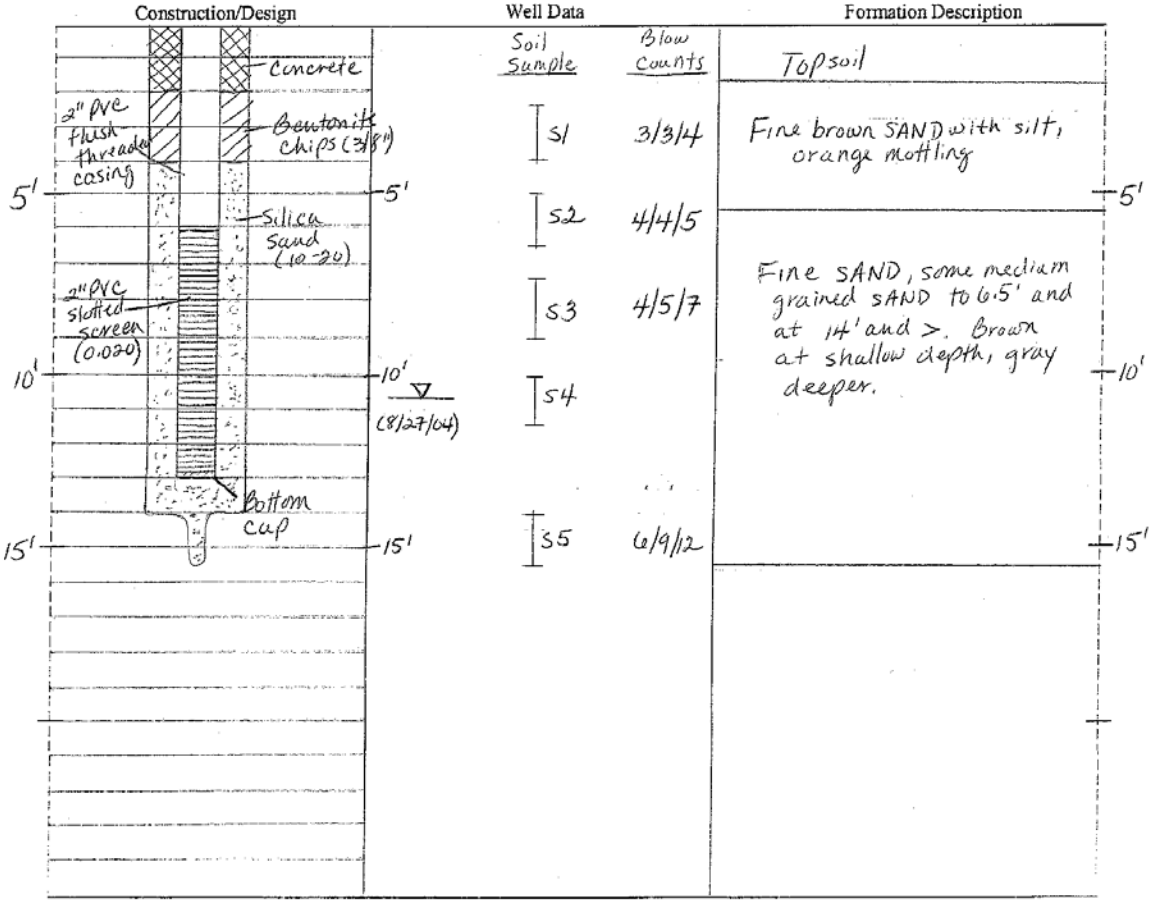
Cased or Uncased Diameter 2" Static Level 10.58'

Date 8/26/04

Driller Holt Drilling

Hydrogeologist Barbara Carey

Drilling Method: Hollow-Stem Auger
Ground Surface Elevation: 128.73'
(From USGS 1:24,000 map, relative to AKG-721.)



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ECY 050-12 (Rev 2 01)

Geologic Log

Unique Ecology Well ID Tag No AKG-726

Site Address H St. Rd.

City Lynden County: Whatcom

Location ___1/4- 1/4 ___1/4 Sec___ Twn___ R___ EWM or WWM circle one

Lat/Long (s, t, r Lat Deg 48 Lat Min/Sec 59/512

Long Deg 122 Long Min/Sec 30/364

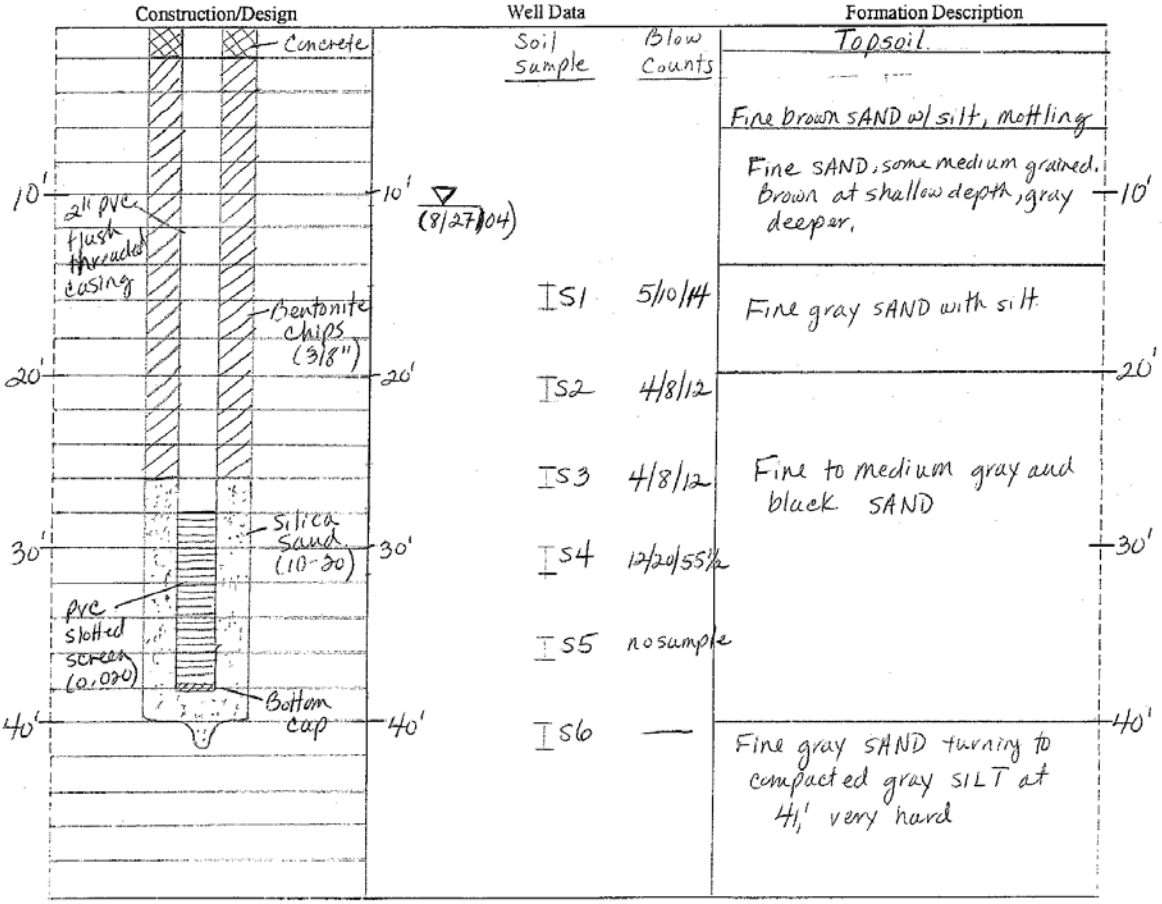
Cased or Uncased Diameter 2" Static Level 10.61'

Date 8/26/04

Driller Holt Drilling

Hydrogeologist Barbara Carey

Drilling method: Hollow-stem Auger
Ground Surface Elevation: 128.68'
(from USGS 1:24,000 map, relative to AKG-721)



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ECY 050-12 (Rev 2-01)

Geologic Log

Unique Ecology Well ID Tag No AKG-727

Site Address H St. Rd.

City Lynden County: Whatcom

Location ___1/4-1/4 ___1/4 Sec___ Twn___ R___ EWM or WWM *circle one*

Lat/Long (s, t, r Lat Deg_____ Lat Min/Sec_____

Long Deg_____ Long Min/Sec_____

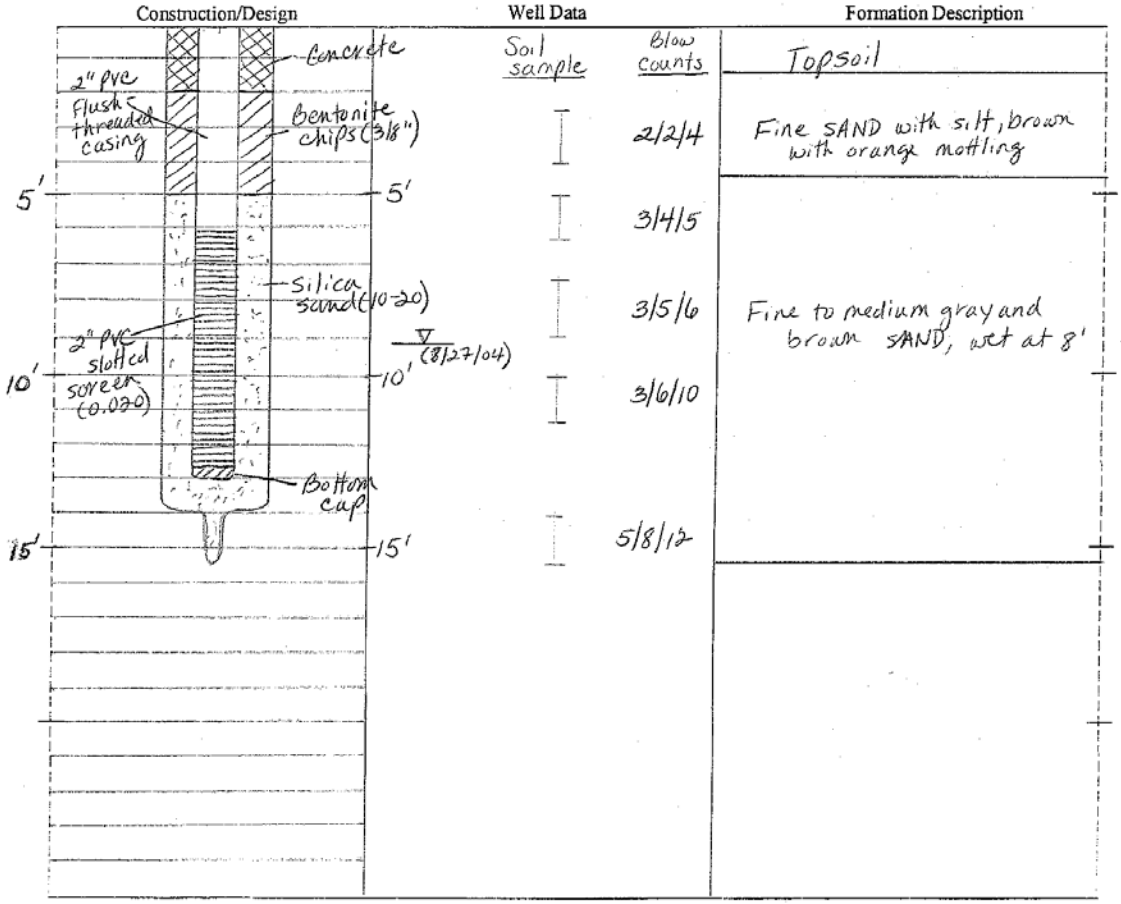
Cased or Uncased Diameter 2" Static Level 9.18'

Date 8/26/04

Driller Holt Drilling

Hydrogeologist Barbara Carey

Well drilling method: Hollow-stem auger
Ground surface elevation: 127.43'
(from USGS 1:24,000 map, relative to AKG-721.)



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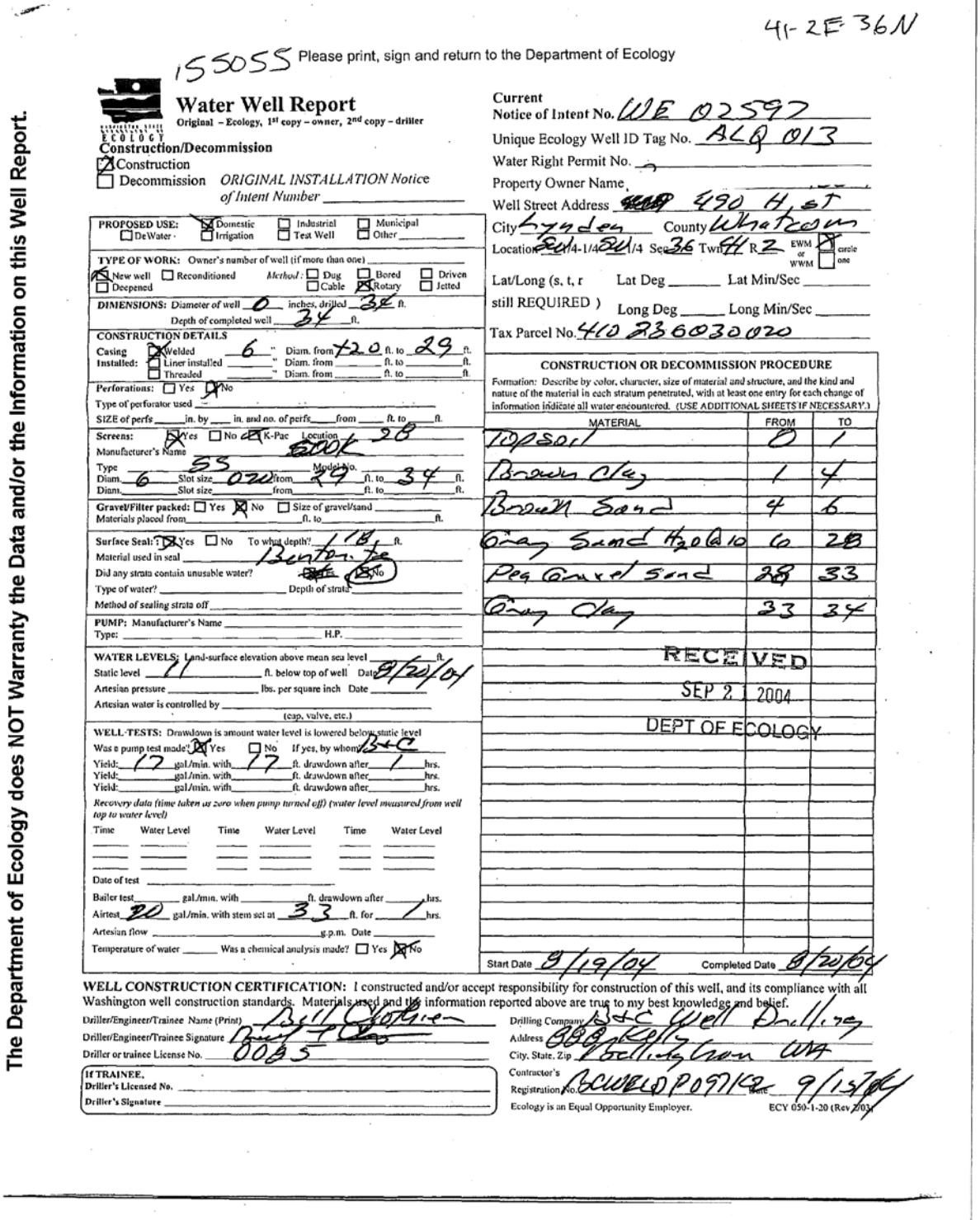
ECY 050-12 (Rev 2/01)

Drilling logs for private wells just north of the study site, ALQ013 and APM737.



41-2E-36N

155055 Please print, sign and return to the Department of Ecology

STATE OF WASHINGTON ECOLOGY

Water Well Report
Original – Ecology, 1st copy – owner, 2nd copy – driller

Construction/Decommission
☒ Construction
☐ Decommission *ORIGINAL INSTALLATION Notice of Intent Number* _____

PROPOSED USE: ☒ Domestic ☐ Industrial ☐ Municipal ☐ DeWater · ☐ Irrigation ☐ Test Well ☐ Other _____

TYPE OF WORK: Owner's number of well (if more than one) _____
☒ New well ☐ Reconditioned *Method:* ☐ Dug ☐ Bored ☐ Driven ☐ Deepened ☐ Cable ☒ Rotary ☐ Jetted

DIMENSIONS: Diameter of well 0 inches, drilled 34 ft.
Depth of completed well 34 ft.

CONSTRUCTION DETAILS
Casing Installed: ☒ Welded 6 " Diam. from +20 ft. to 29 ft.
☐ Liner installed " Diam. from ft. to ft.
☐ Threaded " Diam. from ft. to ft.

Perforations: ☐ Yes ☒ No
Type of perforator used _____
SIZE of perfs ___ in. by ___ in. and no. of perfs ___ from ___ ft. to ___ ft.

Screens: ☒ Yes ☐ No ☒ K-Pac Location 28
Manufacturer's Name Spark
Type SS Model No. 020
Diam. 6 Slot size 020 from 29 ft. to 34 ft.
Diam. ___ Slot size ___ from ___ ft. to ___ ft.

Gravel/Filter packed: ☐ Yes ☒ No ☐ Size of gravel/sand _____
Materials placed from ___ ft. to ___ ft.

Surface Seal: ☒ Yes ☐ No To what depth? 18 ft.
Material used in seal Bentonite
Did any strata contain unusable water? ☐ Yes ☒ No
Type of water? _____ Depth of strata _____
Method of sealing strata off _____

PUMP: Manufacturer's Name _____
Type: _____ H.P. _____

WATER LEVELS: Land-surface elevation above mean sea level _____ ft.
Static level 11 ft. below top of well Date 9/20/04
Artesian pressure _____ lbs. per square inch Date _____
Artesian water is controlled by _____ (cap, valve, etc.)

WELL TESTS: Drawdown is amount water level is lowered below static level
Was a pump test made? ☒ Yes ☐ No If yes, by whom? B+C
Yield: 17 gal./min. with 17 ft. drawdown after 1 hrs.
Yield: ___ gal./min. with ___ ft. drawdown after ___ hrs.
Yield: ___ gal./min. with ___ ft. drawdown after ___ hrs.
Recovery data (time taken as zero when pump turned off) (water level measured from well top to water level)

Time	Water Level	Time	Water Level	Time	Water Level

Date of test _____
Bailer test ___ gal./min. with ___ ft. drawdown after ___ hrs.
Airtest 20 gal./min. with stem set at 33 ft. for 1 hrs.
Artesian flow _____ g.p.m. Date _____
Temperature of water _____ Was a chemical analysis made? ☐ Yes ☒ No

Current
Notice of Intent No. WE 02597
Unique Ecology Well ID Tag No. ALQ 013
Water Right Permit No. _____
Property Owner Name _____
Well Street Address 490 H St
City Lynden County Whatcom
Location SW 1/4-1/4 SW 1/4 Sec 36 Twn 41 R 2 EWM or WWM ☐ circle one
Lat/Long (s, t, r still REQUIRED) Lat Deg ___ Lat Min/Sec ___ Long Deg ___ Long Min/Sec ___
Tax Parcel No. 410236030020

CONSTRUCTION OR DECOMMISSION PROCEDURE
Formation: Describe by color, character, size of material and structure, and the kind and nature of the material in each stratum penetrated, with at least one entry for each change of information indicate all water encountered. (USE ADDITIONAL SHEETS IF NECESSARY.)

MATERIAL	FROM	TO
Topsoil	0	1
Brown Clay	1	4
Brown Sand	4	6
Gray Sand H2O @ 10	6	28
Peg Gravel Sand	28	33
Gray Clay	33	34

RECEIVED
SEP 21 2004
DEPT OF ECOLOGY

Start Date 9/19/04 Completed Date 9/20/04

WELL CONSTRUCTION CERTIFICATION: I constructed and/or accept responsibility for construction of this well, and its compliance with all Washington well construction standards. Materials used and the information reported above are true to my best knowledge and belief.

Driller/Engineer/Trainee Name (Print) Bill Clothier
Driller/Engineer/Trainee Signature _____
Driller or trainee License No. 0085
Drilling Company B+C Well Drilling
Address 6868 Kelly Lynden
City, State, Zip Bellingham WA
Contractor's Registration No. BCWELDP097KR Date 9/15/04

IF TRAINEE,
Driller's Licensed No. _____
Driller's Signature _____

Ecology is an Equal Opportunity Employer. ECY 050-1-20 (Rev 2/03)

The Department of Ecology does NOT Warranty the Data and/or the Information on this Well Report.

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273004

41-2E-36N

WATER WELL REPORT

Original & 1st copy – Ecology, 2nd copy – owner, 3rd copy – driller

Construction/Decommission *("x" in circle)*

☒ Construction

○ Decommission *ORIGINAL INSTALLATION Notice of Intent Number* _____

CURRENT
Notice of Intent No. 218025
Unique Ecology Well ID Tag No. APM737
Water Right Permit No. _____
Property Owner Name _____
Well Street Address 430 H. STREET
City LYNDEN County WHATCOM
Location SW 1/4-1/4 SW 1/4 Sec 36 Twn 41N R 2E (EWM) (WWM) circle one
Lat/Long (s, t, r Still **REQUIRED**) Lat Deg _____ Lat Min/Sec _____
Long Deg _____ Long Min/Sec _____
Tax Parcel No. 410236 090020 0000

PROPOSED USE: ☒ Domestic ☐ Industrial ☐ Municipal ☐ DeWater ☐ Irrigation ☐ Test Well ☐ Other _____

TYPE OF WORK: Owner's number of well (if more than one) _____
☒ New well ☐ Reconditioned *Method:* ☐ Dug ☐ Bored ☐ Driven ☐ Deepened ☐ Cable ☒ Rotary ☐ Jetted

DIMENSIONS: Diameter of well 6 inches, drilled 38 ft.
Depth of completed well 33 1/2 ft.

CONSTRUCTION DETAILS
Casing Installed: ☒ Welded 6" Diam. from +2 ft. to 33 1/2 ft.
☐ Liner installed _____" Diam. from _____ ft. to _____ ft.
☐ Threaded _____" Diam. from _____ ft. to _____ ft.

Perforations: ☐ Yes ☒ No
Type of perforator used _____
SIZE of perfs _____ in. by _____ in. and no. of perfs _____ from _____ ft. to _____ ft.

Screens: ☒ Yes ☐ No ☒ K-Pac Location _____
Manufacturer's Name JOHNSON
Type STAINLESS Model No. _____
Diam. 6 Slot size 15 from 28 1/2 ft. to 33 1/2 ft.
Diam. _____ Slot size _____ from _____ ft. to _____ ft.

Gravel/Filter packed: ☐ Yes ☒ No ☐ Size of gravel/sand _____
Materials placed from _____ ft. to _____ ft.

Surface Seal: ☒ Yes ☐ No To what depth? 18+ ft.
Material used in seal BENTONITE
Did any strata contain unusable water? ☐ Yes ☒ No
Type of water? _____ Depth of strata _____
Method of sealing strata off _____

PUMP: Manufacturer's Name BERKELY
Type: STAINLESS H.P. 1/2

WATER LEVELS: Land-surface elevation above mean sea level _____ ft.
Static level 7 ft. below top of well Date 10/20/2006
Artesian pressure _____ lbs. per square inch Date _____
Artesian water is controlled by _____ (cap, valve, etc.)

WELL TESTS: Drawdown is amount water level is lowered below static level
Was a pump test made? ☒ Yes ☐ No If yes, by whom? J. PETERSON
Yield: 18 gal./min. with 8 ft. drawdown after 4 hrs.
Yield: _____ gal./min. with _____ ft. drawdown after _____ hrs.
Yield: _____ gal./min. with _____ ft. drawdown after _____ hrs.
Recovery data (time taken as zero when pump turned off) (water level measured from well top to water level)

Time	Water Level	Time	Water Level	Time	Water Level

Date of test 10/20/2006
Bailer test _____ gal./min. with _____ ft. drawdown after _____ hrs.
Airtest _____ gal./min. with stem set at _____ ft. for _____ hrs.
Artesian flow _____ g.p.m. Date _____
Temperature of water _____ Was a chemical analysis made? ☒ Yes ☐ No

CONSTRUCTION OR DECOMMISSION PROCEDURE

Formation: Describe by color, character, size of material and structure, and the kind and nature of the material in each stratum penetrated, with at least one entry for each change of information. (USE ADDITIONAL SHEETS IF NECESSARY.)

MATERIAL	FROM	TO
TOPSOIL	0'	1'
HARD BROWN CLAY	1'	8'
MEDIUM - COURSE GREY SAND	8'	25'
GRAVEL/ MEDIUM - COURSE GREY SAND / WATER	25'	34'
BLUE CLAY	34'	38'

RECEIVED
SEP 28 2007
Water Resources Program
Department of Ecology

Start Date 10/19/2006 Completed Date 10/20/2006

WELL CONSTRUCTION CERTIFICATION: I constructed and/or accept responsibility for construction of this well, and its compliance with all Washington well construction standards. Materials used and the information reported above are true to my best knowledge and belief.

☐ Driller ☐ Engineer ☒ Trainee Name (Print) JERRY L. PETERSON
Driller/Engineer/Trainee Signature _____
Driller or trainee License No. 2776T

If TRAINEE,
Driller's Licensed No. 2640
Driller's Signature _____

Drilling Company LIVERMORE & SON, LLC
Address 5355 HOMESTEADER RD.
City, State, Zip DEMING, WA. 98244
Contractor's Registration No. LIVERSL981RC Date 10/20/2006

Ecology is an Equal Opportunity Employer.

ECY 050-1-20 (Rev 3/05) **The Department of Ecology does NOT warranty the Data and/or Information on this Well Report.**

Appendix C. Manure Sampling Standard Operating Procedure (SOP)

Sampling Events (between 4 and 6 per year)

- Late winter/early spring
- Typically after each grass cutting

Items Needed to Manure Sample

- Clean 5-gallon bucket
- Rain suit and boots
- Clean ladle
- Nalgene containers
- Tape and permanent pen
- Log book and pen
- Agros Meter
- Warm water
- Camera

Sampling Methods

- Call the producer to schedule sampling during each manure application.
- Take sample at the discharge of the equipment putting the manure on the field.
- Fill a 5-gallon bucket about ¾ of the way full with sample.
- Label 4 Nalgene containers. Use 2 log numbers for duplicate samples. Label 2 Nalgene containers with 1 log number (DOE M1 in the example) and the other 2 Nalgene containers with another log number (DOE M2).
- Record log numbers in the log book, with sampling date, manure application equipment, and Agros Meter reading for ammonia-N.
- Stir the manure in the bucket vigorously with the ladle, and ladle the manure into the Nalgene containers while the manure is still moving.
- Fill the Nalgene containers about 80% full. (This gives room for the liquid to expand when it freezes).
- Place manure samples on ice and transport to a freezer as soon as possible.

Sampling Ammonia with an Agros Meter

- Take a subsample of the manure in the 5-gallon bucket and conduct an Agros Meter analysis for ammonia following the manufacturer's instructions. Use 80° to 90° F water for the analysis, and record the temperature of the manure-water mix in the cylinder prior to adding chemicals.

Processing Manure Samples for the Contract Lab

- Each manure sample is analyzed for solids, total N, ammonia-N, phosphate, and potash concentration.

- Prior to shipment, type a requisition to the lab with the information needed, put in a Ziploc bag, and placed on top of the Styrofoam cooler (inside a cardboard box).

Appendix D. Irrigation Water Sampling Standard Operating Procedure (SOP)

Sampling Events (2 to 4 times per year)

- Late spring through late summer

Items Needed

- Three 5-gallon buckets with sand in the bottom (used to hold the empty 5-gallon buckets upright while water is going into them)
- 3 clean 5-gallon buckets
- Graduated cylinder
- Tape, timer, pen, and paper

Sampling Methods

- Keep in contact with the producer to schedule sampling for each irrigation event.

- Carry three 5-gallon buckets with sand and the 3 clean 5-gallon buckets into the field where irrigation water will be applied. Place a clean bucket inside of a bucket of sand. The bucket should be in the middle of the area the water is being applied. Place it close to the irrigation hose (but far enough away that the gun will not hit it as it is moving). Place another bucket with sand and clean bucket inside about ¾ of the way across the length of the irrigation water spray to the right of the bucket that was placed in the middle. Place the last bucket with sand and clean bucket about ¾ of the way across the length of the irrigation water spray to the left of the bucket that was placed in the middle.

- These buckets should be in a straight line with each other once they are set out. They should run horizontal to the irrigation water spray. Make sure the water is not hitting them when they are set out (so that you do not miss any of the water that could potentially go into the buckets). Also, make sure that the buckets are far enough away from the reel that when the gun is pulled in all the way, it won't sit there and fill the buckets before it is turned off.

- After irrigation water has been collected into the buckets, retrieve all the buckets.

- Pour the water into a 1,000-ml graduated cylinder, and record the amount (usually between 7,000 and 10,000 ml). *Note: Do not discard the water after you fill the graduated cylinder. You will need it for water samples.*

- Label 4 nalgene containers. Use 2 log numbers (one for the sample and one for the duplicate).

- Label 2 Nalgene containers with 1 log number (DOE I1 in the example) and the other 2 nalgene containers with another log number (DOE I2).

- Record log numbers in the log book, with sampling date and amount of irrigation water applied.

- Stir the irrigation water vigorously with the ladle, and ladle the irrigation water into the Nalgene containers while the irrigation water is still moving.

- Fill the Nalgene containers about 80% full. (This gives room for the liquid to expand when it freezes).

- Place irrigation water samples on ice and transport to freezer as soon as possible.

- Send iced irrigation water samples to the Manchester Environmental Laboratory.

Appendix E. Grass Sampling Standard Operating Procedure (SOP)

Sampling Events (approximately 5 per year)

- Late spring through fall

Items Needed to Grass Sample

- 2 ft by 2 ft PVC pipe square
- Hedge trimmer
- Gas and oil mix
- Pliers to get gas lid off of hedge trimmer
- Garbage bags
- Rubber bands, labels, and permanent pen
- Log book and pen
- GPS and extra set of batteries
- Scale, tote, and garbage bag (for tare) to weigh each individual grass sample

Sampling Methods

- Keep in contact with the producer to schedule grass sampling just prior to each cutting.

- Label 10 manila labels (one for each sampling location) with DOE log number using a sharpie.

- Five grass samples from randomly selected locations in the field will be composited in the laboratory after wet weight and dry weight measurements. The sample procedure will be done to another 5 subsamples for a duplicate sample. Samples will be collected at about the same location each time.

- Attach a rubber band to each label. The rubber band will be used to attach the label to the garbage bag holding the grass sample.

- Take the 2-foot by 2-foot PVC pipe square, hedge trimmer, GPS, GPS coordinates, 5 garbage bags, 5 labels with rubber bands, and camera (optional).

- At each GPS location, place the PVC pipe square in the grass as close to the ground as you can push it. Use the hedge trimmers to cut the grass. Place the grass in a clean garbage bag. Label the bag with a GPS label. Place the garbage bag (with grass) into another garbage bag. Proceed to the next GPS location.

GPS Locations for Grass Samples

Processing Grass Samples for WSU Puyallup

- Transport grass samples to a freezer.

- Prior to placing the grass samples in a freezer, weigh them and record a weight in pounds in the log book.

- The entire grass sample will go to WSU Puyallup for dry weight and nutrient analyses. Contact WSU Puyallup to coordinate shipment time.

Appendix F. Soil Sampling Standard Operating Procedure (SOP)

Sampling Events (25 per year)
- Monthly from January through July and December
- Weekly August through November

Items Needed
- 1-foot soil probe
- Screwdriver to dislodge soil from the soil probe
- 2 buckets
- 2 – 6-inch soil temperature probes
- Log book and pen
- Ice bags and permanent marker
- GPS and extra set of batteries
- GPS locations
- Camera

Sampling Methods

Soil Temperature

- Set one bucket as a marker for the 6-inch temperature probe.

- Insert the temperature probe in the ground near the marker bucket and leave it while collecting soil samples. Read the probe and record the temperature in the log book after collecting soil samples.

- The temperature probes are fairly delicate; therefore, I insert 2 probes at each location to make sure I am getting similar readings. When a variation between the readings occurs, discard the broken one (it's usually pretty obvious), and replace it with a new probe. I usually go through a few probes each year.

Duplicate Sampling Methods

- Collect 15 one-foot soil cores into a clean bucket at the GPS sites randomly chosen across the field. The same 15 sites are sampled each time.

- Discard the loose crop or manure residue at the top of the core before placing the core in the bucket.

- Mix the soil cores in the bucket extensively until the majority of clumps are broken and the soil has been mixed thoroughly (this reduces variability in soil nitrate values between duplicates).

- Collect a second set of 15 one-foot cores (duplicate) into another clean bucket at another 15 GPS sites randomly chosen. The same second group of 15 sites is sampled each time.

GPS Locations in the Field for Soil Samples

Splitting Soil Samples

- Split the mixed composite sample into 3 subsamples and place into 3 clean plastic bags: one sample for the contract laboratory, one for archival at WSU Puyallup, and one annually for a laboratory split replicate.

- Place all samples in a cooler with ice packs and transport to a freezer within one hour of sampling.

Processing Soil Samples for Contract Lab

- Assign each soil sample a log number for nitrate analysis. Send soil samples to contract lab about once per month.

- Once each year (April samples) do a complete soil analysis.

Processing Soil Samples for WSU Puyallup

- The remaining splits of the soil samples are periodically sent to WSU Puyallup for dry matter analysis.

- Type a memo and e-mail it to WSU Puyallup indicating the soil sample log numbers, number of samples, number of packages being shipped, estimated arrival date, and request for soil analysis for Dry Matter.

- FedEx samples to WSU Puyallup.

Appendix G. Monitoring Well Construction Information

Table G.1. Monitoring well construction information. *Measurements are in feet.*

Well ID	Latitude N	Longitude W	Well Elevation[1] (TOC[2])	Well Depth (feet below TOC[2])	Open interval (feet below TOC[2])
AKG721	48.99308562	122.505981	134.00	12.8	5.8-12.8
AKG722	48.99185971	122.504717	130.80	12.1	5.1-12.1
AKG723	48.99109255	122.506064	130.84	12.7	5.7-12.7
AKG724	48.99079669	122.505029	128.97	13.0	6.0-13.0
AKG725	48.99187608	122.506042	132.73	13.0	6.0-13.0
AKG726	48.99187608	122.506042	132.68	38	28-38
AKG727	48.99272965	122.504863	131.43	12.9	5.9-12.9

[1] Elevation of the top of casing for AKG721 was established as an arbitrary datum and assigned a value of 134.00 feet (NAVD88) from a 10-meter Digital Elevation Model spatial coverage. Elevations of other wells were surveyed relative to the top of casing of AKG721 to an accuracy of 0.01 foot.

[2] Top of casing.

Appendix H. Equations Used in the Bradbury and Rothschild (1985) Method for Estimating Hydraulic Conductivity

Eq. 1 $$T = \frac{Q}{4\pi(s_m - s_w)}\left[\ln\left(\frac{2.25Tt}{r_w^{\,2}S}\right) + 2s_p\right]$$

Eq. 2 $$s_w = CQ^2$$

Eq. 3 $$s_p = \frac{1 - L/b}{L/b}\left(\ln\frac{b}{r_w} - G(L/b)\right)$$

Eq. 4 $$G(L/b) = 2.948 - 7.363(L/b) + 11.447(L/b)^2 - 4.675(L/b)^3$$

where:

b - aquifer thickness	s_m - measured drawdown
C - well loss coefficient	s_w - well loss
L - screen length	s_p - partial penetration param
Q - mean pumping rate	S - storativity
r_w - effective radius	T - transmissivity
	t - pumping duration

Appendix I. Quality Assurance Results

Groundwater

Field meters were calibrated at the start of each day according to the manufacturer's instructions. Duplicate field measurements were collected at one monitoring well during each sampling event to assess combined precision of field and lab results. After routine sampling at the duplicate well (initial samples), the pump was turned off for a few minutes before the well was again purged, field measurements repeated (duplicate samples), and water quality samples collected (duplicate samples). The results of the duplicate samples are shown in Table I.6.

The relative standard deviation of the duplicates (RSD) represents the standard deviation of the two duplicate samples (SD) divided by the mean and expressed as a percentage:

$$RSD = \frac{SD}{mean}\ x\ 100$$

Table I.7 summarizes RSD results for each analyte. The mean RSD for temperature, pH, and conductivity was 0.6-1.4 %. The range of RSD values for these parameters was 0-7.2%. The RSD for dissolved oxygen (DO), which was often in the 0-3 mg/L range, was 8.7%. The range of RSD values for DO was 0.2-48%. The lower measurement range for DO tended to amplify the RSD compared to the other parameters. In addition, DO results fluctuated during purging more so than other field parameters, probably due to greater variation in the groundwater than other parameters. Targets were not specified for field parameters in the Quality Assurance Project Plan (Carey, 2004).

Except for the deep well, AKG726, all samples were field-filtered (0.45 um) in-line. From the start of the study until July 7, 2005, samples for ammonia-N, nitrate+nitrite-N, TPN, and total and ortho-phosphorus from AKG726 were filtered at Manchester Environmental Laboratory (MEL). Total phosphorus and total organic carbon (TOC) samples collected on August 17, 2005 at AKG726 were also filtered at MEL. All other samples collected on August 17, 2005 and thereafter at AKG726 were not filtered.

The mean RSD for nitrate+nitrite-N based on field duplicates was 4.6%, for chloride 2.7%, dissolved organic carbon 5.3%, total dissolved solids 2.7%, total persulfate nitrogen 3.9%, and total phosphorus 17%. These values represent the combined field and laboratory precision. The target precision for nutrients was 7%, and that for chloride and dissolved organic carbon (DOC) was 10%. The target was met for the mean RSDs of all parameters except total phosphorus. Individual RSD values over 20% are qualified as estimates in Appendix R, Table R.1.

During six sampling events in 2008, a blank sample of de-ionized water from MEL was collected at the end of the day using the same silastic tubing on the peristaltic pump as was used for monitoring well samples. Results of blank samples were used to evaluate potential cross-contamination from the silastic tubing (Table I.8).

Most of the blank results for the nitrogen series were below detection. On May 6 and June 19, 2008, both nitrate+nitrite-N and total persulfate nitrogen (TPN) were detected at concentrations roughly 1% of field values. These results indicate that using the same piece of silastic tubing (new each sampling event) when purging and sampling each well was not a significant cross-contamination source.

Laboratory quality assurance consisted of duplicate blanks, duplicate samples, spiked samples and check (control) standards. MEL completed internal quality assurance review on all data sets. See MEL (2008, 2012) for laboratory quality assurance methods and standard operations. All results are considered acceptable for use without qualification except for the following:

- September 21, 2004: Total dissolved solids (TDS) samples were analyzed outside acceptable holding time and are qualified as estimates (J).
- September 8 and 21, 2008: Chloride samples were analyzed outside acceptable holding time and are qualified as estimates (J).

Table I.1. Results of split manure samples.

Date	Sample ID	% Solids	Ammonia N (lb/ 1,000 gallons)	Total N (lb/ 1,000 gallons)
8/9/2005	DOE M9	1.69	8.51	11.05
8/9/2005	DOE M11	1.73	8.50	12.75
RSD (%)		**1.65**	**0.08**	**10.1***
8/31/2005	DOE M12	6.97	12.63	22.95
8/31/2005	DOE M14	6.63	10.64	23.80
RSD (%)		**3.54**	**12.1***	**2.57**
7/11/2006	DOE M17	2.37	4.46	11.05
7/11/2006	DOE M19	2.42	4.22	10.20
RSD (%)		**1.48**	**3.91**	**5.66**
3/14/2007	DOE M23	3.65	6.02	14.45
3/14/2007	DOE M25	2.94	5.92	11.05
RSD (%)		**15.2***	**1.18**	**18.9***
3/10/2008	DOE M33	4.28	6.55	19.92
3/10/2008	DOE M35	4.77	6.57	20.75
RSD (%)		**7.66**	**0.22**	**2.89**
5/20/2008	DOE M37	2.85	5.76	--
5/20/2008	DOE M39	3.49	3.72	--
RSD (%)		**14.3***	**30.4***	

* RSD (relative standard deviation) exceeds acceptable limit of 7%.

Table I.2. Results of duplicate grass samples.

Sample	Date	Wet Weight	Average Wet Weight	Wet Weight RSD	Dry Matter	Average Dry Matter	Dry Weight RSD	Crude Protein	Average Crude Protein	Crude Protein RSD
		lbs	lbs	%	%	%	%	%	%	%
DOE-15	7/17/2005	1.55			19.32			14.2		
DOE-16	7/17/2005	0.95			26.22			14.2		
DOE-17	7/17/2005	1.70			18.31			14.2		
DOE-18	7/17/2005	1.40			19.06			14.2		
DOE-19	7/17/2005	2.20	1.56		21.8	20.9		14.2	14.2	
DOE-20	7/17/2005	1.30			19.72			15.1		
DOE-21	7/17/2005	1.40			20.56			15.1		
DOE-22	7/17/2005	1.10			21.96			15.1		
DOE-23	7/17/2005	1.55			17.76			15.1		
DOE-24	7/17/2005	1.50	1.37	**9.17**	20	20.0	**3.25**	15.1	15.1	**4.34**
DOE-25	8/25/2005	1.00			18.06			20.8		
DOE-26	8/25/2005	0.85			21.85			20.8		
DOE-27	8/25/2005	0.40			22.51			20.8		
DOE-28	8/25/2005	0.50			23.27			20.8		
DOE-29	8/25/2005	1.35	0.82		21.13	21.4		20.8	20.8	
DOE-30	8/25/2005	0.75			19.82			22.4		
DOE-31	8/25/2005	1.40			16.54			22.4		
DOE-32	8/25/2005	0.55			21.79			22.4		
DOE-33	8/25/2005	0.65			20.34			22.4		
DOE-34	8/25/2005	0.50	0.77	**4.45**	26.88	21.1	**0.97**	22.4	22.4	**5.24**
DOE-35	12/13/2005	1.25			23.43			21.9		
DOE-36	12/13/2005	1.45			11.09			21.9		
DOE-37	12/13/2005	1.40			11.39			21.9		
DOE-38	12/13/2005	1.95			17.78			21.9		
DOE-39	12/13/2005	2.35	1.68		9.66	14.7		21.9	21.9	
DOE-40	12/13/2005	1.60			12.29			21.2		
DOE-41	12/13/2005	1.85			18.60			21.2		
DOE-42	12/13/2005	1.70			20.61			21.2		
DOE-43	12/13/2005	1.60			20.52			21.2		
DOE-44	12/13/2005	1.65	1.68	**0.00**	18.68	18.1	**15.0***	21.2	21.2	**2.30**
DOE 45	4/21/2006	1.65			15.65			19.7		
DOE 46	4/21/2006	2.70			16.32			19.7		
DOE 47	4/21/2006	3.00			14.80			19.7		
DOE 48	4/21/2006	2.15			14.62			19.7		
DOE 49	4/21/2006	1.95	2.29		14.52	15.2		19.7	19.7	
DOE 50	4/21/2006	1.60			17.29			19.6		
DOE 51	4/21/2006	2.50			17.86			19.6		

Sample	Date	Wet Weight	Average Wet Weight	Wet Weight RSD	Dry Matter	Average Dry Matter	Dry Weight RSD	Crude Protein	Average Crude Protein	Crude Protein RSD
		lbs	lbs	%	%	%	%	%	%	%
DOE 52	4/21/2006	2.05			17.19			19.6		
DOE 53	4/21/2006	2.10			16.72			19.6		
DOE 54	4/21/2006	2.15	2.08	**6.80**	16.80	17.2	**8.68**	19.6	19.6	**0.36**
DOE 55	5/25/2006	0.92			14.61			25.7		
DOE 56	5/25/2006	1.47			15.97			25.7		
DOE 57	5/25/2006	1.21			15.14			25.7		
DOE 58	5/25/2006	0.92			15.64			25.7		
DOE 59	5/25/2006	1.47	1.20		12.00	14.7		25.7	25.7	
DOE 60	5/25/2006	1.61			13.72			23.8		
DOE 61	5/25/2006	1.67			14.99			23.8		
DOE 62	5/25/2006	1.30			15.80			23.8		
DOE 63	5/25/2006	1.47			14.27			23.8		
DOE 64	5/25/2006	1.03	1.42	**11.6***	16.52	15.1	**1.84**	23.8	23.8	**5.43**
DOE 65	7/5/2006	1.25			20.18			17.3		
DOE 66	7/5/2006	17.3			25.20			17.3		
DOE 67	7/5/2006	20.7			24.21			17.3		
DOE 68	7/5/2006	25.6			23.67			17.3		
DOE 69	7/5/2006	29.5	18.84		20.98	22.8		17.3	17.3	
DOE 70	7/5/2006	24.4			23.58			18.7		
DOE 71	7/5/2006	21.8			26.60			18.7		
DOE 72	7/5/2006	10.9			33.50			18.7		
DOE 73	7/5/2006	17.2			27.55			18.7		
DOE 74	7/5/2006	16.1	18.04	**3.07**	27.85	27.8	**13.9***	18.7	18.7	**5.50**
DOE 75	8/15/2006	1.17			17.48			21.6		
DOE 76	8/15/2006	0.90			20.84			21.6		
DOE 77	8/15/2006	0.70			22.20			21.6		
DOE 78	8/15/2006	0.81			21.03			21.6		
DOE 79	8/15/2006	0.66	0.85		25.13	21.3		21.6	21.6	
DOE 80	8/15/2006	1.25			19.30			22.6		
DOE 81	8/15/2006	0.97			23.09			22.6		
DOE 82	8/15/2006	1.08			20.25			22.6		
DOE 83	8/15/2006	1.21			18.54			22.6		
DOE 84	8/15/2006	0.92	1.09	**17.4***	20.05	20.2	**3.71**	22.6	22.6	**3.20**
DOE 85	9/27/2006	1.31			14.75			19.5		
DOE 86	9/27/2006	0.91			20.70			19.5		
DOE 87	9/27/2006	1.35			18.02			19.5		
DOE 88	9/27/2006	1.06			17.95			19.5		
DOE 89	9/27/2006	0.98	1.12		15.93	17.5		19.5	19.5	

Sample	Date	Wet Weight	Average Wet Weight	Wet Weight RSD	Dry Matter	Average Dry Matter	Dry Weight RSD	Crude Protein	Average Crude Protein	Crude Protein RSD
		lbs	lbs	%	%	%	%	%	%	%
DOE 90	9/27/2006	1.41			16.24			21.4		
DOE 91	9/27/2006	1.01			17.93			21.4		
DOE 92	9/27/2006	0.91			19.88			21.4		
DOE 93	9/27/2006	1.26			14.20			21.4		
DOE 94	9/27/2006	0.89	1.10	**1.63**	17.57	17.2	**1.25**	21.4	21.4	**6.57**
DOE 95	5/6/2007	2.65			14.78			18.2		
DOE 96	5/6/2007	3.30			15.92			18.2		
DOE 97	5/6/2007	4.15			13.26			18.2		
DOE 98	5/6/2007	2.90			15.03			18.2		
DOE 99	5/6/2007	2.85	3.17		14.80	14.8		18.2	18.2	
DOE 100	5/6/2007	4.55			15.24			15.9		
DOE 101	5/6/2007	3.70			17.31			15.9		
DOE 102	5/6/2007	3.10			18.12			15.9		
DOE 103	5/6/2007	2.75			17.52			15.9		
DOE 104	5/6/2007	3.30	3.48	**6.59**	14.16	16.5	**7.74**	15.9	15.9	**9.54**
DOE 105	6/14/2007	1.75			15.19			21.1		
DOE 106	6/14/2007	1.25			23.81			21.1		
DOE 107	6/14/2007	1.05			19.77			21.1		
DOE 108	6/14/2007	1.65			18.20			21.1		
DOE 109	6/14/2007	1.60	1.46		17.11	18.8		21.1	21.1	
DOE 110	6/14/2007	1.50			19.45			19.5		
DOE 111	6/14/2007	0.80			20.34			19.5		
DOE 112	6/14/2007	0.70			20.11			19.5		
DOE 113	6/14/2007	1.90			16.51			19.5		
DOE 114	6/14/2007	1.60	1.30	**8.20**	17.99	18.9	**0.25**	19.5	19.5	**5.57**
DOE 115	7/30/2007	1.20			22.80			19.4		
DOE 116	7/30/2007	1.40			19.52			19.4		
DOE 117	7/30/2007	1.05			20.14			19.4		
DOE 118	7/30/2007	1.30						19.4		
DOE 119	7/30/2007	0.95	1.18		19.76	20.6		19.4	19.4	
DOE 120	7/30/2007	1.55			17.12			19.7		
DOE 121	7/30/2007	1.60			19.44			19.7		
DOE 122	7/30/2007	0.90			22.95			19.7		
DOE 123	7/30/2007	1.15			21.32			19.7		
DOE 124	7/30/2007	1.00	1.24	**3.51**	22.22	20.6	**0.20**	19.7	19.7	**1.09**
DOE 125	8/28/2007	0.95			16.27			21.7		
DOE 126	8/28/2007	0.65			22.28			21.7		
DOE 127	8/28/2007	0.95			22.22			21.7		

Sample	Date	Wet Weight	Average Wet Weight	Wet Weight RSD	Dry Matter	Average Dry Matter	Dry Weight RSD	Crude Protein	Average Crude Protein	Crude Protein RSD
		lbs	lbs	%	%	%	%	%	%	%
DOE 128	8/28/2007	0.85			19.72			21.7		
DOE 129	8/28/2007	0.70	0.82		20.38	20.2		21.7	21.7	
DOE 130	8/28/2007	1.60			13.85			23.7		
DOE 131	8/28/2007	0.60			20.16			23.7		
DOE 132	8/28/2007	0.80			21.22			23.7		
DOE 133	8/28/2007	0.85			19.68			23.7		
DOE 134	8/28/2007	0.30	0.83	**0.86**	23.26	19.6	**1.93**	23.7	23.7	**6.23**
DOE 135	10/10/2007	1.30			13.56			25.3		
DOE 136	10/10/2007	0.90			16.56			25.3		
DOE 137	10/10/2007	1.75			16.66			25.3		
DOE 138	10/10/2007	1.40			11.47			25.3		
DOE 139	10/10/2007	1.00	1.27		12.67	14.2		25.3	25.3	
DOE 140	10/10/2007	1.20			10.59			26.2		
DOE 141	10/10/2007	1.10			15.27			26.2		
DOE 142	10/10/2007	0.70			17.07			26.2		
DOE 143	10/10/2007	1.15			13.72			26.2		
DOE 144	10/10/2007	0.60	0.95	**20.4***	13.58	14.0	**0.69**	26.2	26.2	**2.47**
DOE 145	5/9/2008	1.90			18.41			17.5		
DOE 146	5/9/2008	2.10			17.87			17.5		
DOE 147	5/9/2008	1.70			19.26			17.5		
DOE 148	5/9/2008	2.05			17.05			17.5		
DOE 149	5/9/2008	2.25	2.00		14.02	17.3		17.5	17.5	
DOE 150	5/9/2008	2.35			17.16			18.4		
DOE 151	5/9/2008	2.05			17.62			18.4		
DOE 152	5/9/2008	2.25			19.87			18.4		
DOE 153	5/9/2008	1.95			16.82			18.4		
DOE 154	5/9/2008	2.25	2.17	**5.77**	18.99	18.1	**3.07**	18.4	18.4	**3.55**
DOE 155	6/16/2008	1.60			14.91			21.3		
DOE 156	6/16/2008	1.00			20.21			21.3		
DOE 157	6/16/2008	1.15			17.83			21.3		
DOE 158	6/16/2008	1.25			16.66			21.3		
DOE 159	6/16/2008	1.15	1.23		17.15	17.4		21.3	21.3	
DOE 160	6/16/2008	1.40			16.32			22.2		
DOE 161	6/16/2008	1.75			22.96			22.2		
DOE 162	6/16/2008	0.60			19.36			22.2		
DOE 163	6/16/2008	1.10			17.94			22.2		
DOE 164	6/16/2008	1.10	1.19	**2.34**	15.14	18.3	**3.93**	22.2	22.2	**2.93**
DOE 165	7/21/2008	1.10			13.99			21.7		

Sample	Date	Wet Weight	Average Wet Weight	Wet Weight RSD	Dry Matter	Average Dry Matter	Dry Weight RSD	Crude Protein	Average Crude Protein	Crude Protein RSD
		lbs	lbs	%	%	%	%	%	%	%
DOE 166	7/21/2008	0.70			20.94			21.7		
DOE 167	7/21/2008	1.15			20.73			21.7		
DOE 168	7/21/2008	1.05			17.40			21.7		
DOE 169	7/21/2008	1.10	1.02		18.44	18.3		21.7	21.7	
DOE 170	7/21/2008	1.50			14.31			19.3		
DOE 171	7/21/2008	0.85			21.37			19.3		
DOE 172	7/21/2008	1.15			22.01			19.3		
DOE 173	7/21/2008	0.95			19.06			19.3		
DOE 174	7/21/2008	0.80	1.05	**2.05**	22.58	19.9	**5.79**	19.3	19.3	**8.28**
DOE 175	9/2/2008	1.00			10.43			24.4		
DOE 176	9/2/2008	1.60			12.55			24.4		
DOE 177	9/2/2008	1.75			10.71			24.4		
DOE 178	9/2/2008	1.25			10.92			24.4		
DOE 179	9/2/2008	1.80	1.48		13.55	11.6		24.4	24.4	
DOE 180	9/2/2008	1.55			11.76			23.5		
DOE 181	9/2/2008	1.25			10.52			23.5		
DOE 182	9/2/2008	1.15			13.67			23.5		
DOE 183	9/2/2008	0.95			10.72			23.5		
DOE 184	9/2/2008	1.60	1.30	**9.16**	9.41	11.2	**2.59**	23.5	23.5	**2.66**
DOE 185	10/21/2008	9.20			16.83			23.7		
DOE 186	10/21/2008	19.4			18.01			23.7		
DOE 187	10/21/2008	11.5			23.14			23.7		
DOE 188	10/21/2008	11.8			17.52			23.7		
DOE 189	10/21/2008	16.2	13.59		19.53	19.0		23.7	23.7	
DOE 190	10/21/2008	14.2			16.00			25.8		
DOE 191	10/21/2008	14.3			15.03			25.8		
DOE 192	10/21/2008	19.4			19.51			25.8		
DOE 193	10/21/2008	9.80			17.89			25.8		
DOE 194	10/21/2008	14.6	14.42	**4.19**	17.51	17.2	**7.11**	25.8	25.8	**6.00**

* Relative standard deviations (RSDs) that exceeded 10%.

Table I.3. Relative standard deviations (RSDs) for grass - wet weight, dry weight, and crude protein.

	RSD (%)			Number
	Wet Weight	Dry Weight	Crude Protein	
Minimum	0.0	0.20	0.36	18
Maximum	20.4	15.0	9.54	18
Mean	6.51	4.55	4.51	18

Table I.4. Results of soil split samples.

Date	Sample ID	Soil Nitrate	Gravimetric Soil Moisture
		ppm	% of dry weight
11/19/2004	DOE S17	17	--
11/19/2004	Split	16	--
	RSD (%)	**4.3**	--
5/27/2005	DOE S30	27	25.0
5/27/2005	DOE S29	32	24.7
	RSD (%)	**12***	**0.85**
8/11/2005	DOE S39	19	17.1
8/11/2005	DOE S45	17	16.6
	RSD (%)	**7.9***	**2.1**
9/7/2005	DOE S48	25	20.0
9/7/2005	DOE S56	31	19.6
	RSD (%)	**15***	**1.4**
10/4/2005	DOE S57	18	28.7
10/4/2005	DOE S59	14	28.7
	RSD (%)	**18***	**0.0**
11/1/2005	DOE S66	14	42.8
11/1/2005	DOE S68	14	42.9
	RSD (%)	**0.0**	**0.13**
11/29/2005	DOE S77	15	40.9
11/29/2005	DOE S79	13	40.9
	RSD (%)	**10***	**0.0**
3/30/2006	DOE S86	11	36.4
3/30/2006	DOE S88	15	32.5
	RSD (%)	**22***	**7.9**
7/24/2006	DOE S95	38	15.4
7/24/2006	DOE S97	35	14.6
	RSD (%)	**5.8**	**3.8**
8/22/2006	DOE S102	23	13.9
8/22/2006	DOE S104	21	14.6
	RSD (%)	**6.4**	**3.6**
7/23/2008	DOE S180	20.9	26.3
7/23/2008	DOE S182	17.5	26.0
	RSD (%)	**12***	**0.85**
8/29/2008	DOE S189	26.3	37.2
8/29/2008	DOE S191	21.8	37.2
	RSD (%)	**13***	**0.0**
9/26/2008	DOE S198	38.3	32.9
9/26/2008	DOE S200	44.3	32.7
	RSD (%)	**10***	**0.57**
10/31/2008	DOE S209	27.8	37.0
10/31/2008	DOE S211	32.2	36.6
	RSD (%)	**10***	**0.81**

* Relative standard deviation (RSD) exceeded 7%.

Table I.5. Soil nitrate duplicate results, means, and relative standard deviations.

Date	Sample ID	Soil Nitrate (mg/kg)	Average Soil Nitrate (mg/kg)	Standard Deviation of Soil Nitrate	Relative Standard Deviation %
8/25/2004	DOE S1	54	51.5	3.54	6.87
8/25/2004	DOE S2	49			
9/9/2004	DOE S3	49	43.0	8.49	19.7
9/9/2004	DOE S4	37			
9/17/2004	DOE S5	27	28.5	2.12	7.44
9/17/2004	DOE S6	30			
10/1/2004	DOE S7	14	19.0	7.07	37.2*
10/1/2004	DOE S8	24			
10/22/2004	DOE S11	24	26.5	3.54	13.3
10/22/2004	DOE S12	29			
11/12/2004	DOE S15	23	22.5	0.71	3.14
11/12/2004	DOE S16	22			
11/19/2004	DOE S17	17	18.5	2.12	11.5
11/19/2004	DOE S18	20			
12/3/2004	DOE S19	16	16.0	0.00	0.00
12/3/2004	DOE S20	16			
2/22/2005	DOE S22	16	16.5	0.71	4.29
2/22/2005	DOE S23	17			
3/25/2005	DOE S24	15	14.5	0.71	4.88
3/25/2005	DOE S25	14			
4/28/2005	DOE S26	15	16.0	1.41	8.84
4/28/2005	DOE S27	17			
5/27/2005	DOE S28	31	31.5	0.71	2.24
5/27/2005	DOE S29	32			
6/29/2005	DOE S31	13	17.0	5.66	33.3*
6/29/2005	DOE S32	21			
7/28/2005	DOE S35	5	5.5	0.71	12.86
7/28/2005	DOE S36	6			
8/5/2005	DOE S37	5	5.0	0.00	0.00
8/5/2005	DOE S38	5			
8/11/2005	DOE S39	19	19.0	0.00	0.00
8/11/2005	DOE S40	19			
8/17/2005	DOE S41	24	29.5	7.78	26.4*
8/17/2005	DOE S42	35			
8/24/2005	DOE S43	18	21.0	4.24	20.2*
8/24/2005	DOE S44	24			
8/31/2005	DOE S46	29	28.0	1.41	5.05

Date	Sample ID	Soil Nitrate (mg/kg)	Average Soil Nitrate (mg/kg)	Standard Deviation of Soil Nitrate	Relative Standard Deviation %
8/31/2005	DOE S47	27			
9/7/2005	DOE S48	25	30.0	7.07	23.6*
9/7/2005	DOE S49	35			
9/13/2005	DOE S50	22	26.5	6.36	24.0*
9/13/2005	DOE S51	31			
9/21/2005	DOE S52	19	21.0	2.83	13.5
9/21/2005	DOE S53	23			
9/27/2005	DOE S54	14	16.5	3.54	21.4*
9/27/2005	DOE S55	19			
10/4/2005	DOE S57	18	15.5	3.54	22.8*
10/4/2005	DOE S58	13			
10/11/2005	DOE S60	16	16.0	0.00	0.00
10/11/2005	DOE S61	16			
10/18/2005	DOE S62	14	11.5	3.54	30.7*
10/18/2005	DOE S63	9			
10/25/2005	DOE S64	10	22.0	16.97	77.1*
10/25/2005	DOE S65	34			
11/1/2005	DOE S66	14	11.5	3.54	30.7*
11/1/2005	DOE S67	9			
11/10/2005	DOE S71	9	5.5	4.95	90.0*
11/10/2005	DOE S72	2			
11/15/2005	DOE S73	9	10.0	1.41	14.1
11/15/2005	DOE S74	11			
11/21/2005	DOE S75	15	16.5	2.12	12.9
11/21/2005	DOE S76	18			
11/29/2005	DOE S77	15	14.5	0.71	4.88
11/29/2005	DOE S78	14			
12/16/2005	DOE S80	17	17.0	0.00	0.0
12/16/2005	DOE S81	17			
1/19/2006	DOE S82	11	10.0	1.41	14.1
1/19/2006	DOE S83	9			
2/22/2006	DOE S84	14	13.0	1.41	10.9
2/22/2006	DOE S85	12			
3/30/2006	DOE S86	11	12.5	2.12	17.0
3/30/2006	DOE S87	14			
4/27/2006	DOE S91	14	13.5	0.71	5.24
4/27/2006	DOE S92	13			
5/25/2006	DOE S89	27.6	32.8	7.28	22.2*

Date	Sample ID	Soil Nitrate (mg/kg)	Average Soil Nitrate (mg/kg)	Standard Deviation of Soil Nitrate	Relative Standard Deviation %
5/25/2006	DOE S90	37.9			
6/27/2006	DOE S93	21	22.0	1.41	6.43
6/27/2006	DOE S94	23			
7/24/2006	DOE S95	38	40.0	2.83	7.07
7/24/2006	DOE S96	42			
8/3/2006	DOE S98	31	30.5	0.71	2.32
8/3/2006	DOE S99	30			
8/11/2006	DOE S100	29	26.0	4.24	16.3
8/11/2006	DOE S101	23			
8/15/2006	C5420	20.6	19.8	1.20	6.09
8/15/2006	C5421	18.9			
8/22/2006	DOE S102	23	20.5	3.54	17.2
8/22/2006	DOE S103	18			
8/30/2006	DOE S105	24	21.0	4.24	20.2*
8/30/2006	DOE S106	18			
9/6/2006	DOE S107	21	22.5	2.12	9.43
9/6/2006	DOE S108	24			
9/13/2006	DOE S109	16	17.0	1.41	8.32
9/13/2006	DOE S110	18			
9/20/2006	C5542	14	15.5	2.12	13.7
9/20/2006	C5543	17			
9/27/2006	C5544	21	23.0	2.83	12.3
9/27/2006	C5545	25			
10/4/2006	C5546	19	17.0	2.83	16.6
10/4/2006	C5547	15			
10/12/2006	C5548	18	18.0	0.00	0.0
10/12/2006	C5549	18			
10/18/2006	C5656	22	25.0	4.24	17.0
10/18/2006	C5657	28			
10/26/2006	C5658	29	29.0	0.00	0.0
10/26/2006	C5659	29			
11/1/2006	C5660	27	30.5	4.95	16.2
11/1/2006	C5661	34			
11/8/2006	C5590	60	60.0	0.00	0.0
11/8/2006	C5591	60			
11/15/2006	C5662	18	15.5	3.54	22.8*
11/15/2006	C5663	13			
11/21/2006	C5602	14	13.5	0.71	5.24

Date	Sample ID	Soil Nitrate (mg/kg)	Average Soil Nitrate (mg/kg)	Standard Deviation of Soil Nitrate	Relative Standard Deviation %
11/21/2006	C5603	13			
12/20/2006	C5604	13	14.0	1.41	10.1
12/20/2006	C5605	15			
1/26/2007	DOE S111	12.7	11.9	1.13	9.51
1/26/2007	DOE S112	11.1			
2/23/2007	DOE S113	10.2	10.0	0.35	3.55
	DOE S114	9.7			
3/23/2007	DOE S115	6.1	6.1	0.07	1.17
	DOE S116	6.0			
4/25/2007	DOE S117	9.2			
	DOE S118	13.1	12.4	2.96	23.8*
	DOE S119	15.0			
5/16/2007	DOE S120	16.7	18.4	2.33	12.7
	DOE S121	20.0			
6/26/2007	DOE S122	24.4	23.5	1.34	5.73
	DOE S123	22.5			
7/24/2007	DOE S124	21.7	22.6	1.27	5.63
	DOE S125	23.5			
8/7/2007	DOE S126	18.6			
	DOE S127	16.3	17.0	1.36	7.97
	DOE S128	16.2			
8/15/2007	DOE S129	23.3	20.7	3.68	17.8
	DOE S130	18.1			
8/21/2007	DOE S131	20.0	19.9	0.14	0.71
	DOE S132	19.8			
8/28/2007	DOE S133	17.4	18.3	1.27	6.96
	DOE S134	19.2			
9/5/2007	DOE S135	14.3			
	DOE S136	17.2	15.4	1.57	10.2
	DOE S137	14.7			
9/11/2007	DOE S138	27.0	25.3	2.47	9.80
	DOE S139	23.5			
9/18/2007	DOE S140	16.6	15.4	1.77	11.5
	DOE S141	14.1			
9/25/2007	DOE S142	17.2	14.7	3.61	24.6*
	DOE S143	12.1			
10/2/2007	DOE S144	10.9			
	DOE S145	17.9	13.0	4.26	32.8*
	DOE S146	10.2			

Date	Sample ID	Soil Nitrate (mg/kg)	Average Soil Nitrate (mg/kg)	Standard Deviation of Soil Nitrate	Relative Standard Deviation %
10/9/2007	DOE S147	16.7	16.9	0.28	1.67
	DOE S148	17.1			
10/16/2007	DOE S149	18.0	18.8	1.06	5.66
	DOE S150	19.5			
10/23/2007	DOE S151	14.1	14.7	0.78	5.31
	DOE S152	15.2			
10/30/2007	DOE S153	10.8			
	DOE S154	12.8	11.6	1.06	9.12
	DOE S155	11.2			
11/6/2007	DOE S156	11.3	11.5	0.28	2.46
	DOE S157	11.7			
11/13/2007	DOE S158	10.6	10.2	0.57	5.55
	DOE S159	9.8			
11/20/2007	DOE S160	12.6	11.0	2.33	21.3*
	DOE S161	9.3			
11/27/2007	DOE S162	12.4			
	DOE S163	11.4	12.0	0.53	4.41
	DOE S164	12.2			
12/21/2007	DOE S165	19	18.0	1.41	7.86
	DOE S166	17			
1/22/2008	DOE S167	22	20.5	2.12	10.3
	DOE S168	19			
2/22/2008	DOE S169	10.1	10.6	0.71	6.67
	DOE S170	11.1			
3/18/2008	DOE S171	15.5			
	DOE S172	12.7	14.1	1.40	9.93
	DOE S173	14.1			
4/22/2008	DOE S174	16.7	17.4	0.99	5.69
	DOE S175	18.1			
5/27/2008	DOE S176	28.8	29.3	0.64	2.18
	DOE S177	29.7			
6/25/2008	DOE S178	33.5	34.3	1.13	3.30
	DOE S179	35.1			
7/23/2008	DOE S180	19.1			
	DOE S181	15.3	14.1	1.40	9.93
	DOE S182	14.7			
8/6/2008	DOE S183	35.4	29.7	8.06	27.1*
	DOE S184	24.0			
8/15/2008	DOE S185	25.8	25.4	0.57	2.23

Date	Sample ID	Soil Nitrate (mg/kg)	Average Soil Nitrate (mg/kg)	Standard Deviation of Soil Nitrate	Relative Standard Deviation %
	DOE S186	25.0			
8/22/2008	DOE S187	19.2	22.3	4.38	19.7
	DOE S188	25.4			
8/29/2008	DOE S189	26.3			
	DOE S190	15.8	21.3	5.27	24.7*
	DOE S191	21.8			
9/5/2008	DOE S192	22.1	20.9	1.70	8.12
	DOE S193	19.7			
9/12/2008	DOE S194	27.0	29.5	3.54	12.0
	DOE S195	32.0			
9/19/2008	DOE S196	33.9	35.9	2.83	7.88
	DOE S197	37.9			
9/26/2008	DOE S198	38.3			
	DOE S199	44.1	42.2	3.41	8.07
	DOE S200	44.3			
10/3/2008	DOE S201	24.8	26.5	2.40	9.07
	DOE S202	28.2			
10/10/2008	DOE S203	17.6	21.6	5.66	26.2*
	DOE S204	25.6			
10/17/2008	DOE S205	21.2	26.9	7.99	29.8*
	DOE S206	32.5			
10/24/2008	DOE S207	26.2	30.8	6.43	20.9*
	DOE S208	35.3			
10/31/2008	DOE S209	27.8			
	DOE S210	32.0	30.7	2.48	8.10
	DOE S211	32.2			
11/7/2008	DOE S212	9.2	9.6	0.49	5.18
	DOE S213	9.9			
11/14/2008	DOE S214	10.6	10.9	0.42	3.89
	DOE S215	11.2			
11/21/2008	DOE S216	13.3	11.7	2.26	19.3
	DOE S217	10.1			
11/28/2008	DOE S218	12.8			
	DOE S219	15.2	13.3	1.67	12.5
	DOE S220	12.0			

* Relative standard deviation exceeds acceptable limit of 20%.

Table I.6. Relative standard deviation (RSD) of replicate groundwater quality results in mg/L except conductivity (umhos/cm), temperature (^{0}C), and pH (standard units).

Well ID	Date	Temp-erature	pH	Dissolved Oxygen	Field Conductivity	Ammonia-N	Nitrite+ Nitrate-N	Total Persulfate N	Ortho Phosphorus	Total Phosphorus	Chloride	TDS	Dissolved Organic Carbon
September 20-21,2004													
AKG-724	9/21/2004	13.7	4.69	8.60	408	<0.010	19.7	19.2	0.0058	0.0060	18.6	270	1.7
AKG-724	9/21/2004	13.5	4.79	6.90	406	<0.010	20.3	19.6	0.0061	0.0044	19.0	268	1.7
RSD		**1.0**	**1.5**	**15.5**	**0.3**	--	**2.1**	**1.5**	**3.6**	**21.8***	**1.5**	**0.5**	**0.0**
October 18-19, 2004													
AKG-725	10/19/2004	12.1	NA	5.60	444	0.017	26.8	33.2	0.0072	0.0028	19.9	315	1.8
AKG-725	10/19/2004	12.1	NA	6.00	448	0.018	24.3	30.9	0.0075	0.0034	20.0	316	1.9
RSD		**0.0**		**4.9**	**0.6**	**4.0**	**6.9**	**5.1**	**2.9**	**13.7***	**0.4**	**0.2**	**3.8**
November 22-23, 2004													
AKG-725	11/23/2004	11.8	5.72	8.09	486	<0.010	30.8	32.4	0.0054	0.0037	22.6	323	1.8
AKG-725	11/23/2004	11.7	5.71	7.97	474	<0.010	29.4	33.5	0.0056	0.0040	21.6	353	1.4
RSD		**0.6**	**0.1**	**1.1**	**1.8**	--	**3.3**	**2.4**	**2.6**	**5.5**	**3.2**	**6.3**	**17.7**
December 28-29, 2004													
AKG-722	12/28/2004	9.6	5.51	8.30	599	<0.010	45.3	43.7	0.0043	0.0032	30.6	381	4.9
AKG-722	12/28/2004	9.7	5.50	7.40	580	<0.010	43.4	42.1	0.0044	0.0034	29.0	383	4.5
RSD		**0.7**	**0.1**	**8.1**	**2.3**	--	**3.0**	**2.6**	**1.6**	**4.3**	**3.8**	**0.4**	**6.0**
February 1, 2005													
AKG-725	2/1/2005	8.0	5.68	9.60	435	<0.010	34.0	29.9	0.0090	0.0090	16.4	315	1.6
AKG-725	2/1/2005	8.0	5.65	9.70	442	<0.010	31.3	27.3	0.0086	0.0080	16.8	303	1.6
RSD		**0.0**	**0.4**	**0.7**	**1.1**	--	**5.8**	**6.4**	**3.2**	**8.3***	**1.7**	**2.7**	**0.0**
March 2-3, 2005													
AKG-723	3/2/2005	8.6	5.09	3.41	556	<0.010	39.5	39.1	0.0051	0.0037	22.2	358	2.3
AKG-723	3/2/2005	8.7	5.06	3.75	566	<0.010	40.6	39.1	0.0051	0.0036	22.5	394	2.4
RSD		**0.8**	**0.4**	**6.7**	**1.3**	--	**1.9**	**0.0**	**0.0**	**1.9**	**0.9**	**6.8**	**3.0**
March 30-31, 2005													
AKG-727	3/30/2005	9.1	5.16	3.64	364	<0.010	19.2	22.7	0.0049	0.0043	14.9	254	2.2
AKG-727	3/30/2005	9.9	5.48	3.73	362	<0.010	18.4	23.8	0.0048	0.0036	14.7	264	2.1
RSD		**6.0**	**4.3**	**1.7**	**0.4**	--	**3.0**	**3.3**	**1.5**	**12.5***	**1.0**	**2.7**	**3.3**
April 25-26, 2005													
AKG-722	4/25/2005	9.8	5.68	6.87	236	<0.010	11.2	11.0	NA	0.0048	7.14	166	6.8
AKG-722	4/25/2005	9.8	5.66	6.70	237	<0.010	10.8	11.2	NA	0.0039	7.15	170	6.7
RSD		**0.0**	**0.2**	**1.8**	**0.3**	--	**2.6**	**1.3**	--	**14.6***	**0.1**	**1.7**	**1.0**

Well ID	Date	Temp-erature	pH	Dissolved Oxygen	Field Conductivity	Ammonia-N	Nitrite+ Nitrate-N	Total Persulfate N	Ortho Phosphorus	Total Phosphorus	Chloride	TDS	Dissolved Organic Carbon	
May 25-26, 2005														
AKG-725	5/26/2005	10.6	5.79	6.73	475	<0.010	29.3	34.7	NA	0.0473	24.6	362	1.7	
AKG-725	5/26/2005	10.7	5.73	6.75	478	<0.010	29.4	32.6	NA	0.0072	24.5	330	1.8	J
RSD		**0.7**	**0.7**	**0.2**	**0.4**	**--**	**0.2**	**4.4**	**--**	**104.1***	**0.3**	**6.5**	**4.0**	J
July 6-7, 2005														
AKG-722	7/6/2005	12.0	5.43	2.64	278	<0.010	11.9	10.9	NA	0.0038	11.0	200	4.9	
AKG-722	7/6/2005	11.6	5.49	2.39	280	<0.010	11.8	10.8	NA	0.0038	11.3	186	4.8	
RSD		**2.4**	**0.8**	**7.0**	**0.5**	**--**	**0.6**	**0.7**	**--**	**--**	**1.9**	**5.1**	**1.5**	
August 16-17, 2005														
AKG-723	8/16/2005	12.2	5.22	2.83	441	<0.010	28.5	29.6	NA	0.0032	20.0	336	1.3	
AKG-723	8/16/2005	12.6	5.23	2.68	444	<0.010	32.2	29.0	NA	0.0033	20.1	322	1.5	
RSD		**2.3**	**0.1**	**3.8**	**0.5**	**--**	**8.6**	**1.4**	**--**	**2.2**	**0.4**	**3.0**	**10.1**	
September 21-22, 2005														
AKG-727	9/21/2005	13.7	5.19	2.53	383	<0.010	13.2	14.5	NA	0.0037	17.6	254	2.2	
AKG-727	9/21/2005	13.2	5.20	2.60	385	<0.010	13.0	14.5	NA	0.0048	17.6	241	2.3	
RSD		**2.6**	**0.1**	**1.9**	**0.4**	**--**	**1.1**	**0.0**	**--**	**18.3***	**0.0**	**3.7**	**3.1**	
October 19-20, 2005														
AKG-724	10/19/2005	12.6	4.94	6.26	337	<0.010	13.2	12.7	NA	0.0021	19.1	258	2.0	
AKG-724	10/19/2005	12.5	4.90	5.96	325	<0.010	12.9	12.8	NA	0.0190	19.2	256	1.9	
RSD		**0.6**	**0.6**	**3.5**	**2.6**	**--**	**1.6**	**0.6**	**--**	**113.3***	**0.4**	**0.6**	**3.6**	
November 16-17, 2005														
AKG-722	11/16/2005	11.4	5.56	0.85	352	<0.010	9.2	9.09	NA	0.0037	15.5	227	2.9	
AKG-722	11/16/2005	11.0	5.52	0.66	347	<0.010	9.77	8.34	NA	0.0033	15.4	226	2.9	
RSD		**2.5**	**0.5**	**17.8**	**1.0**	**--**	**4.2**	**6.1**	**--**	**8.1***	**0.5**	**0.3**	**0.0**	
December 14-15, 2005														
AKG-724	12/14/2005	10.6	4.67	1.90	426	<0.010	19.0	19.5	NA	0.0023	17.8	287	1.8	
AKG-724	12/14/2005	10.0	4.71	1.32	423	<0.010	19.1	18.9	NA	0.0022	17.7	282	1.7	
RSD		**4.1**	**0.6**	**25.5**	**0.5**	**--**	**0.4**	**2.2**	**--**	**3.1**	**0.4**	**1.2**	**4.0**	
January 10-11, 2006														
AKG-723	1/10/2006	8.7	5.53	3.74	374	<0.010	22.0	18.9	NA	0.0077	13.0	260	4.3	
AKG-723	1/11/2006	8.5	5.50	4.45	338	<0.010	18.5	18.2	NA	0.0071	12.9	267	4.2	
RSD		**1.6**	**0.4**	**12.3**	**7.2**	**--**	**12.2***	**2.7**	**--**	**5.7**	**0.5**	**1.9**	**1.7**	

Well ID	Date	Temp-erature	pH	Dissolved Oxygen	Field Conductivity	Ammonia-N	Nitrite+ Nitrate-N	Total Persulfate N	Ortho Phosphorus	Total Phosphorus	Chloride	TDS	Dissolved Organic Carbon
February 7-8, 2006													
AKG-725	2/8/2006	8.0	5.81	8.40	260	<0.010	9.93	10.0	NA	0.010	8.13	141	2.2
AKG-725	2/8/2006	8.1	5.80	7.43	261	<0.010	10.4	10.8	NA	0.011	8.12	177	2.2
RSD		**0.9**	**0.1**	**8.7**	**0.3**	**--**	**3.3**	**5.4**	**--**	**6.7**	**0.1**	**16.0***	**0.0**
March 7-8, 2006													
AKG-725	3/8/2006	8.2	5.81	6.35	263	<0.010	10.4	12.6	NA	0.012	8.36	196	1.9
AKG-725	3/8/2006	8.4	5.70	6.47	286	<0.010	13.2	13.2	NA	0.012	9.28	204	1.6
RSD		**1.7**	**1.4**	**1.3**	**5.9**	**--**	**16.8***	**3.3**	**--**	**0.0**	**7.4**	**2.8**	**12.1**
April 4-5, 2006													
AKG-722	4/4/2006	10.1	5.58	8.34	226	<0.010	9.94	11.0	NA	<0.0050	10.9	157	7.1
AKG-722	4/4/2006	9.8	5.54	8.40	248	<0.010	11.4	11.5	NA	<0.0050	10.9	177	5.9
RSD		**2.1**	**0.5**	**0.5**	**6.6**	**--**	**9.7***	**3.1**	**--**	**--**	**0.0**	**8.5**	**13.1**
May 17-18, 2006													
AKG-724	5/17/2006	10.5	4.77	1.12	279	<0.010	8.52	9.9	NA	<0.0050	11.8	197	1.5
AKG-724	5/17/2006	10.4	4.80	1.01	273	<0.010	7.32	9.2	NA	<0.0050	12.0	196	1.5
RSD		**0.7**	**0.4**	**7.3**	**1.5**	**--**	**10.7***	**5.3**	**--**	**--**	**1.2**	**0.4**	**0.0**
June 26-27, 2006													
AKG-724	6/26/2006	12.0	4.82	4.20	277	<0.010	9.04	10.8	NA	<0.0050	13.7	192	1.7
AKG-724	6/26/2006	12.4	4.87	4.81	276	<0.010	8.77	8.76	NA	<0.0050	13.9	185	1.7
RSD		**2.3**	**0.7**	**9.6**	**0.3**	**--**	**2.1**	**14.7***	**--**	**--**	**1.0**	**2.6**	**0.0**
August 2-3, 2006													
AKG-722	8/2/2006	12.9	5.48	5.24	275	<0.010	7.44	8.90	NA	0.0033	12.4	197	3.4
AKG-722	8/2/2006	12.4	5.51	6.42	273	<0.010	8.46	9.06	NA	0.0033	12.6	193	3.1
RSD		**2.8**	**0.4**	**14.3**	**0.5**	**--**	**9.1***	**1.3**	**--**	**0.0**	**1.1**	**1.5**	**6.5**
September 13-14, 2006													
AKG-722	9/13/2006	12.1	5.50	1.34	271	<0.010	5.80	5.94	NA	0.0040	12.3	190	3.0
AKG-722	9/13/2006	12.1	5.48	1.64	266	<0.010	6.60	6.51	NA	0.0038	12.4	188	3.5
RSD		**0.0**	**0.3**	**14.2**	**1.3**	**--**	**9.1***	**6.5**	**--**	**3.6**	**0.6**	**0.7**	**10.9***
October 18-19, 2006													
AKG-725	10/18/2006	11.7	5.81	6.07	292	<0.010	10.0	8.20	NA	0.0106	9.20	204	3.9
AKG-725	10/18/2006	11.6	5.81	5.85	292	<0.010	9.54	8.18	NA	0.0108	9.26	204	3.8
RSD		**0.6**	**0.0**	**2.6**	**0.0**	**--**	**3.3**	**0.2**	**--**	**1.3**	**0.5**	**0.0**	**1.8**

Well ID	Date	Temp-erature	pH	Dissolved Oxygen	Field Conductivity	Ammonia-N	Nitrite+ Nitrate-N	Total Persulfate N	Ortho Phosphorus	Total Phosphorus	Chloride	TDS	Dissolved Organic Carbon
November 14-15, 2006													
AKG-722	11/14/2006	10.9	5.65	0.25	312	<0.010	1.82	1.54	NA	0.0050	13.1	201	3.6
AKG-722	11/14/2006	11.0	5.64	0.24	314	<0.010	2.31	2.23	NA	0.0044	13.2	200	4.7
RSD		**0.6**	**0.1**	**2.9**	**0.5**	**--**	**16.8***	**25.9**	**--**	**9.0***	**0.5**	**0.4**	**18.7***
December 12-13, 2006													
AKG-724	12/12/2006	10.4	4.85	4.92	299	<0.010	9.66	8.81	NA	0.0030	17.2	199	1.7
AKG-724	12/12/2006	10.0	4.84	4.15	301	<0.010	9.70	9.60	NA	0.0024	11.1	202	2.3
RSD		**2.8**	**0.1**	**12.0**	**0.5**	**--**	**0.3**	**6.1**	**--**	**15.7***	**30.5***	**1.1**	**21.2***
January 17-18, 2007													
AKG-724	1/17/2007	8.3	4.99	5.56	308	<0.010	13.9	14.3	NA	NA	16.2	215	2.5
AKG-724	1/17/2007	8.5	4.94	4.99	312	<0.010	14.3	15.0	NA	NA	16.2	214	2.2
RSD		**1.7**	**0.7**	**7.6**	**0.9**	**--**	**2.0**	**3.4**	**--**	**--**	**0.0**	**0.3**	**9.0**
February 12-13, 2007													
AKG-723	2/12/2007	8.0	5.38	1.74	355	<0.010	19.6	20.4	NA	NA	11.1	203	3.2
AKG-723	2/12/2007	8.1	5.37	3.51	358	<0.010	19.9	19.7	NA	NA	14.9	251	2.8
RSD		**0.9**	**0.1**	**47.7**	**0.6**	**--**	**1.1**	**2.5**	**--**	**--**	**20.7***	**15.0***	**9.4**
March 28-29, 2007													
AKG-727	3/28/2007	8.9	5.58	2.58	241	<0.010	6.12	6.69	NA	NA	6.80	166	2.4
AKG-727	3/28/2007	8.8	5.55	3.95	243	<0.010	5.68	6.65	NA	NA	6.88	166	2.3
RSD		**0.8**	**0.4**	**29.7**	**0.6**	**--**	**5.3**	**0.4**	**--**	**--**	**0.8**	**0.0**	**3.0**
May 14-15, 2007													
AKG-724	5/14/2007	10.1	5.01	0.87	270	<0.010	11.9	11.9	NA	NA	10.6	179	1.7
AKG-724	5/14/2007	10.0	5.03	0.96	264	<0.010	11.1	9.71	NA	NA	10.8	174	1.7
RSD		**0.7**	**0.3**	**7.0**	**1.6**	**--**	**4.9**	**14.3***	**--**	**--**	**1.3**	**2.0**	**0.0**
June 13-14, 2007													
AKG-727	6/13/2007	10.4	5.46	3.25	278	<0.010	7.63	7.89	NA	NA	7.91	193	2.3
AKG-727	6/13/2007	10.3	5.42	3.14	276	<0.010	7.65	7.84	NA	NA	7.99	190	2.3
RSD		**0.7**	**0.5**	**2.4**	**0.5**	**--**	**0.2**	**0.4**	**--**	**--**	**0.7**	**1.1**	**0.0**
July 30-31, 2007													
AKG-725	7/30/2007	11.3	5.97	7.82	281	<0.010	10.7	11.4	NA	NA	9.88	201	2.0
AKG-725	7/30/2007	11.4	6.00	6.98	287	<0.010	10.9	11.2	NA	NA	9.94	201	1.5
RSD		**0.6**	**0.4**	**8.0**	**1.5**	**--**	**1.3**	**1.3**	**--**	**--**	**0.4**	**0.0**	**20.2***

Well ID	Date	Temp-erature	pH	Dissolved Oxygen	Field Conductivity	Ammonia-N	Nitrite+ Nitrate-N	Total Persulfate N	Ortho Phosphorus	Total Phosphorus	Chloride	TDS	Dissolved Organic Carbon
September 2-3, 2007													
AKG-723	9/2/2007	11.8	5.35	1.87	298	<0.010	15.6	12.6	NA	NA	9.41	209	1.9
AKG-723	9/2/2007	11.7	5.37	1.82	298	<0.010	12.7	12.6	NA	NA	9.47	214	2.0
RSD		**0.6**	**0.3**	**1.9**	**0.0**	**--**	**14.5***	**0.0**	**--**	**--**	**0.4**	**1.7**	**3.6**
October 1-2, 2007													
AKG-723	10/1/2007	11.8	5.33	1.20	299	<0.010	12.7	12.2	NA	NA	8.93	216	1.8
AKG-723	10/1/2007	11.8	5.35	1.05	299	<0.010	12.2	12.2	NA	NA	8.75	207	1.8
RSD		**0.0**	**0.3**	**9.4**	**0.0**	**--**	**2.8**	**0.0**	**--**	**--**	**1.4**	**3.0**	**0.0**
October 30-31, 2007													
AKG-725	10/30/2007	11.4	5.81	4.64	298	<0.010	9.54	9.76	NA	NA	9.08	206	1.7
AKG-725	10/30/2007	11.3	5.84	4.82	297	<0.010	9.66	10.5	NA	NA	9.04	200	1.5
RSD		**0.6**	**0.4**	**2.7**	**0.2**	**--**	**0.9**	**5.2**	**--**	**--**	**0.3**	**2.1**	**8.8**
November 27-28, 2007													
AKG-725	11/28/2007	9.8	5.97	7.99	285	<0.010	10.4	10.0	NA	NA	7.93	191	1.7
AKG-725	11/28/2007	9.8	5.93	7.91	276	<0.010	11.5	10.2	NA	NA	7.96	192	1.6
RSD		**0.0**	**0.5**	**0.7**	**2.3**	**--**	**7.1**	**1.4**	**--**	**--**	**0.3**	**0.4**	**4.3**
January 3-4, 2008													
AKG-724	1/3/2008	8.8	4.95	3.87	231	<0.010	6.68	6.69	NA	NA	7.87	153	1.9
AKG-724	1/3/2008	8.8	4.99	3.75	230	<0.010	6.16	6.17	NA	NA	7.81	156	2.0
RSD		**0.0**	**0.6**	**2.2**	**0.3**	**--**	**5.7**	**5.7**	**--**	**--**	**0.5**	**1.4**	**3.6**
January 30-31, 2008													
AKG-721	1/30/2008	8.0	5.86	10.00	229	<0.010	8.01	9.08	NA	NA	5.79	153	1.7
AKG-721	1/30/2008	8.1	5.86	9.30	226	<0.010	8.03	9.34	NA	NA	7.59	149	1.6
RSD		**0.9**	**0.0**	**5.1**	**0.9**	**--**	**0.2**	**2.0**	**--**	**--**	**19.0***	**1.9**	**4.3**
Feb 27-28, 2008													
AKG-725	2/28/2008	7.6	5.86	9.36	249	<0.010	12.1	12.5	NA	NA	6.04	179	1.7
AKG-725	2/28/2008	7.7	5.84	9.52	249	<0.010	12.2	12.2	NA	NA	6.07	178	1.7
RSD		**0.9**	**0.2**	**1.2**	**0.0**	**--**	**0.6**	**1.7**	**--**	**--**	**0.4**	**0.4**	**0.0**
April 1-2, 2008													
AKG-722	4/1/2008	8.4	5.82	7.85	250	<0.010	9.98	10.7	NA	NA	4.56	169	9.4
AKG-722	4/1/2008	8.1	5.76	6.68	242	<0.010	8.78	9.78	NA	NA	4.72	164	8.4
RSD		**2.6**	**0.7**	**11.4**	**2.3**	**--**	**9.0**	**6.4**	**--**	**--**	**2.4**	**2.1**	**7.9**

Well ID	Date	Temp-erature	pH	Dissolved Oxygen	Field Conductivity	Ammonia-N	Nitrite+ Nitrate-N	Total Persulfate N	Ortho Phosphorus	Total Phosphorus	Chloride	TDS	Dissolved Organic Carbon
May 6-7, 2008													
AKG-725	5/7/2008	9.3	5.89	9.49	229	<0.010	7.53	6.92	NA	NA	4.85	178	1.6
AKG-725	5/7/2008	8.6	5.87	8.87	236	<0.010	7.56	7.53	NA	NA	5.60	180	1.6
RSD		**5.5**	**0.2**	**4.8**	**2.1**	**--**	**0.3**	**6.0**	**--**	**--**	**10.1**	**0.8**	**0.0**
June 18-19, 2008													
AKG-722	6/18/2008	10.4	5.69	5.03	223	<0.010	8.10	8.92	NA	NA	4.40	163	7.6
AKG-722	6/18/2008	10.5	5.62	5.05	222	<0.010	8.19	8.35	NA	NA	4.42	164	6.7
RSD		**0.7**	**0.9**	**0.3**	**0.3**	**--**	**0.8**	**4.7**	**--**	**--**	**0.3**	**0.4**	**8.9**
July 22-23, 2008													
AKG-723	7/22/2008	11.7	5.35	2.03	279	<0.010	8.53	8.32	NA	NA	6.73	185	2.1
AKG-723	7/22/2008	11.4	5.65	1.97	281	<0.010	8.13	8.37	NA	NA	6.67	193	2.0
RSD		**1.8**	**3.9**	**2.1**	**0.5**	**--**	**3.4**	**0.4**	**--**	**--**	**0.6**	**3.0**	**3.4**
Sept. 8-9, 2008													
AKG-725	9/9/2008	11.5	5.84	5.40	243	<0.010	7.63	7.82	NA	NA	4.18	155	1.7
AKG-725	9/9/2008	11.6	5.82	5.60	242	<0.010	7.19	7.40	NA	NA	4.19	165	1.6
RSD		**0.6**	**0.2**	**2.6**	**0.3**	**--**	**4.2**	**3.9**	**--**	**--**	**0.2**	**4.4**	**4.3**
October 7-8, 2008													
AKG-723	10/7/2008	11.9	5.34	2.89	266	<0.010	8.00	8.22	NA	NA	7.16	198	2.0
AKG-723	10/7/2008	11.8	5.30	1.55	267	<0.010	7.55	8.39	NA	NA	7.21	188	1.9
RSD		**0.6**	**0.5**	**42.7**	**0.3**	**--**	**4.1**	**1.4**	**--**	**--**	**0.5**	**3.7**	**3.6**
November 12-13, 2008													
AKG-722	11/12/2008	11.3	5.66	0.45	221	<0.010	1.90	2.21	NA	NA	4.98	147	4.1
AKG-722	11/12/2008	11.2	5.62	0.65	220	<0.010	1.73	1.90	NA	NA	4.76	141	4.0
RSD		**0.6**	**0.5**	**25.7**	**0.3**	**--**	**6.6**	**10.7**	**--**	**--**	**3.2**	**2.9**	**1.7**
December 9-10, 2008													
AKG-723	12/9/2008	10.0	5.44	1.88	274	<0.010	9.42	9.85	NA	NA	6.30	186	4.0
AKG-723	12/9/2008	10.4	5.41	2.10	274	<0.010	9.52	9.79	NA	NA	5.85	198	3.6
RSD		**2.8**	**0.4**	**7.8**	**0.0**	**--**	**0.7**	**0.4**	**--**	**--**	**5.2**	**4.4**	**7.4**

TDS: Total dissolved solids
RSD: Relative standard deviation (%)
* RSD exceeded target (7% for nitrogen and phosphorus compounds and 10% for chloride, TDS, and dissolved organic carbon).

Table I.7. Summary of relative standard deviation (RSD) results for groundwater constituents. *Units are in mg/L unless stated otherwise.*

	Temper-ature (C°)	pH (standard units)	Dissolved Oxygen	Conductivity (field, umhos/cm)	Ammonium-N	Nitrate+ nitrite-N	Total Persulfate N	Ortho Phosphorus	Total Dissolved Phosphorus	Chloride	TDS	Dissolved Organic Carbon
Mean RSD (%)	1.4	0.6	8.7	1.1	4.0	4.6	3.9	2.2	17	2.7	2.7	5.3
Number of samples (n)	47	46	47	47	1	47	47	7	22	47	47	47
Minimum RSD (%)	0	0	0.21	0	4.0	0.18	0	0	0	0	0	0
Maximum RSD (%)	6.0	4.3	48	7.2	4.0	17	26	3.6	113	30	16	21

Table I.8. Field blank results using blank water provided by Manchester Environmental Laboratory (MEL). *Units are in mg/L.*

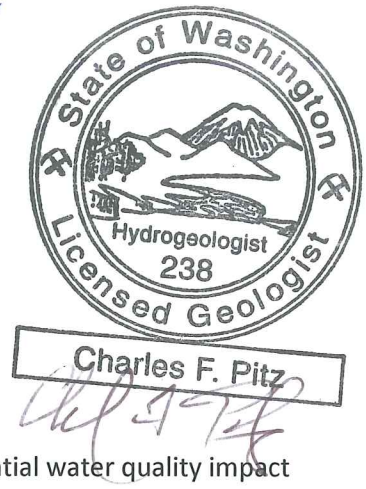
Date	Ammonia-N	Nitrate+ Nitrite-N	Total Persulfate N	Chloride	Total Dissolved Solids	Dissolved Organic Carbon
5/6/2008	<0.010	0.135	0.138	0.13	<10	<1.0
6/19/2008	<0.010	0.024	0.035			
7/23/2008	<0.010	<0.010	<0.025			
9/9/2008	<0.010	<0.010	<0.025			
10/8/2008	<0.010	<0.010	<0.025			<1.0
11/13/2008	<0.010	<0.010	<0.025			

Appendix I.9. Memorandum

Following is an 11-page memorandum, *Nitrogen Injection Modeling Analysis*, from Charles Pitz to Barbara Carey, December 12, 2013, Washington State Department of Ecology.

Washington Department of Ecology

Memorandum



Date: December 12, 2013

To: Barb Carey, L.Hg., EAP-GFFU

From: Charles F. Pitz, L.Hg., EAP-GFFU CFP

Subj: Nitrogen Injection Modeling analysis

This memo summarizes a modeling analysis I conducted to examine the potential water quality impact of the entry of nitrogen-rich manure slurry into a monitoring well used during an EAP groundwater study in Whatcom County.

Problem Statement

Beginning in 2004, Ecology's EA Program (in cooperation with Washington State University) conducted a study of groundwater quality conditions beneath a grass field periodically receiving applications of nitrogen-rich dairy manure slurry. The goal of this study is to develop a mass balance analysis of the fate of nitrogen at the study field, and determine if standard dairy-nutrient management practices are protective of local groundwater conditions.

During the summer of 2004, seven flush-mount groundwater monitoring wells were installed by Ecology in the study field. These wells were regularly sampled by Ecology over the course of the next 6 years for a standard suite of water quality parameters (e.g. nitrate, TDS, chloride).

In early 2005, after surveying the elevations of the top of the monitoring well casings, the sealing well-cap and flush-mount monument cover for one of the study monitoring wells (AKG727) were inadvertently left off of the well (on February 7th). Between February 7th and March 3rd, 2005 (when the error was discovered) the study field received a manure application by the managing farmer. After the well was discovered open in early March, it was purged, and resealed, and remained closed for the duration of the study period (except for subsequent sampling).

There is a concern that entry of manure slurry into the AKG727 well during the period that the well was left open could bias the water quality results collected thereafter from that well, and from additional wells downgradient. A modeling analysis of this problem was requested to gauge the likely impact of this event on the study results.

Analysis Approach

I used a two-dimensional analytical mass transport model to estimate the potential impact of the entry of manure slurry into the AKG727 well on the study field groundwater quality condition. The model selected for the analysis is included in the PRINCE analytical flow and transport model suite (WHS, 1994; Model 3). The model [built on a modification of work by Wilson and Miller (1978)], uses a variation of **Equation 1** to describe the time/concentration distribution of a solute plume resulting from the injection of contaminant mass into one or more injection wells within the model domain. **Equation 1** assumes that mass transport occurs in a homogeneous, anisotropic aquifer with constant dispersion coefficients and groundwater velocity:

$$\frac{\partial C}{\partial t} + V\frac{\partial C}{\partial X} = D_{xx}\frac{\partial^2 C}{\partial X^2} + D_{yy}\frac{\partial^2 C}{\partial X^2} - K_W C - \frac{K_S \rho_b S}{n} - \frac{\rho_b}{n}\frac{\partial S}{\partial t} + \sum_{i=1}^{N}\frac{Q_i C_i^*}{nb}\delta(X - X_i)\delta(Y - Y_i) + \frac{q}{nb}(C^{**} - C) \quad \textbf{(Eq.1)}$$

where:

C = concentration of the dissolved solute [M/L^3]
t = time [T]
V = groundwater seepage velocity [L/T]
D_{xx}, D_{yy} = dispersion coefficients in the X and Y model directions [L^2/T]
K_w, K_s = rate constants for first order decay for liquid and solid phases [1/T]
ρ_b = dry bulk density of the porous medium [M/L^3](term ignored if no sorption assumed)
n = effective porosity of the porous medium [dimensionless]
q = recharge flux rate [L^3/L^{2}T] (term was ignored for the modeling effort – assumed no vertical recharge contribution of nitrogen to the aquifer)
S = concentration of the solute absorbed on the solid phase [M/M](term is ignored if no sorption is assumed)
Q_i = injection rate of well i [L^3/T]
C_i* = concentration of the solute in the injected source fluid [M/L^3]
C** = concentration of the solute in the vertical recharge flux [M/L^3](term was ignored for the modeling effort – assumed no vertical recharge contribution of nitrogen to the aquifer)
N = number of injection wells
$\delta(X\text{-}X_i)$, $\delta(Y\text{-}Y_i)$ = Dirac delta function for the X and Y model domain locations of the injection well(s) [1/L^3]

For this modeling effort, the dispersion coefficient in the X (transverse) and Y (longitudinal) directions were derived using **Equations 2** and **3**, respectively (WHS, 1994; Spitz and Moreno, 1996):

$$D_{xx} = \propto_T V \qquad \textbf{(Eq. 2)}$$

$$D_{yy} = \propto_L V \qquad \textbf{(Eq. 3)}$$

where:

$\propto_T$ = transverse dispersivity [L] and $\propto_L$ = longitudinal dispersivity [L]

Thelongitudinal dispersivity term ($\propto_L$) was derived using **Equation 4**:

$$\propto_L = 0.83 * [log_{10}x]^{2.414} \qquad \text{(Eq. 4)}$$ (Xu and Eckstein, 1995)

where:

x = distance from the plume source to the measurement point (meters).

The transverse dispersivity term ($\propto_T$) was estimated using **Equation 5**:

$$\propto_T = 0.1 \propto_L \qquad \text{(Eq. 5)}$$ (Spitz and Moreno, 1996)

Analytical Model Assumptions

The modified Wilson-Miller solute injection model assumes the following:

- The aquifer described by the model domain is homogeneous, anisotropic, and unsteady-state,
- The role of molecular diffusion on transport of the solute can be considered negligible (WHS, 1994),
- The solute is injected at a constant concentration over the entire thickness of the saturated portion of the aquifer (i.e. constant in the vertical dimension), therefore the model can be run as a two-dimensional solution,
- The effect of the injection rate on the velocity distribution in the model domain is assumed to be negligible,
- The model results report concentrations that are predicted to occur *in addition to* existing conditions. The injection well is the only source of solute within the model domain; the initial solute concentration of the model domain is assumed = 0 mg/L, and no additional upgradient or vertical recharge solute contributions are assumed during the model run.

Model Input Parameters and Assumptions

The injection model allows the user to define a number of input parameters, including:

- The dimensions of the model domain,
- The position of one or more injection wells within the model domain,
- The position of additional "observation" wells within the model domain,
- The concentration of the solute released into the aquifer from the injection well(s),
- The total time period of the model run,
- The specific on/off time period for solute injection,
- The fate and transport characteristics influencing the movement of the solute in the aquifer after injection [advection, dispersion, first-order decay rate, retardation (sorption) factor].

Table 1 presents the model parameter values used to conduct the analysis. I assumed that the solute was transported conservatively within the model domain; no retardation by sorption or first order decay

was assumed for the dissolved solute during transport (i.e. a solute molecule is transported at the same rate as a water molecule). These assumptions result in upper-bound estimates of solute concentration impact.

Table 1 – Model Parameter Values

Model parameter	Input value
Model domain dimensions (approximate dimension of the study field)	X = 932 ft Y = 1206 ft
Injection well coordinates (well AKG727 location relative to an arbitrary 0,0 X/Y origin point at the southwestern corner of the study field)	X = 593 ft Y = 969 ft
Downgradient "observation" well coordinates (relative to an arbitrary 0,0 X/Y origin point at the southwestern corner of the study field)	AKG722: X=620, Y=651 AKG724: X =535, Y=264
Contaminant decay constant (K)	K = 0 (no decay, i.e. conservative transport of the solute)
Plume length of interest (x)(Eq. 3)	x = 707 ft (distance between AKG727 and AKG724; 215 meters)
Dispersion coefficient in the X (transverse) direction (D_{xx})(Eq. 2)	D_{xx} = 1.52 ft^2/day
Dispersion coefficient in the Y (longitudinal) direction (D_{yy})(Eqs.2, 4)	D_{yy} = 15.2 ft^2/day
Groundwater seepage velocity (V)	V = 0.72 ft/day (Carey, 2013)
Direction of groundwater flow in the model domain (Θ)	Θ = 270° (due south)(Carey, 2013)
Retardation factor (R)	R = 1 (no retardation by sorption, conservative transport of the solute)
Porosity (n)	n = 0.25 (Carey, 2013)
Model time period of injection (Carey, 2013)	Day 0 to Day 2 (period of assumed entry of constant concentration manure slurry into well AKG727)
Concentration of injected solute (C_i*)	C_i* = 1085 mg/L (total nitrogen concentration of applied manure slurry; no conversion to nitrate or volatilization loss was assumed)(Carey, 2013)

Model Results

Using the inputs and assumptions described above, key findings include:

- The nitrogen injected into well AKG727 creates a plume that migrates downgradient over time. Dispersion causes the plume to spread both longitudinally and transversally, leading to a significant lowering of the solute concentration with time and distance.
- **Figure 1** illustrates the concentration breakthrough curve for a point 1 foot south of the injection well. **Table 2** summarizes how long the 2-day injection event elevates total nitrogen

concentrations above 3 target concentration benchmarks (1.0, 0.5, and 0.25 mg/L) at this location. These findings can be used as a guide to determine the period of sampling record at well AKG727 that was unacceptably biased by the injection event, depending on your project data quality objectives and goals.

Table 2.

Target Total N concentration of interest (mg/L)	Days from model start that Total N concentration remains above target concentration (days)
1.0	77
0.5	114
0.25	158

- **Figure 2** illustrates the concentration breakthrough curves for the two monitoring wells directly downgradient of the injection well:
    - The peak of the concentration breakthrough curve for the nearest downgradient well (AKG722) occurs approximately 396 days after the model start. The maximum concentration increase observed at the well as a result of the injection event is approximately 0.26 mg/L.
    - The peak of the concentration breakthrough curve for well AKG724 occurs 968 days after the model start. The maximum concentration increase observed at that well as a result of the injection event is 0.08 mg/L.
- The four monitoring wells located in the western half of the field were essentially unaffected by the manure injection to well AKG727 throughout the model run (<<0.01 mg/L). **Figures 3, 4**, and **5** illustrate in map view the predicted Total Nitrogen concentration distribution in groundwater (in mg/L) at the 100, 396, and 968 day time steps.

References

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Waterloo Hydrogeologic Software(WHS), 1994. PRINCE 3.0: Princeton Analytical Models of Flow and Transport (+user's manual), developed by R.W. Cleary and M.J. Ungs. Waterloo, Ontario, Canada.

Wilson, J.L., and Miller, P.J., 1978. Two-dimensional plume in uniform ground-water flow, Journal of the Hydraulics Division, Proceedings of the American Society of Civil Engineers, V. 104, No. HY4, p. 503-514

Xu, M. and Eckstein, Y., 1995. Use of weighted least-squares method in evaluation of the relationship between dispersivity and scale, Ground Water, V. 33, No. 6, p. 905-908

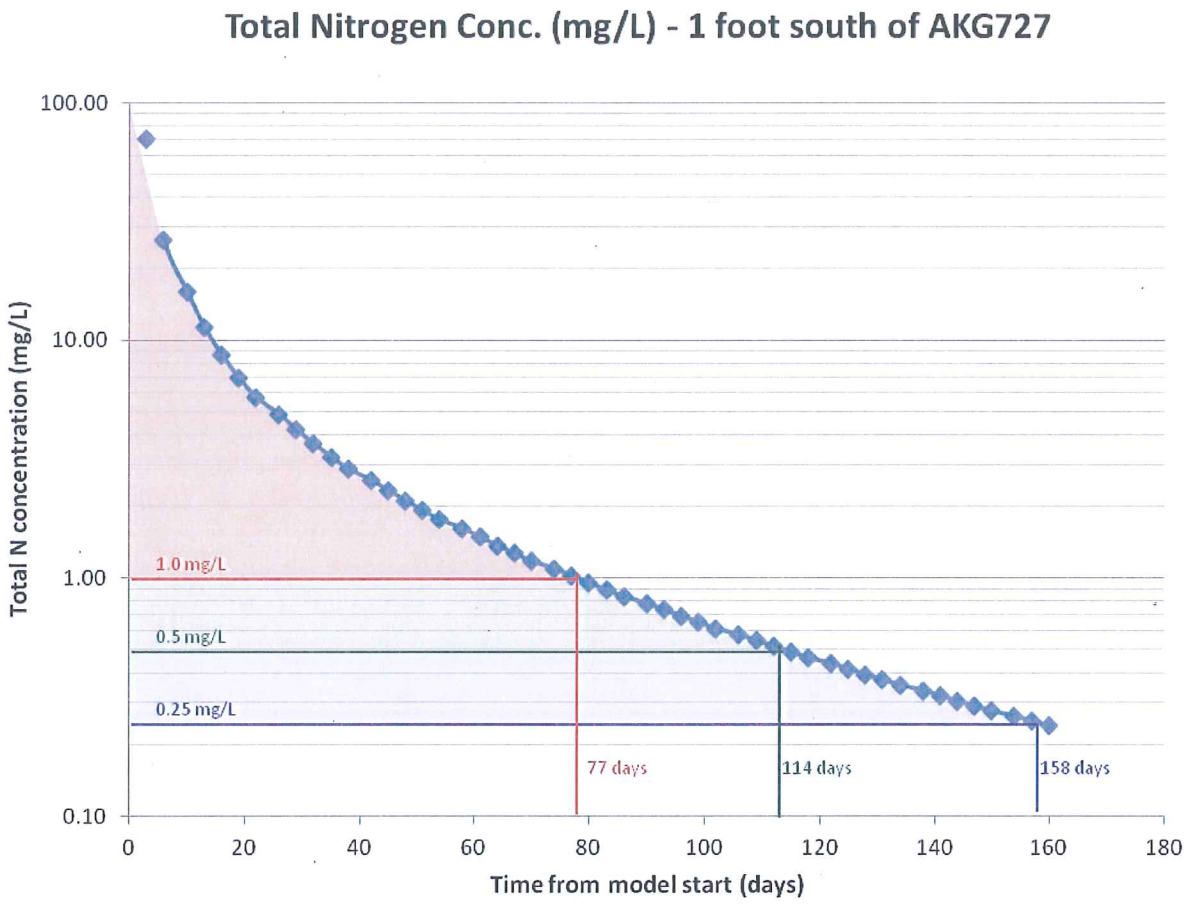


Figure 1 – Time/concentration breakthrough curve immediately downgradient of well AKG727

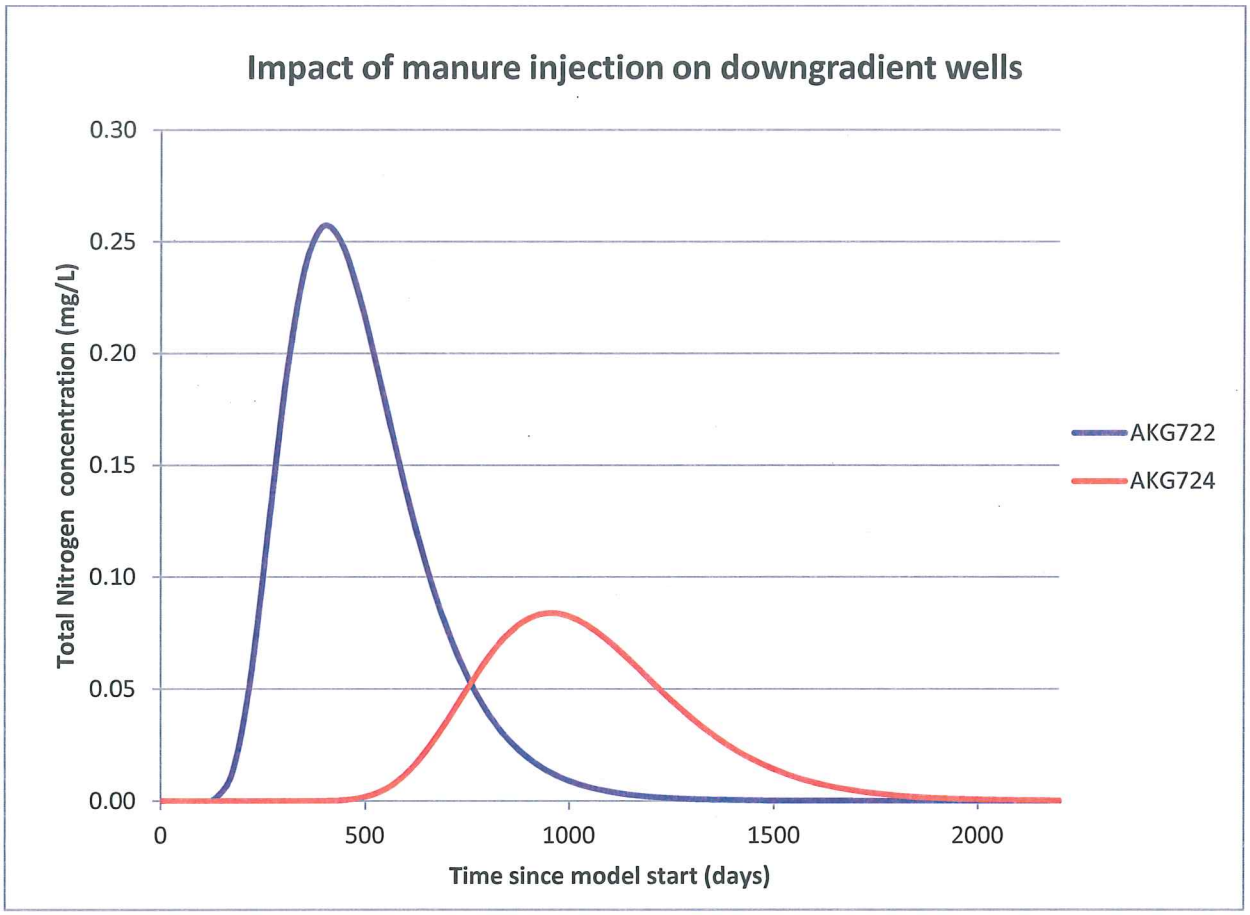


Figure 2. Time-concentration breakthrough curves for downgradient "observation" wells

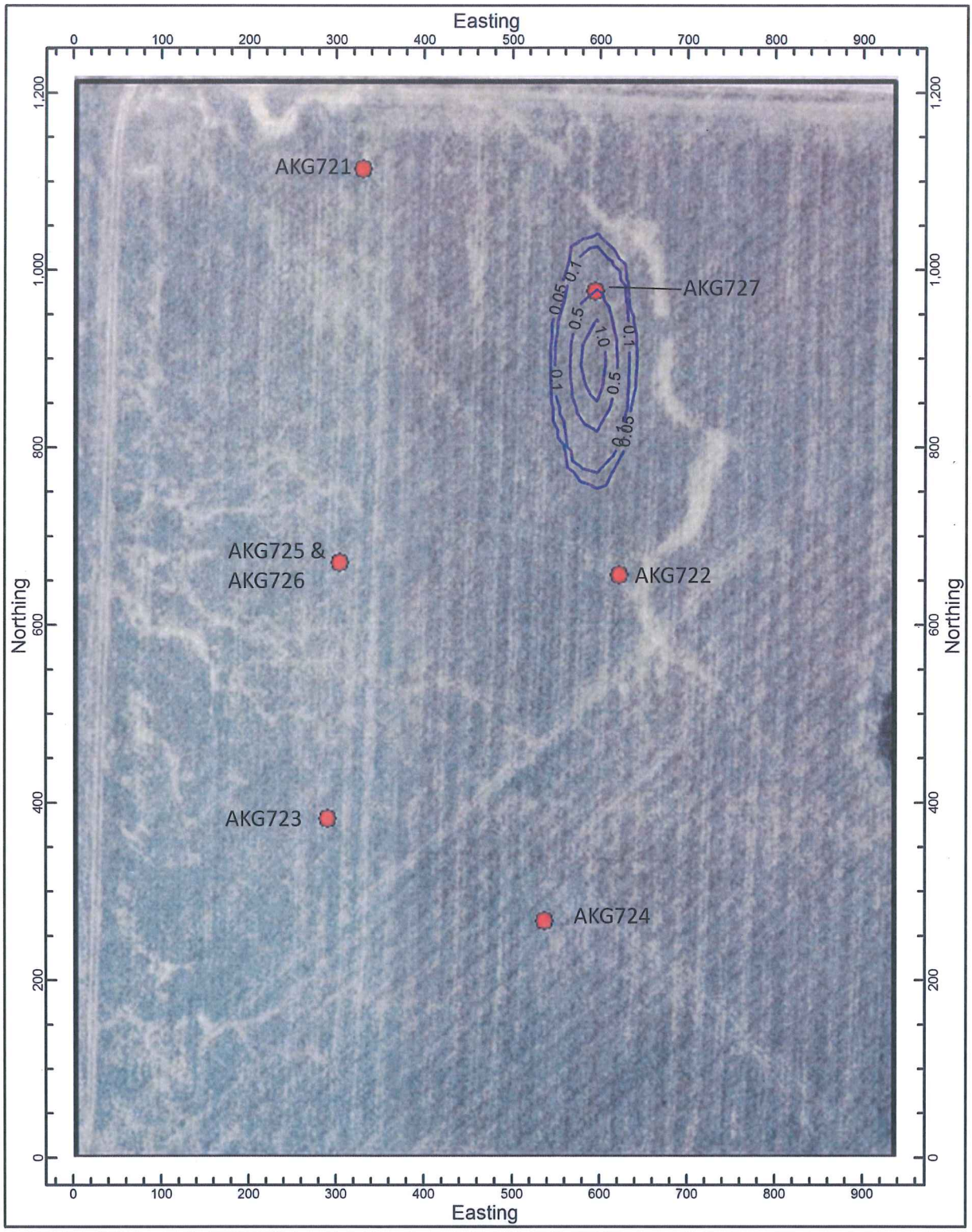


Figure 3 Total Nitrogen Concentration Contour (mg/L) - Model Time Step: 100 days

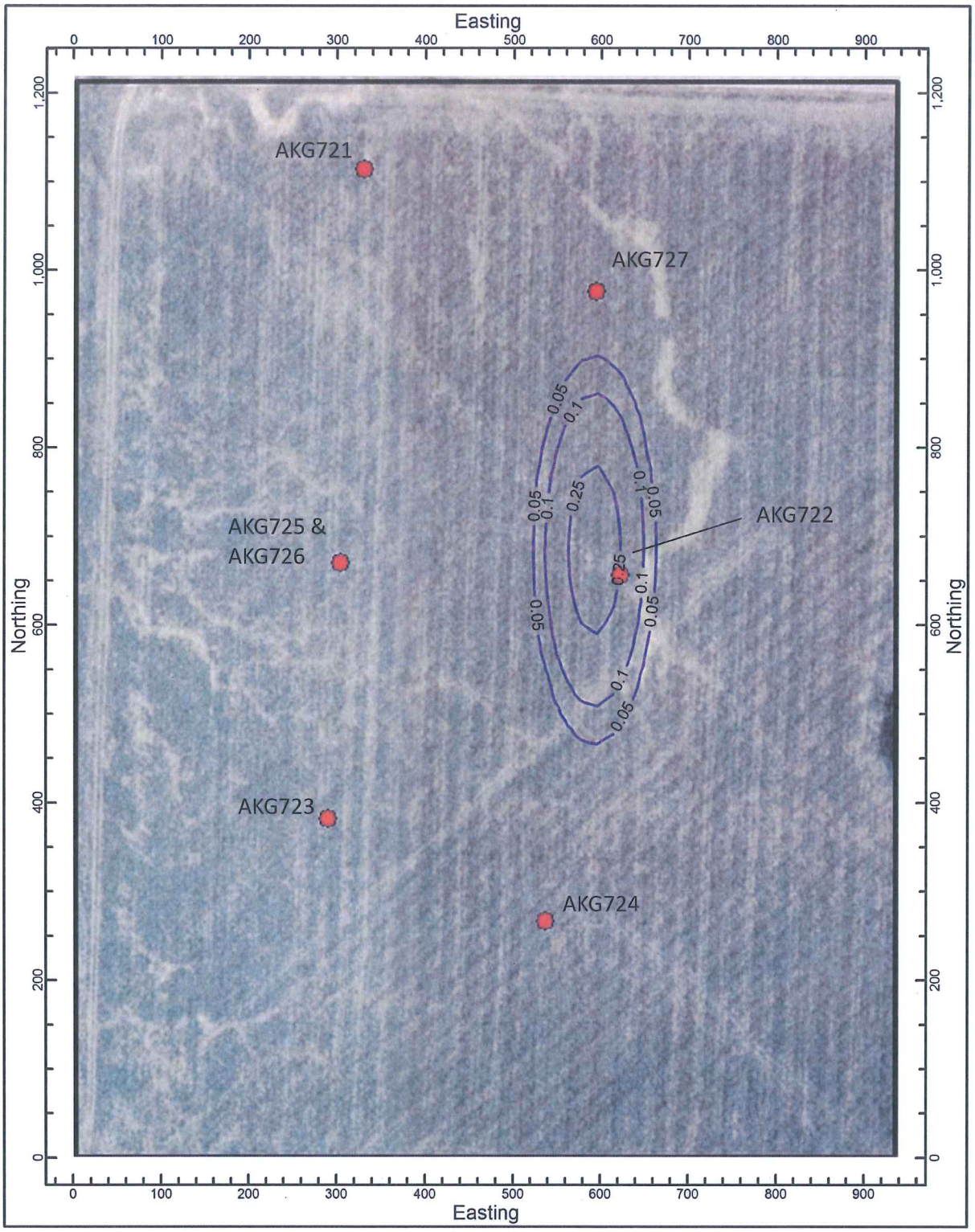


Figure 4 Total Nitrogen Concentration Contour (mg/L) - Model Time Step: 396 days

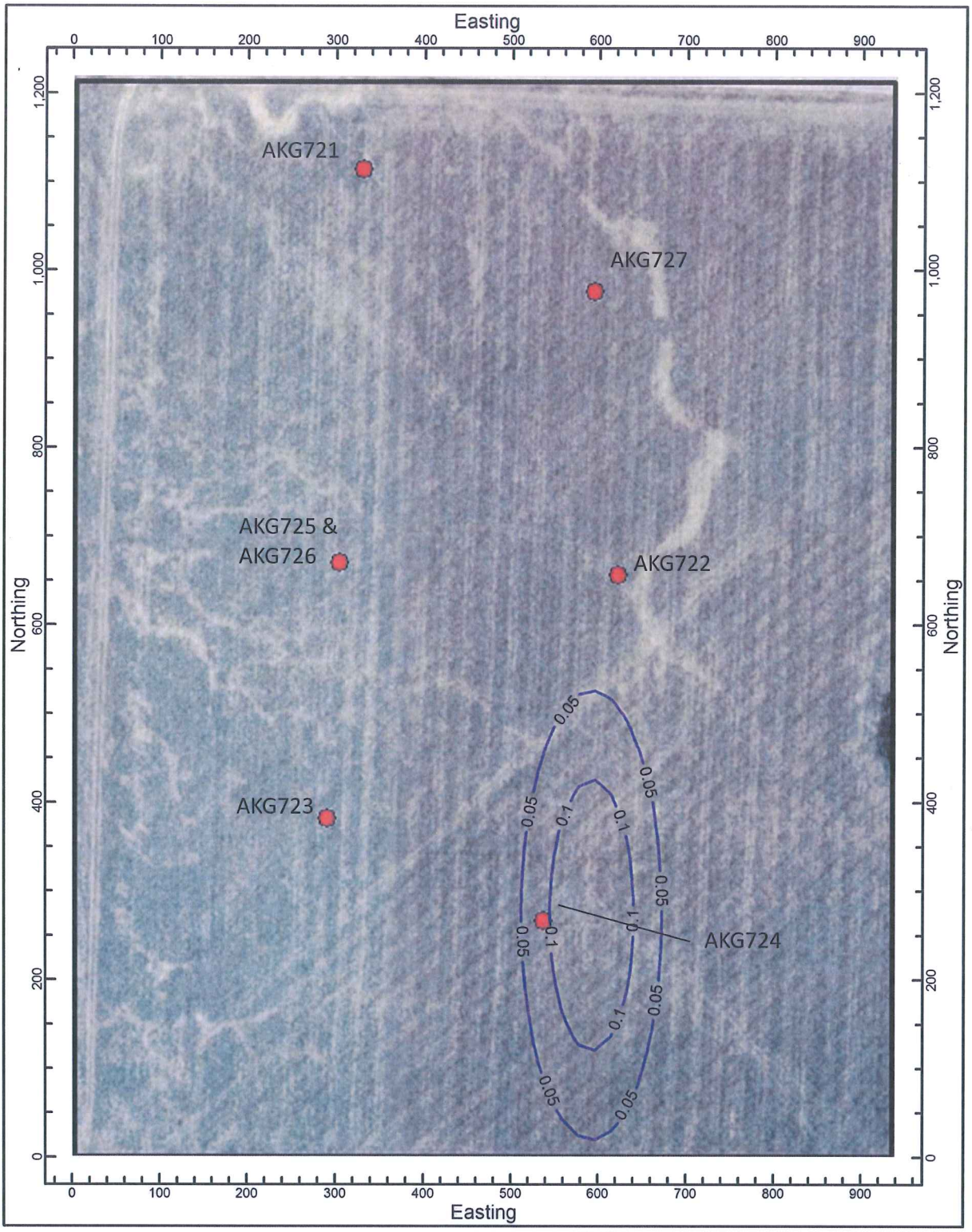


Figure 5 Total Nitrogen Concentration Contour (mg/L) - Model Time Step: 968 days

Appendix J. Precipitation, Air Temperature, Evapotranspiration, and Recharge Data

Table J.1. Monthly precipitation in inches.

For months before the on-site weather station was installed (January through late September 2004) and dates when the weather station failed, precipitation was estimated as 70.7% of precipitation at Abbotsford, B.C. Airport based on the correlation between precipitation at the two sites. (Table J.2. lists daily precipitation totals.)

	2004	2005	2006	2007	2008	2009
January	5.40	4.29	12.45	7.23	4.77	8.95
February	2.45	2.12	2.50	4.26	2.58	1.77
March	4.41	5.52	1.61	9.31	3.87	4.02
April	0.80	4.28	2.56	2.70	1.77	
May	2.84	0.25	1.99	1.48	2.00	
June	1.27	1.48	0.70	1.51	2.22	
July	0.55	0.98	0.24	1.48	1.76	
August	2.56	0.92	0.57	0.67	5.45	
September	3.87	3.71	2.28	3.19	0.67	
October	3.29	6.94	1.95	4.52	2.73	
November	9.43	4.71	11.42	3.17	11.67	
December	7.72	4.75	5.89	6.72	4.32	
Totals	**44.6**	**40.0**	**44.2**	**46.2**	**43.8**	

Table J.2. Daily precipitation data (inches) for the Ecology study site and Abbotsford B.C. Airport.

Table J.2 is available only as a zip file on the web.

Table J.3. Air temperature at the study site except when the weather station failed.

Data from nearby weather stations were used when data were not available from the on-site weather station: www.wunderground.com site KWALYNDEI and the WSU weather station in Lynden (Lat/Long: 49.00176/122.484523).

Table J.3 is available only as a zip file on the web.

Table J.4. Monthly potential evapotranspiration estimates using a modification of the Penman Monteith Equation from www.farmwest.com in inches.

	2004	2005	2006	2007	2008	2009
January	0.59	0.63	0.63	0.71	0.55	0.63
February	1.10	1.34	0.91	0.87	1.02	0.98
March	2.01	1.93	1.85	1.65	1.61	1.30
April	3.54	3.07	2.83	2.64	2.40	2.80
May	3.94	4.13	4.21	4.21	3.78	3.74
June	4.92	3.98	4.61	3.94	4.02	4.53
July	5.67	5.12	5.31	5.12	3.78	5.35
August	4.53	4.92	4.88	4.33	3.94	4.06
September	2.52	3.07	3.46	2.95	2.99	2.87
October	1.65	1.50	1.89	1.46	1.61	1.57
November	0.79	0.75	0.71	0.79	0.79	0.55
December	0.51	0.55	0.55	0.59	0.43	0.43
Totals	**31.8**	**31.0**	**31.9**	**29.3**	**26.9**	**28.8**

Table J.5. Monthly recharge estimates based on precipitation (Table J.1) less potential evapotranspiration (Table J.4) in inches.

	2004	2005	2006	2007	2008	2009
January		3.66	11.82	6.52	4.22	8.32
February		0.78	1.59	3.39	1.56	0.79
March		3.59	0.00	7.66	2.26	2.72
April		1.21	0.00	0.06	0.00	
May		0.00	0.00	0.00	0.00	
June		0.00	0.00	0.00	0.00	
July		0.00	0.00	0.00	0.00	
August	0.00	0.00	0.00	0.00	1.51	
September	1.35	0.64	0.00	0.24	0.00	
October	1.64	5.44	0.06	3.06	1.12	
November	8.64	3.96	10.71	2.38	10.88	
December	7.21	4.20	5.34	6.13	3.89	
Totals	**18.8**	**23.5**	**29.5**	**29.4**	**25.4**	**11.8**

Appendix K. Soil Results

Table K.1. Soil nitrate, soil temperature, and soil moisture data, 2004 through 2008.

The first column continues onto the next page, then continues in the column to the right of the gray column on this page.

Date	Soil Nitrate (mg/kg at 1 foot)		Soil Temperature (degrees C at 6 inches)	Soil Moisture (% of dry weight at 1 foot)		Date	Soil Nitrate (mg/kg at 1 foot)		Soil Temperature (degrees C at 6 inches)	Soil Moisture (% of dry weight at 1 foot)
8/25/2004	51.5			33.3		11/1/2006	30.5		3.3	30.7
9/9/2004	43.0		15.6	28.6		11/8/2006	60.0		7.2	32.3
9/17/2004	28.5		12.2	34.1		11/15/2006	15.5	P	6.1	34.1
10/1/2004	19.0	P	11.1	28.5		11/21/2006	13.5		7.2	33.4
10/12/2004	23.0		12.2	34.3		12/20/2006	14.0			34.1
10/22/2004	26.5		8.3	36.6		1/26/2007	11.9		1.1	35.1
11/5/2004	23.0		5.6	37.4		2/23/2007	10.0		2.2	34.4
11/12/2004	22.5		4.4	35.1		3/23/2007	6.1		5.6	54.7
11/19/2004	18.5		3.3	37.3		4/25/2007	11.2	P	6.7	38.4
12/3/2004	16.0		2.2	38.3		5/16/2007	18.4		15.6	28.6
2/22/2005	16.5		0.0	34.7		6/26/2007	23.5		17.2	27.1
3/25/2005	14.5		5.6	34.0		7/24/2007	22.6		17.8	32.8
4/28/2005	16.0		10.0	25.9		8/7/2007	17.5		16.7	22.8
5/27/2005	31.5		14.4	24.6		8/15/2007	20.7		15.6	19.7
6/29/2005	17.0	P	15.6	22.8		8/21/2007	19.9		16.1	22.2
7/28/2005	5.5		17.8	14.3		8/28/2007	18.3		15.6	24.8
8/5/2005	5.0		17.8	12.7		9/5/2007	15.8		14.4	23.9
8/11/2005	19.0		17.8	17.8		9/11/2007	25.3		14.4	22.8
8/17/2005	29.5	P	16.7	23.0		9/18/2007	15.4		11.7	24.5
8/24/2005	21.0	P	14.4	20.2		9/25/2007	14.7	P	12.2	28.4
8/31/2005	28.0		15.6	19.9		10/2/2007	14.4	P	11.1	40.0
9/7/2005	30.0	P	12.8	20.5		10/9/2007	16.9		10.0	33.9
9/13/2005	26.5	P	12.2	18.0		10/16/2007	18.8		9.4	35.5
9/21/2005	21.0		9.4	16.5		10/23/2007	14.7		8.9	36.5
9/27/2005	16.5	P	12.8	15.2		10/30/2007	11.8		5.6	38.9
10/4/2005	15.5	P	9.4	29.0		11/6/2007	11.5		6.1	35.3
10/11/2005	16.0		5.6	32.2		11/13/2007	10.2		5.0	36.3
10/18/2005	11.5	P	7.2	35.7		11/20/2007	11.0	P	3.3	36.8
10/25/2005	22.0	P	6.7	35.6		11/27/2007	11.9		1.1	36.9
11/1/2005	11.5	P	6.1	43.4		12/21/2007	18.0		0.0	37.0
11/10/2005	5.5	P	3.3	45.6		1/22/2008	20.5		0.0	37.5
11/15/2005	10.0		0.6	36.3		2/22/2008	10.6		4.4	35.2
11/21/2005	16.5		-1.7	35.6		3/18/2008	14.1		4.4	39.3
11/29/2005	14.5		-5.0	43.4		4/22/2008	17.4		4.4	33.4
12/16/2005	17.0		1.1	36.4		5/27/2008	29.3		15.0	35.8

Date	Soil Nitrate (mg/kg at 1 foot)		Soil Temperature (degrees C at 6 inches)	Soil Moisture (% of dry weight at 1 foot)		Date	Soil Nitrate (mg/kg at 1 foot)		Soil Temperature (degrees C at 6 inches)	Soil Moisture (% of dry weight at 1 foot)
1/19/2006	10.0		5.6	41.5		6/25/2008	34.3		13.9	29.6
2/22/2006	13.0		2.2	26.3		7/23/2008	17.2		15.0	25.9
3/30/2006	12.5		7.2	32.1		8/6/2008	29.7	P	16.7	25.3
4/27/2006	13.5		11.1	28.2		8/15/2008	25.4		17.8	29.2
5/25/2006	16.0	P	14.4	19.9		8/22/2008	22.3		15.0	32.9
6/27/2006	22.0		17.2	15.4		8/29/2008	21.1	P	15.0	38.9
7/24/2006	40.0		21.1	15.6		9/5/2008	20.9		12.2	32.5
8/3/2006	30.5		16.7	22.5		9/12/2008	29.5		12.8	29.7
8/11/2006	26.0		16.1	21.4		9/19/2008	35.9		12.8	30.5
8/22/2006	20.5		18.3	14.4		9/26/2008	41.2		13.3	33.2
8/30/2006	21.0	P	14.4	26.6		10/3/2008	26.5		15.6	32.0
9/6/2006	22.5		8.9	22.7		10/10/2008	21.6	P	10.0	32.7
9/13/2006	17.0		8.3	22.8		10/17/2008	26.9	P	11.7	41.0
9/20/2006	15.5		29.9	29.9		10/24/2008	30.8	P	8.9	36.3
9/27/2006	23.0		27.2	27.2		10/31/2008	29.9		11.1	37.0
10/4/2006	17.0		25.5	25.5		11/7/2008	9.6		9.4	50.7
10/12/2006	18.0			24.0		11/14/2008	10.9		7.8	38.4
10/18/2006	25.0			28.8		11/21/2008	11.7		7.2	37.3
10/26/2006	29.0			30.3		11/28/2008			3.3	36.6

P: Results of duplicate samples on this date did not meet the 20% target for relative standard deviation.

Table K.2. Soil chemistry results.

Date	Phos-phorus (Bray)	Potas-sium	Boron	Zinc	Mn	Cu	Fe	Ca	Mg	Na	S	Buffer pH	CEC	Total Bases	Base Satu-ration	pH	E.C.	Est Sat Paste E.C.	Organic Matter	Ammo-nium N
	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm		meq/ 100g	meq/ 100g	%	std. units	m.mhos /cm	m.mhos /cm	%	ppm
4/28/2005	216	625	0.3	8.5	7.6	4.0	128	9.0	3.0	0.20		6.7	18.9	13.8	72.8	6.3	0.20	0.52	7.2	
6/27/2006	198	432	0.2	7.0	5.1	3.6	101	7.7	2.9	0.20		6.4	21.7	11.9	55.0	6.0	0.24	0.62	7.0	16
4/25/2007	183	662	0.5	9.3	9.3	4.0	94	9.9	3.6	0.41		6.5	23.5		66.5	6.3	0.90		8.4	
4/22/2008	196	542	0.6	6.6	4.8	3.1	92	8.3	3.0	0.21	16	6.8	22.3	13	58.2	6.4	0.28	0.73	7.4	5.3

Analytical methods from Galvak, R., D. Horneck, R. O. Miller, and J. Kotuby-Amather, 2003. Soil, Plant, and Water Reference Methods for Western Region, 2003. 2nd Edition.

Mn: manganese
Cu: copper
Fe: iron
Ca: calcium
Mg: magnesium
Na: sodium
S: sulfur

CEC: Cation exchange capacity
E.C: Electrical conductivity

Appendix L. Manure Results

Table L.1. Summary of manure total nitrogen and chloride applied to the study field from 2005 through 2008.

Date	Total N applied (lb/acre)	Annual Total N applied (lb/year)	Chloride applied (lb/acre)	Annual Total chloride applied (lb/acre)
2/18/2005	93		39	
5/13/2005	179		48	
6/27/2005	*41*			
8/9/2005	136+		51	
8/31/2005	195	644	60	198
4/27/2006	171		45	
5/25/2006	**31**			
7/11/2006	102		37	
10/5/2006	90	394	***29***	111
3/14/2007	109+		40	
5/18/2007	132		24	
6/26/2007	**48**			
8/6/2007	69		33	
9/7/2007	77	434	24	121
3/10/2008	171		39	
5/20/2008	193		52	
6/23/2008	145		40	
7/31/2008	98		32	
9/13/2008	108	715	42	205

Bold represent inorganic fertilizer applications.

Italic represents an estimate based on amount of manure applied and Agros field meter ammonia result, because a sample could not be collected.

Bold italic is the estimated chloride applied as the mean ratio of chloride to nitrogen in all applications times lb/acre nitrogen applied.

+ Relative standard deviation (RSD) of duplicates exceeded 7%. See Appendix I, Table I.1, for details.

Table L.2. Nitrogen and chloride data for manure.

Sample Number	Date	Application Method	Solids	Total N	Average Total N	Ammonium N	Average Ammonium N	Chloride	Average Chloride	Rate Applied	Rate Applied	Manure Ammonia N Application Rate	Manure Total N Application Rate	Manure Chloride Application Rate
			%	lbs/1,000 gallons		lbs/1,000 gallons		mg/L		gal/acre	inch/acre	lbs/acre		
DOE M3	2/18/2005	Lagoon	1.63	10.2	10.6	8.69	8.24			8,967	0.330	73.8	95.3	
DOE M4	2/18/2005	Lagoon	1.77	11.1		7.78				8,967	0.330			
DOE M5	2/18/2005	Aerator	1.37	9.35	10.2	8.51	8.02			8,967	0.330	71.9	91.5	
DOE M6	2/18/2005	Aerator	1.39	11.1		7.52		525		8,967	0.330			39.2
DOE M7	5/13/2005	Aerator	3.52	17.9	17.85	11.8	11.8	579		10,000	0.368	118	179	48.2
DOE M8	5/13/2005	Aerator	3.44	17.9		11.4								
	6/27/2005	Injector	No notification, ammonium sample from Agros Meter.									**27**	**41**	
DOE M9	8/9/2005	Injector	1.69	11.1	11.1	8.51	8.18	500		12,309	0.453	101	136	51.2
DOE M10	8/9/2005	Injector	1.69	11.1		7.85								
DOE M12	8/31/2005	Aerator	6.97	23.0	24.7	12.6	12.1	911		7,920	0.292	95.7	195	60.1
DOE M13	8/31/2005	Aerator	6.85	26.4		11.5								
DOE M15	4/27/2006	Aerator	4.87	18.7	19.6	7.71	7.58	617	572	8,750	0.322	66.3	171	44.9
DOE M16	4/27/2006	Aerator	5.24	20.4		7.45		526		8,750	0.322			
DOE M17	7/11/2006	Aerator	2.37	11.1	10.6	4.46	4.20	466		9,622	0.354	40.4	102	37.3
DOE M18	7/11/2006	Aerator	2.27	10.2		3.94				9,622	0.354			
DOE M20	10/5/2006	Aerator	4.22	19.55	20.0	7.64	7.60			4,500	0.166	34.2	89.9	
DOE M21	10/5/2006	Aerator	4.80	20.4		7.55				4,500				
DOE M22	10/5/2006	Aerator	4.29	19.55		7.53				4,500				
DOE M23	3/14/2007	Aerator	3.65	14.5	13.6	6.02	6.11	600	508	8,000	0.295	48.8	109	40.0
DOE M24	3/14/2007	Aerator	3.48	12.8		6.19		415		8,000	0.295			
DOE M26	5/18/2007	Aerator	4.11	18.7	18.3	7.07	7.07	406	406	7,200	0.265	50.9	132	24.3
DOE M27	5/18/2007	Aerator	3.33	17.9										
DOE M29	8/6/2007	Aerator	1.11	7.65	7.23	2.72	2.49	409	413	9,566	0.352	23.8	69.1	32.9
DOE M30	8/6/2007	Aerator	1.04	6.80		2.26		416		9,566	0.352			
DOE M31	9/7/2007	Injector	3.2	11.9	12.8	3.32	3.46	463	473	6,000	0.221	20.7	76.5	23.1
DOE M32	9/7/2007	Injector	2.95	13.6		3.59		483		6,000	0.221			
DOE M33	3/10/2008	Aerator	4.28	19.9	19.5	6.55	6.58	530	530	8,750	0.322	57.5	171	38.6
DOE M34	3/10/2008	Aerator	4.11	19.1		6.60								
DOE M36	3/18/2008	Solids	18.0	6.80		1.20		Applied to the edges of the field and a small amount on the field.						
DOE M37	5/20/2008	Aerator	2.85	16.6	16.6	5.76	5.84	530	535	11,650	0.429	68.0	193	51.9
DOE M38	5/20/2008	Aerator	3.41	16.6		5.91		540		11,650				
DOE M40	6/23/2008	Aerator	5.32	17.4	17.0	9.16	9.365	560	565	8,500	0.313	79.6	145	40.0
DOE M41	6/23/2008	Aerator	5.19	16.6		9.57		570		8,500				
DOE M42	7/31/2008	Injector	1.30	7.47	7.89	4.42	4.36	310	310	12,430	5.771	54.2	98.0	32.1
DOE M43	7/31/2008	Injector	1.32	8.30		4.30		310		12,430				
DOE M44	9/13/2008	Aerator	4.36	17.4	16.6	8.62	8.67	780	780	6,500	3.018	56.3	108	42.2
DOE M45	9/13/2008	Aerator	4.46	15.8		8.71		780		6,500				

N: nitrogen

Bold: Estimate, no laboratory analyses.

Appendix M. Irrigation Water Results

Table M.1. Irrigation water quality data and quality assurance results.

Date	Sample Number	Nitrite+Nitrate-N			Ammonia-N			Total persulfate nitrogen (TPN)		
		Result (mg/L)	Average (mg/L)	RPD (%)	Result (mg/L)	Average (mg/L)	RPD (%)	Result (mg/L)	Average (mg/L)	RPD (%)
9/15/2005	1	0.01	0.0115	26.1	---	---	---	---	---	---
9/15/2005	2	0.013								
10/15/2005	3	0.029	0.032	18.8	---	---	---	---	---	---
10/15/2005	4	0.035								
7/22/2006	5	0.073	0.079	15.2	---	---	---	---	---	---
7/22/2006	6	0.085								
8/22/2006	7	0.049	0.048	4.2	---	---	---	---	---	---
8/22/2006	8	0.047								
7/17/2007	9	0.015	0.0155	6.5	---	---	---	---	---	---
7/17/2007	10	0.016								
8/23/2007	11	0.017	0.0155	19.4	---	---	---	---	---	---
8/23/2007	12	0.014								
9/12/2007	13	0.021	0.0205	4.9	0.794	0.805	2.6	1.37	1.37	0.0
9/12/2007	14	0.02			0.815			1.37		
7/8/2008	15	0.039	0.038	5.3	0.743	0.740	0.8	1.37	1.30	10.8
7/8/2008	16	0.037			0.737			1.23		
8/16/2008	17	0.033	0.033	0.0	0.853	0.841	2.9	1.49	1.30	30.1
8/16/2008	18	0.033			0.829			1.10		

RPD: Relative percent difference

Table M.2. Nitrogen input from irrigation water.

Year	Water applied (gallons/acre)	N loading (lb)[1]
2005[2]	67,900	12
2006	154,541	27
2007	147,480	26
2008	119,776	21

[1] Assumes the average total nitrogen concentration (1.3 mg/L) in all irrigation water, which converts to 1.74×10^{-4} lb N/gallon.

[2] This is an estimate, because the volume applied is estimated (VanWieringen and Harrison, 2009).

Appendix N. Grass Crop Results

Sample	Date	Wet Weight lbs	Dry Matter %	Dry Weight lbs	Swath Dimen-sions 8.5 x 5 ft	Distance Be-tween Swaths 5 ft	Samp-ling Area ft^2	Con-version Factor no. of sample areas/acre	Dry Matter Yield tons/ acre	Average Dry Matter Yield tons/ acre	Crude Protein %	Average Crude Protein %	Standard Deviation Crude Protein %	Co-efficient of Variation Crude Protein %	Nitrate Ion %	Nitrogen Har-vested lbs/ acre	Average Nitrogen Har-vested lbs/ acre
DOE-1	10/4/2004	55.85	13.03	7.28	42.5		67.5	645.3	2.35	1.68	24.4					183.3	131
DOE-2	10/4/2004	26.65	16.73	4.46	42.5		67.5	645.3	1.44		24.4					112.3	
DOE-3	10/4/2004	27.2	16.76	4.56	42.5		67.5	645.3	1.47		24.4					114.8	
DOE-4	10/4/2004	23.55	19.23	4.53	42.5		67.5	645.3	1.46		24.4					114.1	
DOE-5	4/28/2005	2.5	17.67	0.44				10,890	2.41	2.33	15.7	16.74	0.820	4.90	0.31	120.8	125
DOE-6	4/28/2005	2.65	16.95	0.45				10,890	2.45		16.7					130.7	
DOE-7	4/28/2005	2.5	17.65	0.44				10,890	2.40		16.7					128.4	
DOE-8	4/28/2005	2.35	15.2	0.36				10,890	1.94		18					112.0	
DOE-9	4/28/2005	2.6	17.37	0.45				10,890	2.46		16.6					130.6	
DOE-10	6/12/2005	9.65	24.26	2.34	40		77.5	562	0.66	1.32	21.6	18.38	1.871	10.18	0.34	45.5	76
DOE-11	6/12/2005	16.15	26.24	4.24	40		77.5	562	1.19		16.7					63.6	
DOE-12	6/12/2005	28.5	22.65	6.46	40		77.5	562	1.81		17.8					103.3	
DOE-13	6/12/2005	23.95	22.47	5.38	40		77.5	562	1.51		18					87.1	
DOE-14	6/12/2005	22.95	22.25	5.11	40		77.5	562	1.43		17.8					81.7	
DOE-15	7/17/2005	1.55	19.32	0.30				10,890	1.63	1.75	14.2				0.14	74.1	79
DOE-16	7/17/2005	0.95	26.22	0.25				10,890	1.36		14.2					61.6	
DOE-17	7/17/2005	1.7	18.31	0.31				10,890	1.69		14.2					77.0	
DOE-18	7/17/2005	1.4	19.06	0.27				10,890	1.45		14.2					66.0	
DOE-19	7/17/2005	2.2	21.8	0.48				10,890	2.61		14.2					118.7	
DOE-20	7/17/2005	1.3	19.72	0.26				10,890	1.40	1.48	15.1				0.15	67.4	72
DOE-21	7/17/2005	1.4	20.56	0.29				10,890	1.57		15.1					75.7	
DOE-22	7/17/2005	1.1	21.96	0.24				10,890	1.32		15.1					63.6	
DOE-23	7/17/2005	1.55	17.76	0.28				10,890	1.50		15.1					72.4	
DOE-24	7/17/2005	1.5	20	0.30				10,890	1.63		15.1					78.9	
DOE-25	8/25/2005	1	18.06	0.18				10,890	0.98	0.93	20.8				0.62	65.5	62
DOE-26	8/25/2005	0.85	21.85	0.19				10,890	1.01		20.8					67.3	

Sample	Date	Wet Weight	Dry Matter	Dry Weight	Swath Dimen-sions	Distance Be-tween Swaths	Samp-ling Area	Con-version Factor	Dry Matter Yield	Average Dry Matter Yield	Crude Protein	Average Crude Protein	Standard Deviation Crude Protein	Co-efficient of Variation Crude Protein	Nitrate Ion	Nitrogen Har-vested	Average Nitrogen Har-vested
		lbs	%	lbs	8.5 x 5 ft	5 ft	ft^2	no. of sample areas/acre	tons/ acre	tons/ acre	%	%	%	%	%	lbs/ acre	lbs/ acre
DOE-27	8/25/2005	0.4	22.51	0.09				10,890	0.49		20.8					32.6	
DOE-28	8/25/2005	0.5	23.27	0.12				10,890	0.63		20.8					42.2	
DOE-29	8/25/2005	1.35	21.13	0.29				10,890	1.55		20.8					103.4	
DOE-30	8/25/2005	0.75	19.82	0.15				10,890	0.81	0.83	22.4				0.72	58.0	60
DOE-31	8/25/2005	1.4	16.54	0.23				10,890	1.26		22.4					90.4	
DOE-32	8/25/2005	0.55	21.79	0.12				10,890	0.65		22.4					46.8	
DOE-33	8/25/2005	0.65	20.34	0.13				10,890	0.72		22.4					51.6	
DOE-34	8/25/2005	0.5	26.88	0.13				10,890	0.73		22.4					52.5	
DOE-35	12/13/2005	1.25	23.43	0.29				10,890	1.59	1.29	21.9				0.01	111.8	91
DOE-36	12/13/2005	1.45	11.09	0.16				10,890	0.88		21.9					61.4	
DOE-37	12/13/2005	1.4	11.39	0.16				10,890	0.87		21.9					60.8	
DOE-38	12/13/2005	1.95	17.78	0.35				10,890	1.89		21.9					132.3	
DOE-39	12/13/2005	2.35	9.66	0.23				10,890	1.24		21.9					86.6	
DOE-40	12/13/2005	1.6	12.29	0.20*				10,890	1.07	1.66	21.2				0.63	72.6^	113^
DOE-41	12/13/2005	1.85	18.60	0.34*				10,890	1.87		21.2					127.1^	
DOE-42	12/13/2005	1.7	20.61	0.35*				10,890	1.91		21.2					129.4^	
DOE-43	12/13/2005	1.6	20.52	0.33*				10,890	1.79		21.2					121.3^	
DOE-44	12/13/2005	1.65	18.68	0.31*				10,890	1.68		21.2					113.8^	
DOE 45	C5118	1.65	15.65	0.26				10,890	1.41	1.90	19.7				0.48	88.7	119
DOE 46	C5119	2.7	16.32	0.44				10,890	2.40		19.7					151.3	
DOE 47	C5120	3	14.80	0.44				10,890	2.42		19.7					152.4	
DOE 48	C5121	2.15	14.62	0.31				10,890	1.71		19.7					107.9	
DOE 49	C5122	1.95	14.52	0.28				10,890	1.54		19.7					97.2	
DOE 50	C5123	1.6	17.29	0.28				10,890	1.51	1.95	19.6				0.38	94.5	122
DOE 51	C5124	2.5	17.86	0.45				10,890	2.43		19.6					152.4	
DOE 52	C5125	2.05	17.19	0.35				10,890	1.92		19.6					120.3	
DOE 53	C5126	2.1	16.72	0.35				10,890	1.91		19.6					119.9	
DOE 54	C5127	2.15	16.80	0.36				10,890	1.97		19.6					123.3	

Sample	Date	Wet Weight	Dry Matter	Dry Weight	Swath Dimen-sions	Distance Be-tween Swaths	Samp-ling Area	Con-version Factor	Dry Matter Yield	Average Dry Matter Yield	Crude Protein	Average Crude Protein	Standard Deviation Crude Protein	Co-efficient of Variation Crude Protein	Nitrate Ion	Nitrogen Har-vested	Average Nitrogen Har-vested
		lbs	%	lbs	8.5 x 5 ft	5 ft	ft^2	no. of sample areas/acre	tons/ acre	tons/ acre	%	%	%	%	%	lbs/ acre	lbs/ acre
DOE 55	5/25/2006	0.924	14.61	0.13				10,890	0.73	0.95	25.7				1.78	60.4	78
DOE 56	5/25/2006	1.474	15.97	0.24				10,890	1.28		25.7					105.4	
DOE 57	5/25/2006	1.21	15.14	0.18				10,890	1.00		25.7					82.0	
DOE 58	5/25/2006	0.924	15.64	0.14				10,890	0.79		25.7					64.7	
DOE 59	5/25/2006	1.474	12.00	0.18				10,890	0.96		25.7					79.2	
DOE 60	5/25/2006	1.606*	13.72	0.22				10,890	1.20	1.15	23.8				1.56	91.3	88
DOE 61	5/25/2006	1.672*	14.99	0.25				10,890	1.36		23.8					103.9	
DOE 62	5/25/2006	1.298*	15.80	0.21				10,890	1.12		23.8					85.0	
DOE 63	5/25/2006	1.474*	14.27	0.21				10,890	1.15		23.8					87.2	
DOE 64	5/25/2006	1.034*	16.52	0.17				10,890	0.93		23.8					70.8	
DOE 65	7/5/2006	1.25	20.18	0.25				10,890	1.37	1.49	17.3				0.52	76.0	82
DOE 66	7/5/2006	17.25	25.20	4.35	40		77.5	562	1.22		17.3					67.6	
DOE 67	7/5/2006	20.65	24.21	5.00	40		77.5	562	1.40		17.3					77.8	
DOE 68	7/5/2006	25.6	23.67	6.06	40		77.5	562	1.70		17.3					94.3	
DOE 69	7/5/2006	29.45	20.98	6.18	40		77.5	562	1.74		17.3					96.1	
DOE 70	7/5/2006	24.35	23.58	5.74*	40		77.5	562	1.61	1.37	18.7				0.84	96.5^	82^
DOE 71	7/5/2006	21.75	26.60	5.79*	40		77.5	562	1.63		18.7					97.3^	
DOE 72	7/5/2006	10.85	33.50	3.63*	40		77.5	562	1.02		18.7					61.1^	
DOE 73	7/5/2006	17.15	27.55	4.72*	40		77.5	562	1.33		18.7					79.4^	
DOE 74	7/5/2006	16.1	27.85	4.48*	40		77.5	562	1.26		18.7					75.4^	
DOE 75	8/15/2006	1.166	17.48	0.20				10,890	1.11	0.96	21.6				0.94	76.7	67
DOE 76	8/15/2006	0.902	20.84	0.19				10,890	1.02		21.6					70.7	
DOE 77	8/15/2006	0.704	22.20	0.16				10,890	0.85		21.6					58.8	
DOE 78	8/15/2006	0.814	21.03	0.17				10,890	0.93		21.6					64.4	
DOE 79	8/15/2006	0.66	25.13	0.17				10,890	0.90		21.6					62.4	
DOE 80	8/15/2006	1.254*	19.30	0.24				10,890	1.32	1.19	22.6				0.9	95.3	86
DOE 81	8/15/2006	0.968*	23.09	0.22				10,890	1.22		22.6					88.0	
DOE 82	8/15/2006	1.078*	20.25	0.22				10,890	1.19		22.6					86.0	

Sample	Date	Wet Weight	Dry Matter	Dry Weight	Swath Dimen-sions	Distance Be-tween Swaths	Samp-ling Area	Con-version Factor	Dry Matter Yield	Average Dry Matter Yield	Crude Protein	Average Crude Protein	Standard Deviation Crude Protein	Co-efficient of Variation Crude Protein	Nitrate Ion	Nitrogen Har-vested	Average Nitrogen Har-vested
		lbs	%	lbs	8.5 x 5 ft	5 ft	ft^2	no. of sample areas/acre	tons/ acre	tons/ acre	%	%	%	%	%	lbs/ acre	lbs/ acre
DOE 83	8/15/2006	1.21*	18.54	0.22				10,890	1.22		22.6					88.3	
DOE 84	8/15/2006	0.924*	20.05	0.19				10,890	1.01		22.6					73.0	
DOE 85	9/27/2006	1.3112	14.75	0.19				10,890	1.05	1.06	19.5				0.61	65.7	66
DOE 86	9/27/2006	0.9108	20.70	0.19				10,890	1.03		19.5					64.1	
DOE 87	9/27/2006	1.3464	18.02	0.24				10,890	1.32		19.5					82.4	
DOE 88	9/27/2006	1.056	17.95	0.19				10,890	1.03		19.5					64.4	
DOE 89	9/27/2006	0.9812	15.93	0.16				10,890	0.85		19.5					53.1	
DOE 90	9/27/2006	1.4124	16.24	0.23				10,890	1.25	1.01	21.4				0.71	85.5	69
DOE 91	9/27/2006	1.012	17.93	0.18				10,890	0.99		21.4					67.7	
DOE 92	9/27/2006	0.9064	19.88	0.18				10,890	0.98		21.4					67.2	
DOE 93	9/27/2006	1.2584	14.20	0.18				10,890	0.97		21.4					66.6	
DOE 94	9/27/2006	0.8888	17.57	0.16				10,890	0.85		21.4					58.2	
DOE 95	5/6/2007	2.65	14.78	0.39				10,890	2.13	2.53	18.2				0.5	124.2	147
DOE 96	5/6/2007	3.3	15.92	0.53				10,890	2.86		18.2					166.6	
DOE 97	5/6/2007	4.15	13.26	0.55				10,890	3.00		18.2					174.6	
DOE 98	5/6/2007	2.9	15.03	0.44				10,890	2.37		18.2					138.2	
DOE 99	5/6/2007	2.85	14.80	0.42				10,890	2.30		18.2					133.8	
DOE 100	5/6/2007	4.55	15.24	0.69				10,890	3.78	3.10	15.9				0.29	192.1	158
DOE 101	5/6/2007	3.7	17.31	0.64				10,890	3.49		15.9					177.4	
DOE 102	5/6/2007	3.1	18.12	0.56				10,890	3.06		15.9					155.6	
DOE 103	5/6/2007	2.75	17.52	0.48				10,890	2.62		15.9					133.5	
DOE 104	5/6/2007	3.3	14.16	0.47				10,890	2.54		15.9					129.4	
DOE 105	6/14/2007	1.75	15.19	0.27				10,890	1.45	1.46	21.1				1.04	97.7	99
DOE 106	6/14/2007	1.25	23.81	0.30				10,890	1.62		21.1					109.4	
DOE 107	6/14/2007	1.05	19.77	0.21				10,890	1.13		21.1					76.3	
DOE 108	6/14/2007	1.65	18.20	0.30				10,890	1.63		21.1					110.4	
DOE 109	6/14/2007	1.6	17.11	0.27				10,890	1.49		21.1					100.6	
DOE 110	6/14/2007	1.5	19.45	0.29				10,890	1.59	1.30	19.5				0.64	99.1	81

Sample	Date	Wet Weight	Dry Matter	Dry Weight	Swath Dimen-sions	Distance Be-tween Swaths	Samp-ling Area	Con-version Factor	Dry Matter Yield	Average Dry Matter Yield	Crude Protein	Average Crude Protein	Standard Deviation Crude Protein	Co-efficient of Variation Crude Protein	Nitrate Ion	Nitrogen Har-vested	Average Nitrogen Har-vested
		lbs	%	lbs	8.5 x 5 ft	5 ft	ft^2	no. of sample areas/acre	tons/ acre	tons/ acre	%	%	%	%	%	lbs/ acre	lbs/ acre
DOE 111	6/14/2007	0.8	20.34	0.16				10,890	0.89		19.5					55.3	
DOE 112	6/14/2007	0.7	20.11	0.14				10,890	0.77		19.5					47.8	
DOE 113	6/14/2007	1.9	16.51	0.31				10,890	1.71		19.5					106.6	
DOE 114	6/14/2007	1.6	17.99	0.29				10,890	1.57		19.5					97.8	
DOE 115	7/30/2007	1.2	22.80	0.27				10,890	1.49	1.29	19.4				0.6	92.5	80
DOE 116	7/30/2007	1.4	19.52	0.27				10,890	1.49		19.4					92.4	
DOE 117	7/30/2007	1.05	20.14	0.21				10,890	1.15		19.4					71.5	
DOE 118	7/30/2007	1.3						10,890			19.4						
DOE 119	7/30/2007	0.95	19.76	0.19				10,890	1.02		19.4					63.5	
DOE 120	7/30/2007	1.55	17.12	0.27				10,890	1.45	1.36	19.7				0.91	91.1	86
DOE 121	7/30/2007	1.6	19.44	0.31				10,890	1.69		19.7					106.8	
DOE 122	7/30/2007	0.9	22.95	0.21				10,890	1.12		19.7					70.9	
DOE 123	7/30/2007	1.15	21.32	0.25				10,890	1.34		19.7					84.2	
DOE 124	7/30/2007	1	22.22	0.22				10,890	1.21		19.7					76.3	
DOE 125	8/28/2007	0.95	16.27	0.15				10,890	0.84	0.89	21.7				0.33	58.5	62
DOE 126	8/28/2007	0.65	22.28	0.14				10,890	0.79		21.7					54.8	
DOE 127	8/28/2007	0.95	22.22	0.21				10,890	1.15		21.7					79.8	
DOE 128	8/28/2007	0.85	19.72	0.17				10,890	0.91		21.7					63.4	
DOE 129	8/28/2007	0.7	20.38	0.14				10,890	0.78		21.7					53.9	
DOE 130	8/28/2007	1.6	13.85	0.22				10,890	1.21	0.82	23.7				0.44	91.5	62
DOE 131	8/28/2007	0.6	20.16	0.12				10,890	0.66		23.7					49.9	
DOE 132	8/28/2007	0.8	21.22	0.17				10,890	0.92		23.7					70.1	
DOE 133	8/28/2007	0.85	19.68	0.17				10,890	0.91		23.7					69.1	
DOE 134	8/28/2007	0.3	23.26	0.07				10,890	0.38		23.7					28.8	
DOE 135	10/10/2007	1.3	13.56	0.18				10,890	0.96	0.98	25.3				0.71	77.7	80
DOE 136	10/10/2007	0.9	16.56	0.15				10,890	0.81		25.3					65.7	
DOE 137	10/10/2007	1.75	16.66	0.29				10,890	1.59		25.3					128.5	
DOE 138	10/10/2007	1.4	11.47	0.16				10,890	0.87		25.3					70.8	

Sample	Date	Wet Weight	Dry Matter	Dry Weight	Swath Dimen-sions	Distance Be-tween Swaths	Samp-ling Area	Con-version Factor	Dry Matter Yield	Average Dry Matter Yield	Crude Protein	Average Crude Protein	Standard Deviation Crude Protein	Co-efficient of Variation Crude Protein	Nitrate Ion	Nitrogen Har-vested	Average Nitrogen Har-vested
		lbs	%	lbs	8.5 x 5 ft	5 ft	ft^2	no. of sample areas/acre	tons/ acre	tons/ acre	%	%	%	%	%	lbs/ acre	lbs/ acre
DOE 139	10/10/2007	1	12.67	0.13				10,890	0.69		25.3					55.9	
DOE 140	10/10/2007	1.2*	10.59	0.13				10,890	0.69	0.71	26.2				0.89	58.0	60
DOE 141	10/10/2007	1.1*	15.27	0.17				10,890	0.91		26.2					76.7	
DOE 142	10/10/2007	0.7*	17.07	0.12				10,890	0.65		26.2					54.5	
DOE 143	10/10/2007	1.15*	13.72	0.16				10,890	0.86		26.2					72.0	
DOE 144	10/10/2007	0.6*	13.58	0.08				10,890	0.44		26.2					37.2	
DOE 145	5/9/2008	1.9	18.41	0.35				10,890	1.90	1.87	17.5				0.12	106.6	105
DOE 146	5/9/2008	2.1	17.87	0.38				10,890	2.04		17.5					114.4	
DOE 147	5/9/2008	1.7	19.26	0.33				10,890	1.78		17.5					99.8	
DOE 148	5/9/2008	2.05	17.05	0.35				10,890	1.90		17.5					106.6	
DOE 149	5/9/2008	2.25	14.02	0.32				10,890	1.72		17.5					96.2	
DOE 150	5/9/2008	2.35	17.16	0.40				10,890	2.20	2.14	18.4				0.18	129.3	126
DOE 151	5/9/2008	2.05	17.62	0.36				10,890	1.97		18.4					115.8	
DOE 152	5/9/2008	2.25	19.87	0.45				10,890	2.43		18.4					143.3	
DOE 153	5/9/2008	1.95	16.82	0.33				10,890	1.79		18.4					105.2	
DOE 154	5/9/2008	2.25	18.99	0.43				10,890	2.33		18.4					137.0	
DOE 155	6/16/2008	1.6	14.91	0.24				10,890	1.30	1.14	21.3				0.95	88.5	78
DOE 156	6/16/2008	1	20.21	0.20				10,890	1.10		21.3					75.0	
DOE 157	6/16/2008	1.15	17.83	0.21				10,890	1.12		21.3					76.1	
DOE 158	6/16/2008	1.25	16.66	0.21				10,890	1.13		21.3					77.3	
DOE 159	6/16/2008	1.15	17.15	0.20				10,890	1.07		21.3					73.2	
DOE 160	6/16/2008	1.4	16.32	0.23				10,890	1.24	1.21	22.2				0.87	88.4	86
DOE 161	6/16/2008	1.75	22.96	0.40				10,890	2.19		22.2					155.4	
DOE 162	6/16/2008	0.6	19.36	0.12				10,890	0.63		22.2					44.9	
DOE 163	6/16/2008	1.1	17.94	0.20				10,890	1.07		22.2					76.3	
DOE 164	6/16/2008	1.1	15.14	0.17				10,890	0.91		22.2					64.4	
DOE 165	7/21/2008	1.1	13.99	0.15				10,890	0.84	1.01	21.7				0.62	58.2	70
DOE 166	7/21/2008	0.7	20.94	0.15				10,890	0.80		21.7					55.4	

Sample	Date	Wet Weight	Dry Matter	Dry Weight	Swath Dimen-sions	Distance Be-tween Swaths	Samp-ling Area	Con-version Factor	Dry Matter Yield	Average Dry Matter Yield	Crude Protein	Average Crude Protein	Standard Deviation Crude Protein	Co-efficient of Variation Crude Protein	Nitrate Ion	Nitrogen Har-vested	Average Nitrogen Har-vested
		lbs	%	lbs	8.5 x 5 ft	5 ft	ft^2	no. of sample areas/acre	tons/ acre	tons/ acre	%	%	%	%	%	lbs/ acre	lbs/ acre
DOE 167	7/21/2008	1.15	20.73	0.24				10,890	1.30		21.7					90.1	
DOE 168	7/21/2008	1.05	17.40	0.18				10,890	0.99		21.7					69.1	
DOE 169	7/21/2008	1.1	18.44	0.20				10,890	1.10		21.7					76.7	
DOE 170	7/21/2008	1.5	14.31	0.21				10,890	1.17	1.10	19.3				0.42	72.2	68
DOE 171	7/21/2008	0.85	21.37	0.18				10,890	0.99		19.3					61.1	
DOE 172	7/21/2008	1.15	22.01	0.25				10,890	1.38		19.3					85.1	
DOE 173	7/21/2008	0.95	19.06	0.18				10,890	0.99		19.3					60.9	
DOE 174	7/21/2008	0.8	22.58	0.18				10,890	0.98		19.3					60.7	
DOE 175	9/2/2008	1	10.43	0.10				10,890	0.57	0.95	24.4				0.12	44.3	74
DOE 176	9/2/2008	1.6	12.55	0.20				10,890	1.09		24.4					85.4	
DOE 177	9/2/2008	1.75	10.71	0.19				10,890	1.02		24.4					79.7	
DOE 178	9/2/2008	1.25	10.92	0.14				10,890	0.74		24.4					58.0	
DOE 179	9/2/2008	1.8	13.55	0.24				10,890	1.33		24.4					103.7	
DOE 180	9/2/2008	1.55	11.76	0.18				10,890	0.99	0.79	23.5				0.16	74.6	59
DOE 181	9/2/2008	1.25	10.52	0.13				10,890	0.72		23.5					53.8	
DOE 182	9/2/2008	1.15	13.67	0.16				10,890	0.86		23.5					64.4	
DOE 183	9/2/2008	0.95	10.72	0.10				10,890	0.55		23.5					41.7	
DOE 184	9/2/2008	1.6	9.41	0.15				10,890	0.82		23.5					61.6	
DOE 185	10/21/2008	9.2	16.83	1.55	40		72.5	601	0.47	0.78	23.7				0.6	35.3	59
DOE 186	10/21/2008	19.35	18.01	3.49	40		72.5	601	1.05		23.7					79.4	
DOE 187	10/21/2008	11.5	23.14	2.66	40		72.5	601	0.80		23.7					60.7	
DOE 188	10/21/2008	11.75	17.52	2.06	40		72.5	601	0.62		23.7					46.9	
DOE 189	10/21/2008	16.15	19.53	3.15	40		72.5	601	0.95		23.7					71.9	
DOE 190	10/21/2008	14.15	16.00	2.26	40		72.5	601	0.68	0.75	25.8				0.61	56.2	62
DOE 191	10/21/2008	14.25	15.03	2.14	40		72.5	601	0.64		25.8					53.1	
DOE 192	10/21/2008	19.35	19.51	3.77	40		72.5	601	1.13		25.8					93.7	
DOE 193	10/21/2008	9.8	17.89	1.75	40		72.5	601	0.53		25.8					43.5	
DOE 194	10/21/2008	14.55	17.51	2.55	40		72.5	601	0.77		25.8					63.2	

* Relative standard deviation (RSD) exceeded 10% ^ Dry weight values used in calculations were greater than 10%.

Appendix O. Grain Size Data from Monitoring Well Drilling Samples

State of Washington Department of Ecology
Manchester Environmental Laboratory
7411 Beach Drive East
Port Orchard WA. 98366

June 21, 2005

Project: Manure as Fertilizer

Samples: 18-4080-94

Laboratory: Analytical Resources, Inc.

By: Pam Covey

Case Summary

The sediment samples required Grain Size analyses using the ASTM D 422 method. The samples were received at the Manchester Environmental Laboratory and shipped to the contract lab on May 10, 2005 for Grain Size analyses. One sample was analyzed in triplicate and was within the QA limits.

The analyses were reviewed for qualitative and quantitative accuracy, validity and usefulness.

If you have any questions, please call me at 360-871-8827.

1 of 1

Analytical Resources, Incorporated
Analytical Chemists and Consultants

Client: Dept. of Ecology	Project No.: IA93
Client Project: Manure as Fertilizer	

Case Narrative

1. The samples were submitted for grain size analysis according to ASTM methodology. Three samples were to be run for full sieve and hydrometer analysis and the rest for sieve only. A fourth sample was run for hydrometer by mistake.
2. The samples were run in batches, the sieve only samples were run together and the hydrometers were run together. One sample was selected for triplicate analysis by Ecology. The triplicate data is reported on the QA summary.
3. The samples were run according to ASTM D422, with an extra #140 sieve inserted into the sieve stack.
4. The data is provided in summary tables.
5. There were no other noted anomalies in the samples or methods on this project.

Approved by: Harold Berry Date: 6/1/05
Title: Geotechnical Division Manager

4611 South 134th Place, Suite 100 • Tukwila WA 98168 • **206-695-6200** • **206-695-6201** fax

ANALYTICAL RESOURCES INCORPORATED

Washington State Dept. of Ecology
Manure as Fertilizer

Percent Retained in Each Size Fraction

Description	% Gravel	% Coarse Sand	% Medium Sand	% Fine Sand	% Very Coarse Silt	% Coarse Silt	% Medium Silt	% Fine Silt	% Fine Silt	% Very Fine Silt	% Clay
Particle Size (microns)	> 4750	4750-2000	2000-425	425-75	75-32	32-22	22-13	13-9	9-7	7-3.2	<3.2
184080	2.0	0.5	20.5	71.3	5.6						
184081	0.1	0.0	8.1	86.3	5.5						
184082	0.4	6.3	36.8	26.7	29.8						
184083	0.0	0.0	3.0	30.0	20.6	8.7	5.8	4.4	2.9	4.4	20.3
184084	0.0	0.1	5.0	85.2	9.7						
184085	0.0	0.1	0.3	22.6	9.8	4.5	9.0	5.2	5.2	9.0	34.4
184086	0.0	0.9	30.6	59.3	9.2						
184087	14.5	8.5	46.7	25.9	4.4						
184088	0.9	3.8	12.0	29.5	53.8						
184089	0.1	0.2	10.0	82.3	7.4						
184090	0.0	0.1	15.1	79.9	5.0						
184091	0.7	0.2	3.1	92.8	3.2						
184092A	0.0	0.0	0.1	1.9	18.8	9.3	11.0	6.7	5.9	11.0	35.4
184092B	0.0	0.0	0.1	3.2	16.1	9.9	11.6	7.2	9.0	9.0	34.0
184092C	0.0	0.0	0.2	2.7	17.7	9.0	11.7	7.2	6.3	10.8	34.3
184093	0.0	0.0	0.6	62.5	14.3	1.3	2.7	1.3	1.3	2.0	14.0
184094	0.3	0.2	5.7	85.8	8.0						

Key to description (Lab No.) and monitoring well ID's.

Lab No.	Well	Depth (ft)
184082	AKG721	2.5-4
184083	AKG721	5-6.5
184084	AKG721	10-11.5
184080	AKG722	5-6.5
184081	AKG722	10-11.5
184085	AKG723	2.5-4
184086	AKG723	10-11.5
184087	AKG724	7.5-9
184088	AKG725	2.5-4
184089	AKG725	7.5-9
184090	AKG726	15-16.5
184091	AKG726	25-26.5
184092	AKG726	40-41.5
184093	AKG727	2.5-4
184094	AKG727	10-11.5

IA93

ANALYTICAL RESOURCES INCORPORATED

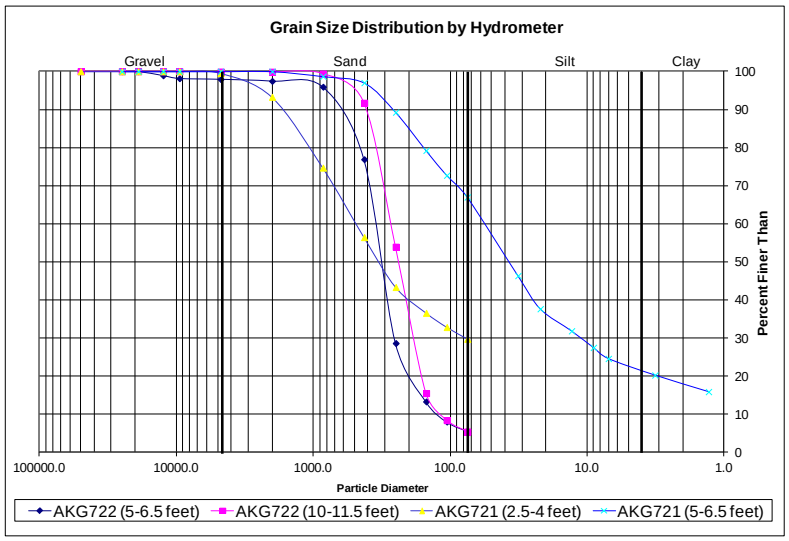
PROJECT:	Washington State Dept. of Ecology	Project No.:	Manure as Fertilizer
ARI Triplicate Sample ID:	IA93M	Batch No.:	IA93 -01
Client Triplicate Sample ID:	184092	Page:	1 of 1

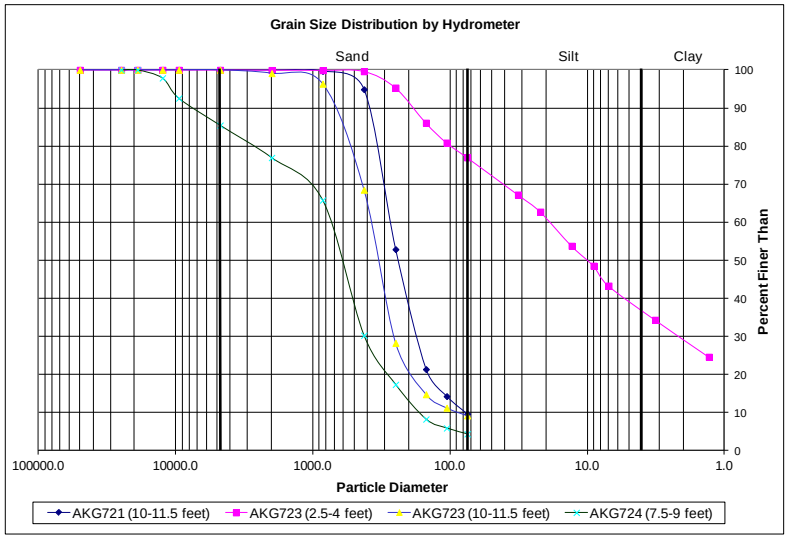
Relative Standard Deviation, By Size

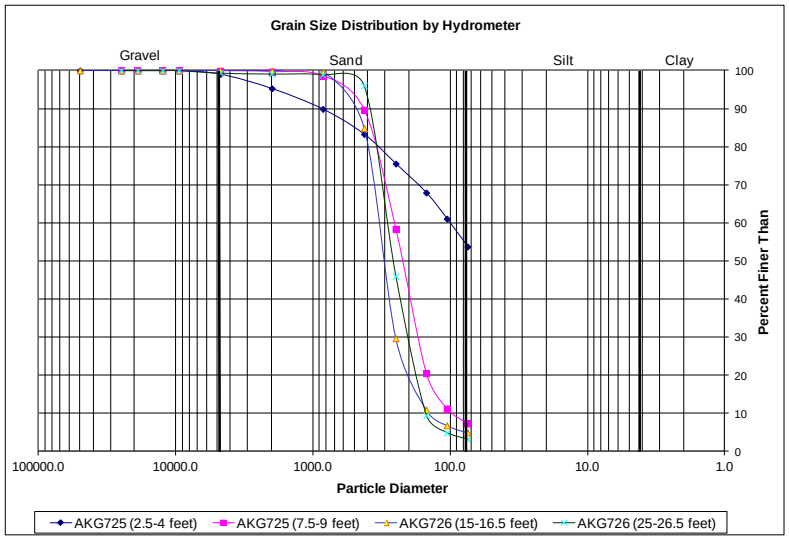
Sample ID	4750	2000	850	425	250	150	106	75	32	22	13	9	7	3.2	1.3
184092A	100.0	100.0	100.0	99.9	99.2	98.5	98.2	98.1	79.3	70.0	59.0	52.3	46.4	35.4	24.5
184092B	100.0	100.0	100.0	99.9	98.5	97.3	96.9	96.7	80.6	70.8	59.1	52.0	43.0	34.0	24.2
184092C	100.0	100.0	100.0	99.8	98.6	97.7	97.3	97.1	79.4	70.4	58.7	51.5	45.1	34.3	24.4
AVE	100.00	100.00	100.00	99.87	98.76	97.82	97.49	97.29	79.77	70.39	58.94	51.89	44.84	34.58	24.34
STDEV	0.00	0.00	0.00	0.07	0.35	0.63	0.68	0.70	0.74	0.39	0.23	0.41	1.71	0.73	0.14
%RSD	0.00	0.00	0.00	0.07	0.35	0.65	0.70	0.72	0.92	0.56	0.39	0.80	3.81	2.11	0.56

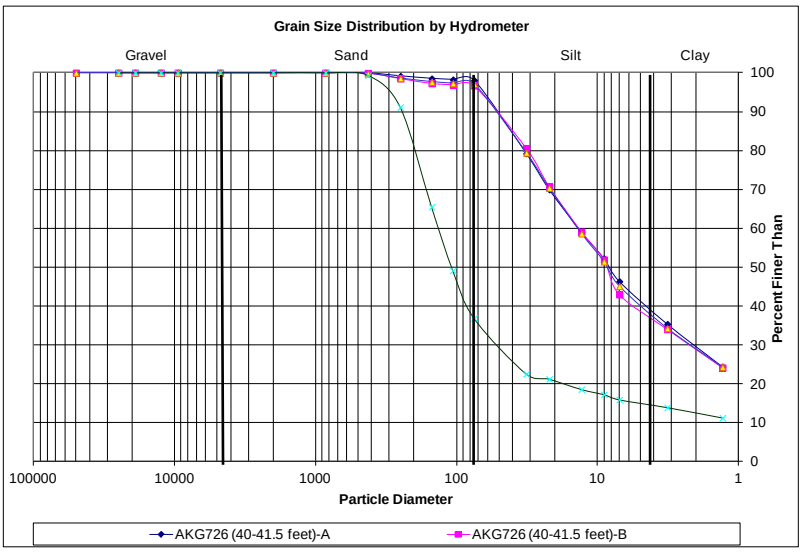
This Triplicate applies to the Batch Containing the Following Samples

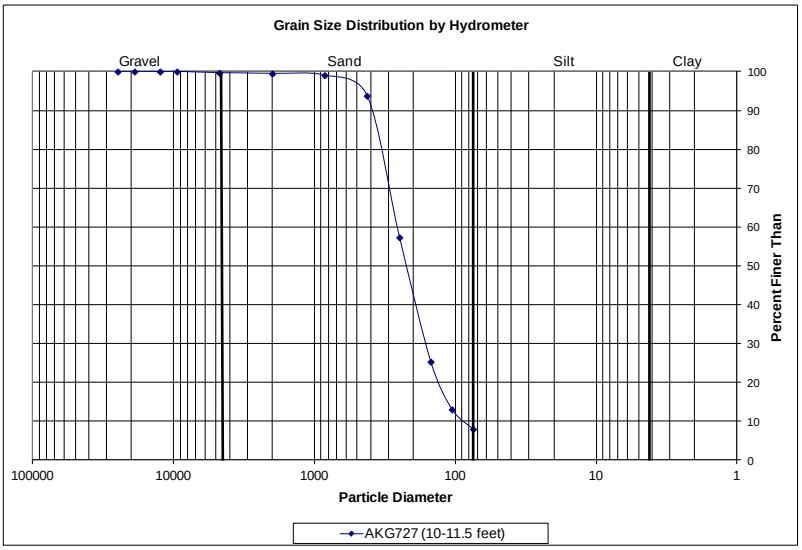
Sample ID	Date Sampled	Date Set up	Date Started	Date Complete	Data Qualifiers
184080	NA	5/13/05	5/19/05	5/23/05	
184081	NA	5/13/05	5/19/05	5/23/05	
184082	NA	5/13/05	5/19/05	5/23/05	
184083	NA	5/16/05	5/19/05	5/23/05	
184084	NA	5/13/05	5/19/05	5/23/05	
184085	NA	5/16/05	5/19/05	5/23/05	
184086	NA	5/13/05	5/19/05	5/23/05	
184087	NA	5/13/05	5/19/05	5/23/05	
184088	NA	5/13/05	5/19/05	5/23/05	
184089	NA	5/13/05	5/19/05	5/23/05	
184090	NA	5/13/05	5/19/05	5/23/05	
184091	NA	5/13/05	5/19/05	5/23/05	
184092A	NA	5/16/05	5/19/05	5/23/05	
184092B	NA	5/17/05	5/19/05	5/23/05	
184092C	NA	5/17/05	5/19/05	5/23/05	
184093	NA	5/16/05	5/19/05	5/23/05	
184094	NA	5/13/05	5/19/05	5/23/05	


Grain Size Distribution by Hydrometer
Gravel
Sand
Silt
Clay
100
90
80
70
60
50
40
30
20
10
0
Percent Finer Than
100000.0
10000.0
1000.0
100.0
10.0
1.0
Particle Diameter
AKG722 (5-6.5 feet)
AKG722 (10-11.5 feet)
AKG721 (2.5-4 feet)
AKG721 (5-6.5 feet)


Grain Size Distribution by Hydrometer
Sand
Silt
Clay
100
90
80
70
60
50
40
30
20
10
0
Percent Finer Than
100000.0
10000.0
1000.0
100.0
10.0
1.0
Particle Diameter
AKG721 (10-11.5 feet)
AKG723 (2.5-4 feet)
AKG723 (10-11.5 feet)
AKG724 (7.5-9 feet)


Grain Size Distribution by Hydrometer
Gravel
Sand
Silt
Clay
100
90
80
70
60
50
40
30
20
10
0
Percent Finer Than
100000.0
10000.0
1000.0
100.0
10.0
1.0
Particle Diameter
AKG725 (2.5-4 feet)
AKG725 (7.5-9 feet)
AKG726 (15-16.5 feet)
AKG726 (25-26.5 feet)


Grain Size Distribution by Hydrometer
Gravel
Sand
Silt
Clay
100
90
80
70
60
50
40
30
20
10
0
Percent Finer Than
100000
10000
1000
100
10
1
Particle Diameter
AKG726 (40-41.5 feet)-A
AKG726 (40-41.5 feet)-B


Grain Size Distribution by Hydrometer
Gravel
Sand
Silt
Clay
100
90
80
70
60
50
40
30
20
10
0
Percent Finer Than
100000
10000
1000
100
10
1
Particle Diameter
AKG727 (10-11.5 feet)

Appendix P. Data and Spreadsheet Results for the Bradbury and Rothschild (1985) Method Using Specific Capacity for Monitoring Wells on April 4, 2006

	Field Data							Estimated Parameters			Calculated Results						
		Depth to Water				Screened Interval											
Location	Well Diam.	Initial	Final	Test Duration	Mean Pumping Rate	Depth to Top	Depth to Bottom	Storage Coeff. (S)	Well Loss Coeff. (C)	Aquifer Thick-ness (b)	Mea-sured Draw-down (s_m)	Saturated Screen Length (L)	Well Loss (s_w)	Partial Pene-tration Parameter (s_p)	Specific Capa-city	**Trans-missivity (T)**	**Conduc-tivity (K)**
	inches	feet	feet	hours	gpm	feet	feet	-	sec^2/ ft^5	feet	feet	feet	feet	-	gpm/ft	**sq ft/sec**	**ft/sec**
AKG-726	2	8.77	8.98	0.4	1.0	28.0	38.0	0.15	0	35	0.21	10.0	0.0E+00	10.93	4.76	**2.8E-02**	**8.02E-04**
AKG-726	2	8.77	8.98	0.4	1.0	28.0	38.0	0.20	0	35	0.21	10.0	0.0E+00	10.93	4.76	**2.8E-02**	**7.95E-04**
AKG-726	2	8.77	8.98	0.4	1.0	28.0	38.0	0.25	0	35	0.21	10.0	0.0E+00	10.93	4.76	**2.8E-02**	**7.90E-04**
AKG-725	2	8.72	8.78	0.25	0.11	6.0	13.0	0.15	0	35	0.06	4.3	0.0E+00	27.49	1.83	**2.1E-02**	**6.10E-04**
AKG-725	2	8.72	8.78	0.25	0.11	6.0	13.0	0.20	0	35	0.06	4.3	0.0E+00	27.49	1.83	**2.1E-02**	**6.07E-04**
AKG-725	2	8.72	8.78	0.25	0.11	6.0	13.0	0.25	0	35	0.06	4.3	0.0E+00	27.49	1.83	**2.1E-02**	**6.05E-04**
AKG-723	2	7.98	8.06	0.25	0.11	5.7	12.7	0.15	0	35	0.08	4.7	0.0E+00	24.95	1.38	**1.5E-02**	**4.19E-04**
AKG-723	2	7.98	8.06	0.25	0.11	5.7	12.7	0.20	0	35	0.08	4.7	0.0E+00	24.95	1.38	**1.5E-02**	**4.17E-04**
AKG-723	2	7.98	8.06	0.25	0.11	5.7	12.7	0.25	0	35	0.08	4.7	0.0E+00	24.95	1.38	**1.5E-02**	**4.16E-04**

See Appendix H for equations used in the spreadsheet.

Appendix Q. Water Level Data

Table Q.1. Water table elevations in feet assuming the elevation of the top of casing at AKG721 is 134.00 feet (NAVD88).

	Well ID						
Date	AKG721	AKG722	AKG723	AKG724	AKG725	AKG726	AKG727
8/26/2004	123.27	122.44	121.11				
8/27/2004				120.72	122.15	122.07	122.25
9/20/2004		122.60			122.20	122.11	123.30
9/21/2004	123.19		121.37	121.32			
10/18/2004	123.58	123.17		122.5			123.75
10/19/2004			122.10		122.74	122.63	
11/22/2004	126.88	126.45		124.95			127.07
11/23/2004			124.94		125.77	125.71	
12/28/2004	130.48	129.10	127.27	126.78	128.74	128.63	130.12
2/1/2005	130.38	128.61	126.49	127.17	128.19	128.11	129.79
3/2/2005	126.59	125.75	124.12	124.04	125.32	125.22	126.45
3/30/2005	129.05	128.39	125.91	126.17			127.89
3/31/2005					126.98	126.94	
4/25/2005	127.49	126.53		124.43			127.29
4/26/2005			124.76		125.96	125.90	
5/25/2005	125.36	124.54		122.81			125.34
5/26/2005			122.87		124.03	123.95	
7/6/2005	124.44	123.63					124.41
7/7/2005			122.11	122.10	123.12	123.03	
8/16/2005	123.72		121.58	121.41			123.75
8/17/2005		122.96			122.56	122.44	
9/22/2005	123.43				122.27	122.17	
9/21/2005		122.68	121.37	121.26			123.39
10/19/2005	123.45	122.82		121.85			123.48
10/20/2005			121.61		122.37	122.28	
11/17/2005		124.73	123.75	123.69			
11/16/2005	125.26				124.32	124.21	125.31
12/14/2005	125.55	124.55		122.94			125.36
12/15/2005			123.15		124.15	124.08	
1/10/2006	132.75						
1/11/2006		NA	129.64	128.43	127.2	127.11	NA
2/7/2006	131.26	129.29	127.66	126.83			130.35
2/8/2006					129.02	128.86	
3/7/2006	126.07	124.95	123.43	123.06			123.80
3/8/2006					124.69	124.58	
4/4/2006	125.37	124.34	122.86	122.64			125.16
4/5/2006					124.01	123.95	
5/17/2006		123.70	NA	122.08			124.50
5/18/2006	124.64				123.35	123.23	
6/26/2006	123.94	123.09		121.61			123.86
6/27/2006			121.71		122.69	122.57	

Date	Well ID						
	AKG721	AKG722	AKG723	AKG724	AKG725	AKG726	AKG727
8/2/2006	123.37	122.59		121.02	122.22		123.32
8/3/2006			121.19			122.09	
9/13/2006	122.92	122.11			121.78		122.78
9/14/2006			120.84	120.61		121.67	
10/18/2006	122.63	121.79			121.52		122.48
10/19/2006			120.71	120.47		121.43	
11/14/2006	124.17	123.26	122.79	123.06			124.14
11/15/2006					123.19	123.11	
12/12/2006	129.75	128.35	126.93	126.47			129.49
12/13/2006					128.84	128.66	
1/17/2007	128.77	126.77		124.42			127.93
1/18/2007			125.09		126.49	126.35	
2/12/2007	126.86	125.62	124.21	123.66			126.48
2/13/2007					125.37	125.23	
3/28/2007	131.52	129.16	128.22	126.88			130.12
3/29/2007					129.49	129.29	
5/14/2007	125.62		122.98	122.56	124.19	NA	125.30
5/15/2007		124.37					
6/13/2007	124.73	123.59					124.46
6/14/2007			122.23	121.92	123.33	123.21	
7/30/2007	123.78	122.74	121.51	121.24	122.52	122.39	123.52
9/2/2007	123.23	122.31	121.10	120.88	122.04	121.92	123.04
10/1/2007	122.95	122.12	121.02	120.91			122.75
10/2/2007					121.89	121.77	
10/30/2007	124.12	123.41		122.34	123.11		124.02
10/31/2007			122.53			123.01	
11/27/2007	124.97	123.99	122.94	123.12			124.68
11/28/2007					123.77	123.65	
1/3/2008	129.82	127.78		125.44			128.97
1/4/2008			125.99		127.56	127.44	
1/30/2008	126.99	125.78	124.38	123.76			126.53
1/31/2008					125.69	125.54	
2/27/2008	126.58	125.37	124.00	123.42			126.16
2/28/2008					125.18	125.03	
4/1/2008	126.67	125.38		123.64			126.28
4/2/2008			123.95		125.09	124.98	
5/6/2008	125.23	124.00	NA	122.30		123.61	124.88
5/7/2008					123.77	9.07	
6/18/2008	124.80	123.80		122.23	123.46		124.57
6/19/2008			122.48			123.33	
7/22/2008	124.24	123.28	121.91			122.85	124.10
7/23/2008				121.51	122.96	9.83	
9/8/2008	124.07	123.14	121.9	121.63		NA	123.88
9/9/2008					122.85		
10/7/2008	123.61	122.68	121.46	121.25			123.41
10/8/2008					122.40	122.25	
11/12/2008	126.49	127.71				NA	128.21

Date	Well ID						
	AKG721	AKG722	AKG723	AKG724	AKG725	AKG726	AKG727
11/13/2008			126.65	126.49	126.92		
12/9/2008	127.93	126.55	125.08		126.26		127.49
12/10/2008				124.92		126.13	
3/18/2009	126.37	125.29	123.96	124.04	124.99	124.87	126.29

Table Q.2. Depth-to-water measurements from the top of the casing in feet.

	Well ID						
Date	AKG721	AKG722	AKG723	AKG724	AKG725	AKG726	AKG727
8/26/2004	10.73	8.36	9.73				
8/27/2004				8.25	10.58	10.61	9.18
9/20/2004		8.20			10.53	10.57	8.13
9/21/2004	10.81		9.47	7.65			
10/18/2004	10.42	7.63		6.47			7.68
10/19/2004			8.74		9.99	10.05	
11/22/2004	7.12	4.35		4.02			4.36
11/23/2004			5.90		6.96	6.97	
12/28/2004	3.52	1.70	3.57	2.19	3.99	4.05	1.31
2/1/2005	3.62	2.19	4.35	1.80	4.54	4.57	1.64
3/2/2005	7.41	5.05	6.72	4.93	7.41	7.46	4.98
3/30/2005	4.95	2.41	4.93	2.80			3.54
3/31/2005					5.75	5.74	
4/25/2005	6.51	4.27		4.54			4.14
4/26/2005			6.08		6.77	6.78	
5/25/2005	8.64	6.26	7.97	6.16			6.09
5/26/2005			7.97		8.70	8.73	
7/6/2005	9.56	7.17					7.02
7/7/2005			8.73	6.87	9.61	9.65	
8/16/2005	10.28		9.26	7.56			7.68
8/17/2005		7.84			10.17	10.24	
9/22/2005	10.57				10.46	10.51	
9/21/2005		8.12	9.47	7.71			8.04
10/19/2005	10.55	7.98		7.12			7.95
10/20/2005			9.23		10.36	10.40	
11/17/2005		6.07	7.09	5.28			
11/16/2005	8.74				8.41	8.47	6.12
12/14/2005	8.45	6.25		6.03			6.07
12/15/2005			7.69		8.58	8.60	
1/10/2006	1.25		1.20	0.51			
1/11/2006			1.25	0.54	1.77	1.86	NA
2/7/2006	2.74	1.51	3.18	2.14			1.08
2/8/2006					3.71	3.82	
3/7/2006	7.93	5.85	7.41	5.91			7.63
3/8/2006					8.04	8.10	
4/4/2006	8.63	6.46	7.98	6.33			6.27
4/5/2006					8.72	8.73	
5/17/2006		7.10	NA	6.89			6.93
5/18/2006	9.36				9.38	9.45	
6/26/2006	10.06	7.71		7.36			7.57
6/27/2006			9.13		10.04	10.11	
8/2/2006	10.63	8.21		7.95	10.51		8.11
8/3/2006			9.65			10.59	
9/13/2006	11.08	8.69			10.95		8.65
9/14/2006			10.00	8.36		11.01	
10/18/2006	11.37	9.01			11.21		8.95

Date	Well ID						
	AKG721	AKG722	AKG723	AKG724	AKG725	AKG726	AKG727
10/19/2006			10.13	8.50		11.25	
11/14/2006	9.83	7.54	8.05	5.91			7.29
11/15/2006					9.54	9.57	
12/12/2006	4.25	2.45	3.91	2.50			1.94
12/13/2006					3.89	4.02	
1/17/2007	5.23	4.03		4.55			3.50
1/18/2007			5.75		6.24	6.33	
2/12/2007	7.14	5.18	6.63	5.31			4.95
2/13/2007					7.36	7.45	
3/28/2007	2.48	1.64	2.62	2.09			1.31
3/29/2007					3.24	3.39	
5/14/2007	8.38		7.86	6.41	8.54	NA	6.13
5/15/2007		6.43					
6/13/2007	9.27	7.21					6.97
6/14/2007			8.61	7.05	9.40	9.47	
7/30/2007	10.22	8.06	9.33	7.73	10.21	10.29	7.91
9/2/2007	10.77	8.49	9.74	8.09	10.69	10.76	8.39
10/1/2007	11.05	8.68	9.82	8.06			8.68
10/2/2007					10.84	10.91	
10/30/2007	9.88	7.39		6.63	9.62		7.41
10/31/2007			8.31			9.67	
11/27/2007	9.03	6.81	7.90	5.85			6.75
11/28/2007					8.96	9.03	
1/3/2008	4.18	3.02		3.53			2.46
1/4/2008			4.85		5.17	5.24	
1/30/2008	7.01	5.02	6.46	5.21			4.90
1/31/2008					7.04	7.14	
2/27/2008	7.42	5.43	6.84	5.55			5.27
2/28/2008					7.55	7.65	
4/1/2008	7.33	5.42		5.33			5.15
4/2/2008			6.89		7.64	7.70	
5/6/2008	8.77	6.80	NA	6.67			6.55
5/7/2008					8.96	9.07	
6/18/2008	9.20	7.00		6.74	9.27		6.86
6/19/2008			8.36			9.35	
7/22/2008	9.76	7.52	8.93				7.33
7/23/2008				7.46	9.77	9.83	
9/8/2008	9.93	7.66	8.94	7.34			7.55
9/9/2008					9.88		
10/7/2008	10.39	8.12	9.38	7.72			8.02
10/8/2008					10.33	10.43	
11/12/2008	7.51	3.09					3.22
11/13/2008			4.19	2.48	5.81		
12/9/2008	6.07	4.25	5.76		6.47		3.94
12/10/2008				4.05		6.55	
3/18/2009	7.63	5.51	6.88	4.93			5.14
3/19/2009					7.74	7.81	

Appendix R. Groundwater Quality Results

Table R.1. Groundwater quality results from monitoring wells.

Field Measurements							Laboratory Analyses[1]																	
Well Tag Number	Sample Date	Depth to Groundwater (ft below top of casing)	Temp-erature (C0)	pH (Standard Units)	Dissolved Oxygen (mg/L)	Conductivity (umhos/cm)	Ammonia-N (mg/L)		Nitrite+ Nitrate-N (mg/L)		Total Persulfate N (mg/L)		Ortho Phosphorus (mg/L)		Total Phosphorus (mg/L)		Chloride (mg/L)	Total Dissolved Solids (mg/L)		Organic Carbon (mg/L)	
AKG-721	8/27/04	10.73																			
AKG-721	9/21/04	10.81	12.7	5.61	9.40	302	0.010	U	17.7		18.4		0.0047		0.0023	P	12.9	224	J	1.1	
AKG-721	10/18/04	10.42	12.5	--	7.80	250	0.017		14.5		14.0		0.0050		0.0020	UP	10.5	196		1.0	U
AKG-721	11/22/04	7.12	12.1	5.70	7.02	338	0.010	U	22.6		23.5		0.0045		0.0025		16.6	217		1.5	
AKG-721	12/28/04	3.52	10.7	5.78	8.80 P	334	0.010	U	21.2		20.9		0.0080		0.0038		14.4	210	J	1.4	
AKG-721	2/1/05	3.62	9.7	5.69	10.3	368	0.010	U	24.2		22.4		0.0070		0.0054		15.5	251		1.9	
AKG-721	3/2/05	7.41	9.4	5.61	8.08	386	0.010	U	25.8		25.3		0.0066		0.0045		19.1	268		1.3	
AKG-721	3/30/05	4.95	10.4	5.72	8.80	367	0.010	U	24.7		23.8		0.0076		0.0061	P	17.4	252		7.1	
AKG-721	4/25/05	6.51	10.5	5.70	9.18	338	0.010	U	22.6		19.8		--		0.0061	P	14.8	245		1.3	
AKG-721	5/25/05	8.64	11.0	5.67	8.30	350	0.010	U	21.7		22.9		--		0.0061	P	16.0	275		3.3	J
AKG-721	7/6/05	9.56	11.6	5.61	7.02	367	0.010	U	24.1		23.3		--		0.0067		16.7	277		2.3	
AKG-721	8/16/05	10.28	12.6	5.77	7.81	359	0.010	U	25.3		24.6		--		0.0033		15.6	268		1.9	
AKG-721	9/21/05	10.57	12.1	5.48	6.85	370	0.010	U	27.1		25.8		--		0.0038	P	16.0	262		1.4	
AKG-721	10/19/05	10.55	12.2	5.73	6.87	418	0.010	U	28.3		27.0		--		0.0040	P	19.1	284		2.3	
AKG-721	11/17/05	8.74	12.5	5.63	5.60	372	0.010	U	24.9		26.1		--		0.0041		17.0	264		1.2	
AKG-721	12/14/05	8.45	11.0	5.59	6.98	307	0.010	U	16.9		15.9		--		0.0065		11.0	229		1.5	
AKG-721	1/10/06	1.25	--	5.86	--	--	0.010	U	11.5		10.9		--		0.0078		7.97	194		2.1	
AKG-721	2/7/06	2.74	9.5	5.79	6.56	252	0.010	U	12.4		12.0		--		0.0095		7.63	187	P	2.1	
AKG-721	3/7/06	7.93	9.2	5.67	8.90	264	0.010	U	12.7		12.3		--		0.0097		8.10	187		1.7	
AKG-721	4/4/06	8.63	10.3	5.84	8.00	245	0.010	U	13.8		11.9		--		0.0050	U	7.84	172		1.6	
AKG-721	5/17/06	9.36	10.2	5.76	8.85	260	0.012	UJ	11.4		11.2		--		0.0050	U	8.28	187		1.2	
AKG-721	6/26/06	10.06	11.5	5.78	7.68	250	0.010	U	10.7		10.6		--		0.0075		8.59	195		1.5	

Field Measurements							Laboratory Analyses[1]																	
Well Tag Number	Sample Date	Depth to Groundwater (ft below top of casing)	Temp-erature (C0)	pH (Standard Units)	Dissolved Oxygen (mg/L)	Conductivity (umhos/cm)	Ammonia-N (mg/L)		Nitrite+ Nitrate-N (mg/L)		Total Persulfate N (mg/L)		Ortho Phosphorus (mg/L)		Total Phosphorus (mg/L)		Chloride (mg/L)		Total Dissolved Solids (mg/L)		Organic Carbon (mg/L)	
AKG-721	8/2/06	10.63	11.9	5.61	7.60 P	264	0.010	U	10.9		12.7		--		0.0047		10.4		197		1.5	
AKG-721	9/13/06	11.08	11.8	5.69	10.54 P	252	0.010	U	12.2		12.6		--		0.0049		9.18		222		1.4	
AKG-721	10/18/06	11.37	12.1	5.80	6.85	244	0.010	U	12.6		11.7		--		0.0045		7.87		169		3.3	
AKG-721	11/14/06	9.83	11.6	5.88	7.30	243	0.010	U	10.7	P	11.1	P	--		0.0063	P	7.52		154		2.3/3.2	JP
AKG-721	12/12/06	4.25	11.0	5.82	7.95 P	249	0.010	U	12.3		11.1		--		0.0079	P	8.98 P		185		1.4	P
AKG-721	1/17/07	5.23	8.9	5.80	10.01 P	257	0.010	U	11.8		12.2		--		--		7.59		174		1.8	
AKG-721	2/12/07	7.14	9.0	5.91	8.29 P	240	0.010	U	9.92		9.90		--		--		7.09		160		1.6	
AKG-721	3/28/07	2.48	8.4	5.98	8.43 P	228	0.010	U	7.78		7.65		--		--		4.22		156		2.0	
AKG-721	5/14/07	8.38	10.8	5.87	9.47	221	0.010	U	7.37		7.29		--		--		5.73		143		1.6	
AKG-721	6/13/07	9.27	10.5	5.90	8.56	232	0.010	U	7.53		7.97	P	--		--		6.68		157		1.5	
AKG-721	7/30/07	10.22	11.8	5.92	7.23 P	244	0.010	U	10.2		10.7		--		--		9.14		171		1.5	
AKG-721	9/2/07	10.77	12.0	5.75	8.24	250	0.010	U	12.1	P	12.0		--		--		9.89		181		1.5	
AKG-721	10/1/07	11.05	11.9	5.75	7.05	268	0.010	U	12.8		13.5		--		--		10.2		200		1.5	
AKG-721	10/30/07	9.88	12.0	5.76	7.94	260	0.010	U	11.6		11.5		--		--		9.11		178		1.4	
AKG-721	11/27/07	9.03	11.1	5.89	8.31	250	0.010	U	10.2		10.3		--		--		6.04		158		1.6	
AKG-721	1/3/08	4.18	9.1	5.92	8.51	220	0.010	U	7.51		8.13		--		--		4.93 P		146		1.9	
AKG-721	1/30/08	7.01	8.0	5.86	10.0	229	0.010	U	8.01		9.08		--		--		5.79		153		1.7	
AKG-721	2/27/08	7.42	8.6	5.87	8.10	214	0.010	U	6.66		6.93		--		--		4.66		154		1.9	
AKG-721	4/1/08	7.33	8.6	5.91	8.08	207	0.010	U	5.53	P	5.53		--		--		4.29		138		1.7	
AKG-721	5/6/08	8.77	9.0	5.96	8.55	207	0.010	U	6.30		6.51		--		--		5.17		152		1.6	
AKG-721	6/18/08	9.20	10.1	5.82	--	221	0.010	U	7.51		7.99		--		--		6.05		154		1.6	
AKG-721	7/22/08	9.76	11.9	5.75	8.03	226	0.010	U	7.35		7.61		--		--		6.18		147		1.6	
AKG-721	8/26/08	10.18	12.1	5.82	--	210	0.010	U	8.02		8.41		--		--		6.54		156		1.6	
AKG-721	9/8/08	9.93	12.9	5.84	6.49	216	0.010	U	7.82		7.37		--		--		6.39 J		135		1.5	
AKG-721	10/7/08	10.39	12.0	5.86	6.31 P	213	0.010	U	6.44		7.07		--		--		6.67		144		1.5	
AKG-721	11/12/08	7.51	11.6	5.87	7.10 P	204	0.010	U	5.42		5.94		--		--		6.22		136		1.5	

Field Measurements							Laboratory Analyses[1]																	
Well Tag Number	Sample Date	Depth to Groundwater (ft below top of casing)	Temp-erature (C0)	pH (Standard Units)	Dissolved Oxygen (mg/L)	Conductivity (umhos/cm)	Ammonia-N (mg/L)		Nitrite+ Nitrate-N (mg/L)		Total Persulfate N (mg/L)		Ortho Phosphorus (mg/L)		Total Phosphorus (mg/L)		Chloride (mg/L)	Total Dissolved Solids (mg/L)		Organic Carbon (mg/L)				
AKG-721	12/9/08	6.07	10.4	5.90	8.61 P	225	0.010	U	7.37		7.54		--		--		6.53	153		1.9				
AKG-721	3/18/09	7.63	8.3	5.83	6.75	233	0.010	U	8.13		8.17		--		--		6.70	156		1.6				
AKG-722	8/27/04	8.36																						
AKG-722	9/21/04	8.20	13.1	5.50	0.10	334	0.010	U	5.60		5.45		0.0066		0.0076	P	15.7	214		2.6				
AKG-722	10/18/04	7.63	12.6	--	0.36	324	0.014		3.49		4.21		0.0054		0.0023	P	15.2	220	J	2.5				
AKG-722	11/22/04	4.35	11.6	5.47	6.35	397	0.010	U	20.6		22.3		0.0033		0.0034		16.6	250		3.2				
AKG-722	12/28/04	1.70	9.6	5.51	8.30 P	599	0.010	U	45.3		43.7		0.0043		0.0032		30.6	381	J	4.9				
AKG-722	2/1/05	2.19	7.7	5.50	7.50	402	0.010	U	23.6		22.3		0.0030	U	0.0037		16.9	274		6.0				
AKG-722	3/2/05	5.05	8.2	5.35	8.61	248	0.010	U	13.1		13.5		0.0034		0.0037		9.06	183		5.6				
AKG-722	3/30/05	2.41	8.6	5.63	4.58	382	0.010	U	26.3		26.7		0.0037		0.0037	P	18.4	261		3.7				
AKG-722	4/25/05	4.27	10.5	5.70	9.18	338	0.010	U	22.6		19.8		--		0.0061	P	14.8	245		1.3				
AKG-722	5/25/05	6.26	10.8	5.49	5.40	265	0.024		12.7		14.7		--		0.0028		9.57	188		7.1	J			
AKG-722	7/6/05	7.17	12.0	5.43	2.64	278	0.010	U	11.9		10.9		--		0.0038		11.0	200		4.9				
AKG-722	8/16/05	7.84	12.4	5.46	2.58	300	0.010	U	10.7		11.9		--		0.0030		12.3	207		3.7				
AKG-722	9/21/05	8.12	12.8	5.36	1.90	316	0.010	U	9.18		12.6		--		0.0038		14.3	210		3.1				
AKG-722	10/19/05	7.98	12.3	5.63	1.13	357	0.010	U	9.89		9.45		--		0.0033		16.7	227		3.0				
AKG-722	11/16/05	6.07	11.4	5.56	0.85	352	0.010	U	9.20		9.09		--		0.0037		15.5	227		2.9				
AKG-722	12/14/05	6.25	10.1	5.39	5.51	254	0.010	U	11.7		10.9		--		0.0038		9.28	193		5.8				
AKG-722	1/10/06		--[2]	--[2]	--[2]	--[2]	--[2]		--[2]		--[2]		--[2]		--[2]		--[2]	--[2]		--[2]				
AKG-722	2/7/06	1.51	8.1	5.80	6.10	156**	0.010	U	10.8		10.7		--		0.0057		10.6	172	P	8.2				
AKG-722	3/7/06	5.85	7.9	5.56	6.28	228	0.010	U	11.3		10.3		--		0.0056		10.3	171		7.3				
AKG-722	4/4/06	6.46	10.1	5.58	8.34	226	0.010	U	9.94		11		--		0.0050	U	10.9	157		7.1				
AKG-722	5/17/06	7.10	10.5	5.32	8.10	240	0.010	U	9.62		9.93		--		0.0050	U	11.2	173		5.1				
AKG-722	6/26/06	7.71	12.4	5.50	6.66	169	0.010	U	9.88		10		--		0.0050	U	13.5	178		3.9				
AKG-722	8/2/06	8.21	12.9	5.48	5.24 P	275	0.010	U	7.44		8.9		--		0.0033		12.4	197		3.4				

Field Measurements							Laboratory Analyses[1]															
Well Tag Number	Sample Date	Depth to Groundwater (ft below top of casing)	Temp-erature (C0)	pH (Standard Units)	Dissolved Oxygen (mg/L)	Conductivity (umhos/cm)	Ammonia-N (mg/L)		Nitrite+ Nitrate-N (mg/L)		Total Persulfate N (mg/L)		Ortho Phosphorus (mg/L)		Total Phosphorus (mg/L)		Chloride (mg/L)		Total Dissolved Solids (mg/L)		Organic Carbon (mg/L)	
AKG-722	9/13/06	8.69	12.1	5.50	1.34 P	271	0.010	U	5.80		5.94		--		0.0040		12.3		190		3.0	
AKG-722	10/18/06	9.01	12.2	5.62	0.51	282	0.010	U	4.59		4.67		--		0.0033		12.7		193		4.7	
AKG-722	11/14/06	7.54	10.9	5.65	0.25	312	0.010	U	1.82	P	1.54	P	--		0.0050	P	13.1		201		3.6	P
AKG-722	12/12/06	2.45	9.8	5.84	7.77 P	373	0.010	U	17.6		17.7		--		0.0053	P	8.89 P		246		6.2	P
AKG-722	1/17/07	4.03	7.1	5.84	10.74 P	328	0.010	U	19.4		20.2		--		--		15.6		232		8.0	
AKG-722	2/12/07	5.18	7.3	5.76	9.66 P	291	0.010	U	15.9		16.6		--		--		15.2 P		161	P	7.4	
AKG-722	3/28/07	1.64	8.4	5.91	8.64 P	231	0.010	U	9.32		8.86		--		--		6.23		164		8.8	
AKG-722	5/14/07	6.43	9.9	5.85	8.31	192	0.010	U	3.71		4.26	P	--		--		5.82		133		8.4	
AKG-722	6/13/07	7.21	10.3	5.77	6.86	210	0.033		5.00		6.46		--		--		6.54		147		7.8	
AKG-722	7/30/07	8.06	12.1	5.73	3.90 P	216	0.010	U	6.79		6.13		--		--		6.19		184		5.3	
AKG-722	9/2/07	8.49	12.4	5.57	2.65	208	0.010	U	3.94	P	4.18		--		--		6.24		149		4.8	
AKG-722	10/1/07	8.68	12.5	5.56	0.75	231	0.010	U	4.71		4.66		--		--		7.38		167		4.2	
AKG-722	10/30/07	7.39	11.9	5.56	0.37	285	0.010	U	3.97		4.15		--		--		8.51		187		3.9	
AKG-722	11/27/07	6.81	10.8	5.74	4.23	216	0.010	U	3.96		4.48		--		--		6.53		151		6.6	
AKG-722	1/3/08	3.02	7.5	5.90	9.06	246	0.010	U	10.5		11.3		--		--		7.13		164		9.1	
AKG-722	1/30/08	5.02	8.1	5.86	9.30	226	0.010	U	8.03		9.34		--		--		7.59 P		149		1.6	
AKG-722	2/27/08	5.43	6.8	5.83	7.46	254	0.010	U	9.72		11.5		--		--		4.84		186		9.6	
AKG-722	4/1/08	5.42	8.6	5.91	8.08	207	0.010	U	5.53	P	5.53		--		--		4.29		138		1.7	
AKG-722	5/6/08	6.8	8.7	5.80	8.07	225	0.010	U	8.63		9.63		--		--		4.63		165		7.5	
AKG-722	6/18/08	7.00	10.4	5.69	5.03	223	0.010	U	8.10		8.92		--		--		4.40		163		7.6	
AKG-722	7/22/08	7.52	12.3	5.63	4.48	227	0.010	U	7.68		7.83		--		--		4.70		157		5.8	
AKG-722	8/26/08	7.98	13.2	5.46	2.10	217	0.010	U	5.97		6.53		--		--		4.66		156		5.0	
AKG-722	9/8/08	7.66	13.6	5.65	1.70	212	0.010	U	5.67		5.88		--		--		4.78 J		140		5.1	
AKG-722	10/7/08	8.12	12.6	5.53	1.58 P	212	0.010	U	3.58		4.19		--		--		4.83		149		5.1	
AKG-722	11/12/08	3.09	11.3	5.66	0.45 P	221	0.010	U	1.90		2.21		--		--		4.98		147		4.1	
AKG-722	12/9/08	4.25	8.9	5.86	7.40 P	339	0.010	U	15.3		15.9		--		--		11.7		217		8.2	

Field Measurements							Laboratory Analyses[1]																	
Well Tag Number	Sample Date	Depth to Groundwater (ft below top of casing)	Temp-erature (C0)	pH (Standard Units)	Dissolved Oxygen (mg/L)	Conductivity (umhos/cm)	Ammonia-N (mg/L)		Nitrite+ Nitrate-N (mg/L)		Total Persulfate N (mg/L)		Ortho Phosphorus (mg/L)		Total Phosphorus (mg/L)		Chloride (mg/L)	Total Dissolved Solids (mg/L)		Organic Carbon (mg/L)			
AKG-722	3/18/09	5.51	7.7	5.70	3.45	267	0.010	U	9.12		9.28		--		--		6.28	182		4.5			
AKG-723	8/27/04	9.73																					
AKG-723	9/21/04	9.47	13.2	5.16	1.50	511	0.010	U	22.2		22.2		0.007		0.0052	P	23.0	350	J	1.6			
AKG-723	10/18/04	8.74	12.4	--	0.77	507	0.012		23.2		25.5		0.006		0.0020	UP	25.4	343		1.5			
AKG-723	11/22/04	5.90	12.0	5.26	1.09	474	0.015		30.6		33.4		0.0047		0.0043		23.3	326		2.8			
AKG-723	12/28/04	3.57	10.1	5.28	3.30 P	517	0.010	U	33.7		35.8		0.0076		0.0053		19.5	351	J	2.9			
AKG-723	2/1/05	4.35	8.7	5.16	3.70	565	0.010	U	39.0		36.7		0.005		0.0043		21.0	392		2.5			
AKG-723	3/2/05	6.72	8.6	5.09	3.41	556	0.010	U	39.5		39.1		0.0051		0.0037		22.2	358		2.3			
AKG-723	3/30/05	4.93	8.9	5.46	6.49	462	0.010	U	34.6		35.1		0.0051		0.0031	P	20.3	313		1.8			
AKG-723	4/26/05	6.08	9.2	5.20	1.35	387	0.015		27.7		27.0		--		0.0047	P	15.4	309		3.3			
AKG-723	5/26/05	7.97	10.1	5.24	3.49	389	0.010		20.4		21.9		--		0.0034		15.9	298		6.7	J		
AKG-723	7/6/05	8.73	11.0	5.22	3.36	426	0.010	U	29.4		27.9		--		0.0031		17.9	323		1.7			
AKG-723	8/16/05	9.26	12.2	5.22	2.83	441	0.010	U	28.5		29.6		--		0.0032		20.0	336		1.3			
AKG-723	9/21/05	9.47	13.3	5.13	1.87	446	0.010	U	27.1		27.1		--		0.0037		19.9	320		1.7			
AKG-723	10/20/05	9.23	12.2	5.32	2.12	438	0.010	U	25.6		24.9		--		0.0036		18.6	316		1.7			
AKG-723	11/16/05	7.09	11.7	5.28	2.35	402	0.010	U	25.6		24.7		--		0.0042		15.4	279		2.5			
AKG-723	12/15/05	7.69	11.3	5.19	2.05	398	0.010	U	21.1		21.3		--		0.0048		16.4	280		2.3			
AKG-723	1/11/06	1.25	8.5	5.50	4.45	338	0.010	U	18.5		18.2		--		0.0071		12.9	267		4.2			
AKG-723	2/7/06	3.18	8.4	5.30	3.33	322	0.010	U	16.4		16.0		--		0.0066		13.0	238	P	3.5			
AKG-723	3/7/06	7.41	8.9	5.25	2.91	311	0.010	U	14.7		13.9		--		0.0051		13.0	234		2.8			
AKG-723	4/4/06	7.98	9.7	5.36	4.49	332	0.010	U	17.5		16.3		--		0.0050	U	13.1	240		2.0			
AKG-723	5/17/06	--3	--3	--3	--3	--3	--3		--3		--3		--3		--3		--3	--3		--3			
AKG-723	6/26/06	9.13	11.2	5.23	4.42	313	0.010	U	14.6		13.6		--		0.0082		12.2	230		1.9			
AKG-723	8/3/06	9.65	11.7	5.19	7.07 P	333	0.010	U	11.4		12.6		--		0.0020	U	14.1	214		1.9			
AKG-723	9/14/06	10.00	11.8	5.30	1.14 P	334	0.010	U	11.9		12.2		--		0.0046		14.6	234		1.9			

Field Measurements							Laboratory Analyses[1]																	
Well Tag Number	Sample Date	Depth to Groundwater (ft below top of casing)	Temp-erature (C0)	pH (Standard Units)	Dissolved Oxygen (mg/L)	Conductivity (umhos/cm)	Ammonia-N (mg/L)		Nitrite+ Nitrate-N (mg/L)		Total Persulfate N (mg/L)		Ortho Phosphorus (mg/L)		Total Phosphorus (mg/L)		Chloride (mg/L)		Total Dissolved Solids (mg/L)		Organic Carbon (mg/L)	
AKG-723	10/18/06	10.13	12.0	5.38	0.16	332	0.010	U	8.93		11.2		--		0.0041		14.6		237		2.8	
AKG-723	11/14/06	8.05	11.1	5.38	0.56	367	0.010	U	5.30	P	5.81	P	--		0.0063	P	15.0		238		3.3	P
AKG-723	12/12/06	3.91	9.5	5.35	4.44 P	377	0.010	U	17.0		16.7		--		0.0076	P	18.6 P		258		3.2	P
AKG-723	1/17/07	5.75	8.1	5.39	0.50 P	335	0.010	U	20.1		19.8		--		--		13.8		247		4.4	
AKG-723	2/12/07	6.63	8.0	5.38	1.74 P	355	0.010	U	19.6		20.4		--		--		11.1 P		203	P	3.2	
AKG-723	3/28/07	2.62	7.9	5.57	3.51 P	271	0.010	U	14.0		15.1		--		--		13.2		197		1.9	
AKG-723	5/14/07	7.86	9.4	5.50	4.49	292	0.010	U	11.9		11.8	P	--		--		7.98		197		2.3	
AKG-723	6/13/07	8.61	9.7	5.44	3.51	306	0.010	U	12.8		12.9		--		--		9.21		211		2.2	
AKG-723	7/30/07	9.33	11.4	5.65	2.42 P	324	0.010	U	14.8		14.2		--		--		12.3		244		1.7	
AKG-723	9/2/07	9.74	11.8	5.35	1.87	298	0.010	U	15.6	P	12.6		--		--		9.41		209		1.9	
AKG-723	10/1/07	9.82	11.8	5.33	1.20	299	0.010	U	12.7		12.2		--		--		8.93		216		1.8	
AKG-723	10/30/07	8.31	11.5	5.43	2.51	293	0.010	U	9.50		10.0		--		--		8.02		205		3.4	
AKG-723	11/27/07	7.90	10.5	5.46	1.63	287	0.010	U	9.28		9.22		--		--		8.27		201		2.6	
AKG-723	1/4/08	4.85	8.6	5.40	2.19	271	0.010	U	9.55		9.99		--		--		6.80		185		3.8	
AKG-723	1/30/08	6.46	7.8	5.38	1.66	253	0.010	U	9.80		10.6		--		--		6.34 P		174		4.2	
AKG-723	2/27/08	6.84	7.4	5.39	2.39	256	0.010	U	11.0		11.4		--		--		5.91		184		4.2	
AKG-723	4/2/08	6.89	8.2	5.37	0.98	260	0.010	U	11.8	P	13.5		--		--		6.23		192		3.8	
AKG-723	5/6/08	--[3]	--[3]	--[3]	--[3]	--[3]	--[3]		--[3]		--[3]		--[3]		--[3]		--[3]		--[3]		--[3]	
AKG-723	6/19/08	8.36	9.8	5.38	2.65	272	0.010	U	9.41		9.8		--		--		6.51		193		2.9	
AKG-723	7/22/08	8.93	11.4	5.65	1.97	281	0.010	U	8.13		8.37		--		--		6.67		193		2.0	
AKG-723	9/8/08	8.94	13.5	5.45	1.69	286	0.010	U	8.51		8.44		--		--		7.01 J		186		2.1	
AKG-723	10/7/08	9.38	11.9	5.34	2.89 P	266	0.010	U	8.00		8.22		--		--		7.16		198		2.0	
AKG-723	11/13/08	4.19	11.7	5.36	3.03 P	292	0.010	U	11.4		12.8		--		--		5.36		206		4.6	
AKG-723	12/9/08	5.76	10.0	5.44	1.88 P	274	0.010	U	9.42		9.85		--		--		6.30		186		4.0	
AKG-723	3/18/09	6.88	7.8	5.41	4.04	320	0.010	U	17.9		14.5		--		--		8.73		232		1.8	

Field Measurements							Laboratory Analyses[1]																	
Well Tag Number	Sample Date	Depth to Groundwater (ft below top of casing)	Temp-erature (C0)	pH (Standard Units)	Dissolved Oxygen (mg/L)	Conductivity (umhos/cm)	Ammonia-N (mg/L)		Nitrite+ Nitrate-N (mg/L)		Total Persulfate N (mg/L)		Ortho Phosphorus (mg/L)		Total Phosphorus (mg/L)		Chloride (mg/L)	Total Dissolved Solids (mg/L)		Organic Carbon (mg/L)			
AKG-724	8/27/04	8.25																						
AKG-724	9/21/04	7.65	13.7	4.69	8.60	408	0.010	U	19.7		19.2		0.0058		0.0060	P	18.6	270	J	1.7				
AKG-724	10/18/04	6.47	12.7	NA	0.00	430	0.010	U	17.2		17.1		0.0049		0.0020	UP	20.8	288		1.6				
AKG-724	11/22/04	4.02	11.9	5.30	1.30	413	0.010	U	15.9		15.6		0.0048		0.0036		19.7	268		2.1				
AKG-724	12/28/04	2.19	10.3	4.83	3.90 P	490	0.010	U	26.8		26.9		0.0075		0.0028		19.6	323	J	1.9				
AKG-724	2/1/05	1.80	8.5	4.82	3.00	422	0.010	U	27.8		26.8		0.0045		0.0021		14.7	285		1.5				
AKG-724	3/2/05	4.93	8.2	4.84	0.87	324	0.010	U	22.1		20.7		0.0050		0.0020		13.3	246		1.2				
AKG-724	3/30/05	2.80	9.1	4.96	2.10	326	0.010	U	18.1		16.0		0.0043		0.0024	P	12.8	218		1.5				
AKG-724	4/25/05	4.54	9.7	4.93	1.04	323	0.010	U	15.7		14.9		--		0.0019	P	10.8	219		1.2				
AKG-724	5/26/05	6.16	10.6	4.93	0.48	342	0.018		16.5		18.7		--		0.0013		12.6	227		1.8	J			
AKG-724	7/7/05	6.87	11.5	4.77	0.36	385	0.010	U	20.3		19.3		--		0.0019		16.4	272		1.7				
AKG-724	8/16/05	7.56	13.3	4.74	0.38	374	0.010	U	18.3		17.2		--		0.0019		17.1	251		1.9				
AKG-724	9/21/05	7.71	13.4	4.63	0.42	381	0.010	U	16.8		18.4		--		0.0040		18.9	247		1.9				
AKG-724	10/19/05	7.12	12.6	4.94	6.26	337	0.010	U	13.2		12.7		--		0.0021		19.1	258		2.0				
AKG-724	11/16/05	5.28	11.3	5.06	1.77	401	0.010	U	17.2		16.4		--		0.0021		17.7	266		1.8				
AKG-724	12/14/05	6.03	10.6	4.67	1.90	426	0.010	U	19.0		19.5		--		0.0023		17.8	287		1.8				
AKG-724	1/10/06	0.54	11.0	4.87	3.54	353	0.010	U	16.9		18.1		--		0.0023		16.0	233	*	2.1				
AKG-724	2/7/06	2.14	8.6	4.92	2.79	312	0.010	U	14.0		15.6		--		0.0050	U	14.5	222	P	2.2				
AKG-724	3/7/06	5.91	8.9	4.82	1.34	310	0.010	U	13.2		12.8		--		0.0050	U	12.8	219		1.6				
AKG-724	4/4/06	6.33	9.6	4.92	2.28	283	0.010	U	8.41		8.79		--		0.0050	U	12.5	197		1.6				
AKG-724	5/17/06	6.89	10.4	4.80	1.01	273	0.010	U	7.32		9.16		--		0.0050	U	12.0	196		1.5				
AKG-724	6/26/06	7.36	12.4	4.87	4.81	276	0.010	U	8.77		8.76		--		0.0050	U	13.9	185		1.7				
AKG-724	8/2/06	7.95	12.3	4.79 P	1.11	298	0.010	U	13.5		13.4		--		0.0037		14.3	232		1.8				
AKG-724	9/14/06	8.36	12.6	4.76 P	0.61	302	0.028		13.0		13.2		--		0.0025		14.0	213		2.2				
AKG-724	10/19/06	8.50	12.4	4.85	0.45	335	0.010	U	14.4		14.2		--		0.0016		14.8	227		3.6				
AKG-724	11/14/06	5.91	11.1	4.84	1.06	342	0.010	U	13.2	P	16.2	P	--		0.0027	P	14.9	216		4.6	P			

Field Measurements							Laboratory Analyses[1]																	
Well Tag Number	Sample Date	Depth to Groundwater (ft below top of casing)	Temp-erature (C0)	pH (Standard Units)	Dissolved Oxygen (mg/L)	Conductivity (umhos/cm)	Ammonia-N (mg/L)		Nitrite+ Nitrate-N (mg/L)		Total Persulfate N (mg/L)		Ortho Phosphorus (mg/L)		Total Phosphorus (mg/L)		Chloride (mg/L)		Total Dissolved Solids (mg/L)		Organic Carbon (mg/L)	
AKG-724	12/12/06	2.50	10.4	4.85	4.92 P	299	0.010	U	9.66		8.81		--		0.0030	P	17.2 P		199		1.7	P
AKG-724	1/17/07	4.55	8.3	4.99	5.56 P	308	0.010	U	13.9		14.3		--		--		16.2 P		215	P	2.5	
AKG-724	2/12/07	5.31	8.4	4.97	4.02 P	337	0.010	U	15.7		16.0		--		--		16.8		222		4.9	
AKG-724	3/28/07	2.09	8.6	5.01	4.97 P	299	0.010	U	14.2		12.8		--		--		8.34		191		3.7	
AKG-724	5/14/07	6.41	10.1	5.01	0.87	270	0.010	U	11.9		11.9	P	--		--		10.6		179		1.7	
AKG-724	6/14/07	7.05	10.7	4.98	0.60	279	0.010	U	6.81		7.42		--		--		8.95		193		1.9	
AKG-724	7/30/07	7.73	12.6	5.20	0.34 P	267	0.010	U	4.56		5.27		--		--		9.46		208		2.2	
AKG-724	9/2/07	8.09	12.7	4.88	0.36	239	0.010	U	2.91	P	2.62		--		--		8.27		181		2.5	
AKG-724	10/1/07	8.06	12.8	4.90	0.34	227	0.010	U	2.42		2.58		--		--		7.47		175		2.0	
AKG-724	10/30/07	6.63	12.4	4.96	0.88	255	0.010	U	4.97		5.21		--		--		9.03		176		1.9	
AKG-724	11/27/07	5.85	11.0	4.94	1.38	255	0.010	U	6.94		6.16		--		--		9.79		180		2.2	
AKG-724	1/3/08	3.53	8.8	4.95	3.87	231	0.010	U	6.68		6.69		--		--		7.87 P		153		1.9	
AKG-724	1/30/08	5.21	7.6	4.95	3.49	237	0.010	U	6.74		7.25		--		--		8.53		161		2.1	
AKG-724	2/27/08	5.55	7.6	4.97	2.71	239	0.010	U	8.00		8.19		--		--		8.61		175		2.6	
AKG-724	4/1/08	5.33	8.3	5.00	1.64	235	0.010	U	5.94	P	6.26		--		--		8.38		160		2.2	
AKG-724	5/6/08	6.67	9.2	5.01	0.67	260	0.010	U	9.98		10.0		--		--		8.76		186		2.3	
AKG-724	6/18/08	6.74	11.0	4.92	0.65	235	0.010	U	5.30		5.82		--		--		6.11		185		2.2	
AKG-724	7/23/08	7.46	12.1	4.68	0.09	252	0.022		7.53		7.01		--		--		6.70		197		2.1	
AKG-724	9/8/08	7.34	13.7	4.88	0.41	270	0.010	U	5.36		5.41		--		--		6.80 J		163		2.1	
AKG-724	10/7/08	7.72	12.9	4.78	0.50 P	238	0.010	U	3.91		4.33		--		--		6.49		177		2.2	
AKG-724	11/13/08	2.48	11.5	4.77	1.64 P	248	0.010	U	6.49		7.09		--		--		7.61		180		2.1	
AKG-724	12/10/08	4.05	10.6	4.89	1.83 P	276	0.010	U	11.0		11.0		--		--		9.31		190		2.2	
AKG-724	3/18/09	4.93	7.5	4.91	1.29	328	0.010	U	15.3		14.3		--		--		14.3		245		1.9	
AKG-725	8/27/04	10.58																						
AKG-725	9/20/04	10.53	12.1	5.34	7.60	438	0.010	U	25.4		23.7		0.0074		0.0048	P	19.2		323	J	1.9	

Field Measurements							Laboratory Analyses[1]																	
Well Tag Number	Sample Date	Depth to Groundwater (ft below top of casing)	Temp-erature (C0)	pH (Standard Units)	Dissolved Oxygen (mg/L)	Conductivity (umhos/cm)	Ammonia-N (mg/L)		Nitrite+ Nitrate-N (mg/L)		Total Persulfate N (mg/L)		Ortho Phosphorus (mg/L)		Total Phosphorus (mg/L)		Chloride (mg/L)	Total Dissolved Solids (mg/L)		Organic Carbon (mg/L)			
AKG-725	10/19/04	9.99	12.1	--	5.60	444	0.017		26.8		33.2		0.0072		0.0028	P	19.9	315		1.8			
AKG-725	11/23/04	6.69	11.8	5.72	8.09	486	0.010	U	30.8		32.4		0.0054		0.0037		22.6	323		1.8			
AKG-725	12/28/04	3.99	9.4	5.72	7.50	P 473	0.010	U	34.7		32.2		0.0110		0.0090		19.6	320	J	1.5			
AKG-725	2/1/05	4.54	8.0	5.68	9.60	435	0.010	U	34.0		29.9		0.0090		0.0090		16.4	315		1.6			
AKG-725	3/2/05	7.41	9.1	4.48	6.85	454	0.010	U	30.3		28.6		0.0094		0.0077		17.1	325		1.5			
AKG-725	3/31/05	5.75	9.1	5.67	6.75	445	0.010	U	24.1		26.2		0.0097		0.0091	P	21.5	322		1.8			
AKG-725	4/26/05	6.77	10.1	5.70	6.80	390	0.011		23.6		24.7		--		0.010	P	13.1	288		1.6			
AKG-725	5/26/05	8.70	10.6	5.79	6.73	475	0.010	U	29.3		34.7		--		0.0473		24.6	362		1.7	J		
AKG-725	7/7/05	9.61	11.3	5.58	6.24	525	0.010	U	35.1		42.7		--		0.0085		28.2	381		2.2			
AKG-725	8/17/05	10.17	11.9	5.64	6.90	538	0.010	U	35.5		37.4		--		0.0085		30.3	418		1.6			
AKG-725	9/22/05	10.46	12.4	5.57	6.54	491	0.010	U	29.0		30.7		--		0.0098		25.0	357		2.0			
AKG-725	10/20/05	10.36	12.2	5.71	5.93	455	0.010	U	24.5		22.8		--		0.010		20.4	307		1.9			
AKG-725	11/17/05	8.41	12.2	5.71	6.50	431	0.010	U	24.8		28.1		--		0.0094		18.7	287		1.8			
AKG-725	12/15/05	8.58	10.8	5.73	6.33	401	0.010	U	22.4		22.5		--		0.010		17.1	292		2.1			
AKG-725	1/11/06	1.77	8.4	5.97	9.71	313	0.010	U	13.8		11.8		--		0.0098		9.4	206		2.2			
AKG-725	2/8/06	3.71	8.1	5.80	7.43	261	0.010	U	10.4		10.8		--		0.011		8.12	177	P	2.2			
AKG-725	3/8/06	8.04	8.4	5.70	6.47	286	0.010	U	13.2		13.2		--		0.012		9.28	204		1.6			
AKG-725	4/5/06	8.72	9.7	5.84	5.48	341	0.010	U	16.1		16.8		--		0.0080		11.6	233		2.1			
AKG-725	5/17/06	9.38	10.1	5.72	8.14	366	0.010	U	19.0		19.0		--		0.0082		16.6	251		1.6			
AKG-725	6/27/06	10.04	11.1	5.81	7.32	324	0.010	U	13.8		10.2		--		0.0129		11.9	223		2.0			
AKG-725	8/2/06	10.51	11.4	5.75	6.18	P 323	0.010	U	10.6		25.0		--		0.0106		12.7	232		2.1			
AKG-725	9/13/06	10.95	11.6	5.68	7.26	P 284	0.010	U	10.5		9.84		--		0.0114		10.8	211		2.3			
AKG-725	10/18/06	11.21	11.7	5.81	6.07	292	0.010	U	10.0		8.20		--		0.0106		9.20	204		3.9			
AKG-725	11/15/06	9.54	11.2	5.76	3.38	323	0.010	U	9.83	P	9.92	P	--		0.0117	P	9.27	213		3.5	P		
AKG-725	12/13/06	3.89	9.6	5.82	10.10	P 339	0.010	U	16.2		15.3		--		0.0116	P	16.6	P	232		1.5	P	
AKG-725	1/18/07	6.24	7.4	5.93	10.24	P 290	0.010	U	16.1		16.5		--		--		11.4	211		2.5			

Field Measurements							Laboratory Analyses[1]																	
Well Tag Number	Sample Date	Depth to Groundwater (ft below top of casing)	Temp-erature (C0)	pH (Standard Units)	Dissolved Oxygen (mg/L)	Conductivity (umhos/cm)	Ammonia-N (mg/L)		Nitrite+ Nitrate-N (mg/L)		Total Persulfate N (mg/L)		Ortho Phosphorus (mg/L)		Total Phosphorus (mg/L)		Chloride (mg/L)		Total Dissolved Solids (mg/L)		Organic Carbon (mg/L)	
AKG-725	2/13/07	7.36	7.5	5.90	8.59 P	296	0.010	U	16.3		16.8		--		--		10.9 P		209	P	1.6	
AKG-725	3/29/07	3.24	7.7	5.89	9.30 P	259	0.010	U	11.7		12.7		--		--		9.95		175		1.6	
AKG-725	5/14/07	8.54	10.0	5.89	9.61	264	0.010	U	10.1		11.4	P	--		--		7.84		175		1.5	
AKG-725	6/14/07	9.40	10.7	5.84	8.55	278	0.010	U	10.9		9.61		--		--		8.13		188		1.6	
AKG-725	7/30/07	10.21	11.3	5.97	7.82 P	281	0.010	U	10.7		11.4		--		--		9.88		201		2.0	
AKG-725	9/2/07	10.69	11.6	5.80	8.67	276	0.010	U	12.5	P	10.5		--		--		9.96		200		1.8	
AKG-725	10/2/07	10.84	11.4	5.82	6.86	288	0.010	U	12.8		11.1		--		--		9.69		211		1.6	
AKG-725	10/30/07	9.62	11.4	5.81	4.64	298	0.010	U	9.54		9.76		--		--		9.08		206		1.7	
AKG-725	11/28/07	8.96	9.8	5.97	7.99	285	0.010	U	10.4		10.0		--		--		7.93		191		1.7	
AKG-725	1/4/08	5.17	8.0	5.84	8.80	252	0.010	U	11.9		12.0		--		--		7.49 P		164		1.6	
AKG-725	1/31/08	7.04	7.0	5.87	9.07	257	0.010	U	12.0		13.1		--		--		6.72		173		1.6	
AKG-725	2/28/08	7.55	7.6	5.86	9.36	249	0.010	U	12.1		12.5		--		--		6.04		179		1.7	
AKG-725	4/1/08	7.64	8.4	5.84	7.28	235	0.010	U	12.0	P	12.2		--		--		6.00		169		1.3	
AKG-725	5/7/08	8.96	9.3	5.89	9.49	229	0.010	U	7.53		6.92		--		--		4.85		178		1.6	
AKG-725	6/18/08	9.27	9.9	5.88	8.06	234	0.010	U	6.42		6.59		--		--		3.91		176		1.7	
AKG-725	7/23/08	9.77	10.9	5.78	7.25	238	0.010	U	6.58		6.15		--		--		3.89		173		2.0	
AKG-725	9/9/08	9.88	11.5	5.84	5.40	243	0.010	U	7.63		7.82		--		--		4.18		155		1.7	
AKG-725	10/8/08	10.33	11.5	5.77	7.68 P	234	0.010	U	8.09		8.53		--		--		4.23		187		1.7	
AKG-725	11/13/08	5.81	11.7	5.83	8.61 P	290	0.010	U	12.90		13.50		--		--		8.85		193		1.5	
AKG-725	12/10/08	6.47	10.1	5.78	8.36 P	365	0.010	U	20.4		20.4		--		--		14.1		240		1.8	
AKG-725	3/19/09	7.74	7.6	5.73	9.04	319	0.010	U	20.1		17.5		--		--		10.5		184		2.1	
AKG-726	8/27/04	10.61																						
AKG-726	9/21/04	10.57	--	--	--	--	--	--	--	--	--	--	--		--		--		--	--	--			
AKG-726	10/19/04	10.05	10.2	--	0.00	428	0.229		0.010	U	0.272		0.0407		0.136	P	18.7		261		1.5			
AKG-726	11/23/04	6.97	10.2	6.62	0.00	418	0.228		0.021		0.300		0.0067		0.146		17.3		261		1.7 (TOC)			

Field Measurements							Laboratory Analyses[1]															
Well Tag Number	Sample Date	Depth to Groundwater (ft below top of casing)	Temp-erature (C0)	pH (Standard Units)	Dissolved Oxygen (mg/L)	Conductivity (umhos/cm)	Ammonia-N (mg/L)		Nitrite+ Nitrate-N (mg/L)		Total Persulfate N (mg/L)		Ortho Phosphorus (mg/L)		Total Phosphorus (mg/L)		Chloride (mg/L)	Total Dissolved Solids (mg/L)		Organic Carbon (mg/L)		
AKG-726	12/28/04	4.05	10.3	6.54	0.18 P	415	0.216		0.010		0.18		0.0100		0.146		14.7	256	J	1.4 (TOC)		
AKG-726	2/1/05	4.57	10.4	6.53	0.90	428	0.220		0.020		0.24		0.0075		0.244		13.8	276		1.7 (TOC)	J	
AKG-726	3/2/05	7.46	10.5	6.17	0.13	432	0.211		0.012		0.21		0.0070		0.134		13.8	275		1.3 (TOC)		
AKG-726	3/31/05	5.74	10.5	5.80	0.07	426	0.248		0.012		0.24		0.0070		0.155	P	14.0	284		1.6 (TOC)		
AKG-726	4/26/05	6.78	10.7	6.61	0.21	435	0.170		0.030		0.18		--		0.129	P	14.0	308		1.3 (TOC)		
AKG-726	5/26/05	8.73	10.8	6.62	0.06	440	0.216		0.011		0.24		--		0.155		13.6	284		2.7	J	
AKG-726	7/7/05	9.65	10.8	6.47	--	424	0.212		0.011		0.24		--		0.133		12.2	292		1.4 (TOC)		
AKG-726	8/17/05	10.24	10.2	6.48	0.33	444	0.222		0.022		0.17		--		0.120		13.0	295		1.4 (TOC)		
AKG-726	9/22/05	10.51	10.1	5.77	0.00	436	0.222		0.022		0.344		--		0.153		12.8	286		1.6 (TOC)		
AKG-726	10/20/05	10.40	10.2	6.78	0.67	417	0.221		0.037		0.319		--		0.1340		12.7	264		1.8 (TOC)		
AKG-726	11/17/05	8.47	--	--	--	--	--		--		--		--		--		--	--		--		
AKG-726	12/15/05	8.60	10.2	6.48	0.27	420	0.227		0.043		0.24		--		0.264		12.1	260		1.8 (TOC)		
AKG-726	1/11/06	1.86	10.1	6.71	0.85	420	0.224		0.049		0.31		--		0.124		12.1	285		1.8 (TOC)		
AKG-726	2/8/06	3.82	10.3	6.69	0.29	401	0.205		0.051		0.324		--		0.113		12.1	277	P		1.7 (TOC)	
AKG-726	3/8/06	8.10	10.2	6.35	0.02	378	0.195		0.036		0.303		--		0.131		12.1	268		1.6 (TOC)		
AKG-726	4/5/06	8.73	10.5	6.60	0.22	373	0.206		0.333		0.386		--		0.148		12.3	261		1.9 (TOC)		
AKG-726	5/18/06	9.45	10.8	6.45	0.88	359	0.209		0.049		0.315		--		0.135		10.2	246		1.4 (TOC)		
AKG-726	6/27/06	10.11	11.7	6.63	0.91	372	0.195		0.075		0.356		--		0.132		11.4	243		1.6 (TOC)		
AKG-726	8/3/06	10.59	10.6	6.49 P	0.22	382	0.219		0.080		0.352		--		0.150		12.8	257		1.8 (TOC)		
AKG-726	9/14/06	11.01	10.4	6.48 P	0.26	364	0.211		0.103		0.311		--		0.135		12.0	246		1.7(TOC)		
AKG-726	10/19/06	11.25	10.6	6.67	0.30	382	0.207		0.026		0.357		--		0.193		13.2	262		2.6(TOC)		
AKG-726	11/15/06	9.57	--	--	--	--	--		--		--		--		--		--	--		--		
AKG-726	12/13/06	4.02	10.2	6.54	0.14 P	381	0.197		0.010	U	0.290	P	--		0.1280		13.9 P	242		3.2	P	
AKG-726	1/18/07	6.33	10.1	6.59	0.00 P	362	0.203		0.010		0.266		--		--		11.7	257		1.7		
AKG-726	2/13/07	7.45	10.3	6.63	0.06 P	371	0.210		0.038		0.274		--		--		11.6 P	247	P	1.8		
AKG-726	3/29/07	3.39	10.2	6.59	0.05 P	352	0.198		0.010	U	0.285		--		--		9.48	236		2.9		

Field Measurements							Laboratory Analyses[1]																	
Well Tag Number	Sample Date	Depth to Groundwater (ft below top of casing)	Temp-erature (C0)	pH (Standard Units)	Dissolved Oxygen (mg/L)	Conductivity (umhos/cm)	Ammonia-N (mg/L)		Nitrite+ Nitrate-N (mg/L)		Total Persulfate N (mg/L)		Ortho Phosphorus (mg/L)		Total Phosphorus (mg/L)		Chloride (mg/L)	Total Dissolved Solids (mg/L)		Organic Carbon (mg/L)				
AKG-726	5/15/07		10.3	6.69	0.05	366	0.204		0.010	U	0.210	P	--		--		8.49	215		1.5				
AKG-726	6/14/07	9.47	10.6	6.62	0.00	365	0.226		0.010	U	0.296		--		--		9.57	230		1.6				
AKG-726	7/30/07	10.29	11.1	6.74	0.63	P 353	0.199		0.010	U	0.257		--		--		10.6	242		1.6				
AKG-726	9/2/07	10.76	10.1	6.60	0.14	354	0.231		0.010	UP	0.285		--		--		11.0	242		2.3				
AKG-726	10/2/07	10.91	10.0	6.62	0.01	378	0.205		0.010	U	0.288		--		--		11.1	244		1.6				
AKG-726	10/31/07	9.67	10.0	6.57	0.07	378	0.197		0.010	UJ	0.373		--		--		11.7	240		1.0	U			
AKG-726	11/28/07	9.03	9.9	6.66	0.09	369	0.200		0.020		0.378		--		--		11.3	228		1.8	TOC			
AKG-726	1/4/08	5.24	--	--	--	--	--		--		--		--		--		--	--		--				
AKG-726	1/31/08	7.14	10.1	6.61	0.09	347	0.193		0.025		0.34		--		--		11.1	235		1.7	TOC			
AKG-726	2/28/08	7.65	--	--	--	--	--		--		--		--		--		--	--		--				
AKG-726	4/1/08	7.70	--	--	--	--	--		--		--		--		--		--	--		--				
AKG-726	5/7/08	9.07	10.2	6.57	0.10	340	0.218		0.020		0.341		--		--		12.2	238		1.8	TOC			
AKG-726	6/18/08	9.35	10.7	6.65	0.18	360	0.225		0.023				--		--		11.0	236		--				
AKG-726	7/23/08	9.83	10.7	6.45	0.00	365	0.223		0.028		0.300		--		--		10.6	223		1.7				
AKG-726	9/9/08		--	--	--	--	--		--		--		--		--		--	--		--				
AKG-726	10/8/08	10.43	10.4	6.65		366	1.01	J	0.017	J	0.804	J	--		--					4.5	J			
AKG-726	11/13/08		--	--	--	--	--	--	--	--	--	--	--		--		--	--	--	--				
AKG-726	12/10/08	6.55	--	--	--	--	--	--	--	--	--	--	--		--		--	--	--	--				
AKG-726	3/19/09	7.81	10.1	6.45	0.17	356	0.209		0.012		0.279		--		--		9.66	221		1.8				
AKG-727	8/27/04	9.18																						
AKG-727	9/20/04	8.13	13.2	5.21	0.00	418	0.010	U	12.7		12.5		0.0079		0.0027	P	21.0	266	J					
AKG-727	10/18/04	7.68	12.8	NA	2.20	393	0.018		12.3		12.0		0.0062		0.0026	P	18.3	255		1.8				
AKG-727	11/22/04	4.36	11.8	5.38	1.00	379	0.010	U	13.3		14.0		0.0047		0.0029		18.0	240		2.3				
AKG-727	12/28/04	1.31	10.4	5.37	4.50	P 407	0.010	U	22.8		23.6		0.0066		0.0034		18.2	268	J	2.4				
AKG-727	2/1/05	1.64	9.5	5.32	4.58	360	0.010	U	19.1		21.8		0.0044		0.0024		14.7	249		2.3				

Field Measurements							Laboratory Analyses[1]																	
Well Tag Number	Sample Date	Depth to Groundwater (ft below top of casing)	Temp-erature (C0)	pH (Standard Units)	Dissolved Oxygen (mg/L)	Conductivity (umhos/cm)	Ammonia-N (mg/L)		Nitrite+ Nitrate-N (mg/L)		Total Persulfate N (mg/L)		Ortho Phosphorus (mg/L)		Total Phosphorus (mg/L)		Chloride (mg/L)	Total Dissolved Solids (mg/L)		Organic Carbon (mg/L)			
AKG-727	3/3/05[5]	4.98	9.4	5.41	3.02	354	0.010		15.4		16.1		0.0052		0.0037		13.8	231		2.0			
AKG-727	3/30/05[5]	3.54	9.1	5.16	3.64	364	0.010	U	19.2		22.7		0.0049		0.0043	P	14.9	254		2.2			
AKG-727	4/25/05[5]	4.14	10.4	5.36	3.55	379	0.012		18.9		19.3		--		0.0034	P	15.5	264		1.8			
AKG-727	5/25/05[5]	6.09	11.1	5.35	3.38	382	0.010	U	18.9		21.1		--		0.0010	U	15.9	266		2.3	J		
AKG-727	7/6/05[5]	7.02	11.5	5.21	2.32	379	0.010	U	17.7		16.9		--		0.0039		16.4	261		2.1			
AKG-727	8/16/05	7.68	13.5	5.28	3.22	366	0.010	U	15.7		15.8		--		0.0035		15.5	255		2.3			
AKG-727	9/21/05	8.04	13.7	5.19	2.53	383	0.010	U	13.2		14.5		--		0.0037		17.6	254		2.2			
AKG-727	10/19/05	7.95	12.5	5.53	1.13	401	0.010	U	12.3		11.9		--		0.0032		19.5	262		2.5			
AKG-727	11/17/05	6.12	12.1	5.36	1.70	396	0.010	U	14.0		14.4		--		0.0034		19.5	254		2.1			
AKG-727	12/14/05	6.07	10.5	5.26	3.04	360	0.010	U	11.8		10.7		--		0.0039		14.9	240		2.3			
AKG-727	1/10/06		--[2]	--[2]	--[2]	--[2]	--[2]		--[2]		--[2]		--[2]		--[2]		--[2]	--[2]		--[2]			
AKG-727	2/7/06	1.08	9.1	5.39	3.82	264	0.010	U	6.70		6.16		--		0.0052		8.46	193	P	3.2			
AKG-727	3/7/06	7.63	8.9	5.33	4.68	270	0.010	U	11.6		8.58		--		0.0071		10.5	199		2.9			
AKG-727	4/4/06	6.27	10.1	5.31	4.48	291	0.010	U	11.0		10.4		--		0.0050	U	9.90	202		2.2			
AKG-727	5/17/06	6.93	11.2	5.22	4.34	268	0.010	U	5.67		6.53		--		0.0050	U	6.48	196		2.1			
AKG-727	6/26/06	7.57	12.7	5.42	3.64	254	0.010	U	2.81		3.16		--		0.0053		5.73	181		2.2			
AKG-727	8/2/06	8.11	12.6	5.36	4.27	P 264	0.010	U	2.06		2.15		--		0.0038		5.27	182		2.2			
AKG-727	9/13/06	8.65	12.0	5.38	1.93	P 268	0.010	U	0.535		0.745		--		0.0035		7.59	193		2.7			
AKG-727	10/18/06	8.95	12.3	5.54	0.59	309	0.010	U	0.896		1.08		--		0.0024		9.89	218		2.8			
AKG-727	11/14/06	7.29	11.2	5.50	1.30	303	0.010	U	1.86	P	2.25	P	--		0.0040	P	9.54	197		3.7	P		
AKG-727	12/12/06	1.94	10.7	5.57	6.17	P 249	0.010	U	4.53		4.66		--		0.0043	P	13.8	P 170		4.9	P		
AKG-727	1/17/07	3.50	8.3	5.44	6.17	P 234	0.010	U	6.61		6.72		--		--		8.47	163		3.3			
AKG-727	2/12/07	4.95	8.4	5.51	5.91	P 251	0.010	U	6.30		6.25		--		--		8.04	P 174	P	2.3			
AKG-727	3/28/07	1.31	8.9	5.58	2.58	P 241	0.010	U	6.12		6.69		--		--		6.80	166		2.4			
AKG-727	5/14/07	6.13	11.1	5.44	3.96	254	0.010	U	6.96		6.22	P	--		--		7.65	165		2.3			
AKG-727	6/13/07	6.97	10.4	5.46	3.25	278	0.010	U	7.63		7.89		--		--		7.91	193		2.3			

Field Measurements							Laboratory Analyses[1]															
Well Tag Number	Sample Date	Depth to Groundwater (ft below top of casing)	Temp-erature (C0)	pH (Standard Units)	Dissolved Oxygen (mg/L)	Conductivity (umhos/cm)	Ammonia-N (mg/L)		Nitrite+ Nitrate-N (mg/L)		Total Persulfate N (mg/L)		Ortho Phosphorus (mg/L)		Total Phosphorus (mg/L)		Chloride (mg/L)	Total Dissolved Solids (mg/L)		Organic Carbon (mg/L)	
AKG-727	7/30/07	7.91	12.4	5.51	2.32 P	269	0.010	U	8.45		7.19		--		--		8.07	188		3.6	
AKG-727	9/2/07	8.39	12.7	5.31	1.35	268	0.010	U	6.30	JP	6.28		--		--		8.05	197		2.5	
AKG-727	10/1/07	8.68	12.4	5.35	0.68	276	0.010	U	5.43		4.87		--		--		7.18	211		2.2	
AKG-727	10/30/07	7.41	12.1	5.41	2.18	268	0.010	U	4.62		5.41		--		--		7.57	169		1.9	
AKG-727	11/27/07	6.75	11.0	5.46	2.35	251	0.010	U	2.84		2.88		--		--		6.41	176		2.2	
AKG-727	1/3/08	2.46	8.8	5.49	4.08	225	0.010	U	4.17		4.11		--		--		4.80	152		2.4	
AKG-727	1/30/08	4.90	7.5	5.55	6.49	223	0.010	U	5.10		5.68		--		--		4.22 P	158		2.4	
AKG-727	2/27/08	5.27	7.7	5.62	5.08	220	0.010	U	4.57		4.76		--		--		4.51	147		2.9	
AKG-727	4/1/08	5.15	8.8	5.45	3.45	219	0.010	U	4.19	P	4.51		--		--		4.15	148		2.2	
AKG-727	5/6/08	6.55	8.9	5.50	3.98	213	0.010	U	5.23		5.15		--		--		4.58	163		2.2	
AKG-727	6/18/08	6.86	10.4	5.36	--	217	0.010	U	4.08		4.37		--		--		4.17	161		2.3	
AKG-727	7/22/08	7.33	13.0	5.33	3.48	225	0.010	U	5.20		4.50		--		--		4.72	157		2.2	
AKG-727	8/26/08	7.85	14.3	5.40	2.35	199	0.010	U	2.85		3.05		--		--		4.35	154		2.20	
AKG-727	9/8/08	7.55	13.6	5.42	1.98	209	0.010	U	2.88		3.06		--		--		4.25 J	129		2.2	
AKG-727	10/7/08	8.02	13.0	5.30	2.04 P	216	0.010	U	2.82		3.43		--		--		5.03	166		2.1	
AKG-727	11/12/08	3.22	11.5	5.64	2.78 P	226	0.010	U	4.37		4.30		--		--		5.09	161		2.4	
AKG-727	12/9/08	3.94	9.9	--	3.71 P	219	0.010	U	3.95		3.77		--		--		4.61	156		2.3	
AKG-727	3/18/09	5.14	7.8	5.41	3.01	240	0.010	U	4.65		4.99		--		--		4.86	158		2.1	

[1]All samples were field-filtered (0.45 um) except AKG726. From the start of the study until July 7, 2005, AKG726 nitrogen and phosphorus samples were filtered at MEL. The August 17, 2005 AKG726 samples for total organic carbon and total phosphorus were filtered at MEL. After August 17, 2005, AKG726 samples were not filtered.

*Meter was too wet to function.

**Lab/field split quality assurance outside acceptable limits. (Lab result: 246 umhos/cm).

[2] Monitoring well was flooded.

[3] We could not locate the well in tall grass.

[4] Relative standard deviation (RSD) of duplicates was outside the 7% acceptance limit.

[5] Data were rejected due to potential contamination.

U: Analyte was not detected at or above the reported result.

P: Duplicate result for the date did not meet the precision objective for that analyte (7% RSD for all analytes except chloride and organic carbon which were 10%) .

Table R.2. Water quality results from upgradient private wells. *See Appendix B for drillers' logs.*

Well Tag Number	Sample Date	Temper-ature (C°)	pH (standard units)	Conductivity (umhos/cm)	Dissolved Oxygen (mg/L)	Ammonia-N (mg/L)	Nitrate+ Nitrite-N (mg/L)	Total Nitrogen (mg/L)	Chloride (mg/L)	Total Dissolved Solids (mg/L)
ALQ013	3/11/2008	7.6	7.1	573	0.0	0.194	0.020	0.394	16.0	--
ALQ013	4/2/2008	7.8	6.7	524	0.0	0.218	0.014	0.491	17.8	364
APM737	3/11/2008	10.0	6.4	380	0.0	0.255	0.021	0.689	17.1	--

Appendix S. Nitrogen Input and Output Parameters Used in Mass Balance Method 1

Table S.1. Nitrogen inputs to the field and soil column based on mass balance Method 1 (Sullivan, 2008) in lb/acre.

N input parameter	2005	2006	2007	2008	Average	Average % of total
Ammonium current year	329	120	123	268	210	46.8
Organic N mineralized from manure -- current year	86	89	97	160	108	24.0
Organic N mineralized from soil organic matter	102	102	102	102	102	22.7
Inorganic fertilizer	0	31	48	0	19.8	4.40
Irrigation	0.8	1.8	1.7	1.4	1.4	0.32
Atmospheric deposition	8	8	8	8	8	1.78

Appendix T. Spreadsheet Model for Determining the Nitrate Mass Load Required to Produce a Specific Nitrate Concentration in Groundwater

by B. Carey and C. Pitz

The spreadsheet model GWNO3-BACKCAST (Pitz, 2014; in preparation) was used to estimate the nitrate mass loading required to produce the shallow groundwater nitrate concentrations observed in the winter and spring during the study.

Model Description

The GWNO3-BACKCAST is a simplified mass balance mixing-box model that allows users to back-calculate the vadose zone leachate and soil nitrate conditions required to generate a given groundwater nitrate concentration in an underlying aquifer. The model is based on modifications of equations presented in Summers et al. (1980) and in this report. A conceptual schematic of the model is presented in Figure T.1. The model allows the user to define a number of site-specific variables, including the hydrologic properties of the site aquifer, upgradient groundwater quality conditions, recharge rates, mixing zone thickness, and saturated zone solute-attenuation rates.

We used the BACKCAST model to develop estimates of the total nitrate mass loading occurring during the late fall/early winter period (Period A – Nov. 1 to Dec. 31) immediately following the end of the growing season. The nitrate mass loads predicted by the model for Period A (for each study year between 2004 and 2008) are reported in units of lbs/acre. These values can be compared directly to mass estimates of end-of-season nitrate residuals developed by crop year farm-field mass balance or fall soil nitrate sampling techniques.

To examine nitrate loading occurring later in the wet-season, we ran a second modeling scenario for each study year for the late winter/early spring period (Period B – Jan. 1 to Mar. 31). This modeling scenario allowed us to evaluate loading conditions occurring well past the end of crop harvest. This model scenario can reveal information about the potential for the wet-season contribution to loading by ongoing mineralization processes in the soil column.

The BACKCAST model is a 4-step model. We used the first two steps of the model to develop predictions for our analysis:

- In **Step 1**, a standard mass balance equation is used to back-calculate the leachate concentration ($C_{LeachateNO3}$) required to produce a given groundwater concentration ($C_{GW\ Outflow\ NO3}$) at the downgradient boundary of a mixing box with thickness (b). The influence of upgradient groundwater inflow into the mixing box is accounted for in the mass balance equation. The mass balance equation is also modified to account for attenuation processes (such as denitrification) acting on the solute within the saturated zone.

- For **Step 2**, it is assumed that the nitrate-enriched leachate calculated in Step 1 originates from a mass of nitrate present in the soil column. Step 2 therefore converts the $C_{LeachateNO3}$

concentration to a nitrate mass value ($NO3_{TotExcess}$) by accounting for the amount of recharge entering the aquifer during the time frame of interest.

A detailed description of the BACKCAST model, including model assumptions and limitations, is presented in the model documentation (Pitz, 2014; in preparation).

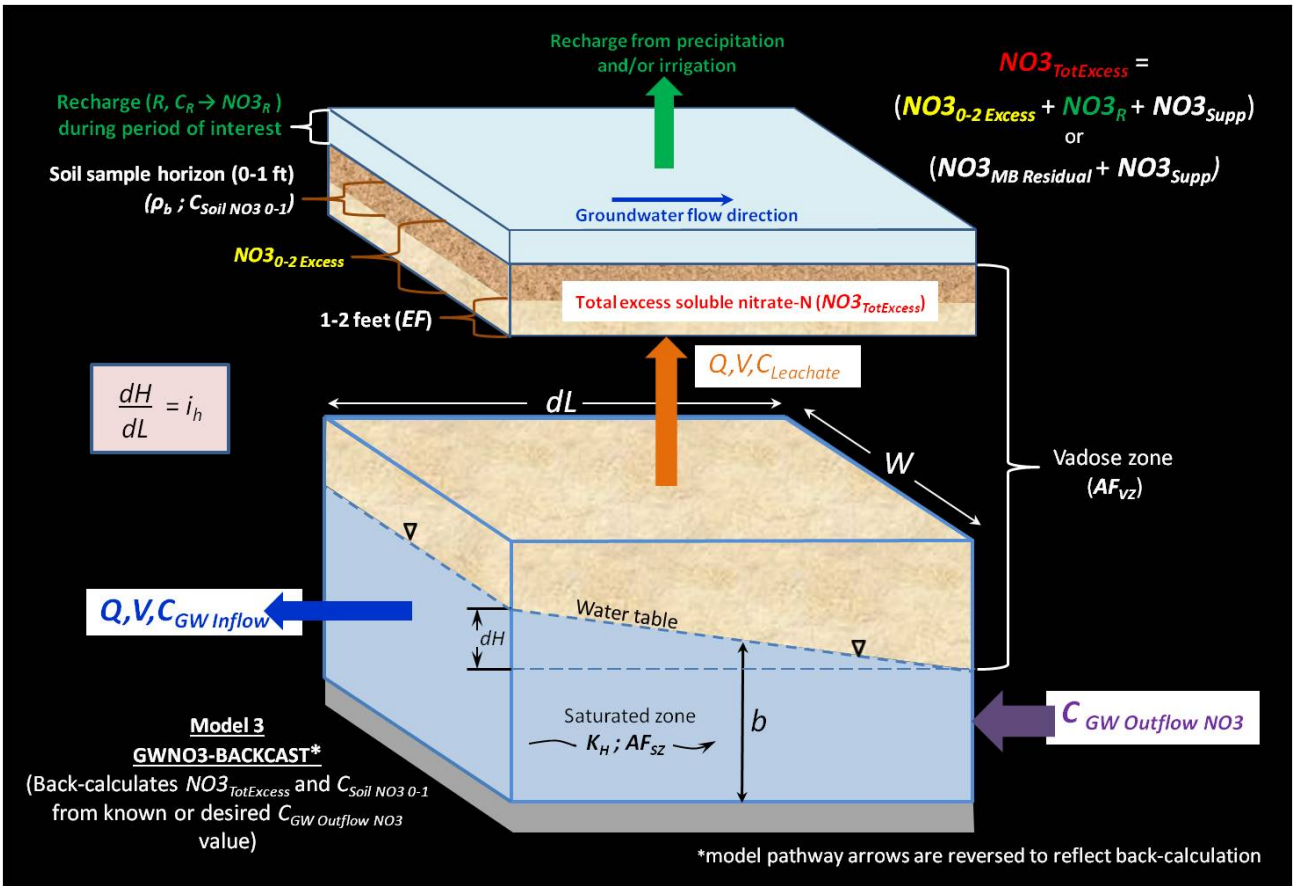


Figure T.1. Schematic of the GWNO3-BACKCAST model used to back-calculate the mass of nitrate required to produce a specified groundwater nitrate concentration.

Model Assumptions

The BACKCAST model assumes the following conditions:

- The model predictions represent a steady state condition at the end of each period of interest.
- The aquifer of interest is unconfined.
- The saturated zone is isotropic and homogeneous; therefore, saturated zone attenuation affects on groundwater concentrations act equally throughout the mixing box. The user-assigned saturated zone attenuation is complete within the time period of interest.
- The full volume of leachate enters the aquifer within the time-period of interest.

- The dissolved leachate entering the aquifer fully mixes with the groundwater entering the upgradient boundary of the mixing box.
- Dissolved nitrate transport through the saturated zone is unaffected by adsorption reactions (i.e., the sorption distribution coefficient (K_d) is assumed = 0 ml/g.).
- Model predictions for the $C_{GW\ Outflow\ NO3}$ value apply to any point at the downgradient boundary of the mixing box.

Model Equations

The BACKCAST equations used for our modeling analysis are:

Step 1

$$C_{Leachate\ NO3} = \frac{C_{GW\ Outflow\ NO3}(V_{Leachate} + V_{GW\ Inflow}) - \left[V_{GW\ Inflow} * C_{GW\ Inflow\ NO3} * \left(1 - \frac{AF_{SZ}}{100}\right)\right]}{V_{Leachate}\left(1 - \frac{AF_{SZ}}{100}\right)} \quad \text{Eq. 1}$$

where, during the period of interest:

$C_{Leachate\ NO3}$ = leachate nitrate concentration that will produce the given $C_{GW\ Outflow\ NO3}$ value (mg NO_3-N/L)
$C_{GW\ Outflow\ NO3}$ = known nitrate-N concentration of groundwater at the downgradient boundary of the mixing box at the end of the period of interest (mg NO_3-N/L)
$V_{Leachate}$ = total volume of leachate entering the mixing box (L)
$V_{GW\ Inflow}$ = total volume of groundwater inflow entering the upgradient side of the mixing box (L)
$C_{GW\ Inflow\ NO3}$ = concentration of nitrate-N in upgradient groundwater inflow prior to entering the mixing box (mg NO_3-N/L)
AF_{SZ} = saturated zone attenuation factor; value representing the percent of concentration reduction that occurs within the saturated zone due to denitrification (percent; 0 to 100%)

where: $$V_{Leachate} = 28.32(dL * W * R) \quad \text{Eq. 2}$$

and: $$V_{GW\ Inflow} = Q_{GW\ Inflow} * t \quad \text{Eq. 3}$$

where: $$Q_{GW\ Inflow} = 28.32(-K_H * b * W * i_H) \quad \text{Eq. 4}$$

and: $$i_H = \left(\frac{dH}{dL}\right) \quad \text{Eq. 5}$$

where, during the period of interest:

dL = length of the field parallel to groundwater flow (ft)
W = width of the field perpendicular to groundwater flow (ft)
R = amount of recharge infiltration (ft)
$Q_{GW\ Inflow}$ = the rate of groundwater inflow entering the upgradient boundary of the mixing box (ft^3/day)

t = the length of the time period of interest (days)
K_H = bulk horizontal hydraulic conductivity (ft/day)
b = average thickness of the saturated zone of interest (ft)
i_H = the horizontal hydraulic gradient across the area of interest (ft/ft)
dH = change in hydraulic head over the distance dL (ft)

Step 2

The amount of excess soluble nitrate mass combining with the site recharge that will result in a given $C_{Leachate\ NO3}$ value is estimated by Equation 6:

$$NO3_{TotExcess} = \frac{2.719(C_{Leachate\ NO3})(R)}{\left(1-\frac{AF_{VZ}}{100}\right)} \qquad \text{Eq. 6}$$

where, during the period of interest:

$NO3_{TotExcess}$ = excess soluble nitrate-N mass that will produce the given $C_{Leachate\ NO3}$ value (lbs NO_3-N/acre)
AF_{VZ} = vadose zone attenuation factor; value that represents the percent of nitrate concentration reduction that occurs during transport of the leachate through the vadose zone (percent; 0 to 100%)

For this analysis, we assumed that no attenuation of the leachate concentration was occurring within the vadose zone; therefore, the AF_{VZ} factor was ignored (set = 0).

Model Input Data and Assumptions

The input variables required to run the BACKCAST model for each period of interest include:

- Nitrate-N concentration in the aquifer (mg/L)
- Amount of recharge (feet)
- Period length of recharge (days)
- Horizontal hydraulic gradient (dimensionless)
- Bulk horizontal hydraulic conductivity (ft/day)
- Saturated zone attenuation factor (%)
- Area of interest (square feet)
- Average depth of the saturated mixing zone (feet)
- Nitrate-N concentration in upgradient groundwater inflow (mg/L)

Table T.1 shows the input data, and resulting model predictions for the $NO3_{TotExcess}$ and $C_{Leachate\ NO3}$values, for each model run. For each wet-season period (A and B), three distinct sub-scenarios were tested:

1. The $C_{GW\ Outflow\ NO3}$ value is assumed to equal the average groundwater nitrate concentration reported for the period of interest from well AKG725. Saturated zone attenuation due to denitrification is assumed to be 0% (model runs A.0 and B.0).
2. The $C_{GW\ Outflow\ NO3}$ value is assumed to equal the average groundwater nitrate concentration reported for the period of interest from all 6 shallow monitoring wells. Saturated zone attenuation due to denitrification is assumed to be 15% (model runs A.15 and B.15).
3. The $C_{GW\ Outflow\ NO3}$ value is assumed to equal the average groundwater nitrate concentration reported for the period of interest from all 6 shallow monitoring wells. Saturated zone attenuation due to denitrification is assumed to be 28%, based on evidence in the study from low-DO monitoring wells (model runs A.28 and B.28).

The background groundwater nitrate concentration, $C_{GW\ Inflow\ NO3}$, was an average of the nitrate concentration in the 6 shallow wells for the month preceding the start of the season (August for Period A, and December for Period B). The area of interest for each model run was assumed to equal a unit square acre.

Table T.1. Input and output data for the model to predict the mass of nitrate necessary to produce winter groundwater nitrate concentrations observed.

Scenario A.0	GW Nitrate-N in AKG725, $C_{GW\ Outflow}$ (mg/L)[1]	Recharge R (feet)[2]	Recharge period, t (days)	Horizontal gradient, i_H (ft/ft)[3]	Hydraulic conductivity (K_H) (feet/day)	Attenuation factor, AF_{SZ} (%)	Aquifer mixing depth, b (feet)	Background GW Nitrate-N, $C_{GW\ Inflow}$ (mg/L)[4]	Mass of Nitrate-N entering GW, $NO3_{TotExcess}$ (lb/acre)	Leachate Nitrate-N concentration, $C_{Leachate\ NO3}$ (mg/L)
2004	32.8	1.57	122	0.0039	53	0	2	10	154	36
2005	23.6	1.19	122	0.0039	53	0	2	15	82	25
2006	13.0	1.34	122	0.0039	53	0	2	10	49	14
2007	11.2	0.98	122	0.0039	53	0	2	8	32	12
2008	16.7	1.32	122	0.0039	53	0	2	5	67	19

Scenario A.15	GW Nitrate-N--mean of 6 shallow wells, $C_{GW\ Outflow}$ (mg/L)[1]	Recharge R (feet)[2]	Recharge period (days)	Horizontal gradient, i_H (ft/ft)[3]	Hydraulic conductivity (K_H) (feet/day)	Attenuation factor, AF_{SZ} (%)	Aquifer mixing depth, b (feet)	Background GW Nitrate-N, $C_{GW\ Inflow}$ (mg/L)	Mass of Nitrate-N entering GW, $NO3_{TotExcess}$ (lb/acre)	Leachate Nitrate-N concentration, $C_{Leachate\ NO3}$ (mg/L)
2004	26.5	1.57	122	0.0039	53	15	2	10	146	34
2005	18.2	1.19	122	0.0039	53	15	2	15	73	23
2006	10.0	1.34	122	0.0039	53	15	2	10	44	12
2007	7.3	0.98	122	0.0039	53	15	2	8	23	8.7
2008	9.2	1.32	122	0.0039	53	15	2	5	42	12

Scenario A.28	GW Nitrate-N--mean of 6 shallow wells, $C_{GW\ Outflow}$ (mg/L)[1]	Recharge R (feet)[2]	Recharge period, t (days)	Horizontal gradient, i_H (ft/ft)[3]	Hydraulic conductivity (K_H) (feet/day)	Attenuation factor, AF_{SZ} (%)	Aquifer mixing depth, b (feet)	Background GW Nitrate-N, $C_{GW\ Inflow}$ (mg/L)	Mass of Nitrate-N entering GW, $NO3_{TotExcess}$ (lb/acre)	Leachate Nitrate-N concentration, $C_{Leachate\ NO3}$ (mg/L)
2004	26.5	1.57	122	0.0039	53	28	2	10	174	41
2005	18.2	1.19	122	0.0039	53	28	2	15	88	27
2006	10.0	1.34	122	0.0039	53	28	2	10	53	15
2007	7.3	0.98	122	0.0039	53	28	2	8	28	11
2008	9.2	1.32	122	0.0039	53	28	2	5	51	14

Scenario B.0[5]	GW Nitrate-N in late winter/early spring-AKG725, $C_{GW\ Outflow}$ (mg/L)[6]	Recharge R (feet)[6]	Recharge period, t (days)	Horizontal gradient, i_H (ft/ft)[7]	Hydraulic conductivity (K_H) (feet/day)	Attenuation factor, AF_{SZ} (%)	Aquifer mixing depth, b (feet)	Background GW Nitrate-N, $C_{GW\ Inflow}$ (mg/L)	Mass of Nitrate-N entering GW, $NO3_{TotExcess}$ (lb/acre)	Leachate Nitrate-N concentration, $C_{Leachate\ NO3}$ (mg/L)
2005	29.5	0.77	90	0.0044	53	0	2	15	69	33
2006	11.4	1.12	90	0.0044	53	0	2	10	35	12
2007	14.7	1.15	90	0.0044	53	0	2	12	47	15
2008	12.0	0.66	90	0.0044	53	0	2	8	24	13
2009	20.1	0.99	90	0.0044	53	0	2	10	59	22

Scenario B.15[5]	GW Nitrate-N in late winter/early spring-mean of 6 shallow wells, $C_{GW\ Outflow}$	Recharge R (feet)[6]	Recharge period, t (days)	Horizontal gradient, i_H (ft/ft)[7]	Hydraulic conductivity (K_H) (feet/day)	Attenuation factor, AF_{SZ} (%)	Aquifer mixing depth, b (feet)	Background GW Nitrate-N, $C_{GW\ Inlow}$ (mg/L)	Mass of Nitrate-N entering GW, $NO3_{TotExcess}$ (lb/acre)	Leachate Nitrate-N concentration, $C_{Leachate\ NO3}$ (mg/L)
2005	25.6	0.77	90	0.0044	53	15	2	15	84	40
2006	13.0	1.12	90	0.0044	53	15	2	10	49	16
2007	13.1	1.15	90	0.0044	53	15	2	12	50	16
2008	8.63	0.66	90	0.0044	53	15	2	8	19	11
2009	12.5	0.99	90	0.0044	53	15	2	10	42	16

Scenario B.28[5]	GW Nitrate-N in late winter/early spring-mean of 6 shallow wells, $C_{GW\ Outflow}$	Recharge R (feet)[6]	Recharge period, t (days)	Horizontal gradient, i_H (ft/ft)[7]	Hydraulic conductivity (K_H) (feet/day)	Attenuation factor, AF_{SZ} (%)	Aquifer mixing depth, b (feet)	Background GW Nitrate-N, $C_{GW\ Inflow}$ (mg/L)	Mass of Nitrate-N entering GW, $NO3_{TotExcess}$ (lb/acre)	Leachate Nitrate-N concentration, $C_{Leachate\ NO3}$ (mg/L)
2005	25.6	0.77	90	0.0044	53	28	2	15	100	48
2006	13.0	1.12	90	0.0044	53	28	2	10	59	20
2007	13.1	1.15	90	0.0044	53	28	2	12	60	19
2008	8.63	0.66	90	0.0044	53	28	2	8	24	13
2009	12.5	0.99	90	0.0044	53	28	2	10	50	19

Notes for Table T.1 are on the following page.

Notes for Table T.1:

[1] Mean of November and December results.
[2] September through December.
[3] Average gradient for December 28, 2004.
[4] Background groundwater nitrate-N concentration based on results the month before the start of the season of interest.
[5] 2009 is based on one date for groundwater nitrate, March 18, 2009.
[6] Mean of January, February, and March results.
[7] Average gradient on March 2, 2005.

Model Predictions

Table T.1 shows the resulting model predictions for the $NO3_{TotExcess}$ and $C_{Leachate\ NO3}$variables for each model run. Depending on the model scenario, the $NO3_{TotExcess}$ values for the fall/early winter period (Scenario A) ranged from 23 to 174 lbs/acre, and $C_{Leachate\ NO3}$values ranged from 9 to 41 mg/L NO_3-N. For the late winter/early spring period (Scenario B), $NO3_{TotExcess}$ values ranged from 19 to 100 lb/acre, and $C_{Leachate\ NO3}$ values ranged from 11 to 48 mg/L.

Table T.2 summarizes the predicted mass of nitrate infiltrating from the soil column needed to produce the groundwater nitrate concentrations observed during the entire high recharge season (September 1 through March 31). These values were determined by summing the $NO3_{TotExcess}$ estimates from Periods A and B.

Table T.2. Annual wet-season nitrate mass added to groundwater and the 5-year average using 3 methods for estimating wet-season groundwater nitrate concentration.

Year[1]	Based on nitrate-N in AKG725 and no denitrification (lb/acre)	Based on mean of 6 wells and 15% denitrification (lb/acre)	Based on mean of 6 wells and 28% denitrification (lb/acre)
Fall 2004-Spring 2005	223	230	274
Fall 2005-Spring 2006	117	122	147
Fall 2006-Spring 2007	96	94	113
Fall 2007-Spring 2008	56	42	52
Fall 2008-Spring 2009	126	84	101
Average	124	115	137

[1] September 1 to March 31.

Sensitivity analysis

To evaluate the sensitivity of the model predictions to the input assumptions, the value for each input variable was varied over a predetermined range, while all other variables were kept constant (Table T.3). The range of values used to test an individual variable was set to match the typical range of uncertainty for the variable. Model scenario A.15 was used to conduct this analysis. The factors that most affected the model predictions were:

- Recharge amount
- Attenuation factor (denitrification)
- Depth of mixing in the aquifer

Table T.3. Sensitivity Analysis Data – Model Scenario A.15

GW Nitrate-N--mean of 6 shallow wells, $C_{GW\ Outflow}$ [1] (mg/L)	Recharge R (feet)^2	Recharge period, t (days)	Horizontal gradient, i_H (ft/ft)[3]	Hydraulic conductivity (K_H) (feet/day)	Attenuation factor, AF_{SZ} (%)	Aquifer mixing depth, b (feet)	Background GW Nitrate-N, $C_{GW\ Inflow\_NO3}$ (mg/L)	Mass of N entering GW, $NO3_{TotExcess}$ (lb/acre)
26.5	1.57	122	0.0039	53	15	2	10	142
26.5	1.47	122	0.0039	53	15	2	10	133
26.5	1.37	122	0.0039	53	15	2	10	125
26.5	1.67	122	0.0039	53	15	2	10	150
26.5	1.77	122	0.0039	53	15	2	10	158

GW Nitrate-N--mean of 6 shallow wells, $C_{GW\ Outflow}$ [1] (mg/L)	Recharge R (feet)^2	Recharge period, t (days)	Horizontal gradient, i_H (ft/ft)[3]	Hydraulic conductivity (K_H) (feet/day)	Attenuation factor, AF_{SZ} (%)	Aquifer mixing depth, b (feet)	Background GW Nitrate-N, $C_{GW\ Inflow\_NO3}$ (mg/L)	Mass of N entering GW, $NO3_{TotExcess}$ (lb/acre)
26.5	1.57	122	0.0039	53	15	2	10	142
26.5	1.57	122	0.0029	53	15	2	10	139
26.5	1.57	122	0.0019	53	15	2	10	135
26.5	1.57	122	0.0049	53	15	2	10	145
26.5	1.57	122	0.0059	53	15	2	10	148

GW Nitrate-N--mean of 6 shallow wells, $C_{GW\ Outflow}$ [1] (mg/L)	Recharge R (feet)^2	Recharge period, t (days)	Horizontal gradient, i_H (ft/ft)[3]	Hydraulic conductivity (K_H) (feet/day)	Attenuation factor, AF_{SZ} (%)	Aquifer mixing depth, b (feet)	Background GW Nitrate-N, $C_{GW\ Inflow\_NO3}$ (mg/L)	Mass of N entering GW, $NO3_{TotExcess}$ (lb/acre)
26.5	1.57	122	0.0039	53	15	2	10	142
26.5	1.57	122	0.0039	80	15	2	10	148
26.5	1.57	122	0.0039	30	15	2	10	136
26.5	1.57	122	0.0039	150	15	2	10	164
26.5	1.57	122	0.0039	270	15	2	10	192

GW Nitrate-N--mean of 6 shallow wells, $C_{GW\ Outflow}$ [1] (mg/L)	Recharge R (feet)^2	Recharge period, t (days)	Horizontal gradient, i_H (ft/ft)[3]	Hydraulic conductivity (K_H) (feet/day)	Attenuation factor, AF_{SZ} (%)	Aquifer mixing depth, b (feet)	Background GW Nitrate-N, $C_{GW\ Inflow\_NO3}$ (mg/L)	Mass of N entering GW, $NO3_{TotExcess}$ (lb/acre)
26.5	1.57	122	0.0039	53	15	2	10	142
26.5	1.57	122	0.0039	53	0	2	10	123
26.5	1.57	122	0.0039	53	10	2	10	136
26.5	1.57	122	0.0039	53	20	2	10	148
26.5	1.57	122	0.0039	53	40	2	10	173
26.5	1.57	122	0.0039	53	60	2	10	197

GW Nitrate-N--mean of 6 shallow wells, $C_{GW\ Outflow}$ [1] (mg/L)	Recharge R (feet)^2	Recharge period, t (days)	Horizontal gradient, i_H (ft/ft)[3]	Hydraulic conductivity (K_H) (feet/day)	Attenuation factor, AF_{SZ} (%)	Aquifer mixing depth, b (feet)	Background GW Nitrate-N, $C_{GW\ Inflow\_NO3}$ (mg/L)	Mass of N entering GW, $NO3_{TotExcess}$ (lb/acre)
26.5	1.57	122	0.0039	53	15	2	10	142
26.5	1.57	122	0.0039	53	15	1	10	136
26.5	1.57	122	0.0039	53	15	3	10	148
26.5	1.57	122	0.0039	53	15	5	10	160
26.5	1.57	122	0.0039	53	15	7	10	173

GW Nitrate-N--mean of 6 shallow wells, $C_{GW\ Outflow}$ [1] (mg/L)	Recharge R (feet)^2	Recharge period, t (days)	Horizontal gradient, i_H (ft/ft)[3]	Hydraulic conductivity (K_H) (feet/day)	Attenuation factor, AF_{SZ} (%)	Aquifer mixing depth, b (feet)	Background GW Nitrate-N, $C_{GW\ Inflow\_NO3}$ (mg/L)	Mass of N entering GW, $NO3_{TotExcess}$ (lb/acre)
26.5	1.57	122	0.0039	53	15	2	10	142
26.5	1.57	122	0.0039	53	15	2	5	145
26.5	1.57	122	0.0039	53	15	2	15	138
26.5	1.57	122	0.0039	53	15	2	20	135
26.5	1.57	122	0.0039	53	15	2	25	130

[1] November and December results.

The sensitivity analysis revealed:

- For each 0.1 foot of additional recharge, the model predicted roughly 8.5 lb/acre more nitrate mass was required to leach from above to explain the observed groundwater concentration.
- For each 10 % increase in attenuation (denitrification), the mass of nitrate leaching required to explain the measured groundwater concentration increased by about 13 lb/acre.
- The depth of mixing that the groundwater samples represents could vary from 2 to 7 feet (the wetted length of the screen). The difference in nitrate mass leached between a 2-foot and 7-foot mixing depth is about 30 lb/acre.

The range of likely hydraulic conductivity values for the site (30 to 80 feet/day) caused a small difference in the nitrate mass required to leach to explain the observed groundwater concentration (12 lb/acre). The background nitrate concentration also did not have a large effect on the back-calculated nitrate mass, because recharge rate, which drives the leachate, was so much higher than the rate of movement in the aquifer, i.e., over 6 times higher in this example (see Figure T.1. $Q_{Leachate}$ and $Q_{GW\ Inflow}$).

Model Limitations

The GWNO3-BACKCAST model is a simplification of the real world and is best used for testing nitrate loading to unconfined aquifers with comparatively shallow water tables. In the field, a complex combination of biological, chemical, and physical reactions can exert influence on the fate and transport of nitrate from the soil zone to an aquifer that are not necessarily accounted for by the model. See Pitz (in preparation) for a full description of the model limitations.

The main limitations of the model are:

- The model does not account for preferential flow that can occur even when there is no measurable recharge. Concentrations of nitrate in preferential flow can be much higher than those from conventional recharge assumed in the model and can be spatially heterogeneous.
- If all of the recharge does not reach the water table in the time specified, the estimate of nitrate leached would be underestimated. This could occur if the time of travel for recharge was greater than the time step used in the model.
- Low permeability layers in the vadose zone could affect the timing and spatial distribution of nitrate at the water table.

Although we believe that the site conditions for the study aquifer reasonably match the model assumptions, the nitrate loading values predicted by the model should be considered approximations.

References

Pitz, C.F., 2014 (In preparation). Spreadsheet models for determining the influence of land applications of fertilizer on underlying groundwater nitrate concentrations. Washington State Department of Ecology, Olympia, WA.

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