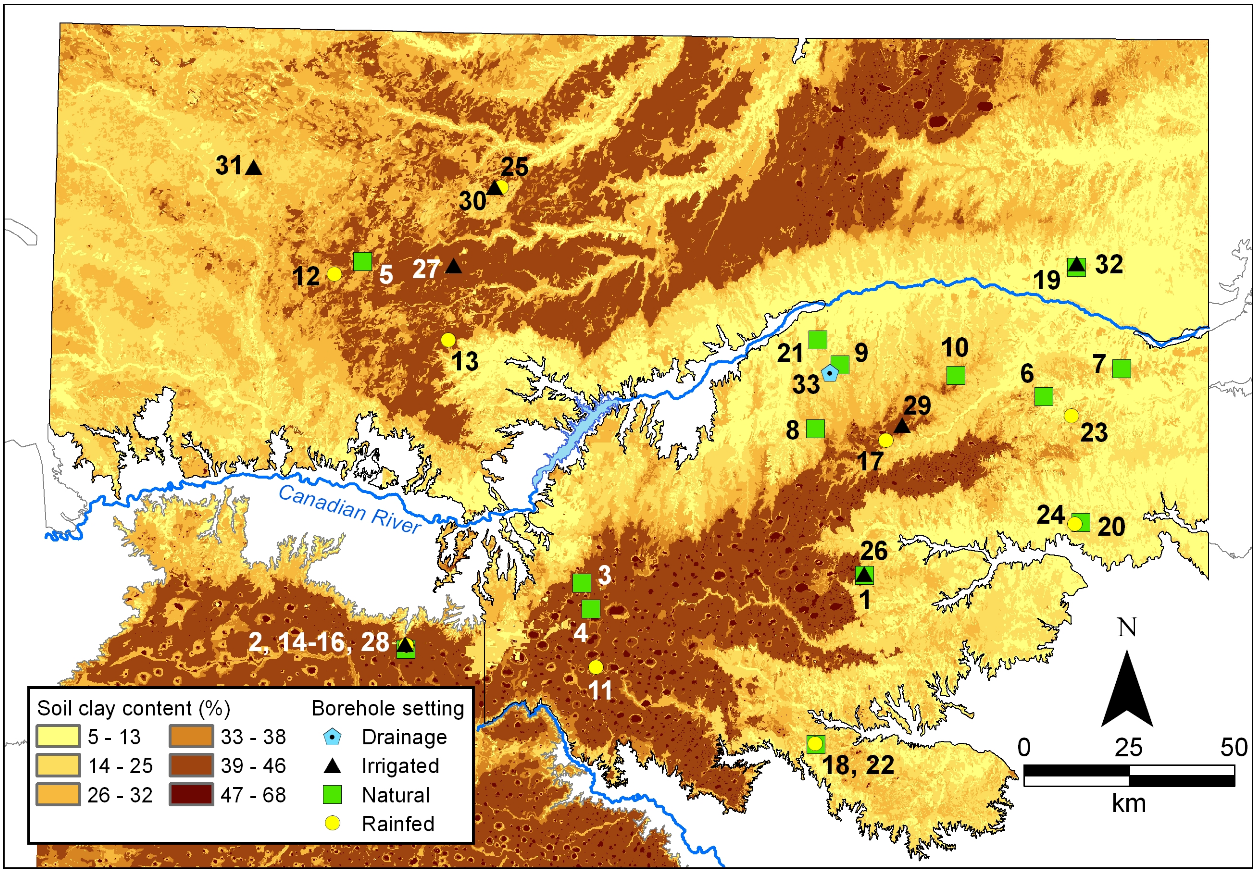

Figure S1. Borehole locations and distribution of soil clay content (SSURGO, USDA, 1995) in the study area.

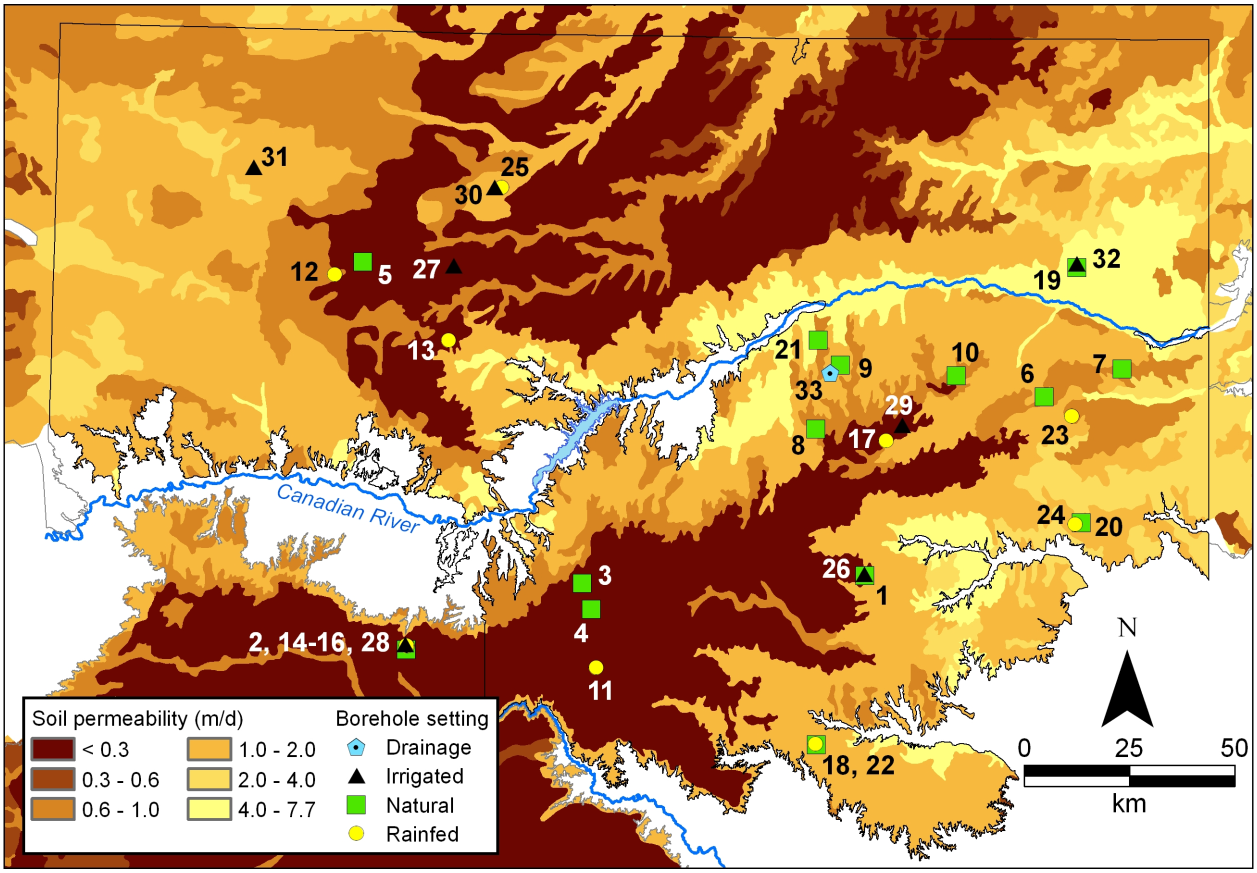

Figure S2. Borehole locations and distribution of soil permeability (STATSGO, USDA, 1994) in the study area.

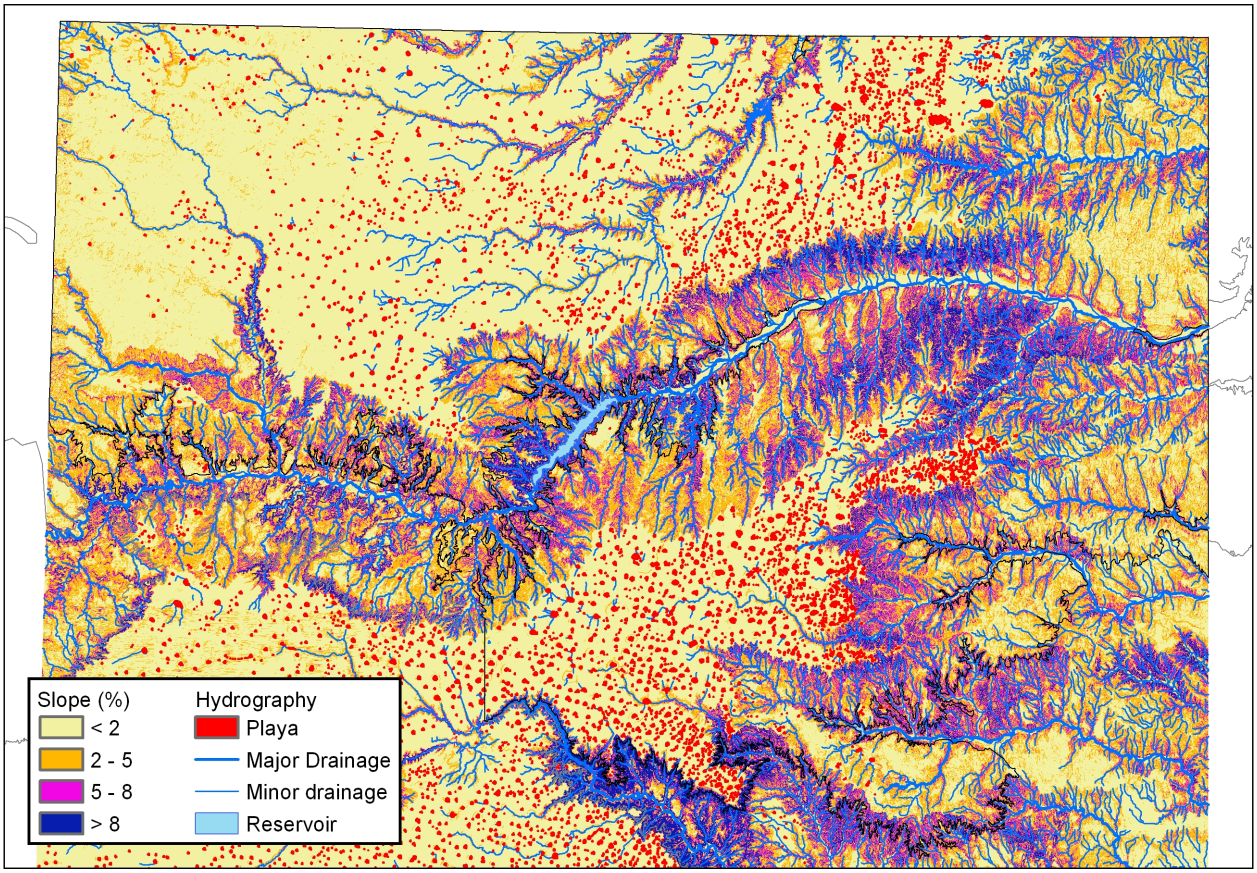

Figure S3. Ground surface slope and drainage network in the study area. Playa areas are not to scale.

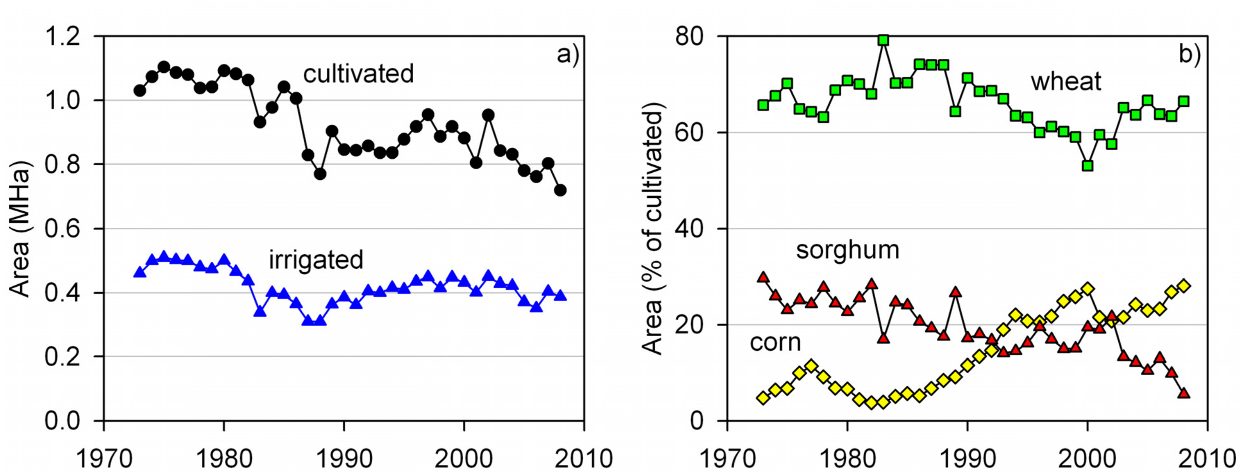

Figure S4. Temporal variation in a) cultivated and irrigated area and b) percentage of cultivated area planted with the major crops (corn, wheat, and sorghum) in the CHP study area (NASS, 1973-2008).

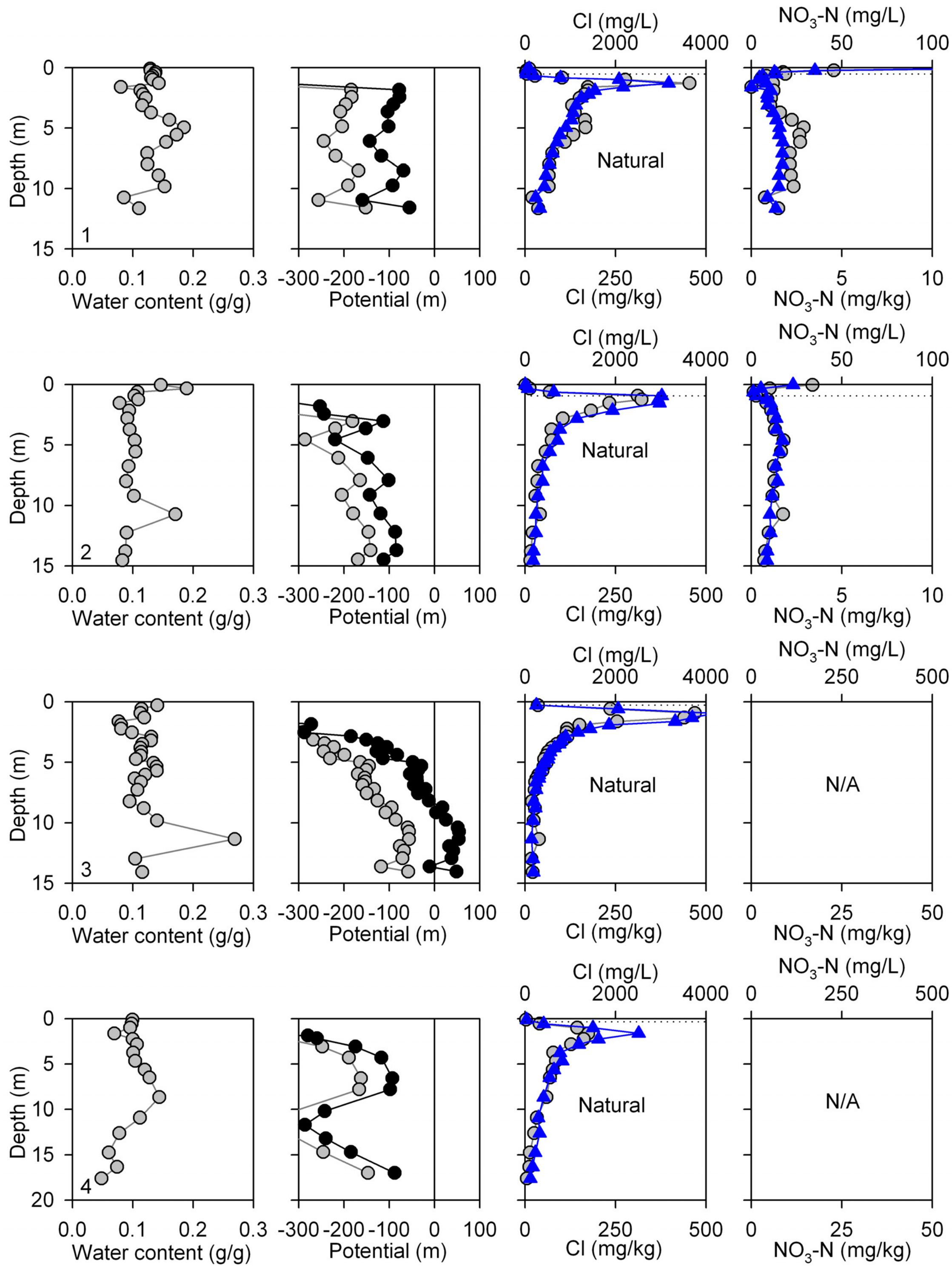

Figure S5. Natural ecosystem borehole profiles of water content, water potential (gray circles), total potential (black circles), and Cl and NO_3-N concentrations (blue triangles: mg/L, gray circles: mg/kg) in fine- to medium-grained soils. Horizontal dotted lines indicate depths of root zones. Borehole locations are shown in Figure 1.

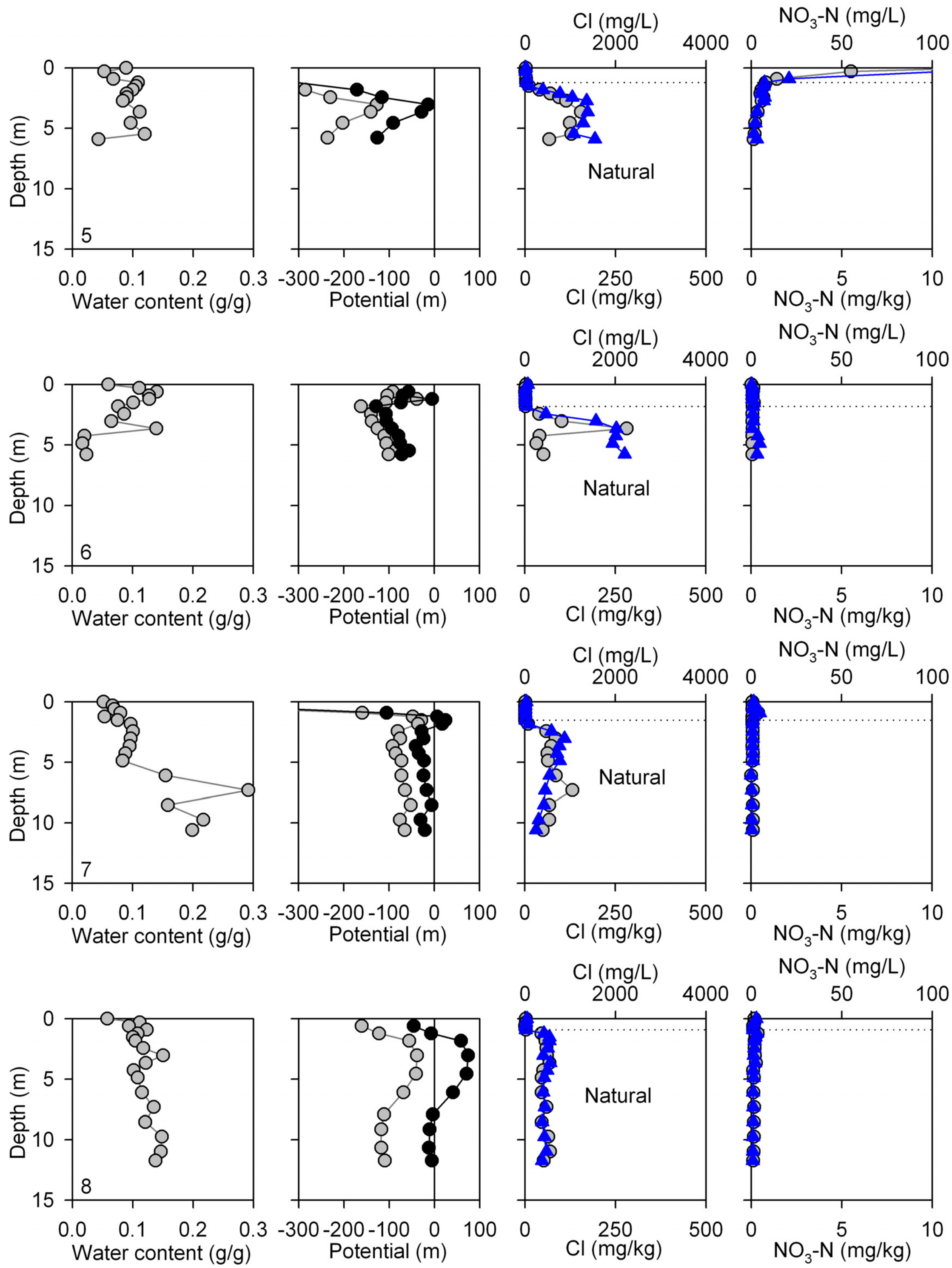

Figure S5 (continued). Natural ecosystem borehole profiles of water content, water potential (gray circles), total potential (black circles), and Cl and NO_3-N concentrations (blue triangles: mg/L, gray circles: mg/kg) in fine- to medium-grained soils. Horizontal dotted lines indicate depths of root zones. Borehole locations are shown in Figure 1.

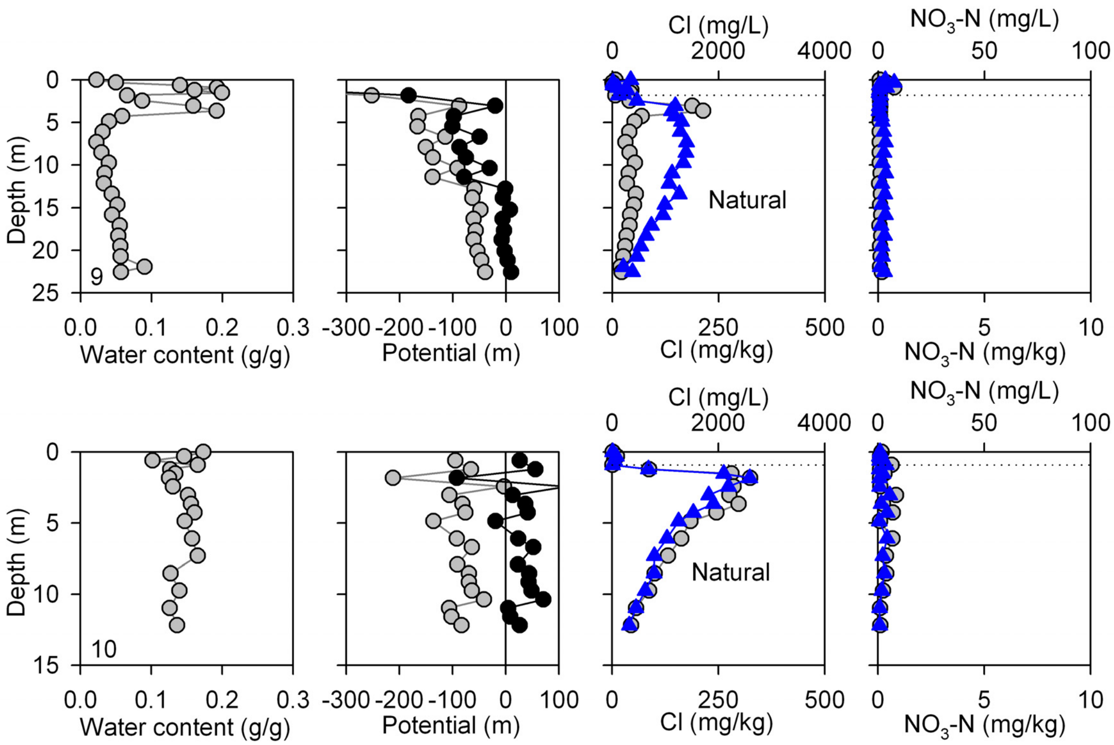

Figure S5 (continued). Natural ecosystem borehole profiles of water content, water potential (gray circles), total potential (black circles), and Cl and NO_3-N concentrations (blue triangles: mg/L, gray circles: mg/kg) in fine- to medium-grained soils. Horizontal dotted lines indicate depths of root zones. Borehole locations are shown in Figure 1.

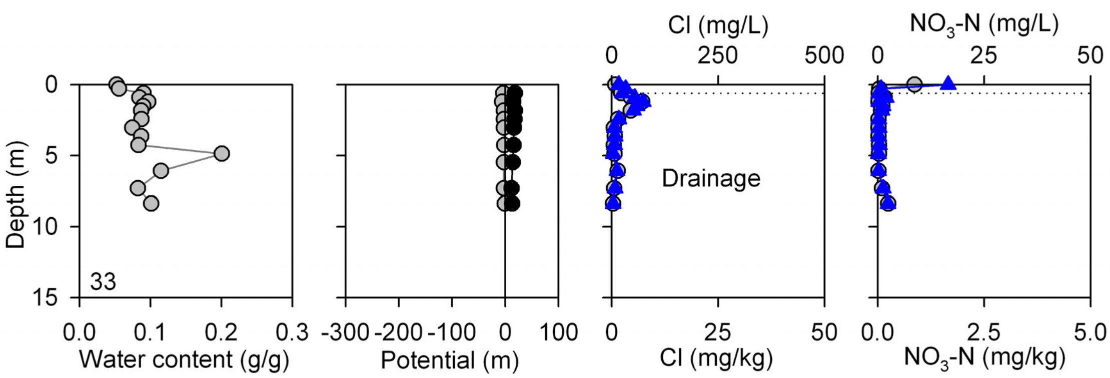

Figure S6. Drainage setting borehole profiles of water content, water potential (gray circles), total potential (black circles), and Cl and NO_3-N concentrations (blue triangles: mg/L, gray circles: mg/kg). Horizontal dotted line indicates depth of root zone. Borehole location is shown in Figure 1.

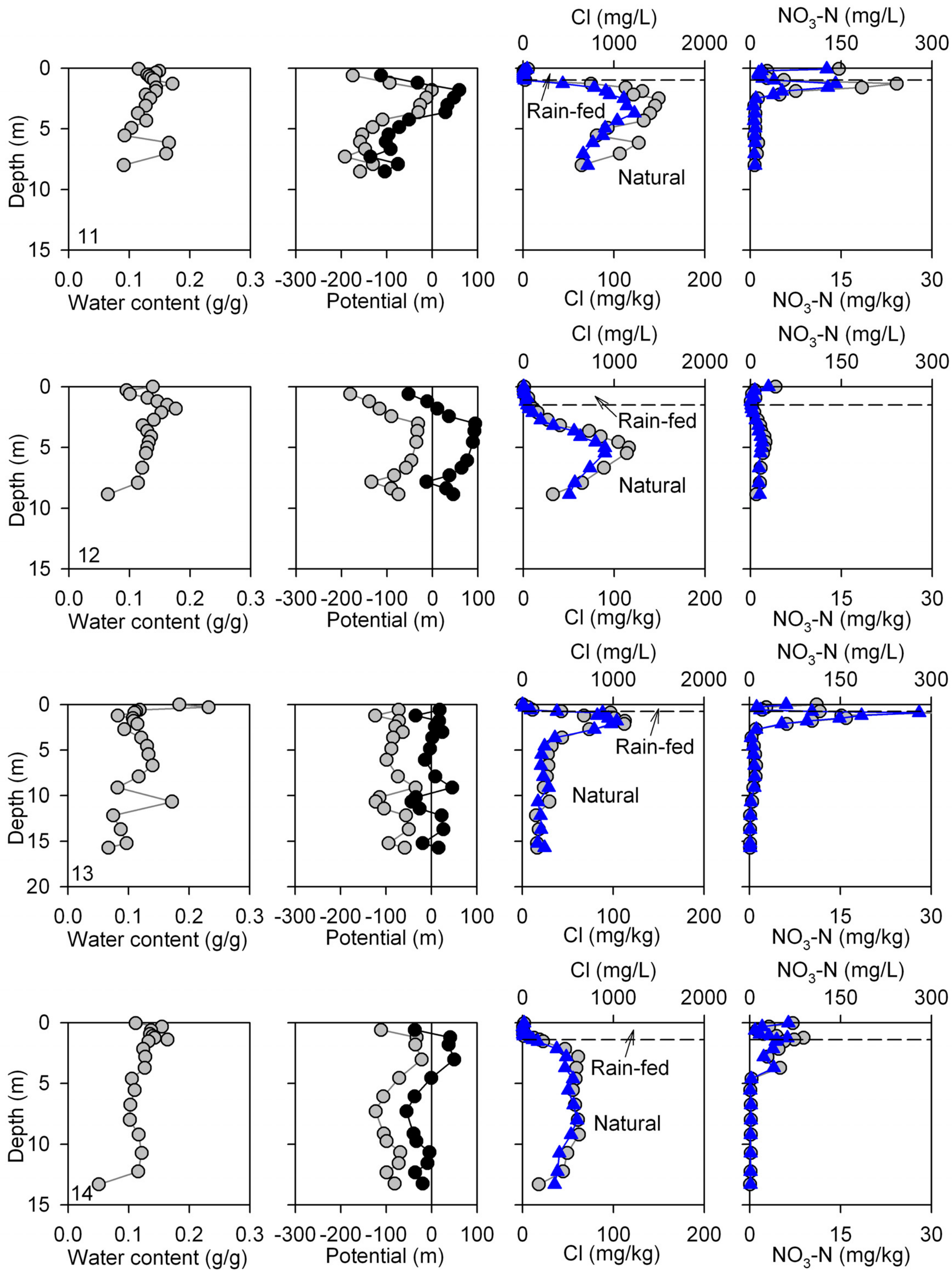

Figure S7. Rain-fed agroecosystem setting borehole profiles of water content, water potential (gray circles), total potential (black circles), and Cl and NO_3-N concentrations (blue triangles: mg/L, gray circles: mg/kg) in fine- to medium-grained soils. Horizontal dashed lines indicate depths of rain-fed agroecosystem impacts in the profiles. Borehole locations are shown in Figure 1.

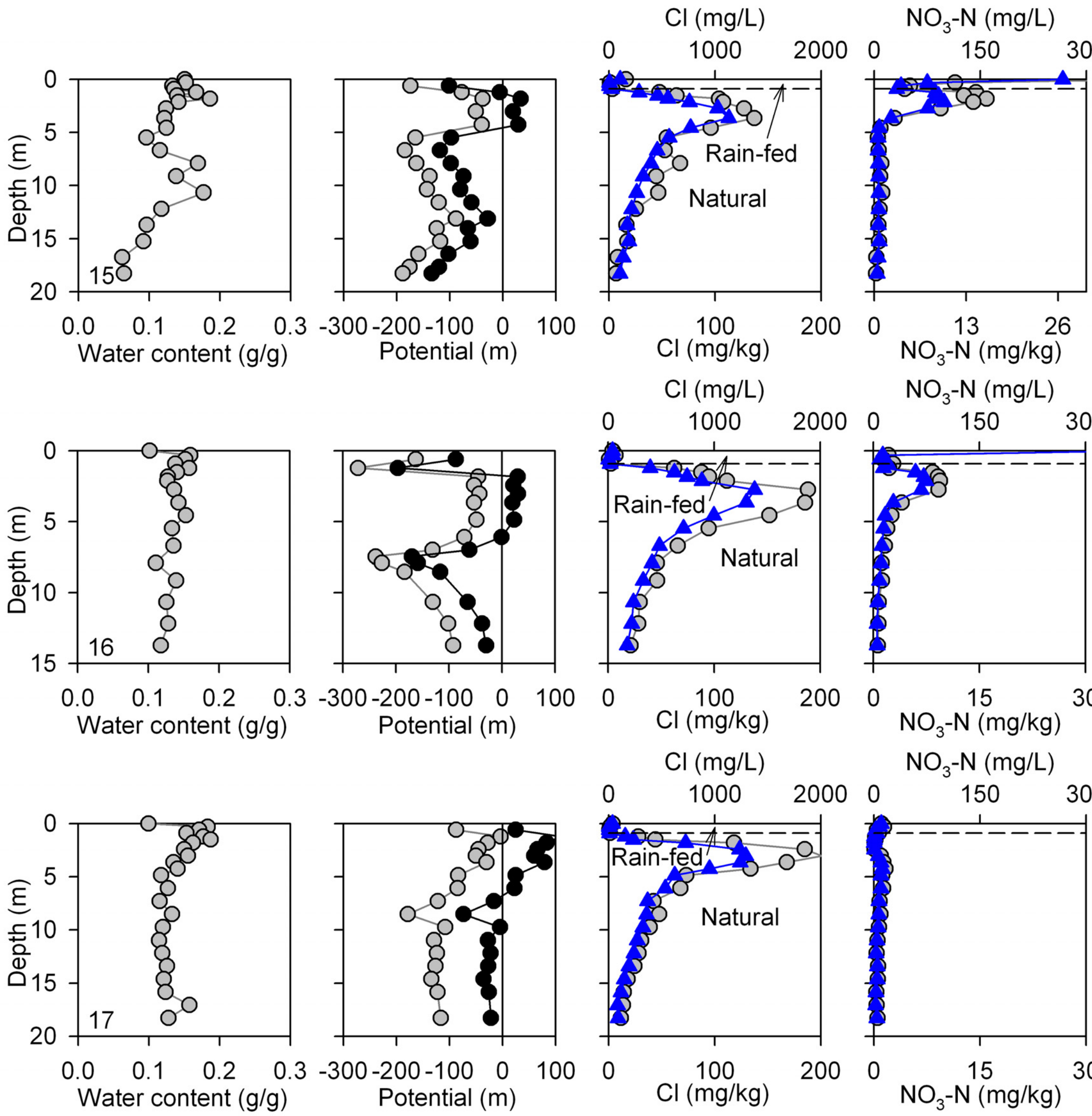

Figure S7 (continued). Rain-fed agroecosystem setting borehole profiles of water content, water potential (gray circles), total potential (black circles), and Cl and NO_3-N concentrations (blue triangles: mg/L, gray circles: mg/kg) in fine- to medium-grained soils. Horizontal dashed lines indicate depths of rain-fed agroecosystem impacts in the profiles. Borehole locations are shown in Figure 1.

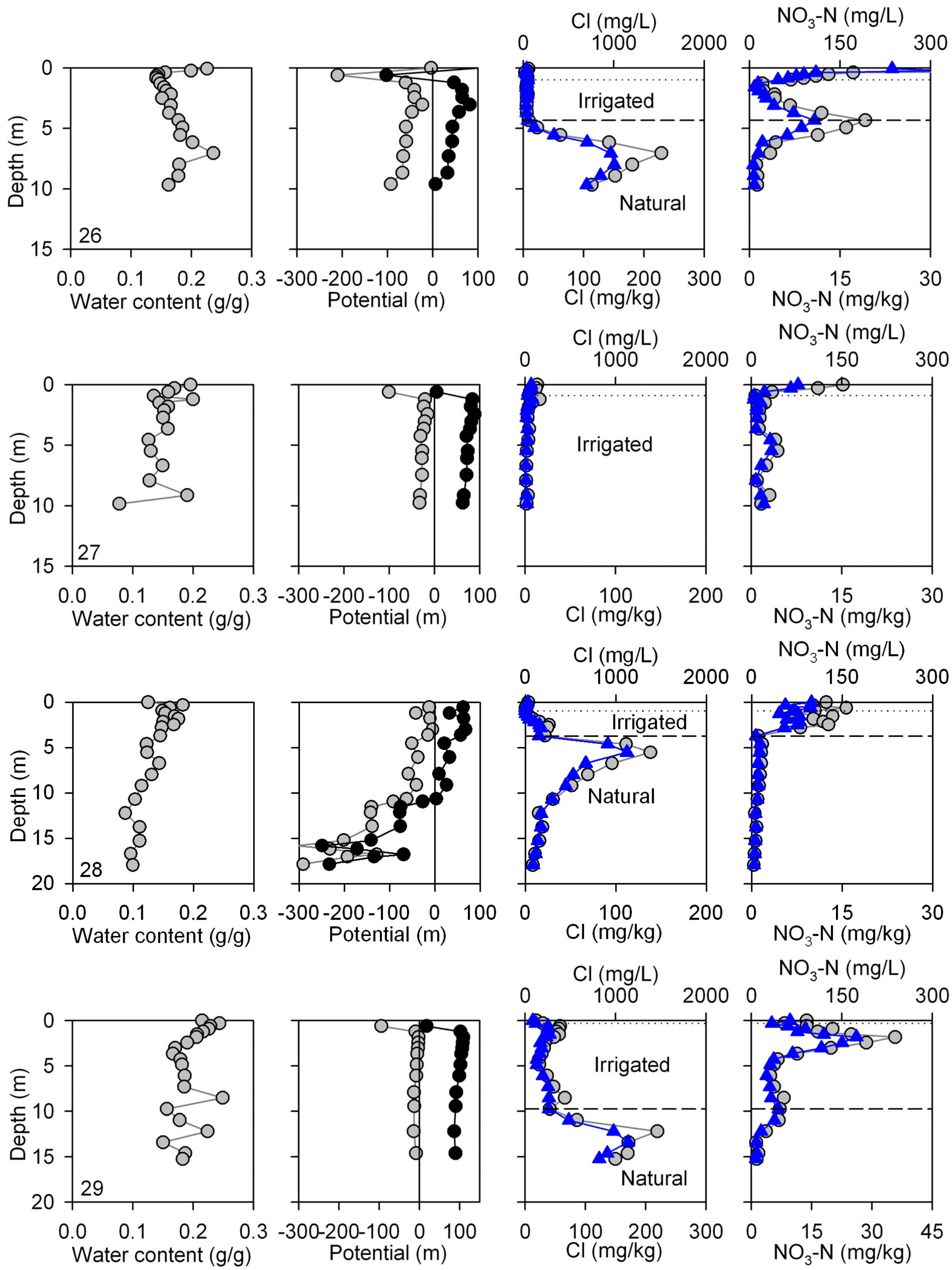

Figure S8. Irrigated agroecosystem setting borehole profiles of water content, water potential (gray circles), total potential (black circles), and Cl and NO_3-N concentrations (blue triangles: mg/L, gray circles: mg/kg) in fine- to medium-grained soils. Horizontal dotted lines indicate depths of root zones. Horizontal dashed lines indicate depths of irrigated agroecosystem impacts in the profiles. Profile 27 is impacted to the maximum depth of sampling. Borehole locations are shown in Figure 1.

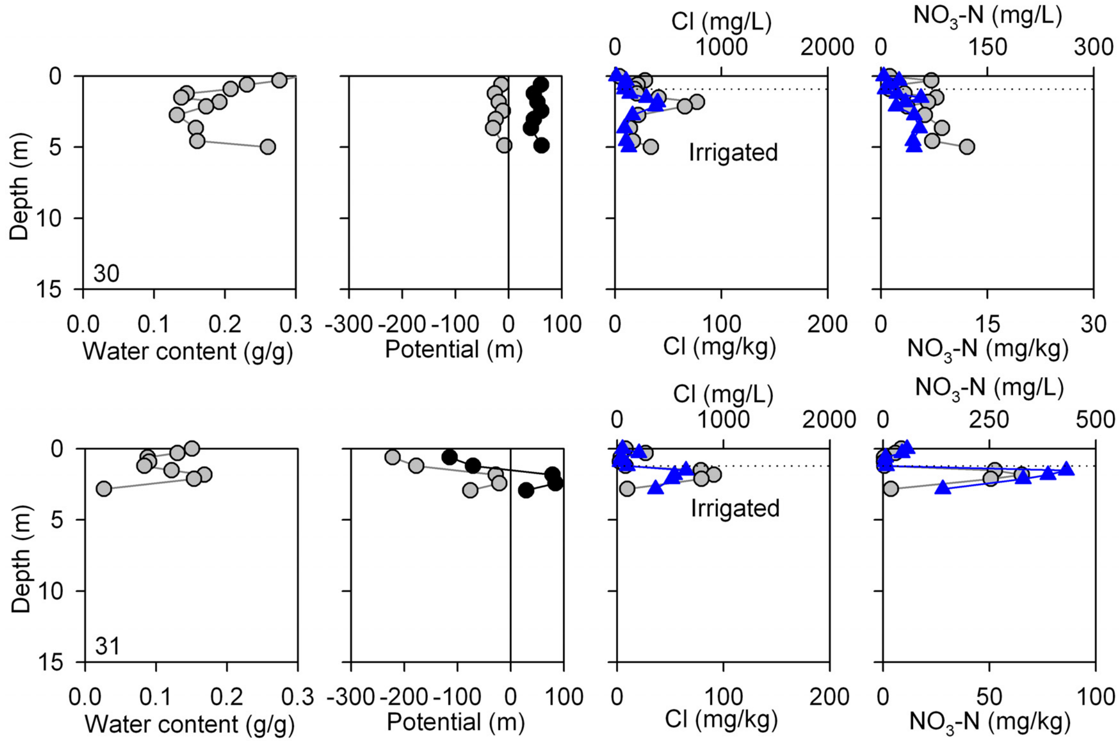

Figure S8 (continued). Irrigated agroecosystem setting borehole profiles of water content, water potential (gray circles), total potential (black circles), and Cl and NO_3-N concentrations (blue triangles: mg/L, gray circles: mg/kg) in fine- to medium-grained soils. Horizontal dotted lines indicate depths of root zones. Profiles 30 and 31 are impacted to the maximum depths of sampling. Borehole locations are shown in Figure 1.

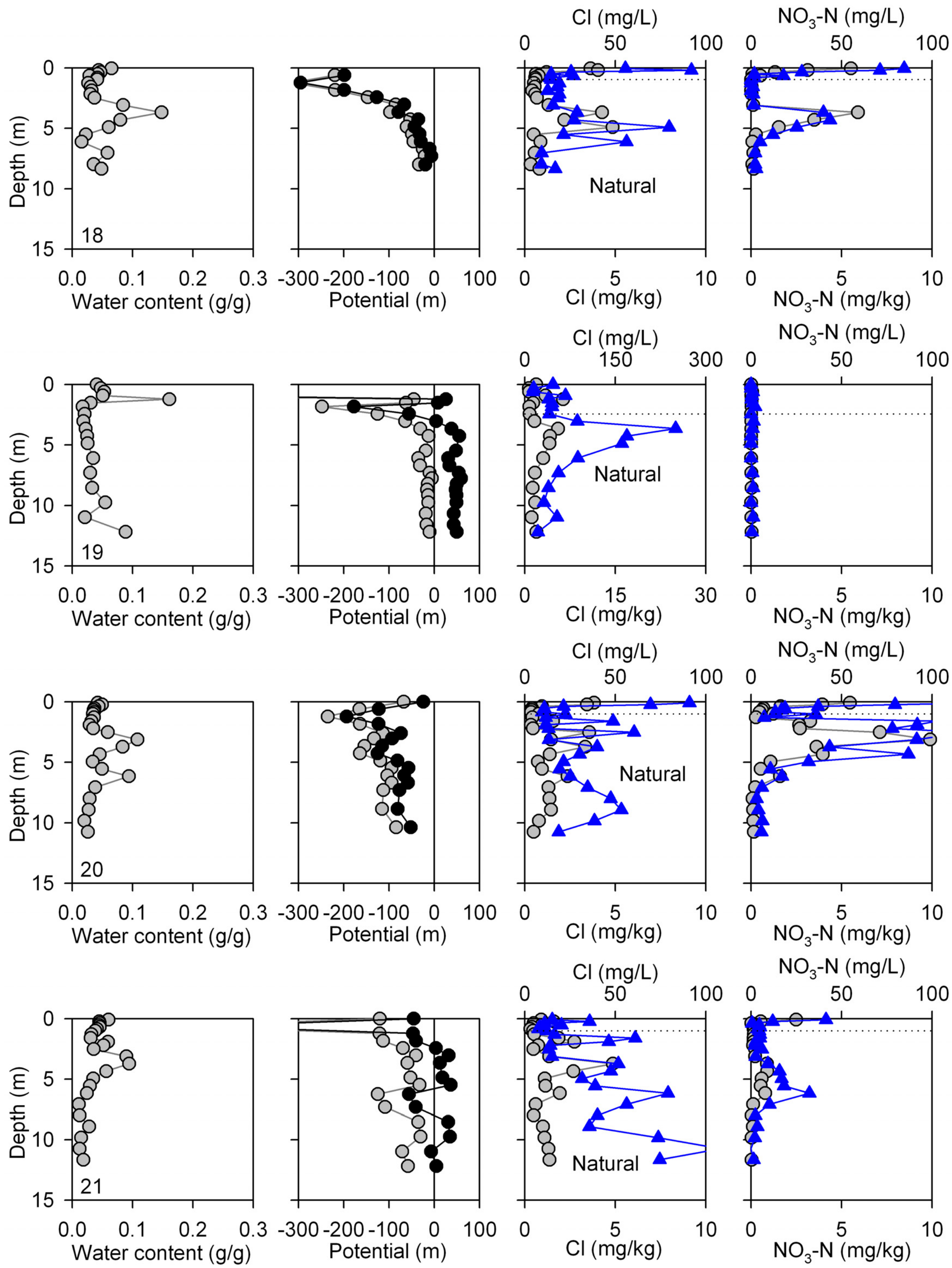

Figure S9. Natural setting borehole profiles of water content, water potential (gray circles), total potential (black circles), and Cl and NO_3-N concentrations (blue triangles: mg/L, gray circles: mg/kg) in medium- to coarse-grained soils. Horizontal dotted lines indicate depths of root zones. Borehole locations are shown in Figure 1.

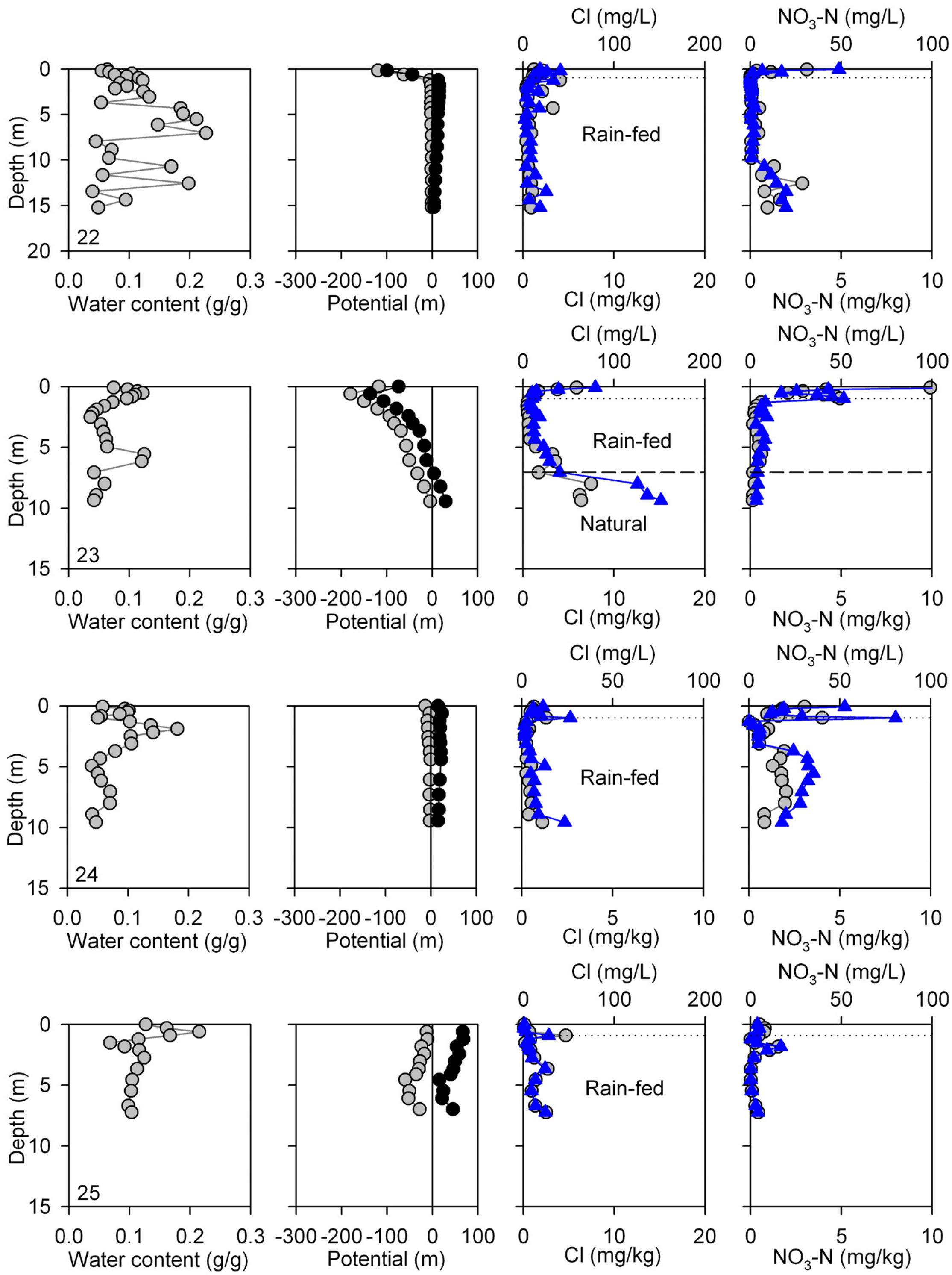

Figure S10. Rain-fed agroecosystem setting borehole profiles of water content, water potential (gray circles), total potential (black circles), and Cl and NO_3-N concentrations (blue triangles: mg/L, gray circles: mg/kg) in medium- to coarse-grained soils. Horizontal dotted lines indicate depths of root zones. Horizontal dashed lines in profile 10 indicate depth of rain-fed agroecosystem impact. Remaining profiles are impacted to the maximum depths of sampling. Borehole locations are shown in Figure 1.

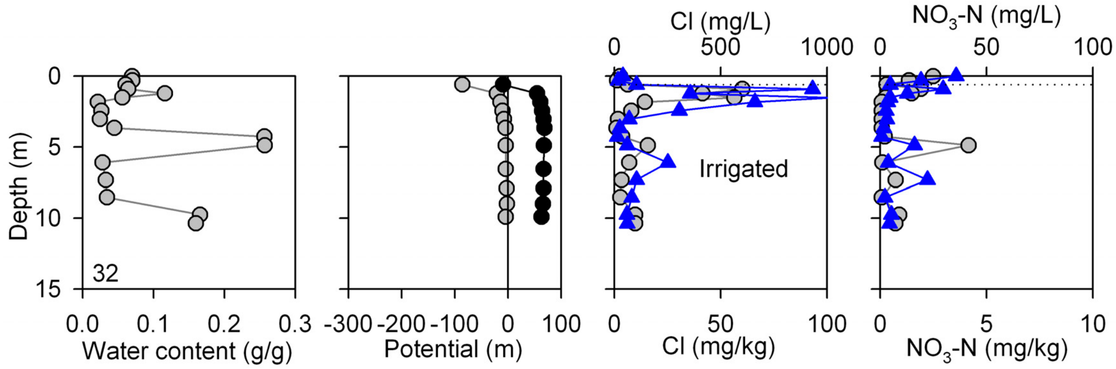

Figure S11. Irrigated agroecosystem setting borehole profiles of water content, water potential (gray circles), total potential (black circles), and Cl and NO_3-N concentrations (blue triangles: mg/L, gray circles: mg/kg) in medium- to coarse-grained soils. Horizontal dotted lines indicate depth of root zone. The profile is impacted to the maximum depth of sampling. Borehole locations are shown in Figure 1.

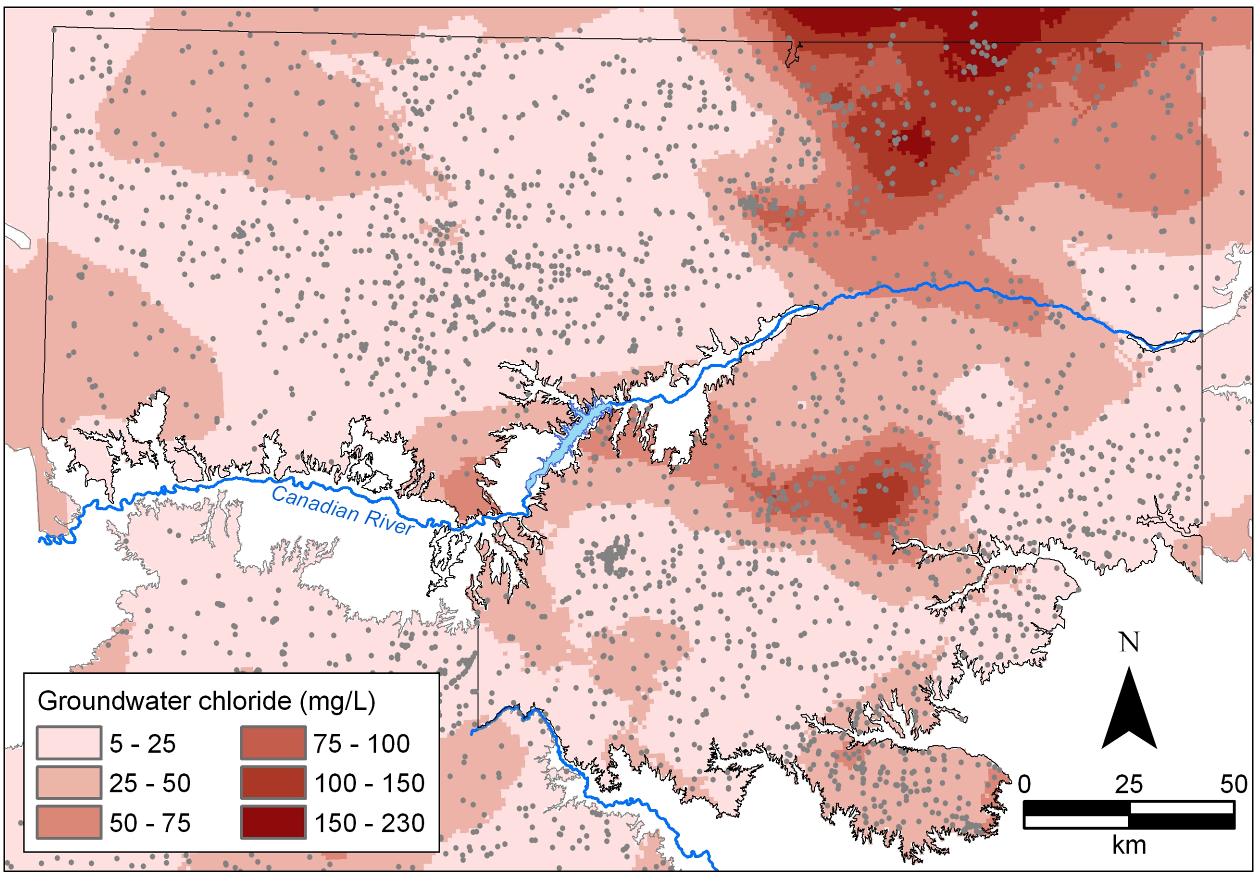

Figure S12. Distribution of groundwater chloride concentrations in the study area. Points represent sampled well locations (N= 2,285 in Texas CHP) (TWDB database).

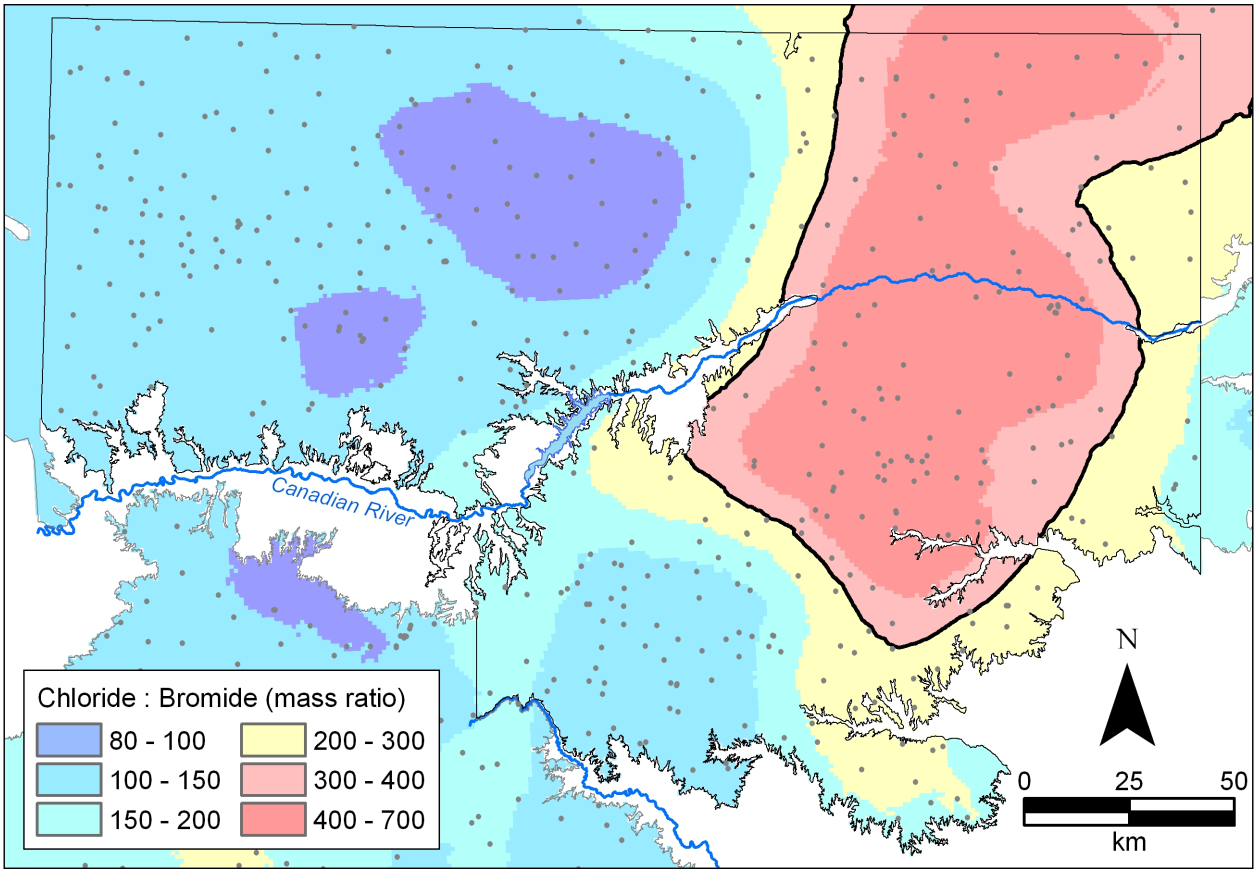

Figure S13. Distribution of groundwater Cl/Br mass concentration ratios in the study area. Points represent sampled well locations (N= 455) in the Texas CHP (TWDB database) and in the surrounding areas of Oklahoma and New Mexico (NWIS database). Contour delineates the Cl/Br > 300 region.

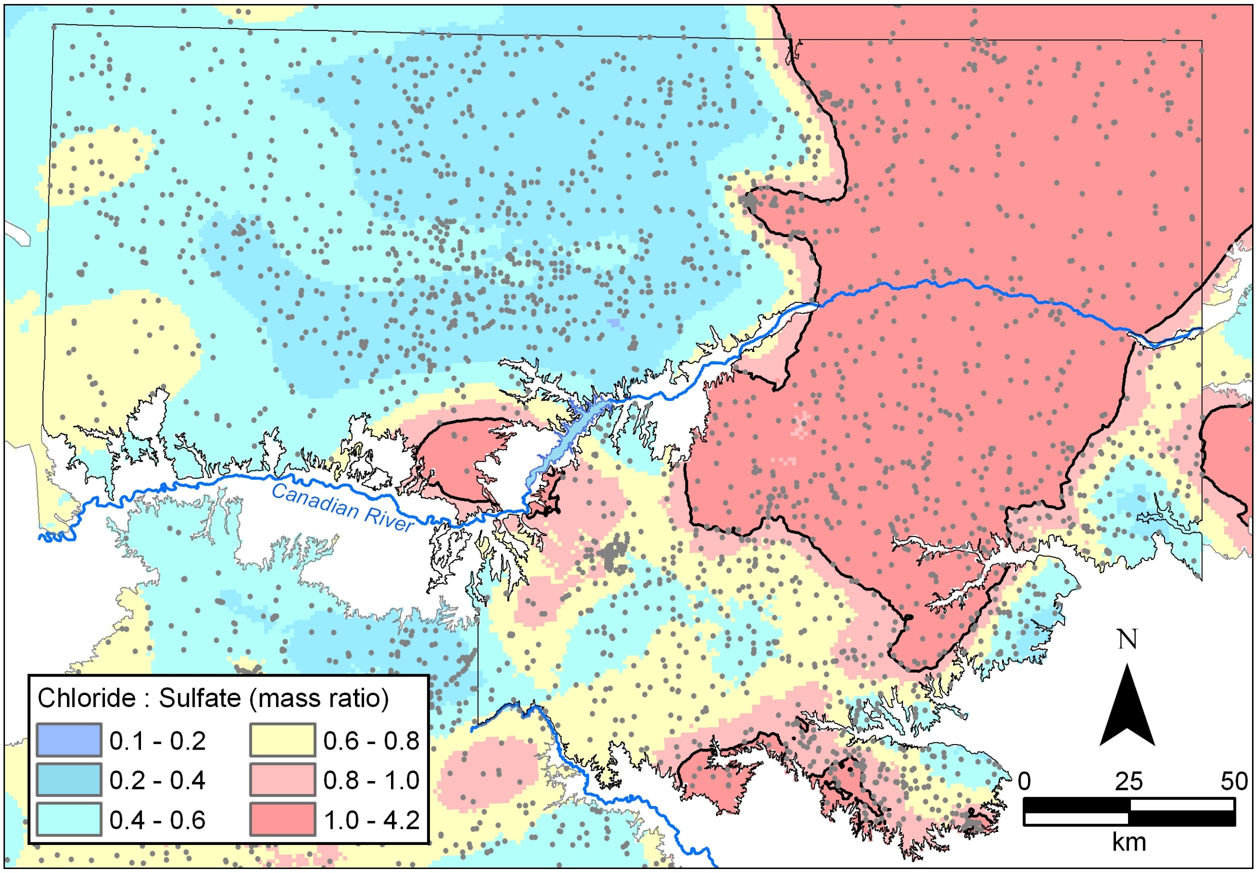

Figure S14. Distribution of groundwater Cl/SO_4 mass concentration ratios in the study area. Points represent sampled well locations (N= 2,545) in the Texas CHP (TWDB database) and in the surrounding areas of Oklahoma and New Mexico (NWIS database). Contour delineates the Cl/SO_4 > 1.0 regions.

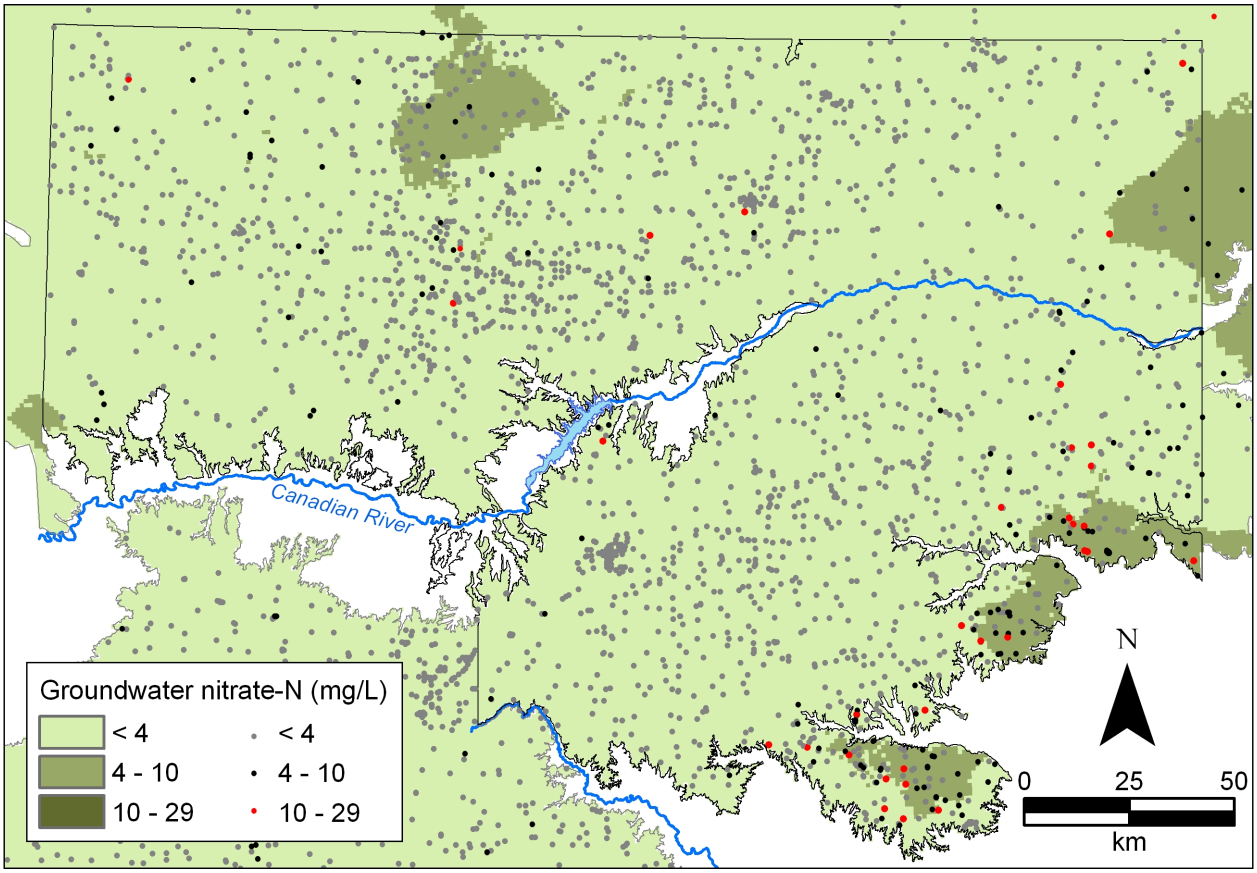

Figure S15. Distribution of groundwater NO_3-N concentrations in the study area. Points represent sampled well locations (N= 2,371) in the Texas CHP (TWDB database) and in the surrounding areas of Oklahoma and New Mexico (NWIS database).

Table S1. Supplemental borehole information.

Profile (Designation)	*Soil Series*	*DTW m*	*Depth m*	*Interval m*	*Cl kg/ha/m*	*N kg/ha/m*
Natural (fine-medium grain soils)						
1 (Gra06-01)	Pullman CL	107	1.7	0.5–11.7	1,800	29
2 (Pot07-04)[1]	Pullman CL	75	14.6	1.0–14.6	1,000	20
3 (Wink)[2]	Pullman CL	111	14.1	1.0–14.1	1,100	–
4 (Playa5)[2]	Pullman CL	73	17.6	1.0–17.6	940	–
5 (Har08-01)	Sunray CL	127	5.9	1.2–5.9	1,700	6.4
6 (Hem07-03)	Dumas L	36	5.8	1.8–5.8	1,300	1.3
7 (Hem07-04)	Dumas L	56	10.6	1.5–10.6	1,200	1.3
8 (Rob07-01)	Estacado CL	117	11.7	0.9–11.7	880	2.6
9 (Rob07-04)	Amarillo FSL	90	22.6	1.8–22.6	790	1.6
10 (Rob07-06)	Olton CL	121	12.2	0.9–12.2	2,500	5.4
Median					1,200	4.0
Rain-fed (fine-medium grain soils)						
11 (Arm06-01)[1]	Pullman CL	61	8.0	1.0–8.0	1,800	52
12 (Har08-03)	Sunray CL	142	8.9	1.2–8.9	1,100	25
13 (Moo08-01)	Sherm SiCL	95	15.7	0.6–15.7	570	34
14 (Pot06-02)[1]	Pullman CL	75	13.3	1.1–13.3	830	22
15 (Pot08-04)	Pullman CL	73	18.3	0.9–18.3	810	37
16 (Pot08-06)	Pullman CL	76	13.7	0.9–13.7	1,200	42
17 (Rob07-03)	Pullman CL	118	18.3	0.9–18.3	890	12
Median					890	34
Natural (medium-coarse grain soils)						
18 (Don06-02)	Springer LFS	23	8.3	1.0–8.3	23	16
19 (Hem07-02)	Dalhart FSL	51	12.2	2.4–12.2	38	<0.3
20 (Whe06-01)	Devol LFS	44	10.7	1.0–10.7	23	32
21 (Rob06-02)	Amarillo FSL	77	11.7	1.0–11.7	23	4.6
Median					23	10
Rain-fed (medium-coarse grain soils)						
22 (Don06-01)	Miles LFS	22	15.2	1.0–8.4	17	2.6
23 (Hem06-01)	Dumas L	43	9.4	1.0–7.5	23	7.8
24 (Whe06-02)	Grandfield LFS	29	9.6	1.0–9.6	6.6	22
25 (She08-02)	Dalhart FSL	88	7.3	0.9–7.3	23	4.3
Median					20	6.1
Irrigated (all soils)						
26 (Gra06-02)	Pullman CL	107	9.7	1.0 - 4.6	100	130
27 (Moo08-02)	Sherm SiCL	112	9.8	0.9 - 6.1	70	39
28 (Pot07-03)	Pullman SiCL	76	18.0	1.0 – 3.7	280	120
29 (Rob07-02)	Pullman CL	112	15.2	0.3 - 10.4	660	190
30 (She08-01)	Gruver CL	85	5.0	0.9 – 5.0	480	110
31 (Dal08-01)	Dallam LFS	112	2.8	1.2 - 2.8	950	620
32 (Hem07-01)	Springer FSL	54	10.4	0.6 - 10.4	180	12
Median					380	130
Drainage						
33 (Rob07-05)						

Profile (Designation): profile number (Figure 1) and borehole designation (first three letters of county name followed by year drilled followed by sequence within year), *Soil Series*: Soil series name and texture (CL: clay loam, SiCL: silty clay loam, L: loam, FSL: fine sandy loam, LFS: loamy fine sand) (SSURGO, USDA, 1995), *DTW*: current depth to water table, *Depth*: borehole total depth, *Interval*: borehole depth interval below the root zone, *Cl* and *N*: chloride and nitrate-N mass inventory normalized by depth interval.

[1]Scanlon et al (2008a)

[2]Scanlon and Goldsmith (1997)

Table S2. Water level hydrograph summary

Well ID	*County*	*Latitude*	*Longitude*	*From*	*To*	*Period (yr)*	*WL Change (m)*	*Rate (m/yr)*	*Recharge (mm/yr)*
550903	Donley	35.14000	-100.75444	1988	2008	21	5.2	0.26	40
551715	Donley	35.16472	-100.74972	1987	2008	22	3.6	0.19	28
551801	Donley	35.13917	-100.68639	1984	2007	24	1.1	0.06	8.6
557803	Donley	35.00583	-100.93778	1976	2008	33	1.0	0.03	4.3
558303	Donley	35.10556	-100.75556	1972	2008	37	2.3	0.09	14
1201502	Donley	34.93472	-100.95389	1976	2008	33	2.1	0.07	11
1201617	Donley	34.92083	-100.91028	1979	2008	30	4.6	0.15	23
1201624	Donley	34.91805	-100.88222	1976	2006	31	5.2	0.15	22
1201904	Donley	34.90111	-100.89667	1979	2005	27	3.3	0.15	22
1203401	Donley	34.93861	-100.71444	1990	1998	9	4.1	0.45	68
1203904	Donley	34.87889	-100.62944	1976	2001	26	3.9	0.16	24
1204805	Donley	34.89444	-100.57055	1987	2007	21	2.9	0.12	18
1212102	Donley	34.86639	-100.60750	1976	1989	14	3.0	0.23	34
464901	Hemphill	36.01583	-100.02750	1976	2009	34	2.7	0.09	13
508301	Hemphill	35.97528	-100.01472	1980	2009	30	2.0	0.09	14
508502	Hemphill	35.95500	-100.06833	1977	2009	33	2.6	0.09	14
515505	Hemphill	35.82444	-100.16778	1975	2009	35	2.9	0.10	15
515901	Hemphill	35.78611	-100.16500	1976	2009	34	1.9	0.05	8.2
516303	Hemphill	35.83389	-100.02472	1980	2009	30	1.3	0.06	8.3
516402	Hemphill	35.80194	-100.10250	1957	2009	53	2.9	0.04	6.7
516901	Hemphill	35.77722	-100.02500	1988	2009	22	1.2	0.06	10
522801	Hemphill	35.66000	-100.30417	1977	2008	32	2.4	0.07	10
522901	Hemphill	35.63028	-100.28972	1975	2009	35	2.2	0.04	5.9
523701	Hemphill	35.62972	-100.21417	1978	2008	31	1.4	0.04	6.7
523801	Hemphill	35.65722	-100.18194	1977	2009	33	2.6	0.10	15
524201	Hemphill	35.71556	-100.04972	1971	2009	39	2.2	0.06	8.4
524701	Hemphill	35.63833	-100.11139	1975	2001	27	3.2	0.10	15
524901	Hemphill	35.64472	-100.01833	1958	1983	26	4.7	0.18	27
531305	Hemphill	35.62389	-100.14333	1976	2001	26	2.6	0.09	13
532203	Hemphill	35.62389	-100.06250	1975	2008	34	3.3	0.11	16
529307	Wheeler	35.58667	-100.37583	1977	2003	27	2.5	0.09	14
530903	Wheeler	35.54028	-100.29111	1977	2008	32	1.3	0.04	6.6
531406	Wheeler	35.55389	-100.24472	1977	2007	31	1.7	0.05	7.5
531703	Wheeler	35.50722	-100.22389	1977	2006	30	2.7	0.07	11
532107	Wheeler	35.59639	-100.11944	1977	2008	32	1.4	0.05	7.8
532206	Wheeler	35.58611	-100.04389	1977	2005	29	5.7	0.21	32
532304	Wheeler	35.59000	-100.01472	1983	1993	11	2.4	0.26	38
545204	Wheeler	35.35694	-100.43083	1973	2007	35	5.1	0.16	25
552307	Wheeler	35.21694	-100.50722	1980	2008	29	3.0	0.10	15
553102	Wheeler	35.22778	-100.46639	1986	2003	18	2.2	0.17	25
					Median	30	2.6	0.09	14

Well ID: Texas state well identification number (TWDB database), *County*: county location, *Latitude, Longitude*: NAD83 well location coordinates, *From, To*: beginning and ending dates of analysis, *Period*: duration of analysis period, *WL Change*: water level change during period of analysis, *Rate*: average annual water level rate of change, *Recharge*: average annual recharge rate assuming negligible horizontal flow and specific yield = 0.15.

Table S3. Changes in groundwater quality by county and combined areas in the Texas CHP region before and after 1981.

County	*Year*	*Number of Wells*	*TDS mg/L*	*N mg/L*
Dallam	1975	75	293	1.6
	1996	97	328	2.3
Donley	1949	180	316	2.7
	1999	60	328	1.0
Hemphill	1976	58	290	1.4
	1998	42	301	1.7
Wheeler	1967	118	282	3.6
	1999	41	298	2.2
Sherman	1969	83	318	2.0
	1993	93	337	2.5
Moore	1969	136	290	1.5
	1993	138	310	2.1
Ochiltree	1969	89	484	1.5
	1994	60	390	2.0
Roberts	1974	55	296	1.3
	1999	66	273	0.5
Armstrong	1981	29	310	1.2
	1999	57	269	0.4
Carson	1970	89	298	1.1
	1999	171	273	1.2
Gray	1970	85	332	1.2
	1999	94	289	1.0
Hansford	1968	119	347	1.6
	1994	59	355	2.2
Hartley	1970	82	299	1.7
	1996	80	302	2.1
Hutchinson	1976	83	297	1.6
	1993	51	292	1.9
Lipscomb	1972	36	428	1.6
	1994	50	374	2.2
Combined	1969	1328	314	1.6
	1996	1190	311	1.7

Year: median sample date, *Number of Wells*: number of wells sampled during period, *TDS*: median total dissolved solids concentration, *N*: median nitrate-N concentration.

Land Use History

Rain-fed profiles
Profile 11 (Arm06-01) – First cultivated in the 1920's.
Profile 12 (Har08-03) – First cultivation unknown, estimate 1945.
Profile 13 (Moo08-01) – First cultivation unknown, estimate 1945.
Profile 14 (Pot06-02) – First cultivated in 1949.
Profile 15 (Pot08-04) – First cultivated in 1949.
Profile 16 (Pot08-06) – First cultivated in 1949.
Profile 17 (Rob07-03) – First cultivation unknown, estimate 1920s.
Profile 22 (Don06-01) – First cultivated in the 1920s. No cultivation during 1970s-80s.
Profile 23 (Hem06-01) – First cultivated in the 1900s.
Profile 24 (Whe06-02) – First cultivated in the 1900s.
Profile 25 (She08-02) – First cultivation unknown, estimate 1945.

Irrigated profiles
Profile 26 (Gra06-02) – First irrigated in the 1960s.
Profile 27 (Moo08-02) – First furrow irrigated in 1989. Center pivot installed in 2005.
Profile 28 (Pot07-03) – Sprinkler system installed in 1989.
Profile 29 (Rob07-02) – First irrigated in the 1950s.
Profile 30 (She08-01) – First furrow irrigated in 1973. Center pivot installed in 1980.
Profile 31 (Dal08-01) – First furrow irrigated in 1972. Center pivot installed in 1978.
Profile 32 (Hem07-01) – Center pivot installed in ~1975.