U.S. FISH AND WILDLIFE SERVICE
ENVIRONMENTAL CONTAMINANTS PROGRAM
REGION 6

AN EVALUATION OF AGRICULTURAL TILE DRAINAGE EXPOSURE AND EFFECTS TO WETLAND SPECIES AND HABITAT WITHIN MADISON WETLAND MANAGEMENT DISTRICT, SOUTH DAKOTA

U.S. Fish and Wildlife Service
South Dakota Ecological Services Field Office
December 2018

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Final Report
Region 6
DEC ID : 201260001
FFS: **6N61**
Congressional District: SD00

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December 2018

U.S. Fish and Wildlife Service
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ACKNOWLEDGEMENTS

Primary funding for this project was provided by the former U.S Fish and Wildlife Service Environmental Contaminants Off-Refuge Program from 2012 to 2015, with additional support from the Region 6 Inventory and Monitoring Program and Region 6 Contingency Funding. The authors received considerable help in completing this study and thank all those involved.

This study would not have been possible without support from the Madison Wetland Management District. Lyman Paul, Justin Rabern, Justin Peterson, and Ryan Park performed many field tasks including site assessments, field measurements, sample collection and nitrate analysis. Bryan Schultz, Natoma Hansen, and Thomas Tornow assisted with project funding, provided technical assistance and managed staff. Kyle Kelsey conducted staff for field work and performed duck egg collections. Wade Briggs and Wayne Oetken provided off-road vehicle training.

Jay Gilbertson and staff at East Dakota Water Development District provided in-kind technical assistance and laboratory nitrate analyses. Kenneth E. Dulik, Liz Rogers, and staff at EPA Region 8 Laboratory provided in-kind technical assistance, sampling supplies, and analytical measurements. Galen Hoogestraat provided in-kind technical assistance, managed USGS involvement, and performed ELISA laboratory analyses. Dr. Daniel Snow performed POCIS analyses and technical assistance. Ken Crabb and Bruce Nierwiensk coordinated sample shipments and contaminant analyses for water, sediment, and biota samples. Regina Wixon coordinated water sample analyses for selenium and nutrients. Liz Berg, Molly Fox, Jessi Vlcek, Jerry Warmbold, and Jeff Wesner with the University of South Dakota assisted with field sample collections, wetland habitat assessments, and macroinvertebrate identification. For funding coordination and review of the project proposal and/or draft reports we thank Maria Boroja, Mark Sattelberg, Christina Kravitz, Kevin Johnson, Sharon Blair, Scott Larson, Robert Gleason, Brian Wangler, Neal Niemuth, Shannon Minerich, Joseph Skorupa, Josh Eash, Mike Coffey, and Cindy Hall.

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ABSTRACT

There are approximately 4.4 million acres of wetlands in the Prairie Pothole Region of the Dakotas that provide essential habitat for wildlife, improve water quality, and provide flood control benefits. However, these wetlands are increasingly receiving discharges from agricultural tile drainage. We measured pollutants in tile effluent and evaluated water quality and habitat degradation at Waterfowl Production Areas (WPAs) managed by the U.S. Fish and Wildlife Service. Eighteen wetland sites were periodically sampled from 2011–2015. These sites were divided into three site categories: 1) "Tile Wetland" for wetland sites that directly receive tile outfall discharges but may also receive surface runoff of agricultural chemicals, 2) "Surface Wetland" for wetland sites that receive surface runoff of agricultural chemicals but have no known tile discharge inputs, and 3) "Reference Wetland" for wetland sites that are well buffered from agricultural chemicals in surface runoff and receive no direct tile outfall discharges. Wildlife exposure to pollutants discharged from agricultural tile drains was evaluated by measuring concentrations of pollutants in wetland sediments, water, waterfowl food items (aquatic invertebrates and plants), and mallard duck eggs. Wetland habitats were evaluated by South Dakota's Wetland Rapid Assessment Protocol and by conducting amphibian surveys and sampling aquatic macroinvertebrates. Concentrations of nutrients, pesticides and selenium in tile effluent exceeded water quality benchmarks for the protection of aquatic life. There were also differences in pollutant concentrations between wetland site categories, with Tile Wetlands having higher concentrations of select pesticides, chlorophyll-a, and selenium than Reference Wetlands. Tile Wetlands also exhibited selenium bioaccumulation in wetland biota (plants, aquatic invertebrates, and duck eggs) and had significantly lower wetland habitat scores and aquatic invertebrate diversity than Reference Wetlands. Selenium-induced reproductive impairment of waterfowl is likely occurring. We recommend actions to reduce agricultural pollutant discharges into public WPA wetlands.

Keywords: Madison Wetland Management District, South Dakota, prairie pothole region, tile drain, agricultural pesticides, Waterfowl Production Area, selenium, atrazine, nutrients, waterfowl, elemental contaminants, metals.

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ACRONYMS AND ABBREVIATIONS

α	alpha significance level	Hg	mercury	PPJV	Prairie Pothole Joint Venture
%	percent	HDPE	high density polyethylene	ppm	parts per million (mg/kg, μg/g, mg/L)
<	less than	HSD	Honest Significant Difference	PPR	Prairie Pothole Region
>	greater than	HSDB	Hazardous Substances Data Bank	QA/QC	Quality Assurance and Quality Control
°C	degrees Celsius	i.e.	in explanation	RL	reporting limit
μS/cm	microSiemens per centimeter	IC	Ion chromatography	S salts	soluble salts
ACF	Analytical Control Facility	ICP-MS	Inductively Coupled Plasma Mass Spectrometry	SAR	sodium absorption ratio
Al	aluminum	ID	identification	SAS	Statistical Analysis System
As	arsenic	kg	kilogram	Sb	antimony
ASTM	American Society for Testing and Materials	LC-MS	liquid chromatography with tandem mass spectrometry	SD	South Dakota
AT	American Toad (*Anaxyrus americanus*)	LOI%	percent loss on ignition	SDAL	South Dakota Agricultural Laboratory
B	boron	LOQ	level of quantification	SDCL	South Dakota Codified Law
Ba	barium	m	meter	SDDENR	South Dakota Department of Environment and Natural Resources
BCF	Boreal Chorus Frog (*Pseudacris maculata*)	max	maximum	SDFO	South Dakota Ecological Services Field Office
Be	beryllium	MCL	maxmum contaminant level	Se	selenium
BMPs	Best Management Practices	MDL	Madison Daily Leader	S.E.	standard error
ca.	approximately	meq	milliequivalents	Service	U.S. Fish and Widlife Service
CCME	Canadian Council of Ministries of the Environment	Mg	magnesium	SM	Standard Methods
Cd	cadmium	mg/kg	milligrams per kilogram (ppm)	SOPs	standard operating procedures
CEC	cation exchange capacity	mg/L	milligrams per liter (ppm)	sp	species
Cr	chromium	ml	milliliter	Sr	strontium
Cu	copper	mmho/cm	millimho per centimeter	TDS	total dissolved solids
CV	coefficient of variation	Mn	manganese	TKN	total Kjeldahl nitrogen
CVMAA	cold vapor mercruy atomic absorption spectrometry	Mo	molybdenum	TN	total nitrogen
CWA	Clean Water Act	MS	mass spectrometry	TP	total phosphorus
District	Madison Wetland Management District	n	sample size	UNL	University of Nebraska at Lincoln
DL	detection limit	N_A	number of samples analyzed	USD	University of South Dakota
DR	direct reading	NA	not applicable	USDOI	U.S. Department of the Interior
dw	dry weight	NC	not collected	USGS	U.S. Geological Survey
e.g.	example given	N_D	number of samples above detection limit	V	vanadium
EC50	median effective concentration	ng/L	nanograms per liter	VES	visual encounter survey
EDWDD	East Dakota Water Development District	Ni	nickel	WMD	Wetland Management District
ELISA	enzyme-linked immunosorbent assay	NLF	Northern Leopard Frog (*Rana pipiens*)	WPA	Waterfowl Production Area
EPA	U.S. Environmental Protection Agency	NPDES	National Pollutant Discharge and Elimination System	WRAP	wetland rapid assessment protocol
ESA	Endangered Species Act	NTU	Nephelometric Turbidity Units	WSC	Water Science Center
ESI	Envirosystems Incorporated	NWQL	National Water Quality Laboratory	WSL	Water Sciences Laboratory
et al.	and others	OIG	Office of Inspector General	WTS	Western Tiger Salamander (*Ambystoma mavortium*)
Fe	iron	OP	orthophosphate	ww	wet weight
FWS	U.S. Fish and Wildlife Service	p	p-value statistical probablility	YSI	Yellow Springs Instrument
GAO	U.S. Government Accountability Office	Pb	lead	YYMMDD	year month day date format
GC-MS	Gas chromatography with tandem mass spectrometry	PC	Pre-cleaned certified	Zn	zinc
GC-FPD	Gas chromatography with flame-photometric detectors	POCIS	polar organic chemical integrative samplers	μg/g	micrograms per gram (ppm)
H'	Shannon diversity scores	ppb	parts per billion (μg/L,	μg/L	micrograms per liter (ppb)

INTRODUCTION

North America's Prairie Pothole Region (PPR), with its 300,000 square miles of grasslands and millions of wetland potholes, is one of the richest wetland systems in the world. The Prairie Pothole Joint Venture (PPJV) portion of the PPR includes 100,000 square miles within five states (Iowa, Minnesota, Montana, North Dakota, and South Dakota; Figure 1). This area provides habitat for hundreds of migratory bird species and pollinators including federally protected imperiled species like the whooping crane (*Grus americana*) and Dakota skipper (*Hesperia dacotae*). However, wildlife habitat has been in decline throughout the PPR for over 100 years and includes both complete loss of wetlands and grasslands as well as degradation of remaining habitat (PPJV 2005). Understanding the scale and causes of continued habitat loss and degradation within the PPR can help identify strategies and management actions needed to avoid, minimize, and, reverse habitat decline. Thus, the aim of this report is to evaluate how public wetlands, managed by the U.S. Fish and Wildlife Service (Service/FWS), are affected by adjacent wetland drainage and row crop conversion. Herein we provide the results of an investigation designed to evaluate the exposure and effects of agricultural surface runoff and subsurface tile drainage into Waterfowl Production Areas (WPAs) within the PPR that are managed by the Madison Wetland Management District (District). This report also includes management recommendations to aid the District in conserving, protecting, and enhancing habitat for the benefit of wildlife and the American people.

Habitat loss in the PPR and South Dakota

Wetland and grassland habitats are in decline throughout the PPR, including South Dakota. The PPR supported 16.6–17 million acres of wetland prior to settlement in the 1800s, but by 2009 only 6.4 million acres of wetland remained, a decline of 61% (Dahl 2014). Most of this wetland loss occurred prior to the 1980s when tile and open-ditch drains eliminated large numbers of wetland basins and converted lands to crop production. However, wetland loss from agriculture drainage is ongoing. Between 1997 and 2009, total wetland area declined by an estimated 74,340 acres or 1.1% (Dahl 2014).

The number of basins in the PPR declined by 110,718 (4%) between 1997 and 2009 (Dahl 2014). Ninety-six percent of basins lost were temporarily flooded emergent and farmed wetlands and an estimated 49% of the wetlands lost between 1997 and 2009 were geospatially-isolated wetlands (Dahl 2014). In South Dakota, an estimated 21,625 wetland basins were lost between 1997 and 2009 (Dahl 1014). The rate of annual wetland loss due to expansion of corn and soybeans within the Dakota PPR was estimated at about 0.3% (Johnston 2013). Although South Dakota was the only state in the PPR to exhibit gains in emergent wetland area, most of these gains are likely attributed to smaller wetland basins either being merged together or merging with larger, wetter basins (Kahara *et al.* 2009; Dahl 2014).

In addition to wetland losses, South Dakota is also losing grasslands. There were an estimated 21.1 million acres of grassland in the PPR in 2009. This represented a 3:1 ratio of grassland to wetland region-wide (Dahl 2014). In South Dakota, 45.6% of grasslands within the PPR have been converted to cropland (Doherty *et al.* 2013).

Role of Habitat Loss on Remaining Wetland Degradation

Loss of grasslands and wetlands often contribute to the degradation of remaining wetland wildlife habitat. In North Dakota, drainage of multiple smaller wetlands into fewer and larger wetlands (consolidation drainage) has resulted in terminal wetlands that are nearly three times larger than those in catchments with no drainage (McCauley *et al.* 2015). These larger terminal wetlands need a much more extreme drought to dry out completely and essentially function as permanently flooded habitats. Consolidation drainage can also lead to water quality degradation of remaining wetlands given that the wetlands being lost often drain a landscape of extensive row crop agriculture. The loss of grasslands can also influence a wetland's condition by both increasing sedimentation and the influx of agricultural chemicals from runoff, or by otherwise reducing or eliminating surrounding habitat suitability (Dahl 2014). Genetically modified row crops are now common throughout the PPR (Krapu *et al.* 2004) and new herbicide resistant crops, coupled with the low cost of herbicides and high crop prices, have been a major force in converting grassland to cropland (PPJV 2005). Prairie pothole wetlands are typically drained for agricultural production by a single outlet ditch or tile drain (Dahl 2014), and often these drainage ditches and tile outfalls discharge directly into wetlands managed by state or federal governments for public use.

Agricultural chemical exposure to wetlands can affect wildlife directly (e.g., the toxicity of pesticides to non-target organisms) or indirectly (e.g., degraded habitat quality from nutrient enrichment). Closed wetland basins that receive subsurface agricultural drainage may be especially susceptible to the accumulation of toxic trace elements and salts in sediments and biota (Blann *et al.* 2009).

Study Sites

The Service has five Wetland Management Districts (WMDs) in eastern South Dakota that cover the entire South Dakota portion of the PPJV (Figure 2). In South Dakota, WMDs were established with the major objectives of wetland preservation, waterfowl and wildlife production, and maintenance of breeding grounds for migratory birds (FWS 2012a). All of South Dakota's WMDs include wetland basins with extensive row crop agricultural production but Madison WMD seems to be the WMD that is most affected by subsurface tile drainage.

The District was established in 1969 when it was formed by the withdrawal of four counties from Waubay WMD and five counties from Lake Andes WMD (FWS 2012a). Tallgrass prairie and agricultural lands comprise most of the district. As of January 2010, the District administered 221 WPAs totaling ca. 38,778 acres and wetland easements totaling ca. 57,074 acres (FWS 2012a).

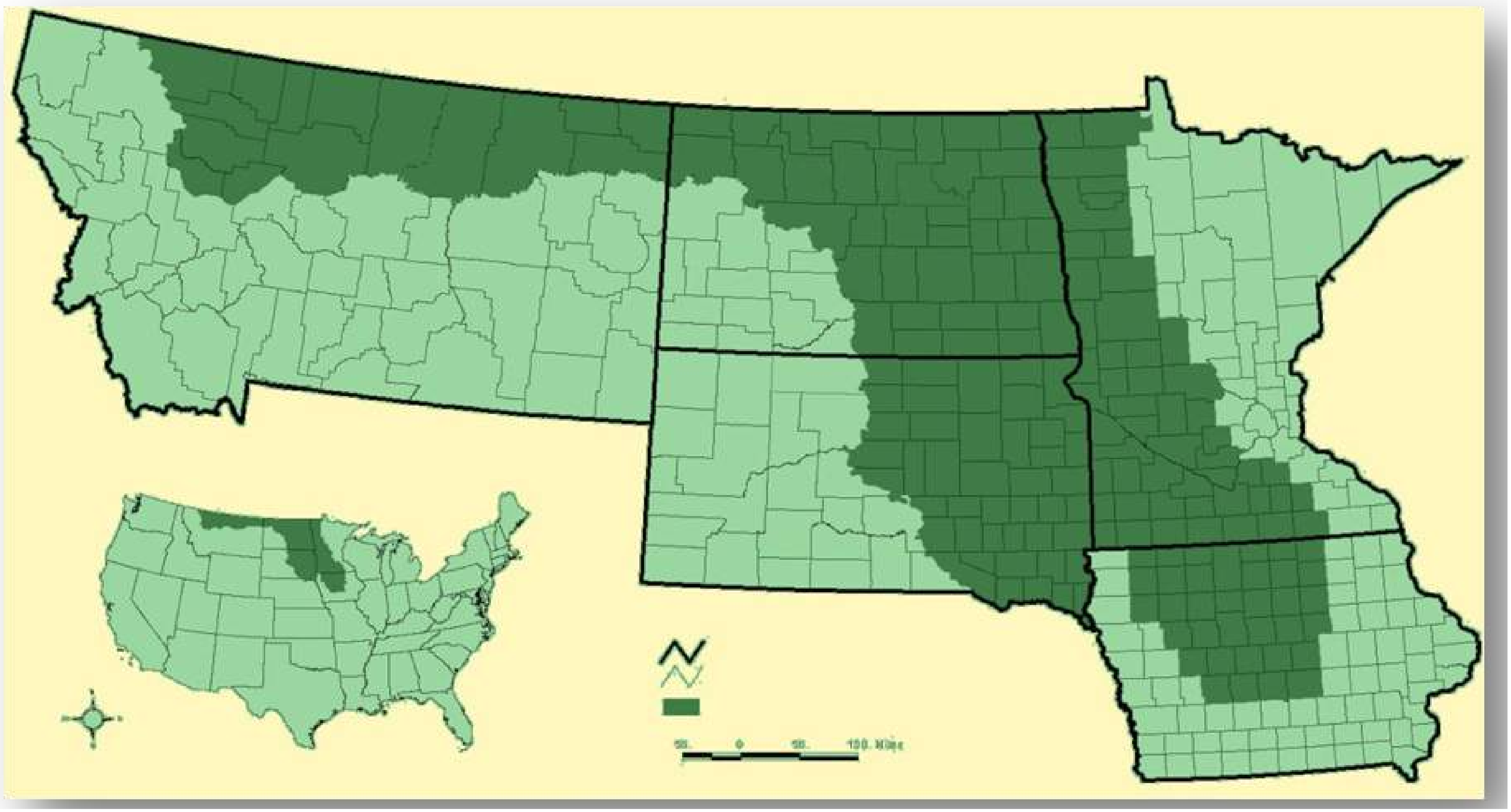

Figure 1. Location of the U.S. Prairie Pothole Joint Venture (from PPJV 2005).

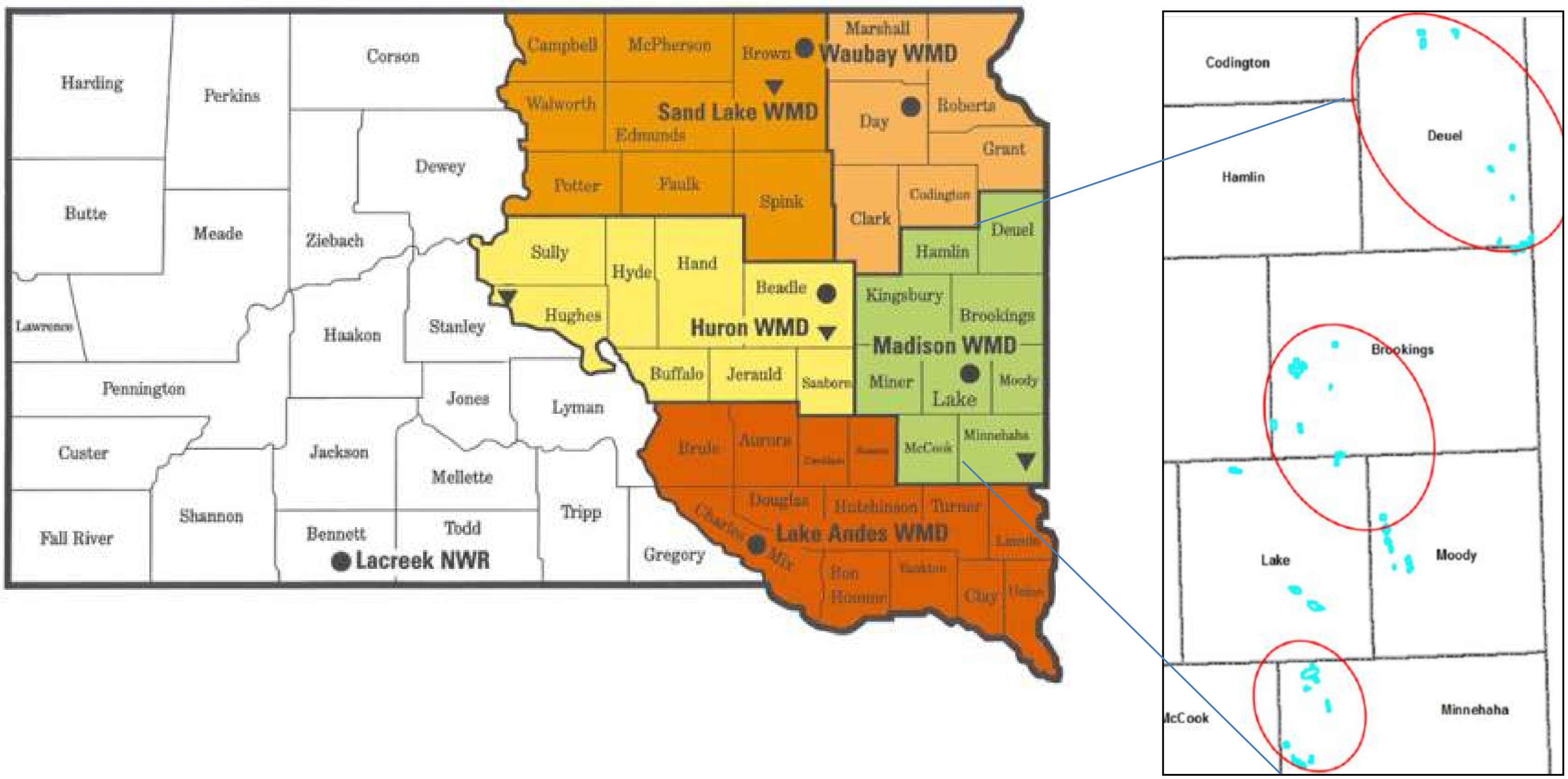

Figure 2. Location of study sites sampled within the Madison Wetland Management District, South Dakota, 2011–2015.
Note: red circles show 3 clustered areas containing the matched “Full Assessment” wetland sites (see text for further explanation).

The District's primary objective is to protect and manage wetlands for waterfowl; however, wetland and grassland habitats within Madison WMD also provide essential habitat for over 38 fish, 57 mammal, 10 amphibian, 11 reptile, and 219 non-waterfowl bird species (FWS 2012a; Ballinger *et al.* 2000). Waterfowl and waterbird species common within the District include blue-winged teal, mallard, snow goose, Canada goose, American white pelican, double-crested cormorant, and shorebirds. Species listed as threatened or endangered under the Endangered Species Act (ESA) that have known or possible occurrence within the District include: Topeka shiner (endangered, known resident), western prairie fringed orchid (threatened, possible resident), northern long-eared bat (threatened, possible resident), whooping crane (endangered, known migrant), piping plover (threatened, known migrant), red knot (threatened, known migrant), Poweshiek skipperling (endangered, possible resident), and the Dakota skipper (threatened, known resident). State listed threatened and endangered species within the District include the lined snake (endangered), banded killifish (endangered), northern redbelly dace (threatened), and the northern river otter (threatened).

Land use in the District is dominated by agricultural production that is supported by use of pesticides and fertilizers. Agricultural production in the area may also include use of subsurface drain tile networks, consisting of perforated plastic pipe that is trenched into cropland. Subsurface drainage tile is installed to maintain the groundwater table below the root zone and facilitate crop production. Since around 2007 there has been an evident increase in subsurface tile drainage throughout the District. According to the Madison Daily Leader (MDL), the number of drainage permits issued in Lake County increased 3-fold in 2010 compared to 2009 and resulted in at least 138 miles of tile (MDL 2011). Although tile drains are installed on private land, they can affect easement wetlands or adjacent public wetlands by altering their hydrology and water quality.

Purpose and Objectives

The purpose of this study was to evaluate habitat modification and water quality degradation from agricultural drainage (surface and subsurface) and potential adverse effects to biota on Service managed wetlands within the District. Our objectives were to determine if District wetlands are impaired by agricultural runoff or tile drain discharges and, if so, identify management actions needed to improve water quality and wetland habitat in support of Service trust natural resources. Service trust natural resources are those resources that, through law or administrative act, are held in trust for the people by the Service. Thus, Service trust resources within the District include endangered species (in accordance with ESA), migratory birds (in accordance with the Migratory Bird Treaty Act), and national wildlife refuge lands (in accordance with the National Wildlife Refuge System Improvement Act). Although all data collection for this study occurred within the District, our study findings may also be applicable outside the District and may benefit wetland conservation actions throughout the PPR.

Wildlife exposure to pollutants discharged from agricultural tile drains was evaluated by measuring concentrations of pollutants in wetland sediments, water, waterfowl food items (aquatic invertebrates and plants), and mallard duck eggs. Water samples from tile drain outfalls and wetland sites were tested for pesticides, elemental contaminants, nutrients, and water quality parameters including chlorophyll-a, pH, temperature, and conductivity. Additionally, a South Dakota Wetland Rapid Assessment Protocol (Bouchard *et al.* 2008) was utilized to quantify overall habitat quality of WPAs. Differences in amphibian and aquatic invertebrate abundance and diversity were also compared among WPA wetlands.

METHODS

Sample site locations, field measurements and sample collections are summarized herein with additional tables in Appendix A. Additional information including raw data for field measurements and sample collections are available upon request to the Service's South Dakota Ecological Services Field Office.

Site Locations and Treatments

Sites sampled within the District were categorized as: 1) Tile Outfall, 2) Tile Wetland, 3) Surface Wetland, and 4) Reference Wetland. Tile Outfalls included tile effluent either directly from the tile outfall pipe, if accessible, or immediately after the outfall pipe at the point-of-entry into the WPA (or easement wetland for Chris1T). Tile Wetland, Surface Wetland, and Reference Wetland sites (collectively referred to as wetland sites) were located within select WPAs but sampling was not robust enough to represent the entire WPA, which often includes numerous wetlands. Our most robust sampling included eighteen "Full Assessment" WPA wetland sites that were periodically sampled between 2011–2015 (Table 1). These sites were initially split six each as Tile Wetland, Surface Wetland, or Reference Wetland. However, Mund1 was changed from a Surface Wetland to a Tile Wetland after we discovered that tile effluent drains into the site. Reference Wetlands were buffered from agricultural chemicals in surface runoff and received no direct tile outfall discharges, whereas Tile Wetlands and Surface Wetlands were less protected from agricultural drainage (Figure 3; Appendix B, Figures B.1–B.18). Tile Wetlands were selected based on known discharges of tile effluent that enters the wetland directly or through a narrow drainage pathway. Surface Wetlands were selected based on a suspected substantial surface runoff pathway from adjacent agricultural fields but without direct (unbuffered) influent from tile outfalls. The distinction between Surface Wetland and Tile Wetland sites was limited based on the likelihood that Tile Wetlands received some surface runoff of agricultural chemicals and that Surface Wetlands may receive buffered tile effluent via drainage ditches or through wetland buffers. For example, 2Petr1A was categorized as a Surface Wetland despite two Tile Outfalls (2Petr1 and 2Petr2) located near the WPA boundary (Appendix Figure B.11).

This was because no discharge was ever observed from the 2Petr1 Tile Outfall during the study, and flow from the 2Petr2 Tile Outfall only occurred on three occasions and had to cross approximately 793 meters of wetland buffer before entering the wetland site.

In addition to our “Full Assessment” wetland sites we sampled 32 “Monitoring” sites (Table 1). These sites were sampled on at least three occasions and include Tile Outfalls and WPA wetland sites that were not selected for Full Assessment but sampled periodically from 2011–2015. An additional 18 sites, including nine Tile Outfalls, were identified and some sampled (Appendix Table A.1). However, these sites were not selected for routine monitoring based on timing of discovery, funding, or logistical constraints.

Table 1. Full assessment and monitoring site locations within the Madison Wetland Management District, South Dakota, 2011–2015.

Site Class	WPA Name	Site ID	Site Category	County	Latitude	Longitude
Full Assessment	Acheson	Ache1A	Tile Wetland	Minnehaha	43.80265	-97.06099
	Buffalo Lake	Buff1	Reference Wetland	Minnehaha	43.82198	-97.06055
	Coteau Prairie	Cote1	Reference Wetland	Deuel	44.89677	-96.71534
	Ericksrud	Bols1A	Tile Wetland	Brookings	44.25180	-97.05822
	Gerdink	Gerk1A	Tile Wetland	Brookings	44.20316	-96.95567
	Johnson I (W)	John1	Surface Wetland	Deuel	44.62656	-96.49994
	Johnson II (H)	Hejo1A	Tile Wetland	Deuel	44.55886	-96.45526
	Lost Lake	Lost1	Reference Wetland	Minnehaha	43.67738	-97.05740
	Mundahl	Mund1	Tile Wetland	Deuel	44.67450	-96.55058
	Nelson	NelsA1	Tile Wetland	Deuel	44.90948	-96.63166
	Petri II	2Petr1A	Surface Wetland	Minnehaha	43.67917	-97.09314
	Pettigrew	Pett1	Reference Wetland	Moody	44.09261	-96.85030
	Pittenger	Pitt1	Reference Wetland	Brookings	44.38685	-96.96482
	Ramsey	Rams1	Surface Wetland	Brookings	44.19257	-96.96624
	Schaefer	Schae1	Surface Wetland	Minnehaha	43.81241	-97.03603
	Schafer	Schaf1	Reference Wetland	Deuel	44.91568	-96.71692
	Voelker II	Volk1	Tile Wetland	Minnehaha	43.71030	-97.11206
	Ziegler	Zieg1	Surface Wetland	Brookings	44.31348	-96.97758
Monitoring	Acheson	Ache1	Tile Outfall	Minnehaha	43.80386	-97.06112
	Adams	Adam1	Tile Outfall	Deuel	44.55471	-96.54202
	Adams	Adam2	Tile Outfall	Deuel	44.55944	-96.53613
	Benson	Bens1	Tile Outfall	Moody	44.04837	-96.83823
	Buffalo Lake	Buff1T	Tile Outfall	Minnehaha	43.81959	-97.06115
	Buffalo Lake	B2	Reference Wetland	Minnehaha	43.82343	-97.06390
	Clear Lake	Clea2	Tile Outfall	Minnehaha	43.77238	-97.00484
	Dry Lake	Dryl1	Tile Outfall	Brookings	44.33907	-97.05684
	Dry Lake	Dryl2	Tile Outfall	Brookings	44.34044	-97.05042
	Dry Lake	Dryl3	Tile Outfall	Brookings	44.35501	-97.07024
	Ericksrud	Bols1	Tile Outfall	Brookings	44.25135	-97.05583
	Gerdink	Gerk1	Tile Outfall	Brookings	44.20462	-96.95564
	Habeger	Habe1	Tile Outfall	Lake	44.18375	-97.05985
	Heinricy	H1	Surface Wetland	Moody	44.00565	-96.82803
	Johnson II (H)	Hejo1	Tile Outfall	Deuel	44.55900	-96.46032
	Johnson II (H)	Hejo2	Tile Outfall	Deuel	44.55886	-96.45526
	Kleinsasser	Klei1	Tile Outfall	Moody	44.02030	-96.79378
	Kleinsasser	Klein5	Reference Wetland	Moody	44.00927	-96.79752
	Lee Hofer	Whof1	Tile Outfall	Minnehaha	43.68860	-97.07895
	Long Lake	Long1	Tile Outfall	Lake	43.94480	-97.04908
	Long Lake	Long2	Tile Outfall	Lake	43.93507	-97.03806
	Long Lake	Long2A	Tile Wetland	Lake	43.93659	-97.03675
	Madison	Madi1	Tile Outfall	Lake	43.97325	-97.09068
	Madison	Madi3	Tile Outfall	Lake	43.96415	-97.07488
	Mundahl	Mund1T	Tile Outfall	Deuel	44.67557	-96.54634
	Nelson	Nels1	Tile Outfall	Deuel	44.90942	-96.63178
	Petri II	2Petr1	Tile Outfall	Minnehaha	43.67870	-97.09194
	Petri II	2Petr2	Tile Outfall	Minnehaha	43.68346	-97.08966
	Petsch	Pets1A	Tile Wetland	Moody	43.99556	-96.78871
	Petsch	Pets1	Tile Outfall	Moody	43.99562	-96.78788
	Reaves	Reev1	Tile Outfall	Moody	44.05850	-96.85001
	Christensen	Chris1T	Tile Outfall	Moody	43.81960	-97.03324
	Severson	Seve1	Reference Wetland	Deuel	44.71651	-96.49824
	Werner-Hoffer	Whof1	Tile Outfall	Minnehaha	43.68860	-97.07895
	Thornber	Thor1	Tile Outfall	Moody	44.03672	-96.83344

Figure 3. Sample site category examples for agricultural tile and surface drainage water quality study, Madison Wetland Management District, South Dakota. A) Reference Wetland: a wetland site that is buffered from agricultural chemicals in surface runoff and receives no direct tile outfall discharges. B) Surface Wetland: a wetland site that receives surface runoff of agricultural chemicals (e.g., ditches draining adjacent cropland enter Ziegler from north and south) but does not receive direct (unbuffered) agricultural tile effluent. C) Tile Wetland: a wetland site that receives tile effluent directly or through a narrow drainage pathway (yellow triangle indicates location of a Tile Outfall) but may also receive some surface agricultural runoff. Note: red line = Waterfowl Production Area boundary.

Contaminant Assessments

Sample Collections

All samples for contaminant measurements (Table 2) were collected by Service personnel from the South Dakota Ecological Services Field Office (SDFO) or the District using standard operating procedures (SOPs). Sampling equipment was decontaminated between sites according to Service SOPs. Water samples were not filtered in the field and only water samples for nitrate analysis were filtered at the laboratory when turbidity did not allow for direct instrument reading.

Sample containers were either provided by the processing laboratory or obtained from Environmental Sampling Supply (http://www.essvial.com/) as certified clean (PC Class). Water grab samples for analysis of all pesticides and selenium by the South Dakota Agricultural Laboratory (SDAL) were collected in amber glass containers. Samples measured for elemental contaminant measurement, by Envirosystems Incorporated (ESI) or the U.S. Environmental Protection Agency (EPA), were collected in high density polyethylene (HDPE) containers. Wetland sediment samples were collected from the upper 2–4 inches of the wetland bottom using a clean stainless steel spoon. Sediment samples were analyzed individually and whole (i.e., were not sieved to separate particulate sizes).

Aquatic invertebrate samples for elemental contaminants analysis were collected as either “mixed invertebrates” or snails. Mixed invertebrate samples consisted of all species, except snails, that were captured in aquatic dip nets by sweeping below the water surface. Snails were collected from the wetland water surface and picked from their shells using cleaned forceps to form composite samples for each site.

Aquatic vegetation and mallard duck (*Anas platyrhynchos*) eggs were hand-picked using nitrile gloves. Vegetation samples were collected into HDPE certified clean containers and duck eggs were placed in egg cartons for transfer to the SDFO where whole egg mass was measured to the nearest gram (OHAUS balance model CT6000). Egg contents were identified as fertile or nonfertile and then transferred into HDPE containers for elemental contaminant analysis by cutting the eggshell at the equator with a clean surgical blade.

Table 2. Summary of collections and methods for samples from Waterfowl Production Areas within Madison Wetland Management District, South Dakota 2011–2015.

Matrix	Dates Collected	Number of samples	Analysis	Lab	Method[1]
Water	2011–2014, April–October	556	Nitrates	EDWDD	spectrophotometry
	2013–2014, April–September	415	Atrazine and Glyphosate	USGS WSC	magnetic particle ELISA
	2013–2014, May–August	319	Selenium	SDAL	fluorometric SM3500-Se-C
	2012–2015, April–November	236	Pesticides	EPA R8	LC-MS, R8 Lab method
	2013–2014, May–August	201	Total Kjeldahl Nitrogen	SDAL	EPA 351.3
	2013–2014, May–August	201	Total Phosphorus	SDAL	SM 4500PE
	2012 and 2015, April–November	80	Elemental Contaminants	EPA R8	ICP-MS 200.7 and 200.8/6020
	2012, April–September	34	Total Nitrogen	EPA R8	combustion ASTM 5176
	2012, April–September	32	Chlorophyll a and b	EPA R8	EPA 447.0
	2012, April–September	34	Ammonia	EPA R8	EPA 350.1
	2012, April–September	34	Anions[2]	EPA R8	ICP EPA 300.0
	2012, April–September	34	Hardness	EPA R8	SM 2340B
	2012, April–September	34	Nitrate and Nitrites	EPA R8	colorimetry EPA 353.2
	2012, April–September	34	Orthophosphate	EPA R8	colorimetry EPA 365.3
	2012, April–September	34	Total Phosphorus	EPA R8	EPA 365.4
	2012, July	30	Elemental Contaminants	ESI	ICP-MS and CVMAA
	2013, May	12	Pesticides	USGS NWQL	GC-FPD method 2003
POCIS field deployed	2013–2015, May–September	128	Herbicides	UNL-WSC	GC-MS
	2013–2015, May–September	128	Neonicotinoids	UNL-WSC	GC-MS
Sediments	2012–2014, April–September	100	Elemental Contaminants	ESI	ICP-MS and CVMAA
	2013, August	54	Routine Soil Analysis and SAR	WARD	ICP and spectrophotometry
Biota[3]	2012–2015, July–August	104	Elemental Contaminants	ESI	ICP-MS and CVMAA

Note: samples collected do not include QA/QC or site categories not assessed (e.g., ditches); [1] see methods section of the report for method details; [2] anions include chlorides, total dissolved solids, sulfates and fluoride; [3] biota samples include duck eggs, aquatic invertebrates, minnows, crayfish, and snails (see Appendix Tables A.13). See page xv for abbreviation definitions.

All samples were kept chilled in the field using ice packs or a portable refrigerator. Water samples collected for total recoverable analysis by EPA or ESI were preserved in the field at a pH near 2.0 using certified clean nitric acid. Samples for analysis of pesticides, nutrients, chlorophyll-a, and metals by the EPA Region 8 Laboratory (Denver, CO) were shipped overnight on ice within three days of field collection. Water grab samples for nutrient and selenium testing by SDAL (Brookings, SD) were hand delivered to the lab within three days of field collection. Water grab samples for nitrate analysis by the East Dakota Water Development District (EDWDD) in Brookings, SD, were analyzed by Service or EDWDD staff within the week of sample collection. Samples collected for atrazine and glyphosate measurement by enzyme linked immunosorbent assay (ELISA) were kept refrigerated until they were shipped overnight to the U.S. Geological Survey (USGS) Water Science Center (WSC) laboratory in Rapid City, SD. Sediment and tissue samples for elemental contaminant analysis by ESI or Ward Laboratories, Inc. (Kearney, NE) were stored in a freezer at minus 20°C prior to shipment.

Field Water Quality Measures

Field water quality measurements at wetland sites included specific conductivity, pH, chlorophyll-a, water temperature, and turbidity. These measurements were also taken at Tile Outfalls when appropriate (e.g., turbidity was not routinely taken from Tile Outfalls). A Yellow Springs Instrument (YSI) Model 6820-V2 Series water quality multimeter (sonde) was used to measure specific conductivity, pH, chlorophyll-a, and water temperature. Measurements and calibration of the sonde were in accordance with its operational manual and the “YSI Model 6-Series Sonde” SOP. Turbidity was measured using a Hach 2100Q Portable Turbidimeter in accordance with its operational manual.

Water quality measures were taken periodically between April and November in 2013 and 2014 (Appendix Table A.2; n=410) by Service employees or students from the University of South Dakota (USD). Water quality at Full Assessment sites was typically measured at least twice monthly from May through August in 2013 and 2014, and opportunistically at monitoring sites. Dry conditions resulted in only one sampling occasion in August 2013, at all sites and also prevented sampling of Acheson WPA in 2014. Thus, for matched comparisons of Full Assessment wetland sites samples were limited to 38 and 40 sampling occasions for each wetland site category in 2013 and 2014, respectively, with all sites for a given year having the same sample size per month (Appendix Table A.3). Water quality measures for Tile Outfalls included 58 and 70 samples in 2013 and 2014, respectively (Appendix Table A.3; n=362).

Pesticides

A total of 791 site samples spanning 93 pesticide products were tested for during this study by using four different laboratories and a combination of analytical and ELISA methods (Table 2; Appendix Table A.4). Samples included both water grab samples (*n*=663) and polar organic chemical integrative samplers (POCIS; *n*=128). Analytical testing of water samples for pesticides were performed by two laboratories: the EPA Region 8 Laboratory from 2012–2015 (*n*=270) and the USGS National Water Quality Laboratory (NWQL), also in Denver, in 2013 (*n*=12; Appendix Table A.5). Samples for analysis by the EPA Region 8 Laboratory were limited to about 15 sites per month and were thus focused on Tile Outfalls. Thus, water grab samples from wetland sites were only opportunistically collected for analytical analysis by EPA when there were not enough Tile Outfall samples to fill the quota. Analytical sampling for pesticides by NWQL was focused only on wetland sites but was limited to one occasion per site in May 2013.

Atrazine and glyphosate, two of the most common herbicides for row crops in South Dakota, were also measured from 2012–2014 in water grab samples (*n*=415) by ELISA at the WSC. Atrazine was also measured by analytical methods (see above paragraph), whereas glyphosate was not. In addition to water grab samples, 30 pesticide products were sampled using POCIS. POCIS are sampling devices manufactured by Environmental Sampling Technologies (St. Joseph, MO) that are designed to provide integrated time-weighted average concentrations of water-soluble (polar) organic chemicals from aqueous environments (USGS 2004a). Their use is considered a passive sampling technique because POCIS have no moving parts and require no power or supervision during use. A total of 128 POCIS were deployed at select wetland sites and Tile Outfalls from 2013–2015 (Table 3; Appendix Table A.6) and analyzed by the University of Nebraska Water Sciences Laboratory (WSL), in Lincoln, NE.

Table 3. Number of polar organic chemical integrative samplers (POCIS) deployed at sites within Madison Wetland Management District, South Dakota, 2013–2015.

Year	Site Category	Number of Sites with POCIS	Deployment Dates	Retrevial Dates
2013	Reference Wetland	6	May 14–16	June 11–12
		6	June 11–12	July 9–10
		6	July 9–10	August 12–14
	Surface Wetland	5	May 13–16	June 10–12
		4	June 10–12	July 8–10
		5	July 8–10	August 12–14
	Tile Outfall	5	May 13–15	June 10–12
		9	June 10–12	July 8–10
		3	July 8–10	August 12–13
	Tile Wetland	5	May 13–15	June 10–12
		5	June 10–12	July 8–10
		5	July 8–10	August 12–14
2014	Reference Wetland	6	June 10–11	July 8–9
		6	July 8–9	August 11–12
	Surface Wetland	5	June 10–11	July 8–9
		4	July 8–9	August 11–12
	Tile Outfall	7	June 9–10	July 7–8
		8	July 7–8	August 11
	Tile Wetland	6	June 10–11	July 8–9
		6	July 8–9	August 11–12
2015	Surface Wetland	5	May 12–13	September 20
	Tile Outfall	5	May 12–13	September 20
	Tile Wetland	6	May 12–13	September 20

At each site, POCIS were protected by constraining them in perforated stainless steel canisters that were kept submerged by either anchoring them to a flag at wetland sites or to a brick placed in a Tile Outfall (Appendix Figure B.19). POCIS containing the Oasis HLB sorbent were deployed for periods of 17–110 days, depending on tile flow, wetland water conditions, and logistics. The Oasis HLB is a universal solid-phase extraction sorbent widely used for sampling a large range of chemical classes from water (USGS 2004a; Alvarez 2010). Once retrieved, POCIS were wrapped in aluminum foil, bagged, placed in shipping tins, and stored frozen until shipped to the WSL. To evaluate relative differences in POCIS pesticide uptake between site categories, we selected matched sets of POCIS that were deployed at similar dates and durations (Table 3).

The ELISA analyses were completed using Abraxis (Westminister, PA) kits for atrazine and glyphosate using methods described by Abraxis (Abraxis 2014a, b). In brief, samples were mixed with an enzyme conjugate (enzyme labeled atrazine or glyphosate) followed by paramagnetic particles attached with antibodies specific to atrazine or glyphosate. Atrazine or glyphosate, and other closely related compounds in the sample, compete with the labeled enzymes for antibody binding sites on the magnetic particles. At the end of a 15 minute incubation period, a magnetic field is applied and unbound reagents decanted. The presence of each herbicide is detected by adding a color reagent. The color developed is quantified by a spectrophotometer (Ohmicron RPA-I™ Photometric Analyzer) and is inversely proportional to the concentration of herbicide in the sample. The range of quantification was 0.05–5 micrograms per liter (µg/L) and 0.15–5 µg/L for atrazine and glyphosate, respectively. Samples that reached the maximum range for each test were not diluted and rerun to estimate a final concentration.

Although 415 samples were submitted for ELISA testing, samples for data interpretation were limited to those that had a coefficient of variation (CV) of 15% or less [CV = (standard deviation / mean) × 100]. This eliminated five samples for atrazine and 83 samples for glyphosate. The 83 glyphosate samples that were removed based on a greater than (>) 15% CV included 16 Surface Wetlands, 22 Tile Wetlands, 24 Tile Outfalls, and 21 Reference Wetlands and included 33 samples > 0.15 ppb (i.e., did not bias only low values). This resulted in 410 and 332 samples for comparisons among study site categories for atrazine and glyphosate, respectively (Appendix Table A.7).

Nutrients and Anions

Nutrients measured in water samples included nitrates, total phosphorus (TP), orthophosphate as phosphorus (OP), total Kjeldahl nitrogen (TKN), and total nitrogen (Table 2). Nitrates were measured most frequently, usually two or three occasions per month, followed by monthly sampling for TKN and TP. Total nitrogen (TN) and OP were analyzed by EPA only from April–September 2012. The bulk of nitrate analysis was performed by Service staff at the EDWDD, where we evaluated 556 samples that were analyzed in duplicate with a Hach DR/4000 spectrophotometer (Table 2; Appendix Table A.8).

Total phosphorus and TKN were measured by SDAL in a total of 201 water grab samples that were collected semimonthly from May–August in 2013 and 2014 (Appendix Table A.9). In addition the EPA Region 8 Laboratory analyzed 34 water samples, collected from April–September of 2012, for OP, TN, and TP (Appendix Table A.10). Measures of TP by SDAL and EPA were combined for data interpretation.

Other measures of nutrients determined by the EPA Region 8 Laboratory included chlorophyll-a, chlorophyll-b, nitrates, nitrites, and ammonia nitrogen for samples collected in 2012 (Table 2; Appendix Table A.11). These samples were collected from Tile Outfalls (*n*=16–18) and wetland sites (*n*=16). Given the availability of more robust data from matched wetland sites (i.e., nitrates measured by EDWDD and chlorophyll-a measured with the sonde), comparisons across site categories did not include data in Appendix Table A.11.

Chloride, total dissolved solids (TDS), hardness, sulfates, and fluoride were also opportunistically measured by the EPA Region 8 Laboratory in water samples collected in 2012 (Table 2; Appendix Table A.12). These anions were sampled unevenly across site categories that included Tile Outfalls (*n*=15–18), Tile Wetlands (*n*=7), Surface Wetlands (*n*=4), and Reference Wetlands (*n*=5). Small sample sizes precluded anion comparisons across sites but values were compared to water quality standards and/or benchmarks.

Elemental Contaminants

Elemental contaminants were measured in sediments, water, crayfish, aquatic macroinvertebrates, snails, duck eggs, fish, and wetland plants collected from multiple sites (Table 2). All samples were collected by SDFO personnel and either submitted through the Service's Analytical Control Facility (ACF) to ESI (*n*=236; Appendix Table A.13), the EPA Region 8 Laboratory (*n*=80; Appendix A.14), Ward Laboratories (*n*=54; Appendix Table A.15), or SDAL (*n*=319, for selenium only; Appendix Table A.16).

For samples submitted through ACF, detailed descriptions of lab methods including sample preparation, sample digestion, Quality Assurance and Quality Control (QA/QC), raw data results, and detection limits are provided in catalogs and available upon request (ACF 2017). In brief, the analysis of duplicate samples, spiked samples, and standard reference materials generally indicated acceptable levels of precision and accuracy, and limits of detection were within ACF contract requirements. For elemental contaminants analyses, all sediment and biota samples were freeze dried, percent moisture was determined, and results were provided as wet weight (ww) and dry weight (dw) concentrations. Inductively coupled plasma atomic emission spectrometry was used to determine concentrations of aluminum (Al), antimony (Sb), boron (B), barium (Ba), beryllium (Be), cadmium (Cd), chromium (Cr), copper (Cu), iron (Fe), magnesium (Mg), manganese (Mn), molybdenum (Mo), nickel (Ni), lead (Pb), strontium (Sr), vanadium (V), and zinc (Zn). Mercury (Hg) concentrations were determined by Cold Vapor Mercury Atomic Absorption (CVMAA) and graphite furnace atomic absorption was used to measure arsenic (As), selenium (Se), and small concentrations of Pb and Cd.

Elemental contaminants in water grab samples were measured by the EPA Region 8 Laboratory by Inductively Coupled Plasma Mass Spectroscopy (ICP-MS; Table 2). These samples were not part of the original proposal but were collected opportunistically in 2012 and 2015 and did not include methods for mercury. Most of the water grab samples for testing by the EPA Region 8 Laboratory were from Tile Outfalls (n=57) compared to Reference Wetlands (n=5), Surface Wetlands (n=7), and Tile Wetlands (n=11). To evaluate concentrations of elemental contaminants in water at study sites, EPA Region 8 Laboratory results (n=80) were combined with results from ESI, which included the average of five samples per site for each of six sites (Bols1A, Cote1, Gerk1A, Hejo1A, Nels1A, and Seve1) sampled in 2012. To evaluate concentrations of selenium in water, results were combined for SDAL (n=319), ESI (n=6), and the EPA Region 8 Laboratory (n=80) for a total of 405 water samples.

A total of 54 sediment samples were analyzed for elements (S-4 Routine soil analysis) by Ward Laboratories. This test includes pH, soluble salts, organic matter, nitrate, phosphorus (P), sum of cations, potassium (K), calcium (Ca), Mg, sodium (Na), sulfur (S), Zn, Fe, Mn, and Cu. The 54 samples consisted of three samples from each Full Assessment site. In addition, 100 sediment samples were collected and analyzed by ESI for trace elements (Table 2; Appendix Table A.13). These 100 samples included five samples each from: seven Reference Wetlands (n=35), five Surface Wetland (n=25) and eight Tile Wetlands (n=40). High concentrations of selenium in agricultural tile drainage effluent have been a concern to wildlife managers since the early 1980's, when death and deformities in fish and wildlife at Kesterson National Refuge were linked to elevated tissue concentrations of selenium (Lemly 1993). Thus for this study, selenium was measured in water, sediments and biota by multiple labs. Water samples were tested solely for selenium by SDAL whereas selenium measurements by ESI or the EPA Region 8 Laboratory were part of an elemental contaminants analysis (Table 2). The bulk of selenium data in water were measured in monthly water grab samples analyzed by SDAL using a derivatization colorimetry method (fluorometric; SM3500-Se-C).

Pollutants Not Measured

It should be noted that this investigation should not be considered all-encompassing in its effort to measure pollutants discharged from agricultural tile. For example, we did not perform any sampling for pathogens, hormones, pharmaceuticals, bio-insecticides, or all of the pesticides that can reasonably be expected to occur in agricultural tile effluent.

Although we sampled for 93 pesticide compounds, we know of at least 36 pesticide compounds that were not tested for, but are registered for agricultural use within the study area (Appendix Table A.17). Some pesticides that are commonly used on corn (e.g., imazapyr) are not included in laboratory pesticide panels simply because they require more specialized equipment, specialized techniques, and are thus more difficult and costly to test for. Surfactants used in pesticide formulations, like nonylphenol polyethoxylate and polyethoxylated tallow amine, are also toxic to aquatic life but were not included in the pesticide scans for this study.

In addition to the pesticides, nutrients, and selenium that we measured in subsurface tile drainage discharges, recent studies have identified other pollutants of concern. Land application of livestock manure to tile drained land, and the subsequent transport of pathogens by subsurface drainage to surface waters, has been identified as a major pathogen transport pathway (Jamieson *et al.* 2002; Tomer *et al.* 2010). Tile effluent drained from lands that receive manure applications have also been found to contain veterinary antibiotics (Kay *et al.* 2004) and estrogens (Burnison *et al.* 2003; Gall *et al.* 2011).

Bio-insecticides registered for use on corn and soybean fields in South Dakota include the products Grandevo and Regalia. Grandevo is produced by a bacterium (*Chromobacterium subtsugae*, Strain PRAA4-1T) and includes a number of compounds aimed at causing a combination of effects including repellency, oral toxicity, reduced egg hatch, and reduced fecundity in targeted insects and mites. Regalia uses the extract from the giant knotweed plant (*Reynoutria sachalinensis*) that activates an internal defense mechanism in plants that prevents growth of certain plant pathogens. It is unclear if tile drainage may be an exposure pathway for bio-insecticides or if such an exposure may result in harmful environmental effects. Future water quality assessments should consider testing for bio-insecticides that may be applied on adjacent agricultural fields.

Biological Assessments

Wetland Rapid Assessment Protocol

At Full Assessment sites (*n*=18) we conducted a Wetland Rapid Assessment Protocol (herein, WRAP) to measure overall habitat quality. This WRAP is specific to eastern South Dakota and has been used with success to measure overall wetland habitat quality within the region (Bouchard *et al*. 2008). Previously validated WRAP scores have been found to positively correlate with the landscape development intensity index (Brown and Vivas 2005), and provide a relatively quick approach for collecting site-specific information on wetlands that is of important use by land managers (Bouchard *et al*. 2008). This WRAP provides point values that are summed across various characteristics of wetlands, including size, landscape setting, hydrology, vegetation, and water quality attributes, with greater WRAP scores indicating higher quality wetlands. WRAP scores were calculated at each of these 18 wetlands each month from May–July in 2013 and 2014.

Amphibian Surveys

At each Full Assessment wetland site, we established four 30-m survey transects to sample larval and adult amphibians each month from May–July of 2013 and 2014 (*n*=432 transects). Transects usually followed the shoreline of the wetland and were ca. 1–2 m into the wetland from the shoreline in order to maximize amphibian encounters. Occasionally at smaller wetland sites, we were unable to have four 30-m transects, and as a result, some transects were 18–22 m. Observers slowly walked each transect, conducting a visual encounter survey (VES) for adult and larval amphibians that were observed within 5 m on either side of transect. The abundance and species of amphibians encountered along each transect were recorded.

Aquatic macrophytes, algae, and turbidity made the quantification of amphibian larvae difficult. Thus, we also conducted plot surveys for larval amphibians along these transects. Three randomly generated points were chosen along each transect to sample for amphibian larvae. At each of these three random points, a 1-m^2 plot was examined visually and a dipnet was swept through the plot to collect larval amphibians. Larval amphibian species richness and abundance in each plot (n=1,296 plots) were recorded.

We collected 2–3 individuals of each amphibian species encountered at each wetland every year to provide a verifiable record of species occurrence. We euthanized voucher specimens via immersion in MS-222, recorded mass and snout–vent length measurements and took a tissue sample (liver or tail clips) before fixing specimens in a buffered 10% formalin solution for a minimum of 48 hours. Afterwards, specimens were placed in rinse ethanol solutions before being transferred for long-term storage in 70% ethanol. All specimens were deposited at the Biodiversity Collections at the University of Texas at Austin.

Wetland Aquatic Invertebrates

In addition to amphibian surveys, we also collected aquatic invertebrates along each of the four 30-m transects. Three different habitat types were quantified along each transect: emergent vegetation, submergent vegetation, and substrate. The percentages of each of these habitats were quantified along each transect, (including 5 m on either side of transect). Not all habitats types were present along each transect and relative abundances of each habitat type varied across transects and sampling dates. An aquatic D-net was used to conduct 10 sweeps within each habitat type that was present along the transect. The 10 sweeps within a particular habitat were spaced out along each transect to maximize the number of aquatic invertebrates collected. The collected samples were then placed in labeled whirl-paks and preserved with 70% ethanol. Invertebrates were sorted out of the vegetation and debris at USD, and placed in labeled glass vials containing new 70% ethanol until they were counted and identified. Aquatic hexapods (Hexapoda) were identified down to family and all other aquatic invertebrates were identified to either class or order.

Quality Assurance and Quality Control

Quality Assurance and Quality Control (QA/QC) included field blanks and duplicates as well as laboratory standards, replicates, blanks and split samples. Each laboratory has their own set of SOPs and QA/QC protocols that are available upon request. For analytical chemical residue measurements, precision and accuracy of laboratory analyses were confirmed with procedural blanks, duplicate analyses, test recoveries of spiked material, and reference materials. For chemical residue measurements by ELISA, samples were analyzed in duplicate and each batch of samples included a blank, a control, and three standards. Nitrate analysis at EDWDD included blanks, standard references, and duplicates. For each batch of water samples measured at EDWDD, split samples, representing a gradient of nitrate detections, were also measured for nitrates using ion chromatography at SDAL.

For analytical testing of pesticides, QA/QC included field blanks and duplicates. Approximately 10% of field samples for pesticide analysis by the EPA Region 8 Laboratory were comprised of field duplicates or blanks and were uniquely marked by field personnel but indistinguishable by laboratory personnel as a non-field sample. POCIS deployments also included the use of field blanks.

Statistical Analyses

All statistical calculations were performed with JMP® Version 11 software (SAS Institute 2002). Where means are provided, the "±" refers to a standard error (S.E.) unless otherwise noted. Data were typically nonparametric; therefore, a Kruskal-Wallis nonparametric one-way analysis of variance was used to test for significance among three groups and paired Wilcoxon rank sum tests were used to test significance between groups. If more than 50% of the sample size was above the detection limit (DL) or reporting limit (RL) for a particular contaminant, then half the DL or RL was substituted for statistical analyses, unless otherwise noted. For selenium analysis by SDAL, half the level of quantification (LOQ) was substituted for statistical analyses. If 50% or more of the samples were below the DL, RL or LOQ, then results were not analyzed statistically unless noted otherwise. Use of the term "significant" in this report indicates statistical analysis using an alpha significance level (α) of 0.05.

WRAP scores were analyzed using a full factorial model with WRAP score as the response variable and three factors: site category, month and year. Afterwards, Tukey's Honest Significant Difference (HSD) post-hoc comparisons were then conducted on effects that were significant ($p < 0.05$) to determine where differences exist. Separate analyses were conducted on each amphibian survey type: visual encounter survey and plot surveys. Due to the limited number of amphibian observations within a given transect or at a specific site during a discrete sampling period, VES amphibian data were summed from May–July for each year. Similarly, larval amphibian data from the plot surveys were summed across months for a given year at a site. We then used these summed amphibian data to calculate Shannon diversity scores (H'). Amphibian diversity data did not meet the assumptions of parametric data (for both VES and plot data) and were analyzed across site categories and between years using nonparametric analyses (Mann-Whitney U or Kruskal-Wallis tests) followed by sequential Bonferroni corrections to avoid inflating Type I error (initial $\alpha = 0.05$). If nonparametric tests were significant after sequential Bonferroni corrections, we used Wilcoxon multiple comparison tests to determine where significant differences occur. Shannon diversity scores (H') of aquatic invertebrates were calculated for each habitat type (emergent vegetation, submergent vegetation, substrate) sampled along each transect during a site visit. Unlike amphibian diversity data, aquatic invertebrate diversity data met the assumptions of parametric data. Due to the large number of factors potentially influencing invertebrate diversity (wetland site category, habitat type, month, year), we examined AIC scores from backwards elimination stepwise model selection to choose the best model using only individual factors and two-way interaction terms. If factors were significant, we followed up with Tukey's HSD post-hoc tests to determine where differences existed. We also used non-parametric Kruskal-Wallis tests followed by Wilcoxon multiple comparison tests to examine how the abundance of particular invertebrate classes or orders varied across site treatments.

RESULTS

Site Locations and Treatments

Our distinction between Surface Wetlands and Tile Wetlands was limited by not knowing the location of all tile outfalls and that Tile Wetlands are also likely to receive some surface runoff from adjacent row crop fields. Tile outfall locations are only reported to the Madison WMD if the county they are in has a drainage board and the drainage from the proposed tiling project is adjacent to a WPA. Yet, we identified at least 35 tile outfalls within the Madison WMD that either discharge directly into WPAs or drain into WPAs after discharging into road ditches (Table 1; Appendix Table A.1). Pollutants discharged by tile may flow in ditches for miles before reaching a wetland; thus, Surface Wetlands may also receive tile discharges from unknown tile outfalls. Tile Wetlands can also receive surface runoff, especially during high rainfalls, and we witnessed runoff events where soil from adjacent agricultural fields completely covered tile outfalls (Appendix Figure B.20).

The distinction of Reference Wetlands was more straightforward although the effectiveness of vegetated buffers in filtering agricultural pollutants likely varied within the site category. At the Pitt1 Reference Wetland on 15 May 2013, we observed a crop duster spraying pasture adjacent to the site (Appendix Figure B.21) indicating a clear potential for aerial drift onto the wetland site. Furthermore, many of the herbicides used in corn and soybean production (e.g., acetochlor, atrazine, metolachlor) have also been detected in rain from similar agricultural areas (Vogel *et al.* 2008).

Comparisons of biological measures among wetland sites were also likely limited by variation among the biological measures due to influence of hydrology, fish, and wetland size (Wilcox *et al.* 2002; Chipps *et al*. 2006; Hentges and Stewart 2010). Our effort to select sites located in close proximity and of similar habitat and size were aimed at minimizing such variation. Our biological metrics reported herein covered only two years with annual precipitation in the area being below normal in 2013 and above normal in 2014.

Contaminant Assessments

Field Water Quality Measures

For matched sites, water temperature from Tile Outfalls averaged 14.4 ± 0.4°C (*n*=126) and was not significantly different between 2013 and 2014. Water temperatures sampled at wetland sites were significantly different between 2013 and 2014 for Reference Wetlands but not Tile Wetlands or Surface Wetlands. Tile Outfall effluent was significantly colder than samples from wetland sites in 2013 and 2014 (Table 4). Water grab samples from Tile Wetland sites averaged colder than other wetland sites in 2013 and 2014 (Table 4). There are no temperature water quality standards for wetlands in South Dakota, although many wetland processes (e.g., organic matter decomposition, nitrogen cycling reactions) are affected by temperature. For example, colder wetland water temperatures tend to result in lower nitrogen removal (Kadlec and Reddy 2001).

Measures of pH were significantly lower in Tile Outfalls and Tile Wetlands compared to Reference Wetlands or Surface Wetlands. For Tile Outfalls, mean pH was near neutral both years but significantly lower in 2014 (7.44 ± 0.03) than in 2013 (7.61 ± 0.06). South Dakota's water quality criteria range for wetlands pH (6.0–9.5) was exceeded on seven occasions when considering all water samples analyzed for pH (Appendix Table A.2; *n*=410). These exceedances occurred at Reference Wetlands (*n*=3), Surface Wetlands (*n*=3) and a single measurement at a Tile Outfall site. Such intermittent exceedances are not necessarily cause for concern at wetland sites as carbon dioxide fixation by submerged macrophytes and algae during the day can result in pH values greater than 10 (Lewis *et al.* 1999). The single pH exceedance from a Tile Outfall (Pets1 in 2013) may be an anomaly as pH from this site was only measured on one other occasion in 2014 and was 7.76.

Specific conductivity was not significantly different between 2013 and 2014 at Tile Outfalls, Tile Wetlands, or Surface Wetlands. For both 2013 and 2014 combined, specific conductivity at matched Surface Wetlands (*n*=74) averaged 1,540 ± 97 microsiemens per centimeter (µS/cm) and was significantly greater than at Tile Outfalls (1,293 ± 73; *n*=119) and Tile Wetlands (1,364 ± 116; *n*=64). Specific conductivity at Tile Outfalls in 2013 averaged significantly lower than at Surface Wetlands or Reference Wetlands but there were no significant differences in specific conductivity among site categories in 2014 (Table 4).

For all water samples with measured specific conductivity (Appendix Table A.2; *n*=380), South Dakota water quality criteria for wetlands were exceeded on 41 occasions. These exceedances included Tile Outfalls (*n*=8), Tile Wetlands (*n*=13), Surface Wetlands (*n*=14), and Reference Wetlands (*n*=6). South Dakota water quality standards for specific conductivity were exceeded for Category 9 (fish and wildlife propagation) and Category 10 (irrigation) beneficial uses. The only exceedance of the Category 9 beneficial use standard (i.e., 30 day average > 4,000 μS/cm) was from a Tile Outfall into Habeger WPA during June and July of 2014 (averages of 4,122 μS/cm and 4,138 μS/cm, respectively). The Habeger Tile Outfall was also the only site that exceeded the one day maximum standard of 4,375 μS/cm for South Dakota's Category 10 beneficial use. The 30-day average Category 10 beneficial use standard of 2,500 μS/cm was exceeded on 26 occasions. Criteria exceedances for specific conductivity occurred at nine sites including; two Tile Outfalls (Habe1, Dryl1), two Reference Wetlands (Buff1, Lost1), two Surface Wetlands (2Petr1A, Rams1), and three Tile Wetlands (Volk1A, Ache1A, Gerk1A).

Concentrations of chlorophyll-a varied among site categories each year but were not significantly different between years within each site category (Table 4). In 2013 and 2014, chlorophyll-a was significantly lower at Reference Wetlands than Tile Wetlands or Surface Wetlands; whereas, Tile Wetlands and Surface wetlands had statistically similar chlorophyll-a concentrations each year (Table 4). For both years combined, concentrations of chlorophyll-a averaged 34.3 ± 5.1 μg/L at Tile Wetlands, which was significantly greater than at Reference Wetlands (13.5 ± 1.7 μg/L; Figure 4). Although a framework for development of regional water quality benchmarks for nutrients in wetlands has been established (EPA 2008), we are not aware of any numeric nutrient criteria for prairie pothole wetlands. Thus, we used national nutrient benchmarks for lakes and reservoirs to compare concentrations of chlorophyll-a among site categories. The chlorophyll-a benchmark concentrations (8.59 μg/L) for lakes and reservoirs in the Corn Belt and Northern Great Plains ecoregion (EPA 2000) was frequently exceeded at all wetland sites. For all wetland site samples, the benchmark for chlorophyll-a (8.59 μg/L) was exceeded in 83 of 103 samples (81%) from Tile Wetlands, 62 out of 79 samples

(78%) from Surface Wetlands, and 56 out of 95 samples (59%) from Reference Wetlands. The highest chlorophyll-a measurements for each site category were > 500 μg/L, 239.3 μg/L, and 89.3 μg/L for Tile Wetlands, Surface Wetlands, and Reference Wetlands, respectively. Higher concentrations of chlorophyll-a in wetlands are associated with increased exposure to nutrients including nitrates (Balali *et al.* 2013). Thus, chlorophyll-a measures the biological response to nutrient enrichment and is likely higher at tile sites due to the discharge of nitrates, other forms of nitrogen, and phosphorus.

Turbidity is also a response variable that can be used as an indicator of increasing algal biomass due to nutrient enrichment. For matched sites, turbidity at Reference Wetland sites (mean = 4 ± 1 NTUs; n=69) was significantly lower than turbidity at Surface Wetlands or Tile Wetlands (Figure 4). However, there was no significant difference in turbidity between Surface Wetlands (9 ± 2 NTUs; n=69) and Tile Wetlands (14 ± 3 NTUs; n=72). Unlike chlorophyll-a, turbidity measures include non-biological particulates that are suspended in the water column. Although care was taken while sampling to not capture sediments suspended from entering the wetland, wind action and other mechanisms can cause sediments to be suspended and collected during water grab sample collection.

Table 4. Measurements of water temperature, pH, and specific conductivity at matched sites within the Madison Wetland Management District, South Dakota, 2013–2014.

Date	Site Category	N	Mean ± S.E.	Range		N	Mean ± S.E.	Range	
		Water Temperature (°C)				Chlorophyll-a (µg/L)			
2013	Tile Outfall	56	14.9 ± 0.7	6.2 – 32.3	A	NA			
	Tile Wetland	38	19.9 ± 0.7	11.4 – 28.3	B	38	34.8 ± 6.66	< 0.1 – 218	A
	Surface Wetland	38	22.4 ± 0.7	12.8 – 31.1	C	38	32.4 ± 5.17	5.4 – 141	A
	Reference Wetland	38	22 ± 0.6	13.7 – 28.3	C	38	16.6 ± 3.16	< 0.1 – 89.3	B
2014	Tile Outfall	70	14.0 ± 0.5	4.4 – 24.2	A	NA			
	Tile Wetland	40	18.3 ± 0.6	9.0 – 25.9	B	40	33.7 ± 7.71	1 – 221	A
	Surface Wetland	40	20.0 ± 0.6	12.0 – 27.1	C	40	21.1 ± 5.83	1.9 – 239	A
	Reference Wetland	40	19.7 ± 0.6	11.5 – 26.5	BC	40	10.5 ± 1.14	3.4 – 36.8	B
		pH (standard units)				Specific Conductivity (µS/cm)			
2013	Tile Outfall	56	7.61 ± 0.06	6.98 – 9.56	A	49	1,239 ± 96	8 – 2,943	A
	Tile Wetland	38	7.72 ± 0.05	6.86 – 8.47	B	34	1,533 ± 181	531 – 3,863	AB
	Surface Wetland	38	8.51 ± 0.09	7.54 – 9.83	C	34	1,712 ± 155	454 – 3,538	B
	Reference Wetland	38	8.41 ± 0.11	7.04 – 10.12	C	34	1,648 ± 78	1,018 – 2,752	B
2014	Tile Outfall	70	7.44 ± 0.03	6.88 – 8.27	A	70	1,330 ± 104	20 – 4,513	A
	Tile Wetland	40	7.74 ± 0.06	7.14 – 8.88	B	40	1,220 ± 147	9 – 3,322	A
	Surface Wetland	40	8.24 ± 0.06	7.33 – 8.92	C	40	1,395 ± 117	7 – 2,701	A
	Reference Wetland	40	7.96 ± 0.07	7.06 – 8.78	D	39	1,128 ± 48	716 – 1,811	A

Note: NA = not applicable; N = sample size; S.E. = standard error; superscript letters indicate significant differences ($p < 0.05$) as determined by a Kruskal -Wallis test followed by pairwise Wilcoxon rank sums tests. All measurements were from a Yellow Springs Instrument (YSI) Model 6820-V2 Series water quality multimeter.

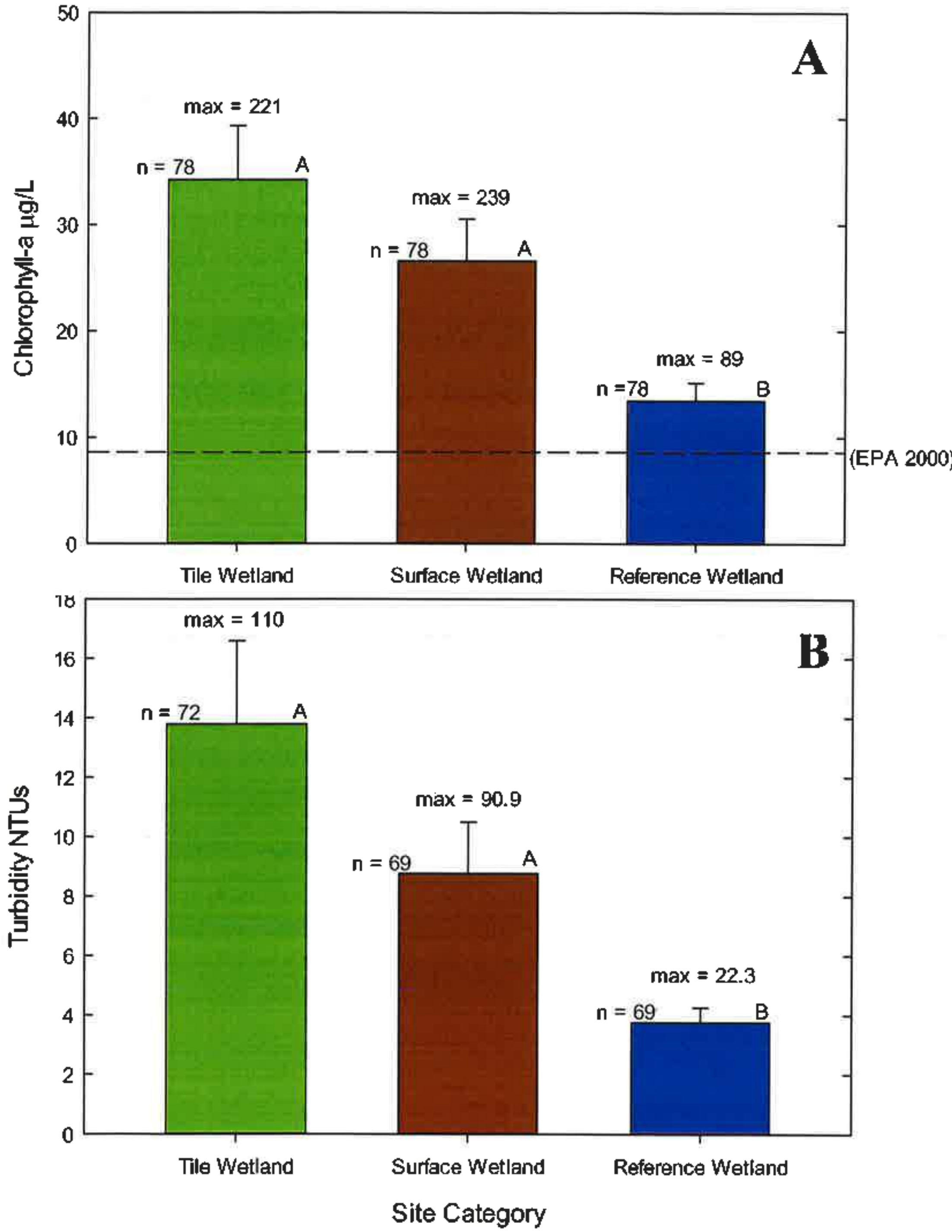

Figure 4. Mean concentrations of chlorophyll-a (A) and turbidity (B) in water from matched wetland sites within the Madison Wetland Management District, South Dakota, 2013–2014. Note: n = sample size; max = the maximum concentration detected; letters above each bar indicate significant differences ($p < 0.05$) as determined by a Kruskal-Wallis test followed by pairwise Wilcoxon rank sums tests. Dashed line is the EPA benchmark for chlorophyll-a in lakes and reservoirs in the Corn Belt and Northern Great Plains ecoregion.

Pesticides

Overall, a total of 34 pesticide compounds (26 herbicides, seven insecticides and one fungicide) were detected in water grab or POCIS samples from Tile Outfalls and wetland sites (Appendix Table A.4). Tile Outfalls had the greatest number of pesticides detected (*n*=31), followed by Surface Wetlands (*n*=27), Tile Wetlands (*n*=22), and Reference Wetlands (*n*=18; Table 5).

If a particular pesticide was detected in a water grab sample by the EPA Region 8 Laboratory, then it was also detected by other sampling or analytical methods (i.e., USGS analytical, ELISA, or POCIS) that also tested for it. Pesticides detected in Tile Wetland sites were generally also detected at Surface Wetland sites, with the exception of a single detection of triclopyr (Garlon), detected only at Nels1A on 11 August 2014. Garlon can be used by WMD staff to control woody plants and such use may have resulted in this detection.

Pesticides only detected in Tile Outfalls included the herbicides bromoxynil (e.g., Vendetta, WildCard) and propachlor (not registered) and the insecticides tefluthrin (e.g., Force, Precept) and dimethoate (e.g., Drexel, Dimate). Propachlor was discontinued by Monsanto in 1998 with no estimated use in South Dakota after 2001 (USGS 2017). However, in addition to the single detection of propachlor ESA from a Tile Outfall (Hejo2), its other metabolite (propachlor OA) was detected at five Tile Outfalls and a Surface Wetland (2Petr1A). These detections of propachlor may be due to carryover in soils from when the pesticide was heavily used within the WMD in the 1990s (USGS 2017).

Table 5. Number of pesticide products detected by type at each site category sampled within the Madison Wetland Management District, South Dakota, 2012–2015.

Pesticide Type	Site Category			
	Tile Outfall	Reference Wetland	Surface Wetland	Tile Wetland
Herbicide	23	14	21	18
Insecticide	7	4	5	3
Fungicide	1	0	1	1
TOTALS	31	18	27	22

The absence of bromoxynil above the reporting limit at wetland sites may be a result of its quick degradation by hydrolysis and photolysis in sunlit surface waters (Muir *et al.* 1991; HSDB 2012). Tefluthrin and dimethoate were not tested for in water grab samples but were measured using POCIS (see section below). These two insecticides may not have been detected at wetland sites because of their more limited use and rapid degradation. Tefluthrin is expected to volatize from water surfaces (HSDB 2011) and would likely degrade quickly after it daylights from tile outfalls. Dimethoate is stable to hydrolysis and photolysis but quickly degrades in soil (HSDB 2007).

Two herbicides (prometon and 2,4,5-TP) were only detected on one occasion but are not registered for use in field crops. Prometon was detected in a POCIS at a Surface Wetland (Rams1) and 2,4,5-TP was detected in a water grab sample at a Tile Wetland (Mund1). Prometon (Pramitol) may be applied to noncrop areas including farm buildings, parking areas, and fence rows but it is not included in Madison WMD's integrated pest management plan (FWS 2008). A few aquatic herbicides (e.g., Aquathol K, Cascade Aquatic Herbicide) that are registered for use in drainage canals, ditches, and irrigation canals include 2,4,5-TP as an ingredient; however, agricultural use of 2,4,5-TP (Silvex) was banned in 1985 (HSDB 2008; Kelly Registration Systems 2017).

A total of 24 pesticides were detected in tile effluent when combining both ELISA and analytical results from the EPA Region 8 Laboratory and USGS NWQL (Table 6). Five herbicides (atrazine, glyphosate, acetochlor, imazethapyr, metolachlor) were detected in tile effluent in over 50% of the Tile Outfall samples tested (Table 6). Acetochlor OA was the most frequently detected herbicide compound found in 77% of Tile Outfall samples, followed by metolachlor ESA (69%). The parent compounds for these herbicides were found less frequently with acetochlor and metolachlor detected in 25% and 23% of samples, respectively. Conversely, atrazine was the most frequently detected (66%) parent herbicide compound and was detected more often than its two metabolites (de-ethyl and de-isopropyl atrazine).

In addition to herbicides, four systemic pesticides commonly used as seed treatments for corn or soybeans were also detected in Tile Outfall water grab samples. They included three neonicotinoid insecticides (clothianidin, thiamethoxam, imidacloprid) and one fungicide (metalaxyl; Table 6). Clothianidin was the most frequently detected

(39%), followed by thiamethoxam (11%), metalaxyl (5%), and imidacloprid (4%). Neonicotinoids were not frequently detected at wetland sites in water grab samples tested by EPA (Table 7). Imidacloprid was not detected in all 83 wetland water grab samples tested whereas thiamethoxam and clothianidin were detected in 6% of wetland samples with Surface Wetlands having the most detections (*n*=6; Table 7).

Table 6. Summary stats for concentrations of pesticides detected at Tile Outfalls in water grab samples from wetland sites within the Madison Wetland Management District, South Dakota, 2012–2015.

				Concentration (ng/L)	
Trace Element	RL (ng/L)	N_D/N_A	Percent	Mean ± S.E.	Maximum
Atrazine (ELISA)*	50	106 / 154	69%	402 ± 74	6,540
Glyphosate (ELISA)*	75	77 / 131	59%	386 ± 83	5,580
2,4-D	10	43 / 154	28%	40 ± 8	316
Acetochlor	20	39 / 154	25%	160 ± 34	1,000
Acetochlor OA*	20	118 / 154	77%	559 ± 100	9,360
Atrazine*	10	102 / 154	66%	142 ± 22	1,580
Atrazine de-ethyl*	20	86 / 154	55%	69 ± 11	1,050
Atrazine de-isopropyl	20	46 / 154	30%	60 ± 11	478
Bentazon	10	3 / 154	2%	48 ± 24	94
Bromoxynil	10	4 / 154	3%	42 ± 26	121
Clothianidin	20	53 / 135	39%	51 ± 4	128
Dimethenamid	10	1 / 154	1%	NA	120
Dimethenamid ESA	20	11 / 154	7%	95 ± 46	538
Imazethapyr*	10	79 / 147	54%	73 ± 32	4,670
Imidacloprid	20	6 / 154	4%	52 ± 12	88
Metalaxyl	10	7 / 154	5%	41 ± 23	175
Metolachlor	10	35 / 154	23%	87 ± 34	1,160
Metolachlor ESA*	20	106 / 154	69%	358 ± 45	3,200
Metribuzin	20	11 / 154	7%	125 ± 31	317
Propachlor ESA	10	1 / 154	1%	NA	113
Propachlor OA	20	4 / 154	3%	13 ± 1	16
Propazine	20	7 / 154	5%	57 ± 24	201
Simazine	20	1 / 154	1%	NA	42
Thiamethoxam	20	17 / 154	11%	226 ± 144	2,490
Triclopyr	20	1 / 154	1%	NA	143

Note: RL = reporting limit, N_D = number of samples above detection, N_A = number of samples analyzed, S.E. = standard error. NA = not applicable, ng/L = nanograms per liter; ELISA = enzyme linked immunosorbent assay, * = half the RL was used to calculate the mean and S.E., otherwise only detects were used.

Concentrations of pesticides in Tile Outfalls exceeded water quality benchmarks for two herbicides (atrazine and metolachlor) and all three neonicotinoids. For atrazine, EPA's aquatic life benchmark of 1 ng/L, to protect vascular plants from acute effects (EPA 2014), is actually below the EPA Laboratory reporting limit of 10 ng/L. Thus, concentrations of atrazine in Tile Outfalls exceeded this benchmark in at least 66% of the samples tested (i.e., all samples that were above the RL). To protect invertebrates from chronic exposure to metolachlor, EPA has a freshwater benchmark of 1,000 ng/L (EPA 2014) and this benchmark was exceeded on one occasion in a Tile Outfall (1,160 ng/L at Reev1). To evaluate neonicotinoid concentrations in Tile Outfalls we used thresholds for acute and chronic exposure that were developed based on a recent synthesizes of published data on neonicotinoid toxicity to 49 species of aquatic invertebrates (Morrissey *et al.* 2015). Tile Outfall effluent measured in this study exceeded a chronic benchmark of 35 ng/L on 40 occasions and an acute benchmark of 200 ng/L on four occasions (Figure 5). The highest measured concentration of a neonicotinoid in a Tile Outfall was thiamethoxam (2,490 ng/L) from Bols1 in June 2013.

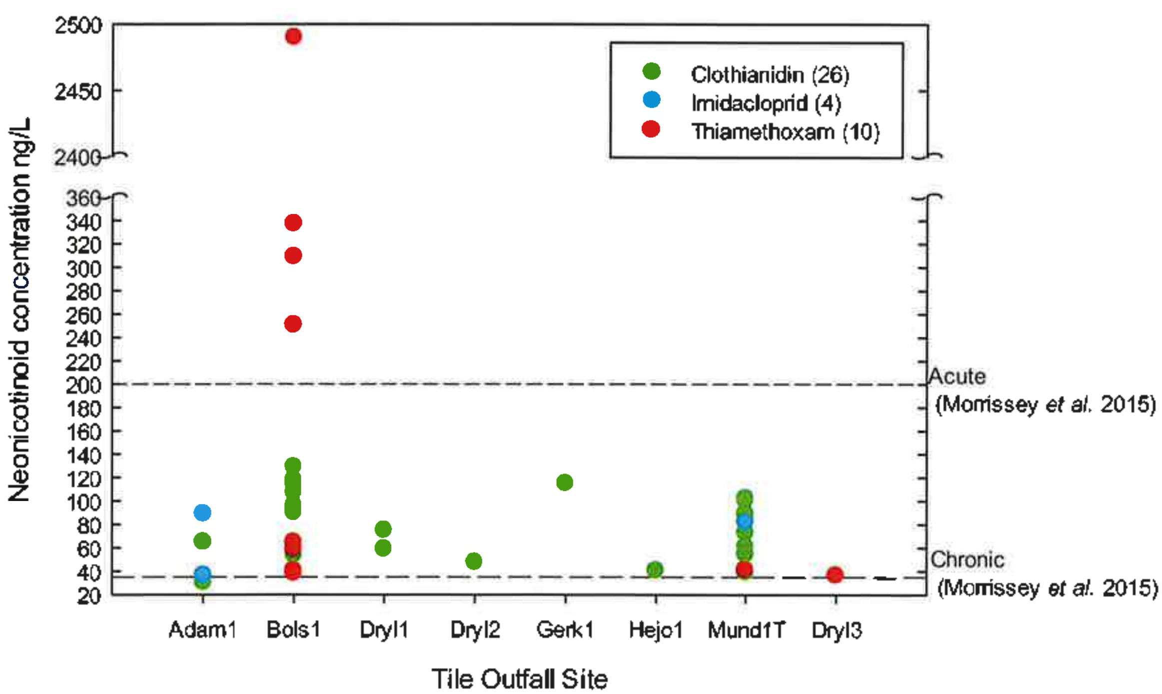

Figure 5. Neonicotinoid concentrations in Tile Outfalls above water benchmark concentrations for the protection of aquatic invertebrates, Madison Wetland Management District, South Dakota, 2012–2015. Note: number in parentheses indicate number of benchmark exceedances.

For wetland sites, analytical measurements of pesticides in wetland water samples were evaluated by combining the 12 samples collected and tested by USGS in May 2013 with the more robust sampling effort for testing by EPA from 2012–2014 (Table 7). This added detections for six herbicide compounds that were detected and at concentrations < 1 µg/L (Appendix Table A.5). The only pesticide detected by USGS that was also not detected by the EPA Region 8 Laboratory was ametryn, an herbicide that was not included in EPA's pesticide panel. All four detections of ametryn by USGS included samples from all three wetland site categories and were near the detection limit (Table 7).

We collected additional water samples for ELISA tests to measure atrazine and glyphosate because both herbicides are frequently used in South Dakota and have been linked to harmful effects to non-target wildlife, especially amphibians (Howe *et al.* 2004; Relyea 2005a–d; Rimayi *et al.* 2018). The ELISA data is the only information we have on glyphosate exposure in our WPAs, which is important given that its use has always been allowed on Refuge lands, unlike atrazine or neonicotinoid insecticides (FWS 2014).

For water samples tested by ELISA methods, atrazine was detected in 106 of 154 (69%) of water grab samples from Tile Outfalls. For all sites, concentrations of atrazine averaged < 0.6 µg/L and were significantly greater at Tile Wetlands and Surface Wetlands than Reference Wetlands (Figure 6). All sites had mean atrazine concentrations above the EPA's 0.001 µg/L acute aquatic life benchmark for vascular plants (EPA 2014). Although our detection limit for measuring atrazine by ELISA was 0.05 µg/L, exposure of *Elodea canadensis* (common waterweed) to atrazine concentrations of 0.001 µg/L for 14 days can result in a 50% reduction in biomass (McGregor *et al.* 2008).

Glyphosate was detected in 77 of 131 (59%) of water grab samples from Tile Outfalls and was more frequently detected at Tile Wetland sites than Reference Wetlands (Figure 6). Samples reached the maximum range of detection (5 µg/L) on seven occasions (four from the Bols1 Tile Outfall and one per each wetland category; Appendix Table A.6). Unlike atrazine, glyphosate is used by District staff to control noxious weeds and this may account for the 5 µg/L glyphosate concentration detected at the Buff1 Reference Wetland in 2013. There are no water quality standards for glyphosate, but no sites had concentrations above an interim Canadian guideline of 65 µg/L (CCME 1999).

Table 7. Summary stats for concentrations of pesticides detected in water grab samples from wetland sites within the Madison Wetland Management District, South Dakota, 2012–2015.

		Reference Wetlands			Surface Wetlands			Tile Wetlands		
			Concentration (ng/L) ww			Concentration (ng/L) ww			Concentration (ng/L) ww	
Pesticide	RL (ng/L)	N_D/N_A	Mean ± S.E.	Maximum	N_D/N_A	Mean ± S.E.	Maximum	N_D/N_A	Mean ± S.E.	Maximum
Atrazine (ELISA)*	50	84 / 94	219 ± 13	570	70 / 73	517 ± 79	4,900	84 / 89	428 ± 51	2,840
Glyphosate (ELISA)*	100	52 / 75	276 ± 71	> 5,000	44 / 57	612 ± 131	> 5,000	51 / 69	541 ± 119	> 5,000
2,4,5-TP	10	0 / 18	NA	NA	0 / 27	NA	NA	1 / 35	NA	72
2,4-D*	10	15 / 18	45 ± 12	207	27 / 27	61 ± 26	693	35 / 35	67 ± 30	1000
Acetochlor	20	7 / 22	183 ± 41	360	9 / 30	163 ± 73	720	6 / 40	276 ± 87	660
Acetochlor OA*	20	16 / 18	91 ± 19	286	27 / 27	797 ± 179	4,000	35 / 35	514 ± 92	2870
Alachlor OA	20	0 / 18	NA	NA	1 / 27	NA	127	1 / 35	NA	65
Ametryn	50	1 / 4	NA	50	1 / 3	NA	50	2 / 5	55 ± 5	60
Atrazine*	10	16 / 22	60 ± 13	181	30 / 30	246 ± 127	2,840	40 / 40	32 ± 7	170
Atrazine de-ethyl	20	12 / 22	59 ± 9	117	15 / 30	148 ± 65	778	15 / 40	46 ± 5	70
Atrazine de-isopropyl	20	7 / 22	47 ± 5	70	6 / 30	85 ± 24	174	6 / 40	45 ± 3	50
Bentazon	10	0 / 18	NA	NA	5 / 27	14 ± 1	17	2 / 35	39 ± 21	60
Clothianidin	20	1 / 13	NA	25	3 / 23	27 ± 3	33	0 / 28	NA	NA
Dimethenamid ESA	20	0 / 18	NA	NA	3 / 27	28 ± 4	33	1 / 35	NA	32
Imazethapyr	20	3 / 16	18 ± 4	23	2 / 24	43 ± 19	63	15 / 35	118 ± 33	411
Metalaxyl	10	0 / 18	NA	NA	1 / 27	NA	12	0 / 35	NA	NA
Metolachlor	10	7 / 22	29 ± 6	60	6 / 30	29 ± 5	50	7 / 40	29 ± 6	60
Metolachlor ESA	20	0 / 18	NA	NA	17 / 27	74 ± 10	169	16 / 35	182 ± 45	531
Metribuzin	20	0 / 22	NA	NA	0 / 30	NA	NA	1 / 40	NA	87
Propachlor OA	10	0 / 18	NA	NA	1 / 27	NA	133	0 / 35	NA	NA
Thiamethoxam	20	1 / 18	NA	21	3 / 27	26 ± 4	34	1 / 35	NA	31
Triclopyr	20	0 / 18	NA	NA	0 / 27	NA	NA	1 / 35	NA	37

Note: RL = reporting limit, N_D = number of samples above detection, N_A = number of samples analyzed, S.E. = standard error, NA = not applicable, ng/L = nanograms per liter, ww = wet weight, ELISA = enzyme linked immunosorbent assay, * = half the RL was used to calculate the mean and S.E., otherwise only detects were used.

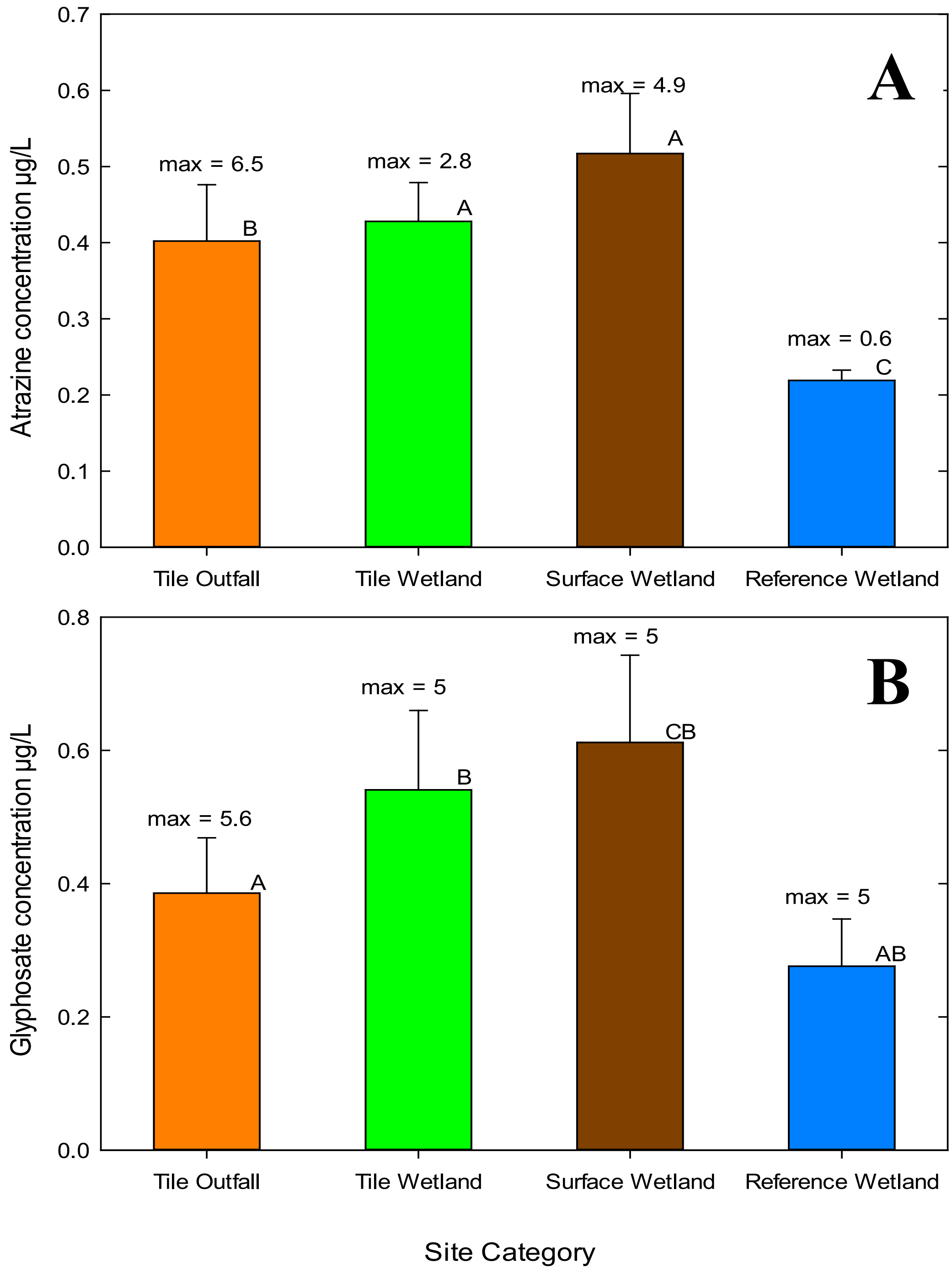

Figure 6. Mean concentration of atrazine (A) and glyphosate (B) in water grab samples analyzed by ELISA and collected from Tile Outfalls and wetland sites within the Madison Wetland Management District, South Dakota, 2011–2013. Note: max = the maximum concentration detected; letters above each bar indicate significant differences ($p < 0.05$) as determined by a Kruskal-Wallis test followed by pairwise Wilcoxon rank sums tests.

Pesticides measured in POCIS

The use of POCIS allowed us to measure low levels of pesticides that may have been missed with our monthly water grab sampling technique and also gave us a way to quantitatively compare pesticide exposure among wetland sites. The POCIS scan included 13 pesticides not tested for in water grab samples and confirmed the presence of pesticides detected by water grab methods (Appendix Table A.4).

Each pesticide detected in water grab samples was also detected by POCIS if included in the POCIS scan. Insecticides detected in POCIS but were not tested for in water grab samples included the insecticides acetamiprid (n=9 detects), dimethoate (n=1, Nels1), and thiacloprid (n=2; Mund1, Thor1). All of these insecticides were detected in Tile Outfalls; however, acetamiprid was most frequently detected at Reference Wetlands (n=7). Acetamiprid is registered for use in a variety of products in South Dakota (e.g., Anarchy, Assail, Justice) and may be commonly applied by aerial or foliar spray applications (Kelly Registration Systems 2017).

Pesticides detected in POCIS samples that were not detected in water grab samples by EPA or USGS included the herbicides alachlor and prometon. Alachlor is the active ingredient in three products (Intrro, Lariat, and Micro-Tech) registered for use in South Dakota on multiple crops including corn, soybean, and sorghum (Kelly Registration Systems 2017). However, prometon is not registered for use in South Dakota crop fields but may be applied to non-crop areas including farm buildings, parking areas, and fence rows (Kelly Registration Systems 2017). Although prometon has been widely detected in U.S. groundwater surface waters from agricultural areas and can be widespread in the hydrologic system (Capel *et al.* 1999; Spalding *et al.* 2003; Toccalino *et al.* 2014), we only detected it once in a Surface Wetland (Rams1). Based on its currently limited use, we would not expect prometon to be a pollutant frequently associated with tile effluent. Conversely, alachlor was detected in 24 POCIS samples that included nine Tile Outfalls and all three wetland site categories. It is an herbicide associated with tile effluent; however, it was not detected in 154 tile outfall samples analyzed. The breakdown metabolite of alachlor, alachlor oxanilic acid (alachlor OA) was detected by EPA, but only twice (Nels1A, 2Petr1A) and not in tile effluent. It is unclear why there is this difference between the POCIS and grab sample results for alachlor, though this may be related to the lower detection limits afforded in passive samplers or to increased persistence in wetland soils (Miller and Chin 2005). However, its importance relative to other herbicides associated with tile is likely low based on the low concentrations detected relative to other herbicides and its detection at concentrations well below EPA's water quality benchmark of 1,640 ng/L (EPA 2014).

The sum of pesticides in POCIS deployed in 2013 and 2014 averaged higher in Tile Outfalls and Surface Wetlands than Tile Wetlands or References Wetlands (Figure 7). Surface Wetlands and Tile Wetlands had significantly greater concentrations of neonicotinoid insecticides (clothianidin, imidacloprid, and thiamethoxam) than Reference Wetlands (Figure 8). However, there was no significant difference in POCIS neonicotinoid concentrations between Surface Wetlands and Tile Wetlands. Concentrations of imidacloprid were similar in Tile Outfalls and Tile Wetlands, whereas clothianidin and thiamethoxam concentrations in Tile Outfalls were significantly greater than wetland sites. In 2015, additional POCIS were deployed at Tile Outfalls, Surface Wetlands, and Tile Wetlands from May into September. For the combined POCIS data (2013–2015), Tile Wetlands had significantly greater average concentrations of atrazine, and sum of pesticides than Surface Wetlands. These results were mostly driven by high concentrations of atrazine (12,656 ng/POCIS) and metolachlor (16,326 ng/POCIS) at the Hejo1A Tile Wetland. Although these concentrations were much higher than the other Tile Wetland sites, they were similar to those in the Hejo1 Tile Outfall (atrazine: 11,972 ng/POCIS, metolachlor: 20,928 ng/POCIS). Surface Wetlands had significantly higher concentrations of de-ethyl atrazine, de-isopropyl atrazine, and propazine than Tile Wetlands. The herbicide metribuzin (Axiom) was only detected in POCIS deployed at Tile Wetlands and Tile Outfalls. For the combined POCIS data (2013–2015), Tile Outfalls had significantly greater concentrations of the fungicide metalaxyl and neonicotinoids (clothianidin, imidacloprid, and thiamethoxam) than Tile Wetlands or Surface Wetlands.

The frequent detection of clothianidin at Reference Wetlands may result from it being a degradation product of thiamethoxam and the potential wind dispersion of neonicotinoids in contaminated soil (Schaafsma *et al.* 2015).

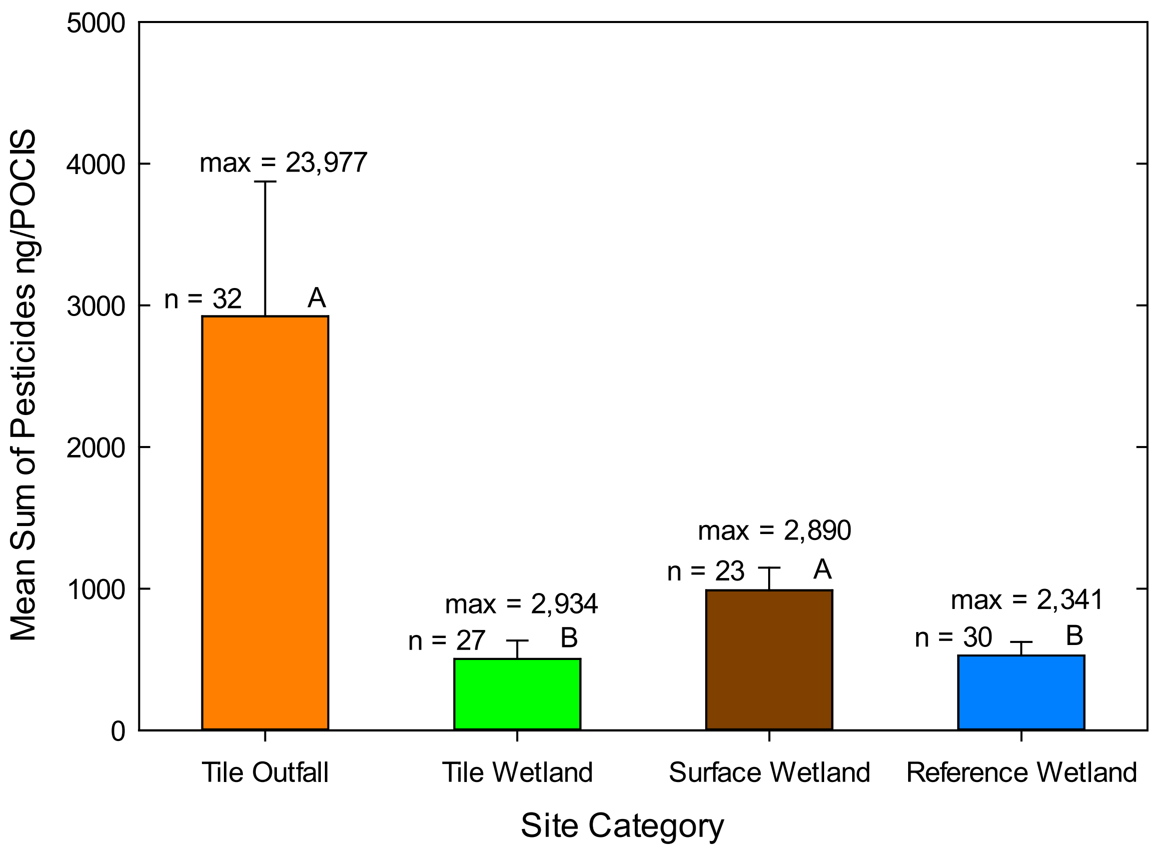

Figure 7. Mean sum of pesticides in polar organic chemical integrative samplers (POCIS) deployed in Tile Outfalls and wetland sites within the Madison Wetland Management District, South Dakota, 2013–2014. Note: *n* = sample size; max = maximum concentration detected; letters above each bar indicate significant differences ($p < 0.05$) as determined by a Kruskal-Wallis test followed by pairwise Wilcoxon rank sums tests.

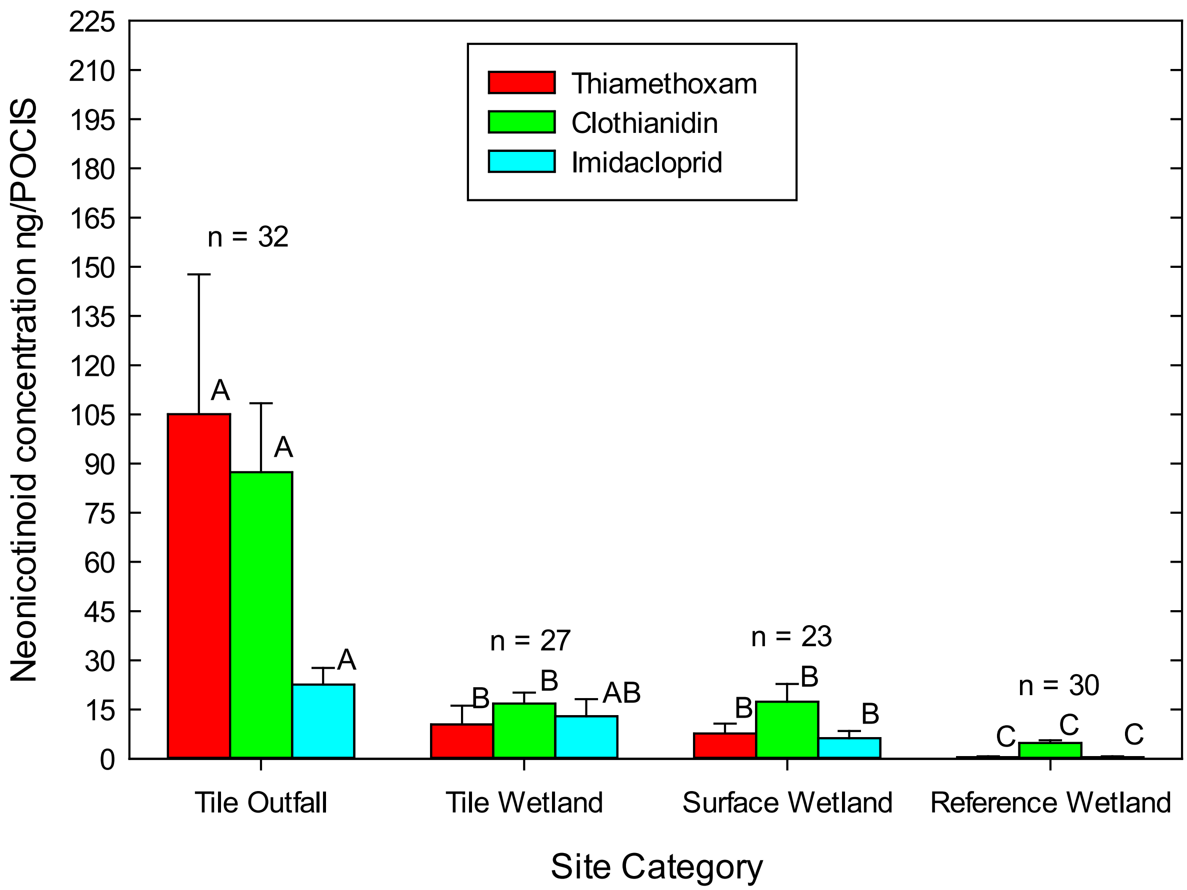

Figure 8. Mean concentrations of neonicotinoid insecticides in polar organic chemical integrative samplers (POCIS) deployed in Tile Outfalls and wetland sites within the Madison Wetland Management District, South Dakota, 2013–2014. Note: *n* = sample size; letters above each bar indicate significant differences ($p < 0.05$) as determined by a Kruskal-Wallis test followed by pairwise Wilcoxon rank sums tests.

Nutrients and Anions

Concentrations of nitrate in Tile Outfalls averaged 11 ± 0.5 mg/L and frequently exceeded water quality criteria for the protection of human health and aquatic life (Figure 9). The Maximum Contaminant Level (MCL) of 10 mg/L nitrate, a national water quality standard to protect human health, was exceeded on average in Tile Outfalls and on 118 separate occasions. Many Tile Outfalls discharge into Tile Wetland sites and are likely responsible for high nitrate readings at Tile Wetlands. For example, the highest nitrate reading from a wetland site was 29 mg/L from Gerk1A measured on 10 June 2013 (Figure 9). Tile Wetland sites had an average nitrate concentration of 0.96 ± 0.3 mg/L; whereas Reference Wetland sites and Surface Wetland sites had average nitrate concentrations below 0.6 mg/L, a suggested baseline by USGS for surface waters in the U.S. (USGS 1995; Figure 9). Tile Wetland sites were also the only wetland sites that had nitrate concentrations above 3 mg/L and Minnesota's draft chronic water quality criterion of 4.9 mg/L nitrate (Monson 2010).

Measurements of nitrate in tile effluent were most robust for the months of May through August (i.e., $n > 25$) and when averaged across these months, they exceeded 10 mg/L each year sampled (2011–2014) with no significant differences in nitrate concentrations between years (Figure 10). Nitrate concentrations in Tile Outfalls were above water quality benchmarks for each month sampled, but were significantly greatest in June and July when compared to May and August (Figure 10).

Nitrate concentrations in samples measured by the EPA Region 8 Laboratory averaged 8.9 ± 1.5 mg/L in Tile Outfalls (n=19) and exceeded Minnesota's draft chronic water quality criterion of 4.9 mg/L nitrate on 14 occasions (Appendix Table A.11). For wetland sites, nitrate concentrations averaged 3.9 ± 2.1 mg/L at Tile Wetlands (n=8) and were mostly below detection (i.e., < 0.005 mg/L) at Surface Wetlands and Reference Wetlands.

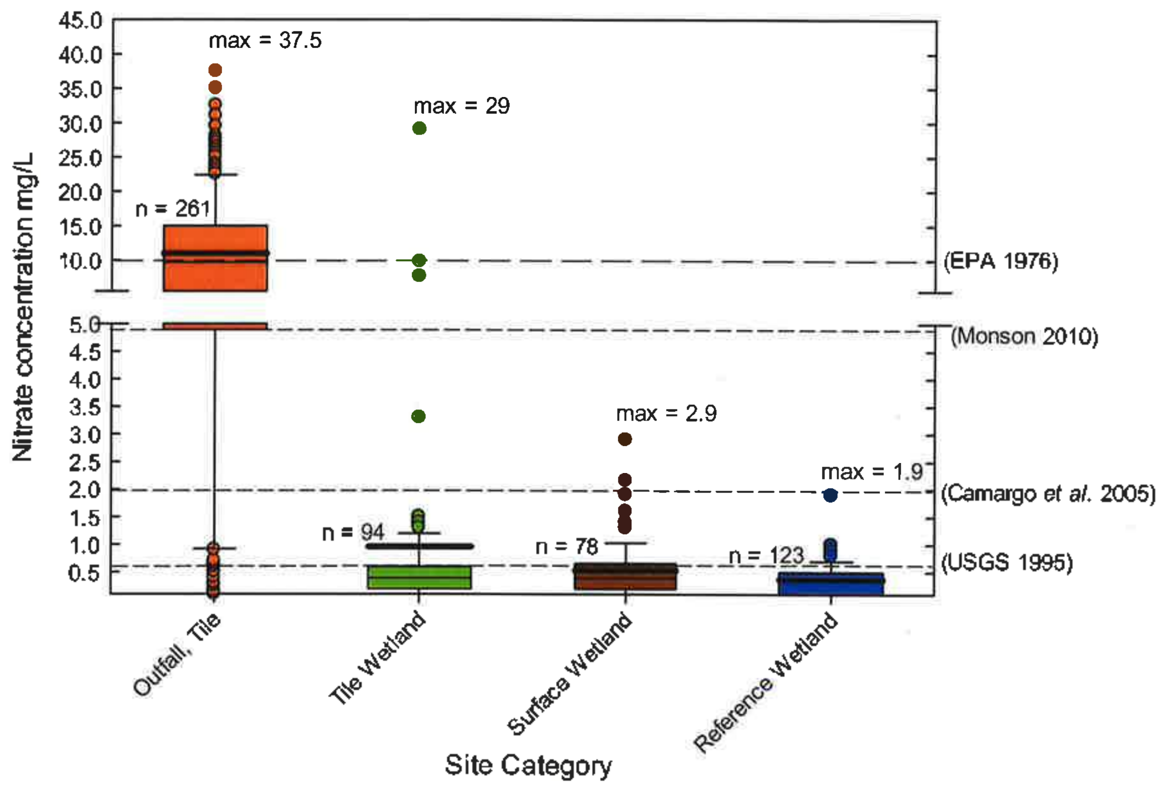

Figure 9. Box plot of nitrate concentrations from water samples collected from Tile Outfalls and wetland sites within the Madison Wetland Management District, South Dakota, 2011–2014. Note: only includes samples measured at EDWDD; *n* = sample size; max = maximum concentration detected; thick lines for each bar denotes the site category average; letters for wetland sites indicate significant differences ($p < 0.05$) as determined by a Kruskal-Wallis test followed by pairwise Wilcoxon rank sums tests. Horizontal reference lines are for the human health water quality standard (EPA 1976), Minnesota's draft chronic aquatic life criterion (Monson 2010), a benchmark to protect aquatic invertebrates (Camargo *et al.* 2005) and a baseline for indicating the absence of significant anthropogenic sources (USGS 1995).

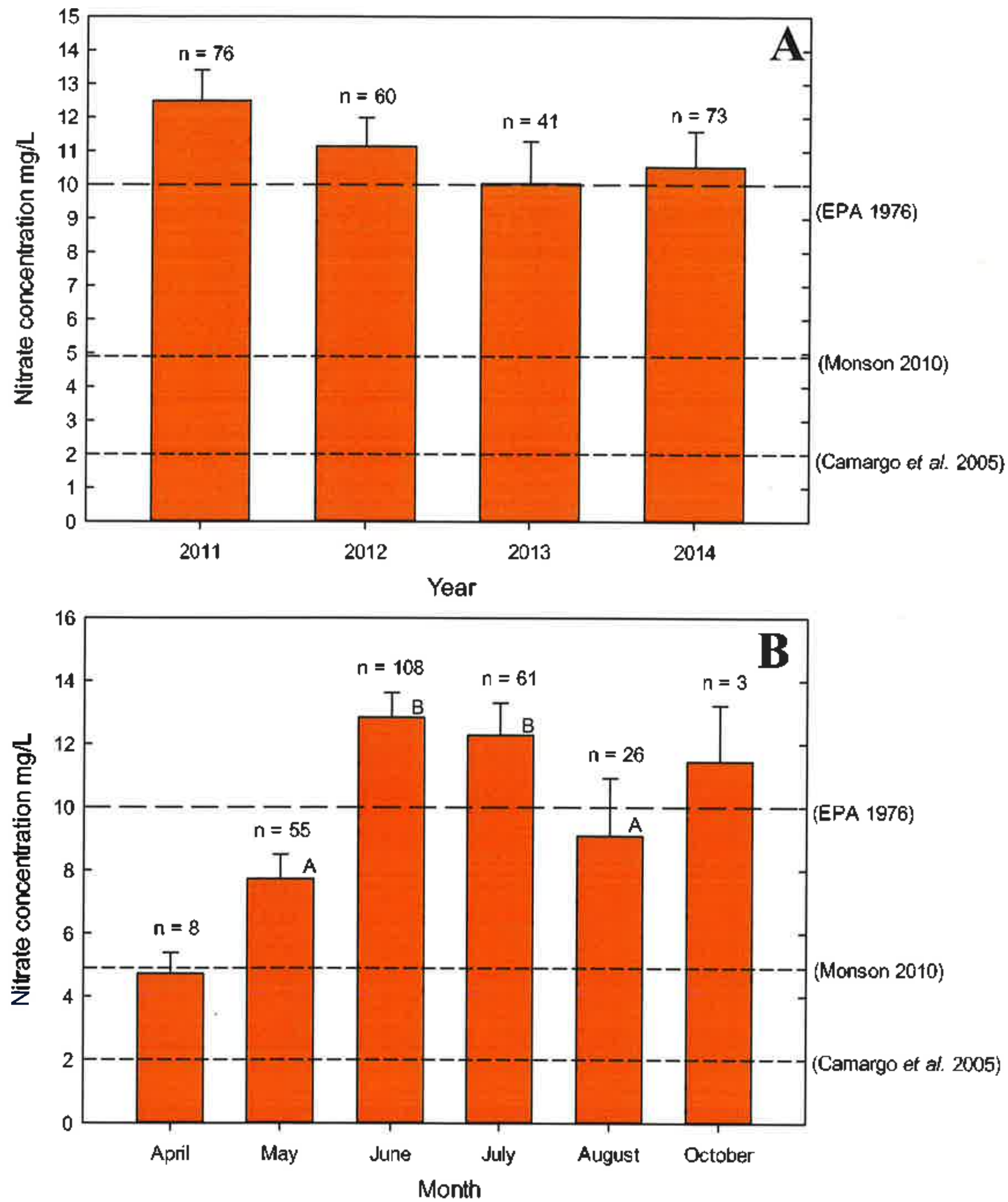

Figure 10. Mean concentrations of nitrate by year (A) and by month (B) in water samples from Tile Outfalls within the Madison Wetland Management District, South Dakota, 2011–2014. Note: (A) includes May to August samples; (B) only months May–August had sufficient sample size for statistical analyses; *n* = sample size; letters above each bar indicate significant differences ($p < 0.05$) as determined by pairwise Wilcoxon rank sums tests. Horizontal reference lines are for the human health water quality standard (EPA 1976), Minnesota's draft chronic aquatic life criterion (Monson 2010) and a benchmark to protect aquatic invertebrates (Camargo *et al.* 2005).

South Dakota's aquatic life criteria for nitrate, which includes a chronic criterion of 50 mg/L per 30 day average and an acute criterion of 88 mg/L for a daily maximum (SDDENR 2016), were not exceeded in water grab samples collected for this study. However, these criteria were first implemented in 1977, and current scientific studies indicate that a chronic water quality criterion between 2–5 mg/L is needed to protect aquatic life (Camargo *et al.* 2005; Suplee *et al.* 2008; Monson 2010).

For nitrites, concentrations were below detection in half of the samples analyzed with the highest detected concentration of only 0.106 mg/L from a Tile Outfall. Nitrite concentrations measured were lower than 2 mg/L, a potential threshold for lethality to sensitive freshwater invertebrates (Alonso and Camargo 2006). The much lower concentrations of nitrite relative to nitrate is expected given that in oxygenated natural water systems it is rapidly oxidized to nitrate (EPA 1986).

We are not aware of any numeric nitrogen nutrient criteria for prairie pothole wetlands. Thus, we used EPA's national TN benchmark of 0.781 mg/L for lakes and reservoirs within Aggregate Ecoregion VI (Corn Belt and Northern Great Plains) to evaluate TN and TKN (EPA 2000; Figure 11). Total nitrogen, which is the combination of TKN and nitrate-nitrite nitrogen, was significantly greater in Tile Outfalls than wetland sites. The highest TN concentration measured was 26.9 mg/L at the Reev1 Tile Outfall. All wetland categories had TN concentrations above the benchmark, but there were no significant difference in TN concentrations among wetland categories (Figure 11).

Concentrations of TKN also exceeded EPA's 0.781 mg/L TN benchmark at each wetland site category (Figure 11). Concentrations of TKN in Tile Outfalls averaged 1.31 $\pm$ 0.12 mg/L (n=43) but were significantly greater at wetland sites with no significant differences in TKN between wetland categories (Figure 11).

Our combined results for nitrates, TN, and TKN indicate that Tile Outfalls are a significant source of nitrogen pollution to WPA wetland sites. Most of the nitrogen inputs from tile effluent are in the form of nitrates; however, concentrations of TKN alone also exceeded EPA's nutrient benchmark for TN.

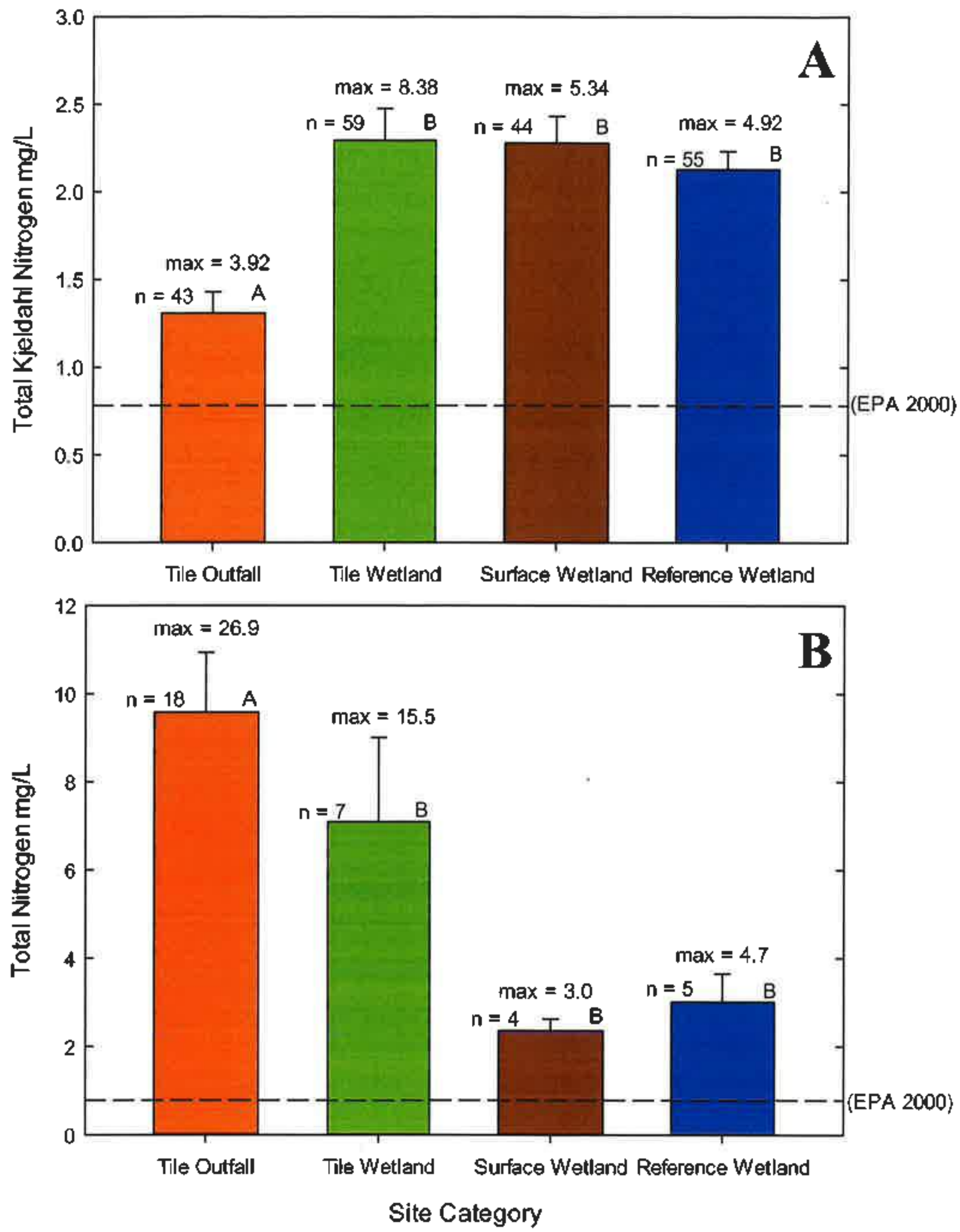

Figure 11. Mean concentrations of total Kjeldahl nitrogen (A) and total Nitrogen (B) in water grab samples from Tile Outfalls and wetland sites within Madison Wetland Management District, South Dakota, 2012–2014. Note: *n* = sample size; max = maximum concentration detected; letters above each bar indicate significant differences ($p < 0.05$) as determined by a Kruskal-Wallis test followed by pairwise Wilcoxon rank sums tests. The horizontal reference line is for the total nitrogen water quality benchmark for lakes and reservoirs in the Corn Belt and Northern Great Plains Ecoregion (EPA 2000).

Phosphorus is an essential element that occurs naturally at low levels in water, detritus, and biota. It is also discharged unnaturally into the environment as fertilizers, industrial detergents and domestic sewage. Total phosphorus (TP) is the sum of organic and inorganic forms of phosphorus and is the measure used by EPA to establish nutrient benchmarks for surface waters (EPA 2000). Mean concentration of TP was 0.18 ± 0.03 mg/L in Tile Outfalls (n=43), but were significantly greater at Tile Wetlands and Surface Wetlands (Figure 12). Although a framework for development of regional water quality benchmarks for nutrients in wetlands has been established (EPA 2008), we are not aware of any numeric phosphorus nutrient criteria for prairie pothole wetlands. The EPA's benchmark for TP in lakes and reservoirs within Aggregate Ecoregion VI (Corn Belt and Northern Great Plains) is 0.0375 mg/L (EPA 2000). This benchmark was exceeded at all wetland categories and in Tile Outfalls (Figure 12). Higher TP concentrations at wetland sites than tile effluent is likely a result of the wetland water grab samples containing more detritus and microorganisms that bind phosphorus.

Orthophosphate (OP) is the form of phosphorus that is most readily utilized by biota and is also the main constituent in fertilizers used for agriculture. The ratio of OP:TP concentrations were typically > 1 at Tile Outfalls and < 1 at wetland sites (Figure 12). It is counterintuitive that OP concentrations could be greater than TP concentrations in paired samples taken at nearly the same time. Ratios of OP:TP > 1 only occurred when OP concentrations were less than 200 µg/L and may be a result of positive interference among anions at low concentrations. However the average percent recovery in QA/QC samples for both OP and TP methods in 2012 was 102%.

Lower OP:TP ratios at wetland sites are expected as these sites have biota that readily take up orthophosphate, which is evident in our measures of chlorophyll-a. Conversely, tile discharges likely lack biological uptake. Thus, most of the phosphorus detected in tile effluent is reactive dissolved phosphorus and is available for bacterial and plant growth when discharged to WPA sites, whereas much of the phosphorus detected in water grab samples from wetland sites was likely bound phosphorus that was already assimilated by biota or absorbed to particulates.

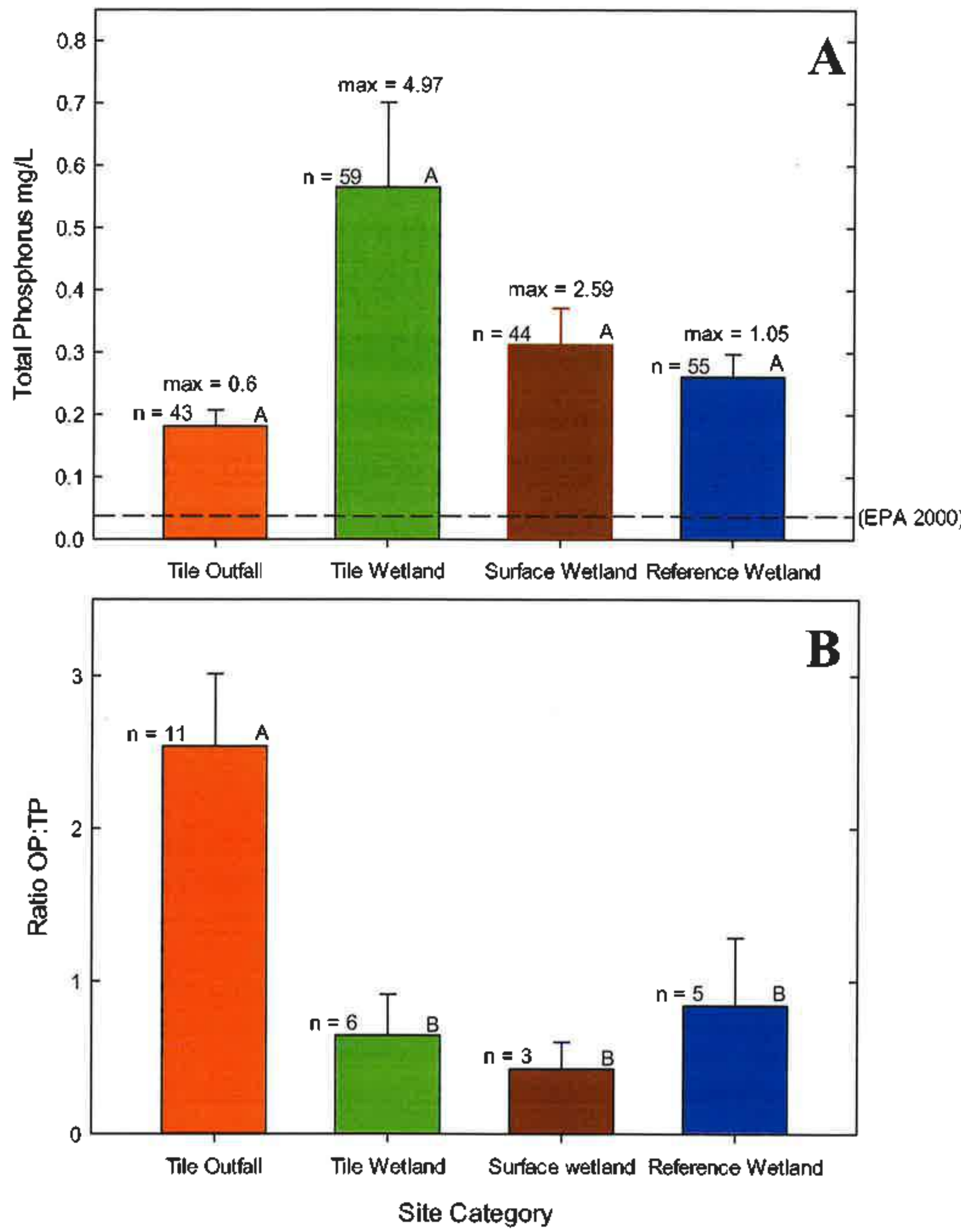

Figure 12. Mean concentrations of total phosphorus (A) and mean ratio of dissolved orthophosphate to total phosphorus (B) in water grab samples from Tile Outfalls and wetland sites within the Madison Wetland Management District, South Dakota, 2012.
Note: TP = total phosphorus; OP = orthophosphate as phosphorus; *n* = sample size; max = maximum concentration detected; letters above each bar indicate significant differences ($p < 0.05$) as determined by a Kruskal-Wallis test followed by pairwise Wilcoxon rank sums tests.

Total dissolved solids (TDS) is the sum of all common ions in freshwater and TDS toxicity is dependent on the ionic composition (Soucek *et al.* 2010). Aquatic life water quality standards for TDS were exceeded on two occasions (Appendix Table A.18). The South Dakota acute TDS criterion of 4,375 mg/L was exceeded at a Tile Outfall and the chronic standard of 2,500 mg/L was exceeded at a Tile Wetland. Concentrations of chlorides did not exceed the acute or chronic aquatic life standards of 860 and 230 mg/L, respectively. Aquatic life standards for warmwater species have not been developed for sulfates or fluorides. Sulfate concentrations exceeded South Dakota's acute and chronic drinking water criteria of 1,000 mg/L and 1,750 mg/L in 13 and 20 water samples, respectively (Appendix Table A.18). Concentrations of fluoride did not exceed a 4 mg/L South Dakota drinking water criterion with the highest detected concentration of 1.8 mg/L from a Tile Outfall (Appendix Table A.12).

Ammonia nitrogen was below the RL (0.05 mg/L) in 28 of 34 samples measured by the EPA Region 8 Laboratory (Appendix Table A.11). This high number of non-detects is not too surprising as applied ammonia is typically converted to nitrate in the soil before it enters into subsurface tile (Patni *et al.*1996 as cited by Blann *et al.* 2009). The six samples that were above detection limits for ammonia included a single detection from a Tile Outfall of 0.127 mg/L. South Dakota water quality standards for total ammonia are equation based and related to water temperature and pH. Water temperature and pH were not measured when ammonia samples were collected in 2012. However, our number of non-detects and the single low concentration detected from a Tile Outfall does not indicate that Tile Outfalls are typically an important exposure pathway for ammonia transport to Tile Wetlands.

Elemental Contaminants

Water. Elements detected in tile effluent that occasionally exceeded water quality benchmarks included aluminum, barium, calcium, iron, magnesium, and selenium (Table 8; Appendix Table A.18). These elemental contaminants that exceeded water quality benchmarks are further discussed below with the contaminant of most concern, selenium, discussed last. Total mercury was below detection (< 0.005 µg/L) in all 30 water samples tested by ESI.

The national acute aquatic life criterion for aluminum (750 µg/L) was exceeded in five samples including two Tile Outfalls, two Tile Wetlands, and one Surface Wetland (Appendix Table A.18). The chronic water quality criterion for aluminum (87 µg/L) was exceeded on 23 occasions. Newly proposed aluminum national water quality criteria, that are less stringent (i.e., 1,400 µg/L for acute and 390 µg/L for chronic), were exceeded less frequently (EPA 2017; Appendix Table A.18). Although concentrations of detected aluminum where highest at Tile Outfall and Tile Wetland sites, most samples from Tile Outfalls had aluminum concentrations below the analytical RL (Table 8). Similar results were reported for tile effluent in North Dakota where nine of 248 samples exceeded 750 µg/L and concentrations ranged from non-detectable to 4,740 µg/L (Johnson 2010). Aluminum toxicity and bioavailability to aquatic biota is largely dependent on its solubility and generally increases as pH decreases (Gensemer and Playle 1999). Aluminum bioavailability and toxicity to aquatic species at wetland sites are not likely a concern based on the relatively high pH measured at these sites. For this study, we also measured total recoverable aluminum, which includes bound aluminum, whereas the standard is for dissolved aluminum in filtered water samples. However, tile effluent high in aluminum may result in impairment of aquatic life in streams that receive the discharge directly (Johnson 2010).

Table 8. Summary statistics for concentrations of elemental contaminants in water grab samples from Tile Outfalls within the Madison Wetland Management District, South Dakota, 2012 and 2015.

		Tile Outfall			
			Concentration (ug/L)		Published Benchmark or Threshold (ug/L)
Trace Element	RL (ug/L)	N_D/N_A	Mean ± S.E.	Range	
Aluminum	100	10 / 57	446 ± 142	< 100 – 1,570	87 [1], 750 [2]
Arsenic	1	26 / 57	3.8 ± 0.3	< 1 – 8.2	150 [1], 340 [2]
Barium	4	57 / 57	57 ± 3	18 – 119	110 [3]
Boron	100	21 / 57	199 ± 35	< 100 – 638	13,000 [4]
Calcium	100	57 / 57	184,919 ± 10,526	87,500 – 396,000	116,000 [5]
Iron	100	16 / 57	435 ± 110	< 100 – 1,810	1,000 [1]
Lead	0.5	5 / 57	0.9 ± 0.2	< 0.5 – 1.5	2.5 [1], 65 [2]
Magnesium	100	57 / 57	94,965 ± 8,435	36,200 – 310,000	82,000 [5]
Manganese*	2	42 / 57	116 ± 45	< 2 – 1,860	2,300 [3]
Molybdenum*	5	30 / 57	9 ± 1	< 5 – 23	120 [4]
Nickel	1	20 / 57	10 ± 1	< 1 – 21	52 [1], 470 [2]
Phosphorus*	0.01	12 / 18	49 ± 18	< 10 – 326	37.5 [6]
Potassium	1000	18 / 18	3,323 ± 562	1750 – 10,600	53,000 [5]
Selenium*	1	54 / 57	16 ± 4	< 1 – 144	1.5 [1]
SDAL Selenium	0.1	70 / 70	13 ± 3	0.2 – 109	1.5 [1]
Sodium	500	57 / 57	50,585 ± 13,768	5,850 – 523,000	680,000 [5]
Strontium	2	57 / 57	791 ± 75	243 – 2,790	15,000 [3]
Thallium	0.5	6 / 39	0.7 ± 0.2	< 0.5 – 1.9	110 [3]
Vanadium	10	4 / 18	16 ± 3	< 10 – 25	280 [3]

Note: RL = minimum Reporting Limit, N_D = number of samples above detection, N_A = number of samples analyzed, S.E. = standard error, * = half the RL was used to calculate the mean and S.E., otherwise only detects were used. 1 = national freshwater chronic aquatic life criterion, 2 = national freshwater acute aquatic life criterion, 3 = tier II secondary acute value (Suter and Tsao 1996), 4 = toxicity threshold (USDOI 1998), 5 = lowest chronic value (Suter and Tsao 1996), 6 = national ambient water quality criteria recommendation (EPA 2000).

Concentrations of iron also exceeded the national chronic freshwater aquatic life criterion in five samples. Similar to aluminum, the majority of tile effluent samples had non-detectable concentrations of iron and iron toxicity to aquatic life depends on bioavailability. Bivalent and trivalent irons are the primary forms of concern in aquatic environments whereas natural organometallic or humic iron compounds have little effect on aquatic life (EPA 1986). However, excess iron can reduce wetland plant growth by forming iron plaques on the roots (Van der Welle *et al.* 2007; Saaltink *et al*. 2017). In the current study, Tile Outfalls and Tile Wetland water and sediment (see section below) had higher concentrations of iron than Reference Wetlands. Thus, iron toxicity to wetland plants from tile effluent may be a concern at select sites.

Phosphorus was frequently detected by analytical sampling of tile effluent and wetland sites (Table 8; Appendix Table A.19). Although phosphorus is usually not directly toxic to aquatic life, in excess it can lead to eutrophication and wetland degradation. Of the 35 water samples measured for phosphorus, 21 samples were above EPA's 37.5 μg/L benchmark for the Corn Belt and Northern Great Plains. Exceedances included samples from Tile Outfalls (*n*=7), Reference Wetlands (*n*=4), Surface Wetlands (*n*=4) and Tile Wetlands (*n*=7; Appendix Table A.18).

Barium was detected in all samples and was, on average, below the 110 μg/L acute water quality screening benchmark at all sites (Table 8; Appendix Table A.19). Exceedances occurred in six samples total that included each site category (Appendix Table A.18). This benchmark is based on the secondary acute values used by EPA when data was insufficient to calculate a water quality criterion and may be considered conservative (Suter and Tsao 1996). Based on the background concentrations from Reference Wetland sites and the overall infrequent exceedances, barium toxicity at WPA sites is not a concern.

Calcium and magnesium were also detected in all 57 Tile Outfall samples tested and on average were above water quality benchmarks. Calcium and magnesium are not considered highly toxic, but nonetheless, chronic water quality benchmarks for both elements have been derived from toxicity testing with daphnids (Suter and Tsao 1996). Average concentrations of calcium exceeded the 116,000 μg/L benchmark at Tile Wetlands and Surface Wetlands but not Reference Wetlands (Appendix Table A.19). Magnesium concentrations exceeded the 82,000 μg/L on average at all wetland sites but was significantly lower in Tile Outfalls than Surface Wetlands or Tile Wetlands. Tile effluent is a source for these elements to ender surface waters and but given that there were no significant differences in calcium or magnesium among wetland sites, other sources may be more important and wetlands in the study area may have naturally high concentrations of these elements.

Manganese and potassium did not exceed their benchmarks in Tile Outfalls but exceedances were detected at wetland sites (Table 8; Appendix Table A.18). A water grab sample (and its duplicate) collected at Petri II WPA in September 2012 exceeded a 2,300 µg/L secondary acute benchmark for manganese (Suter and Tsao 1996). Manganese pollution at our wetland sites is not a concern given the exceedances were rare, with 57 samples tested in total and most with concentrations well below the benchmark. Conversely, potassium pollution is a concern despite having only one exceedance detected. The 53,000 µg/L chronic benchmark for potassium was exceeded at Voelker II WPA in a sample with 81,300 µg/L potassium (Appendix Table A.18). This site has tile that drains areas adjacent to a cattle feedlot with effluent going to a road ditch and into a private wetland before entering the WPA. Potassium is a major ion in animal feedlot manure runoff (USGS 1998; Gilley *et al.* 2010). The EPA only tested 35 samples total for potassium in 2012 and Voelker II WPA was only sampled for potassium on one occasion. More sampling of this site for potassium may find more exceedances given that tile drainage of agricultural land that receives manure applications is an important exposure pathway.

Selenium in agricultural tile effluent has a history of causing harm to fish and wildlife in receiving habitats (Seiler *et al.* 2003). South Dakota's alkaline soils can favor the formation of calcium and sodium selenates, which are very water soluble and bioavailable forms of selenium (Irwin *et al.*1997). Thus, our assessment of selenium included additional sampling for testing by SDAL to build a more robust data set that consists of conventional ICP-MS analytical results (EPA and ESI labs) and fluorometric results by SDAL. Sensitivity of selenium detection and reporting differed among the labs with the EPA Region 8 Laboratory using a RL of 1 µg/L, ESI using a DL of 0.01 µg/L, and SDAL using a DL of 0.1 µg/L and a LOQ of 0.4 µg/L. Selenium results are described below for the ICP-MS results (ESI and EPA Region 8 Lab, n=86), the more robust fluorometric results (n=319), and for all the results combined (n=405).

Selenium was detected in 95% of Tile Outfall samples tested by ICP-MS (n=57; Table 8). Selenium in Tile Outfalls averaged 16 ± 4 µg/L, with the highest concentration of 144 µg/L detected from the Habe1 Tile Outfall on 8 July 2015.

Selenium was detected in all 70 Tile Outfall samples tested by SDAL with only one sample (Mund1T, sampled 29 July 2014) below the LOQ. Concentrations of selenium in Tile Outfalls averaged 12.8 ± 2.6 µg/L with a maximum of 109 µg/L at Habe1 on 25 August 2014. Conversely, at Reference Wetland sites, selenium concentrations were above the LOQ (0.4 µg/L) in only 17% of samples tested with a maximum of 1.3 µg/L at Schaf1 on 29 July 2014. The national average background concentration of waterborne selenium in freshwater systems is 0.1–0.4 µg/L, whereas published "safe" concentrations range from 0.5–5 µg/L (Maier and Knight 1994). For the combined selenium results in water (n=405), concentrations of selenium in Tile Outfalls averaged 14 ± 2 µg/L, a concentration almost three-fold greater than South Dakota's current chronic aquatic life criterion of 5 µg/L and almost ten-fold greater than the current national chronic criterion of 1.5 µg/L (Figure 13). Reference Wetland sites also had a significantly lower selenium concentration when compared to Tile Wetland or Surface Wetland sites. Tile Wetlands had significantly greater average concentration of selenium (2.4 ± 0.3 µg/L) than other wetland sites and were the only wetland site category with an average selenium concentration above the 1.5 µg/L national aquatic life criterion (Figure 13). Overall, selenium in Tile Outfalls, Tile Wetlands, and Surface Wetlands exceeded the 1.5 µg/L chronic aquatic life criterion on 101, 37, and 4 occasions, respectively. There were no exceedances of the criterion at Reference Wetlands (Appendix Table A.16).

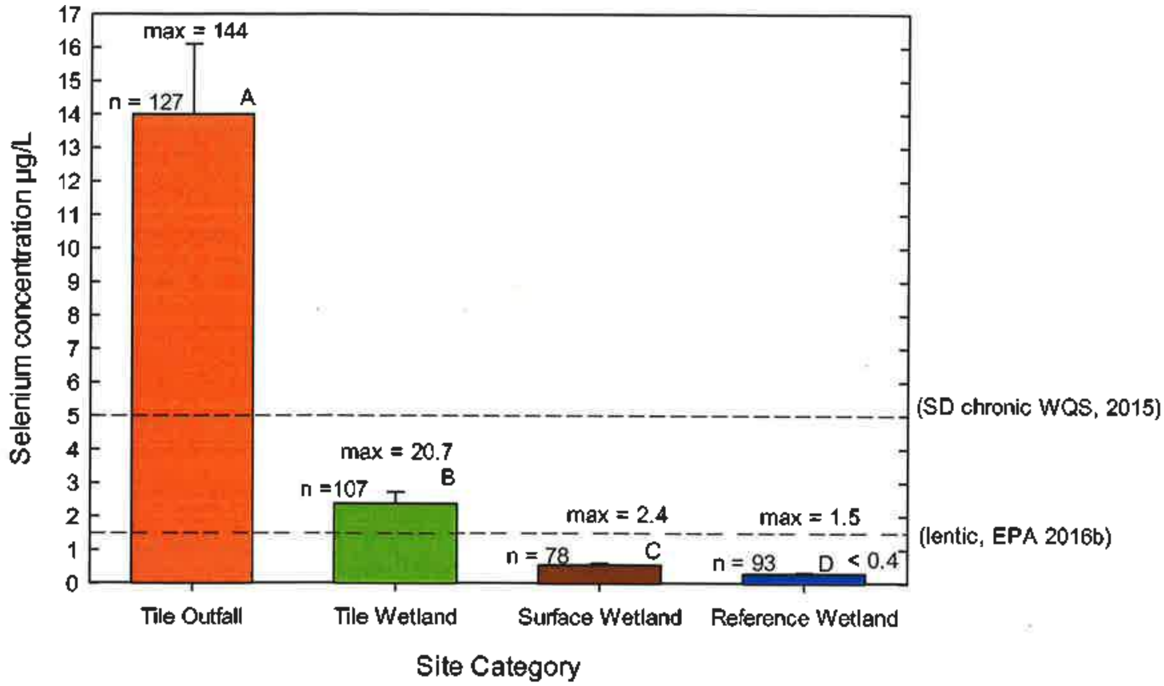

Figure 13. Mean concentrations of selenium in water samples from Tile Outfalls and wetland sites within the Madison Wetland Management District, South Dakota, 2012–2015. Note: *n* = sample size; max = the maximum concentration detected; letters above each bar indicate significant differences ($p < 0.05$) as determined by a Kruskal-Wallis test followed by pairwise Wilcoxon rank sums tests. Reference lines are for a 5 µg/L South Dakota chronic water quality criterion for protection of aquatic life (SDDENR 2016) and a 1.5 µg/L national chronic water quality criterion for protection of aquatic life (EPA 2016b). Most samples from Reference Wetlands had selenium concentrations less than the 0.4 µg/L LOQ.

Sediment. Sediments from Tile Wetland sites had significantly greater concentrations of antimony, arsenic, cobalt, iron, sodium, tin, and zinc than sediments from Reference Wetland sites (Appendix Table A.20). All wetland site categories had average concentrations of antimony, manganese, nickel, selenium, strontium, and zinc in sediments that were above national background concentrations (Shakette and Boerngen 1984; Buchman 2008; Appendix Table A.20). Tile Wetlands, Surface Wetlands, and Reference Wetlands all had sediments with selenium concentrations within 1–4 milligrams per kilogram (mg/kg), a level of concern range (USDOI 1998). However, average concentrations of selenium did not exceed an ecological sediment guideline of 2 mg/kg dw (Lemly 2002 as cited by Seiler *et al.* 2003; Appendix Table A.20). These thresholds for selenium should be viewed with caution as our sediment sampling methods were different than wetland assessments reported elsewhere. For example, the National Irrigation Water Quality Program (Seiler *et al.* 2003) mixed several samples at each site and sieved samples in the laboratory prior to analysis. Strontium was the only element significantly greater on Reference Wetland sites than Surface Wetland or Tile Wetland sites. The higher strontium concentrations may be natural as strontium and calcium may be influenced by deposition of calcium carbonate as a consequence of evaporation or photosynthesis (Yohn *et al.* 2003).

Sediment chemistry results from Ward Laboratories were highly variable among sites. For example, concentrations of sodium in sediments were highest at Tile Wetland sites Volk1 and Bols1 but also the lowest at Nels1 (Appendix Table A.15). There were no significant differences in Ward sediment chemistry among wetland sites when results were first averaged for each site. However, significant differences were detected when samples from Reference Wetlands were compared to the combined Surface and Tile Wetlands as "non-buffered wetlands." Reference Wetlands had lower concentrations of calcium and sodium (Figure 14).

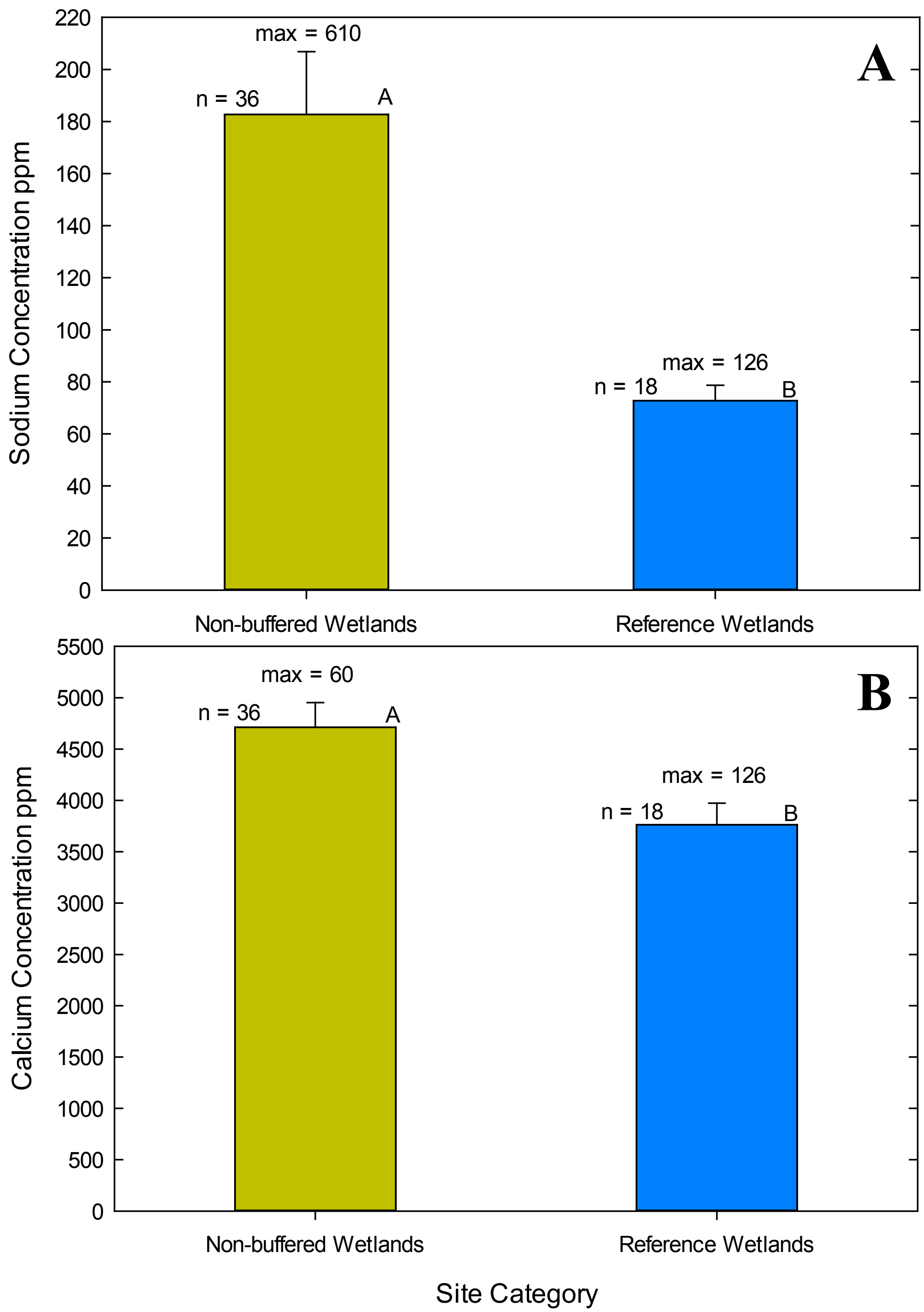

Figure 14. Mean concentrations of sodium (A) and calcium (B) in sediment samples from wetland sites within the Madison Wetland Management District, South Dakota, 2013.
Note: *n* = sample size; max = the maximum concentration detected; letters above each bar indicate significant differences ($p < 0.05$) as determined by a Tukey-HSD test.

Vegetation. Waterfowl plant food items sampled for elemental contaminants included common duckweed (*Lemna minor*), pondweed (*Potmogeton* spp.), and filamentous algae (species unknown). A total of 24 composite samples of aquatic vegetation were compared across Tile Wetland (*n*=10), Surface Wetland (*n*=7) and Reference Wetland (*n*=7) sites. Vegetation samples from Reference Wetland sites had concentrations of selenium below detection in six of seven samples with a single detection of 0.32 mg/kg dw selenium at Buff1. Reference Wetlands had significantly lower concentrations of selenium in vegetation than Tile Wetlands or Surface Wetlands. A sample of common duckweed from a Tile Wetland (Volk1) exceeded a dietary benchmark of 3 mg/kg (Lemly 1996; Seiler *et al.* 2003) in (Figure 15; Appendix Table A.21). Concentrations of selenium in filamentous algae sample from a Tile Wetland (Gerk1) also exceeded a 0.1–2.0 mg/kg dw background range for freshwater macrophytes (USDOI 1998); whereas all vegetation samples from Reference Wetlands and Surface Wetlands were within the background range for selenium.

Aquatic Invertebrates. A total of 20 snail and 19 mixed aquatic invertebrate samples were collected from Tile Wetland (*n*=8 and 7, respectively), Surface Wetland (*n*=6 each), and Reference Wetland (*n*=6 each) sites. Concentrations of selenium were above detection limits in all aquatic invertebrates samples tested and were significantly greater in snail samples from Tile Wetlands and Surface Wetlands than Reference Wetlands. Mixed invertebrate and snail samples exceeded a 3–8 mg/kg dw dietary benchmark for reproductive impairment in birds (USDOI 1998) only at Tile Wetland sites (Figure 15). These exceedances included four composite snail samples and one mixed aquatic invertebrate sample (Appendix Table A.21). These results indicate that aquatic invertebrate food items for waterfowl at Tile Wetland sites contain potentially harmful concentrations of selenium and may result in decreased reproductive success in waterbirds that are sensitive to selenium, including mallard ducks.

Duck Eggs. A total of 25 mallard duck eggs from seven nests were collected in 2015 from uplands adjacent to two WPAs (Wenk and Gerdink) that receive agricultural tile discharges (Appendix Table A.21). Sixteen of 25 eggs were unfertile, eight were fertile, and one was undetermined. There was no significant difference in selenium concentrations between fertile and unfertile eggs. Mean concentrations of selenium in the five eggs collected from two nests at Gerdink WPA (1.9 ± 0.4 mg/kg dw) were significantly lower than in the 20 eggs collected from Wenk WPA (3.9 ± 0.3 mg/kg dw). One egg from Wenk WPA had a selenium concentration of 8.83 mg/kg dw and was above a 6 mg/kg dw threshold concentration for increased risk of egg inviability (Figure 15; Seiler *et al.* 2003).

Based on the logistic regression relationship between egg viability (hatchability) and egg selenium concentration for mallards reported by Ohlendorf (2003), the high value of 8.83 mg/kg Se dw that we detected in our small sample of eggs would be associated with an expected reproductive impairment of 3.7% with a 95% confidence interval of 0–17% (Skorupa, personal communication 2018). Furthermore, although we sampled 25 eggs, those came from just seven mallard hens (nests), which is our true sample size for statistical independence. One of those seven hens produced an egg containing enough selenium to pose a risk of reproductive impairment, for an estimate of 14.3% “affected hens” and a binomial 95% confidence interval of 0.5–53.4% affected hens (Skorupa, personal communication 2018).

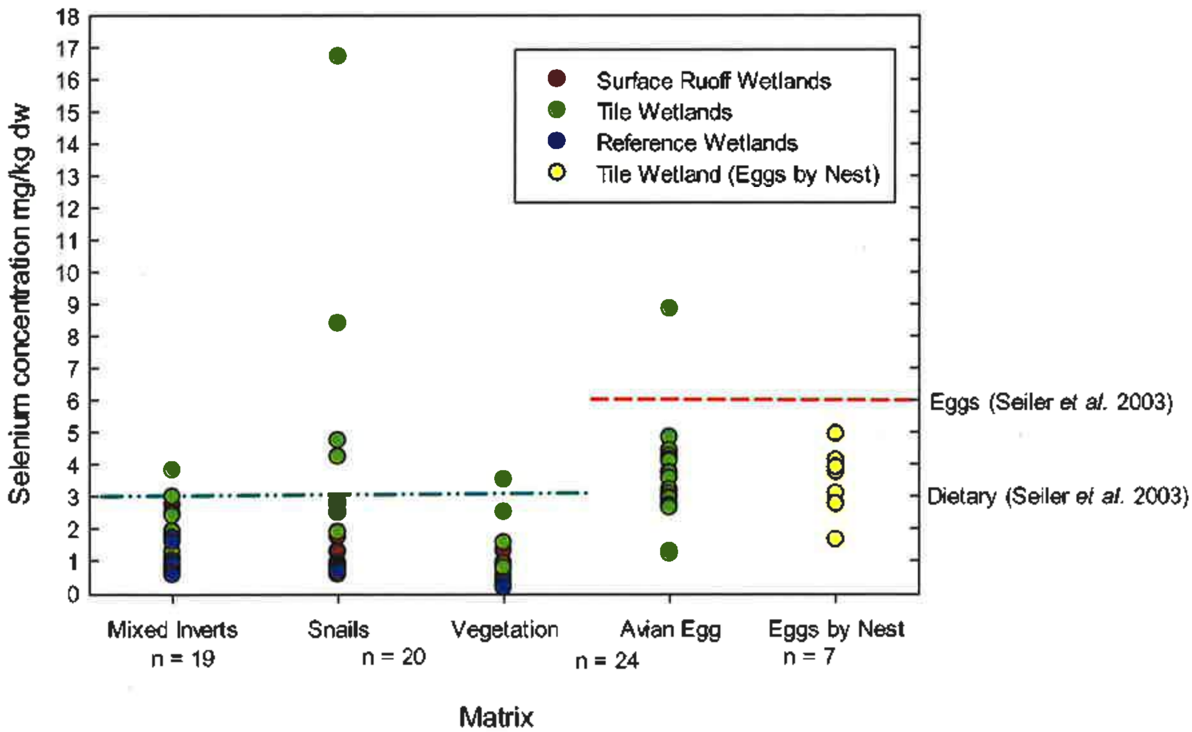

Figure 15. Dry weight concentrations of selenium in biological samples from Waterfowl Production Area wetland sites, Madison Wetland Management District, South Dakota, 2012–2015. Note: *n* = sample size; horizontal reference lines for dry weight are for a dietary 3.0 mg/kg effects threshold for aquatic food-chain organisms consumed by fish and wildlife and a 6.0 mg/kg threshold concentration for increased risk of egg inviability (Seiler *et al.* 2003).

Biological Assessments

Below are limited interpretations of WRAP scores, amphibian surveys, and aquatic invertebrates with more detailed assessment available in a doctoral dissertation (Davis 2018, Chapters 2 and 3). Other related work not presented herein include a field study examining stress hormones and ranavirus in larval Western Tiger Salamanders from agricultural wetlands (Davis 2018, Chapter 4) and the effects of imidacloprid, selenium, and ranavirus on larval Boreal Chorus Frogs (Davis 2018, Chapter 5).

Wetland Rapid Assessment Protocol

Average wetland site WRAP scores by site ranged from 73.6 ± 1.2 at Pett1 (Reference Wetland) to 52.6 ± 1.1 at Nels1 (Tile Wetland). Reference Wetlands (n=6) had the highest mean WRAP score whereas the four lowest scores were from Tile Wetlands (Appendix Table A.22). The highest WRAP score of 79 was at Coteau Prairie WPA in July 2014. Comparatively, South Dakota WRAP scores determined for 50 wetlands in 2006 and 2007 ranged from 45 to 95 (Bouchard *et al.* 2008).

Wetland WRAP scores were significantly different among wetland sites ($p < 0.0001$) and month ($p = 0.0005$), but not year ($p = 0.08$). None of the interactive terms between any of the factors (e.g., site category*month) were significant. Reference Wetlands had the highest wetland habitat WRAP scores whereas WRAP scores for Tile Wetlands were significantly lower than Reference Wetlands ($p < 0.0001$) and Surface Wetlands ($p = 0.0022$), and WRAP scores for Surface Wetlands were significantly lower than Reference Wetlands ($p < 0.0001$; Figure 16). Wetland WRAP scores in May were significantly lower than those in June ($p = 0.0260$) and July ($p = 0.0004$); however, there was no difference in WRAP scores from June to July ($p = 0.362$; Figure 16). When grouped by wetland site category, WRAP scores positively increased across months (May–July) for Reference Wetlands ($p = 0.004$) and Surface Wetlands ($p = 0.007$), but not Tile Wetlands ($p = 0.088$; Figure 17).

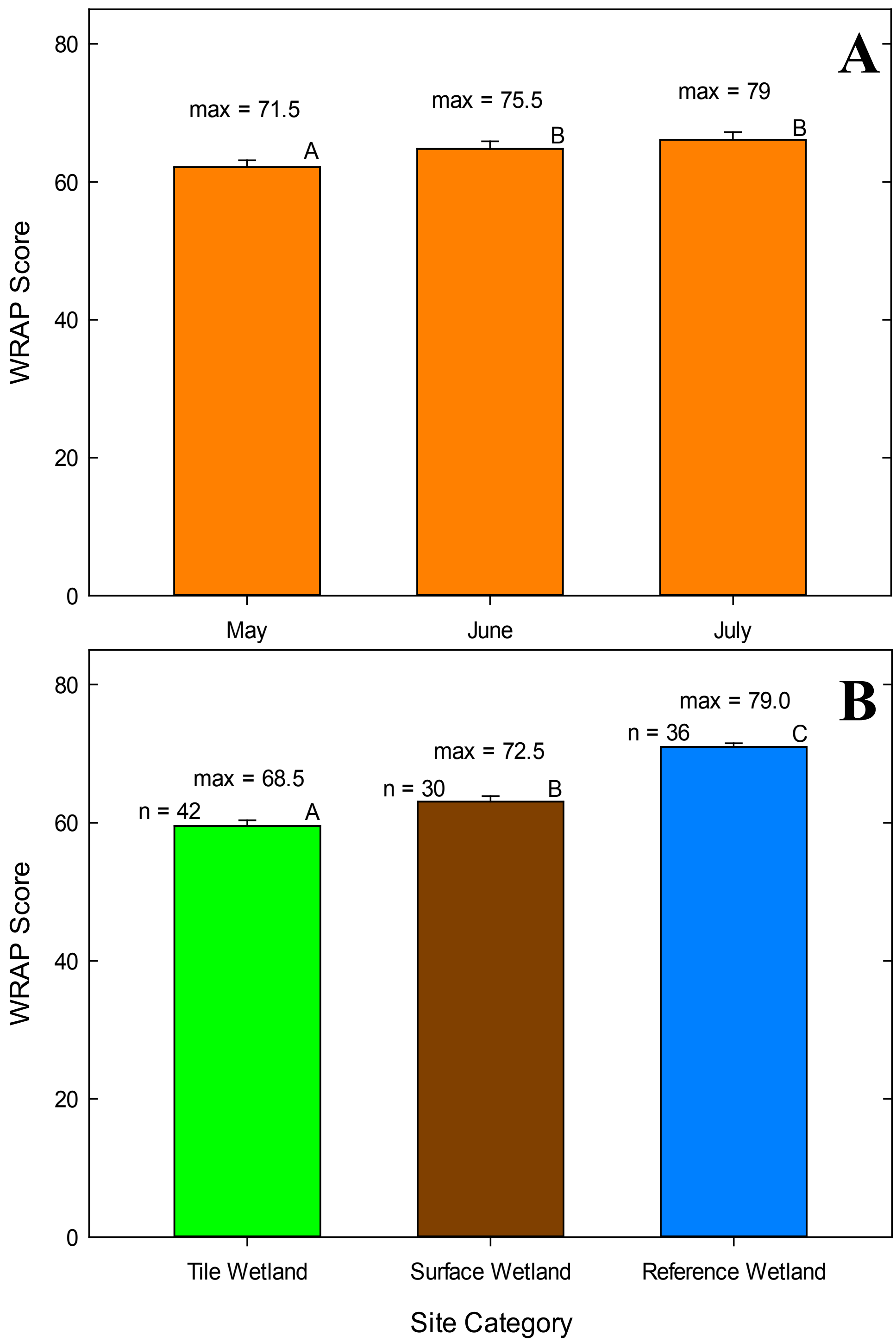

Figure 16. Mean South Dakota Wetland Rapid Assessment Protocol (WRAP) score for months (A) and wetland sites (B) within the Madison Wetland Management District, South Dakota, 2013–2014. Note: *n* = sample size; max = the maximum WRAP score reported; letters above each bar indicate significant differences ($p < 0.05$) as determined by Tukey's HSD tests.

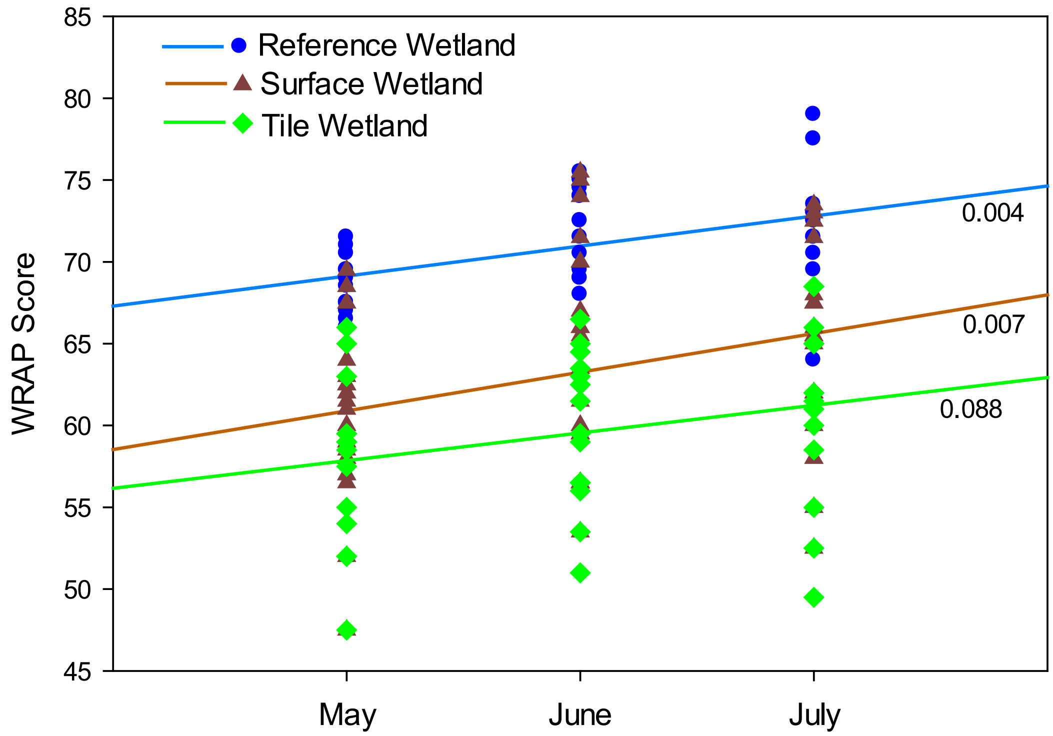

Figure 17. Bivariate fit of South Dakota Wetland Rapid Assessment Protocol (WRAP) scores by month for wetland sites within the Madison Wetland Management District, South Dakota, 2013–2014. Note: level of significance within a site across months, as determined by analysis of variance, is presented below each regression line.

Amphibian Surveys

Four amphibian species were documented by surveys including the American Toad (*Anaxyrus americanus*), Boreal Chorus Frog (*Pseudacris maculata*), Northern Leopard Frog (*Rana pipiens*), and Western Tiger Salamander (*Ambystoma mavortium*). These species were found at every wetland site category. Occurrence records for amphibians totaled 635 by visual encounter surveys and 692 by survey plots and were greater in 2013 (n=1,102) than 2014 (n=225; Table 9). Northern Leopard Frogs were the most abundant amphibian detected in both 2013 and 2014, followed by Boreal Chorus Frogs and American Toads. The presence of these three species of calling anurans was verified by the use of call-recording boxes placed in sampled wetlands. Environmental conditions such as high wind precluded the quantitative use of these data but allowed us to confirm that these were the only three species of anurans using wetland sites as breeding habitat.

Despite the size of both larval and adult Western Tiger Salamanders, this species had the fewest number of detections. Detection of adult salamanders was rare and no reproduction was directly observed (e.g., pairs in amplexus, recently laid eggs), though evidence of reproduction occurring was verified by the presence of larval salamanders. When in wetlands, adult Western Tiger Salamanders often rest at the bottom of wetlands unless going to or from the surface of the water to respire. This behavior likely makes detection of individuals difficult compared to adult anurans that were often at the water's surface or edge while calling or in amplexus. Further, densities of larval salamanders are expected to be much lower than that from larval anurans, which often form schools or forage in groups, facilitating detection.

Northern Leopard Frogs, American Toads, and Boreal Chorus Frogs were found at every site surveyed except for two Tile Wetlands (Mundahl and Nelson), which had no occurrence records for Northern Leopard Frogs (Table 9). Western Tiger Salamanders were documented at ten WPA sites that included all six Reference Wetlands, three Tile Wetlands, and one Surface Wetland (Appendix Table A.23).

Amphibian diversity from visual encounter surveys was significantly greater in 2013 than 2014 ($p = 0.0001$), but did not significantly differ among wetland sites ($p = 0.84$). Whereas, larval amphibian diversity from plot surveys did not significantly differ among site categories ($p = 0.48$) or between years ($p = 0.24$). Greater precipitation in 2014 may have made it more difficult to detect amphibians during surveys given that an increase in their habitat that would allow them to disperse more.

A total of 290 vouchered specimens were collected at WPAs in 2013 and 2014 (Appendix Table A.23). These voucher specimens represent verifiable records for these species, many of which were distributional records, helping to fill in gaps in the known range of these species (Davis 2018). In addition to amphibians, nine vouchers of three species of reptiles were also collected including the Snapping Turtle (*Chelydra serpentina*), Painted Turtle (*Chrysemys picta*), and Plains Gartersnake (*Thamnophis radix*). These three species of reptiles likely exist at most of these wetland sites, but our survey methods were not designed around their detection.

Table 9. Occurrence records for amphibian species at wetland sites within the Madison Wetland Management District, South Dakota, 2013–2014.

		Occurrence by Visual Encounter Surveys by Year								Occurrence by Survey Plots by Year							
		2013				2014				2013				2014			
Site Name	Site Category	AT	BCF	NLF	WTS	AT	BCF	NLF	WTS	AT	BCF	NLF	WTS	AT	BCF	NLF	WTS
Ache1A	Tile Wetland	12	4	52	–	–	4	–	–	–	110	15	–	–	–	2	–
Bufo1	Reference Wetland	3	3	3	–	2	–	2	1	–	8	15	5	–	–	–	–
Cote1	Reference Wetland	4	1	2	1	–	1	–	–	5	–	9	–	–	–	–	–
Bols1A	Tile Wetland	7	10	3	–	–	–	–	–	–	–	–	–	–	–	–	–
Gerk1A	Tile Wetland	3	10	6	–	–	–	–	–	–	–	–	–	1	–	–	–
John1	Surface Wetland	5	9	1	–	–	–	–	–	82	–	–	–	–	–	–	–
Hejo1A	Tile Wetland	2	10	6	–	–	–	–	–	–	–	–	–	–	–	–	–
Lost1	Reference Wetland	2	–	20	–	1	1	17	–	18	15	–	6	–	1	14	–
Mund1	Tile Wetland	3	8	–	3	–	–	–	–	–	–	–	–	–	–	–	–
Nels1A	Tile Wetland	–	8	–	–	–	–	–	–	127	16	–	–	–	–	–	–
2Petr1A	Surface Wetland	2	5	116	3	6	17	43	1	13	28	14	1	–	5	25	–
Pett1	Reference Wetland	5	19	69	2	–	–	–	–	–	–	18	–	–	–	14	1
Pitt1	Reference Wetland	4	9	–	–	–	–	1	–	–	–	–	–	–	–	1	–
Rams1	Surface Wetland	5	20	12	–	–	–	–	–	–	–	3	–	29	–	–	–
Schae1	Surface Wetland	18	1	2	–	16	–	1	–	–	–	2	–	3	–	–	–
Schaf1	Reference Wetland	1	4	2	–	–	–	–	–	75	–	–	–	–	–	–	–
Volk1	Tile Wetland	–	7	2	–	1	8	1	–	1	5	–	–	–	–	–	–
Zieg1	Surface Wetland	1	1	–	–	–	–	–	–	–	–	–	–	1	2	2	–

Note: AT = American Toad (*Anaxyrus americanus*), BCF = Boreal Chorus Frog (*Pseudacris maculata*), NLF = Northern Leopard Frog (*Rana pipiens*), WTS = Western Tiger Salamander (*Ambystoma mavortium*).

Wetland Aquatic Invertebrates

In total, 209,322 aquatic invertebrates were collected from the 18 full assessment wetland sites in 2013 and 2014, representing 59 different taxonomic groups (Appendix Table A.24). Backward elimination stepwise model selection resulted in the best-fit model that included site category, habitat, month, and year, as well as the interactions between site category and month, site category and year, and habitat and year. These factors were then included in a model to determine their significance and to identify where differences occurred. Aquatic invertebrate diversity was significantly different among site categories ($p = 0.003$), with diversity at Tile Wetlands being significantly lower than diversity at both Reference Wetlands ($p = 0.030$) and Surface Wetlands ($p = 0.003$), with no difference between Reference Wetlands and Surface Wetlands ($p = 0.74$; Figure 18). We also found a significant difference in aquatic invertebrate diversity across habitat types ($p < 0.0001$), with diversity in substrate samples being significantly lower than diversity in both emergent and submergent vegetation samples (both $p < 0.0001$), and no difference in diversity between emergent vegetation and submergent vegetation samples ($p = 0.99$; Figure 18). Aquatic invertebrate diversity also significantly differed across sampled months ($p < 0.0001$; Figure 18). Aquatic invertebrate diversity increased from May to June ($p < 0.0001$) and June to July ($p < 0.0001$; Figure 18). The interaction between site category and month was significant ($p < 0.0001$; Figure 18). Diversity across site categories by month revealed no differences among site categories in May ($p = 0.11$) and June (0.49; $p = 0.61$); however, in July there were significant differences in diversity ($p < 0.0001$), with Tile Wetlands having significantly lower diversity than both Reference Wetlands ($p < 0.0001$) and Surface Wetlands ($p < 0.0001$). The remaining two interactions of site category and year ($p = 0.12$) and year and habitat ($p = 0.09$) were non-significant.

When examining aquatic invertebrate abundances, we found significant differences in the class Oligochaeta ($p = 0.046$) and the orders Amphipoda ($p = 0.005$), Coleoptera ($p < 0.001$), Diptera ($p = 0.036$), Ephemeroptera ($p = 0.026$), Odonata ($p = 0.008$), Prosobranchia ($p = 0.009$), and Pulmonata ($p < 0.0001$; Table 10). There were no differences in abundance in all other taxa across site treatments. Reference Wetlands had significantly higher abundances of Ephemeroptera, Odonata, and Pulmonata compared to Tile Wetlands (Table 10). Conversely, Tile Wetlands had a greater abundance of Oligochaeta and Diptera than Reference Wetlands (Table 10). Surface Wetlands had greater abundance of Amphipoda, Coleoptera, and Prosobranchia than both Reference Wetlands and Tile Wetlands (Table 10).

Table 10. Mean aquatic invertebrate abundance by taxa at wetland sites within the Madison Wetland Management District, South Dakota, 2013–2014.

	Abundance as Number of Individuals (Mean ± Standard Error)		
Taxa	Reference Wetland	Surface Wetland	Tile Wetland
Oligochaeta	4.9 ± 1.4	10.2 ± 2.3	13.1 ± 3.5
Amphipoda	20.3 ± 7.3	53.1 ± 9.8	27.2 ± 8.1
Coleoptera	14 ± 1.5	26.4 ± 2.6	28 ± 6.4
Diptera	87.7 ± 18.5	95.5 ± 29.2	167 ± 44
Ephemeroptera	31 ± 6.7	36.2 ± 7	13.7 ± 3
Odonata	36.6 ± 8.6	33.1 ± 6.1	15.5 ± 4.2
Prosobranchia	117.8 ± 25.1	194.6 ± 45.6	175.9 ± 43.7
Pulmonata	358.9 ± 80	340.9 ± 48.3	113.9 ± 16.9

Note: Abundances were calculated from the number of individuals collected across habitats (substrate, submergent vegetation, and emergent vegetation) and site visits.

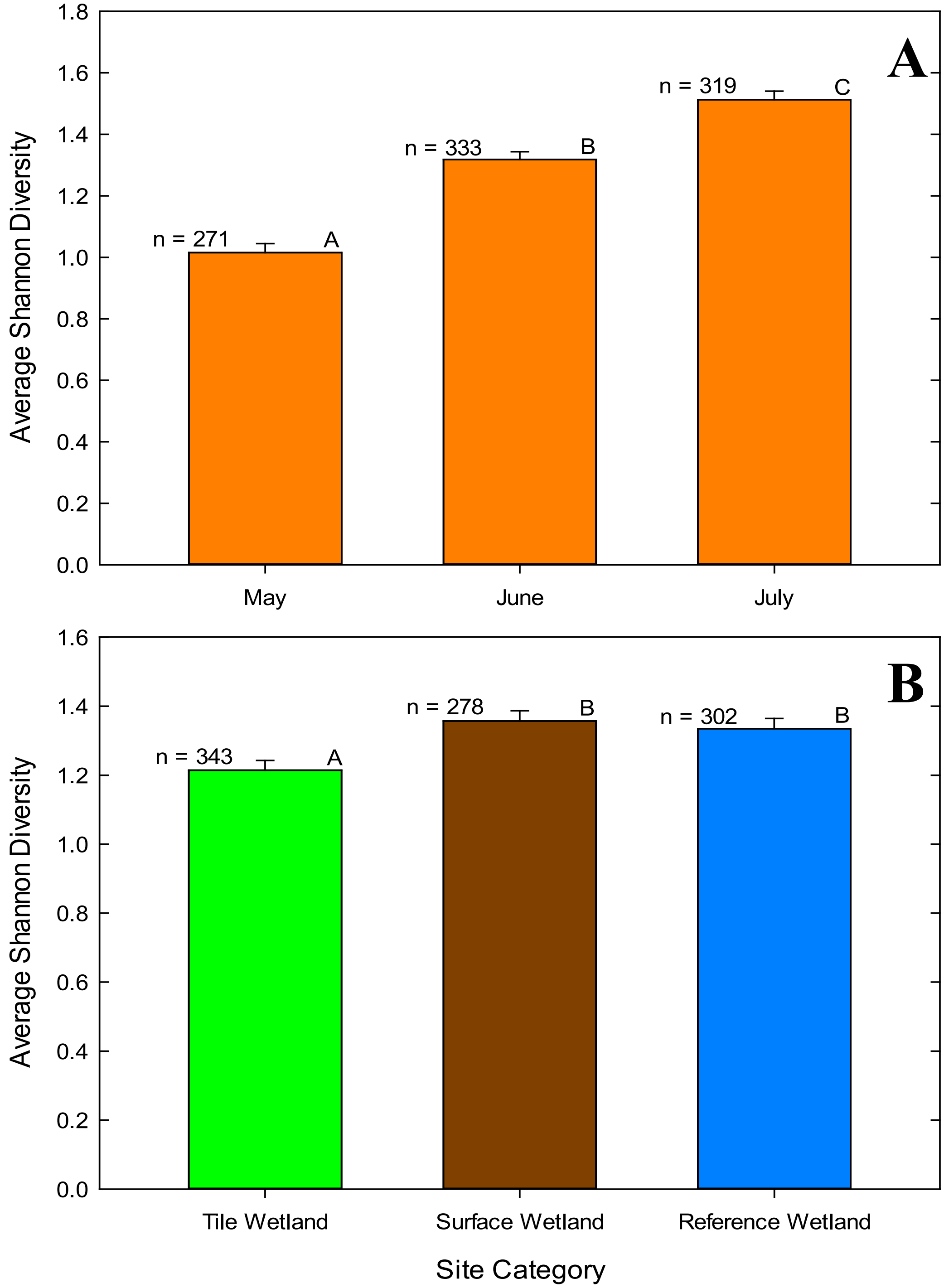

Figure 18. Mean aquatic macroinvertebrate diversity by month (A) and wetland site category (B), Madison Wetland Management District, South Dakota, 2013–2014. Note: *n* = sample size; letters above each bar indicate significant differences ($p < 0.05$) as determined by Tukey's HSD tests.

DISCUSSION

Waterfowl habitat protection is a primary management emphasis for hundreds of WPAs in eastern South Dakota. However, recent expansion of the use of agricultural tile drainage within WPA watersheds has resulted in concerns over wetland habitat loss and degradation. In South Dakota an estimated 21,625 wetland basins were lost between 1997 and 2009 (Dahl 2014). Although it is not clear how many wetlands basins in South Dakota have been lost due to agricultural tile drainage, targeted tiling has occurred and pattern tiling fields around wetlands is also expected to intercept watershed runoff and result in further wetland loss (Oslund *et al.* 2010; Tangen and Finocchiaro 2017). In addition to wetland loss, subsurface agricultural tile drainage discharges groundwater that would otherwise be held in storage or lost through evapotranspiration (Novak *et al.* 2016). Thus, changes in wetland hydrology where semi-permanent wetlands function more like permanent basins, may be expected in wetlands that receive substantial tile drainage (McCauley *et al.* 2015).

Water quality of agricultural tile discharges are also troubling, as pollutants discharged in tile effluent at concentrations of concern can include phosphorus, nitrates, pesticides (e.g., atrazine), estrogens, pathogens, veterinary antibiotics, anions (e.g, sulfate, chlorides), and selenium (Kladivko *et al.* 1999; Burnison *et al.* 2003; Kay *et al*. 2004; Haack and Duris 2008; Blann *et al.* 2009; Johnson 2010; King *et al.* 2015; Andersen *et al.* 2016; Vermont 2017). Previous studies have evaluated agricultural surface runoff into public wetlands managed as WPAs (Ruelle and Henry 1993; Riens *et al.* 2013). However, we are not aware of any studies that have focused on agricultural tile discharges of pollutants directly into WPAs.

Our study objective was to evaluate water quality and wetland habitat degradation at WPA wetland sites that receive pesticides, nutrients and elemental contaminants (e.g., selenium and potassium salts) from agricultural tile discharges and surface runoff. We measured concentrations of nutrients, pesticides and elemental contaminants in tile discharges as well as wetland water, sediments and biota at sites with and without prominent surface and subsurface agricultural drainage pathways. Exposures to contaminants were compared to protective benchmarks established in the scientific literature and also to biological measurements (e.g., aquatic macroinvertebrate diversity, amphibian richness, and WRAP scores) at our wetland sites. We hypothesized that WPA wetland habitats are exposed to varying concentrations of agricultural pollutants in both surface runoff and agricultural tile discharges, and that these exposures are related to changes in aquatic macroinvertebrates assemblages and wetland habitat quality.

In the current study, concentrations of pollutants were generally similar between Tile Wetlands and Surface Wetlands; whereas, Reference Wetlands had better water quality with lower concentrations of most pollutants. These results indicate the importance of having completely intact vegetative buffers around wetlands. Conversely, our Surface Wetlands and Tile Wetlands received unbuffered drainage and had similar concentrations of most pesticides (e.g. atrazine, glyphosate, neonicotinoids) suggesting that both surface runoff and tile effluent are important exposure pathways. There is also the possibility that some of our Surface Wetlands (e.g., Rams1, John1, Zieg1) may receive tile effluent from tile outfalls that we are unaware of as there is no database of tile outfalls for South Dakota. The tile outfalls sampled in this study could be observed from public ground, but there are likely many more tile outfalls located on private property that are unseen by the public but drain into surface ditches that enter WPAs. Thus, the clearest distinction for water quality comparisons was between Reference Wetlands as "Protected Wetlands" and the combined Surface and Tile Wetlands as "Unprotected Wetlands." Reference Wetlands had lower concentrations of turbidity, chlorophyll-a, selenium, and herbicides (atrazine, glypohosate, acetochlor OA, imazathapyr) than Surface Wetlands or Tile Wetlands. The sum of neonicotinoid insecticides measured in POCIS was also lower at Reference Wetlands than at Tile Wetlands or Surface Wetlands suggesting that both surface and subsurface drainage result in significant loading of these pollutants into wetlands.

Although we likely had some overlap in pollutant exposure pathways for Surface Wetlands and Tile Wetlands, we did detect differences in pollutant concentrations and biological receptors between these two site categories. Tile Wetlands had higher concentrations of selenium and lower water temperatures and pH. We suspect that Tile Wetlands receive substantially more nitrates than Surface Wetlands, but because nitrates are quickly assimilated by wetland biota (Kirk and Kronzucker 2005), we did not detect significant differences in wetland nitrate concentrations between Surface Wetlands and Tile Wetlands. Tile Wetlands also had the lowest wetland habitat WRAP scores and only at Tile Wetlands did WRAP scores fail to improve significantly over the growing season. These differences were likely attributed to tile effluent loading of pollutants, especially nitrates, into Tile Wetlands.

Tile effluent is an alternate pollutant exposure pathway to surface runoff that can have higher concentrations of nitrates, pesticides, salts, and toxic trace elements. Tile drainage of corn and soybean agricultural areas in the Midwest is the greatest contributor of the nitrate contamination that leads to hypoxia in the Gulf of Mexico (David *et al.* 2010). In North Dakota's Red River Valley, subsurface tile drainage is installed to decrease salinization and tile effluent discharges frequently had selenium and sulfate concentrations above aquatic life water quality standards (Johnson 2010).

Although water discharged from tile effluent is often filtered through the soil and can thus have lower concentrations of some pollutants than local surface runoff, tile effluent can still be an important pathway for these pollutants. For example, phosphorus and pathogens are removed by soils through physical trapping or adsorption to particulates. Still, field studies have shown that preferential flow of applied manure through macropores or tile risers can result in the significant transport of pathogens and phosphorus through tile drainage systems under all manure application protocols and environmental conditions (Jamieson *et al.* 2002; King *et al.* 2015). Eight of 12 manure spreading events at Ontario field sites resulted in water quality degradation within 20 minutes to 6 hours of manure application and at two sites liquid manure was observed to rapidly penetrate soil and increase tile effluent flow (Dean and Foran 1992).

In eastern South Dakota, surface runoff is predicted to decrease with increased drainage intensity within the same soil type and water yield is expected to increase with increased drainage intensity (Karki 2017). Thus, some expect that reducing surface runoff by tiling will improve water quality (Schuh 2008). However, tiling does not prevent surface runoff from occurring but instead creates an exposure pathway that presents additional water quality issues. For example, Best Management Practices (BMPs) aimed at intercepting surface runoff, such as riparian filer strips can be bypassed by tile. A study of phosphorus transport pathways to streams in east central Illinois concluded that phosphorus loads were greatly increased by extreme overland runoff discharges (i.e., application of phosphorus fertilizer on frozen soils before a rain event) in some years; but that tile drainage was likely an important contributor of dissolved reactive phosphorus every year (Gentry *et al.* 2007). Thus, large rain events and frozen ground will result in surface runoff regardless of subsurface drainage, and tile placement can mobilize dissolved contaminants in groundwater (e.g., nitrates, phosphorus, selenium, salts, and select pesticides) and discharge them at harmful concentrations.

Our sampling did not indicate that Tile Outfalls are an important exposure pathway for ammonia into WPA wetlands. However, our sampling of ammonia was limited and could have easily missed times when tile may act as a conduit for ammonia delivery to surface waters. Ammonia may be found in tile effluent immediately following applications of anhydrous ammonia nitrogen fertilizer or liquid manure entry to tile drains (Fleming and Ford 2004). Furthermore, storm events resulting in high subsurface drain flows following application of anhydrous ammonia fertilizer or liquid manure to drained fields have been known to cause ammonia and pathogen discharges at concentrations toxic to aquatic life and cause impairment of human recreational uses (Dean and Foran 1992; Fleming and Bradshaw 1992; Geohring *et al.* 2001; Jamieson *et al.* 2002; McLellan *et al.* 1993 as cited by Blann *et al.* 2009). The transport of ammonia and other pollutants to surface waters via subsurface outfalls are especially a concern when preferential flow is an issue or when surface inlets or intakes (risers) circumvent soil filtration and interaction with pollutants before entering the tile system.

Our study had several limitations. The pollutants we measured did not include all of the chemicals that are applied to row-crop agriculture in eastern South Dakota. For example, we did not test for all of the pesticides registered for agricultural use in the state, nor did we test for antibiotics, hormones or pathogens, although others have found these pollutants in tile effluent. We were also limited by not having aquatic life water quality standards for the pollutants that we frequently detected in tile effluent or wetland water (e.g., atrazine, clothianidin, nitrate). The goal of the Clean Water Act (CWA) is to "restore and maintain the chemical, physical, and biological integrity of our nation's waters." To meet this goal, pollutants must not be present in harmful concentrations. Thus, the CWA requires that water quality standards for potentially harmful pollutants be developed and revised every three years. Having water quality standards are important because they are derived with the intention of protecting 95% of a group of diverse genera including aquatic invertebrates (EPA 2010). Thus, without water quality standards there is more uncertainty about the effects of pollutants to aquatic life. Our assessment was further limited in that it does not account for chemical mixtures. Wetland organisms are typically exposed to numerous agricultural pollutants simultaneously or in sequence. In a mixture of pollutants, each single pollutant may be present at or below its toxic level but by acting together they can collectively have a significant effect (Faust *et al.* 1994; Chèvre *et al.* 2006; Qu *et al.* 2011). This is often expected to occur when pesticides are of the same family such as the triazine herbicides atrazine, simazine and propazine (EPA 2002). However, pesticides developed to target different pest organisms can also share similar harmful effects. For example, atrazine (herbicide), imidacloprid (neonicotinoid insecticide), and mancozeb (fungicide), as a group, are both registered for use on South Dakota corn fields and have endocrine disrupting effects on thyroid homeostasis (Xiang *et al.* 2017).

Despite limitations in study design and the complexity of our wetland sites, our results indicate that agricultural tile drains in South Dakota can discharge concentrations of nutrients, pesticides, salts, and selenium that exceed water quality benchmarks and are likely harmful to wildlife. These pollutants can effect waterfowl production by either direct toxicity (e.g., selenium induced reproductive effects) or indirectly (e.g., excessive nutrients effects on wetland vegetation).

We found that tile effluent is a source of excess phosphorus and nitrogen to District WPAs that is likely contributing to algal blooms and wetland degradation (i.e., lower WRAP scores). Although nutrients are necessary for the proper functioning of biological communities, excessive nutrient enrichment can cause harmful algal blooms (HABs), plant overgrowth, increased sediment accumulation rates, and reduced water clarity (EPA 2000). In turn, these changes lead to increased turbidity, decreased levels of dissolved oxygen, habitat degradation, and changes in plant and animal species diversity (EPA 2000). Cyanobacterial blooms can produce toxins that affect liver and brain function of birds and mammals, potentially resulting in die-offs of ducks, coots, and geese (Friend and Franson 1999). Hypoxia (low oxygen concentrations), caused by algal respiration and the decomposition of plant matter (stimulated by the increase in available organic carbon), can asphyxiate fish and aquatic invertebrates (Buss *et al.* 2005; Blann *et al.* 2009). In wetlands, excessive nutrients can produce algal mats or slimes and create habitats that are unattractive and have less foraging potential (i.e., fewer seeds and invertebrates) for migrating or breeding bird populations (Gaiser and Lang 1998; Green and Galatowitsch 2002; Blann *et al.* 2009; Riens *et al.* 2013). Excessive nutrients in wetlands also harm amphibians by promoting pathogenic infections and disease in amphibians (Johnson *et al.* 2007). Recreational use of WPAs, especially areas that have boat access, can also be affected by the human health exposure to HABs. Human contact or ingestion of HABs can cause skin rashes, respiratory difficulty, gastro-intestinal distress, fatigue, muscle and joint pains, and severe neurologic symptoms that persist indefinitely (Hudnell and Dortch 2008).

The Safe Drinking Water Act MCL for nitrate only applies to surface waters in South Dakota with a “domestic water supply” beneficial use, which does not include any of our wetland sites. However, the standard does apply in three segments of the Big Sioux River that extends from the Brookings/Moody county line to Sioux Falls (SDDENR 2016). Tile effluent sampled in this study include sites that are hydraulically connected to the Big Sioux River as are many other tile outfalls that discharge directly into its prairie stream tributaries. Although wetlands are valued as important in mitigating nitrate pollution by denitrification, their capacity to remove nitrogen from surface waters is limited and potentially to their own detriment. A meta-analysis of 419 published estimates of denitrification in wetlands found that denitrification was on average 50% greater in vegetated sediments than nearby non-vegetated sediments (Alldred and Baines 2016). Agricultural drainage reduces water storage in the soil, increases the effective drainage area, and increases water conveyance (Blann *et al.* 2009). Thus, tile drainage may reduce wetland denitrification within a watershed by converting seasonal wetlands into more permanent ponded waterbodies. Reduced wetland denitrification and the accumulation of tile discharges within the Big Sioux watershed may eventually result in the need for costly nitrate removal. For example, nitrate concentrations in the Des Moines and Raccoon rivers in neighboring Iowa cost the Des Moines Water Works approximately 1.5 million dollars in 2016, based on costs to operate their nitrate removal facility for 177 days (Stecker 2016).

Reducing phosphorus inputs has been the traditionally prescribed solution to prevent HABs based on the assumption that phosphorus universally limits HABs formation in lakes; however, whole-lake experiments indicate that HABs are often stimulated more by combined phosphorus and nitrogen inputs (Paerl *et al.* 2016). This is because anthropogenic nitrogen and phosphorus loading has increased dramatically in recent decades and biological nitrogen fixation cannot always meet ecosystem nitrogen needs (Paerl *et al.* 2016).

As WPAs receive more agricultural drainage, including direct discharges of dissolved nitrogen and phosphorus from tile outfalls, we can expect that the ecosystem services they provide will shift towards nutrient treatment and away from wildlife habitat (Engelhardt and Ritchie 2001; Zedler 2003; Hansson *et al.* 2005; Dale and Polasky 2007). Such a shift would be counter to the responsibility and authority under the Refuge Improvement Act to "protect the health and safety of the public or any fish or wildlife population" on Refuge lands.

Excessive nutrient enrichment of surface waters has been a national concern for decades and continues to be a leading cause for water quality impairments throughout the

U.S. (EPA 1998, 2016a; OIG 2009). In South Dakota, “runoff carrying sediment and nutrients from agricultural land is the major nonpoint pollution source” (SDDENR 2016). The Service has requested that South Dakota adopt numeric nutrient standards for aquatic life to address concerns that nutrient enrichment causes adverse habitat modification of National Wildlife Refuge System lands and habitat for aquatic dependent migratory birds, amphibians, and federally listed species including pallid sturgeon, Topeka shiner, whooping crane, interior least tern, and piping plover (FWS 2011, 2014). However, under the existing laws, nutrient runoff from agricultural land is considered nonpoint source pollution and thus is only addressed by federal law through voluntary measures (USGAO 2013). Given that voluntary measures under the CWA have not been as successful as CWA regulations to address point source pathways, excessive nutrients are not likely to be adequately addressed without the addition of enforced regulatory options (Schnnor 2014; Rundquist and Cox 2014). Although some states have developed regulations to address nonpoint source pollution (Bryant and Goldman-Carter 2016), South Dakota Codified Law 1-40-4.1 does not allow a delegated state program to be more stringent than the comparable federal program. Thus, excessive nutrients will likely continue to be an issue in South Dakota.

In addition to nutrients, 31 different pesticide compounds were detected in Tile Outfalls and many of those same pollutants were also detected at wetlands sites. Pesticides frequently measured in Tile Outfalls at concentrations above water quality benchmarks included two herbicides (atrazine and metolachlor) and three neonicotinoid insecticides (clothianidin, imidacloprid, and thiamethoxam).

Most aquatic benchmarks for atrazine are higher than the average concentrations we detected at Tile Outfalls or our wetland sites. However, the average concentration detected at Surface Wetlands was above 0.5 μg/L, a concentration that can cause endocrine disruption to aquatic organisms. Concentrations of atrazine as low as 0.5 μg/L shifted water flea (*Daphnia pulicaria*) sex ratios towards males (Dewey 1986) and reduced egg production of fathead minnow (*Pimephales promelas*) attributable to effects on oocyte maturation (Tillitt *et al.* 2010). The highest concentration of atrazine detected using ELISA was from a Tile Outfall (Bols1; 6.54 μg/L), indicating that tile may discharge harmful concentrations of atrazine directly to wetlands or streams. Others have reported higher maximum concentrations of atrazine in tile effluent including 29 μg/L from a cornfield in Canada (Milburn *et al.* 1995). Milburn *et al.* (1995) also recorded a maximum atrazine concentration of 150 μg/L in tile effluent following an accidental release of ca. 60 grams of atrazine into one of the field plots. A three year study on pesticide and nitrate losses to subsurface tile as affected by drain spacing (5, 10 and 20 m), found that atrazine removed by subsurface drains was greater for tiled fields with 5-m spacing than 20-m spacing, with maximum concentrations up to 80 μg/L in tile effluent (Kladivko *et al.* 1999).

Atrazine is commonly applied to corn, sorghum, and soybean crops in South Dakota and its use is estimated to have increased from 2008 to 2014 (USGS 2017). However, atrazine in Tile Outfalls and wetland sites from the current study were detected at lower concentrations than WPAs in Nebraska. In 2009, buffered and nonbuffered WPA wetland sites in Nebraska's Rainwater Basin had mean atrazine concentrations of 0.8 ± 0.1 and 5.8 ± 3.1 μg/L, respectively (Riens *et al.* 2013). Sites sampled in the Rainwater Basin included surface runoff only with no sites receiving known subsurface tile effluent. Atrazine absorbs to sediments and others have reported low concentrations in tile during times of low precipitation versus higher precipitation (see review by Kladivko *et al*. 2001). A 4-year study in Ohio found that herbicide (atrazine and alachlor) losses from corn and soybean fields were greater in runoff than in subsurface discharges (Logan *et al.* 1994). Two years of the study (1987, 1988) experienced drought and 2 years (1989, 1990) experienced above normal precipitation. Tile flow was minimal in 1987 and 1988, but accounted for 67–85% of the total flow (total of surface runoff plus subsurface drainage) in 1989 and 1990 (Logan *et al.* 1994; Kladivko *et al.* 2001). Herbicides were most frequently detected in tile flow events during the wettest year (1990).

In the current study, water grab samples were scheduled snap shots of effluent discharges and atrazine concentrations would be expected to be higher had our sampling coincided with precipitation events. According to Kladivko *et al*. (2001), "pesticide concentrations in subsurface drain flow generally increase abruptly at the beginning of a drainage event and may peak slightly before or coincident with the hydrograph peak. Concentrations then drop rapidly, often changing by two orders of magnitude during an event. A grab sample taken at the peak of a plot of pesticide concentration versus time would overestimate average concentrations and mass losses, while a sample taken far down on the recession limb would likely underestimate concentrations and mass losses."

The results of the current study indicate that neonicotinoids, especially clothianidin and thiamethoxam, are leaching into subsurface tile drains and are directly discharged into WPAs. This is not surprising given their widespread use and environmental fate characteristics. Neonicotinoid seed treatments are routinely applied to more than 80% of corn seed planted in North America and are likely to be transported to aquatic habitats due to their high water solubility, low soil binding affinity, and limited translocation efficacy into crops (Alford and Krupke 2017; Miles *et al.* 2017). Fish, amphibians, and other vertebrate species tend to be tolerant to neonicotinoid toxicity relative to insects because neonicotinoids are designed to strongly bind to nicotinic acetylcholine receptors, which provide the majority of neurotransmission in insects (Moffat *et al.* 2016). Neonicotinoid blockage of postsynaptic nicotinic acetylcholine receptors in insects is virtually irreversible, resulting in persistent activation of the central nervous system and cumulative effects over time (Tennekes and Sanchex-Bayo 2011; Mineau and Palmer 2013). Neonicotinoids can result in a variety of lethal and sublethal effects to aquatic invertebrates including altered emergence, growth, sex ratios, feeding, swimming, burrowing behavior, and immobility (Roessink *et al.* 2013; Pisa *et al.* 2015; Nyman *et al.* 2016). However, neonicotinoid toxicity to aquatic invertebrates is also highly variable depending on both the species and neonicotinoid compound. Toxicity testing indicates that snails and cladocerans (water fleas) are relatively tolerant to neonicotinoids whereas, Ephemeroptera (mayflies) and Trichoptera (caddisflies) are more sensitive (Morrissey *et al.* 2015; Miles *et al.* 2017). Neonicotinoid toxicity to Chironomidae (midges) in the laboratory appears to also be variable with some species (e.g., *Eristalis tenax*) being relatively tolerant and other species (e.g., *Chironomus riparius* and *C. dilutes*) being highly sensitive (Morrissey *et al.* 2015; Saraiva *et al.* 2017; Basley *et al.* 2018).

There can also be differences among neonicotinoids in their toxicity to a particular species. For example, imidacloprid and clothianidin had comparable chronic toxicities to *C. dilutus*; whereas, thiamethoxam induced comparable effects in the laboratory only at concentrations an order of magnitude higher (Cavallaro *et al.* 2017). A comparison of the acute toxicity median effect concentrations (EC50) to *C. riparius* also found the relative order of toxicity was imidacloprid (20 μg/L) ≥ clothianidin (22 μg/L) > thiamethoxam (35 μg/L; Mineau and Palmer 2013). However, it should be noted that thiamethoxam, under field conditions, readily degrades to clothianidin and thus likely becomes more toxic (Cavallaro *et al.* 2017).

Differences in seasonality when aquatic invertebrates are collected for laboratory toxicity testing can also be a factor that affects neonicotinoid toxicity. The chronic toxicity of imidacloprid to the summer generation of a mayfly species (*Cloeon dipterum*) was five times more toxic than the overwintering generation (Roessink *et al.* 2013; Van den Brink *et al.* 2016). Temperature effects were also tested and had a slight effect on sensitivity but could not fully explain the differences. Differences in sensitivity between summer and overwintering generations were also found for three other insect species (Van den Brink *et al.* 2016).

Concentrations of neonicotinoids discharged in Tile Outfalls were lower than toxicity benchmarks for some of the more tolerant species in the scientific literature but exceeded benchmarks for more sensitive aquatic invertebrates. For example, the highest concentration of thiamethoxam detected in this study was 2.49 μg/L, whereas 100 μg/L thiamethoxam exposure to a hoverfly species (*Eristalis tenax*) in the lab resulted in no observed effects to survival or development (Basley *et al.* 2018). However in a field microcosm study, exposure to pulsed concentrations of imidacloprid (time-weighted average concentrations of 2.3 μg/L) resulted in decreased abundance and emergence of Ephemeroptera and decreased survival of chironomid species of the subfamilies Tanypodinae and Orthocladiinae (Colombo *et al.* 2013). In contrast, imidacloprid exposures resulted in the gastropod *Radix* sp. to become dominant, probably due to decreased competition for food with sensitive species (Colombo *et al.* 2013). The authors concluded that repeated short-term exposures of imidacloprid at low concentration levels might affect aquatic ecosystems even under optimal conditions for photodegradation. Another community-level mesocosm experiment found that clothianidin reduced the abundance of predatory aquatic invertebrates, which benefited clothianidin-tolerant herbivores in the community by increasing their survival by 50% (Miles *et al.* 2017). Maximum neonicotinoid water borne concentrations in the mesocosm were 0.67 μg/L clothianidin, 0.18 μg/L imidacloprid, and 0.02 μg/L thiamethoxam (Miles *et al.* 2017).

In addition to water-borne neonicotinoid exposure to aquatic invertebrates, dietary exposure may also be an exposure pathway for shredders that forage on plants containing neonicotinoids (Englert *et al*. 2017). Dietary exposure may be more of an issue in temporary wetlands located in the middle of row-crop fields than in WPA wetlands where neonicotinoids are less likely to be concentrated in sediments and surrounding vegetation.

The neonicotinoid benchmarks used for this study (Morrissey *et al.* 2015) were based on a comprehensive species sensitivity distribution analysis of 214 toxicity tests of 48 species and concluded that "any long-term neonicotinoid concentrations in water exceeding 0.035 μg/L or short-term peak exposures exceeding 0.2 μg/L can affect sensitive aquatic invertebrate populations." Although these benchmarks may not account for environmental conditions that occur outside the laboratory (Moore *et al.* 2016), they also do not apply safety factors that have been developed for extrapolations including inter and intra-species uncertainty (Calabrese and Baldwin 1993). The use of such safety factors may be appropriate based on the uncertainties that remain with toxicity sensitivity among aquatic invertebrates, sublethal effects, differences among neonicotinoid toxicities, and exposure duration and pathways.

We did not frequently test wetland water grab samples for neonicotinoids but instead used POCIS to evaluate wetland pesticide exposure. Still, clothianidin and thiamethoxam were usually below detection limits in water grab samples from wetland sites; whereas, our POCIS results frequently (90% of samples) found clothianidin with less frequent detections of thiamethoxam and imidacloprid. These results indicate that the limited water grab sampling likely missed pulsed exposures of neonicotinoids that were likely picked up by POCIS that were deployed throughout the field season. Furthermore, differences in sampling methods are likely important as water grab samples are typically taken near the water surface where photodegradation of neonicotinoids may more likely occur. Having POCIS submerged in water that was less exposed to sunlight may also explain differences in POCIS detection versus water grab sample non-detections. Others have detected neonicotinoids in wetlands at much higher concentrations than what we detected. In Canada's Prairie Pothole wetlands, clothianidin and thiamethoxam were most frequently detected (91% of samples) following ice-out within watersheds with high-density canola or soybean production (Main *et al.* 2014). Peak concentrations of 1.49 μg/L thiamethoxam and 3.11 μg/L clothianidin were detected during the summer of 2012. These higher concentrations were found in wetlands located within canola fields, unlike our sampling of WPAs where neonicotinoids have to move off the field before reaching the wetlands. In the Southern High Plains of Texas, playa wetlands had much higher concentrations of thiamethoxam than the current study with maximum concentrations of 20.1 μg/L and 225 μg/L in crop playas and grassland playas, respectively (Anderson *et al*. 2013). Grassland playas also had higher concentrations of malathion and acephate insecticides, leading the authors to conclude that harmful pesticide exposure is not limited to organisms inhabiting crop playas but that grass playas are also likely at risk to pesticides from spray drift and/or runoff.

Tile drainage is used to address soil salinization of agricultural land (Schuh 2008) and although there were no significant differences in specific conductivity concentrations at our wetland sites, specific conductivity concentrations in Tile Outfalls exceeded water quality standards on several occasions. A lower average specific conductivity (484 μS/cm) was reported for tile effluent draining a soybean and corn crop dominated watershed of Iowa (Gali *et al.* 2012). However, this Iowa study measured specific conductivity at 30-minute intervals from March–August 2011, and included sampling during rainfall events, whereas the current study had fewer sampling occasions that occurred mostly during dry weather. Others have reported an inverse relation between specific conductivity and water flow due to the dilution of ions in the flow (Leibowitz and Vining 2003; Gali *et al.* 2012) and this likely explains why the current study found a lower mean specific conductivity at Tile Outfalls than wetland sites where evaporation results in higher salt concentrations.

Selenium was the only pollutant in Tile Outfalls and Tile Wetlands sites that frequently exceeded South Dakota aquatic life water quality standards and our results indicate that tile effluent is a significant exposure pathway for transporting selenium into wetlands. Although wetlands can have high biological productivity and increased biological uptake that can lower waterborne selenium concentrations (Ohlendorf 2003), we found that Tile Wetlands had significantly greater concentrations of selenium in water compared to Surface Wetlands and Reference Wetlands. Concentrations of selenium in plants and aquatic invertebrates only exceeded avian dietary toxicity thresholds for impaired reproduction at Tile Wetlands, indicating selenium bioaccumulation. However, selenium bioaccumulation in aquatic invertebrates, fish, and duck eggs at Tile Wetlands was not as high as some other sites with known selenium contamination (Seiler *et al.* 2003). For example, agricultural subsurface tile drainage into Kesterson Reservoir, California, resulted in concentration of selenium that exceeded 300 mg/kg dw in some samples of algae, submerged rooted plants, chironomids, and mosquitofish (Saiki and Lowe 1987).

Selenium is an essential nutrient in animals and some plants (Ohlendorf 2003); however, the narrow margin of safety between selenium deficiency and toxicity make it one of the most toxic nutrients (USDOI 1998). Nutritionally optimal dietary selenium exposure is generally reported as 0.1–0.3 mg/kg dw; whereas, threshold values for dietary toxicity in animals are generally reported as 2–5 mg/kg dw (USDOI 1998). Adverse effects of selenium exposure to fish and/or avian species include abnormal embryonic development, decreased hatchability, reduced growth, reproductive failure, and mortality

(Lemly 1996; Heinz 1996; Seiler *et al.* 2003). Fish and aquatic birds are the most sensitive animals to selenium toxicity and they are most vulnerable at early life stages (Ohlendorf 2003). Reproductive effects to fish and waterfowl from exposure to selenium are well documented by laboratory and field investigations (reviewed by USDOI 1998; Hamilton 2004). Mallards are especially sensitive to a selenium induced decrease in egg hatchability (Ohlendorf 2003), an effect that can be difficult to detect without examining eggs and conducting brood surveys.

The wide range of selenium in Tile Outfalls (< 0.4–144 µg/L) may be a result of its natural occurrence in the soil. Naturally high concentrations of selenium are found in eastern South Dakota soils that are derived from glacial deposits and Upper Cretaceous marine sedimentary rocks (Moxon *et al.* 1950; Seiler *et al* 1999; USGS 2004b). Selenium can be found at toxic concentrations in waterbodies due to natural leaching but agricultural irrigation can accelerate the release of selenium from geologic sources, making it more available to fish and wildlife (Hamilton 2004). Wetlands that are terminal and have no outlet during non-flood years can be especially at risk of selenium contamination as selenium accumulates but is not flushed out during normal spring runoff (Seiler *et al.*1999).

Tile installation (e.g., depth, spacing) and farming practices (e.g., manure application) may also contribute to how much selenium is discharged from tile. Selenium is often added to animal feed as a nutritional supplement and is of environmental concern in manure fertilizer, especially liquid manures associated with swine or cattle feedlots (EPA 2003a; Lemly 2004). Phosphorus fertilizer materials can also be high in selenium, especially when taken from western phosphate deposits (Robbins and Carter 1970). Tile installed at shallower depths and with tighter spacing would likely offer less filtration and a more direct pathway for pollutants to be discharged to surface waters (Kladivko *et al.* 1999). Tile risers (tile inlets extending above the soil) provide a direct pathway for movement of sediment, nutrients, and agrochemicals to surface waters (Feyereisen *et al.* 2015).

Wetland WRAP scores are a measure of current habitat conditions and Tile Wetlands exhibited significantly lower scores than Surface Wetlands suggesting that Tile Wetlands are poorer quality habitats. However, what is most interesting is the difference in scores among these sites over the seasons. A difference in WRAP scores across months (May–July) at a single site is to be expected as vegetation elements of the score increase during the growing season. Survey events at wetland sites in May often had little to no floating aquatic and submerged vegetation and low non-emergent/emergent vegetation ratios, resulting in lower WRAP scores. As temperatures increased from May to June, WRAP scores increased due to aquatic macrophytes becoming established through the growing season. By June and July, mats of algae would cover a large percentage of open water in Tile Wetlands, likely produced by increased levels of nutrients at these sites from the tile drain effluent. These large mats of algae would result in reduced or absent patches of submerged aquatic macrophytes. The combination of large mats of algae and reduced or absent aquatic vegetation lowers WRAP scores at Tile Wetlands, helping to drive the differences between site categories. In addition to WRAP scores being overall lower at Tile Wetlands, WRAP scores at Tile Wetlands did not significantly increase from May to July, unlike those from Reference and Surface Wetlands. This suggests that WRAP scores for Tile Wetlands remain the same throughout the growing season, with factors such as the emergence of aquatic macrophytes through the months adding points to the WRAP score, but they are cancelled out by the appearance of large mats of algae.

Given that the use of these WRAP scores were validated for use in the Prairie Pothole Region of eastern South Dakota (Bouchard *et al.* 2008), their use allows for a quick, yet robust evaluation of wetland sites. This may be particularly informative to District staff who are either documenting the degradation of wetland habitat due to encroaching agriculture or the installation of nearby tile drains, but also to document the recovery of wetlands sites where habitat restoration has occurred or recovery coinciding with the removal of tile drain effluent.

Amphibian diversity did not differ significantly among wetland sites categories when evaluated by visual encounter survey methods or plot surveys. This nonsignificant difference may be driven by the low overall number of amphibian species using these wetlands (n=4). Furthermore, the amphibian species at our wetland sites may be more tolerant to environmental contaminants compared to other taxa, such as aquatic invertebrates (Kerby *et al.* 2010). Nonetheless, these data serve as an important baseline for future monitoring efforts, especially if wetland habitats are restored (e.g., tile effluent no longer enters a particular wetland) or further degraded.

We found significant differences in aquatic invertebrate diversity among wetland site categories, with Tile Wetlands having significantly lower diversity than Reference Wetlands and Surface Wetlands. Though the exact mechanisms contributing to the pattern of decreased aquatic invertebrate diversity in Tile Wetlands warrants further examination, concentrations of nutrients, pesticides, and potentially other contaminants discharged from Tile Outfalls into Tile Wetlands may be having negative direct or indirect effects on individual taxa. For example, contaminant exposure may directly affect individuals through mortality, resulting in decreased abundance or local extirpation of more sensitive taxa. Neonicotinoid insecticides, which were detected at high levels in Tile Outfalls and Tile Wetlands, are known to cause a wide range of negative effects on aquatic invertebrates (Morrissey *et al.* 2015; Pisa *et al.* 2015) as well as vertebrates (Gibbons *et al.* 2015). Low levels of neonicotinoid insecticides may result in mortality of several orders of aquatic insects, including Ephemeroptera (Roessink *et al.* 2013), which may be driving the lower abundance of Ephemeroptera in Tile Wetlands. Ephemeroptera had decreased abundance and emergence when exposed to pulses of imidacloprid in a microcosm setting despite optimal sunlight conditions for photolysis (Colombo *et al.* 2013). Diptera has also been identified as an order that shows sensitivity to neonicotinoid insecticides (Morrissey *et al.* 2015). Surprisingly, we observed a greater overall abundance of Diptera in Tile Wetlands, primarily driven by the family Chironomidae, which might have a greater resistance to contaminants than other dipterans. Compared to Ephemeroptera, Oligochaete worms were more resistant to effects of the neonicotinoid imidacloprid (Alexander *et al.* 2007) and are often associated with nutrient-enriched, eutrophic wetlands (Davis and Bidwell 2008), and higher abundances of Oligochaete worms were detected in Tile Wetlands.

Indirect effects from pollutant discharges may include habitat modification due to excess nutrients in Tile Wetlands, resulting in decreased habitat or resource availability. Advanced eutrophication of PPR wetlands in northwest Iowa was found to severely limit the abundance and composition of cladoceran fauna (Gaiser and Land 1998). Another comparison of amphipod (*Gammarus* and *Hyalella*) density and water quality among 356 upper Midwest wetlands found that Iowa PPR wetlands lacked *Gammarus* completely and had the highest chlorophyll-a concentrations and lowest *Hyalella azteca* density (Anteau and Afton 2008). The authors concluded that their estimates of amphipods, fish, and turbidity were consistent with low wetland quality and resulted in lower food availability for various wildlife species, especially lesser scaup (*Aythya affinis*). Hentges and Stewart (2010) also reported that invertebrate densities and taxonomic diversity in Iowa PPR wetlands were negatively related to turbidity, water-column concentrations of nitrogen and phosphorus, and the presence of large-bodied fish. Factors associated with wetlands that appeared to be in the best condition included high invertebrate abundance and diversity, abundant plant/coarse particulate organic matter, presence of tiger salamanders (*Ambystoma* sp.), and absence of large-bodied fish (Hentges and Stewart 2010).

Many of the aquatic invertebrate taxa found at our wetland sites are a crucial food source for waterfowl. Female ducks during the breeding season shift from a winter diet of seeds and plant material to a spring diet that consists mainly of aquatic invertebrates, with different duck species depending differentially on various wetland aquatic invertebrate prey (Eldridge 1990). Thus, negative effects of tile drainage on aquatic invertebrates may hinder migratory waterfowl recruitment.

Our results from Tile Wetlands are similar to others who have observed negative effects of agricultural land use on wetland invertebrates (Euliss and Mushet 1999; Anteau and Afton 2008; Riens *et al.* 2013); however, we did not find differences in aquatic invertebrate diversity between Surface Wetlands and Reference Wetlands despite differences in water quality. These results from Surface Wetlands are similar to Tangen *et al.* (2003) who found no strong influence of agricultural land use surrounding PPR wetlands on aquatic invertebrates. Although agricultural pollution can alter wetland aquatic invertebrates communities (Euliss and Mushet 1999; Riens *et al.* 2013), natural variability can preclude their use as metrics to assess anthropogenic disturbance (Wilcox *et al.* 2002; Tangen *et al.* 2003). Aquatic invertebrates in North Dakota PPR wetlands were found to have a high degree of natural disturbance (e.g., presence of fish, temporal changes) and a low diversity community of resilient aquatic invertebrates, thus leading the authors to conclude that land-use practices did not significantly influence the makeup of the aquatic macroinvertebrate community in the wetlands studied (Tangen *et al.* 2003).

The difference in aquatic invertebrate diversity at our wetland sites across months is not surprising. In May, many taxa have not yet become established at these wetlands due to the water recently thawing or may be difficult to detect because they are present as eggs or small larvae. By June, aquatic invertebrate diversity had significantly increased and continued to increase into July. If sampling had continued into the fall then diversity would have likely decreased, corresponding with the timing of metamorphosis, dispersal, and reproduction for many taxa (Butler 1984). What is less certain is why we observed higher aquatic invertebrate diversity in 2014 compared to 2013, despite no change in sampling effort or methodology. Annual precipitation was below average in 2013 and above normal in 2014, and annual differences in weather, temperature, and hydrology are known to strongly influence invertebrates (Hart 1985; reviewed by Batzer and Wissinger 1996; Sim *et al.* 2013) and result in differences in phenology, emergence, colonization, and other aspects of aquatic invertebrate natural and life history.

Wetlands in the PPR are often interconnected with prairie streams, lakes and rivers. In Iowa streams that drain watersheds dominated by corn and soybean rotation agriculture, neonicotinoids were frequently detected at potentially harmful concentrations (Hladik *et al.* 2014). Thus, cumulative effects from tile drainage (i.e., wetland loss and degradation of existing surface waters) in the PPR may be especially detrimental to fish and wildlife. In South Dakota, recovery of aquatic-dependent species that are federally listed under the Endangered Species Act (e.g., Topeka shiner, pallid sturgeon, whooping crane) may also be at risk. In addition to habitat loss and degradation, Topeka shiners may also be especially sensitive to selenium toxicity. Topeka shiners and zebrafish are members of the same family of fishes (Cyprinidae) and although we do not know how sensitive Topeka shiners are to selenium toxicity, zebrafish are the most sensitive fish species studied (Thomas and Janz 2015).

Conclusions

Pollutants that are water soluble and flow easily from the soil into agricultural tile drainage often bypass buffer strips and are discharged directly into road ditches, streams and wetlands. This study evaluated surface and subsurface agricultural pollutant exposure pathways into public wetlands managed for wildlife habitat. We identified nutrients, anions, pesticides and selenium as pollutants of concern that were measured at concentrations above water quality criteria or benchmarks for the protection of aquatic life. Tile Outfalls discharged a mixture of pesticides, nutrients, salts, elemental contaminants, and likely other pollutants that we did not measure such as bacteria, pharmaceuticals, and hormones. Our Tile Wetland sites exhibited signs of habitat degradation including high chlorophyll-a concentrations, selenium accumulation, lower WRAP scores, and decreased aquatic invertebrate diversity. Wetland sites that received excessive nutrients had increased algae and degraded habitat indicating a potentially lower foraging potential (i.e., fewer seeds and invertebrates) for migrating or breeding waterfowl populations. Given that WPAs are managed primarily for nesting waterfowl, insecticide exposure is of particular concern because aquatic invertebrates play a critical role in the diet of both egg-laying hens and ducklings. High selenium is also a concern given that ducks are especially susceptible to selenium-induced decreases in egg hatchability, an effect that can be difficult to document without intensive, large sample size, nest monitoring (e.g., Seiler *et al*. 2003). Our very small sample of eggs from just seven mallard hens was enough to establish that selenium-induced reproductive impairment is likely already occurring, and that a worst-case scenario of 53% of all hens being affected cannot be ruled-out statistically.

Management Recommendations

Actions are needed to address the exposure of tile effluent pollutants to WPAs managed by the Service, but they are severely limited by the lack of laws, water quality standards, and incentives to implement measures aimed at improving water quality. Pollution from agricultural tile drainage in South Dakota is considered nonpoint source and is unregulated by state or federal agencies responsible for protecting water quality. A few counties have established a permit system for drainage as per South Dakota codified law (46A-10A-30), but they do not address water quality degradation from tile. Furthermore, many of the pollutants that we found above concentrations of concern do not have numeric water quality standards, or have standards that need to be updated. There are many farming techniques or BMPs that are capable of limiting pollutants in agricultural surface or subsurface drainage; however, many of these BMPs are costly and incentives for producers to adopt them are lacking. Thus, we encourage Service management and our partners in conservation to support the following recommendations. These recommendations are aimed at developing the necessary tools to address tile drainage pollutants while, in the interim, minimizing injury to Refuge lands and trust wildlife species.

Continue to Comment on County Drainage Permits

The results of this study support the findings of others that tile effluent can contribute to water quality degradation (Blann *et al*. 2009; Gedlinske 2014) and decreased aquatic biodiversity (Leet *et al*. 2012). Despite these findings, pollution from agricultural tile drainage is currently unregulated and incentives are lacking for voluntary implementation of BMPs aimed at improving tile effluent water quality. In South Dakota, there is no state government oversight for tile drainage and only a few counties have drainage boards that require a permit before a tile project can be installed. These permits are not known to require any conditions aimed at protecting water quality but serve as a notice to adjacent downgradient neighbors. These neighbors then have an opportunity to request a drainage board hearing if they have concerns. In counties without drainage boards, Refuge managers are not notified of drainage projects that discharge into WPAs.

We recommend that Service WMDs continue to object to county drainage permits that allow for direct agricultural tile discharges into WPAs. In addition to attending the hearings in person, we recommend that FWS submits response letters to the county drainage board and the landowner(s) proposing to install the tile. The response letter should identify concerns with tile drainage pollutants entering the WPA as well as other concerns (e.g., excess water into the WPA) and how they would likely result in decreased waterfowl production. We recommend the letters object to receiving tile drainage effluent unless the discharges are treated prior to entering the WPA and warn that untreated tile effluent is likely to result in injury to Service trust resources. The letter should request that if the county permits tile drainage onto the WPA to occur, then it should also require at least one structural practice on every drainage outlet, which could be a bioreactor, a control structure for drainage water management, or a saturated buffer. In addition, the landowner discharging to the WPA should be required to submit a nutrient management plan to help assure that nutrient applications do not exceed actual crop production requirements and that the timing of nutrient applications minimize nutrient loss. The nutrient management plan should include monitoring soil nutrient concentrations prior to land application of fertilizers as well as sampling for nitrates, pesticides and selenium in tile effluent entering the WPA to evaluate effectiveness of BMPs and drainage management. To prevent harmful discharges of pesticides in tile effluent, the drainage permit should also request that landowners discharging to the WPA avoid the prophylactic application of pesticides as seed treatments in support of the Service's prior policies to use integrated pest management methods and avoid the use neonicotinoid seed treatments on Refuge lands (FWS 2010, 2014). If monitoring determines that tile drainage pollutants are entering the WPA at concentrations above benchmarks for the protection of aquatic species found on the WPA wetlands (e.g., aquatic invertebrates, waterfowl) then additional BMPs (e.g., use of cover crops, constructed wetlands) or other actions to eliminate harmful discharges should be implemented by the tile owner.

Develop/Support a State Registry of Tile Drainage Projects

It is important to know where tile drainage occurs in South Dakota in order to evaluate how it affects water quality. The USGS developed a data layer of known tile drainage projects in eastern South Dakota based on permit records and observations of recently placed tile (Finocchiaro 2014). However, data is missing, especially for counties without local drainage boards. Improved data on the extent of tile drainage would contribute to a better understanding of the large-scale environmental effects of nutrient pollution and the cost-effectiveness of nutrient abatement strategies (Sugg 2007). Even without regulations to address pollutants discharged in tile, knowing what percentage of a watershed has agricultural tile is useful when evaluating other point sources that discharge nitrates. For example, the Big Sioux River and its tributaries are permitted, under the CWA authorized National Pollution Discharge and Elimination System (NPDES) program, to receive discharges with high concentrations of nitrates from municipal wastewater treatment plants and industrial facilities. Understanding the nitrate loading in the watershed is important when developing NPDES permit discharge limits for nitrates and other nutrients. Thus, knowing the location of drain tile in South Dakota could guide limited funding for BMP efforts aimed at improving water quality and would allow for before and after comparisons to evaluate which BMP strategies are most effective. An effort to develop a South Dakota registry for tile projects was attempted by the South Dakota legislature in 2015 (Senate Bill 2). It is unclear why this measure failed, but efforts to work with the legislature should continue as should other efforts to improve understanding of tile drainage locations in South Dakota.

Develop Numeric Water Quality Standards for Tile Pollutants

Water quality standards are the basis for other CWA programs including the development of municipal and industrial discharge permits and listings for water quality impairments that guide strategies and funding for water quality improvement projects. Section 303 of the CWA requires states to modify and improve their water quality standards at least once every three years. It is EPA's responsibility to approve or deny the state's triennial review and to also develop national water quality criteria for states to adopt as regulatory standards. However, South Dakota does not have updated numeric aquatic life water quality criteria for any of the pollutants of concern that we found in tile effluent (i.e., selenium, nitrates, phosphorus, sulfates, atrazine, neonicotinoid insecticides). For example, EPA's national criteria for ammonia and selenium were finalized in 2013 and 2015, respectively, and are more stringent than South Dakota's current criteria. For nitrates, EPA has not developed national aquatic life criteria, but South Dakota has aquatic life criteria that are not likely protective of sensitive fish or aquatic invertebrates. South Dakota does not have aquatic life criteria for sulfates, atrazine or neonicotinoids. For atrazine, aquatic life criteria were published by EPA as drafts in 1986, 2001, and 2003 but after 30 years there remain no finalized national criteria. Thus, there is ample opportunity for the Service and our partners in conservation to support needed changes in water quality standards by participating in South Dakota's triennial reviews and requesting that EPA and SDDENR develop and implement updated aquatic life criteria.

Promote a Mix of Voluntary and Required Measures to Address Tile Pollutants

There are a variety of strategies (e.g., tile outfall control structures, bioreactors, constructed wetlands, use of cover crops) that can help minimize water quality degradation from agricultural drainage. However, county drainage boards have not used their permitting authority to require any of these strategies because of their cost. Instead, these measures are promoted as voluntary BMPs and producers are encouraged to seek cost-shares and technical assistance through conservation programs.

Although the use of BPMs and voluntary conservation programs have value in preventing much greater environmental degradation than is currently occurring, it is increasingly clear that continuing to rely on an entirely voluntary approach of BMP implementation will not produce the desired results (Schnoor 2014; Bryant and Goldman 2016). With the exception of a bioreactor at Wenk WPA, that was part of a study by South Dakota State University (Kjaersgaard *et al*. 2013), we did not observe any control structures on tile outfalls that discharged to WPAs. Instead, we frequently observed unabated direct discharges of tile effluent into wetlands and road ditches and the use of tile risers to drain row-crop fields. It is very likely that without much greater incentives, there will be little to no use of BMP strategies to mitigate pollutants discharged by tile. Therefore, a mix of regulatory and voluntary measures is likely needed to address water quality degradation from tile effluent (Bryant and Goldman-Carter 2016).

Encourage States and EPA to consider Tile Outfalls as Point Source Pollution

Strong arguments can be made that agricultural subsurface drainage into surface waters are point sources of pollution (Thomas and Leighton-Schwartz 1990). Plaintiffs have contended that tile discharges meet the definition of point source and should be considered separate from the CWA exemptions for agricultural storm water runoff and irrigation return flows (*Pacific Coast v. Glaser* 2013; *Board of Water Works v. SAC County* 2017); however, both cases were dismissed prior to ruling on whether tile discharges are point sources. Under the CWA, the term “pollutant” includes “agricultural waste discharged into water” and “point source pollution” is defined as “any discernable, confined and discrete conveyance, including but not limited to any pipe, ditch, channel, tunnel, conduit, well, discrete fissure, container, or vessel or other floating craft, from which pollutants are or may be discharged. This term does not include agricultural storm water discharges and return flows from irrigated agriculture.” The term “nonpoint source” is not defined by the CWA; however, it labels agricultural activities, including runoff from fields and forest lands as nonpoint sources and it is widely understood to be the type of pollution that arises from many dispersed activities over large areas and is not traceable to any single discrete source (Laitos and Ruckriegle 2013).

Tile outfalls are a “discrete conveyance” by a “pipe” as described under the CWA definition of point source. The CWA exemptions for irrigation or stormwater discharges should not apply to most row crop fields in South Dakota given that many of the fields are not irrigated and that tile flow occurs separately from storm water runoff during precipitation events. If not for the tile pipe conveyance, subsurface agricultural pollution would likely return to surface waters in a much more delayed and filtered fashion. Unlike nonpoint source runoff, pollutants in tile are collected by a network of pipes and thus could be treated prior to discharge. Thus, we recommend support for the contention that tile drainage is point source pollution. Such a stance by the Service would not be unprecedented. In 2012, the Service recommended to the Minnesota Board of Water and Soil Resources that Minnesota change its policy to recognize agricultural tile drainage outlets as a “point source” discharge for water quality purposes (FWS 2012b).

The distinction of tile drainage as point source or nonpoint source is important given that the CWA includes federal regulation of point sources but leaves regulatory discretion of nonpoint sources solely to the states (Laitos and Ruckriegle 2013). Under the CWA the states are directed but not required to control nonpoint sources from agriculture. Thus, states commonly address agricultural nonpoint source pollution strictly on a voluntary basis. Consequently, more than 40 years after enactment of the CWA, and more than 25 years after Congress amended it to institute a program to control nonpoint source pollution, a majority of our nation’s waters continue to be impaired (USGAO 2013). The scale of tile drainage projects nowadays, where entire sections of land are pattern tiled, is much greater than the clay tile installations of the past. Collectively, subsurface tile drainage likely discharges much more nitrates, pesticides, and selenium than permitted point source facilities in South Dakota. Agricultural tile drainage should be considered an industrial practice where agricultural wastewater laden with pesticides and excess nutrients are mixed with groundwater pollutants prior to discharge in a manner that is much different and separate from nonpoint source surface runoff pollution.

If Not Point Source then Regulate as Nonpoint Source

States have authority under the CWA to regulate agricultural nonpoint sources of water pollution (Laitos and Ruckriegle 2013). States may issue permits for nonpoint source pollution under their NPDES program (Thomas and Leighton-Schwartz 1990). California has performance based policies designed to limit nutrient pollution by requiring dischargers to follow nonpoint source implementation plans (Bryant and Goldman-Carter 2016). Tile drainage is a defined water conveyance system with discrete outlets at which nutrient concentrations in water flows could be measured and taxed directly (Bryant and Goldman-Carter 2016). Thus, if politically possible, South Dakota could require permits for tile outfall discharges and set effluent limits or pollution taxes. Instead of having optional country level drainage districts or no drainage authority, South Dakota could have an optional county level system with the state government filling in when counties choose to not have drainage boards. The state or county drainage district could have the authority to administer permits and monitor for nitrates at key watershed locations where tile effluent is likely to affect surface waters of the state including streams, rivers, lakes and wetlands. Watersheds contributing acceptable concentrations of nitrate could receive positive incentives (e.g., reduced permit and monitoring fees), whereas watersheds high in nitrates would be targeted for water quality BMP improvement cost-shares but could also face negative incentives such as increased permit and monitoring fees if tile effluent limitation exceedances are not addressed. Such a mix of voluntary and non-voluntary measures at a local watershed scale would encourage farming communities to be more independently responsible for keeping and maintaining water quality and would level the playing field between those watersheds with inhabitants that tend to pollute and those that are successfully using BMPs to protect water quality. Under the current voluntary system, a neighbor that chooses to plant cover crop can be at increased risk for the following crop and thus at a disadvantage to the neighbor that doesn’t plant a cover crop (University of Illinois 2010). Although the establishment of regulatory controls over tile drainage would face tremendous political barriers, without oversight to address harmful tile outfall discharges affected land owners may have to seek mitigation for water quality related damages through the courts.

Pursue Mitigation for Injury to Public Lands from Tile Drainage

The Madison WMD manages WPAs as wildlife habitat and act under the Department of the Interior as trustees that are responsible for protecting WPAs as public resources for the benefit of all Americans. Our study results indicate that pollutants discharged by tile outfalls directly into WPAs can result in water quality degradation and injury to wetland habitat and Refuge wildlife. Madison WMD staff has often provided letters and/or attended county drainage board hearings to object to receiving agricultural tile effluent from neighboring properties; however, such projects have always proceeded without modification. Although we recommend that Madison WMD continue to use the latest scientific information to support concerns expressed to county drainage boards, we also recommend consideration of legal action.

Excessive nutrient loading from tile outfalls that result in measurable habitat degradation may be a violation of state and federal environmental laws (Davidson and Weeks 1997; EPA 2003b). In counties with drainage boards, South Dakota Codified Law (SDCL) 46A-10A-20 requires the permitting authority (county) to make determinations with regard to the effects of the proposed drainage, including that "The drainage creates no unreasonable hardship or injury to the owner of the land receiving the drainage." Such rulings by the county could be appealed in court. South Dakota's water quality standards Section 74:51:01:09 (Nuisance aquatic life) states that "Materials which produce nuisance aquatic life may not be discharged or caused to be discharged into surface waters of the state in concentrations that impair a beneficial use or create a human health problem." And Section 74:51:01:12 (Biological integrity of waters) states that "all waters of the state must be free from substances, whether attributable to human-induced point source discharges or nonpoint source activities, in concentrations or combinations which will adversely impact the structure and function of indigenous or intentionally introduced aquatic communities." The CWA has similar narrative criteria (54 F.R.28627,

1989) and Section 101 (a) states that “The objective of this Act is to restore and maintain the chemical, physical, and biological integrity of the Nation's waters.” All WPA wetland sites are “waters of the state” and many also be “waters of the U.S.” based on site-specific wetland jurisdictional determinations.

Recommended Future Priority Research

This study focused primarily on documenting the extent to which various contaminants associated with tile drainage were being released into the environment and moving into the aquatic food web, thus posing potential hazards to wildlife, particularly breeding waterfowl. Only a minimal set of data for mallard eggs was collected for assessing the likelihood that the food web selenium hazard was being translated into actual risk of reproductive impairment among breeding waterfowl. That minimal set of data delineated boundaries of “statistical plausibility” that still include troubling worst case scenarios (up to 53% affected hens). Therefore, it is recommended that a rigorously designed study focused on more comprehensively sampling mallard eggs for selenium concentrations and monitoring the associated reproductive performance of exposed mallard hens be considered the highest priority for future research efforts.

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APPENDIX A: ADDITIONAL TABLES

Table A.1. Additional study sites including tile outfalls that were found but not included for routine monitoring, Madison Wetland Management District, South Dakota, 2012–2014.

WPA Name	Site ID	Site Category	County	Latitude	Longitude	Notes
Benson	Bens1	Tile Outfall	Moody	44.04837	-96.83823	Tile outfall at fenceline
Black Slough	Blks1	Tile Outfall	Deuel	44.54489	-96.48071	Tile outfall to road right-of-way that enters WPA
Black Slough	Blks2	Tile Outfall	Deuel	44.55087	-96.46628	Tile that enters WPA from road ditch that also drains feedlot area
Clear Lake	CleaA1	Tile Wetland	Minnehaha	43.77242	-97.00496	Lake that receives tile discharges
Clear Lake	Clea1	Tile Outfall	Minnehaha	43.77306	-97.00485	Outfall not sampled on private ground
Clear Lake	Clea3	Tile Outfall	Minnehaha	43.77208	-97.00484	Southern most outfall at WPA border
Heinricy	Hein1	Tile Wetland	Moody	44.00608	-96.82715	Ditch enters WPA that likely receives tile, cannot see outfall from WPA
Johnson II (H)	Hejo3	Ditch	Deuel	44.56247	-96.45263	Ditch enters WPA that likely receives tile, cannot see outfall from WPA
Kattke	Katt1	Tile Outfall	Lake	44.17397	-97.20992	Tile outfall onto private wetland that joins WPA
Lund	Lund1	Tile Wetland	Brookings	44.34069	-96.98921	Wetland likely receives tile from the north, cannot see outfall from WPA
Madison	Madi2	Ditch	Lake	43.96149	-97.08073	Ditch that likely receives tile, cannot see outfall from WPA
Murfield	Murf1	Tile Outfall	Lake	44.16720	-96.99070	Tile outfall usually submerged in the road ditch, not sampled
Peterson	Pete1	Tile Outfall	Hamlin	44.55849	-97.46138	Tile outfall, only sampled once, away from other sites
Petri I	1Petr cul	Culvert	Minnehaha	43.57209	-97.05915	Culvert that enters Rehfeldt Slough and Petri I WPA
Struckman	Stru1	Tile Wetland	Hamlin	44.80011	-97.41866	Ditch enters WPA that likely receives tile, cannot see outfall from WPA
Swartz*	Swar1	Tile Outfall	Lake	44.08691	-96.90892	Tile outfall in road ditch that drains to Swartz GPA
Wenk	Wenk1	Tile Outfall	Brookings	44.2467717	-97.128088	Tile that enters WPA from bioreactor located on private ground to the south.
Wenk	Wenk1A	Tile Wetland	Brookings	44.24845	-97.12572	Wetland that receives Wenk1 effluent after approximately 300 meters of ditch
Wern	Wern1	Ditch	Minnehaha	43.68860	-97.07895	Ditch that received tile outfall (Whof1) that was removed

Note: * = site is a Game Production Area managed by South Dakota, not a federal Waterfowl Production Area (WPA).

Table A.2. Water quality measurements at select study sites, Madison Wetland Management District, South Dakota, 2013–2014.

				YSI Model 6820-V2 Readings			
Site	Date	Time	Turbidity (NTUs)	Water Temperature (ºC)	Specific Conductivity (µs/cm)	pH	Chlorophyll-a (µg/L)
2Petr1A	4/3/2013	14:10	18.7	6.31	Error	7.94	18.4
2Petr1A	5/16/2013	17:04	NC	20	3490	8.41	44.2
2Petr1A	5/21/2013	9:36	2.47	12.82	3431	8.43	29.3
2Petr1A	6/12/2013	11:29	0.5	19.93	2179	8.7	8.3
2Petr1A	6/27/2013	13:04	2.65	25.83	1503	8.66	8.8
2Petr1A	7/10/2013	9:46	4.21	22.63	3264	9.35	10.8
2Petr1A	7/22/2013	10:46	7.87	23.62	3538	8.31	37.7
2Petr1A	8/12/2013	12:51	7.28	28.3	2680	8.37	94.5
Ache1	6/12/2013	10:20	0.53	13.31	1001	7.45	1.6
Ache1A	5/16/2013	15:40	NC	21.25	2361	8.43	54.2
Ache1A	5/21/2013	10:51	6.42	15.97	2305	8.18	28.8
Ache1A	6/12/2013	10:07	2.04	19.57	1993	9.24	< 0.1
Ache1A	6/27/2013	14:25	3.94	29.52	2113	9.15	8
Ache1A	7/10/2013	10:52	4.64	24.17	2490	8.79	20.8
Ache1A	7/22/2013	13:11	4.35	29.92	2879	9.02	21.4
Ache1A	8/12/2013	11:51	8.81	25.22	2104	8.64	24.7
Adam1	5/7/2013	13:38	1.93	10.94	Error	8.21	44.8
Adam1	5/15/2013	14:59	NC	9.46	831	8.25	20.6
Adam1	6/11/2013	8:41	2.41	14.32	669	7.47	16.1
Adam1	7/9/2013	17:39	NC	21.44	568	7.84	14
Adam1	7/23/2013	14:35	NC	18.69	772	8.23	1.7
Bols1	5/8/2013	8:30	1.47	6.93	Error	7.36	< 0.1
Bols1	5/15/2013	20:06	NC	NC	NC	NC	NC
Bols1	5/20/2013	15:20	4.37	9.06	1596	7.57	3.5
Bols1	6/10/2013	14:35	1.38	15.32	1599	7.12	7.4
Bols1	6/26/2013	15:21	17.7	23.48	1212	7.51	10.5
Bols1	7/10/2013	13:35	1.09	17.42	1926	7.04	6.1
Bols1	8/14/2013	8:40	NC	18.67	1678	6.98	6.7
Bols1A	5/15/2013	19:51	NC	20.34	1857	7.85	55.8
Bols1A	5/20/2013	15:15	4.54	18.71	973	7.78	21.4
Bols1A	6/10/2013	14:46	1.17	18.54	1839	7.15	17
Bols1A	6/26/2013	15:28	1.57	27.74	1753	7.79	13.2
Bols1A	7/10/2013	13:52	3.62	23.76	1912	7.36	84.1
Bols1A	7/24/2013	8:00	23.2	19.3	1904	7.51	59.3
Bols1A	8/14/2013	9:07	43.5	15.85	1907	7.29	194.1
Buff1	5/16/2013	13:30	NC	21.89	3013	8.24	15.8
Buff1	5/21/2013	11:50	2.39	16.58	2804	8.28	21.3
Buff1	6/12/2013	9:10	1.01	19.72	1991	7.76	15
Buff1	6/27/2013	15:11	29.1	28.67	2003	9.35	11.3
Buff1	7/10/2013	11:50	2.7	22.38	2082	9.65	11.8
Buff1	7/22/2013	15:17	6.09	27.79	2369	9.06	42.9
Buff1	8/12/2013	10:46	4.29	22.12	2012	8.41	35.3
Buff1T	5/16/2013	14:40	NC	9.48	1555	7.89	30.6
Buff1T	6/12/2013	9:19	NC	11.24	1845	7.6	2.5
Buff1T	7/10/2013	11:38	NC	19.69	2020	7.62	4.4
Buff1T	8/12/2013	11:33	NC	16.16	2075	7.77	1.5
Clea2	6/25/2013	13:56	NC	17.37	8	7.46	< 0.1
Clea2	8/14/2013	16:40	NC	17.1	1396	7.65	1
Cote1	5/7/2013	10:17	4.2	13.73	Error	8.43	12.4
Cote1	5/14/2013	13:58	NC	20.14	1897	8.87	23.4
Cote1	5/20/2013	9:55	3.12	18.75	1863	8.93	11.6
Cote1	6/11/2013	12:56	4.89	21.55	1811	8.13	5.1
Cote1	6/26/2013	9:30	2.48	24.97	1635	8.94	5.6
Cote1	7/9/2013	9:16	1.37	24.67	1700	9.33	6.7
Cote1	7/23/2013	10:39	3.04	22.57	1640	9.36	6.3
Cote1	8/13/2013	12:41	0.99	24.55	1693	9.69	52
Dryl1	5/15/2013	17:20	NC	21.65	2511	8.67	NC
Dryl1	6/11/2013	19:37	NC	15.94	2943	7.22	4.4
Dryl1	7/9/2013	19:41	NC	18.3	2740	7.17	5.8

Table A.2. Continued.

Site	Date	Time	Turbidity (NTUs)	YSI Model 6820-V2 Readings: Water Temperature (ºC)	Specific Conductivity (µs/cm)	pH	Chlorophyll-a (µg/L)
Dryl3	6/11/2013	20:02	NC	9.75	2149	7.11	1.4
Dryl3	7/9/2013	19:54	NC	16.07	2088	7.17	3.1
Gerk1	4/2/2013	15:30	NC	4.66	Error	Error	11.5
Gerk1	5/8/2013	9:30	1.63	7.82	Error	7.53	3.6
Gerk1	5/13/2013	19:05	NC	17.11	Error	7.38	48.6
Gerk1	6/10/2013	13:07	1.44	11.63	2215	7.27	19.9
Gerk1	6/26/2013	NC	4.37	NC	NC	NC	NC
Gerk1	7/8/2013	17:41	NC	29	2253	7.64	13.6
Gerk1A	5/8/2013	9:30	4.47	13	Error	7.92	13.1
Gerk1A	5/13/2013	19:30	NC	18.93	Error	8.44	29.9
Gerk1A	5/20/2013	16:00	1.97	19.21	2283	7.79	14.4
Gerk1A	6/10/2013	13:07	1.5	19.72	2172	8.47	8.2
Gerk1A	6/26/2013	14:17	2.93	13.35	2120	7.74	4
Gerk1A	7/8/2013	18:12	3.15	27.8	2278	8.18	83.5
Gerk1A	7/24/2013	10:05	72.1	21.94	2525	7.94	62.2
Gerk1A	8/12/2013	17:46	23.1	28.32	2565	8.1	218.1
Hejo1	4/2/2013	10:53	NC	2.95	Error	7.71	3.3
Hejo1	5/7/2013	13:10	0.33	8.25	Error	7.88	1.3
Hejo1	5/15/2013	14:24	NC	6.16	959	8.1	1.5
Hejo1	5/20/2013	12:49	0.44	6.68	909	8.09	1.3
Hejo1	6/11/2013	9:10	0.31	9.01	1001	7.37	< 0.1
Hejo1	6/26/2013	12:03	32.9	15.41	741	7.56	5.2
Hejo1	7/9/2013	17:12	0.47	14.96	1033	7.41	2
Hejo1	7/23/2013	13:11	10.7	14.72	893	7.97	2.2
Hejo1A	5/15/2013	14:00	NC	16.6	1084	7.88	10.1
Hejo1A	5/20/2013	12:55	6.81	18.64	1099	7.71	12.3
Hejo1A	6/11/2013	9:25	1.88	18.02	970	7.53	12.5
Hejo1A	6/26/2013	11:48	2.27	24.49	787	7.7	6.9
Hejo1A	7/9/2013	16:56	2.04	24.96	881	7.49	46.5
Hejo1A	7/23/2013	13:27	2.84	23.16	840	7.57	22.9
Hejo1A	8/13/2013	9:01	24.4	18.33	898	7.5	16.6
Hejo2	6/11/2013	9:36	0.59	10.07	1171	7.45	1.4
Hejo2	7/9/2013	16:33	NC	16.01	1202	7.57	2.3
John1	5/7/2013	12:40	15.2	15.92	Error	9.83	32.6
John1	5/14/2013	20:05	NC	20.18	627	9.66	46.3
John1	5/20/2013	12:18	3.88	18.77	669	8.72	8.4
John1	6/11/2013	10:09	10.8	18.05	638	7.8	7.7
John1	6/26/2013	11:20	14.9	23.68	454	7.88	8.1
John1	7/9/2013	15:12	5.4	26.65	521	8.75	8.7
John1	7/23/2013	12:30	3.9	23.32	559	8.13	8.6
John1	8/13/2013	9:42	6.32	21.88	555	8.7	13.4
Long1	6/12/2013	8:36	NC	10.25	1577	7.59	25.1
Long2	4/23/2013	15:11	NC	5.1	NC	7.7	1
Lost1	4/3/2013	11:03	28.3	5.13	Error	7.42	27.5
Lost1	5/16/2013	16:28	NC	20.21	1416	10.12	28.7
Lost1	5/21/2013	10:16	10.4	16.69	1456	9.11	5.4
Lost1	6/12/2013	10:53	2.04	20.59	2245	7.78	6.8
Lost1	6/27/2013	13:30	8.85	27.22	2530	8.7	7.5
Lost1	7/10/2013	10:16	2.33	24.92	2629	8.02	7.1
Lost1	7/22/2013	12:38	2.93	26.97	2689	8.21	10.6
Lost1	8/12/2013	13:19	3.81	25.12	2752	8.4	6.9
Mund1	5/7/2013	12:15	2.51	13.97	Error	7.49	< 0.1
Mund1	5/14/2013	16:15	NC	18.73	851	7.52	27.8
Mund1	5/20/2013	11:55	3	16.8	845	7.56	13.8
Mund1	6/11/2013	10:52	1.99	17.79	873	7.45	8.6
Mund1	6/26/2013	10:52	4.76	24.12	531	7.83	9.8
Mund1	7/9/2013	14:14	5.21	24.08	532	7.22	28.4
Mund1	7/23/2013	11:43	90.9	19.56	611	6.86	108.3
Mund1	8/13/2013	10:27	5.77	16.49	720	7.38	59.7

Table A.2. Continued.

Site	Date	Time	Turbidity (NTUs)	YSI Model 6820-V2 Readings Water Temperature (ºC)	Specific Conductivity (µs/cm)	pH	Chlorophyll-a (µg/L)
Mund1T	5/14/2013	16:58	NC	9.31	662	7.69	< 0.1
Mund1T	6/11/2013	10:39	3.1	15.52	526	7.37	18.1
Mund1T	7/9/2013	13:41	1.24	21.64	504	7.34	9.6
Mund1T	7/23/2013	12:05	13.8	17.71	759	7.24	< 0.1
Mund1T	8/13/2013	10:42	4.67	16.56	863	7.52	20.2
Nels1	5/7/2013	10:58	1.39	12.83	Error	7.63	14.1
Nels1	5/14/2013	18:45	NC	16.61	580	7.79	15.4
Nels1	5/20/2013	10:55	1.27	14.57	681	7.78	18.3
Nels1	6/11/2013	12:09	1.32	17.32	36	7.39	< 0.1
Nels1	6/26/2013	10:05	2.26	21.51	527	7.51	15.6
Nels1	7/9/2013	11:52	4.85	20.79	661	7.55	17.7
Nels1	7/23/2013	8:38	14.8	16.13	819	7.66	11.9
Nels1	8/13/2013	11:38	42.6	15.43	951	7.78	19
Nels1A	5/7/2013	11:00	1.44	11.42	Error	7.63	9.9
Nels1A	5/14/2013	18:52	NC	17.57	569	8.3	21.5
Nels1A	5/20/2013	10:55	2.43	17.48	648	8.28	18.9
Nels1A	6/11/2013	12:09	1.4	17.79	662	7.68	15
Nels1A	6/26/2013	10:06	2.16	21.69	655	7.56	14.7
Nels1A	7/9/2013	12:09	3.32	21.48	640	7.67	35.4
Nels1A	7/23/2013	8:43	2.5	16.12	819	7.66	12.1
Nels1A	8/13/2013	11:47	4.7	21.35	663	7.94	16
Pets1	7/10/2013	16:53	NC	32.27	1126	9.56	46.7
Pett1	4/2/2013	16:28	NC	16.21	Error	9.12	17
Pett1	5/13/2013	15:35	NC	20.34	Error	8.48	5.9
Pett1	5/20/2013	17:00	2.96	18.36	1678	8.2	8
Pett1	6/10/2013	11:20	0.85	18.58	1492	7.81	11.1
Pett1	6/26/2013	13:22	1.68	28.34	1444	8.61	8.8
Pett1	7/8/2013	15:30	1.92	23.58	1585	7.04	37.9
Pett1	7/24/2013	11:20	4.99	19.49	1393	7.36	89.3
Pett1	8/12/2013	15:40	2.97	22.02	1482	7.08	81.1
Pitt1	5/7/2013	15:05	18.2	18.71	Error	9.17	< 0.1
Pitt1	5/15/2013	16:05	NC	19.67	1290	8.05	24.4
Pitt1	5/20/2013	14:15	22.3	20.16	1311	7.83	28.2
PItt1	6/10/2013	15:41	2.4	20.88	1290	7.85	8.3
Pitt1	6/26/2013	16:29	2.9	26.73	1018	8.45	7.6
Pitt1	7/9/2013	20:38	NC	27.56	1067	8.77	16.2
Pitt1	7/23/2013	15:40	2.3	25.43	1052	8.16	9.4
Pitt1	8/14/2013	12:12	1.15	22.34	1049	8.79	24.4
Rams1	5/8/2013	10:10	9.07	13.67	Error	8.27	45.9
Rams1	5/13/2013	20:22	NC	17.28	Error	8.21	27.8
Rams1	5/20/2013	16:20	2.44	19.68	2512	7.92	17.3
Rams1	6/10/2013	13:46	2.71	19.85	2312	8.55	10.3
Rams1	6/26/2013	14:40	2.33	27.27	1662	8.69	5.9
Rams1	7/8/2013	19:12	NC	31.11	2503	9.11	10
Rams1	7/24/2013	9:30	2.63	23.71	2573	8.67	6.9
Rams1	8/12/2013	17:07	1.47	27.06	2673	9.55	5.4
Reev1	4/2/2013	17:08	NC	5.94	Error	7.58	4.3
Reev1	5/6/2013	16:05	NC	8.1	NC	7.55	1
Reev1	6/12/2013	7:05	NC	9.62	853	7.49	4.4
Reev1	7/10/2013	7:20	NC	13.57	1476	7.41	23
Reev1	8/14/2013	13:51	NC	16.75	1318	7.59	1.7
Schae1	5/16/2013	15:15	NC	20.47	1464	8.89	48.7
Schae1	5/21/2013	11:21	27.3	16.86	1411	8.82	52.7
Schae1	6/12/2013	9:43	31.2	19.58	1373	8.56	76
Schae1	6/27/2013	14:53	40.7	28.26	1402	8.82	51.2
Schae1	7/10/2013	11:20	30.2	26.23	1447	8.95	77.5
Schae1	7/22/2013	14:46	90.6	30.17	1496	8.93	105.5
Schae1	8/12/2013	11:11	33.5	24.16	1382	8.97	141.3
Schaf1	5/7/2013	9:47	1.79	14.27	Error	8.6	4.3

Table A.2. Continued.

Site	Date	Time	Turbidity (NTUs)	YSI Model 6820-V2 Readings Water Temperature (ºC)	Specific Conductivity (µs/cm)	pH	Chlorophyll-a (µg/L)
Schaf1	5/14/2013	14:43	NC	21.42	1390	8.76	7.8
Schaf1	5/20/2013	9:40	5.71	19.21	1440	8.35	18.9
Schaf1	6/11/2013	13:20	2.27	20.97	1520	8.19	4
Schaf1	6/26/2013	9:13	1.54	24.43	1515	8.06	5.4
Schaf1	7/9/2013	8:39	3.02	25.28	1655	8	15.6
Schaf1	7/23/2013	10:10	5.29	22.28	1647	7.86	11.3
Schaf1	8/13/2013	12:27	17.8	23.32	1752	7.98	5.8
Thor1	6/12/2013	Thor1	NC	10.13	1225	7.35	1.6
Volk1	5/16/2013	17:35	NC	19.41	3045	7.9	46.7
Volk1	5/21/2013	9:05	16.8	14.05	2904	7.85	28.5
Volk1	6/12/2013	12:13	15.3	19.33	2239	7.42	24.5
Volk1	6/27/2013	12:37	110	26.73	2714	7.54	28.5
Volk1	7/10/2013	9:15	72	22.32	3520	7.65	117.2
Volk1	7/22/2013	12:09	32.9	27.83	3717	7.75	52.4
Volk1	8/12/2013	12:15	33.5	22.19	3863	7.44	64.3
Zieg1	5/7/2013	15:50	NC	18.61	Error	8.27	8.4
Zieg1	5/15/2013	18:10	NC	22.12	1442	8.32	12.1
Zieg1	5/20/2013	14:40	2.38	20.01	1514	7.87	16.6
Zieg1	6/10/2013	15:15	1.18	18.72	1633	7.67	12.8
Zieg1	6/26/2013	16:00	2.38	26.63	998	7.83	10.3
Zieg1	7/10/2013	14:32	6.53	28.88	1275	7.54	45
Zieg1	7/23/2013	16:14	7.19	27.9	1404	7.79	52.8
Zieg1	8/14/2013	10:50	6.4	20.72	1608	7.54	24.8
2Petr1A	5/7/2014	15:53	1.53	17.97	2125	8.27	8.4
2Petr1A	5/19/2014	8:25	2.24	13.16	2193	7.98	10.1
2Petr1A	6/11/2014	15:02	2.63	23.73	1322	8.31	13.19
2Petr1A	6/23/2014	7:50	7.29	19.5	757	7.33	8.7
2Petr1A	7/9/2014	13:05	5.61	23.2	935	7.47	20.4
2Petr1A	7/28/2014	9:43	NC	18.2	1213	7.58	22.6
2Petr1A	8/12/2014	7:49	61.20	14.4	1244	7.86	30.5
2Petr1A	8/25/2014	8:13	9.64	17.9	1157	7.52	29.5
Ache1	6/11/2014	13:31	NC	15.85	1125	7.32	1
Ache1	6/23/2014	9:16	NC	13.9	1018	7.26	1
Adam1	5/6/2014	14:35	NC	9.0	866	7.99	19.2
Adam1	5/20/2014	12:29	NC	12.0	901	7.93	23.1
Adam1	6/10/2014	14:26	NC	18.1	884	7.56	8.1
Adam1	6/24/2014	12:50	NC	20.0	664	7.36	9.4
Adam1	7/8/2014	14:35	NC	16.9	697	8.27	1.8
Adam2	9/10/2014	11:26	NC	16.7	1217	7.93	2.6
Bens1	6/9/2014	17:43	NC	12.0	1451	7.20	3
Bols1	5/6/2014	16:40	NC	4.4	1891	7.48	2.4
Bols1	6/10/2014	16:45	NC	16.4	1263	7.11	7.8
Bols1	6/23/2014	14:38	NC	20.4	783	7.24	7.4
Bols1	7/8/2014	16:51	NC	18.9	1167	7.00	10.5
Bols1	7/30/2014	10:43	NC	19.3	1128	7.35	6.8
Bols1	8/11/2014	14:10	NC	20.5	1410	6.88	7.3
Bols1	8/25/2014	14:43	NC	20.2	1081	7.19	7.6
Bols1A	5/6/2014	16:48	2.07	12.7	1822	7.84	21.2
Bols1A	5/19/2014	14:24	1.46	15.5	1842	7.64	5
Bols1A	6/10/2014	17:10	1.97	22.5	1567	7.65	4.4
Bols1A	6/23/2014	14:54	1.33	26.4	1330	7.65	4.2
Bols1A	7/8/2014	17:14	6.66	22.7	1190	7.43	> 500
Bols1A	7/30/2014	10:53	6.78	19.3	1337	7.31	63.5
Bols1A	8/11/2014	14:28	9.64	21.4	1250	7.63	9.6
Bols1A	8/25/2014	14:50	7.12	21.4	1213	7.36	29.1
Buff1	5/7/2014	13:40	1.72	15	1986	8.71	13.2

Table A.2. Continued.

				YSI Model 6820-V2 Readings			
Site	Date	Time	Turbidity (NTUs)	Water Temperature (°C)	Specific Conductivity (µs/cm)	pH	Chlorophyll-a (µg/L)
Buff1	5/19/2014	10:10	1.02	13.99	1871	8.26	8.6
Buff1	6/11/2014	13:11	6.66	22.81	1753	8.37	12.12
Buff1	6/23/2014	10:13	Error	21.3	1660	7.65	14.9
Buff1	7/9/2014	16:03	4.08	26.3	error	7.84	30.1
Buff1	7/28/2014	11:48	NC	20.7	1394	7.86	24.6
Buff1	8/12/2014	9:53	9.66	19.2	1534	7.89	34.1
Buff1	8/25/2014	11:07	3.86	20.4	1380	7.86	29.6
Buff1T	6/11/2014	13:01	NC	15.89	2062	7.25	0.28
Buff1T	6/23/2014	10:05	NC	12.9	2239	7.52	0.9
Buff1T	7/9/2014	16:11	NC	13.2	1014	7.30	1
Clea2	7/9/2014	14:20	NC	10.9	959	7.40	0.6
Clea2	7/28/2014	10:50	NC	14.7	1059	7.72	3.2
Clea2	8/12/2014	9:00	NC	14.5	1104	7.70	2.4
Clea2	8/25/2014	9:18	NC	13.8	1019	7.60	1.7
Cote1	5/6/2014	10:35	2.73	11.8	1102	8.65	11.2
Cote1	5/20/2014	8:29	0.92	15.8	1186	8.34	3.4
Cote1	6/10/2014	9:48	0.99	19.5	1366	7.81	5.3
Cote1	6/24/2014	8:42	1.32	22.7	1084	7.78	5.5
Cote1	7/8/2014	10:57	1.47	22.2	1135	7.91	4.8
Cote1	7/29/2014	15:47	6.51	21.9	1232	8.20	9.8
Cote1	8/11/2014	8:42	4.77	19.6	1189	8.03	7.1
Cote1	8/26/2014	9:10	1.89	19.2	1185	8.23	14.5
Dryl1	6/10/2014	16:20	NC	18.0	2813	7.28	7.1
Dryl3	6/10/2014	16:00	NC	10.1	2269	7.10	5
Dryl3	6/23/2014	16:32	NC	13.9	2008	7.50	1.4
Dryl3	7/8/2014	16:11	NC	13.7	1895	7.34	3.2
Dryl3	8/25/2014	16:38	NC	16.3	1879	7.30	3.7
Gerk1	6/11/2014	9:15	NC	12.5	2487	7.40	3.1
Gerk1A	5/7/2014	8:50	2.34	11.7	2555	8.62	15.8
Gerk1A	5/19/2014	13:29	1.23	15.4	2399	8.88	4.9
Gerk1A	6/11/2014	8:55	2.51	19.4	2421	7.76	16.9
Gerk1A	6/23/2014	13:42	3.84	25.9	2231	7.85	10.3
Gerk1A	7/9/2014	9:15	11.40	20.3	2162	7.49	38.5
Gerk1A	7/30/2014	11:53	6.28	23.4	2341	8.25	58
Gerk1A	8/12/2014	12:48	11.90	24.4	2442	8.14	72.8
Gerk1A	8/25/2014	13:10	11.60	23.4	2214	7.90	107.4
Habe1	6/11/2014	10:05	NC	15.4	4513	7.80	1.3
Habe1	6/23/2014	12:50	NC	13.7	3731	7.27	0.6
Habe1	7/9/2014	10:07	NC	14.3	3762	7.27	15.4
Habe1	8/25/2014	14:09	NC	16.2	3991	7.93	3.8
Hejo1	5/6/2014	13:57	NC	5.7	886	7.74	1.4
Hejo1	6/10/2014	13:20	NC	9.5	994	7.66	2.3
Hejo1	6/24/2014	11:50	NC	12.3	858	7.53	0.9
Hejo1	7/8/2014	13:19	NC	12.9	826	7.60	0.2
Hejo1A	5/6/2014	14:10	2.09	12.9	788	8.32	7.9
Hejo1A	5/20/2014	12:00	1.25	17.3	804	7.82	8.2
Hejo1A	6/10/2014	13:30	1.55	21.4	697	8.04	4.6
Hejo1A	6/24/2014	12:05	1.33	24.2	573	7.63	1.2
Hejo1A	7/8/2014	14:00	6.24	21.9	712	7.44	7.9
Hejo1A	7/29/2014	9:05	3.60	17.9	9	8.28	1
Hejo1A	8/11/2014	11:35	11.70	19.9	596	7.69	8.7
Hejo1A	8/26/2014	12:40	35.80	18.8	613	7.51	29.2
Hejo2	6/10/2014	13:55	NC	13.1	1095	7.40	1.4
Hejo2	6/24/2014	12:12	NC	24.2	573	7.63	1.2
Hejo2	7/8/2014	14:08	NA	21.9	712	7.44	7.9
John1	5/6/2014	13:25	4.80	12.5	517	8.62	10.7
John1	5/20/2014	11:24	2.55	17.3	533	8.65	5.6
John1	6/10/2014	12:40	2.97	20.1	531	8.04	11.8
John1	6/24/2014	11:20	3.09	23.8	459	8.10	9.1

Table A.2. Continued.

				YSI Model 6820-V2 Readings			
Site	Date	Time	Turbidity (NTUs)	Water Temperature (ºC)	Specific Conductivity (µs/cm)	pH	Chlorophyll-a (µg/L)
John1	7/8/2014	12:45	2.97	22.1	486	8.21	7.9
John1	7/29/2014	10:37	6.07	22.8	7	8.31	1.9
John1	8/11/2014	11:00	9.24	20.1	496	7.99	17.3
John1	8/26/2014	12:06	8.09	21.5	493	8.40	21
Long1	6/9/2014	14:51	NC	10.3	1405	7.08	10.3
Long1	7/7/2014	15:25	NC	13.3	1160	7.01	18.5
Long2	6/9/2014	15:20	NC	10.3	2025	7.21	1.2
Long2	6/23/2014	10:45	NC	12.7	2433	7.51	< 0.1
Long2	7/7/2014	15:51	NC	12.9	1566	7.13	3.3
Lost1	5/7/2014	14:50	6.50	13.8	1755	8.64	16.2
Lost1	5/19/2014	9:03	3.42	13.9	1811	8.23	3.7
Lost1	6/11/2014	15:32	2.60	24.18	1760	8.78	5.03
Lost1	6/23/2014	8:25	Error	22.7	1721	7.36	6.1
Lost1	7/9/2014	13:40	1.70	25.7	error	7.40	6.6
Lost1	7/28/2014	10:10	NC	21.4	1371	7.58	6.2
Lost1	8/12/2014	8:15	3.00	20.6	1395	7.53	8.7
Lost1	8/25/2014	8:36	2.52	22.7	1284	7.48	7.6
Mund1	5/6/2014	12:50	4.68	11.2	750	7.57	23.1
Mund1	5/20/2014	10:42	1.40	15.6	786	7.63	5.6
Mund1	6/10/2014	11:50	1.17	18.2	589	7.40	8.7
Mund1	6/24/2014	10:46	1.06	22.7	377	7.34	7.1
Mund1	7/8/2014	12:14	0.92	18.5	407	7.31	7.9
Mund1	7/29/2014	12:05	3.91	16.3	379	7.57	24.4
Mund1	8/11/2014	10:38	9.92	17.4	187	7.64	13.9
Mund1	8/26/2014	11:31	24.50	16.1	393	7.57	13.1
Mund1T	5/6/2014	12:39	NC	4.79	769	7.44	2.9
Mund1T	6/10/2014	11:35	NC	14.17	557	7.61	8.9
Mund1T	6/24/2014	10:35	NC	18.31	417	7.4	7.3
Mund1T	7/8/2014	11:59	NC	20.62	359	7.37	8.6
Mund1T	7/29/2014	11:50	NC	16.2	578	7.47	47.9
Mund1T	8/11/2014	10:18	NC	16.6	533	7.38	9.2
Mund1T	8/26/2014	11:20	NC	16.7	662	7.48	6.1
Nels1	5/6/2014	11:24	NC	8.3	20	7.45	13
Nels1	5/20/2014	9:24	NC	12.3	455	7.43	13.8
Nels1	6/10/2014	10:35	NC	15.0	784	7.44	14
Nels1	6/24/2014	9:34	NC	19.3	399	7.30	12
Nels1	7/8/2014	9:34	NC	18.9	544	7.37	16.2
Nels1	8/11/2014	9:27	NC	17.2	450	7.40	23.8
Nels1	8/26/2014	10:07	NC	14.8	542	7.57	15.8
Nels1A	5/6/2014	11:30	1.23	9.0	645	7.55	10.6
Nels1A	5/20/2014	9:22	1.67	13.6	778	7.63	7.8
Nels1A	6/10/2014	10:31	2.39	15.6	796	7.66	34
Nels1A	6/24/2014	9:30	6.11	19.4	414	7.55	10.9
Nels1A	7/8/2014	9:30	2.02	19.7	529	7.73	15.3
Nels1A	7/29/2014	13:45	5.53	20.0	600	8.38	40.2
Nels1A	8/11/2014	9:22	5.59	17.8	461	7.88	25.7
Nels1A	8/26/2014	10:04	6.16	16.9	545	7.76	17
Pets1	6/9/2014	16:10	NC	13.6	1590	7.46	2.2
Pets1	7/7/2014	16:39	NC	15.0	1277	7.76	0.8
Pets1A	6/9/2014	16:25	97.60	23.3	1172	8.90	112
Pets1A	7/7/2014	16:36	NC	25.2	996	8.95	142.9
Pets1A	10/8/2014	11:25	NC	10.3	1045	9.13	101.5
Pett1	5/7/2014	10:40	1.17	11.5	754	7.78	18.9
Pett1	5/19/2014	12:00	0.83	13.0	754	7.51	12.5
Pett1	6/11/2014	10:57	0.63	19.4	1066	7.43	9.5
Pett1	6/23/2014	12:05	1.33	21.9	823	7.31	10.5
Pett1	7/9/2014	11:09	1.48	20.2	779	7.06	16.9
Pett1	7/28/2014	13:18	NC	19.9	799	7.49	28.9
Pett1	8/12/2014	11:52	1.80	20.1	831	7.57	16.6

Table A.2. Continued.

Site	Date	Time	Turbidity (NTUs)	YSI Model 6820-V2 Readings: Water Temperature (°C)	Specific Conductivity (μs/cm)	pH	Chlorophyll-a (μg/L)
Pett1	8/25/2014	12:20	5.78	18.8	716	7.65	16.3
Pitt1	5/6/2014	15:30	4.12	13.9	859	8.68	10.5
Pitt1	5/20/2014	13:42	1.11	18.7	911	8.68	4.8
Pitt1	6/10/2014	15:32	1.28	22.4	888	7.75	5.1
Pitt1	6/23/2014	15:55	1.33	26.5	957	8.09	6.1
Pitt1	7/8/2014	15:38	3.52	24.0	875	7.80	8.6
Pitt1	7/30/2014	7:53	12.80	20.7	920	8.03	24.4
Pitt1	8/11/2014	12:50	4.91	22.0	846	8.03	15.2
Pitt1	8/25/2014	15:59	11.70	22.7	808	8.18	36.8
Rams1	5/7/2014	8:10	1.97	12.0	2652	7.85	11
Rams1	5/19/2014	13:10	0.90	15.0	2627	8.24	2.8
Rams1	6/11/2014	8:34	4.15	20.8	2701	7.74	6.8
Rams1	6/23/2014	13:25	1.65	25.3	2649	8.35	5.4
Rams1	7/9/2014	8:38	4.94	20.9	2326	7.94	60.2
Rams1	7/30/2014	13:06	4.76	24.3	2444	8.18	24.7
Rams1	8/12/2014	12:34	4.42	22.6	2557	7.99	22.9
Rams1	8/25/2014	13:34	6.45	23.4	2394	8.49	12.6
Reev1	5/7/2014	11:12	NC	8.6	1151	7.52	2.5
Reev1	5/19/2014	11:41	NC	7.2	1396	7.60	1.4
Reev1	6/9/2014	17:15	NC	11.4	1415	7.29	2
Reev1	6/23/2014	11:47	NC	13.1	1464	7.55	1.2
Reev1	7/7/2014	17:47	NC	13.1	1221	7.27	10.3
Schae1	5/7/2014	13:10	6.36	14.6	1646	8.65	22.2
Schae1	5/19/2014	9:53	9.69	13.7	1575	8.71	10.7
Schae1	6/11/2014	12:35	4.27	23.4	1483	8.55	15.4
Schae1	6/23/2014	9:50	2.76	23.4	1591	8.41	10.5
Schae1	7/9/2014	15:35	3.39	24.7	785	8.92	21.9
Schae1	7/28/2014	11:30	NC	21.1	1291	8.84	14.5
Schae1	8/12/2014	9:31	4.04	19.6	1343	8.65	23.6
Schae1	8/25/2014	10:48	8.74	20.7	1196	8.59	22.2
Schaf1	5/6/2014	10:20	1.12	12.0	1355	8.57	11.9
Schaf1	5/20/2014	8:10	1.31	16.1	1363	8.37	4.3
Schaf1	6/10/2014	9:28	0.90	19.5	1403	7.90	3.6
Schaf1	6/24/2014	8:22	0.99	23.2	1083	7.96	3.9
Schaf1	7/8/2014	10:30	1.14	22.1	1115	7.99	6.4
Schaf1	7/29/2014	14:53	2.12	21.7	1195	8.22	11
Schaf1	8/11/2014	8:23	2.18	19.2	1194	8.20	6
Schaf1	8/26/2014	8:45	2.36	19.3	1140	8.10	8.5
Thor1	5/7/2014	11:36	NC	5.8	1337	7.79	0.8
Thor1	5/19/2014	11:16	NC	7.1	1348	7.61	< 0.1
Thor1	6/9/2014	16:58	NC	11.4	1353	7.28	0.7
Thor1	6/23/2014	11:35	NC	12.9	1707	7.60	0.3
Thor1	7/7/2014	17:12	NC	13.4	1128	7.23	0.3
Volk1	5/7/2014	15:20	2.81	18.4	3220	8.31	100.2
Volk1	5/19/2014	7:58	3.37	13.0	3322	7.62	31.2
Volk1	6/11/2014	14:30	11.40	24.16	3067	7.55	18.42
Volk1	6/23/2014	7:22	13.10	20.3	1840	7.14	26.2
Volk1	7/9/2014	12:30	47.80	19.7	1298	7.37	22.5
Volk1	7/28/2014	9:15	NC	17.6	1173	7.34	208.9
Volk1	8/12/2014	7:07	58.30	15.7	1289	7.33	60.7
Volk1	8/25/2014	7:29	101.00	18.2	1381	7.24	221.1
Zieg1	5/6/2014	16:00	1.06	15.0	1606	8.31	25
Zieg1	5/19/2014	14:58	0.94	16.4	1719	8.28	7.3
Zieg1	6/10/2014	18:00	1.51	22.0	1338	7.60	11
Zieg1	6/23/2014	15:25	1.82	27.1	1321	8.44	6.9
Zieg1	7/8/2014	17:46	4.30	24.0	1228	8.68	11.5
Zieg1	7/30/2014	8:57	2.51	19.1	1028	8.07	239.3
Zieg1	8/11/2014	13:38	4.96	20.6	919	8.91	14.3
Zieg1	8/25/2014	15:30	3.33	22.0	901	8.41	11.5

Note: NC = not collected, < = less than the detection limit.

Table A.3. Water quality measurements at matched sites within Madison Wetland Management District, South Dakota, 2013–2014.

Site	Date	Site Category	Time	HACH 21000Q Turbidity (NTUs)	YSI Model 6820-V2 Readings: Water Temperature (°C)	Specific Conductivity (µs/cm)	pH	Chlorophyll-a (µg/L)
Pitt1	5/7/2013	Reference Wetland	15:05	18.2	18.71	Error	9.17	0.05
Schaf1	5/7/2013	Reference Wetland	9:47	1.79	14.27	Error	8.6	4.3
Cote1	5/7/2013	Reference Wetland	10:17	4.2	13.73	Error	8.43	12.4
Pett1	5/13/2013	Reference Wetland	15:35	NC	20.34	Error	8.48	5.9
Schaf1	5/14/2013	Reference Wetland	14:43	NC	21.42	1390	8.76	7.8
Cote1	5/14/2013	Reference Wetland	13:58	NC	20.14	1897	8.87	23.4
Pitt1	5/15/2013	Reference Wetland	16:05	NC	19.67	1290	8.05	24.4
Lost1	5/16/2013	Reference Wetland	16:28	NC	20.21	1416	10.12	28.7
Pett1	5/20/2013	Reference Wetland	17:00	2.96	18.36	1678	8.2	8
Cote1	5/20/2013	Reference Wetland	9:55	3.12	18.75	1863	8.93	11.6
Schaf1	5/20/2013	Reference Wetland	9:40	5.71	19.21	1440	8.35	18.9
Pitt1	5/20/2013	Reference Wetland	14:15	22.3	20.16	1311	7.83	28.2
Lost1	5/21/2013	Reference Wetland	10:16	10.4	16.69	1456	9.11	5.4
Pitt1	6/10/2013	Reference Wetland	15:41	2.4	20.88	1290	7.85	8.3
Pett1	6/10/2013	Reference Wetland	11:20	0.85	18.58	1492	7.81	11.1
Schaf1	6/11/2013	Reference Wetland	13:20	2.27	20.97	1520	8.19	4
Cote1	6/11/2013	Reference Wetland	12:56	4.89	21.55	1811	8.13	5.1
Lost1	6/12/2013	Reference Wetland	10:53	2.04	20.59	2245	7.78	6.8
Schaf1	6/26/2013	Reference Wetland	9:13	1.54	24.43	1515	8.06	5.4
Cote1	6/26/2013	Reference Wetland	9:30	2.48	24.97	1635	8.94	5.6
Pitt1	6/26/2013	Reference Wetland	16:29	2.9	26.73	1018	8.45	7.6
Pett1	6/26/2013	Reference Wetland	13:22	1.68	28.34	1444	8.61	8.8
Lost1	6/27/2013	Reference Wetland	13:30	8.85	27.22	2530	8.7	7.5
Pett1	7/8/2013	Reference Wetland	15:30	1.92	23.58	1585	7.04	37.9
Cote1	7/9/2013	Reference Wetland	9:16	1.37	24.67	1700	9.33	6.7
Schaf1	7/9/2013	Reference Wetland	8:39	3.02	25.28	1655	8	15.6
Pitt1	7/9/2013	Reference Wetland	20:38	NR	27.56	1067	8.77	16.2
Lost1	7/10/2013	Reference Wetland	10:16	2.33	24.92	2629	8.02	7.1
Lost1	7/22/2013	Reference Wetland	12:38	2.93	26.97	2689	8.21	10.6
Cote1	7/23/2013	Reference Wetland	10:39	3.04	22.57	1640	9.36	6.3
Pitt1	7/23/2013	Reference Wetland	15:40	2.3	25.43	1052	8.16	9.4
Schaf1	7/23/2013	Reference Wetland	10:10	5.29	22.28	1647	7.86	11.3
Pett1	7/24/2013	Reference Wetland	11:20	4.99	19.49	1393	7.36	89.3
Lost1	8/12/2013	Reference Wetland	13:19	3.81	25.12	2752	8.4	6.9
Pett1	8/12/2013	Reference Wetland	15:40	2.97	22.02	1482	7.08	81.1
Schaf1	8/13/2013	Reference Wetland	12:27	17.8	23.32	1752	7.98	5.8
Cote1	8/13/2013	Reference Wetland	12:41	0.99	24.55	1693	9.69	52
Pitt1	8/14/2013	Reference Wetland	12:12	1.15	22.34	1049	8.79	24.4
Pitt1	5/6/2014	Reference Wetland	15:30	4.12	13.9	859	8.68	10.5
Cote1	5/6/2014	Reference Wetland	10:35	2.73	11.8	1102	8.65	11.2
Schaf1	5/6/2014	Reference Wetland	10:20	1.12	12.0	1355	8.57	11.9
Lost1	5/7/2014	Reference Wetland	14:50	6.50	13.8	1755	8.64	16.2
Pett1	5/7/2014	Reference Wetland	10:40	1.17	11.5	754	7.78	18.9
Lost1	5/19/2014	Reference Wetland	9:03	3.42	13.9	1811	8.23	3.7
Pett1	5/19/2014	Reference Wetland	12:00	0.83	13.0	754	7.51	12.5
Cote1	5/20/2014	Reference Wetland	8:29	0.92	15.8	1186	8.34	3.4
Schaf1	5/20/2014	Reference Wetland	8:10	1.31	16.1	1363	8.37	4.3
Pitt1	5/20/2014	Reference Wetland	13:42	1.11	18.7	911	8.68	4.8
Schaf1	6/10/2014	Reference Wetland	9:28	0.90	19.5	1403	7.90	3.6
Pitt1	6/10/2014	Reference Wetland	15:32	1.28	22.4	888	7.75	5.1
Cote1	6/10/2014	Reference Wetland	9:48	0.99	19.5	1366	7.81	5.3
Lost1	6/11/2014	Reference Wetland	15:32	2.60	24.18	1760	8.78	5.03

Table A.3. Continued.

Site	Date	Site Category	Time	HACH 21000Q Turbidity (NTUs)	YSI Model 6820-V2 Readings Water Temperature (°C)	Specific Conductivity (µs/cm)	pH	Chlorophyll-a (µg/L)
Pett1	6/11/2014	Reference Wetland	10:57	0.63	19.4	1066	7.43	9.5
Lost1	6/23/2014	Reference Wetland	8:25	Error	22.7	1721	7.36	6.1
Pitt1	6/23/2014	Reference Wetland	15:55	1.33	26.5	957	8.09	6.1
Pett1	6/23/2014	Reference Wetland	12:05	1.33	21.9	823	7.31	10.5
Schaf1	6/24/2014	Reference Wetland	8:22	0.99	23.2	1083	7.96	3.9
Cote1	6/24/2014	Reference Wetland	8:42	1.32	22.7	1084	7.78	5.5
Cote1	7/8/2014	Reference Wetland	10:57	1.47	22.2	1135	7.91	4.8
Schaf1	7/8/2014	Reference Wetland	10:30	1.14	22.1	1115	7.99	6.4
Pitt1	7/8/2014	Reference Wetland	15:38	3.52	24.0	875	7.80	8.6
Lost1	7/9/2014	Reference Wetland	13:40	1.70	25.7	error	7.40	6.6
Pett1	7/9/2014	Reference Wetland	11:09	1.48	20.2	779	7.06	16.9
Lost1	7/28/2014	Reference Wetland	10:10	NC	21.4	1371	7.58	6.2
Pett1	7/28/2014	Reference Wetland	13:18	NC	19.9	799	7.49	28.9
Cote1	7/29/2014	Reference Wetland	15:47	6.51	21.9	1232	8.20	9.8
Schaf1	7/29/2014	Reference Wetland	14:53	2.12	21.7	1195	8.22	11
Pitt1	7/30/2014	Reference Wetland	7:53	12.80	20.7	920	8.03	24.4
Schaf1	8/11/2014	Reference Wetland	8:23	2.18	19.2	1194	8.20	6
Cote1	8/11/2014	Reference Wetland	8:42	4.77	19.6	1189	8.03	7.1
Pitt1	8/11/2014	Reference Wetland	12:50	4.91	22.0	846	8.03	15.2
Lost1	8/12/2014	Reference Wetland	8:15	3.00	20.6	1395	7.53	8.7
Pett1	8/12/2014	Reference Wetland	11:52	1.80	20.1	831	7.57	16.6
Lost1	8/25/2014	Reference Wetland	8:36	2.52	22.7	1284	7.48	7.6
Pett1	8/25/2014	Reference Wetland	12:20	5.78	18.8	716	7.65	16.3
Pitt1	8/25/2014	Reference Wetland	15:59	11.70	22.7	808	8.18	36.8
Schaf1	8/26/2014	Reference Wetland	8:45	2.36	19.3	1140	8.10	8.5
Cote1	8/26/2014	Reference Wetland	9:10	1.89	19.2	1185	8.23	14.5
Zieg1	5/7/2013	Surface Wetland	15:50	NC	18.61	Error	8.27	8.4
John1	5/7/2013	Surface Wetland	12:40	15.2	15.92	Error	9.83	32.6
Rams1	5/8/2013	Surface Wetland	10:10	9.07	13.67	Error	8.27	45.9
Rams1	5/13/2013	Surface Wetland	20:22	NC	17.28	Error	8.21	27.8
John1	5/14/2013	Surface Wetland	20:05	NC	20.18	627	9.66	46.3
Zieg1	5/15/2013	Surface Wetland	18:10	NC	22.12	1442	8.32	12.1
2Petr1A	5/16/2013	Surface Wetland	17:04	NC	20	3490	8.41	44.2
Schae1	5/16/2013	Surface Wetland	15:15	NC	20.47	1464	8.89	48.7
John1	5/20/2013	Surface Wetland	12:18	3.88	18.77	669	8.72	8.4
Zieg1	5/20/2013	Surface Wetland	14:40	2.38	20.01	1514	7.87	16.6
Rams1	5/20/2013	Surface Wetland	16:20	2.44	19.68	2512	7.92	17.3
2Petr1A	5/21/2013	Surface Wetland	9:36	2.47	12.82	3431	8.43	29.3
Schae1	5/21/2013	Surface Wetland	11:21	27.3	16.86	1411	8.82	52.7
Rams1	6/10/2013	Surface Wetland	13:46	2.71	19.85	2312	8.55	10.3
Zieg1	6/10/2013	Surface Wetland	15:15	1.18	18.72	1633	7.67	12.8
John1	6/11/2013	Surface Wetland	10:09	10.8	18.05	638	7.8	7.7
2Petr1A	6/12/2013	Surface Wetland	11:29	0.5	19.93	2179	8.7	8.3
Schae1	6/12/2013	Surface Wetland	9:43	31.2	19.58	1373	8.56	76
Rams1	6/26/2013	Surface Wetland	14:40	2.33	27.27	1662	8.69	5.9
John1	6/26/2013	Surface Wetland	11:20	14.9	23.68	454	7.88	8.1
Zieg1	6/26/2013	Surface Wetland	16:00	2.38	26.63	998	7.83	10.3
2Petr1A	6/27/2013	Surface Wetland	13:04	2.65	25.83	1503	8.66	8.8
Schae1	6/27/2013	Surface Wetland	14:53	40.7	28.26	1402	8.82	51.2
Rams1	7/8/2013	Surface Wetland	19:12	NC	31.11	2503	9.11	10
John1	7/9/2013	Surface Wetland	15:12	5.4	26.65	521	8.75	8.7
2Petr1A	7/10/2013	Surface Wetland	9:46	4.21	22.63	3264	9.35	10.8

Table A.3. Continued.

Site	Date	Site Category	Time	HACH 21000Q Turbidity (NTUs)	YSI Model 6820-V2 Readings: Water Temperature (ºC)	Specific Conductivity (µs/cm)	pH	Chlorophyll-a (µg/L)
Zieg1	7/10/2013	Surface Wetland	14:32	6.53	28.88	1275	7.54	45
Schae1	7/10/2013	Surface Wetland	11:20	30.2	26.23	1447	8.95	77.5
2Petr1A	7/22/2013	Surface Wetland	10:46	7.87	23.62	3538	8.31	37.7
Schae1	7/22/2013	Surface Wetland	14:46	90.6	30.17	1496	8.93	105.5
John1	7/23/2013	Surface Wetland	12:30	3.9	23.32	559	8.13	8.6
Zieg1	7/23/2013	Surface Wetland	16:14	7.19	27.9	1404	7.79	52.8
Rams1	7/24/2013	Surface Wetland	9:30	2.63	23.71	2573	8.67	6.9
Rams1	8/12/2013	Surface Wetland	17:07	1.47	27.06	2673	9.55	5.4
2Petr1A	8/12/2013	Surface Wetland	12:51	7.28	28.3	2680	8.37	94.5
Schae1	8/12/2013	Surface Wetland	11:11	33.5	24.16	1382	8.97	141.3
John1	8/13/2013	Surface Wetland	9:42	6.32	21.88	555	8.7	13.4
Zieg1	8/14/2013	Surface Wetland	10:50	6.4	20.72	1608	7.54	24.8
John1	5/6/2014	Surface Wetland	13:25	4.80	12.5	517	8.62	10.7
Zieg1	5/6/2014	Surface Wetland	16:00	1.06	15.0	1606	8.31	25
2Petr1A	5/7/2014	Surface Wetland	15:53	1.53	17.97	2125	8.27	8.4
Rams1	5/7/2014	Surface Wetland	8:10	1.97	12.0	2652	7.85	11
Schae1	5/7/2014	Surface Wetland	13:10	6.36	14.6	1646	8.65	22.2
Rams1	5/19/2014	Surface Wetland	13:10	0.90	15.0	2627	8.24	2.8
Zieg1	5/19/2014	Surface Wetland	14:58	0.94	16.4	1719	8.28	7.3
2Petr1A	5/19/2014	Surface Wetland	8:25	2.24	13.16	2193	7.98	10.1
Schae1	5/19/2014	Surface Wetland	9:53	9.69	13.7	1575	8.71	10.7
John1	5/20/2014	Surface Wetland	11:24	2.55	17.3	533	8.65	5.6
Zieg1	6/10/2014	Surface Wetland	18:00	1.51	22.0	1338	7.60	11
John1	6/10/2014	Surface Wetland	12:40	2.97	20.1	531	8.04	11.8
Rams1	6/11/2014	Surface Wetland	8:34	4.15	20.8	2701	7.74	6.8
2Petr1A	6/11/2014	Surface Wetland	15:02	2.63	23.73	1322	8.31	13.19
Schae1	6/11/2014	Surface Wetland	12:35	4.27	23.4	1483	8.55	15.4
Rams1	6/23/2014	Surface Wetland	13:25	1.65	25.3	2649	8.35	5.4
Zieg1	6/23/2014	Surface Wetland	15:25	1.82	27.1	1321	8.44	6.9
2Petr1A	6/23/2014	Surface Wetland	7:50	7.29	19.5	757	7.33	8.7
Schae1	6/23/2014	Surface Wetland	9:50	2.76	23.4	1591	8.41	10.5
John1	6/24/2014	Surface Wetland	11:20	3.09	23.8	459	8.10	9.1
John1	7/8/2014	Surface Wetland	12:45	2.97	22.1	486	8.21	7.9
Zieg1	7/8/2014	Surface Wetland	17:46	4.30	24.0	1228	8.68	11.5
2Petr1A	7/9/2014	Surface Wetland	13:05	5.61	23.2	935	7.47	20.4
Schae1	7/9/2014	Surface Wetland	15:35	3.39	24.7	785	8.92	21.9
Rams1	7/9/2014	Surface Wetland	8:38	4.94	20.9	2326	7.94	60.2
Schae1	7/28/2014	Surface Wetland	11:30	NC	21.1	1291	8.84	14.5
2Petr1A	7/28/2014	Surface Wetland	9:43	NC	18.2	1213	7.58	22.6
John1	7/29/2014	Surface Wetland	10:37	6.07	22.8	7	8.31	1.9
Rams1	7/30/2014	Surface Wetland	13:06	4.76	24.3	2444	8.18	24.7
Zieg1	7/30/2014	Surface Wetland	8:57	2.51	19.1	1028	8.07	239.3
Zieg1	8/11/2014	Surface Wetland	13:38	4.96	20.6	919	8.91	14.3
John1	8/11/2014	Surface Wetland	11:00	9.24	20.1	496	7.99	17.3
Rams1	8/12/2014	Surface Wetland	12:34	4.42	22.6	2557	7.99	22.9
Schae1	8/12/2014	Surface Wetland	9:31	4.04	19.6	1343	8.65	23.6
2Petr1A	8/12/2014	Surface Wetland	7:49	61.20	14.4	1244	7.86	30.5
Zieg1	8/25/2014	Surface Wetland	15:30	3.33	22.0	901	8.41	11.5
Rams1	8/25/2014	Surface Wetland	13:34	6.45	23.4	2394	8.49	12.6
Schae1	8/25/2014	Surface Wetland	10:48	8.74	20.7	1196	8.59	22.2
2Petr1A	8/25/2014	Surface Wetland	8:13	9.64	17.9	1157	7.52	29.5
John1	8/26/2014	Surface Wetland	12:06	8.09	21.5	493	8.40	21

Table A.3. Continued.

Site	Date	Site Category	Time	HACH 21000Q Turbidity (NTUs)	YSI Model 6820-V2 Readings Water Temperature (ºC)	Specific Conductivity (µs/cm)	pH	Chlorophyll-a (µg/L)
Reev1	5/6/2013	Tile Outfall	16:05	NC	8.1	NC	7.55	1
Hejo1	5/7/2013	Tile Outfall	13:10	0.33	8.25	Error	7.88	1.3
Nels1	5/7/2013	Tile Outfall	10:58	1.39	12.83	Error	7.63	14.1
Adam1	5/7/2013	Tile Outfall	13:38	1.93	10.94	Error	8.21	44.8
Bols1	5/8/2013	Tile Outfall	8:30	1.47	6.93	Error	7.36	0.05
Gerk1	5/8/2013	Tile Outfall	9:30	1.63	7.82	Error	7.53	3.6
Gerk1	5/13/2013	Tile Outfall	19:05	NC	17.11	Error	7.38	48.6
Mund1T	5/14/2013	Tile Outfall	16:58	NC	9.31	662	7.69	0.05
Nels1	5/14/2013	Tile Outfall	18:45	NC	16.61	580	7.79	15.4
Hejo1	5/15/2013	Tile Outfall	14:24	NC	6.16	959	8.1	1.5
Adam1	5/15/2013	Tile Outfall	14:59	NR	9.46	831	8.25	20.6
Dryl1	5/15/2013	Tile Outfall	17:20	NC	21.65	2511	8.67	NA
Bols1	5/15/2013	Tile Outfall	20:06	NC	XD	XD	XD	XD
Buff1T	5/16/2013	Tile Outfall	14:40	NC	9.48	1555	7.89	30.6
Hejo1	5/20/2013	Tile Outfall	12:49	0.44	6.68	909	8.09	1.3
Bols1	5/20/2013	Tile Outfall	15:20	4.37	9.06	1596	7.57	3.5
Nels1	5/20/2013	Tile Outfall	10:55	1.27	14.57	681	7.78	18.3
Bols1	6/10/2013	Tile Outfall	14:35	1.38	15.32	1599	7.12	7.4
Gerk1	6/10/2013	Tile Outfall	13:07	1.44	11.63	2215	7.27	19.9
Nels1	6/11/2013	Tile Outfall	12:09	1.32	17.32	36	7.39	0.05
Hejo1	6/11/2013	Tile Outfall	9:10	0.31	9.01	1001	7.37	0.05
Dryl3	6/11/2013	Tile Outfall	20:02	NR	9.75	2149	7.11	1.4
Hejo2	6/11/2013	Tile Outfall	9:36	0.59	10.07	1171	7.45	1.4
Dryl1	6/11/2013	Tile Outfall	19:37	NR	15.94	2943	7.22	4.4
Adam1	6/11/2013	Tile Outfall	8:41	2.41	14.32	669	7.47	16.1
Mund1T	6/11/2013	Tile Outfall	10:39	3.1	15.52	526	7.37	18.1
Thor1	6/12/2013	Tile Outfall	7:37	NC	10.13	1225	7.35	1.6
Ache1	6/12/2013	Tile Outfall	10:20	0.53	13.31	1001	7.45	1.6
Buff1T	6/12/2013	Tile Outfall	9:19	NR	11.24	1845	7.6	2.5
Reev1	6/12/2013	Tile Outfall	7:05	NR	9.62	853	7.49	4.4
Long1	6/12/2013	Tile Outfall	8:36	NR	10.25	1577	7.59	25.1
Clea2	6/25/2013	Tile Outfall	13:56	NC	17.37	8	7.46	0.05
Hejo1	6/26/2013	Tile Outfall	12:03	32.9	15.41	741	7.56	5.2
Bols1	6/26/2013	Tile Outfall	15:21	17.7	23.48	1212	7.51	10.5
Nels1	6/26/2013	Tile Outfall	10:05	2.26	21.51	527	7.51	15.6
Gerk1	6/26/2013	Tile Outfall	XD	4.37	XD	XD	XD	XD
Gerk1	7/8/2013	Tile Outfall	17:41	NC	29	2253	7.64	13.6
Hejo1	7/9/2013	Tile Outfall	17:12	0.47	14.96	1033	7.41	2
Hejo2	7/9/2013	Tile Outfall	16:33	NC	16.01	1202	7.57	2.3
Dryl3	7/9/2013	Tile Outfall	19:54	NC	16.07	2088	7.17	3.1
Dryl1	7/9/2013	Tile Outfall	19:41	NC	18.3	2740	7.17	5.8
Mund1T	7/9/2013	Tile Outfall	13:41	1.24	21.64	504	7.34	9.6
Adam1	7/9/2013	Tile Outfall	17:39	NR	21.44	568	7.84	14
Nels1	7/9/2013	Tile Outfall	11:52	4.85	20.79	661	7.55	17.7
Buff1T	7/10/2013	Tile Outfall	11:38	NR	19.69	2020	7.62	4.4
Bols1	7/10/2013	Tile Outfall	13:35	1.09	17.42	1926	7.04	6.1
Reev1	7/10/2013	Tile Outfall	7:20	NR	13.57	1476	7.41	23
Pets1	7/10/2013	Tile Outfall	16:53	NR	32.27	1126	9.56	46.7
Mund1T	7/23/2013	Tile Outfall	12:05	13.8	17.71	759	7.24	0.05
Adam1	7/23/2013	Tile Outfall	14:35	NC	18.69	772	8.23	1.7
Hejo1	7/23/2013	Tile Outfall	13:11	10.7	14.72	893	7.97	2.2
Nels1	7/23/2013	Tile Outfall	8:38	14.8	16.13	819	7.66	11.9

Table A.3. Continued.

Site	Date	Site Category	Time	HACH 21000Q Turbidity (NTUs)	YSI Model 6820-V2 Readings Water Temperature (ºC)	Specific Conductivity (µs/cm)	pH	Chlorophyll-a (µg/L)
Buff1T	8/12/2013	Tile Outfall	11:33	NR	16.16	2075	7.77	1.5
Nels1	8/13/2013	Tile Outfall	11:38	42.6	15.43	951	7.78	19
Mund1T	8/13/2013	Tile Outfall	10:42	4.67	16.56	863	7.52	20.2
Clea2	8/14/2013	Tile Outfall	16:40	NC	17.1	1396	7.65	1
Reev1	8/14/2013	Tile Outfall	13:51	NC	16.75	1318	7.59	1.7
Bols1	8/14/2013	Tile Outfall	8:40	NC	18.67	1678	6.98	6.7
Hejo1	5/6/2014	Tile Outfall	13:57	NC	5.7	886	7.74	1.4
Bols1	5/6/2014	Tile Outfall	16:40	NC	4.4	1891	7.48	2.4
Mund1T	5/6/2014	Tile Outfall	12:39	NC	4.79	769	7.44	2.9
Nels1	5/6/2014	Tile Outfall	11:24	NC	8.3	20	7.45	13
Adam1	5/6/2014	Tile Outfall	14:35	NC	9.0	866	7.99	19.2
Thor1	5/7/2014	Tile Outfall	11:36	NC	5.8	1337	7.79	0.8
Reev1	5/7/2014	Tile Outfall	11:12	NC	8.6	1151	7.52	2.5
Thor1	5/19/2014	Tile Outfall	11:16	NC	7.1	1348	7.61	0.05
Reev1	5/19/2014	Tile Outfall	11:41	NC	7.2	1396	7.60	1.4
Nels1	5/20/2014	Tile Outfall	9:24	NC	12.3	455	7.43	13.8
Adam1	5/20/2014	Tile Outfall	12:29	NC	12.0	901	7.93	23.1
Thor1	6/9/2014	Tile Outfall	16:58	NC	11.4	1353	7.28	0.7
Long2	6/9/2014	Tile Outfall	15:20	NC	10.3	2025	7.21	1.2
Reev1	6/9/2014	Tile Outfall	17:15	NC	11.4	1415	7.29	2
Pets1	6/9/2014	Tile Outfall	16:10	NC	13.6	1590	7.46	2.2
Bens1	6/9/2014	Tile Outfall	17:43	NC	12.0	1451	7.20	3
Long1	6/9/2014	Tile Outfall	14:51	NC	10.3	1405	7.08	10.3
Hejo2	6/10/2014	Tile Outfall	13:55	NC	13.1	1095	7.40	1.4
Hejo1	6/10/2014	Tile Outfall	13:20	NC	9.5	994	7.66	2.3
Dryl3	6/10/2014	Tile Outfall	16:00	NC	10.1	2269	7.10	5
Dryl1	6/10/2014	Tile Outfall	16:20	NC	18.0	2813	7.28	7.1
Bols1	6/10/2014	Tile Outfall	16:45	NC	16.4	1263	7.11	7.8
Adam1	6/10/2014	Tile Outfall	14:26	NC	18.1	884	7.56	8.1
Mund1T	6/10/2014	Tile Outfall	11:35	NC	14.17	557	7.61	8.9
Nels1	6/10/2014	Tile Outfall	10:35	NC	15.0	784	7.44	14
Buff1T	6/11/2014	Tile Outfall	13:01	NA	15.89	2062	7.25	0.28
Ache1	6/11/2014	Tile Outfall	13:31	NA	15.85	1125	7.32	1
Habe1	6/11/2014	Tile Outfall	10:05	NA	15.4	4513	7.80	1.3
Gerk1	6/11/2014	Tile Outfall	9:15	NA	12.5	2487	7.40	3.1
Long2	6/23/2014	Tile Outfall	10:45	NC	12.7	2433	7.51	0.05
Thor1	6/23/2014	Tile Outfall	11:35	NC	12.9	1707	7.60	0.3
Habe1	6/23/2014	Tile Outfall	12:50	NC	13.7	3731	7.27	0.6
Buff1T	6/23/2014	Tile Outfall	10:05	NC	12.9	2239	7.52	0.9
Ache1	6/23/2014	Tile Outfall	9:16	NC	13.9	1018	7.26	1
Reev1	6/23/2014	Tile Outfall	11:47	NC	13.1	1464	7.55	1.2
Dryl3	6/23/2014	Tile Outfall	16:32	NC	13.9	2008	7.50	1.4
Bols1	6/23/2014	Tile Outfall	14:38	NC	20.4	783	7.24	7.4
Hejo1	6/24/2014	Tile Outfall	11:50	NC	12.3	858	7.53	0.9
Hejo2	6/24/2014	Tile Outfall	12:12	NC	24.2	573	7.63	1.2
Mund1T	6/24/2014	Tile Outfall	10:35	NC	18.31	417	7.4	7.3
Adam1	6/24/2014	Tile Outfall	12:50	NC	20.0	664	7.36	9.4
Nels1	6/24/2014	Tile Outfall	9:34	NC	19.3	399	7.30	12
Thor1	7/7/2014	Tile Outfall	17:12	NC	13.4	1128	7.23	0.3
Pets1	7/7/2014	Tile Outfall	16:39	NC	15.0	1277	7.76	0.8
Long2	7/7/2014	Tile Outfall	15:51	NC	12.9	1566	7.13	3.3
Reev1	7/7/2014	Tile Outfall	17:47	NC	13.1	1221	7.27	10.3

Table A.3. Continued.

Site	Date	Site Category	Time	HACH 21000Q Turbidity (NTUs)	YSI Model 6820-V2 Readings: Water Temperature (ºC)	Specific Conductivity (µs/cm)	pH	Chlorophyll-a (µg/L)
Long1	7/7/2014	Tile Outfall	15:25	NC	13.3	1160	7.01	18.5
Hejo1	7/8/2014	Tile Outfall	13:19	NC	12.9	826	7.60	0.2
Adam1	7/8/2014	Tile Outfall	14:35	NA	16.9	697	8.27	1.8
Dryl3	7/8/2014	Tile Outfall	16:11	NA	13.7	1895	7.34	3.2
Hejo2	7/8/2014	Tile Outfall	14:08	NA	21.9	712	7.44	7.9
Mund1T	7/8/2014	Tile Outfall	11:59	NA	20.62	359	7.37	8.6
Bols1	7/8/2014	Tile Outfall	16:51	NA	18.9	1167	7.00	10.5
Nels1	7/8/2014	Tile Outfall	9:34	NA	18.9	544	7.37	16.2
Clea2	7/9/2014	Tile Outfall	14:20	NA	10.9	959	7.40	0.6
Buff1T	7/9/2014	Tile Outfall	16:11	NC	13.2	1014	7.30	1
Habe1	7/9/2014	Tile Outfall	10:07	NC	14.3	3762	7.27	15.4
Clea2	7/28/2014	Tile Outfall	10:50	NC	14.7	1059	7.72	3.2
Mund1T	7/29/2014	Tile Outfall	11:50	NC	16.2	578	7.47	47.9
Bols1	7/30/2014	Tile Outfall	10:43	NC	19.3	1128	7.35	6.8
Bols1	8/11/2014	Tile Outfall	14:10	NC	20.5	1410	6.88	7.3
Mund1T	8/11/2014	Tile Outfall	10:18	NC	16.6	533	7.38	9.2
Nels1	8/11/2014	Tile Outfall	9:27	NC	17.2	450	7.40	23.8
Clea2	8/12/2014	Tile Outfall	9:00	NC	14.5	1104	7.70	2.4
Clea2	8/25/2014	Tile Outfall	9:18	NC	13.8	1019	7.60	1.7
Dryl3	8/25/2014	Tile Outfall	16:38	NC	16.3	1879	7.30	3.7
Habe1	8/25/2014	Tile Outfall	14:09	NC	16.2	3991	7.93	3.8
Bols1	8/25/2014	Tile Outfall	14:43	NC	20.2	1081	7.19	7.6
Mund1T	8/26/2014	Tile Outfall	11:20	NC	16.7	662	7.48	6.1
Nels1	8/26/2014	Tile Outfall	10:07	NC	14.8	542	7.57	15.8
Mund1	5/7/2013	Tile Wetland	12:15	2.51	13.97	Error	7.49	0.05
Nels1A	5/7/2013	Tile Wetland	11:00	1.44	11.42	Error	7.63	9.9
Gerk1A	5/8/2013	Tile Wetland	9:30	4.47	13	Error	7.92	13.1
Gerk1A	5/13/2013	Tile Wetland	19:30	NC	18.93	Error	8.44	29.9
Nels1A	5/14/2013	Tile Wetland	18:52	NC	17.57	569	8.3	21.5
Mund1	5/14/2013	Tile Wetland	16:15	NC	18.73	851	7.52	27.8
Hejo1A	5/15/2013	Tile Wetland	14:00	NC	16.6	1084	7.88	10.1
Volk1A	5/16/2013	Tile Wetland	17:35	NC	19.41	3045	7.9	46.7
Hejo1A	5/20/2013	Tile Wetland	12:55	6.81	18.64	1099	7.71	12.3
Mund1	5/20/2013	Tile Wetland	11:55	3	16.8	845	7.56	13.8
Gerk1A	5/20/2013	Tile Wetland	16:00	1.97	19.21	2283	7.79	14.4
Nels1A	5/20/2013	Tile Wetland	10:55	2.43	17.48	648	8.28	18.9
Volk1A	5/21/2013	Tile Wetland	9:05	16.8	14.05	2904	7.85	28.5
Gerk1A	6/10/2013	Tile Wetland	13:07	1.5	19.72	2172	8.47	8.2
Mund1	6/11/2013	Tile Wetland	10:52	1.99	17.79	873	7.45	8.6
Hejo1A	6/11/2013	Tile Wetland	9:25	1.88	18.02	970	7.53	12.5
Nels1A	6/11/2013	Tile Wetland	12:09	1.4	17.79	662	7.68	15
Volk1A	6/12/2013	Tile Wetland	12:13	15.3	19.33	2239	7.42	24.5
Gerk1A	6/26/2013	Tile Wetland	14:17	2.93	13.35	2120	7.74	4
Hejo1A	6/26/2013	Tile Wetland	11:48	2.27	24.49	787	7.7	6.9
Mund1	6/26/2013	Tile Wetland	10:52	4.76	24.12	531	7.83	9.8
Nels1A	6/26/2013	Tile Wetland	10:06	2.16	21.69	655	7.56	14.7
Volk1A	6/27/2013	Tile Wetland	12:37	110	26.73	2714	7.54	28.5
Gerk1A	7/8/2013	Tile Wetland	18:12	3.15	27.8	2278	8.18	83.5
Mund1	7/9/2013	Tile Wetland	14:14	5.21	24.08	532	7.22	28.4
Nels1A	7/9/2013	Tile Wetland	12:09	3.32	21.48	640	7.67	35.4
Hejo1A	7/9/2013	Tile Wetland	16:56	2.04	24.96	881	7.49	46.5
Volk1A	7/10/2013	Tile Wetland	9:15	72	22.32	3520	7.65	117.2

Table A.3. Continued.

Site	Date	Site Category	Time	HACH 21000Q Turbidity (NTUs)	YSI Model 6820-V2 Readings: Water Temperature (°C)	Specific Conductivity (µs/cm)	pH	Chlorophyll-a (µg/L)
Volk1A	7/22/2013	Tile Wetland	12:09	32.9	27.83	3717	7.75	52.4
Nels1A	7/23/2013	Tile Wetland	8:43	2.5	16.12	819	7.66	12.1
Hejo1A	7/23/2013	Tile Wetland	13:27	2.84	23.16	840	7.57	22.9
Mund1	7/23/2013	Tile Wetland	11:43	90.9	19.56	611	6.86	108.3
Gerk1A	7/24/2013	Tile Wetland	10:05	72.1	21.94	2525	7.94	62.2
Volk1A	8/12/2013	Tile Wetland	12:15	33.5	22.19	3863	7.44	64.3
Gerk1A	8/12/2013	Tile Wetland	17:46	23.1	28.32	2565	8.1	218.1
Nels1A	8/13/2013	Tile Wetland	11:47	4.7	21.35	663	7.94	16
Hejo1A	8/13/2013	Tile Wetland	9:01	24.4	18.33	898	7.5	16.6
Mund1	8/13/2013	Tile Wetland	10:27	5.77	16.49	720	7.38	59.7
Hejo1A	5/6/2014	Tile Wetland	14:10	2.09	12.9	788	8.32	7.9
Nels1A	5/6/2014	Tile Wetland	11:30	1.23	9.0	645	7.55	10.6
Mund1	5/6/2014	Tile Wetland	12:50	4.68	11.2	750	7.57	23.1
Gerk1A	5/7/2014	Tile Wetland	8:50	2.34	11.7	2555	8.62	15.8
Volk1A	5/7/2014	Tile Wetland	15:20	2.81	18.4	3220	8.31	100.2
Gerk1A	5/19/2014	Tile Wetland	13:29	1.23	15.4	2399	8.88	4.9
Volk1A	5/19/2014	Tile Wetland	7:58	3.37	13.0	3322	7.62	31.2
Mund1	5/20/2014	Tile Wetland	10:42	1.40	15.6	786	7.63	5.6
Nels1A	5/20/2014	Tile Wetland	9:22	1.67	13.6	778	7.63	7.8
Hejo1A	5/20/2014	Tile Wetland	12:00	1.25	17.3	804	7.82	8.2
Hejo1A	6/10/2014	Tile Wetland	13:30	1.55	21.4	697	8.04	4.6
Mund1	6/10/2014	Tile Wetland	11:50	1.17	18.2	589	7.40	8.7
Nels1A	6/10/2014	Tile Wetland	10:31	2.39	15.6	796	7.66	34
Gerk1A	6/11/2014	Tile Wetland	8:55	2.51	19.4	2421	7.76	16.9
Volk1A	6/11/2014	Tile Wetland	14:30	11.40	24.16	3067	7.55	18.42
Gerk1A	6/23/2014	Tile Wetland	13:42	3.84	25.9	2231	7.85	10.3
Volk1A	6/23/2014	Tile Wetland	7:22	13.10	20.3	1840	7.14	26.2
Hejo1A	6/24/2014	Tile Wetland	12:05	1.33	24.2	573	7.63	1.2
Mund1	6/24/2014	Tile Wetland	10:46	1.06	22.7	377	7.34	7.1
Nels1A	6/24/2014	Tile Wetland	9:30	6.11	19.4	414	7.55	10.9
Hejo1A	7/8/2014	Tile Wetland	14:00	6.24	21.9	712	7.44	7.9
Mund1	7/8/2014	Tile Wetland	12:14	0.92	18.5	407	7.31	7.9
Nels1A	7/8/2014	Tile Wetland	9:30	2.02	19.7	529	7.73	15.3
Volk1A	7/9/2014	Tile Wetland	12:30	47.80	19.7	1298	7.37	22.5
Gerk1A	7/9/2014	Tile Wetland	9:15	11.40	20.3	2162	7.49	38.5
Volk1A	7/28/2014	Tile Wetland	9:15	NC	17.6	1173	7.34	208.9
Hejo1A	7/29/2014	Tile Wetland	9:05	3.60	17.9	9	8.28	1
Mund1	7/29/2014	Tile Wetland	12:05	3.91	16.3	379	7.57	24.4
Nels1A	7/29/2014	Tile Wetland	13:45	5.53	20.0	600	8.38	40.2
Gerk1A	7/30/2014	Tile Wetland	11:53	6.28	23.4	2341	8.25	58
Hejo1A	8/11/2014	Tile Wetland	11:35	11.70	19.9	596	7.69	8.7
Mund1	8/11/2014	Tile Wetland	10:38	9.92	17.4	187	7.64	13.9
Nels1A	8/11/2014	Tile Wetland	9:22	5.59	17.8	461	7.88	25.7
Volk1A	8/12/2014	Tile Wetland	7:07	58.30	15.7	1289	7.33	60.7
Gerk1A	8/12/2014	Tile Wetland	12:48	11.90	24.4	2442	8.14	72.8
Gerk1A	8/25/2014	Tile Wetland	13:10	11.60	23.4	2214	7.90	107.4
Volk1A	8/25/2014	Tile Wetland	7:29	101.00	18.2	1381	7.24	221.1
Mund1	8/26/2014	Tile Wetland	11:31	24.50	16.1	393	7.57	13.1
Nels1A	8/26/2014	Tile Wetland	10:04	6.16	16.9	545	7.76	17
Hejo1A	8/26/2014	Tile Wetland	12:40	35.80	18.8	613	7.51	29.2

Note: NC = not collected, NA = not applicable, < = less than the detection limit.

Table A.4. Pesticides included in laboratory scans and whether they were detected in water grab samples or polar organic chemical integrative samplers (POCIS) taken from sites within the Madison Wetland Management District, South Dakota, 2012–2015.

Class	Pesticide Active Ingredient	EPA Region 8 Laboratory	USGS NWQL	University of Nebraska WSL (POCIS)	USGS South Dakota Water Science Center	Detected By
Herbicide	2,4,5-T	Yes	No	No	No	None
	2,4,5-TP	Yes	No	No	No	EPA
	2,4-D	Yes	No	No	No	EPA
	Acetochlor	Yes	Yes	Yes	No	All
	Acetochlor OA	Yes	No	No	No	EPA
	Alachlor	Yes	No	Yes	No	POCIS
	Alachlor OA	Yes	No	No	No	EPA
	Ametryn	No	Yes	No	No	USGS
	Atraton	Yes	No	No	No	None
	Atrazine de-ethyl	Yes	Yes	Yes	No	All
	Atrazine de-isopropyl	Yes	Yes	Yes	No	All
	Atrazine	Yes	Yes	Yes	Yes	All
	Bentazon	Yes	No	No	No	EPA
	Bromacil	Yes	yes	No	No	None
	Bromoxynil	Yes	No	No	No	EPA
	Butachlor ESA	Yes	Yes	No	No	EPA
	Butylate	No	Yes	Yes	No	None
	Chlorimuron ethyl	Yes	No	No	No	None
	Chlorsulfuron	Yes	No	No	No	None
	Cyanazine	Yes	Yes	Yes	No	None
	Cycloate	No	Yes	No	No	None
	Dacthal monoacid	Yes	No	No	No	None
	Dichloroprop	Yes	No	No	No	None
	Dimethachlor	Yes	No	No	No	None
	Dimethenamid	Yes	No	Yes	No	EPA, POCIS
	Dimethenamid ESA	Yes	No	No	No	EPA
	Diphenamid	No	Yes	No	No	None
	Diuron	Yes	No	No	No	None
	Diuron Metabolite	Yes	No	No	No	None
	EPTC	Yes	No	No	No	None
	Foramsulfuron	Yes	No	No	No	None
	Glyphosate	No	No	No	Yes	ELISA
	Hexazinone	Yes	Yes	No	No	None
	Imazaquin	Yes	No	No	No	None
	Imazethapyr	Yes	No	No	No	EPA
	Linuron	Yes	No	No	No	None
	MCPP	Yes	No	No	No	None
	Metolachlor	Yes	No	Yes	No	EPA, POCIS
	Metolachlor ESA	Yes	Yes	No	No	EPA, USGS
	Metribuzin	Yes	Yes	Yes	No	EPA, POCIS
	Monuron	Yes	No	No	No	None
	Neburon	Yes	No	No	No	None
	Norflorazon	No	No	Yes	No	None
	Oryzalin	Yes	No	No	No	None
	Pendimethalin	No	No	Yes	No	None
	Prometon	Yes	Yes	Yes	No	POCIS
	Prometryn	No	Yes	No	No	None
	Propachlor	Yes	Yes	Yes	No	None
	Propachlor ESA	Yes	No	No	No	EPA
	Propachlor OA	Yes	No	No	No	EPA
	Propazine	Yes	Yes	Yes	No	EPA, POCIS
	Simazine	Yes	Yes	Yes	No	EPA, POCIS
	Simetryn	No	Yes	No	No	None
	Sulfometuron methyl	Yes	No	No	No	None
	Tebuthiuron	Yes	No	No	No	None
	Terbacil	No	Yes	no	No	None
	Terbuthylazine	Yes	No	No	No	None
	Triclopyr	Yes	No	No	No	EPA
	Trifluralin	No	Yes	Yes	No	None
	Vernolate	No	yes	No	No	None

Table A.4. Continued.

Class	Pesticide Active Ingredient	EPA Region 8 Laboratory	USGS NWQL	University of Nebraska WSL (POCIS)	USGS South Dakota Water Science Center	Detected By
Insecticide	3-Hydroxycarbofuran	Yes	No	No	No	None
	Acetamiprid	No	No	Yes	No	POCIS
	Aldicarb	Yes	No	No	No	None
	Aldicarb sulfone	Yes	No	Yes	No	None
	Aldicarb sulfoxide	Yes	No	No	No	None
	Carbaryl	Yes	No	No	No	None
	Carbofuran	Yes	No	No	No	None
	Clothianidin	Yes	No	Yes	No	EPA, POCIS
	Diazinon	Yes	no	no	No	None
	Dimethoate	No	No	Yes	No	POCIS
	Dinotefuran	No	No	Yes	No	None
	Disulfoton sulfone	Yes	No	No	No	None
	Ethoprop	Yes	No	No	No	None
	Fipronil	Yes	No	No	No	None
	Fipronil sulfide	Yes	No	No	No	None
	Fipronil sulfone	Yes	No	No	No	None
	Imidacloprid	Yes	No	Yes	No	EPA, POCIS
	Malathion	Yes	No	No	No	None
	Methiocarb	Yes	No	No	No	None
	Methomyl	Yes	No	No	No	None
	Oxamyl	Yes	No	No	No	None
	Permethrin	No	No	Yes	No	None
	Propoxur	Yes	No	No	No	None
	Telfluthrin	No	No	Yes	No	POCIS
	Terbufos	No	No	Yes	No	None
	Thiacloprid	No	No	Yes	No	POCIS
	Thiamethoxam	Yes	No	Yes	No	EPA, POCIS
Fungicide	Azoxystrobin	Yes	No	No	No	None
	Carboxin	No	Yes	no	No	None
	Chlorothalonil	No	No	Yes	No	None
	Metalaxyl	Yes	No	Yes	No	EPA,POCIS
	Propiconazole	Yes	No	No	No	None
	Tebuconazole	Yes	No	No	No	None

Note: POCIS = sampled using polar organic chemical integrative samplers.

Table A.5. Concentrations of herbicides in wetland water as measured by the U.S. Geological Survey National Water Quality Laboratory from sites within Madison Wetland Management District, South Dakota, 2013.

		Herbicide Concentration (micrograms per liter)					
Field ID	Site Category	Acetochlor	Ametryn	Atrazine	Deisopropylatrazi	Deethylatrazine	Metolachlor
Cote1	Reference Wetland	0.22	< 0.05	0.08	0.05	0.06	0.03
Pett1	Reference Wetland	0.36	< 0.05	0.15	0.07	0.09	0.06
Pitt1	Reference Wetland	0.15	0.05	0.07	0.05	0.06	0.03
Schaf1	Reference Wetland	0.15	< 0.05	0.07	0.04	0.05	0.03
John1	Surface Wetland	0.17	< 0.05	0.07	0.04	0.05	0.03
Rams1	Surface Wetland	0.18	0.05	0.08	0.04	0.05	0.03
Zieg1	Surface Wetland	0.72	< 0.05	0.23	0.06	0.08	0.05
Bols1	Tile Wetland	0.29	0.05	0.17	0.05	0.07	0.06
Gerk1	Tile Wetland	0.18	0.06	0.1	0.04	0.05	0.03
Hejo1	Tile Wetland	0.16	< 0.05	0.06	< 0.05	0.04	0.02
Mund1	Tile Wetland	0.66	< 0.05	0.08	0.05	0.06	0.04
Nels1	Tile Wetland	0.32	< 0.05	0.13	0.05	0.06	0.02

Note: < = less than the detection limit,

Table A.6. Pesticide concentrations in polar organic chemical integrative samplers (POCIS) deployed at sites within Madison Wetland Management District, South Dakota, 2013–2015.

Sample ID	Deployment Date	POCIS Days	Acetochlor	Atrazine	Alachlor	Chlorthalonil	DEA	DIA	Dimethenamid	Metolachlor	Prometon	Propazine	Simazine	Metribuzin	Acetamiprid	Clothianidin	Dimethoate	Dinotefuran	Imidacloprid	Metalaxyl	Thiacloprid	Thiamethoxam
Pett1	5/13/2013	28	946.75	815.11	< 2.0	< 2.0	223.1	48.96	< 2.0	259.49	< 2.0	29.4	< 2.0	< 2.0	< 0.05	17.784	NA	< 0.05	< 0.05	NA	< 0.05	< 0.05
Gerk1	5/13/2013	28	604.54	596.93	< 2.0	< 2.0	144.09	43.05	< 2.0	15.39	< 2.0	14.96	< 2.0	< 2.0	< 0.05	32.366	NA	< 0.05	< 0.05	NA	< 0.05	< 0.05
Gerk1A	5/13/2013	28	115.92	174.93	< 2.0	< 2.0	38.51	35.17	< 2.0	24.4	< 2.0	12.01	2.25	< 2.0	< 0.05	16.01	NA	< 0.05	< 0.05	NA	< 0.05	< 0.05
Rams1	5/13/2013	28	364.31	666.54	< 2.0	< 2.0	77.58	28.89	< 2.0	42.24	< 2.0	26.66	0.21	< 2.0	< 0.05	3.995	NA	< 0.05	< 0.05	NA	< 0.05	< 0.05
Cote1	5/14/2013	28	550.12	259.25	< 2.0	< 2.0	87.28	26.34	< 2.0	60.49	< 2.0	15.77	< 2.0	< 2.0	< 0.05	5.414	NA	< 0.05	< 0.05	NA	< 0.05	< 0.05
Schaf1	6/11/2013	29	237.3	171.16	< 2.0	< 2.0	76.04	23.79	< 2.0	35.33	< 2.0	10.77	0.94	< 2.0	< 0.05	6.405	NA	< 0.05	< 0.05	NA	< 0.05	< 0.05
Mund1	5/14/2013	28	194.02	65.24	< 2.0	< 2.0	31.62	21.81	< 2.0	22.74	< 2.0	12.15	< 2.0	< 2.0	< 0.05	8.115	NA	< 0.05	< 0.05	NA	< 0.05	< 0.05
Nels1	5/14/2013	28	471.84	549.01	< 2.0	< 2.0	109.08	35.88	< 2.0	29.14	< 2.0	21.85	1.32	< 2.0	< 0.05	23.955	NA	< 0.05	< 0.05	NA	< 0.05	< 0.05
Nels1A	5/14/2013	28	677.95	389.99	< 2.0	< 2.0	112.57	40.01	< 2.0	29.14	< 2.0	17.35	2.58	< 2.0	< 0.05	20.552	NA	< 0.05	< 0.05	NA	< 0.05	< 0.05
Hejo1	7/9/2013	35	523.96	26.11	< 2.0	< 2.0	21.88	< 2.0	< 2.0	11.63	< 2.0	1.18	< 2.0	< 2.0	< 0.05	23.77	NA	< 0.05	18.525	NA	< 0.05	15.573
Mund1T	5/14/2013	28	1135.7	390.68	< 2.0	< 2.0	216.22	40.15	< 2.0	71.93	< 2.0	9.26	< 2.0	< 2.0	< 0.05	88.467	NA	< 0.05	15.28	NA	< 0.05	< 0.05
Hejo1A	7/9/2013	35	184.69	72.01	< 2.0	< 2.0	32.51	< 2.0	< 2.0	47.59	< 2.0	6.21	< 2.0	< 2.0	< 0.05	5.567	NA	< 0.05	1.736	NA	< 0.05	2.26
Pitt1	5/16/2013	27	181.48	159.48	< 2.0	< 2.0	82.55	23.53	< 2.0	42.08	< 2.0	8.19	< 2.0	< 2.0	< 0.05	0.045	NA	< 0.05	< 0.05	NA	< 0.05	< 0.05
Zieg1	5/16/2013	27	1127.3	620.92	< 2.0	< 2.0	153.5	48.76	< 2.0	84.48	< 2.0	15.95	1.66	< 2.0	< 0.05	9.065	NA	< 0.05	< 0.05	NA	< 0.05	< 0.05
Bols1A	5/15/2013	28	10.88	15.88	< 2.0	< 2.0	14	< 2.0	< 2.0	10.26	< 2.0	5.82	< 2.0	< 2.0	< 0.05	< 0.05	NA	< 0.05	< 0.05	NA	< 0.05	< 0.05
Bols1	7/10/2013	35	47.73	154.68	< 2.0	< 2.0	98.76	34.9	< 2.0	28.11	< 2.0	4.67	< 2.0	< 2.0	< 0.05	34.653	NA	< 0.05	10.807	NA	< 0.05	318.583
Buff1	5/15/2013	28	15.62	24.76	< 2.0	< 2.0	11.13	< 2.0	< 2.0	4.04	< 2.0	1.64	< 2.0	< 2.0	< 0.05	< 0.05	NA	< 0.05	< 0.05	NA	< 0.05	< 0.05
Schae1	5/15/2013	28	422.44	714.66	< 2.0	< 2.0	165.99	42.94	< 2.0	116.14	< 2.0	20.91	0.59	< 2.0	< 0.05	7.025	NA	< 0.05	< 0.05	NA	< 0.05	< 0.05
Lost1	5/15/2013	28	430.87	574.35	< 2.0	< 2.0	241.61	91.54	< 2.0	111.74	< 2.0	15.52	0.09	< 2.0	< 0.05	6.824	NA	< 0.05	< 0.05	NA	< 0.05	< 0.05
2Petr1A	5/16/2013	27	443.84	1078.16	< 2.0	< 2.0	407.67	84.67	< 2.0	137.48	< 2.0	31.57	0.58	< 2.0	< 0.05	18.198	NA	< 0.05	< 0.05	NA	< 0.05	< 0.05
Pett1	7/8/2013	35	< 2.0	< 2.0	183.87	< 2.0	74.44	< 2.0	< 2.0	10.6	< 2.0	8.5	1.16	< 2.0	< 0.05	1.588	NA	< 0.05	< 0.05	NA	< 0.05	1.059
Gerk1	6/10/2013	29	337.3	508.76	< 2.0	< 2.0	98.04	< 2.0	< 2.0	19.81	< 2.0	15.68	1.16	< 2.0	< 0.05	24.388	NA	< 0.05	< 0.05	NA	< 0.05	< 0.05
Gerk1A	7/8/2013	35	< 2.0	48.06	< 2.0	< 2.0	18.62	< 2.0	< 2.0	< 2.0	< 2.0	2.32	0.81	< 2.0	< 0.05	10.022	NA	< 0.05	< 0.05	NA	< 0.05	< 0.05
Rams1	7/8/2013	35	10.56	< 2.0	149.13	< 2.0	32.05	< 2.0	< 2.0	< 2.0	< 2.0	8.59	2.34	< 2.0	< 0.05	2.732	NA	< 0.05	< 0.05	NA	< 0.05	< 0.05
Cote1	7/9/2013	35	< 2.0	< 2.0	233.85	< 2.0	64.16	< 2.0	< 2.0	8.56	< 2.0	10.63	4.85	< 2.0	< 0.05	< 0.05	NA	< 0.05	< 0.05	NA	< 0.05	< 0.05
Schaf1	5/14/2013	28	11.97	104.3	< 2.0	< 2.0	28.7	< 2.0	< 2.0	43.89	< 2.0	4.9	1.26	< 2.0	< 0.05	7.942	NA	< 0.05	< 0.05	NA	< 0.05	< 0.05

Table A.6. Continued.

Sample ID	Deployment Date	POCIS Days	Acetochlor	Atrazine	Alachlor	Chlorthalonil	DEA	DIA	Dimethenamid	Metolachlor	Prometon	Propazine	Simazine	Metribuzin	Acetamiprid	Clothianidin	Dimethoate	Dinotefuran	Imidacloprid	Metalaxyl	Thiacloprid	Thiamethoxam
Mund1	7/9/2013	35	< 2.0	< 2.0	27.71	< 2.0	14.11	< 2.0	< 2.0	10.04	< 2.0	1.78	< 2.0	< 2.0	< 0.05	4.101	NA	< 0.05	1.859	NA	< 0.05	0.574
Nels1	6/11/2013	29	6313.1	7910.51	< 2.0	< 2.0	222.17	32.59	543.5	293.36	< 2.0	229.1	< 2.0	< 2.0	< 0.05	29.546	NA	< 0.05	24.52	NA	< 0.05	< 0.05
Nels1A	7/9/2013	35	6.72	< 2.0	79.74	< 2.0	59.17	< 2.0	< 2.0	5.95	< 2.0	3.79	< 2.0	< 2.0	< 0.05	3.817	NA	< 0.05	1.69	NA	< 0.05	5.211
Hejo1	5/14/2013	28	16.89	37.8	< 2.0	< 2.0	33.7	< 2.0	< 2.0	112.88	< 2.0	1.52	0.32	< 2.0	< 0.05	52.709	NA	< 0.05	19.162	NA	< 0.05	12.598
Mund1T	7/9/2013	35	37.73	< 0.2	522.39	< 0.2	172.1	32.56	< 0.2	128.19	< 0.2	18.66	< 0.2	< 0.2	< 0.05	64.919	NA	< 0.05	15.197	NA	< 0.05	7.914
Hejo1A	5/14/2013	28	15.95	145	< 0.2	< 0.2	90.21	< 0.2	< 0.2	617.14	< 0.2	6.47	1.39	< 0.2	< 0.05	28.99	NA	< 0.05	19.001	NA	< 0.05	< 0.05
Pitt1	7/10/2013	35	< 0.2	< 0.2	230.24	< 0.2	76.26	< 0.2	< 0.2	24.29	< 0.2	9.4	< 0.2	< 0.2	0.158	< 0.05	NA	< 0.05	< 0.05	NA	< 0.05	< 0.05
Zieg1	7/10/2013	35	27.41	< 0.2	359.96	< 0.2	135.9	< 0.2	< 0.2	51.11	< 0.2	13.06	< 0.2	< 0.2	< 0.05	9.735	NA	< 0.05	9.538	NA	< 0.05	14.656
Bols1A	7/10/2013	35	4.69	< 0.2	6.40	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2	< 0.05	< 0.05	NA	< 0.05	< 0.05	NA	< 0.05	1.433
Bols1	7/10/2013	33	2.19	112.58	< 0.2	< 0.2	122.72	42.19	< 0.2	11.03	< 0.2	2.8	< 0.2	< 0.2	< 0.05	115.23	NA	< 0.05	25.976	NA	< 0.05	649.731
Buff1	7/10/2013	33	< 0.2	< 0.2	383.67	< 0.2	153.03	< 0.2	< 0.2	7.3	< 0.2	13.54	3.14	< 0.2	< 0.05	0.852	NA	< 0.05	< 0.05	NA	< 0.05	< 0.05
Schae1	7/10/2013	33	< 0.2	< 0.2	372.90	< 0.2	105.37	40.49	< 0.2	9.42	< 0.2	15.35	1.75	< 0.2	< 0.05	< 0.05	NA	< 0.05	< 0.05	NA	< 0.05	< 0.05
Lost1	7/10/2013	33	22.24	< 0.2	724.48	< 0.2	236.21	48.09	< 0.2	28.27	< 0.2	23.27	< 0.2	< 0.2	< 0.05	1.661	NA	< 0.05	< 0.05	NA	< 0.05	< 0.05
2Petr1A	7/10/2013	33	3.86	< 0.2	336.56	< 0.2	167.2	< 0.2	< 0.2	1.52	< 0.2	11.94	< 0.2	< 0.2	< 0.05	0.396	NA	< 0.05	0.293	NA	< 0.05	< 0.05
Long1	6/12/2013	29	20.57	< 0.2	49.99	< 0.2	24.54	< 0.2	< 0.2	2.22	< 0.2	1.34	0.65	< 0.2	< 0.05	8.909	NA	< 0.05	< 0.05	NA	< 0.05	0.48
Bufo1T	6/12/2013	29	13.06	< 0.2	308.64	< 0.2	162.43	< 0.2	< 0.2	4.11	< 0.2	5.01	0.15	< 0.2	< 0.05	9.083	NA	< 0.05	0.389	NA	< 0.05	2.845
Ache1	6/12/2013	29	15.68	< 0.2	48.09	< 0.2	41.6	< 0.2	< 0.2	1.3	< 0.2	1.86	< 0.2	< 0.2	< 0.05	7.198	NA	< 0.05	< 0.05	NA	< 0.05	1.332
Buff1	6/12/2013	29	104.69	356.77	< 0.2	< 0.2	176.03	< 0.2	< 0.2	97.41	< 0.2	10.32	3.14	< 0.2	< 0.05	7.939	NA	< 0.05	< 0.05	NA	< 0.05	< 0.05
Schae1	6/12/2013	29	78.38	711.77	< 0.2	< 0.2	200.45	< 0.2	< 0.2	109.5	< 0.2	21.52	1.86	< 0.2	< 0.05	0.224	NA	< 0.05	< 0.05	NA	< 0.05	< 0.05
2Petr1A	6/12/2013	29	4.44	126.05	< 0.2	< 0.2	50.86	< 0.2	< 0.2	14.4	< 0.2	3.59	< 0.2	< 0.2	< 0.05	< 0.05	NA	< 0.05	< 0.05	NA	< 0.05	< 0.05
Lost1	6/12/2013	29	120.41	905.23	< 0.2	< 0.2	351.69	77.49	< 0.2	176.33	< 0.2	25.77	1.07	< 0.2	< 0.05	5.259	NA	< 0.05	< 0.05	NA	< 0.05	< 0.05
Pett1	6/10/2013	29	22.38	301.83	< 0.2	< 0.2	64.87	< 0.2	< 0.2	89.16	< 0.2	10.05	1.47	< 0.2	< 0.05	6.404	NA	< 0.05	< 0.05	NA	< 0.05	< 0.05
Gerk1A	6/10/2013	29	6.65	38.09	< 0.2	< 0.2	8.33	< 0.2	< 0.2	3.25	< 0.2	2.01	0.77	< 0.2	< 0.05	7.673	NA	< 0.05	< 0.05	NA	< 0.05	< 0.05
Rams1	6/10/2013	29	199.62	2325.86	< 0.2	< 0.2	166.5	< 0.2	< 0.2	120.39	< 0.2	75.67	< 0.2	< 0.2	< 0.05	2.252	NA	< 0.05	< 0.05	NA	< 0.05	< 0.05
Hejo1A	6/11/2013	29	162.84	112.17	< 0.2	< 0.2	42.88	< 0.2	< 0.2	1567.09	< 0.2	3.77	< 0.2	< 0.2	< 0.05	23.464	NA	< 0.05	9.659	NA	< 0.05	< 0.05

Table A.6. Continued.

Sample ID	Deployment Date	POCIS Days	Acetochlor	Atrazine	Alachlor	Chlorthalonil	DEA	DIA	Dimethenamid	Metolachlor	Prometon	Propazine	Simazine	Metribuzin	Acetamiprid	Clothianidin	Dimethoate	Dinotefuran	Imidacloprid	Metalaxyl	Thiacloprid	Thiamethoxam
Hejo1	6/11/2013	29	639.96	134.53	< 0.2	< 0.2	76.95	< 0.2	< 0.2	91.68	< 0.2	3.02	< 0.2	< 0.2	< 0.05	88.255	NA	< 0.05	107.91	NA	< 0.05	79.339
John1	5/14/2013	28	117.66	536.32	< 0.2	< 0.2	246.37	44.53	< 0.2	84.27	< 0.2	15.88	< 0.2	< 0.2	< 0.05	17.179	NA	< 0.05	3.446	NA	< 0.05	36.058
John1B	7/9/2013	35	223.5	< 0.2	1263.46	< 0.2	212.16	30.68	< 0.2	28.52	< 0.2	29.11	< 0.2	< 0.2	< 0.05	9.288	NA	< 0.05	7.435	NA	< 0.05	2.261
Mund1	6/11/2013	29	207.9	250.09	< 0.2	< 0.2	77.95	< 0.2	< 0.2	125.44	< 0.2	7.33	< 0.2	< 0.2	< 0.05	26.361	NA	< 0.05	7.381	NA	< 0.05	< 0.05
Mund1T	6/11/2013	29	930.74	1052.4	< 0.2	< 0.2	393.43	76.55	< 0.2	217.5	< 0.2	19.69	2.2	< 0.2	< 0.05	169.82	NA	< 0.05	97.888	NA	< 0.05	34.789
Nels1A	6/11/2013	29	83.34	425.18	< 0.2	< 0.2	218.2	< 0.2	< 0.2	63.08	< 0.2	11.25	< 0.2	< 0.2	< 0.05	27.149	NA	< 0.05	7.54	NA	< 0.05	31.097
Cote1	6/11/2013	29	57.96	292.75	< 0.2	< 0.2	89.42	< 0.2	< 0.2	80.17	< 0.2	9.54	3.7	< 0.2	< 0.05	6.978	NA	< 0.05	< 0.05	NA	< 0.05	< 0.05
Schaf1	7/9/2013	35	8.97	< 0.2	101.06	< 0.2	31.9	< 0.2	< 0.2	6.48	< 0.2	5.68	< 0.2	< 0.2	< 0.05	0.77	NA	< 0.05	< 0.05	NA	< 0.05	< 0.05
Bols1A	6/12/2013	29	< 0.2	11.73	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2	< 0.05	13.078	NA	< 0.05	< 0.05	NA	< 0.05	< 0.05
Bols1	6/12/2013	29	82.25	520.01	< 0.2	< 0.2	203.01	51.79	< 0.2	153.39	< 0.2	15.64	1.74	< 0.2	< 0.05	117.02	NA	< 0.05	24.461	NA	< 0.05	1041.11
Pitt1	6/12/2013	29	35.25	175.34	< 0.2	< 0.2	48.66	< 0.2	< 0.2	46.41	< 0.2	5.4	< 0.2	< 0.2	< 0.05	6.601	NA	< 0.05	< 0.05	NA	< 0.05	< 0.05
Zieg1	6/12/2013	29	19.77	134.25	< 0.2	< 0.2	28	< 0.2	< 0.2	27.45	< 0.2	4.98	< 0.2	< 0.2	< 0.05	32.192	NA	< 0.05	18.461	NA	< 0.05	8.098
Thor1	6/12/2013	29	< 0.2	< 0.2	10.98	< 0.2	< 0.2	< 0.2	< 0.2	0.33	< 0.2	0.33	< 0.2	< 0.2	< 0.05	< 0.05	NA	< 0.05	< 0.05	NA	0.089	< 0.05
Lost1	7/9/2014	34	< 5.0	114.59	< 5.0	NA	102.71	58.37	< 5.0	22	< 5.0	4.54	3.85	< 5.0	0.226	4.6176	NA	< 0.2	< 0.2	NA	< 0.2	< 0.2
Buff1	7/9/2014	34	< 5.0	89.1	< 5.0	NA	37.85	< 5.0	< 5.0	10.35	< 5.0	3.69	1.38	< 5.0	0.133	3.5536	NA	< 0.2	< 0.2	NA	< 0.2	< 0.2
Nels1A	7/8/2014	34	< 5.0	64.21	< 5.0	< 5.0	75.92	< 5.0	< 5.0	10.14	< 5.0	2.89	< 5.0	< 5.0	< 0.2	13.376	NA	< 0.2	12.877	NA	< 0.2	< 0.2
Mund1	7/8/2014	34	< 5.0	39.44	< 5.0	< 5.0	14.81	< 5.0	< 5.0	41.12	< 5.0	1.56	3.99	9.5	< 0.2	2.8752	NA	< 0.2	1.5568	NA	< 0.2	3.8944
Nels1	7/8/2014	34	< 5.0	168.86	< 5.0	< 5.0	161.1	41.55	< 5.0	18.92	< 5.0	5.75	4.17	< 5.0	< 0.2	37.901	NA	< 0.2	46.309	NA	< 0.2	16.9936
Hejo1A	7/8/2014	34	< 5.0	18.67	< 5.0	< 5.0	17.49	< 5.0	< 5.0	68.69	< 5.0	1.31	< 5.0	< 5.0	< 0.2	18.246	NA	< 0.2	44.986	NA	< 0.2	< 0.2
Pett1	7/9/2014	34	< 5.0	126.65	< 5.0	< 5.0	79.28	< 5.0	< 5.0	20.91	< 5.0	3.91	0.02	< 5.0	< 0.2	5.3744	NA	< 0.2	1.8976	NA	< 0.2	< 0.2
Long2	7/8/2014	34	< 5.0	80.69	< 5.0	< 5.0	64.51	< 5.0	< 5.0	46.45	< 5.0	1.71	0.4	26.6	< 0.2	31.389	NA	< 0.2	2.6416	NA	< 0.2	71.1536
Thor1	7/8/2014	34	< 5.0	1.76	< 5.0	< 5.0	7.02	< 5.0	< 5.0	1.01	< 5.0	1.58	< 5.0	< 5.0	< 0.2	< 0.2	NA	< 0.2	< 0.2	NA	< 0.2	< 0.2
Volk1	7/9/2014	34	< 5.0	12.66	< 5.0	NA	8.35	< 5.0	< 5.0	609.62	< 5.0	1.27	1.49	404.35	< 0.2	44.208	NA	< 0.2	36.654	NA	< 0.2	98.16
Reev1	7/9/2014	34	< 5.0	83.45	< 5.0	NA	81.72	< 5.0	< 5.0	277.71	< 5.0	1.56	0.52	< 5.0	< 0.2	32.499	NA	< 0.2	3.7488	NA	< 0.2	19.9904

Table A.6. Continued.

Sample ID	Deployment Date	POCIS Days	Acetochlor	Atrazine	Alachlor	Chlorthalonil	DEA	DIA	Dimethenamid	Metolachlor	Prometon	Propazine	Simazine	Metribuzin	Acetamiprid	Clothianidin	Dimethoate	Dinotefuran	Imidacloprid	Metalaxyl	Thiacloprid	Thiamethoxam
2Petr1A	7/9/2014	34	< 5.0	84.65	< 5.0	NA	38.04	< 5.0	< 5.0	6.07	< 5.0	2.01	0.61	< 5.0	< 0.2	21.016	NA	< 0.2	< 0.2	NA	< 0.2	< 0.2
Gerk1a	7/9/2014	34	2.91	8.38	< 5.0	NA	10.1	< 5.0	< 5.0	2.18	< 5.0	3.53	2.66	< 5.0	< 0.2	0.5456	NA	< 0.2	< 0.2	NA	< 0.2	< 0.2
Rams1	7/9/2014	34	159.27	1014.14	< 5.0	NA	24.43	< 5.0	< 5.0	162.64	65.6	13.61	17.3	< 5.0	1.506	13.474	NA	< 0.2	6.7712	NA	< 0.2	51.432
Mund1	6/10/2014	29	< 5.0	15.64	< 5.0	NA	6.82	< 5.0	< 5.0	286.12	< 5.0	< 5.0	1.01	43.23	< 0.2	3.5904	NA	< 0.2	4.1184	NA	3.699	< 0.2
Reev1	6/9/2014	29	59.48	175.24	< 5.0	< 5.0	107.46	< 5.0	< 5.0	1857.64	< 5.0	3.17	0.16	< 5.0	< 0.2	76.181	NA	< 0.2	18.061	NA	< 0.2	26.9616
Nels1A	6/10/2014	29	32.67	277.8	< 5.0	< 5.0	123.42	< 5.0	< 5.0	26.34	< 5.0	5.38	2.3	< 5.0	< 0.2	47.616	NA	< 0.2	39	NA	< 0.2	8.7808
Nels1	6/10/2014	29	129.18	1021.02	< 5.0	< 5.0	354.83	49.9	< 5.0	87.79	< 5.0	17.83	10.3	< 5.0	0.162	62.392	NA	< 0.2	60.07	NA	< 0.2	16.7552
Cote1	6/10/2014	29	17.75	144.36	< 5.0	< 5.0	33.72	< 5.0	< 5.0	19.1	< 5.0	2.6	< 5.0	< 5.0	4.4	1.6192	NA	< 0.2	< 0.2	NA	< 0.2	< 0.2
Schaf1	6/10/2014	29	< 5.0	67.54	< 5.0	< 5.0	46.75	< 5.0	< 5.0	8.61	< 5.0	2.06	0.44	< 5.0	0.797	1.36	NA	< 0.2	< 0.2	NA	< 0.2	< 0.2
Mund1T	6/10/2014	29	214.41	5211.77	< 5.0	< 5.0	434.23	81.63	< 5.0	96.29	< 5.0	98	< 5.0	< 5.0	< 0.2	194.75	NA	< 0.2	32.656	NA	< 0.2	18.3248
Long1	6/9/2014	29	< 5.0	52.96	< 5.0	< 5.0	22.48	< 5.0	< 5.0	2.02	< 5.0	1.54	0.7	< 5.0	< 0.2	11.957	NA	< 0.2	< 0.2	NA	< 0.2	< 0.2
Long2	6/9/2014	29	172.29	583.47	< 5.0	< 5.0	139.68	< 5.0	2.2	402	< 5.0	11.85	0.9	103.32	< 0.2	53.314	NA	< 0.2	4.7952	NA	< 0.2	19.8464
Thor1	6/9/2014	29	12.49	20.67	< 5.0	< 5.0	20.33	< 5.0	2.27	1.61	< 5.0	0.76	< 5.0	< 5.0	< 0.2	24.381	NA	< 0.2	< 0.2	NA	< 0.2	< 0.2
Buff1	6/11/2014	29	40.94	210.79	< 5.0	< 5.0	47.33	< 5.0	< 5.0	33.54	< 5.0	4.53	3.62	< 5.0	< 0.2	14.979	NA	< 0.2	4.8496	NA	< 0.2	3.52
Schae1	6/11/2014	29	29.37	450.23	< 5.0	< 5.0	56.83	< 5.0	< 5.0	63.91	< 5.0	9.88	0.84	< 5.0	< 0.2	4.352	NA	< 0.2	< 0.2	NA	< 0.2	< 0.2
Lost1	6/11/2014	29	36.1	242.39	< 5.0	< 5.0	199.35	39.78	< 5.0	83.51	< 5.0	5.49	< 5.0	< 5.0	< 0.2	8.8144	NA	< 0.2	1.5776	NA	< 0.2	6.144
2Petr1A	6/11/2014	29	152.44	641.94	< 5.0	< 5.0	59.98	< 5.0	2.94	62.93	< 5.0	10.62	1.05	< 5.0	< 0.2	116.47	NA	< 0.2	3.3456	NA	< 0.2	5.688
Volk1	6/11/2014	29	15.62	67.11	< 5.0	< 5.0	19.99	< 5.0	< 5.0	1053.9	< 5.0	3.66	2.58	1562.3	< 0.2	57.243	NA	< 0.2	28.251	NA	< 0.2	122.994
Pett1	6/11/2014	29	47.86	279.6	< 5.0	< 5.0	66.27	< 5.0	< 5.0	91.61	< 5.0	7.63	< 5.0	< 5.0	< 0.2	14.41	NA	< 0.2	5.3488	NA	< 0.2	3.9872
Bols1	7/8/2014	34	683.97	7462.14	< 5.0	< 5.0	1461.6	227.1	< 5.0	60.65	< 5.0	142.4	< 5.0	< 5.0	< 0.2	454.7	NA	< 0.2	75.064	NA	< 0.2	674.136
Bols1A	7/8/2014	34	< 5.0	21.9	< 5.0	< 5.0	7.63	< 5.0	< 5.0	14.09	< 5.0	0.94	2.55	< 5.0	< 0.2	5.3616	NA	< 0.2	< 0.2	NA	< 0.2	< 0.2
Hejo1	7/8/2014	34	< 5.0	7.44	< 5.0	< 5.0	19.61	< 5.0	< 5.0	4	< 5.0	0.69	0.47	< 5.0	< 0.2	61.39	NA	< 0.2	28.906	NA	< 0.2	3.5936
Pitt1	6/10/2014	29	< 5.0	52.6	< 5.0	< 5.0	23.8	< 5.0	< 5.0	10.18	< 5.0	1.8	0.91	< 5.0	< 0.2	1.8736	NA	< 0.2	< 0.2	NA	< 0.2	< 0.2
John1	6/10/2014	29	190.64	1049.73	< 5.0	< 5.0	147.19	< 5.0	18.59	113.45	< 5.0	21.16	0.53	< 5.0	< 0.2	27.928	NA	< 0.2	40.2	NA	< 0.2	< 0.2
Zieg1	6/10/2014	29	97.67	348.46	< 5.0	< 5.0	34.93	13.53	< 5.0	86.22	< 5.0	11.53	< 5.0	< 5.0	< 0.2	65.562	NA	< 0.2	29.766	NA	< 0.2	34.0912
Gerk1a	6/11/2014	29	< 5.0	14.19	< 5.0	< 5.0	9.43	< 5.0	< 5.0	8.66	< 5.0	1.42	2.3	< 5.0	< 0.2	2.512	NA	< 0.2	2.3968	NA	< 0.2	< 0.2
Rams1	6/11/2014	29	< 5.0	47.3	< 5.0	< 5.0	14.81	< 5.0	< 5.0	16.75	< 5.0	4.28	0.7	< 5.0	< 0.2	3.0256	NA	< 0.2	< 0.2	NA	< 0.2	< 0.2

Table A.6. Continued.

Sample ID	Deployment Date	POCIS Days	Acetochlor	Atrazine	Alachlor	Chlorthalonil	DEA	DIA	Dimethenamid	Metolachlor	Prometon	Propazine	Simazine	Metribuzin	Acetamiprid	Clothianidin	Dimethoate	Dinotefuran	Imidacloprid	Metalaxyl	Thiacloprid	Thiamethoxam
Hejo1A	6/10/2014	29	11.046	34.5825	< 5.0	< 5.0	13.028	< 5.0	< 5.0	246.721	< 5.0	1.549	4.55	1.5487	< 0.2	58.938	NA	< 0.2	130.63	NA	< 0.2	7.44
Bols1	6/10/2014	29	5113	15245.8	< 5.0	< 5.0	2174.2	366.6	< 5.0	143.78	< 5.0	260.6	< 5.0	< 5.0	< 0.2	348.93	NA	< 0.2	45.074	NA	< 0.2	278.638
Bols1A	6/10/2014	29	14.16	44.57	< 5.0	< 5.0	20.12	< 5.0	< 5.0	12.9	< 5.0	2.28	4.64	< 5.0	< 0.2	4.7264	NA	< 0.2	< 0.2	NA	< 0.2	< 0.2
Pitt1	7/8/2014	34	< 5.0	31.26	< 5.0	< 5.0	21.4	< 5.0	< 5.0	7.92	< 5.0	1.92	0.51	< 5.0	< 0.2	2.4	NA	< 0.2	< 0.2	NA	< 0.2	< 0.2
Cote1	7/8/2014	34	< 5.0	57	< 5.0	< 5.0	40.21	< 5.0	< 5.0	6.21	< 5.0	2	< 5.0	< 5.0	6.862	< 0.2	NA	< 0.2	< 0.2	NA	< 0.2	< 0.2
Long1	7/8/2014	34	39.41	214.16	< 5.0	< 5.0	65.29	< 5.0	< 5.0	3.02	< 5.0	4.56	1.25	< 5.0	< 0.2	53.541	NA	< 0.2	< 0.2	NA	< 0.2	3.4096
Mund1T	7/8/2014	34	105.14	9691.82	< 5.0	< 5.0	1240.7	200	< 5.0	175.62	< 5.0	156	< 5.0	< 5.0	< 0.2	461.1	NA	< 0.2	45.374	NA	< 0.2	47.784
John1	7/8/2014	34	18.16	370.42	< 5.0	< 5.0	126.56	< 5.0	< 5.0	20.31	< 5.0	6.88	< 5.0	< 5.0	< 0.2	14.112	NA	< 0.2	13.088	NA	< 0.2	3.712
Zieg1	7/8/2014	34	< 5.0	54.6	< 5.0	< 5.0	10.57	< 5.0	< 5.0	14.45	< 5.0	3.33	0.26	< 5.0	< 0.2	21.211	NA	< 0.2	11.094	NA	< 0.2	21.0912
Schaf1	6/10/2014	29	29.63	242.52	< 5.0	< 5.0	50.86	< 5.0	< 5.0	45.78	< 5.0	4.4	< 5.0	< 5.0	< 0.2	2.3968	NA	< 0.2	0.8416	NA	< 0.2	< 0.2
Nels1A	5/12/2015	110	< 5.0	12.91	< 5.0	< 5.0	6.59	< 5.0	< 5.0	75.85	< 5.0	< 5.0	0.61	74.66	< 0.5	29.455	< 0.5	< 0.5	17.56	< 5.0	< 0.5	< 0.5
Zieg1	5/12/2015	110	< 5.0	198.99	< 5.0	< 5.0	54.52	< 5.0	< 5.0	73.94	< 5.0	4.06	< 5.0	< 5.0	< 0.5	38.728	< 0.5	< 0.5	22.742	< 5.0	< 0.5	< 0.5
Bols1A	5/12/2015	110	< 5.0	25.62	< 5.0	< 5.0	8.62	< 5.0	< 5.0	25.59	< 5.0	< 5.0	< 5.0	< 5.0	< 0.5	9.482	< 0.5	< 0.5	< 0.5	< 5.0	< 0.5	< 0.5
Bols1	5/12/2015	110	60.21	3352.26	< 5.0	< 5.0	1050.5	< 5.0	< 5.0	127.35	< 5.0	34.44	< 5.0	< 5.0	< 0.5	620.75	< 0.5	< 0.5	455.24	121.26	< 0.5	210.485
Habe1	5/13/2015	109	< 5.0	39.49	< 5.0	< 5.0	25.39	< 5.0	< 5.0	4.02	< 5.0	< 5.0	< 5.0	< 5.0	< 0.5	180.79	< 0.5	< 0.5	32.091	6.248	< 0.5	97.725
Gerk1a	5/13/2015	109	< 5.0	4.84	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0	< 0.5	10.083	< 0.5	< 0.5	< 0.5	< 5.0	< 0.5	< 0.5
Rams1	5/13/2015	109	< 5.0	130.6	< 5.0	< 5.0	14.38	< 5.0	< 5.0	32.88	< 5.0	< 5.0	< 5.0	< 5.0	< 0.5	27.206	< 0.5	< 0.5	< 0.5	< 5.0	< 0.5	< 0.5
Schae1	5/12/2015	110	< 5.0	9.93	< 5.0	< 5.0	12.73	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0	< 0.5	20.853	< 0.5	< 0.5	< 0.5	< 5.0	< 0.5	< 0.5
Habe1A	5/13/2015	109	< 5.0	6.88	< 5.0	< 5.0	5.55	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 5.0	< 0.5	< 0.5
Nels1	5/12/2015	110	208.63	841.02	< 5.0	< 5.0	106.77	< 5.0	< 5.0	1794.15	< 5.0	10.24	< 5.0	< 5.0	< 0.5	55.308	10.82	< 0.5	57.907	17.379	< 0.5	< 0.5
2Petr1A	5/12/2015	110	< 5.0	17.2	< 5.0	< 5.0	4.28	< 5.0	< 5.0	30.84	< 5.0	< 5.0	< 5.0	< 5.0	< 0.5	17.411	< 0.5	< 0.5	< 0.5	< 5.0	< 0.5	< 0.5
Hejo1	5/12/2015	110	79.15	11971.6	< 5.0	< 5.0	370.89	25.84	< 5.0	20927.6	< 5.0	93.56	< 5.0	< 5.0	< 0.5	181.91	< 0.5	< 0.5	91.145	46.69	< 0.5	< 0.5
Mund1T	5/12/2015	110	1605.8	3407.16	< 5.0	< 5.0	605.6	68.95	< 5.0	647.8	< 5.0	33.44	< 5.0	1703.4	< 0.5	476.83	< 0.5	< 0.5	40.043	54.084	< 0.5	52.568
John1	5/12/2015	110	118.94	338.38	< 5.0	< 5.0	41.7	< 5.0	< 5.0	153.63	< 5.0	5.56	< 5.0	< 5.0	< 0.5	9.459	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5
Mund1	5/12/2015	110	34.92	38.05	< 5.0	< 5.0	7.03	< 5.0	< 5.0	55.39	< 5.0	< 5.0	< 5.0	< 5.0	< 0.5	16.054	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5
Hejo1A	5/12/2015	110	67.82	12655.8	< 5.0	< 5.0	648.87	< 5.0	< 5.0	16326.3	< 5.0	122.1	< 5.0	< 5.0	< 0.5	69.594	< 0.5	< 0.5	44.15	14.228	< 0.5	< 0.5

Note: < = less than the detection limit, NA = not applicable.

Table A.7. Concentrations of atrazine and glyphosate measured by enzyme linked immunosorbent assay (ELISA) from sites within Madison Wetland Management District, South Dakota, 2012–2014.

Field Sample ID	Site Category	Date Collected (YYMMDD)	Atrazine Concentration (ppb)	Percent Coefficient of Variation for Atrazine	Glyphosate Concentration (ppb)	Percent Coefficient of Variation for Glyphosate
2Petr1A	Surface Wetland	120501	0.29	2%	< 0.075	8%
2Petr1A	Surface Wetland	120522	0.25	3%	< 0.075	50%
2Petr1A	Surface Wetland	120605	0.24	3%	0.120	0%
2Petr1A	Surface Wetland	120905	4.9	6%	0.740	93%
2Petr1A	Surface Wetland	130403	0.67	7%	0.170	11%
2Petr1A	Surface Wetland	130516	0.33	0%	< 0.1	3%
2Petr1A	Surface Wetland	130521	0.55	12%	0.120	22%
2Petr1A	Surface Wetland	130612	0.22	1%	0.100	19%
2Petr1A	Surface Wetland	130627	0.44	1%	1.810	2%
2Petr1A	Surface Wetland	130710	0.84	0%	1.520	11%
2Petr1A	Surface Wetland	130727	0.65	8%	> 5.0	1%
2Petr1A	Surface Wetland	140519	0.34	3%	0.180	9%
2Petr1A	Surface Wetland	140608	2.15	9%	0.170	17%
2Petr1A	Surface Wetland	140623	0.74	13%	< 0.1	3%
2Petr1A	Surface Wetland	140709	0.235	7%	0.580	0%
2Petr1A	Surface Wetland	140728	0.49	1%	0.510	7%
2Petr1A	Surface Wetland	140812	0.415	3%	0.290	19%
Ache1	Tile Outfall	120522	0.05	1%	0.190	78%
Ache1	Tile Outfall	120605	0.09	4%	< 0.075	7%
Ache1	Tile Outfall	130516	0.22	4%	0.110	1%
Ache1	Tile Outfall	130521	0.37	2%	0.260	13%
Ache1	Tile Outfall	130612	0.17	5%	< 0.1	20%
Ache1	Tile Outfall	130627	0.67	1%	1.970	8%
Ache1	Tile Outfall	140611	< 0.05	8%	< 0.1	3%
Ache1	Tile Outfall	140623	0.08	8%	0.100	12%
Ache1A	Tile Wetland	120905	0.33	0%	0.310	9%
Ache1A	Tile Wetland	130612	0.23	4%	< 0.1	16%
Ache1A	Tile Wetland	130710	0.88	8%	3.970	5%
Ache1A	Tile Wetland	130727	0.46	4%	0.690	15%
Adam1	Tile Outfall	120523	0.2	1%	0.250	9%
Adam1	Tile Outfall	120606	0.08	3%	0.110	6%
Adam1	Tile Outfall	130507	0.47	3%	0.240	23%
Adam1	Tile Outfall	130611	1.04	3%	0.260	6%
Adam1	Tile Outfall	130709	0.43	2%	> 5.0	5%
Adam1	Tile Outfall	130723	0.23	10%	0.180	5%
Adam1	Tile Outfall	140506	0.43	0%	0.330	9%
Adam1	Tile Outfall	140520	0.395	0%	0.250	24%
Adam1	Tile Outfall	140610	0.63	1%	0.100	21%
Adam1	Tile Outfall	140624	1.86	6%	0.810	1%
Bols1	Tile Outfall	120606	0.47	0%	0.120	5%
Bols1	Tile Outfall	130508	0.11	1%	< 0.1	24%
Bols1	Tile Outfall	130520	0.16	3%	< 0.1	1%
Bols1	Tile Outfall	130610	0.25	6%	0.200	5%
Bols1	Tile Outfall	130626	0.54	5%	> 5.0	2%
Bols1	Tile Outfall	130710	0.14	5%	2.340	12%
Bols1	Tile Outfall	130814	0.5	3%	> 5.0	1%
Bols1	Tile Outfall	140506	0.26	5%	< 0.1	4%

Table A.7 Continued.

Field Sample ID	Site Category	Date Collected (YYMMDD)	Atrazine Concentration (ppb)	Percent Coefficient of Variation for Atrazine	Glyphosate Concentration (ppb)	Percent Coefficient of Variation for Glyphosate
Bols1	Tile Outfall	140610	5.060	4%	< 0.1	13%
Bols1	Tile Outfall	140623	6.540	5%	2.250	21%
Bols1	Tile Outfall	140708	5.345	2%	5.580	14%
Bols1	Tile Outfall	140730	2.390	6%	0.240	10%
Bols1	Tile Outfall	140811	1.995	3%	< 0.1	4%
Bols1	Tile Outfall	140825	1.975	7%	0.190	4%
Bols1A	Tile Wetland	130516	0.140	0%	0.050	4%
Bols1A	Tile Wetland	130520	0.360	4%	< 0.1	18%
Bols1A	Tile Wetland	130610	0.220	1%	< 0.1	11%
Bols1A	Tile Wetland	130626	0.180	3%	0.310	4%
Bols1A	Tile Wetland	130710	0.130	3%	0.140	24%
Bols1A	Tile Wetland	130724	0.140	2%	0.480	10%
Bols1A	Tile Wetland	130814	0.310	4%	0.380	18%
Bols1A	Tile Wetland	140506	0.260	7%	0.100	5%
Bols1A	Tile Wetland	140519	0.080	13%	0.130	1%
Bols1A	Tile Wetland	140610	0.185	1%	< 0.1	21%
Bols1A	Tile Wetland	140623	0.935	4%	0.330	2%
Bols1A	Tile Wetland	140708	0.430	0%	0.110	1%
Bols1A	Tile Wetland	140730	0.390	0%	< 0.1	34%
Bols1A	Tile Wetland	140811	0.380	1%	< 0.1	4%
Bols1A	Tile Wetland	140825	0.185	2%	< 0.1	2%
Buff1	Reference Wetland	120522	< 0.05	0%	< 0.075	5%
Buff1	Reference Wetland	120605	0.160	3%	0.367	8%
Buff1	Reference Wetland	120618	0.265	1%	0.472	0%
Buff1	Reference Wetland	120709	0.100	4%	0.290	59%
Buff1	Reference Wetland	130516	0.150	5%	< 0.1	7%
Buff1	Reference Wetland	130521	0.290	5%	0.140	15%
Buff1	Reference Wetland	130612	0.180	4%	0.920	1%
Buff1	Reference Wetland	130627	0.390	4%	1.690	3%
Buff1	Reference Wetland	130708	0.360	17%	> 5.0	1%
Buff1	Reference Wetland	130720	0.250	2%	0.590	16%
Buff1	Reference Wetland	140507	0.405	3%	0.100	8%
Buff1	Reference Wetland	140519	0.310	3%	0.190	4%
Buff1	Reference Wetland	140611	0.260	3%	0.170	8%
Buff1	Reference Wetland	140623	0.215	3%	0.200	3%
Buff1	Reference Wetland	140709	0.155	2%	0.160	4%
Buff1	Reference Wetland	140728	0.210	2%	0.100	8%
Buff1	Reference Wetland	140812	0.210	1%	< 0.1	37%
Buff1T	Tile Outfall	130508	0.070	1%	< 0.1	13%
Buff1T	Tile Outfall	140611	< 0.05	2%	< 0.1	0%
Buff1T	Tile Outfall	140623	0.740	6%	0.340	4%
Clea2	Tile Outfall	140728	0.300	3%	< 0.1	3%
Clea2	Tile Outfall	140812	0.210	3%	< 0.1	2%
Clea2	Tile Outfall	140825	0.085	2%	< 0.1	2%
Cote1	Reference Wetland	130507	0.070	0%	< 0.1	14%
Cote1	Reference Wetland	130520	0.230	4%	< 0.1	6%
Cote1	Reference Wetland	130611	0.100	6%	0.250	10%

Table A.7 Continued.

Field Sample ID	Site Category	Date Collected (YYMMDD)	Atrazine Concentration (ppb)	Percent Coefficient of Variation for Atrazine	Glyphosate Concentration (ppb)	Percent Coefficient of Variation for Glyphosate
Cote1	Reference Wetland	130626	0.180	0%	0.110	5%
Cote1	Reference Wetland	130709	0.210	1%	0.280	1%
Cote1	Reference Wetland	130723	0.250	1%	0.180	5%
Cote1	Reference Wetland	140506	0.300	4%	< 0.1	4%
Cote1	Reference Wetland	140520	0.245	3%	< 0.1	13%
Cote1	Reference Wetland	140610	0.085	2%	< 0.1	19%
Cote1	Reference Wetland	140624	0.260	8%	0.170	3%
Cote1	Reference Wetland	140708	< 0.05	3%	0.170	3%
Cote1	Reference Wetland	140729	0.160	5%	< 0.1	28%
Cote1	Reference Wetland	140811	< 0.05	4%	0.180	1%
Cote1	Reference Wetland	140826	< 0.05	3%	< 0.1	3%
Dryl1	Tile Outfall	120502	< 0.05	1%	< 0.075	28%
Dryl1	Tile Outfall	120522	< 0.05	3%	0.130	1%
Dryl1	Tile Outfall	120605	< 0.05	1%	0.180	6%
Dryl1	Tile Outfall	130515	0.150	4%	< 0.1	2%
Dryl1	Tile Outfall	130611	< 0.05	1%	0.250	1%
Dryl1	Tile Outfall	130709	0.170	6%	0.630	6%
Dryl1	Tile Outfall	140610	< 0.05	3%	< 0.1	5%
Dryl3	Tile Outfall	130611	0.050	5%	0.120	23%
Dryl3	Tile Outfall	130709	0.070	4%	0.190	6%
Dryl3	Tile Outfall	140610	< 0.05	2%	< 0.1	11%
Dryl3	Tile Outfall	140623	< 0.05	1%	0.170	8%
Dryl3	Tile Outfall	140825	< 0.05	1%	< 0.1	4%
Gerk1	Tile Outfall	120522	0.990	13%	< 0.075	22%
Gerk1	Tile Outfall	120605	0.415	2%	0.220	8%
Gerk1	Tile Outfall	120620	0.135	5%	0.665	2%
Gerk1	Tile Outfall	120709	0.090	1%	< 0.075	13%
Gerk1	Tile Outfall	130508	< 0.05	3%	0.120	2%
Gerk1	Tile Outfall	130610	0.700	19%	0.120	5%
Gerk1	Tile Outfall	130626	0.170	2%	0.140	8%
Gerk1	Tile Outfall	130708	0.260	3%	1.050	6%
Gerk1	Tile Outfall	140611	< 0.05	0%	0.120	2%
Gerk1A	Tile Wetland	120905	0.260	6%	0.310	11%
Gerk1A	Tile Wetland	130508	0.080	0%	< 0.1	7%
Gerk1A	Tile Wetland	130520	0.220	27%	< 0.1	9%
Gerk1A	Tile Wetland	130610	2.380	6%	0.130	4%
Gerk1A	Tile Wetland	130626	1.450	1%	1.020	10%
Gerk1A	Tile Wetland	130708	0.700	1%	0.190	2%
Gerk1A	Tile Wetland	130724	0.640	6%	0.430	19%
Gerk1A	Tile Wetland	130812	0.540	3%	0.270	22%
Gerk1A	Tile Wetland	140507	0.360	1%	0.110	22%
Gerk1A	Tile Wetland	140519	0.260	4%	0.110	5%
Gerk1A	Tile Wetland	140611	0.085	3%	0.140	5%
Gerk1A	Tile Wetland	140623	0.325	10%	0.240	6%
Gerk1A	Tile Wetland	140709	0.330	7%	0.170	3%
Gerk1A	Tile Wetland	140730	0.400	3%	< 0.1	27%
Gerk1A	Tile Wetland	140812	0.165	1%	< 0.1	23%

Table A.7 Continued.

Field Sample ID	Site Category	Date Collected (YYMMDD)	Atrazine Concentration (ppb)	Percent Coefficient of Variation for Atrazine	Glyphosate Concentration (ppb)	Percent Coefficient of Variation for Glyphosate
Habe1	Tile Outfall	140611	< 0.05	7%	< 0.1	4%
Habe1	Tile Outfall	140623	< 0.05	0%	0.130	2%
Habe1	Tile Outfall	140825	< 0.05	2%	0.110	4%
Hejo1	Tile Outfall	120523	< 0.05	2%	< 0.075	35%
Hejo1	Tile Outfall	120606	< 0.05	1%	0.110	4%
Hejo1	Tile Outfall	120618	0.080	2%	< 0.075	6%
Hejo1	Tile Outfall	120711	< 0.05	4%	< 0.075	20%
Hejo1	Tile Outfall	130408	< 0.05	1%	< 0.1	8%
Hejo1	Tile Outfall	130520	0.130	1%	< 0.1	4%
Hejo1	Tile Outfall	130611	0.310	3%	< 0.1	3%
Hejo1	Tile Outfall	130627	0.230	5%	2.240	10%
Hejo1	Tile Outfall	130709	0.070	2%	0.120	24%
Hejo1	Tile Outfall	130723	< 0.05	1%	0.870	6%
Hejo1	Tile Outfall	140610	< 0.05	1%	< 0.1	22%
Hejo1	Tile Outfall	140624	< 0.05	5%	< 0.1	8%
Hejo1	Tile Outfall	140708	< 0.05	3%	0.110	2%
Hejo1A	Tile Wetland	130520	0.240	4%	< 0.1	0%
Hejo1A	Tile Wetland	130611	0.410	4%	0.140	7%
Hejo1A	Tile Wetland	130626	0.320	5%	1.700	14%
Hejo1A	Tile Wetland	130709	0.250	0%	0.320	4%
Hejo1A	Tile Wetland	130723	0.160	10%	0.170	3%
Hejo1A	Tile Wetland	130813	0.250	2%	0.190	25%
Hejo1A	Tile Wetland	140506	0.345	5%	0.100	12%
Hejo1A	Tile Wetland	140519	< 0.05	7%	0.100	5%
Hejo1A	Tile Wetland	140610	< 0.05	6%	< 0.1	9%
Hejo1A	Tile Wetland	140624	0.115	3%	0.200	1%
Hejo1A	Tile Wetland	140708	0.095	8%	0.150	0%
Hejo1A	Tile Wetland	140729	0.065	9%	0.140	6%
Hejo1A	Tile Wetland	140811	0.105	6%	< 0.1	9%
Hejo1A	Tile Wetland	140826	0.075	1%	< 0.1	3%
Hejo2	Tile Outfall	120606	0.245	8%	0.120	5%
Hejo2	Tile Outfall	120618	0.160	1%	0.150	6%
Hejo2	Tile Outfall	130611	0.290	2%	0.140	17%
Hejo2	Tile Outfall	130709	< 0.05	4%	0.290	8%
Hejo2	Tile Outfall	140610	< 0.05	3%	< 0.1	3%
Hejo2	Tile Outfall	140624	< 0.05	4%	< 0.1	3%
Hejo2	Tile Outfall	140708	< 0.05	1%	0.100	6%
John1	Surface Wetland	120905	0.100	3%	0.220	12%
John1	Surface Wetland	130507	0.130	1%	< 0.1	5%
John1	Surface Wetland	130520	0.270	1%	< 0.1	26%
John1	Surface Wetland	130611	1.880	3%	0.250	5%
John1	Surface Wetland	130626	1.960	4%	3.130	3%
John1	Surface Wetland	130709	1.450	7%	1.830	8%
John1	Surface Wetland	130723	1.020	2%	1.490	5%
John1	Surface Wetland	130813	1.020	2%	0.200	1%
John1	Surface Wetland	140506	0.205	5%	< 0.1	13%
John1	Surface Wetland	140520	0.240	2%	< 0.1	24%

Table A.7 Continued.

Field Sample ID	Site Category	Date Collected (YYMMDD)	Atrazine Concentration (ppb)	Percent Coefficient of Variation for Atrazine	Glyphosate Concentration (ppb)	Percent Coefficient of Variation for Glyphosate
John1	Surface Wetland	140610	0.135	5%	0.150	4%
John1	Surface Wetland	140624	0.465	2%	0.110	3%
John1	Surface Wetland	140708	0.335	0%	0.320	3%
John1	Surface Wetland	140729	0.405	7%	< 0.1	7%
John1	Surface Wetland	140811	0.300	0%	0.110	10%
Long1	Tile Outfall	120410	< 0.05	4%	< 0.075	6%
Long1	Tile Outfall	120501	< 0.05	6%	< 0.075	11%
Long1	Tile Outfall	120523	< 0.05	0%	< 0.075	10%
Long1	Tile Outfall	120605	< 0.05	0%	0.100	1%
Long1	Tile Outfall	120618	< 0.05	1%	0.130	1%
Long1	Tile Outfall	120709	< 0.05	7%	0.160	4%
Long1	Tile Outfall	140609	0.180	0%	0.110	7%
Long2	Tile Outfall	120410	0.090	0%	< 0.075	7%
Long2	Tile Outfall	120501	0.090	2%	< 0.075	2%
Long2	Tile Outfall	120523	0.060	4%	0.120	2%
Long2	Tile Outfall	120605	< 0.05	3%	0.110	1%
Long2	Tile Outfall	120618	0.125	3%	< 0.075	42%
Long2	Tile Outfall	120709	< 0.05	1%	0.090	69%
Long2	Tile Outfall	130530	0.060	2%	< 0.1	3%
Long2	Tile Outfall	140609	< 0.05	0%	0.110	8%
Long2	Tile Outfall	140623	0.160	3%	0.110	3%
Lost1	Reference Wetland	120501	0.170	5%	< 0.075	43%
Lost1	Reference Wetland	120522	0.130	1%	0.140	1%
Lost1	Reference Wetland	120605	0.265	1%	0.276	16%
Lost1	Reference Wetland	120618	0.440	3%	1.335	3%
Lost1	Reference Wetland	120709	0.290	3%	0.180	51%
Lost1	Reference Wetland	120905	0.370	5%	0.120	74%
Lost1	Reference Wetland	130403	0.200	1%	< 0.1	27%
Lost1	Reference Wetland	130521	0.170	4%	0.150	3%
Lost1	Reference Wetland	130612	0.180	5%	0.120	6%
Lost1	Reference Wetland	130627	0.310	0%	> 5.0	18%
Lost1	Reference Wetland	130710	0.570	3%	> 5.0	25%
Lost1	Reference Wetland	130722	0.330	2%	0.600	5%
Lost1	Reference Wetland	140507	0.265	3%	< 0.1	6%
Lost1	Reference Wetland	140519	0.150	3%	0.520	13%
Lost1	Reference Wetland	140611	0.150	0%	0.230	15%
Lost1	Reference Wetland	140623	0.255	6%	0.140	2%
Lost1	Reference Wetland	140709	0.175	8%	< 0.1	3%
Lost1	Reference Wetland	140728	0.155	9%	< 0.1	17%
Lost1	Reference Wetland	140812	0.285	5%	0.140	8%
Mund1	Tile Wetland	130507	0.150	2%	< 0.1	10%
Mund1	Tile Wetland	130611	0.420	2%	0.100	2%
Mund1	Tile Wetland	130626	0.390	0%	3.750	31%
Mund1	Tile Wetland	130709	0.420	2%	1.010	12%
Mund1	Tile Wetland	130723	0.270	3%	1.930	23%
Mund1	Tile Wetland	130813	0.300	3%	2.670	26%
Mund1	Tile Wetland	140506	0.120	3%	< 0.1	4%

Table A.7 Continued.

Field Sample ID	Site Category	Date Collected (YYMMDD)	Atrazine Concentration (ppb)	Percent Coefficient of Variation for Atrazine	Glyphosate Concentration (ppb)	Percent Coefficient of Variation for Glyphosate
Mund1	Tile Wetland	140520	0.175	3%	< 0.1	15%
Mund1	Tile Wetland	140610	< 0.05	1%	< 0.1	24%
Mund1	Tile Wetland	140624	1.240	3%	0.140	11%
Mund1	Tile Wetland	140708	1.490	3%	0.330	3%
Mund1	Tile Wetland	140729	0.710	9%	< 0.1	1%
Mund1	Tile Wetland	140811	0.460	4%	0.150	4%
Mund1	Tile Wetland	140826	0.550	2%	< 0.1	2%
Mund1T	Tile Outfall	130514	0.090	4%	< 0.1	1%
Mund1T	Tile Outfall	130520	0.260	4%	0.110	2%
Mund1T	Tile Outfall	130611	0.740	3%	< 0.1	0%
Mund1T	Tile Outfall	130709	0.520	1%	0.320	11%
Mund1T	Tile Outfall	130723	0.290	0%	< 0.1	6%
Mund1T	Tile Outfall	130813	0.460	0%	0.100	9%
Mund1T	Tile Outfall	140506	0.150	1%	< 0.1	14%
Mund1T	Tile Outfall	140610	2.630	6%	< 0.1	18%
Mund1T	Tile Outfall	140624	2.820	9%	< 0.1	1%
Mund1T	Tile Outfall	140729	2.590	10%	< 0.1	2%
Mund1T	Tile Outfall	140811	1.830	0%	< 0.1	20%
Mund1T	Tile Outfall	140826	2.180	3%	< 0.1	14%
Nels1	Tile Outfall	120502	0.080	4%	< 0.075	11%
Nels1	Tile Outfall	120523	0.070	2%	1.025	9%
Nels1	Tile Outfall	120606	0.140	0%	0.120	3%
Nels1	Tile Outfall	120618	0.080	1%	0.130	37%
Nels1	Tile Outfall	120711	< 0.05	4%	1.700	18%
Nels1	Tile Outfall	130507	0.110	1%	0.320	9%
Nels1	Tile Outfall	130520	0.330	3%	0.220	4%
Nels1	Tile Outfall	130611	0.520	0%	0.160	30%
Nels1	Tile Outfall	130626	0.480	8%	0.480	4%
Nels1	Tile Outfall	130709	0.170	2%	0.530	7%
Nels1	Tile Outfall	130723	0.140	0%	0.400	3%
Nels1	Tile Outfall	130813	0.100	0%	0.230	12%
Nels1	Tile Outfall	140506	0.420	6%	0.120	2%
Nels1	Tile Outfall	140520	0.210	2%	< 0.1	5%
Nels1	Tile Outfall	140610	0.090	1%	< 0.1	7%
Nels1	Tile Outfall	140624	1.125	1%	0.680	3%
Nels1	Tile Outfall	140708	0.210	1%	0.580	21%
Nels1	Tile Outfall	140811	0.180	14%	2.430	12%
Nels1	Tile Outfall	140826	< 0.05	1%	1.530	3%
Nels1A	Tile Wetland	120905	< 0.05	3%	< 0.075	7%
Nels1A	Tile Wetland	130507	0.190	1%	0.130	15%
Nels1A	Tile Wetland	130520	0.290	5%	0.120	1%
Nels1A	Tile Wetland	130611	0.540	5%	0.140	1%
Nels1A	Tile Wetland	130626	0.450	6%	0.510	4%
Nels1A	Tile Wetland	130709	0.200	1%	0.850	25%
Nels1A	Tile Wetland	130723	0.140	2%	0.380	20%
Nels1A	Tile Wetland	130813	0.190	1%	0.660	11%
Nels1A	Tile Wetland	140506	0.285	7%	< 0.1	2%

Table A.7 Continued.

Field Sample ID	Site Category	Date Collected (YYMMDD)	Atrazine Concentration (ppb)	Percent Coefficient of Variation for Atrazine	Glyphosate Concentration (ppb)	Percent Coefficient of Variation for Glyphosate
Nels1A	Tile Wetland	140520	0.325	4%	< 0.1	12%
Nels1A	Tile Wetland	140610	0.130	3%	< 0.1	14%
Nels1A	Tile Wetland	140624	1.305	1%	1.230	0%
Nels1A	Tile Wetland	140708	0.230	26%	0.540	7%
Nels1A	Tile Wetland	140729	0.135	1%	0.160	12%
Nels1A	Tile Wetland	140811	0.205	6%	2.360	5%
Nels1A	Tile Wetland	140826	< 0.05	0%	0.580	0%
Pett1	Reference Wetland	120906	< 0.05	3%	< 0.075	0%
Pett1	Reference Wetland	130520	0.300	0%	< 0.1	11%
Pett1	Reference Wetland	130610	0.250	4%	0.120	10%
Pett1	Reference Wetland	130626	0.450	6%	0.310	6%
Pett1	Reference Wetland	130708	0.080	1%	0.140	9%
Pett1	Reference Wetland	130724	0.240	0%	0.410	31%
Pett1	Reference Wetland	140507	0.570	4%	< 0.1	14%
Pett1	Reference Wetland	140519	0.315	7%	0.120	0%
Pett1	Reference Wetland	140611	0.255	4%	< 0.1	17%
Pett1	Reference Wetland	140623	0.525	7%	0.360	4%
Pett1	Reference Wetland	140709	0.555	10%	< 0.1	28%
Pett1	Reference Wetland	140728	0.295	4%	0.100	2%
Pett1	Reference Wetland	140812	0.245	3%	< 0.1	5%
Pitt1	Reference Wetland	120905	0.080	17%	< 0.075	29%
Pitt1	Reference Wetland	130507	0.130	9%	< 0.1	6%
Pitt1	Reference Wetland	130520	0.360	0%	< 0.1	13%
Pitt1	Reference Wetland	130610	0.490	3%	0.100	3%
Pitt1	Reference Wetland	130626	0.220	0%	0.700	11%
Pitt1	Reference Wetland	130709	0.350	2%	0.410	4%
Pitt1	Reference Wetland	130723	0.190	6%	0.240	2%
Pitt1	Reference Wetland	130814	0.300	2%	0.550	17%
Pitt1	Reference Wetland	140506	0.170	4%	0.120	2%
Pitt1	Reference Wetland	140520	0.165	2%	0.120	2%
Pitt1	Reference Wetland	140610	< 0.05	2%	0.120	2%
Pitt1	Reference Wetland	140623	0.110	4%	0.130	7%
Pitt1	Reference Wetland	140708	0.155	4%	0.120	1%
Pitt1	Reference Wetland	140730	0.075	11%	< 0.1	28%
Pitt1	Reference Wetland	140811	0.105	3%	< 0.1	11%
Rams1	Surface Wetland	120905	0.100	2%	< 0.075	2%
Rams1	Surface Wetland	130508	< 0.05	2%	< 0.1	7%
Rams1	Surface Wetland	130520	0.360	6%	0.380	4%
Rams1	Surface Wetland	130610	0.760	1%	< 0.1	15%
Rams1	Surface Wetland	130626	0.670	5%	0.250	8%
Rams1	Surface Wetland	130708	0.430	0%	0.370	19%
Rams1	Surface Wetland	130724	0.390	1%	0.350	7%
Rams1	Surface Wetland	130812	0.430	1%	0.460	1%
Rams1	Surface Wetland	140507	< 0.05	1%	0.110	7%
Rams1	Surface Wetland	140519	0.170	5%	0.120	1%
Rams1	Surface Wetland	140611	< 0.05	8%	0.100	1%
Rams1	Surface Wetland	140623	0.120	1%	0.140	12%

Table A.7 Continued.

Field Sample ID	Site Category	Date Collected (YYMMDD)	Atrazine Concentration (ppb)	Percent Coefficient of Variation for Atrazine	Glyphosate Concentration (ppb)	Percent Coefficient of Variation for Glyphosate
Rams1	Surface Wetland	140709	0.150	0%	0.190	3%
Rams1	Surface Wetland	140730	0.115	1%	< 0.1	16%
Rams1	Surface Wetland	140812	0.165	8%	< 0.1	46%
Reev1	Tile Outfall	120522	0.070	1%	< 0.075	11%
Reev1	Tile Outfall	120605	0.180	2%	0.110	0%
Reev1	Tile Outfall	120620	0.260	1%	0.334	7%
Reev1	Tile Outfall	120709	0.090	4%	< 0.075	34%
Reev1	Tile Outfall	130506	0.100	12%	< 0.1	2%
Reev1	Tile Outfall	130612	0.260	15%	< 0.1	15%
Reev1	Tile Outfall	130710	0.310	1%	0.320	2%
Reev1	Tile Outfall	140507	0.325	5%	< 0.1	11%
Reev1	Tile Outfall	140519	< 0.05	1%	0.150	1%
Reev1	Tile Outfall	140609	0.080	3%	< 0.1	1%
Reev1	Tile Outfall	140623	0.270	8%	0.130	3%
Schae1	Surface Wetland	130516	0.120	12%	< 0.1	6%
Schae1	Surface Wetland	130521	0.290	2%	0.230	20%
Schae1	Surface Wetland	130612	0.170	0%	0.140	19%
Schae1	Surface Wetland	130627	0.360	2%	0.770	2%
Schae1	Surface Wetland	130710	0.200	2%	1.990	2%
Schae1	Surface Wetland	130722	0.320	9%	0.290	4%
Schae1	Surface Wetland	140507	0.395	5%	< 0.1	0%
Schae1	Surface Wetland	140519	0.165	4%	0.180	6%
Schae1	Surface Wetland	140611	0.090	9%	0.230	2%
Schae1	Surface Wetland	140623	0.470	1%	2.870	4%
Schae1	Surface Wetland	140709	0.100	5%	0.610	6%
Schae1	Surface Wetland	140728	0.230	4%	< 0.1	1%
Schae1	Surface Wetland	140812	0.355	6%	0.200	7%
Schaf1	Reference Wetland	120905	< 0.05	2%	< 0.075	11%
Schaf1	Reference Wetland	130507	< 0.05	5%	< 0.1	1%
Schaf1	Reference Wetland	130520	0.210	0%	< 0.1	5%
Schaf1	Reference Wetland	130611	0.070	7%	0.250	8%
Schaf1	Reference Wetland	130626	0.200	3%	0.160	6%
Schaf1	Reference Wetland	130709	0.110	0%	0.250	6%
Schaf1	Reference Wetland	130723	0.070	3%	0.210	17%
Schaf1	Reference Wetland	130813	0.210	2%	0.180	8%
Schaf1	Reference Wetland	140506	0.185	5%	< 0.1	8%
Schaf1	Reference Wetland	140520	0.325	2%	0.560	5%
Schaf1	Reference Wetland	140610	< 0.05	2%	< 0.1	1%
Schaf1	Reference Wetland	140624	0.315	3%	0.120	4%
Schaf1	Reference Wetland	140708	0.190	3%	0.120	1%
Schaf1	Reference Wetland	140729	0.240	1%	< 0.1	8%
Schaf1	Reference Wetland	140811	< 0.05	4%	< 0.1	9%
Seve1	Reference Wetland	120523	0.110	1%	0.240	4%
Seve1	Reference Wetland	120606	0.200	4%	0.250	4%
Seve1	Reference Wetland	120618	0.450	2%	0.100	39%
Thor1	Tile Outfall	120501	0.070	3%	< 0.075	6%
Thor1	Tile Outfall	120502	0.050	2%	< 0.075	8%

Table A.7 Continued.

Field Sample ID	Site Category	Date Collected (YYMMDD)	Atrazine Concentration (ppb)	Percent Coefficient of Variation for Atrazine	Glyphosate Concentration (ppb)	Percent Coefficient of Variation for Glyphosate
Thor1	Tile Outfall	120522	< 0.05	3%	< 0.075	6%
Thor1	Tile Outfall	120605	< 0.05	2%	< 0.075	15%
Thor1	Tile Outfall	120620	0.095	2%	0.220	11%
Thor1	Tile Outfall	130506	< 0.05	4%	< 0.1	1%
Thor1	Tile Outfall	130612	0.050	5%	0.120	14%
Thor1	Tile Outfall	140507	0.070	2%	< 0.1	4%
Thor1	Tile Outfall	140519	< 0.05	5%	0.110	1%
Thor1	Tile Outfall	140609	< 0.05	2%	< 0.1	15%
Thor1	Tile Outfall	140623	< 0.05	0%	0.170	4%
Volk1	Tile Wetland	130516	0.300	2%	0.150	17%
Volk1	Tile Wetland	130521	0.420	8%	0.580	2%
Volk1	Tile Wetland	130612	2.840	9%	1.210	11%
Volk1	Tile Wetland	130627	1.900	6%	4.690	10%
Volk1	Tile Wetland	130710	1.110	7%	> 5.0	0%
Volk1	Tile Wetland	130722	0.840	6%	> 5.0	30%
Volk1	Tile Wetland	140507	0.595	9%	< 0.1	19%
Volk1	Tile Wetland	140519	0.445	0%	0.420	12%
Volk1	Tile Wetland	140611	0.180	3%	0.360	5%
Volk1	Tile Wetland	140623	0.305	2%	0.780	7%
Volk1	Tile Wetland	140709	0.105	3%	1.220	11%
Volk1	Tile Wetland	140728	0.605	5%	2.210	4%
Volk1	Tile Wetland	140812	0.605	11%	0.620	60%
Whof1	Tile Outfall	120522	< 0.05	0%	< 0.075	4%
Whof1	Tile Outfall	120605	< 0.05	5%	0.110	7%
Whof1	Tile Outfall	120618	< 0.05	4%	0.110	1%
Whof1	Tile Outfall	130530	0.140	2%	< 0.1	11%
Zieg1	Surface Wetland	130520	0.890	4%	< 0.1	3%
Zieg1	Surface Wetland	130610	0.300	2%	0.160	5%
Zieg1	Surface Wetland	130626	0.530	3%	2.880	9%
Zieg1	Surface Wetland	130710	0.400	2%	1.580	79%
Zieg1	Surface Wetland	130723	0.330	4%	0.390	7%
Zieg1	Surface Wetland	130814	0.410	0%	2.400	7%
Zieg1	Surface Wetland	140506	0.345	7%	0.130	3%
Zieg1	Surface Wetland	140519	0.115	1%	< 0.1	21%
Zieg1	Surface Wetland	140610	0.695	5%	0.190	15%
Zieg1	Surface Wetland	140623	1.165	8%	0.630	6%
Zieg1	Surface Wetland	140708	1.175	2%	0.410	8%
Zieg1	Surface Wetland	140730	0.195	5%	0.140	1%
Zieg1	Surface Wetland	140811	0.305	1%	< 0.1	34%

Note: YYMMDD = year, month, day format, ppb = parts per billion or micrograms per liter, < = less than the detection limit.

Table A.8. Concentrations of nitrate in water samples from select study sites within Madison Wetland Management District, South Dakota, 2011–2014.

Lab Number	Year	Month	Date Collected (MMDDYY)	Site ID	Site Category	Nitrate Concentration mg/L
12-008	2012	May	5/1/2012	2Petr1A	Surface Wetland	0.5
12-100	2012	September	9/5/2012	2Petr1A	Surface Wetland	0.3
13-008	2013	April	4/8/2013	2Petr1A	Surface Wetland	1.6
13-076	2013	June	6/12/2013	2Petr1A	Surface Wetland	0.2
13-117	2013	June	6/27/2013	2Petr1A	Surface Wetland	0.3
13-126	2013	July	7/10/2013	2Petr1A	Surface Wetland	0.45
13-184	2013	July	7/22/2013	2Petr1A	Surface Wetland	0.35
14-006	2014	May	5/7/2014	2Petr1A	Surface Wetland	0.5
14-043	2014	May	5/19/2014	2Petr1A	Surface Wetland	0.5
14-055	2014	June	6/11/2014	2Petr1A	Surface Wetland	0.2
14-105	2014	June	6/23/2014	2Petr1A	Surface Wetland	0.1
14-122	2014	July	7/9/2014	2Petr1A	Surface Wetland	0.1
14-147	2014	July	7/28/2014	2Petr1A	Surface Wetland	0.2
14-172	2014	August	8/12/2014	2Petr1A	Surface Wetland	0.1
14-203	2014	August	8/25/2014	2Petr1A	Surface Wetland	0.1
12-018	2012	May	5/22/2012	2Petr2	Tile Outfall	13.5
12-044	2012	June	6/5/2012	2Petr2	Tile Outfall	13.5
13-074	2013	June	6/12/2013	2Petr2	Tile Outfall	25
11-021	2011	May	5/3/2011	Ache1	Tile Outfall	6.1
11-035	2011	June	6/2/2011	Ache1	Tile Outfall	6.5
11-069	2011	June	6/21/2011	Ache1	Tile Outfall	17
11-083	2011	June	6/27/2011	Ache1	Tile Outfall	6.9
11-110	2011	July	7/11/2011	Ache1	Tile Outfall	8.45
11-136	2011	July	7/26/2011	Ache1	Tile Outfall	7
12-024	2012	May	5/22/2012	Ache1	Tile Outfall	7
12-041	2012	June	6/5/2012	Ache1	Tile Outfall	7.2
13-070	2013	June	6/12/2013	Ache1	Tile Outfall	13.5
14-053	2014	June	6/11/2014	Ache1	Tile Outfall	8.7
14-085	2014	June	6/23/2014	Ache1	Tile Outfall	8.55
12-097	2012	September	9/5/2012	Ache1A	Tile Wetland	1.2
13-043	2013	May	5/21/2013	Ache1A	Tile Wetland	1
13-067	2013	June	6/12/2013	Ache1A	Tile Wetland	0.8
13-116	2013	June	6/27/2013	Ache1A	Tile Wetland	0.8
13-122	2013	July	7/10/2013	Ache1A	Tile Wetland	1.05
13-182	2013	July	7/22/2013	Ache1A	Tile Wetland	1.3
12-029	2012	May	5/23/2012	Adam1	Tile Outfall	9.2
12-058	2012	June	6/6/2012	Adam1	Tile Outfall	15.5
13-020	2013	May	5/7/2013	Adam1	Tile Outfall	9.2
13-091	2013	June	6/11/2013	Adam1	Tile Outfall	6.9
13-198	2013	July	7/23/2013	Adam1	Tile Outfall	17
14-018	2014	May	5/6/2014	Adam1	Tile Outfall	1.6
14-031	2014	May	5/20/2014	Adam1	Tile Outfall	5
14-070	2014	June	6/10/2014	Adam1	Tile Outfall	9.7
14-098	2014	June	6/24/2014	Adam1	Tile Outfall	7.9
14-125	2014	July	7/8/2014	Adam1	Tile Outfall	25.5
14-171	2014	August	8/11/2014	Adam2	Tile Outfall	14
11-033	2011	June	6/2/2011	B2	Reference Wetland	0.2
11-051	2011	June	6/13/2011	B2	Reference Wetland	0.1
11-082	2011	June	6/27/2011	B2	Reference Wetland	0.3
11-108	2011	July	7/11/2011	B2	Reference Wetland	0.3
11-134	2011	July	7/26/2011	B2	Reference Wetland	0.1

Table A.8. Continued.

Lab Number	Year	Month	Date Collected (MMDDYY)	Site ID	Site Category	Nitrate Concentration mg/L
11-183	2011	August	8/9/2011	B2	Reference Wetland	0.25
11-072	2011	June	6/22/2011	Bens1	Tile Outfall	15
11-096	2011	June	6/28/2011	Bens1	Tile Outfall	14
11-124	2011	July	7/12/2011	Bens1	Tile Outfall	16
11-150	2011	July	7/27/2011	Bens1	Tile Outfall	15
11-193	2011	August	8/9/2011	Bens1	Tile Outfall	22
11-206	2011	August	8/22/2011	Bens1	Tile Outfall	12
12-049	2012	June	6/5/2012	Bens1	Tile Outfall	14.5
14-062	2014	June	6/9/2014	Bens1	Tile Outfall	21
11-043	2011	June	6/3/2011	Bols1	Tile Outfall	2.05
11-063	2011	June	6/14/2011	Bols1	Tile Outfall	2.6
11-098	2011	June	6/28/2011	Bols1	Tile Outfall	1.5
11-125	2011	July	7/12/2011	Bols1	Tile Outfall	1.35
12-059	2012	June	6/6/2012	Bols1	Tile Outfall	1.75
13-015	2013	April	4/8/2013	Bols1	Tile Outfall	3.7
13-031	2013	May	5/8/2013	Bols1	Tile Outfall	1.2
13-035	2013	May	5/20/2013	Bols1	Tile Outfall	3.6
13-065	2013	June	6/10/2013	Bols1	Tile Outfall	3.5
13-115	2013	June	6/26/2013	Bols1	Tile Outfall	0.9
13-143	2013	July	7/10/2013	Bols1	Tile Outfall	2.2
14-014	2014	May	5/6/2014	Bols1	Tile Outfall	2.7
14-049	2014	June	6/10/2014	Bols1	Tile Outfall	15
14-106	2014	June	6/23/2014	Bols1	Tile Outfall	7.65
14-128	2014	July	7/8/2014	Bols1	Tile Outfall	2.6
14-163	2014	July	7/30/2014	Bols1	Tile Outfall	1
14-169	2014	August	8/11/2014	Bols1	Tile Outfall	2.5
14-196	2014	August	8/25/2014	Bols1	Tile Outfall	0.1
13-036	2013	May	5/20/2013	Bols1A	Tile Wetland	0.4
13-055	2013	June	6/10/2013	Bols1A	Tile Wetland	0.4
13-102	2013	June	6/26/2013	Bols1A	Tile Wetland	0.4
13-142	2013	July	7/10/2013	Bols1A	Tile Wetland	0.4
13-201	2013	July	7/24/2013	Bols1A	Tile Wetland	0.5
14-019	2014	May	5/6/2014	Bols1A	Tile Wetland	0.4
14-037	2014	May	5/19/2014	Bols1A	Tile Wetland	0.4
14-056	2014	June	6/10/2014	Bols1A	Tile Wetland	0.4
14-081	2014	June	6/23/2014	Bols1A	Tile Wetland	0.25
14-124	2014	July	7/8/2014	Bols1A	Tile Wetland	0.15
14-159	2014	July	7/30/2014	Bols1A	Tile Wetland	0.3
14-166	2014	August	8/11/2014	Bols1A	Tile Wetland	0.1
14-208	2014	August	8/25/2014	Bols1A	Tile Wetland	0.1
12-001	2012	May	5/1/2012	Buff1	Reference Wetland	0.5
12-015	2012	May	5/22/2012	Buff1	Reference Wetland	0.5
12-036	2012	June	6/5/2012	Buff1	Reference Wetland	0.6
12-073	2012	June	6/18/2012	Buff1	Reference Wetland	0.4
12-074	2012	July	7/9/2012	Buff1	Reference Wetland	0.6
13-042	2013	May	5/21/2013	Buff1	Reference Wetland	0.6
13-078	2013	June	6/12/2013	Buff1	Reference Wetland	0.4
13-121	2013	June	6/27/2013	Buff1	Reference Wetland	0.2
13-123	2013	July	7/10/2013	Buff1	Reference Wetland	0.1
13-186	2013	July	7/22/2013	Buff1	Reference Wetland	0.1
14-015	2014	May	5/7/2014	Buff1	Reference Wetland	0.5

Table A.8. Continued.

Lab Number	Year	Month	Date Collected (MMDDYY)	Site ID	Site Category	Nitrate Concentration mg/L
14-039	2014	May	5/19/2014	Buff1	Reference Wetland	0.5
14-051	2014	June	6/11/2014	Buff1	Reference Wetland	0.5
14-110	2014	June	6/23/2014	Buff1	Reference Wetland	0.1
14-113	2014	July	7/9/2014	Buff1	Reference Wetland	0.3
14-149	2014	July	7/28/2014	Buff1	Reference Wetland	0.3
14-175	2014	August	8/12/2014	Buff1	Reference Wetland	0.2
14-201	2014	August	8/25/2014	Buff1	Reference Wetland	0.2
13-030	2013	May	5/8/2013	Buff1T	Tile Outfall	2.9
13-125	2013	July	7/10/2013	Buff1T	Tile Outfall	3.7
14-058	2014	June	6/11/2014	Buff1T	Tile Outfall	6.55
14-084	2014	June	6/23/2014	Buff1T	Tile Outfall	8.45
11-030	2011	June	6/2/2011	Chris1T	Tile Outfall	22
11-057	2011	June	6/14/2011	Chris1T	Tile Outfall	22.5
11-087	2011	June	6/27/2011	Chris1T	Tile Outfall	21
11-114	2011	July	7/11/2011	Chris1T	Tile Outfall	3.6
11-140	2011	July	7/26/2011	Chris1T	Tile Outfall	14
11-186	2011	August	8/9/2011	Chris1T	Tile Outfall	32.5
11-207	2011	August	8/22/2011	Chris1T	Tile Outfall	31
14-119	2014	July	7/9/2014	Clea2	Tile Outfall	13
14-148	2014	July	7/28/2014	Clea2	Tile Outfall	8.85
14-176	2014	August	8/12/2014	Clea2	Tile Outfall	9.6
14-204	2014	August	8/25/2014	Clea2	Tile Outfall	0.15
12-087	2012	July	7/23/2012	Clea2	Tile Outfall	12
13-061	2013	May	5/30/2013	Clea2	Tile Outfall	10
13-027	2013	May	5/7/2013	Cote1	Reference Wetland	0.8
13-048	2013	May	5/20/2013	Cote1	Reference Wetland	0.8
13-080	2013	June	6/11/2013	Cote1	Reference Wetland	0.8
13-109	2013	June	6/26/2013	Cote1	Reference Wetland	0.7
13-197	2013	July	7/23/2013	Cote1	Reference Wetland	0.8
14-024	2014	May	5/20/2014	Cote1	Reference Wetland	0.5
14-080	2014	June	6/9/2014	Cote1	Reference Wetland	0.55
14-096	2014	June	6/24/2014	Cote1	Reference Wetland	0.1
14-131	2014	July	7/8/2014	Cote1	Reference Wetland	0.15
14-155	2014	July	7/29/2014	Cote1	Reference Wetland	0.6
14-185	2014	August	8/11/2014	Cote1	Reference Wetland	0.1
14-200	2014	August	8/26/2014	Cote1	Reference Wetland	0.1
12-013	2012	May	5/2/2012	Dryl1	Tile Outfall	5.2
12-020	2012	May	5/22/2012	Dryl1	Tile Outfall	9.05
12-045	2012	June	6/5/2012	Dryl1	Tile Outfall	9.15
13-004	2013	April	4/1/2013	Dryl1	Tile Outfall	5.1
13-134	2013	July	7/10/2013	Dryl1	Tile Outfall	14
14-067	2014	June	6/10/2014	Dryl1	Tile Outfall	20
12-021	2012	May	5/22/2012	Dryl2	Tile Outfall	4.2
12-040	2012	June	6/5/2012	Dryl2	Tile Outfall	3.4
13-077	2013	June	6/11/2013	Dryl2	Tile Outfall	20
13-083	2013	June	6/11/2013	Dryl3	Tile Outfall	15
13-129	2013	July	7/10/2013	Dryl3	Tile Outfall	25
14-072	2014	June	6/10/2014	Dryl3	Tile Outfall	19
14-091	2014	June	6/23/2014	Dryl3	Tile Outfall	24
14-126	2014	July	7/8/2014	Dryl3	Tile Outfall	15
14-145	2014	July	7/28/2014	Dryl3	Tile Outfall	14.5

Table A.8. Continued.

Lab Number	Year	Month	Date Collected (MMDDYY)	Site ID	Site Category	Nitrate Concentration mg/L
14-198	2014	August	8/25/2014	Dryl3	Tile Outfall	0.3
12-022	2012	May	5/22/2012	Gerk1	Tile Outfall	3.7
12-038	2012	June	6/5/2012	Gerk1	Tile Outfall	6.5
12-061	2012	June	6/20/2012	Gerk1	Tile Outfall	8.15
12-075	2012	July	7/9/2012	Gerk1	Tile Outfall	7.5
13-016	2013	April	4/8/2013	Gerk1	Tile Outfall	2.5
13-022	2013	May	5/8/2013	Gerk1	Tile Outfall	7.6
13-057	2013	June	6/10/2013	Gerk1	Tile Outfall	17
13-111	2013	June	6/26/2013	Gerk1	Tile Outfall	9.9
14-047	2014	May	5/12/2014	Gerk1	Tile Outfall	0.6
12-093	2012	September	9/5/2012	Gerk1A	Tile Wetland	0.3
13-023	2013	May	5/8/2013	Gerk1A	Tile Wetland	0.3
13-073	2013	May	5/13/2013	Gerk1A	Tile Wetland	0.3
13-041	2013	May	5/20/2013	Gerk1A	Tile Wetland	0.6
13-056	2013	June	6/10/2013	Gerk1A	Tile Wetland	29
13-100	2013	June	6/26/2013	Gerk1A	Tile Wetland	7.6
13-144	2013	July	7/8/2013	Gerk1A	Tile Wetland	0.3
13-200	2013	July	7/24/2013	Gerk1A	Tile Wetland	0.5
14-002	2014	May	5/7/2014	Gerk1A	Tile Wetland	0.65
14-041	2014	May	5/19/2014	Gerk1A	Tile Wetland	0.6
14-060	2014	June	6/11/2014	Gerk1A	Tile Wetland	0.4
14-107	2014	June	6/23/2014	Gerk1A	Tile Wetland	0.1
14-120	2014	July	7/9/2014	Gerk1A	Tile Wetland	0.6
14-162	2014	July	7/30/2014	Gerk1A	Tile Wetland	0.6
14-170	2014	August	8/12/2014	Gerk1A	Tile Wetland	0.35
14-189	2014	August	8/25/2014	Gerk1A	Tile Wetland	0.1
11-020	2011	May	5/3/2011	Hein1	Surface Wetland	1.9
11-039	2011	June	6/2/2011	Hein1	Surface Wetland	2.15
11-092	2011	June	6/28/2011	Hein1	Surface Wetland	2.9
11-123	2011	July	7/12/2011	Hein1	Surface Wetland	1.9
11-148	2011	July	7/27/2011	Hein1	Surface Wetland	0.1
14-052	2014	June	6/11/2014	Habe1	Tile Outfall	35
14-088	2014	June	6/23/2014	Habe1	Tile Outfall	37.5
14-117	2014	July	7/9/2014	Habe1	Tile Outfall	35
14-195	2014	August	8/25/2014	Habe1	Tile Outfall	0.1
12-032	2012	May	5/23/2012	Hejo1	Tile Outfall	8.6
12-055	2012	June	6/6/2012	Hejo1	Tile Outfall	8.5
12-067	2012	June	6/18/2012	Hejo1	Tile Outfall	9.25
12-082	2012	July	7/11/2012	Hejo1	Tile Outfall	9
13-005	2013	April	4/1/2013	Hejo1	Tile Outfall	6.1
13-007	2013	April	4/8/2013	Hejo1	Tile Outfall	6
13-019	2013	May	5/7/2013	Hejo1	Tile Outfall	9.5
13-053	2013	May	5/20/2013	Hejo1	Tile Outfall	9.3
13-087	2013	June	6/11/2013	Hejo1	Tile Outfall	15.5
13-108	2013	June	6/26/2013	Hejo1	Tile Outfall	15
13-135	2013	July	7/9/2013	Hejo1	Tile Outfall	19
13-190	2013	July	7/23/2013	Hejo1	Tile Outfall	16
14-009	2014	May	5/6/2014	Hejo1	Tile Outfall	5.5
14-044	2014	May	5/13/2014	Hejo1	Tile Outfall	7.7
14-075	2014	June	6/11/2014	Hejo1	Tile Outfall	0.3
14-092	2014	June	6/24/2014	Hejo1	Tile Outfall	8.75

Table A.8. Continued.

Lab Number	Year	Month	Date Collected (MMDDYY)	Site ID	Site Category	Nitrate Concentration mg/L
14-134	2014	July	7/8/2014	Hejo1	Tile Outfall	9.6
13-062	2013	May	5/15/2013	Hejo1A	Tile Wetland	0.3
13-047	2013	May	5/20/2013	Hejo1A	Tile Wetland	0.35
13-084	2013	June	6/11/2013	Hejo1A	Tile Wetland	3.3
13-114	2013	June	6/26/2013	Hejo1A	Tile Wetland	1.4
13-131	2013	July	7/9/2013	Hejo1A	Tile Wetland	0.25
13-195	2013	July	7/23/2013	Hejo1A	Tile Wetland	0.2
14-022	2014	May	5/6/2014	Hejo1A	Tile Wetland	0.2
14-035	2014	May	5/19/2014	Hejo1A	Tile Wetland	0.3
14-065	2014	June	6/10/2014	Hejo1A	Tile Wetland	9.75
14-099	2014	June	6/24/2014	Hejo1A	Tile Wetland	0.1
14-140	2014	July	7/8/2014	Hejo1A	Tile Wetland	0.2
14-157	2014	July	7/29/2014	Hejo1A	Tile Wetland	0.4
14-168	2014	August	8/11/2014	Hejo1A	Tile Wetland	0.1
14-188	2014	August	8/26/2014	Hejo1A	Tile Wetland	0.1
12-053	2012	June	6/6/2012	Hejo2	Tile Outfall	10.1
12-063	2012	June	6/18/2012	Hejo2	Tile Outfall	13.5
13-082	2013	June	6/11/2013	Hejo2	Tile Outfall	23.5
14-048	2014	June	6/10/2014	Hejo2	Tile Outfall	15
14-093	2014	June	6/24/2014	Hejo2	Tile Outfall	14
14-118	2014	July	7/8/2014	Hejo2	Tile Outfall	17
12-099	2012	September	9/5/2012	John1	Surface Wetland	0.25
13-029	2013	May	5/7/2013	John1	Surface Wetland	0.5
13-050	2013	May	5/20/2013	John1	Surface Wetland	0.5
13-089	2013	June	6/11/2013	John1	Surface Wetland	1.4
13-103	2013	June	6/26/2013	John1	Surface Wetland	1.3
13-133	2013	July	7/9/2013	John1	Surface Wetland	0.3
13-193	2013	July	7/23/2013	John1	Surface Wetland	0.3
14-003	2014	May	5/6/2014	John1	Surface Wetland	0.3
14-028	2014	May	5/20/2014	John1	Surface Wetland	0.4
14-069	2014	June	6/10/2014	John1	Surface Wetland	0.4
14-101	2014	June	6/24/2014	John1	Surface Wetland	0.1
14-130	2014	July	7/8/2014	John1	Surface Wetland	0.1
14-156	2014	July	7/29/2014	John1	Surface Wetland	0.4
14-183	2014	August	8/11/2014	John1	Surface Wetland	0.1
14-205	2014	August	8/26/2014	John1	Surface Wetland	0.1
11-097	2011	June	6/28/2011	Klien5	Reference Wetland	0.1
11-119	2011	July	7/11/2011	Klien5	Reference Wetland	0.2
11-145	2011	July	7/26/2011	Klien5	Reference Wetland	0.1
11-192	2011	August	8/9/2011	Klien5	Reference Wetland	0.5
11-013	2011	May	5/3/2011	Klie1	Tile Outfall	24
11-040	2011	June	6/2/2011	Klie1	Tile Outfall	26
11-061	2011	June	6/14/2011	Klie1	Tile Outfall	27
11-093	2011	June	6/28/2011	Klie1	Tile Outfall	26
11-121	2011	July	7/11/2011	Klie1	Tile Outfall	28
11-147	2011	July	7/26/2011	Klie1	Tile Outfall	25
12-023	2012	May	5/22/2012	Klie1	Tile Outfall	25.5
12-037	2012	June	6/5/2012	Klie1	Tile Outfall	27.5
11-221	2011	October	10/12/2011	Long1	Tile Outfall	15
11-019	2011	May	5/3/2011	Long1	Tile Outfall	10
11-028	2011	June	6/2/2011	Long1	Tile Outfall	14

Table A.8. Continued.

Lab Number	Year	Month	Date Collected (MMDDYY)	Site ID	Site Category	Nitrate Concentration mg/L
11-048	2011	June	6/13/2011	Long1	Tile Outfall	14
11-079	2011	June	6/27/2011	Long1	Tile Outfall	14
11-106	2011	July	7/11/2011	Long1	Tile Outfall	15
11-133	2011	July	7/26/2011	Long1	Tile Outfall	14.5
11-180	2011	August	8/9/2011	Long1	Tile Outfall	9.05
11-202	2011	August	8/22/2011	Long1	Tile Outfall	14.5
12-005	2012	May	5/1/2012	Long1	Tile Outfall	9.75
12-034	2012	May	5/23/2012	Long1	Tile Outfall	10.35
12-047	2012	June	6/5/2012	Long1	Tile Outfall	13
12-065	2012	June	6/18/2012	Long1	Tile Outfall	16
12-079	2012	July	7/9/2012	Long1	Tile Outfall	12.5
12-085	2012	July	7/23/2012	Long1	Tile Outfall	10.2
13-140	2013	July	7/10/2013	Long1	Tile Outfall	7.2
14-129	2014	July	7/7/2014	Long1	Tile Outfall	8.75
11-011	2011	May	5/3/2011	Long2	Tile Outfall	6.1
11-029	2011	June	6/2/2011	Long2	Tile Outfall	8
11-049	2011	June	6/13/2011	Long2	Tile Outfall	9.6
11-080	2011	June	6/27/2011	Long2	Tile Outfall	9.5
11-107	2011	July	7/11/2011	Long2	Tile Outfall	7.4
11-155	2011	July	7/27/2011	Long2	Tile Outfall	9.7
11-181	2011	August	8/9/2011	Long2	Tile Outfall	15
11-203	2011	August	8/22/2011	Long2	Tile Outfall	8.05
11-222	2011	October	10/12/2011	Long2	Tile Outfall	9.5
12-004	2012	May	5/1/2012	Long2	Tile Outfall	9.5
12-027	2012	May	5/23/2012	Long2	Tile Outfall	16.5
12-043	2012	June	6/5/2012	Long2	Tile Outfall	16.5
12-066	2012	June	6/18/2012	Long2	Tile Outfall	15
12-078	2012	July	7/9/2012	Long2	Tile Outfall	10.15
13-016	2013	April	4/23/2013	Long2	Tile Outfall	4.85
13-071	2013	May	5/30/2013	Long2	Tile Outfall	9
14-064	2014	June	6/9/2014	Long2	Tile Outfall	13
14-086	2014	June	6/23/2014	Long2	Tile Outfall	17.5
14-138	2014	July	7/7/2014	Long2	Tile Outfall	9.55
11-017	2011	May	5/3/2011	Lost1	Reference Wetland	0.1
11-037	2011	June	6/2/2011	Lost1	Reference Wetland	0.3
11-054	2011	June	6/13/2011	Lost1	Reference Wetland	0.1
11-084	2011	June	6/27/2011	Lost1	Reference Wetland	0.3
11-111	2011	July	7/11/2011	Lost1	Reference Wetland	0.2
11-137	2011	July	7/26/2011	Lost1	Reference Wetland	0.15
11-184	2011	August	8/9/2011	Lost1	Reference Wetland	0.2
11-200	2011	August	8/22/2011	Lost1	Reference Wetland	0.8
12-003	2012	May	5/1/2012	Lost1	Reference Wetland	0.5
12-025	2012	May	5/22/2012	Lost1	Reference Wetland	0.6
12-050	2012	June	6/5/2012	Lost1	Reference Wetland	0.7
12-072	2012	June	6/18/2012	Lost1	Reference Wetland	0.8
12-076	2012	July	7/9/2012	Lost1	Reference Wetland	0.6
12-096	2012	September	9/5/2012	Lost1	Reference Wetland	1.9
13-011	2013	April	4/8/2013	Lost1	Reference Wetland	0.7
13-098	2013	May	5/16/2013	Lost1	Reference Wetland	0.6
13-044	2013	May	5/21/2013	Lost1	Reference Wetland	0.5
13-068	2013	June	6/12/2013	Lost1	Reference Wetland	0.7

Table A.8. Continued.

Lab Number	Year	Month	Date Collected (MMDDYY)	Site ID	Site Category	Nitrate Concentration mg/L
13-094	2013	June	6/12/2013	Lost1	Reference Wetland	0.4
13-118	2013	June	6/27/2013	Lost1	Reference Wetland	0.4
13-127	2013	July	7/10/2013	Lost1	Reference Wetland	0.4
13-183	2013	July	7/22/2013	Lost1	Reference Wetland	0.4
14-016	2014	May	5/7/2014	Lost1	Reference Wetland	0.2
14-034	2014	May	5/19/2014	Lost1	Reference Wetland	0.3
14-094	2014	June	6/23/2014	Lost1	Reference Wetland	0.1
14-121	2014	July	7/9/2014	Lost1	Reference Wetland	0.1
14-143	2014	July	7/28/2014	Lost1	Reference Wetland	0.1
14-173	2014	August	8/12/2014	Lost1	Reference Wetland	0.1
14-209	2014	August	8/25/2014	Lost1	Reference Wetland	0.3
14-059	2014	June	6/9/2014	Madi1	Tile Outfall	20.5
11-010	2011	May	5/3/2011	Madi1	Tile Outfall	13.5
11-025	2011	June	6/2/2011	Madi1	Tile Outfall	15
11-046	2011	June	6/13/2011	Madi1	Tile Outfall	18
11-066	2011	June	6/21/2011	Madi1	Tile Outfall	9.7
11-077	2011	June	6/27/2011	Madi1	Tile Outfall	15.5
11-104	2011	July	7/11/2011	Madi1	Tile Outfall	9.85
11-131	2011	July	7/26/2011	Madi1	Tile Outfall	15
11-179	2011	August	8/9/2011	Madi1	Tile Outfall	15
11-199	2011	August	8/22/2011	Madi1	Tile Outfall	9.85
12-035	2012	May	5/23/2012	Madi1	Tile Outfall	15
11-027	2011	June	6/2/2011	Madi3	Tile Outfall	21
11-045	2011	June	6/13/2011	Madi3	Tile Outfall	20
11-065	2011	June	6/21/2011	Madi3	Tile Outfall	19
11-076	2011	June	6/27/2011	Madi3	Tile Outfall	20
11-103	2011	July	7/11/2011	Madi3	Tile Outfall	19
11-130	2011	July	7/26/2011	Madi3	Tile Outfall	3.5
11-177	2011	August	8/9/2011	Madi3	Tile Outfall	16
12-042	2012	June	6/5/2012	Madi3	Tile Outfall	23
11-224	2011	October	10/12/2011	Madi4	Tile Outfall	9.85
12-007	2012	May	5/1/2012	Madi4	Tile Outfall	10
12-033	2012	May	5/23/2012	Madi4	Tile Outfall	16
12-101	2012	September	9/5/2012	Mund1	Tile Wetland	0.4
13-026	2013	May	5/7/2013	Mund1	Tile Wetland	0.35
13-051	2013	May	5/20/2013	Mund1	Tile Wetland	0.45
13-090	2013	June	6/11/2013	Mund1	Tile Wetland	0.3
13-104	2013	June	6/26/2013	Mund1	Tile Wetland	0.2
13-151	2013	July	7/9/2013	Mund1	Tile Wetland	0.2
13-192	2013	July	7/23/2013	Mund1	Tile Wetland	0.4
14-007	2014	May	5/6/2014	Mund1	Tile Wetland	0.3
14-029	2014	May	5/20/2014	Mund1	Tile Wetland	0.3
14-068	2014	June	6/10/2014	Mund1	Tile Wetland	0.4
14-097	2014	June	6/24/2014	Mund1	Tile Wetland	0.1
14-142	2014	July	7/8/2014	Mund1	Tile Wetland	0.2
14-152	2014	July	7/29/2014	Mund1	Tile Wetland	0.2
14-186	2014	August	8/11/2014	Mund1	Tile Wetland	0.1
14-187	2014	August	8/26/2014	Mund1	Tile Wetland	0.15
13-081	2013	June	6/11/2013	Mund1T	Tile Outfall	3.95
13-147	2013	July	7/8/2013	Mund1T	Tile Outfall	2
13-189	2013	July	7/23/2013	Mund1T	Tile Outfall	13

Table A.8. Continued.

Lab Number	Year	Month	Date Collected (MMDDYY)	Site ID	Site Category	Nitrate Concentration mg/L
14-017	2014	May	5/6/2014	Mund1T	Tile Outfall	7.9
14-045	2014	May	5/13/2014	Mund1T	Tile Outfall	6.8
14-071	2014	June	6/10/2014	Mund1T	Tile Outfall	8.9
14-100	2014	June	6/24/2014	Mund1T	Tile Outfall	4.95
14-133	2014	July	7/8/2014	Mund1T	Tile Outfall	3
14-153	2014	July	7/29/2014	Mund1T	Tile Outfall	7.5
14-178	2014	August	8/11/2014	Mund1T	Tile Outfall	6.65
14-190	2014	August	8/26/2014	Mund1T	Tile Outfall	0.1
11-075	2011	June	6/23/2011	Nels1	Tile Outfall	1.2
11-102	2011	June	6/29/2011	Nels1	Tile Outfall	0.7
11-129	2011	July	7/13/2011	Nels1	Tile Outfall	0.7
11-154	2011	July	7/27/2011	Nels1	Tile Outfall	0.7
11-162	2011	August	8/2/2011	Nels1	Tile Outfall	0.25
11-197	2011	August	8/10/2011	Nels1	Tile Outfall	1.3
11-215	2011	August	8/23/2011	Nels1	Tile Outfall	3.1
12-014	2012	May	5/2/2012	Nels1	Tile Outfall	0.6
12-026	2012	May	5/23/2012	Nels1	Tile Outfall	1.35
12-052	2012	June	6/6/2012	Nels1	Tile Outfall	1.4
12-068	2012	June	6/18/2012	Nels1	Tile Outfall	3.3
12-081	2012	July	7/11/2012	Nels1	Tile Outfall	17.5
12-086	2012	July	7/23/2012	Nels1	Tile Outfall	17
13-024	2013	May	5/7/2013	Nels1	Tile Outfall	0.3
13-049	2013	May	5/20/2013	Nels1	Tile Outfall	0.4
13-085	2013	June	6/11/2013	Nels1	Tile Outfall	0.65
13-113	2013	June	6/26/2013	Nels1	Tile Outfall	0.7
13-149	2013	July	7/9/2013	Nels1	Tile Outfall	0.7
14-005	2014	May	5/6/2014	Nels1	Tile Outfall	0.6
14-036	2014	May	5/20/2014	Nels1	Tile Outfall	0.7
14-077	2014	June	6/11/2014	Nels1	Tile Outfall	1.1
14-082	2014	June	6/24/2014	Nels1	Tile Outfall	0.5
14-141	2014	July	7/8/2014	Nels1	Tile Outfall	0.7
14-179	2014	August	8/11/2014	Nels1	Tile Outfall	0.1
14-193	2014	August	8/26/2014	Nels1	Tile Outfall	0.1
12-098	2012	September	9/5/2012	Nels1A	Tile Wetland	0.1
13-025	2013	May	5/7/2013	Nels1A	Tile Wetland	0.4
13-054	2013	May	5/20/2013	Nels1A	Tile Wetland	0.6
13-069	2013	June	6/11/2013	Nels1A	Tile Wetland	1.1
13-105	2013	June	6/26/2013	Nels1A	Tile Wetland	1.4
13-150	2013	July	7/9/2013	Nels1A	Tile Wetland	1.1
13-191	2013	July	7/23/2013	Nels1A	Tile Wetland	0.6
14-010	2014	May	5/6/2014	Nels1A	Tile Wetland	1
14-030	2014	May	5/20/2014	Nels1A	Tile Wetland	1.2
14-073	2014	June	6/10/2014	Nels1A	Tile Wetland	0.9
14-108	2014	June	6/24/2014	Nels1A	Tile Wetland	0.35
14-139	2014	July	7/8/2014	Nels1A	Tile Wetland	1.2
14-154	2014	July	7/29/2014	Nels1A	Tile Wetland	1.5
14-181	2014	August	8/11/2014	Nels1A	Tile Wetland	0.5
14-191	2014	August	8/26/2014	Nels1A	Tile Wetland	0.1
12-080	2012	July	7/11/2012	Pets1	Tile Outfall	14.5
13-009	2013	April	4/8/2013	Pets1	Tile Outfall	7.45
14-079	2014	June	6/9/2014	Pets1	Tile Outfall	19

Table A.8. Continued.

Lab Number	Year	Month	Date Collected (MMDDYY)	Site ID	Site Category	Nitrate Concentration mg/L
14-137	2014	July	7/7/2014	Pets1	Tile Outfall	21.5
12-089	2012	September	9/6/2012	Pett1	Reference Wetland	0.9
13-013	2013	April	4/8/2013	Pett1	Reference Wetland	0.7
13-075	2013	May	5/13/2013	Pett1	Reference Wetland	0.2
13-038	2013	May	5/20/2013	Pett1	Reference Wetland	0.5
13-064	2013	June	6/10/2013	Pett1	Reference Wetland	0.3
13-101	2013	June	6/26/2013	Pett1	Reference Wetland	0.3
13-145	2013	July	7/8/2013	Pett1	Reference Wetland	0.3
13-203	2013	July	7/24/2013	Pett1	Reference Wetland	0.2
14-020	2014	May	5/7/2014	Pett1	Reference Wetland	0.1
14-040	2014	May	5/19/2014	Pett1	Reference Wetland	0.1
14-057	2014	June	6/11/2014	Pett1	Reference Wetland	0.1
14-104	2014	June	6/23/2014	Pett1	Reference Wetland	0.1
14-115	2014	July	7/9/2014	Pett1	Reference Wetland	0.1
14-150	2014	July	7/28/2014	Pett1	Reference Wetland	0.1
14-167	2014	August	8/12/2014	Pett1	Reference Wetland	0.1
14-202	2014	August	8/25/2014	Pett1	Reference Wetland	0.1
12-094	2012	September	9/5/2012	Pitt1	Reference Wetland	1
13-034	2013	May	5/8/2013	Pitt1	Reference Wetland	0.4
13-046	2013	May	5/20/2013	Pitt1	Reference Wetland	0.6
13-059	2013	June	6/10/2013	Pitt1	Reference Wetland	0.5
13-110	2013	June	6/26/2013	Pitt1	Reference Wetland	0.3
13-132	2013	July	7/9/2013	Pitt1	Reference Wetland	0.35
13-196	2013	July	7/23/2013	Pitt1	Reference Wetland	0.4
14-004	2014	May	5/6/2014	Pitt1	Reference Wetland	0.3
14-023	2014	May	5/20/2014	Pitt1	Reference Wetland	0.4
14-066	2014	June	6/10/2014	Pitt1	Reference Wetland	0.35
14-102	2014	June	6/23/2014	Pitt1	Reference Wetland	0.1
14-127	2014	July	7/8/2014	Pitt1	Reference Wetland	0.4
14-144	2014	July	7/28/2014	Pitt1	Reference Wetland	0.4
14-180	2014	August	8/11/2014	Pitt1	Reference Wetland	0.1
14-197	2014	August	8/25/2014	Pitt1	Reference Wetland	0.1
12-095	2012	September	9/5/2012	Rams1	Surface Wetland	0.7
13-032	2013	May	5/8/2013	Rams1	Surface Wetland	0.4
13-095	2013	May	5/13/2013	Rams1	Surface Wetland	0.5
13-040	2013	May	5/20/2013	Rams1	Surface Wetland	0.6
13-058	2013	June	6/10/2013	Rams1	Surface Wetland	0.55
13-099	2013	June	6/26/2013	Rams1	Surface Wetland	0.5
13-146	2013	July	7/8/2013	Rams1	Surface Wetland	0.6
13-202	2013	July	7/24/2013	Rams1	Surface Wetland	0.5
14-013	2014	May	5/7/2014	Rams1	Surface Wetland	0.6
14-025	2014	May	5/19/2014	Rams1	Surface Wetland	0.6
14-074	2014	June	6/11/2014	Rams1	Surface Wetland	0.6
14-095	2014	June	6/23/2014	Rams1	Surface Wetland	0.3
14-114	2014	July	7/9/2014	Rams1	Surface Wetland	0.6
14-160	2014	July	7/30/2014	Rams1	Surface Wetland	0.7
14-165	2014	August	8/12/2014	Rams1	Surface Wetland	0.7
14-192	2014	August	8/25/2014	Rams1	Surface Wetland	0.1
12-016	2012	May	5/22/2012	Reev1	Tile Outfall	21.5
12-051	2012	June	6/5/2012	Reev1	Tile Outfall	21
12-060	2012	June	6/20/2012	Reev1	Tile Outfall	20

Table A.8. Continued.

Lab Number	Year	Month	Date Collected (MMDDYY)	Site ID	Site Category	Nitrate Concentration mg/L
12-077	2012	July	7/9/2012	Reev1	Tile Outfall	29.5
13-012	2013	April	4/8/2013	Reev1	Tile Outfall	2.1
13-086	2013	June	6/12/2013	Reev1	Tile Outfall	26.5
13-130	2013	July	7/10/2013	Reev1	Tile Outfall	24
14-001	2014	May	5/7/2014	Reev1	Tile Outfall	11.85
14-038	2014	May	5/19/2014	Reev1	Tile Outfall	12
14-078	2014	June	6/9/2014	Reev1	Tile Outfall	23
14-087	2014	June	6/23/2014	Reev1	Tile Outfall	26.5
14-116	2014	July	7/7/2014	Reev1	Tile Outfall	26.5
12-102	2012	September	9/6/2012	Schae1	Surface Wetland	0.7
13-066	2013	June	6/12/2013	Schae1	Surface Wetland	0.4
13-119	2013	June	6/27/2013	Schae1	Surface Wetland	0.65
13-124	2013	July	7/10/2013	Schae1	Surface Wetland	0.8
13-185	2013	July	7/22/2013	Schae1	Surface Wetland	0.7
14-012	2014	May	5/7/2014	Schae1	Surface Wetland	1
14-042	2014	May	5/19/2014	Schae1	Surface Wetland	1
14-054	2014	June	6/11/2014	Schae1	Surface Wetland	0.85
14-089	2014	June	6/23/2014	Schae1	Surface Wetland	0.8
14-112	2014	July	7/9/2014	Schae1	Surface Wetland	0.9
14-151	2014	July	7/28/2014	Schae1	Surface Wetland	0.9
14-182	2014	August	8/12/2014	Schae1	Surface Wetland	0.35
14-206	2014	August	8/25/2014	Schae1	Surface Wetland	0.1
12-088	2012	September	9/5/2012	Schaf1	Reference Wetland	0.7
13-021	2013	May	5/7/2013	Schaf1	Reference Wetland	0.4
13-045	2013	May	5/20/2013	Schaf1	Reference Wetland	0.4
13-088	2013	June	6/11/2013	Schaf1	Reference Wetland	0.5
13-107	2013	June	6/26/2013	Schaf1	Reference Wetland	0.4
13-148	2013	July	7/8/2013	Schaf1	Reference Wetland	0.55
13-188	2013	July	7/23/2013	Schaf1	Reference Wetland	0.5
14-032	2014	May	5/20/2014	Schaf1	Reference Wetland	0.4
14-076	2014	June	6/11/2014	Schaf1	Reference Wetland	0.4
14-103	2014	June	6/24/2014	Schaf1	Reference Wetland	0.1
14-136	2014	July	7/8/2014	Schaf1	Reference Wetland	0.4
14-158	2014	July	7/29/2014	Schaf1	Reference Wetland	0.5
14-177	2014	August	8/11/2014	Schaf1	Reference Wetland	0.1
14-194	2014	August	8/26/2014	Schaf1	Reference Wetland	0.1
11-101	2011	June	6/29/2011	Seve1	Reference Wetland	0.1
11-128	2011	July	7/13/2011	Seve1	Reference Wetland	0.1
11-152	2011	July	7/27/2011	Seve1	Reference Wetland	0.1
11-198	2011	August	8/10/2011	Seve1	Reference Wetland	0.2
11-214	2011	August	8/23/2011	Seve1	Reference Wetland	0.35
12-009	2012	May	5/2/2012	Seve1	Reference Wetland	0.6
12-028	2012	May	5/23/2012	Seve1	Reference Wetland	0.5
12-056	2012	June	6/6/2012	Seve1	Reference Wetland	0.6
12-071	2012	June	6/18/2012	Seve1	Reference Wetland	0.45
11-041	2011	June	6/2/2011	Thor1	Tile Outfall	0.9
11-062	2011	June	6/14/2011	Thor1	Tile Outfall	0.4
12-002	2012	May	5/1/2012	Thor1	Tile Outfall	1.7
12-011	2012	May	5/2/2012	Thor1	Tile Outfall	1.6
12-019	2012	May	5/22/2012	Thor1	Tile Outfall	6
12-048	2012	June	6/5/2012	Thor1	Tile Outfall	5.6

Table A.8. Continued.

Lab Number	Year	Month	Date Collected (MMDDYY)	Site ID	Site Category	Nitrate Concentration mg/L
12-062	2012	June	6/20/2012	Thor1	Tile Outfall	5.5
13-079	2013	June	6/12/2013	Thor1	Tile Outfall	4.4
14-011	2014	May	5/7/2014	Thor1	Tile Outfall	5
14-027	2014	May	5/19/2014	Thor1	Tile Outfall	5.8
14-063	2014	June	6/9/2014	Thor1	Tile Outfall	13
14-090	2014	June	6/23/2014	Thor1	Tile Outfall	17
14-132	2014	July	7/7/2014	Thor1	Tile Outfall	10
11-023	2011	May	5/3/2011	Volk1	Tile Wetland	0.25
13-097	2013	May	5/16/2013	Volk1	Tile Wetland	0.1
13-037	2013	May	5/21/2013	Volk1	Tile Wetland	0.1
13-093	2013	June	6/12/2013	Volk1	Tile Wetland	0.6
13-120	2013	June	6/27/2013	Volk1	Tile Wetland	0.4
13-128	2013	July	7/10/2013	Volk1	Tile Wetland	0.1
13-187	2013	July	7/22/2013	Volk1	Tile Wetland	0.1
14-021	2014	May	5/7/2014	Volk1	Tile Wetland	0.6
14-026	2014	May	5/19/2014	Volk1	Tile Wetland	0.7
14-061	2014	June	6/11/2014	Volk1	Tile Wetland	0.6
14-109	2014	June	6/23/2014	Volk1	Tile Wetland	0.1
14-111	2014	July	7/9/2014	Volk1	Tile Wetland	0.2
14-146	2014	July	7/28/2014	Volk1	Tile Wetland	0.4
14-174	2014	August	8/12/2014	Volk1	Tile Wetland	0.1
14-199	2014	August	8/25/2014	Volk1	Tile Wetland	0.1
11-008	2011	May	5/3/2011	Whof1	Tile Outfall	10.3
11-036	2011	June	6/2/2011	Whof1	Tile Outfall	9.95
11-085	2011	June	6/27/2011	Whof1	Tile Outfall	10.15
11-112	2011	July	7/11/2011	Whof1	Tile Outfall	10.2
11-138	2011	July	7/26/2011	Whof1	Tile Outfall	12
11-185	2011	August	8/9/2011	Whof1	Tile Outfall	13
12-017	2012	May	5/22/2012	Whof1	Tile Outfall	9.9
12-046	2012	June	6/5/2012	Whof1	Tile Outfall	10.1
12-069	2012	June	6/18/2012	Whof1	Tile Outfall	14
13-092	2013	May	5/30/2013	Whof1	Tile Outfall	2.7
13-028	2013	May	5/7/2013	Zieg1	Surface Wetland	0.2
13-039	2013	May	5/20/2013	Zieg1	Surface Wetland	0.2
13-060	2013	June	6/10/2013	Zieg1	Surface Wetland	0.25
13-112	2013	June	6/26/2013	Zieg1	Surface Wetland	0.15
13-141	2013	July	7/10/2013	Zieg1	Surface Wetland	0.2
13-194	2013	July	7/23/2013	Zieg1	Surface Wetland	0.2
14-008	2014	May	5/6/2014	Zieg1	Surface Wetland	0.3
14-033	2014	May	5/19/2014	Zieg1	Surface Wetland	0.3
14-050	2014	June	6/10/2014	Zieg1	Surface Wetland	0.3
14-083	2014	June	6/23/2014	Zieg1	Surface Wetland	0.1
14-123	2014	July	7/8/2014	Zieg1	Surface Wetland	0.2
14-161	2014	July	7/30/2014	Zieg1	Surface Wetland	0.2
14-184	2014	August	8/11/2014	Zieg1	Surface Wetland	0.1
14-207	2014	August	8/25/2014	Zieg1	Surface Wetland	0.1

Note: mg/L = milligrams per liter, < = less than the detection limit.

Table A.9. Total phosphorus and total Kjeldahl nitrogen concentrations measured by the South Dakota Agricultural Laboratory in water samples from select study sites within Madison Wetland Management District, South Dakota, 2013–2014.

Analyte	Site	Result	LOD	Method	Date Collected	Lab
Total Phosphorus	2Petr1A	0.1240	0.01	SM 4500PE	5/7/2014	SDAL
Total Phosphorus	2Petr1A	0.0476	0.01	SM 4500PE	6/10/2014	SDAL
Total Phosphorus	2Petr1A	0.3810	0.01	SM 4500PE	7/9/2014	SDAL
Total Phosphorus	2Petr1A	2.5900	0.01	SM 4500PE	8/12/2014	SDAL
Total Kjeldahl Nitrogen	2Petr1A	2.8300	0.01	EPA 351.3	5/21/2013	SDAL
Total Phosphorus	2Petr1A	0.4220	0.01	SM 4500PE	5/21/2013	SDAL
Total Kjeldahl Nitrogen	2Petr1A	1.5000	0.01	EPA 351.3	6/12/2013	SDAL
Total Phosphorus	2Petr1A	0.0297	0.01	SM 4500PE	6/12/2013	SDAL
Total Kjeldahl Nitrogen	2Petr1A	1.9100	0.01	EPA 351.3	6/26/2013	SDAL
Total Phosphorus	2Petr1A	0.0573	0.01	SM 4500PE	6/26/2013	SDAL
Total Kjeldahl Nitrogen	2Petr1A	2.7600	0.01	EPA 351.3	7/8/2013	SDAL
Total Phosphorus	2Petr1A	0.1270	0.01	SM 4500PE	7/8/2013	SDAL
Total Kjeldahl Nitrogen	2Petr1A	2.3900	0.01	EPA 351.3	7/22/2013	SDAL
Total Phosphorus	2Petr1A	0.7140	0.01	SM 4500PE	7/22/2013	SDAL
Total Kjeldahl Nitrogen	2Petr1A	1.4900	0.01	EPA 351.3	5/7/2014	SDAL
Total Kjeldahl Nitrogen	2Petr1A	1.4500	0.01	EPA 351.3	6/10/2014	SDAL
Total Kjeldahl Nitrogen	2Petr1A	1.8200	1.03	EPA 351.3	7/9/2014	SDAL
Total Kjeldahl Nitrogen	2Petr1A	3.8500	0.01	EPA 351.3	8/12/2014	SDAL
Total Kjeldahl Nitrogen	Ache1	1.5200	0.01	EPA 351.3	6/12/2013	SDAL
Total Phosphorus	Ache1	0.0792	0.01	SM 4500PE	6/12/2013	SDAL
Total Kjeldahl Nitrogen	Ache1	2.6500	0.01	EPA 351.3	6/26/2013	SDAL
Total Phosphorus	Ache1	0.2770	0.01	SM 4500PE	6/26/2013	SDAL
Total Kjeldahl Nitrogen	Ache1A	4.0500	0.01	EPA 351.3	5/21/2013	SDAL
Total Phosphorus	Ache1A	0.3620	0.01	SM 4500PE	5/21/2013	SDAL
Total Kjeldahl Nitrogen	Ache1A	2.8300	0.01	EPA 351.3	6/12/2013	SDAL
Total Phosphorus	Ache1A	0.2450	0.01	SM 4500PE	6/12/2013	SDAL
Total Kjeldahl Nitrogen	Ache1A	3.6900	0.01	EPA 351.3	7/10/2013	SDAL
Total Kjeldahl Nitrogen	Ache1A	4.6600	0.01	EPA 351.3	7/22/2013	SDAL
Total Phosphorus	Ache1A	0.2120	0.01	SM 4500PE	7/22/2013	SDAL
Total Phosphorus	Ache1A	0.1550	0.01	SM 4500PE	7/10/2013	SDAL
Total Kjeldahl Nitrogen	Adam2	0.6420	0.01	EPA 351.3	8/11/2014	SDAL
Total Phosphorus	Adam2	0.0373	0.01	SM 4500PE	8/11/2014	SDAL
Total Kjeldahl Nitrogen	Bols1	0.3050	0.01	EPA 351.3	5/8/2013	SDAL
Total Phosphorus	Bols1	0.0567	0.01	SM 4500PE	5/8/2013	SDAL

Table A.9. Continued.

Analyte	Site	Result	LOD	Method	Date Collected	Lab
Total Kjeldahl Nitrogen	Bols1	0.6040	0.01	EPA 351.3	5/20/2013	SDAL
Total Phosphorus	Bols1	0.1170	0.01	SM 4500PE	5/20/2013	SDAL
Total Kjeldahl Nitrogen	Bols1	1.0100	0.01	EPA 351.3	6/12/2013	SDAL
Total Kjeldahl Nitrogen	Bols1	2.0600	0.01	EPA 351.3	6/26/2013	SDAL
Total Phosphorus	Bols1	0.6220	0.01	SM 4500PE	6/26/2013	SDAL
Total Kjeldahl Nitrogen	Bols1	0.8760	0.01	EPA 351.3	7/10/2013	SDAL
Total Kjeldahl Nitrogen	Bols1	2.3600	0.01	EPA 351.3	7/24/2013	SDAL
Total Phosphorus	Bols1	0.2890	0.01	SM 4500PE	7/24/2013	SDAL
Total Kjeldahl Nitrogen	Bols1	0.4180	0.01	EPA 351.3	5/6/2014	SDAL
Total Phosphorus	Bols1	0.1730	0.01	SM 4500PE	5/6/2014	SDAL
Total Kjeldahl Nitrogen	Bols1	1.2300	0.01	EPA 351.3	6/10/2014	SDAL
Total Phosphorus	Bols1	0.5140	0.01	SM 4500PE	6/10/2014	SDAL
Total Kjeldahl Nitrogen	Bols1	0.8300	1.03	EPA 351.3	7/8/2014	SDAL
Total Phosphorus	Bols1	0.5550	0.01	SM 4500PE	7/8/2014	SDAL
Total Kjeldahl Nitrogen	Bols1	1.6500	0.01	EPA 351.3	8/11/2014	SDAL
Total Phosphorus	Bols1	0.4840	0.01	SM 4500PE	8/11/2014	SDAL
Total Phosphorus	Bols1	0.3520	0.01	SM 4500PE	7/10/2013	SDAL
Total Phosphorus	Bols1	0.4720	0.01	SM 4500PE	6/12/2013	SDAL
Total Kjeldahl Nitrogen	Bols1A	1.6100	0.01	EPA 351.3	5/20/2013	SDAL
Total Phosphorus	Bols1A	0.2820	0.01	SM 4500PE	5/20/2013	SDAL
Total Kjeldahl Nitrogen	Bols1A	1.5100	0.01	EPA 351.3	6/12/2013	SDAL
Total Kjeldahl Nitrogen	Bols1A	1.6600	0.01	EPA 351.3	6/26/2013	SDAL
Total Phosphorus	Bols1A	0.3080	0.01	SM 4500PE	6/26/2013	SDAL
Total Kjeldahl Nitrogen	Bols1A	1.4500	0.01	EPA 351.3	7/10/2013	SDAL
Total Kjeldahl Nitrogen	Bols1A	2.5400	0.01	EPA 351.3	5/6/2014	SDAL
Total Phosphorus	Bols1A	0.2670	0.01	SM 4500PE	5/6/2014	SDAL
Total Kjeldahl Nitrogen	Bols1A	1.9800	0.01	EPA 351.3	6/10/2014	SDAL
Total Phosphorus	Bols1A	0.5550	0.01	SM 4500PE	6/10/2014	SDAL
Total Kjeldahl Nitrogen	Bols1A	1.5900	1.03	EPA 351.3	7/8/2014	SDAL
Total Phosphorus	Bols1A	0.5560	0.01	SM 4500PE	7/8/2014	SDAL
Total Kjeldahl Nitrogen	Bols1A	1.9900	0.01	EPA 351.3	8/11/2014	SDAL
Total Phosphorus	Bols1A	0.4700	0.01	SM 4500PE	8/11/2014	SDAL
Total Phosphorus	Bols1A	0.4480	0.01	SM 4500PE	7/10/2013	SDAL
Total Phosphorus	Bols1A	0.2420	0.01	SM 4500PE	6/12/2013	SDAL

Table A.9. Continued.

Analyte	Site	Result	LOD	Method	Date Collected	Lab
Total Kjeldahl Nitrogen	Buff1	2.0400	0.01	EPA 351.3	6/26/2013	SDAL
Total Phosphorus	Buff1	0.0458	0.01	SM 4500PE	6/26/2013	SDAL
Total Kjeldahl Nitrogen	Buff1	1.7800	0.01	EPA 351.3	5/7/2014	SDAL
Total Phosphorus	Buff1	0.2420	0.01	SM 4500PE	5/7/2014	SDAL
Total Kjeldahl Nitrogen	Buff1	3.1000	0.01	EPA 351.3	6/10/2014	SDAL
Total Phosphorus	Buff1	0.4020	0.01	SM 4500PE	6/10/2014	SDAL
Total Kjeldahl Nitrogen	Buff1	2.0000	1.03	EPA 351.3	7/9/2014	SDAL
Total Phosphorus	Buff1	0.2570	0.01	SM 4500PE	7/9/2014	SDAL
Total Kjeldahl Nitrogen	Buff1	4.9200	0.01	EPA 351.3	8/12/2014	SDAL
Total Phosphorus	Buff1	0.6490	0.01	SM 4500PE	8/12/2014	SDAL
Total Kjeldahl Nitrogen	Buff1	2.8100	0.01	EPA 351.3	5/21/2013	SDAL
Total Phosphorus	Buff1	0.2610	0.01	SM 4500PE	5/21/2013	SDAL
Total Kjeldahl Nitrogen	Buff1	1.9300	0.01	EPA 351.3	6/12/2013	SDAL
Total Phosphorus	Buff1	0.3950	0.01	SM 4500PE	6/12/2013	SDAL
Total Kjeldahl Nitrogen	Buff1	2.4400	0.01	EPA 351.3	7/10/2013	SDAL
Total Phosphorus	Buff1	0.2060	0.01	SM 4500PE	7/10/2013	SDAL
Total Kjeldahl Nitrogen	Buff1	2.8600	0.01	EPA 351.3	7/22/2013	SDAL
Total Phosphorus	Buff1	0.2800	0.01	SM 4500PE	7/22/2013	SDAL
Total Kjeldahl Nitrogen	Clea2	0.7640	0.01	EPA 351.3	8/12/2014	SDAL
Total Phosphorus	Clea2	> 0.01	0.01	SM 4500PE	8/12/2014	SDAL
Total Kjeldahl Nitrogen	Cote1	2.5700	0.01	EPA 351.3	5/20/2013	SDAL
Total Phosphorus	Cote1	0.1340	0.01	SM 4500PE	5/20/2013	SDAL
Total Kjeldahl Nitrogen	Cote1	2.2500	0.01	EPA 351.3	6/11/2013	SDAL
Total Kjeldahl Nitrogen	Cote1	2.2300	0.01	EPA 351.3	6/26/2013	SDAL
Total Kjeldahl Nitrogen	Cote1	2.3300	0.01	EPA 351.3	7/9/2013	SDAL
Total Kjeldahl Nitrogen	Cote1	2.3200	0.01	EPA 351.3	7/23/2013	SDAL
Total Phosphorus	Cote1	0.1690	0.01	SM 4500PE	7/23/2013	SDAL
Total Kjeldahl Nitrogen	Cote1	2.5000	0.01	EPA 351.3	5/6/2014	SDAL
Total Phosphorus	Cote1	0.0490	0.01	SM 4500PE	5/6/2014	SDAL
Total Kjeldahl Nitrogen	Cote1	1.9400	0.01	EPA 351.3	6/10/2014	SDAL
Total Phosphorus	Cote1	0.0236	0.01	SM 4500PE	6/10/2014	SDAL
Total Kjeldahl Nitrogen	Cote1	2.3000	1.03	EPA 351.3	7/8/2014	SDAL
Total Phosphorus	Cote1	0.0540	0.01	SM 4500PE	7/8/2014	SDAL
Total Kjeldahl Nitrogen	Cote1	2.1100	0.01	EPA 351.3	8/11/2014	SDAL

Table A.9. Continued.

Analyte	Site	Result	LOD	Method	Date Collected	Lab
Total Phosphorus	Cote1	0.0600	0.01	SM 4500PE	8/11/2014	SDAL
Total Phosphorus	Cote1	0.0337	0.01	SM 4500PE	7/9/2013	SDAL
Total Phosphorus	Cote1	0.0472	0.01	SM 4500PE	6/11/2013	SDAL
Total Phosphorus	Cote1	> 0.01	0.01	SM 4500PE	6/26/2013	SDAL
Total Kjeldahl Nitrogen	Gerk1	1.7500	0.01	EPA 351.3	5/8/2013	SDAL
Total Phosphorus	Gerk1	0.1040	0.01	SM 4500PE	5/8/2013	SDAL
Total Kjeldahl Nitrogen	Gerk1	0.6890	0.01	EPA 351.3	6/10/2013	SDAL
Total Kjeldahl Nitrogen	Gerk1	0.8690	0.01	EPA 351.3	6/26/2013	SDAL
Total Phosphorus	Gerk1	> 0.01	0.01	SM 4500PE	6/26/2013	SDAL
Total Phosphorus	Gerk1	0.0934	0.01	SM 4500PE	6/10/2013	SDAL
Total Kjeldahl Nitrogen	Gerk1A	1.5200	0.01	EPA 351.3	5/8/2013	SDAL
Total Phosphorus	Gerk1A	0.0920	0.01	SM 4500PE	5/8/2013	SDAL
Total Kjeldahl Nitrogen	Gerk1A	1.3400	0.01	EPA 351.3	5/20/2013	SDAL
Total Phosphorus	Gerk1A	0.3460	0.01	SM 4500PE	5/20/2013	SDAL
Total Kjeldahl Nitrogen	Gerk1A	2.0600	0.01	EPA 351.3	6/10/2013	SDAL
Total Phosphorus	Gerk1A	0.2040	0.01	SM 4500PE	6/10/2013	SDAL
Total Kjeldahl Nitrogen	Gerk1A	1.5700	0.01	EPA 351.3	6/26/2013	SDAL
Total Phosphorus	Gerk1A	> 0.01	0.01	SM 4500PE	6/26/2013	SDAL
Total Kjeldahl Nitrogen	Gerk1A	1.8400	0.01	EPA 351.3	7/8/2013	SDAL
Total Phosphorus	Gerk1A	0.0489	0.01	SM 4500PE	7/8/2013	SDAL
Total Kjeldahl Nitrogen	Gerk1A	2.5600	0.01	EPA 351.3	7/24/2013	SDAL
Total Phosphorus	Gerk1A	0.2980	0.01	SM 4500PE	7/24/2013	SDAL
Total Kjeldahl Nitrogen	Gerk1A	2.3800	0.01	EPA 351.3	5/7/2014	SDAL
Total Phosphorus	Gerk1A	0.0795	0.01	SM 4500PE	5/7/2014	SDAL
Total Kjeldahl Nitrogen	Gerk1A	2.1300	0.01	EPA 351.3	6/10/2014	SDAL
Total Phosphorus	Gerk1A	0.0739	0.01	SM 4500PE	6/10/2014	SDAL
Total Kjeldahl Nitrogen	Gerk1A	2.2900	1.03	EPA 351.3	7/8/2014	SDAL
Total Phosphorus	Gerk1A	0.1290	0.01	SM 4500PE	7/8/2014	SDAL
Total Kjeldahl Nitrogen	Gerk1A	2.8800	0.01	EPA 351.3	8/12/2014	SDAL
Total Phosphorus	Gerk1A	0.1410	0.01	SM 4500PE	8/12/2014	SDAL
Total Kjeldahl Nitrogen	Hejo1	0.4890	0.01	EPA 351.3	5/7/2013	SDAL
Total Phosphorus	Hejo1	0.0860	0.01	SM 4500PE	5/7/2013	SDAL
Total Kjeldahl Nitrogen	Hejo1	0.5510	0.01	EPA 351.3	5/20/2013	SDAL
Total Phosphorus	Hejo1	0.0312	0.01	SM 4500PE	5/20/2013	SDAL

Table A.9. Continued.

Analyte	Site	Result	LOD	Method	Date Collected	Lab
Total Kjeldahl Nitrogen	Hejo1	1.0200	0.01	EPA 351.3	6/11/2013	SDAL
Total Phosphorus	Hejo1	0.0317	0.01	SM 4500PE	6/11/2013	SDAL
Total Kjeldahl Nitrogen	Hejo1	0.6840	0.01	EPA 351.3	6/26/2013	SDAL
Total Phosphorus	Hejo1	0.0449	0.01	SM 4500PE	6/26/2013	SDAL
Total Kjeldahl Nitrogen	Hejo1	0.2850	0.01	EPA 351.3	7/9/2013	SDAL
Total Phosphorus	Hejo1	0.0830	0.01	SM 4500PE	7/9/2013	SDAL
Total Kjeldahl Nitrogen	Hejo1	0.5870	0.01	EPA 351.3	7/23/2013	SDAL
Total Phosphorus	Hejo1	0.2850	0.01	SM 4500PE	7/23/2013	SDAL
Total Kjeldahl Nitrogen	Hejo1	1.3400	0.01	EPA 351.3	6/10/2014	SDAL
Total Phosphorus	Hejo1	0.0275	0.01	SM 4500PE	6/10/2014	SDAL
Total Kjeldahl Nitrogen	Hejo1	0.6500	1.03	EPA 351.3	7/8/2014	SDAL
Total Phosphorus	Hejo1	0.0440	0.01	SM 4500PE	7/8/2014	SDAL
Total Kjeldahl Nitrogen	Hejo1A	1.3400	0.01	EPA 351.3	5/20/2013	SDAL
Total Phosphorus	Hejo1A	0.0760	0.01	SM 4500PE	5/20/2013	SDAL
Total Kjeldahl Nitrogen	Hejo1A	1.1000	0.01	EPA 351.3	6/11/2013	SDAL
Total Phosphorus	Hejo1A	> 0.01	0.01	SM 4500PE	6/11/2013	SDAL
Total Kjeldahl Nitrogen	Hejo1A	1.3800	0.01	EPA 351.3	6/26/2013	SDAL
Total Phosphorus	Hejo1A	0.0603	0.01	SM 4500PE	6/26/2013	SDAL
Total Kjeldahl Nitrogen	Hejo1A	1.0200	0.01	EPA 351.3	7/9/2013	SDAL
Total Phosphorus	Hejo1A	0.1310	0.01	SM 4500PE	7/9/2013	SDAL
Total Kjeldahl Nitrogen	Hejo1A	1.5400	0.01	EPA 351.3	7/23/2013	SDAL
Total Phosphorus	Hejo1A	0.1570	0.01	SM 4500PE	7/23/2013	SDAL
Total Kjeldahl Nitrogen	Hejo1A	1.0300	0.01	EPA 351.3	5/6/2014	SDAL
Total Phosphorus	Hejo1A	0.0480	0.01	SM 4500PE	5/6/2014	SDAL
Total Kjeldahl Nitrogen	Hejo1A	1.6900	0.01	EPA 351.3	6/10/2014	SDAL
Total Phosphorus	Hejo1A	0.0100	0.01	SM 4500PE	6/10/2014	SDAL
Total Kjeldahl Nitrogen	Hejo1A	1.4600	1.03	EPA 351.3	7/8/2014	SDAL
Total Phosphorus	Hejo1A	0.0830	0.01	SM 4500PE	7/8/2014	SDAL
Total Kjeldahl Nitrogen	Hejo1A	1.7600	0.01	EPA 351.3	8/11/2014	SDAL
Total Phosphorus	Hejo1A	0.1110	0.01	SM 4500PE	8/11/2014	SDAL
Total Kjeldahl Nitrogen	Hejo2	0.2370	0.01	EPA 351.3	7/9/2013	SDAL
Total Phosphorus	Hejo2	0.0228	0.01	SM 4500PE	7/9/2013	SDAL
Total Kjeldahl Nitrogen	John1	1.8800	0.01	EPA 351.3	5/7/2013	SDAL
Total Phosphorus	John1	0.0528	0.01	SM 4500PE	5/7/2013	SDAL

Table A.9. Continued.

Analyte	Site	Result	LOD	Method	Date Collected	Lab
Total Kjeldahl Nitrogen	John1	1.6600	0.01	EPA 351.3	5/20/2013	SDAL
Total Phosphorus	John1	0.1010	0.01	SM 4500PE	5/20/2013	SDAL
Total Kjeldahl Nitrogen	John1	1.6500	0.01	EPA 351.3	6/26/2013	SDAL
Total Phosphorus	John1	0.2460	0.01	SM 4500PE	6/26/2013	SDAL
Total Kjeldahl Nitrogen	John1	1.5400	0.01	EPA 351.3	7/23/2013	SDAL
Total Phosphorus	John1	0.4370	0.01	SM 4500PE	7/23/2013	SDAL
Total Kjeldahl Nitrogen	John1	2.1300	0.01	EPA 351.3	5/6/2014	SDAL
Total Phosphorus	John1	0.0795	0.01	SM 4500PE	5/6/2014	SDAL
Total Kjeldahl Nitrogen	John1	2.1600	0.01	EPA 351.3	6/10/2014	SDAL
Total Phosphorus	John1	0.1430	0.01	SM 4500PE	6/10/2014	SDAL
Total Kjeldahl Nitrogen	John1	1.3600	1.03	EPA 351.3	7/8/2014	SDAL
Total Phosphorus	John1	0.1040	0.01	SM 4500PE	7/8/2014	SDAL
Total Kjeldahl Nitrogen	John1	1.7200	0.01	EPA 351.3	8/11/2014	SDAL
Total Phosphorus	John1	0.1260	0.01	SM 4500PE	8/11/2014	SDAL
Total Kjeldahl Nitrogen	John1	1.4100	0.01	EPA 351.3	7/9/2013	SDAL
Total Phosphorus	John1	0.2470	0.01	SM 4500PE	7/9/2013	SDAL
Total Kjeldahl Nitrogen	Long1	2.7000	0.01	EPA 351.3	6/12/2013	SDAL
Total Phosphorus	Long1	0.1850	0.01	SM 4500PE	6/12/2013	SDAL
Total Kjeldahl Nitrogen	Lost1	2.7900	0.01	EPA 351.3	5/21/2013	SDAL
Total Phosphorus	Lost1	0.5290	0.01	SM 4500PE	5/21/2013	SDAL
Total Kjeldahl Nitrogen	Lost1	2.1500	0.01	EPA 351.3	6/12/2013	SDAL
Total Phosphorus	Lost1	0.1580	0.01	SM 4500PE	6/12/2013	SDAL
Total Kjeldahl Nitrogen	Lost1	1.6600	0.01	EPA 351.3	6/26/2013	SDAL
Total Phosphorus	Lost1	0.0895	0.01	SM 4500PE	6/26/2013	SDAL
Total Kjeldahl Nitrogen	Lost1	1.8200	0.01	EPA 351.3	7/22/2013	SDAL
Total Phosphorus	Lost1	0.3460	0.01	SM 4500PE	7/22/2013	SDAL
Total Kjeldahl Nitrogen	Lost1	1.3200	0.01	EPA 351.3	5/7/2014	SDAL
Total Phosphorus	Lost1	0.2480	0.01	SM 4500PE	5/7/2014	SDAL
Total Kjeldahl Nitrogen	Lost1	1.0600	0.01	EPA 351.3	6/10/2014	SDAL
Total Phosphorus	Lost1	0.3550	0.01	SM 4500PE	6/10/2014	SDAL
Total Kjeldahl Nitrogen	Lost1	1.5300	1.03	EPA 351.3	7/9/2014	SDAL
Total Phosphorus	Lost1	0.6130	0.01	SM 4500PE	7/9/2014	SDAL
Total Kjeldahl Nitrogen	Lost1	1.4600	0.01	EPA 351.3	8/12/2014	SDAL
Total Phosphorus	Lost1	0.9320	0.01	SM 4500PE	8/12/2014	SDAL

Table A.9. Continued.

Analyte	Site	Result	LOD	Method	Date Collected	Lab
Total Kjeldahl Nitrogen	Lost1	1.7200	0.01	EPA 351.3	7/10/2013	SDAL
Total Phosphorus	Lost1	0.1800	0.01	SM 4500PE	7/10/2013	SDAL
Total Kjeldahl Nitrogen	Mund1	1.4100	0.01	EPA 351.3	5/20/2013	SDAL
Total Phosphorus	Mund1	0.5310	0.01	SM 4500PE	5/20/2013	SDAL
Total Kjeldahl Nitrogen	Mund1	0.9660	0.01	EPA 351.3	6/26/2013	SDAL
Total Phosphorus	Mund1	0.0286	0.01	SM 4500PE	6/26/2013	SDAL
Total Kjeldahl Nitrogen	Mund1	1.8700	0.01	EPA 351.3	7/23/2013	SDAL
Total Phosphorus	Mund1	0.1910	0.01	SM 4500PE	7/23/2013	SDAL
Total Kjeldahl Nitrogen	Mund1	1.7900	0.01	EPA 351.3	5/6/2014	SDAL
Total Phosphorus	Mund1	0.0445	0.01	SM 4500PE	5/6/2014	SDAL
Total Kjeldahl Nitrogen	Mund1	1.8800	0.01	EPA 351.3	6/10/2014	SDAL
Total Phosphorus	Mund1	0.0413	0.01	SM 4500PE	6/10/2014	SDAL
Total Kjeldahl Nitrogen	Mund1	1.2300	1.03	EPA 351.3	7/8/2014	SDAL
Total Phosphorus	Mund1	0.1140	0.01	SM 4500PE	7/8/2014	SDAL
Total Kjeldahl Nitrogen	Mund1	1.1900	0.01	EPA 351.3	8/11/2014	SDAL
Total Phosphorus	Mund1	0.0906	0.01	SM 4500PE	8/11/2014	SDAL
Total Kjeldahl Nitrogen	Mund1	1.3000	0.01	EPA 351.3	7/9/2013	SDAL
Total Phosphorus	Mund1	0.1380	0.01	SM 4500PE	7/9/2013	SDAL
Total Kjeldahl Nitrogen	Mund1	0.8060	0.01	EPA 351.3	6/11/2013	SDAL
Total Phosphorus	Mund1	> 0.01	0.01	SM 4500PE	6/11/2013	SDAL
Total Kjeldahl Nitrogen	Mund1T	0.2990	0.01	EPA 351.3	7/23/2013	SDAL
Total Phosphorus	Mund1T	0.1570	0.01	SM 4500PE	7/23/2013	SDAL
Total Kjeldahl Nitrogen	Mund1T	2.1700	0.01	EPA 351.3	5/6/2014	SDAL
Total Phosphorus	Mund1T	0.0750	0.01	SM 4500PE	5/6/2014	SDAL
Total Kjeldahl Nitrogen	Mund1T	1.6900	0.01	EPA 351.3	6/10/2014	SDAL
Total Phosphorus	Mund1T	0.2500	0.01	SM 4500PE	6/10/2014	SDAL
Total Kjeldahl Nitrogen	Mund1T	0.9980	0.01	EPA 351.3	8/11/2014	SDAL
Total Phosphorus	Mund1T	0.1930	0.01	SM 4500PE	8/11/2014	SDAL
Total Kjeldahl Nitrogen	Mund1T	1.6600	0.01	EPA 351.3	7/9/2013	SDAL
Total Phosphorus	Mund1T	0.2770	0.01	SM 4500PE	7/9/2013	SDAL
Total Kjeldahl Nitrogen	Nels1	1.3800	0.01	EPA 351.3	5/7/2013	SDAL
Total Phosphorus	Nels1	0.0956	0.01	SM 4500PE	5/7/2013	SDAL
Total Kjeldahl Nitrogen	Nels1	1.1100	0.01	EPA 351.3	5/20/2013	SDAL

Table A.9. Continued.

Analyte	Site	Result	LOD	Method	Date Collected	Lab
Total Phosphorus	Nels1	0.1990	0.01	SM 4500PE	5/20/2013	SDAL
Total Kjeldahl Nitrogen	Nels1	1.5700	0.01	EPA 351.3	6/26/2013	SDAL
Total Phosphorus	Nels1	0.0663	0.01	SM 4500PE	6/26/2013	SDAL
Total Kjeldahl Nitrogen	Nels1	3.9200	0.01	EPA 351.3	7/23/2013	SDAL
Total Phosphorus	Nels1	0.2480	0.01	SM 4500PE	7/23/2013	SDAL
Total Kjeldahl Nitrogen	Nels1	1.7400	0.01	EPA 351.3	5/6/2014	SDAL
Total Phosphorus	Nels1	0.0385	0.01	SM 4500PE	5/6/2014	SDAL
Total Kjeldahl Nitrogen	Nels1	2.5200	0.01	EPA 351.3	6/10/2014	SDAL
Total Phosphorus	Nels1	0.1160	0.01	SM 4500PE	6/10/2014	SDAL
Total Kjeldahl Nitrogen	Nels1	1.5600	1.03	EPA 351.3	7/8/2014	SDAL
Total Phosphorus	Nels1	0.3550	0.01	SM 4500PE	7/8/2014	SDAL
Total Kjeldahl Nitrogen	Nels1	1.5100	0.01	EPA 351.3	8/11/2014	SDAL
Total Phosphorus	Nels1	0.2720	0.01	SM 4500PE	8/11/2014	SDAL
Total Kjeldahl Nitrogen	Nels1	2.4600	0.01	EPA 351.3	7/9/2013	SDAL
Total Phosphorus	Nels1	0.3790	0.01	SM 4500PE	7/9/2013	SDAL
Total Kjeldahl Nitrogen	Nels1	1.2300	0.01	EPA 351.3	6/11/2013	SDAL
Total Phosphorus	Nels1	> 0.01	0.01	SM 4500PE	6/11/2013	SDAL
Total Kjeldahl Nitrogen	Nels1A	0.8980	0.01	EPA 351.3	5/7/2013	SDAL
Total Phosphorus	Nels1A	0.0892	0.01	SM 4500PE	5/7/2013	SDAL
Total Kjeldahl Nitrogen	Nels1A	1.1900	0.01	EPA 351.3	5/20/2013	SDAL
Total Phosphorus	Nels1A	0.2540	0.01	SM 4500PE	5/20/2013	SDAL
Total Kjeldahl Nitrogen	Nels1A	1.7100	0.01	EPA 351.3	6/26/2013	SDAL
Total Phosphorus	Nels1A	0.0453	0.01	SM 4500PE	6/26/2013	SDAL
Total Kjeldahl Nitrogen	Nels1A	1.6600	0.01	EPA 351.3	7/23/2013	SDAL
Total Phosphorus	Nels1A	0.1870	0.01	SM 4500PE	7/23/2013	SDAL
Total Kjeldahl Nitrogen	Nels1A	1.6600	0.01	EPA 351.3	5/6/2014	SDAL
Total Phosphorus	Nels1A	0.0500	0.01	SM 4500PE	5/6/2014	SDAL
Total Kjeldahl Nitrogen	Nels1A	3.0600	0.01	EPA 351.3	6/10/2014	SDAL
Total Phosphorus	Nels1A	0.0932	0.01	SM 4500PE	6/10/2014	SDAL
Total Kjeldahl Nitrogen	Nels1A	2.1100	1.03	EPA 351.3	7/8/2014	SDAL
Total Phosphorus	Nels1A	0.1940	0.01	SM 4500PE	7/8/2014	SDAL
Total Kjeldahl Nitrogen	Nels1A	2.1500	0.01	EPA 351.3	8/11/2014	SDAL
Total Phosphorus	Nels1A	0.3980	0.01	SM 4500PE	8/11/2014	SDAL

Table A.9. Continued.

Analyte	Site	Result	LOD	Method	Date Collected	Lab
Total Kjeldahl Nitrogen	Nels1A	2.4900	0.01	EPA 351.3	7/9/2013	SDAL
Total Phosphorus	Nels1A	0.2280	0.01	SM 4500PE	7/9/2013	SDAL
Total Kjeldahl Nitrogen	Nels1A	1.2200	0.01	EPA 351.3	6/11/2013	SDAL
Total Phosphorus	Nels1A	> 0.01	0.01	SM 4500PE	6/11/2013	SDAL
Total Kjeldahl Nitrogen	Pett1	1.4500	0.01	EPA 351.3	6/10/2013	SDAL
Total Phosphorus	Pett1	0.3390	0.01	SM 4500PE	6/10/2013	SDAL
Total Kjeldahl Nitrogen	Pett1	1.6800	0.01	EPA 351.3	6/26/2013	SDAL
Total Phosphorus	Pett1	0.4000	0.01	SM 4500PE	6/26/2013	SDAL
Total Kjeldahl Nitrogen	Pett1	3.3100	0.01	EPA 351.3	7/24/2013	SDAL
Total Phosphorus	Pett1	0.4580	0.01	SM 4500PE	7/24/2013	SDAL
Total Kjeldahl Nitrogen	Pett1	1.3200	0.01	EPA 351.3	5/7/2014	SDAL
Total Phosphorus	Pett1	0.6440	0.01	SM 4500PE	5/7/2014	SDAL
Total Kjeldahl Nitrogen	Pett1	2.0400	0.01	EPA 351.3	6/10/2014	SDAL
Total Phosphorus	Pett1	1.0500	0.01	SM 4500PE	6/10/2014	SDAL
Total Kjeldahl Nitrogen	Pett1	1.9300	1.03	EPA 351.3	7/9/2014	SDAL
Total Phosphorus	Pett1	0.9700	0.01	SM 4500PE	7/9/2014	SDAL
Total Kjeldahl Nitrogen	Pett1	3.0900	0.01	EPA 351.3	8/12/2014	SDAL
Total Phosphorus	Pett1	0.9730	0.01	SM 4500PE	8/12/2014	SDAL
Total Kjeldahl Nitrogen	Pett1	1.8700	0.01	EPA 351.3	7/8/2013	SDAL
Total Phosphorus	Pett1	0.3120	0.01	SM 4500PE	7/8/2013	SDAL
Total Kjeldahl Nitrogen	Pitt1	4.6100	0.01	EPA 351.3	5/7/2013	SDAL
Total Phosphorus	Pitt1	0.6210	0.01	SM 4500PE	5/7/2013	SDAL
Total Kjeldahl Nitrogen	Pitt1	1.5200	0.01	EPA 351.3	5/20/2013	SDAL
Total Phosphorus	Pitt1	0.2610	0.01	SM 4500PE	5/20/2013	SDAL
Total Kjeldahl Nitrogen	Pitt1	3.5400	0.01	EPA 351.3	6/10/2013	SDAL
Total Phosphorus	Pitt1	0.0467	0.01	SM 4500PE	6/10/2013	SDAL
Total Kjeldahl Nitrogen	Pitt1	1.2900	0.01	EPA 351.3	6/26/2013	SDAL
Total Phosphorus	Pitt1	0.3800	0.01	SM 4500PE	6/26/2013	SDAL
Total Kjeldahl Nitrogen	Pitt1	1.6500	0.01	EPA 351.3	7/9/2013	SDAL
Total Phosphorus	Pitt1	0.0839	0.01	SM 4500PE	7/9/2013	SDAL
Total Kjeldahl Nitrogen	Pitt1	1.6500	0.01	EPA 351.3	7/23/2013	SDAL
Total Phosphorus	Pitt1	0.1960	0.01	SM 4500PE	7/23/2013	SDAL
Total Kjeldahl Nitrogen	Pitt1	1.8900	0.01	EPA 351.3	5/6/2014	SDAL

Table A.9. Continued.

Analyte	Site	Result	LOD	Method	Date Collected	Lab
Total Phosphorus	Pitt1	0.0435	0.01	SM 4500PE	5/6/2014	SDAL
Total Kjeldahl Nitrogen	Pitt1	1.7600	0.01	EPA 351.3	6/10/2014	SDAL
Total Phosphorus	Pitt1	0.0624	0.01	SM 4500PE	6/10/2014	SDAL
Total Kjeldahl Nitrogen	Pitt1	1.8200	1.03	EPA 351.3	7/8/2014	SDAL
Total Phosphorus	Pitt1	0.1130	0.01	SM 4500PE	7/8/2014	SDAL
Total Kjeldahl Nitrogen	Pitt1	2.0000	0.01	EPA 351.3	8/11/2014	SDAL
Total Phosphorus	Pitt1	0.1420	0.01	SM 4500PE	8/11/2014	SDAL
Total Kjeldahl Nitrogen	Rams1	1.3200	0.01	EPA 351.3	5/7/2013	SDAL
Total Phosphorus	Rams1	0.1180	0.01	SM 4500PE	5/7/2013	SDAL
Total Kjeldahl Nitrogen	Rams1	1.5200	0.01	EPA 351.3	5/20/2013	SDAL
Total Phosphorus	Rams1	0.1740	0.01	SM 4500PE	5/20/2013	SDAL
Total Kjeldahl Nitrogen	Rams1	1.7200	0.01	EPA 351.3	6/26/2013	SDAL
Total Phosphorus	Rams1	0.2060	0.01	SM 4500PE	6/26/2013	SDAL
Total Kjeldahl Nitrogen	Rams1	1.9200	0.01	EPA 351.3	7/24/2013	SDAL
Total Phosphorus	Rams1	0.2860	0.01	SM 4500PE	7/24/2013	SDAL
Total Kjeldahl Nitrogen	Rams1	1.7600	0.01	EPA 351.3	5/7/2014	SDAL
Total Phosphorus	Rams1	0.1140	0.01	SM 4500PE	5/7/2014	SDAL
Total Kjeldahl Nitrogen	Rams1	2.8500	0.01	EPA 351.3	6/10/2014	SDAL
Total Phosphorus	Rams1	0.3130	0.01	SM 4500PE	6/10/2014	SDAL
Total Kjeldahl Nitrogen	Rams1	1.9300	1.03	EPA 351.3	7/9/2014	SDAL
Total Phosphorus	Rams1	0.3200	0.01	SM 4500PE	7/9/2014	SDAL
Total Kjeldahl Nitrogen	Rams1	3.1000	0.01	EPA 351.3	8/12/2014	SDAL
Total Phosphorus	Rams1	0.4010	0.01	SM 4500PE	8/12/2014	SDAL
Total Kjeldahl Nitrogen	Rams1	1.9500	0.01	EPA 351.3	7/8/2013	SDAL
Total Phosphorus	Rams1	0.1650	0.01	SM 4500PE	7/8/2013	SDAL
Total Kjeldahl Nitrogen	Reev1	1.6300	0.01	EPA 351.3	6/12/2013	SDAL
Total Phosphorus	Reev1	> 0.01	0.01	SM 4500PE	6/12/2013	SDAL
Total Kjeldahl Nitrogen	Schae1	3.7600	0.01	EPA 351.3	6/12/2013	SDAL
Total Phosphorus	Schae1	0.1940	0.01	SM 4500PE	6/12/2013	SDAL
Total Kjeldahl Nitrogen	Schae1	4.6700	0.01	EPA 351.3	6/26/2013	SDAL
Total Phosphorus	Schae1	0.4720	0.01	SM 4500PE	6/26/2013	SDAL
Total Kjeldahl Nitrogen	Schae1	5.0100	0.01	EPA 351.3	7/22/2013	SDAL
Total Phosphorus	Schae1	0.2790	0.01	SM 4500PE	7/22/2013	SDAL

Table A.9. Continued.

Analyte	Site	Result	LOD	Method	Date Collected	Lab
Total Kjeldahl Nitrogen	Schae1	2.7700	0.01	EPA 351.3	5/7/2014	SDAL
Total Phosphorus	Schae1	0.1360	0.01	SM 4500PE	5/7/2014	SDAL
Total Kjeldahl Nitrogen	Schae1	2.9100	0.01	EPA 351.3	6/10/2014	SDAL
Total Phosphorus	Schae1	0.1420	0.01	SM 4500PE	6/10/2014	SDAL
Total Kjeldahl Nitrogen	Schae1	2.9100	1.03	EPA 351.3	7/9/2014	SDAL
Total Phosphorus	Schae1	0.2470	0.01	SM 4500PE	7/9/2014	SDAL
Total Kjeldahl Nitrogen	Schae1	3.7200	0.01	EPA 351.3	8/12/2014	SDAL
Total Phosphorus	Schae1	0.2840	0.01	SM 4500PE	8/12/2014	SDAL
Total Kjeldahl Nitrogen	Schae1	5.3400	0.01	EPA 351.3	7/10/2013	SDAL
Total Phosphorus	Schae1	0.4180	0.01	SM 4500PE	7/10/2013	SDAL
Total Kjeldahl Nitrogen	Schaf1	1.4000	0.01	EPA 351.3	5/7/2013	SDAL
Total Phosphorus	Schaf1	0.0482	0.01	SM 4500PE	5/7/2013	SDAL
Total Kjeldahl Nitrogen	Schaf1	1.7200	0.01	EPA 351.3	5/20/2013	SDAL
Total Phosphorus	Schaf1	0.2220	0.01	SM 4500PE	5/20/2013	SDAL
Total Kjeldahl Nitrogen	Schaf1	1.2900	0.01	EPA 351.3	6/11/2013	SDAL
Total Phosphorus	Schaf1	> 0.01	0.01	SM 4500PE	6/11/2013	SDAL
Total Kjeldahl Nitrogen	Schaf1	1.6000	0.01	EPA 351.3	6/26/2013	SDAL
Total Phosphorus	Schaf1	> 0.01	0.01	SM 4500PE	6/26/2013	SDAL
Total Kjeldahl Nitrogen	Schaf1	2.5600	0.01	EPA 351.3	7/23/2013	SDAL
Total Phosphorus	Schaf1	0.0724	0.01	SM 4500PE	7/23/2013	SDAL
Total Kjeldahl Nitrogen	Schaf1	1.6700	0.01	EPA 351.3	5/6/2014	SDAL
Total Phosphorus	Schaf1	0.0100	0.01	SM 4500PE	5/6/2014	SDAL
Total Kjeldahl Nitrogen	Schaf1	3.2300	0.01	EPA 351.3	6/10/2014	SDAL
Total Phosphorus	Schaf1	0.0252	0.01	SM 4500PE	6/10/2014	SDAL
Total Kjeldahl Nitrogen	Schaf1	1.4600	1.03	EPA 351.3	7/8/2014	SDAL
Total Phosphorus	Schaf1	0.0380	0.01	SM 4500PE	7/8/2014	SDAL
Total Kjeldahl Nitrogen	Schaf1	1.6500	0.01	EPA 351.3	8/11/2014	SDAL
Total Phosphorus	Schaf1	0.0433	0.01	SM 4500PE	8/11/2014	SDAL
Total Kjeldahl Nitrogen	Schaf1	2.1400	0.01	EPA 351.3	7/9/2013	SDAL
Total Phosphorus	Schaf1	0.0234	0.01	SM 4500PE	7/9/2013	SDAL
Total Kjeldahl Nitrogen	Volk1	4.8600	0.01	EPA 351.3	5/21/2013	SDAL
Total Phosphorus	Volk1	1.4200	0.01	SM 4500PE	5/21/2013	SDAL
Total Kjeldahl Nitrogen	Volk1	2.9300	0.01	EPA 351.3	6/26/2013	SDAL

Table A.9. Continued.

Analyte	Site	Result	LOD	Method	Date Collected	Lab
Total Phosphorus	Volk1	2.9000	0.01	SM 4500PE	6/26/2013	SDAL
Total Kjeldahl Nitrogen	Volk1	3.9600	0.01	EPA 351.3	7/22/2013	SDAL
Total Phosphorus	Volk1	2.9800	0.01	SM 4500PE	7/22/2013	SDAL
Total Kjeldahl Nitrogen	Volk1	3.2000	0.01	EPA 351.3	5/7/2014	SDAL
Total Phosphorus	Volk1	0.9370	0.01	SM 4500PE	5/7/2014	SDAL
Total Kjeldahl Nitrogen	Volk1	4.2500	0.01	EPA 351.3	6/10/2014	SDAL
Total Phosphorus	Volk1	3.5100	0.01	SM 4500PE	6/10/2014	SDAL
Total Kjeldahl Nitrogen	Volk1	6.1900	1.03	EPA 351.3	7/8/2014	SDAL
Total Phosphorus	Volk1	3.6100	0.01	SM 4500PE	7/8/2014	SDAL
Total Kjeldahl Nitrogen	Volk1	8.3800	0.01	EPA 351.3	8/12/2014	SDAL
Total Phosphorus	Volk1	4.9700	0.01	SM 4500PE	8/12/2014	SDAL
Total Kjeldahl Nitrogen	Volk1	4.2100	0.01	EPA 351.3	7/10/2013	SDAL
Total Phosphorus	Volk1	2.8200	0.01	SM 4500PE	7/10/2013	SDAL
Total Kjeldahl Nitrogen	Volk1	4.2900	0.01	EPA 351.3	6/12/2013	SDAL
Total Phosphorus	Volk1	1.2400	0.01	SM 4500PE	6/12/2013	SDAL
Total Kjeldahl Nitrogen	Zieg1	1.5100	0.01	EPA 351.3	5/20/2013	SDAL
Total Phosphorus	Zieg1	0.5330	0.01	SM 4500PE	5/20/2013	SDAL
Total Kjeldahl Nitrogen	Zieg1	1.3300	0.01	EPA 351.3	6/26/2013	SDAL
Total Phosphorus	Zieg1	0.3170	0.01	SM 4500PE	6/26/2013	SDAL
Total Kjeldahl Nitrogen	Zieg1	2.0000	0.01	EPA 351.3	7/23/2013	SDAL
Total Phosphorus	Zieg1	0.7450	0.01	SM 4500PE	7/23/2013	SDAL
Total Kjeldahl Nitrogen	Zieg1	1.8000	0.01	EPA 351.3	5/6/2014	SDAL
Total Phosphorus	Zieg1	0.2790	0.01	SM 4500PE	5/6/2014	SDAL
Total Kjeldahl Nitrogen	Zieg1	2.1900	0.01	EPA 351.3	6/10/2014	SDAL
Total Phosphorus	Zieg1	0.3930	0.01	SM 4500PE	6/10/2014	SDAL
Total Kjeldahl Nitrogen	Zieg1	1.9500	1.03	EPA 351.3	7/8/2014	SDAL
Total Phosphorus	Zieg1	0.3640	0.01	SM 4500PE	7/8/2014	SDAL
Total Kjeldahl Nitrogen	Zieg1	1.7200	0.01	EPA 351.3	8/11/2014	SDAL
Total Phosphorus	Zieg1	0.1250	0.01	SM 4500PE	8/11/2014	SDAL
Total Kjeldahl Nitrogen	Zieg1	2.0700	0.01	EPA 351.3	7/10/2013	SDAL
Total Phosphorus	Zieg1	0.4490	0.01	SM 4500PE	7/10/2013	SDAL
Total Kjeldahl Nitrogen	Zieg1	1.0300	0.01	EPA 351.3	6/10/2013	SDAL
Total Phosphorus	Zieg1	0.2490	0.01	SM 4500PE	6/10/2013	SDAL

Note: mg/L = milligrams per liter, < = less than the detection limit.

Table A.10. Total nitrogen, total phosphorus and orthophosphate concentrations measured by EPA R8 Laboratory in water samples from select study sites within Madison Wetland Management District, South Dakota, 2012.

Analyte	Site	Site Category	Result	Units	LOD	Method	Date Collected	Lab
Total Nitrogen	2PetrA1	Surface Wetland	3	mg/L	0.1	ASTM 5176	9/5/2012	EPA R8 Lab
Total Nitrogen	2PetrA2	Surface Wetland	3	mg/L	0.1	ASTM 5176	9/5/2012	EPA R8 Lab
Total Nitrogen	Ache1	Outfall, Tile	7	mg/L	0.1	ASTM 5176	6/6/2012	EPA R8 Lab
Total Nitrogen	Ache1A	Tile Wetland	4	mg/L	0.1	ASTM 5176	9/5/2012	EPA R8 Lab
Total Nitrogen	BUFO1	Reference Wetland	2	mg/L	0.1	ASTM 5176	5/2/2012	EPA R8 Lab
Total Nitrogen	DRYL1	Outfall, Tile	5	mg/L	0.1	ASTM 5176	5/2/2012	EPA R8 Lab
Total Nitrogen	Gerk1	Outfall, Tile	8	mg/L	0.1	ASTM 5176	6/6/2012	EPA R8 Lab
Total Nitrogen	Gerk1A	Tile Wetland	2	mg/L	0.1	ASTM 5176	9/5/2012	EPA R8 Lab
Total Nitrogen	Hejo1	Outfall, Tile	9	mg/L	0.1	ASTM 5176	6/6/2012	EPA R8 Lab
Total Nitrogen	Hejo1A	Tile Wetland	9	mg/L	0.1	ASTM 5176	7/11/2012	EPA R8 Lab
Total Nitrogen	John1	Surface Wetland	3	mg/L	0.1	ASTM 5176	9/5/2012	EPA R8 Lab
Total Nitrogen	Long1	Outfall, Tile	10	mg/L	0.1	ASTM 5176	4/10/2012	EPA R8 Lab
Total Nitrogen	Long1	Outfall, Tile	10	mg/L	0.1	ASTM 5176	5/2/2012	EPA R8 Lab
Total Nitrogen	Long1	Outfall, Tile	12	mg/L	0.1	ASTM 5176	6/6/2012	EPA R8 Lab
Total Nitrogen	Long1	Outfall, Tile	11	mg/L	0.1	ASTM 5176	7/11/2012	EPA R8 Lab
Total Nitrogen	Long2	Outfall, Tile	9	mg/L	0.1	ASTM 5176	4/10/2012	EPA R8 Lab
Total Nitrogen	Long2	Outfall, Tile	11	mg/L	0.1	ASTM 5176	5/2/2012	EPA R8 Lab
Total Nitrogen	Long2	Outfall, Tile	15	mg/L	0.1	ASTM 5176	6/6/2012	EPA R8 Lab
Total Nitrogen	Long2A	Tile Wetland	10	mg/L	0.1	ASTM 5176	7/11/2012	EPA R8 Lab
Total Nitrogen	Long3	Outfall, Tile	10	mg/L	0.1	ASTM 5176	4/10/2012	EPA R8 Lab
Total Nitrogen	Lost1	Reference Wetland	3	mg/L	0.1	ASTM 5176	7/11/2012	EPA R8 Lab
Total Nitrogen	Lost1	Reference Wetland	5	mg/L	0.1	ASTM 5176	9/5/2012	EPA R8 Lab
Total Nitrogen	Nels1	Outfall, Tile	2	mg/L	0.1	ASTM 5176	5/2/2012	EPA R8 Lab
Total Nitrogen	Nels1	Outfall, Tile	2	mg/L	0.1	ASTM 5176	6/6/2012	EPA R8 Lab
Total Nitrogen	Nels1A	Tile Wetland	16	mg/L	0.1	ASTM 5176	7/11/2012	EPA R8 Lab
Total Nitrogen	Nels1A	Tile Wetland	2	mg/L	0.1	ASTM 5176	9/5/2012	EPA R8 Lab
Total Nitrogen	Pets1	Outfall, Tile	13	mg/L	0.1	ASTM 5176	7/11/2012	EPA R8 Lab
Total Nitrogen	Pitt1	Reference Wetland	3	mg/L	0.1	ASTM 5176	9/5/2012	EPA R8 Lab
Total Nitrogen	Rams1	Surface Wetland	2	mg/L	0.1	ASTM 5176	9/5/2012	EPA R8 Lab
Total Nitrogen	Reev1	Outfall, Tile	27	mg/L	0.1	ASTM 5176	7/11/2012	EPA R8 Lab
Total Nitrogen	Schae1	Surface Wetland	2	mg/L	0.1	ASTM 5176	9/5/2012	EPA R8 Lab
Total Nitrogen	Thor1	Outfall, Tile	1	mg/L	0.1	ASTM 5176	5/2/2012	EPA R8 Lab
Total Nitrogen	Volk1	Tile Wetland	8	mg/L	0.1	ASTM 5176	7/11/2012	EPA R8 Lab
Total Nitrogen	Wern1	Outfall, Tile	11	mg/L	0.1	ASTM 5176	6/6/2012	EPA R8 Lab

Table A.10. Continued.

Analyte	Site		Result		LOD	Method	Date Collected	Lab
Orthophosphate as P	2Petr1A	Surface Wetland	279	ug/L	5	EPA 365.3	9/5/2012	EPA R8 Lab
Orthophosphate as P	2PetrA2	Surface Wetland	304	ug/L	5	EPA 365.3	9/5/2012	EPA R8 Lab
Orthophosphate as P	Ache1	Outfall, Tile	55	ug/L	5	EPA 365.3	6/6/2012	EPA R8 Lab
Orthophosphate as P	Ache1A	Tile Wetland	104	ug/L	5	EPA 365.3	9/5/2012	EPA R8 Lab
Orthophosphate as P	BUFO1	Reference Wetland	846	ug/L	5	EPA 365.3	5/2/2012	EPA R8 Lab
Orthophosphate as P	Dryl1	Outfall, Tile	309	ug/L	5	EPA 365.3	5/2/2012	EPA R8 Lab
Orthophosphate as P	Gerk1	Outfall, Tile	109	ug/L	5	EPA 365.3	6/6/2012	EPA R8 Lab
Orthophosphate as P	Gerk1A	Tile Wetland	178	ug/L	5	EPA 365.3	9/5/2012	EPA R8 Lab
Orthophosphate as P	Hejo1	Outfall, Tile	48	ug/L	5	EPA 365.3	6/6/2012	EPA R8 Lab
Orthophosphate as P	Hejo1A	Tile Wetland	60	ug/L	5	EPA 365.3	7/11/2012	EPA R8 Lab
Orthophosphate as P	John1	Surface Wetland	141	ug/L	5	EPA 365.3	9/5/2012	EPA R8 Lab
Orthophosphate as P	Long1	Outfall, Tile	56	ug/L	5	EPA 365.3	4/10/2012	EPA R8 Lab
Orthophosphate as P	Long1	Outfall, Tile	64	ug/L	5	EPA 365.3	5/2/2012	EPA R8 Lab
Orthophosphate as P	Long1	Outfall, Tile	8	ug/L	5	EPA 365.3	6/6/2012	EPA R8 Lab
Orthophosphate as P	Long1	Outfall, Tile	64	ug/L	5	EPA 365.3	7/11/2012	EPA R8 Lab
Orthophosphate as P	Long2	Outfall, Tile	41	ug/L	5	EPA 365.3	4/10/2012	EPA R8 Lab
Orthophosphate as P	Long2	Outfall, Tile	61	ug/L	5	EPA 365.3	5/2/2012	EPA R8 Lab
Orthophosphate as P	Long2	Outfall, Tile	78	ug/L	5	EPA 365.3	6/6/2012	EPA R8 Lab
Orthophosphate as P	Long2A	Tile Wetland	62	ug/L	5	EPA 365.3	7/11/2012	EPA R8 Lab
Orthophosphate as P	Long3	Outfall, Tile	39	ug/L	5	EPA 365.3	4/10/2012	EPA R8 Lab
Orthophosphate as P	Lost1	Reference Wetland	20	ug/L	5	EPA 365.3	7/11/2012	EPA R8 Lab
Orthophosphate as P	Lost1	Reference Wetland	168	ug/L	5	EPA 365.3	9/5/2012	EPA R8 Lab
Orthophosphate as P	Nels1	Outfall, Tile	62	ug/L	5	EPA 365.3	5/2/2012	EPA R8 Lab
Orthophosphate as P	Nels1	Outfall, Tile	124	ug/L	5	EPA 365.3	6/6/2012	EPA R8 Lab
Orthophosphate as P	Nels1A	Tile Wetland	58	ug/L	5	EPA 365.3	7/11/2012	EPA R8 Lab
Orthophosphate as P	Nels1A	Tile Wetland	51	ug/L	5	EPA 365.3	9/5/2012	EPA R8 Lab
Orthophosphate as P	Pets1	Outfall, Tile	60	ug/L	5	EPA 365.3	7/11/2012	EPA R8 Lab
Orthophosphate as P	Pitt1	Reference Wetland	123	ug/L	5	EPA 365.3	9/5/2012	EPA R8 Lab
Orthophosphate as P	Rams1	Surface Wetland	35	ug/L	5	EPA 365.3	9/5/2012	EPA R8 Lab
Orthophosphate as P	Reev1	Outfall, Tile	119	ug/L	5	EPA 365.3	7/11/2012	EPA R8 Lab
Orthophosphate as P	Schaf1	Surface Wetland	70	ug/L	5	EPA 365.3	9/5/2012	EPA R8 Lab
Orthophosphate as P	Thor1	Outfall, Tile	76	ug/L	5	EPA 365.3	5/2/2012	EPA R8 Lab
Orthophosphate as P	Volk1	Tile Wetland	477	ug/L	5	EPA 365.3	7/11/2012	EPA R8 Lab
Orthophosphate as P	Wern1	Outfall, Tile	68	ug/L	5	EPA 365.3	6/6/2012	EPA R8 Lab

Table A.10. Continued.

Analyte	Site		Result		LOD	Method	Date Collected	Lab
Total Phosphorus	2PetrA1	Surface Wetland	1,160	ug/L	10	EPA 365.4 - TP	9/5/2012	EPA R8 Lab
Total Phosphorus	2PetrA2	Surface Wetland	1,200	ug/L	10	EPA 365.4 - TP	9/5/2012	EPA R8 Lab
Total Phosphorus	Ache1	Outfall, Tile	40	ug/L	10	EPA 365.4 - TP	6/6/2012	EPA R8 Lab
Total Phosphorus	Ache1A	Tile Wetland	257	ug/L	10	EPA 365.4 - TP	9/5/2012	EPA R8 Lab
Total Phosphorus	BUFO1	Reference Wetland	989	ug/L	10	EPA 365.4 - TP	5/2/2012	EPA R8 Lab
Total Phosphorus	DRYL1	Outfall, Tile	326	ug/L	10	EPA 365.4 - TP	5/2/2012	EPA R8 Lab
Total Phosphorus	Gerk1	Outfall, Tile	45	ug/L	10	EPA 365.4 - TP	6/6/2012	EPA R8 Lab
Total Phosphorus	Gerk1A	Tile Wetland	248	ug/L	10	EPA 365.4 - TP	9/5/2012	EPA R8 Lab
Total Phosphorus	Hejo1	Outfall, Tile	< 10	ug/L	10	EPA 365.4 - TP	6/6/2012	EPA R8 Lab
Total Phosphorus	Hejo1A	Tile Wetland	131	ug/L	10	EPA 365.4 - TP	7/11/2012	EPA R8 Lab
Total Phosphorus	John1	Surface Wetland	542	ug/L	10	EPA 365.4 - TP	9/5/2012	EPA R8 Lab
Total Phosphorus	Long1	Outfall, Tile	< 10	ug/L	10	EPA 365.4 - TP	4/10/2012	EPA R8 Lab
Total Phosphorus	Long1	Outfall, Tile	< 10	ug/L	10	EPA 365.4 - TP	5/2/2012	EPA R8 Lab
Total Phosphorus	Long1	Outfall, Tile	< 10	ug/L	10	EPA 365.4 - TP	6/6/2012	EPA R8 Lab
Total Phosphorus	Long1	Outfall, Tile	15	ug/L	10	EPA 365.4 - TP	7/11/2012	EPA R8 Lab
Total Phosphorus	Long2	Outfall, Tile	< 10	ug/L	10	EPA 365.4 - TP	4/10/2012	EPA R8 Lab
Total Phosphorus	Long2	Outfall, Tile	11	ug/L	10	EPA 365.4 - TP	5/2/2012	EPA R8 Lab
Total Phosphorus	Long2	Outfall, Tile	< 10	ug/L	10	EPA 365.4 - TP	6/6/2012	EPA R8 Lab
Total Phosphorus	Long2A	Tile Wetland	< 10	ug/L	10	EPA 365.4 - TP	7/11/2012	EPA R8 Lab
Total Phosphorus	Long3	Outfall, Tile	10	ug/L	10	EPA 365.4 - TP	4/10/2012	EPA R8 Lab
Total Phosphorus	Lost1	Reference Wetland	246	ug/L	10	EPA 365.4 - TP	7/11/2012	EPA R8 Lab
Total Phosphorus	Lost1	Reference Wetland	998	ug/L	10	EPA 365.4 - TP	9/5/2012	EPA R8 Lab
Total Phosphorus	Nels1	Outfall, Tile	45	ug/L	10	EPA 365.4 - TP	5/2/2012	EPA R8 Lab
Total Phosphorus	Nels1	Outfall, Tile	89	ug/L	10	EPA 365.4 - TP	6/6/2012	EPA R8 Lab
Total Phosphorus	Nels1A	Tile Wetland	31	ug/L	10	EPA 365.4 - TP	7/11/2012	EPA R8 Lab
Total Phosphorus	Nels1A	Tile Wetland	360	ug/L	10	EPA 365.4 - TP	9/5/2012	EPA R8 Lab
Total Phosphorus	Pets1	Outfall, Tile	20	ug/L	10	EPA 365.4 - TP	7/11/2012	EPA R8 Lab
Total Phosphorus	Pitt1	Reference Wetland	218	ug/L	10	EPA 365.4 - TP	9/5/2012	EPA R8 Lab
Total Phosphorus	Rams1	Surface Wetland	45	ug/L	10	EPA 365.4 - TP	9/5/2012	EPA R8 Lab
Total Phosphorus	Reev1	Outfall, Tile	112	ug/L	10	EPA 365.4 - TP	7/11/2012	EPA R8 Lab
Total Phosphorus	Schaf1	Surface Wetland	28	ug/L	10	EPA 365.4 - TP	9/5/2012	EPA R8 Lab
Total Phosphorus	Thor1	Outfall, Tile	35	ug/L	10	EPA 365.4 - TP	5/2/2012	EPA R8 Lab
Total Phosphorus	Volk1	Tile Wetland	2,050	ug/L	10	EPA 365.4 - TP	7/11/2012	EPA R8 Lab
Total Phosphorus	Wern1	Outfall, Tile	16	ug/L	10	EPA 365.4 - TP	6/6/2012	EPA R8 Lab

Note: ug/L = micrograms per liter, < = less than the detection limit.

Table A.11. Ammonia, nitrate, chlorophyll-a, and chlorophyll-b concentrations measured by EPA R8 Laboratory in water samples from select study sites within Madison Wetland Management District, South Dakota, 2012.

Sample Name	Site Category	Lab Number	Date Sampled	Analyte	Result	Report Limit	Units
Long1	Outfall, Tile	1204020-01	4/10/2012	Ammonia as N	<0.050	0.05	mg/L
Long2	Outfall, Tile	1204020-02	4/10/2012	Ammonia as N	<0.050	0.05	mg/L
Long3	Outfall, Tile	1204020-03	4/10/2012	Ammonia as N	<0.050	0.05	mg/L
Nels1	Outfall, tile	1205023-03	5/2/2012	Ammonia as N	<0.050	0.05	mg/L
Dryl1	Outfall, Tile	1205023-01	5/2/2012	Ammonia as N	<0.050	0.05	mg/L
Thor1	Outfall, Tile	1205023-02	5/2/2012	Ammonia as N	<0.050	0.05	mg/L
Long1	Outfall, Tile	1205023-07	5/2/2012	Ammonia as N	<0.050	0.05	mg/L
Long2	Outfall, Tile	1205023-08	5/2/2012	Ammonia as N	<0.050	0.05	mg/L
Nels1	Outfall, tile	1206023-01	6/6/2012	Ammonia as N	<0.050	0.05	mg/L
Hejo1	Outfall, Tile	1206023-02	6/6/2012	Ammonia as N	<0.050	0.05	mg/L
Gerk1	Outfall, Tile	1206023-04	6/6/2012	Ammonia as N	<0.050	0.05	mg/L
Long1	Outfall, Tile	1206023-06	6/6/2012	Ammonia as N	<0.050	0.05	mg/L
Long2	Outfall, Tile	1206023-07	6/6/2012	Ammonia as N	<0.050	0.05	mg/L
Ache1	Outfall, Tile	1206023-08	6/6/2012	Ammonia as N	<0.050	0.05	mg/L
Wern1	Outfall, Tile	1206023-10	6/6/2012	Ammonia as N	<0.050	0.05	mg/L
Reev1	Outfall, Tile	1207019-04	7/11/2012	Ammonia as N	0.127	0.05	mg/L
Pets1	Outfall, Tile	1207019-05	7/11/2012	Ammonia as N	<0.050	0.05	mg/L
Long1	Outfall, Tile	1207019-06	7/11/2012	Ammonia as N	<0.050	0.05	mg/L
BUFO1	Reference	1205023-09	5/2/2012	Ammonia as N	0.077	0.05	mg/L
Lost1	Reference	1207019-09	7/11/2012	Ammonia as N	<0.050	0.05	mg/L
Schaf1	Reference	1209013-01	9/5/2012	Ammonia as N	<0.050	0.05	mg/L
Pitt1	Reference	1209013-04	9/5/2012	Ammonia as N	0.063	0.05	mg/L
Lost1	Reference	1209013-10	9/5/2012	Ammonia as N	0.057	0.05	mg/L
John1	Surface Wetland	1209013-03	9/5/2012	Ammonia as N	<0.050	0.05	mg/L
Rams1	Surface Wetland	1209013-06	9/5/2012	Ammonia as N	<0.050	0.05	mg/L
2Petr1A	Surface Wetland	1209013-08	9/5/2012	Ammonia as N	<0.050	0.05	mg/L
2PetrA2	Surface Wetland	1209013-09	9/5/2012	Ammonia as N	<0.050	0.05	mg/L
Nels1A	Tile Wetland	1207019-01	7/11/2012	Ammonia as N	<0.050	0.05	mg/L
Hejo1A	Tile Wetland	1207019-02	7/11/2012	Ammonia as N	<0.050	0.05	mg/L
Long2A	Tile Wetland	1207019-07	7/11/2012	Ammonia as N	<0.050	0.05	mg/L
Volk1	Tile Wetland	1207019-08	7/11/2012	Ammonia as N	1.02	0.05	mg/L
Nels1A	Tile Wetland	1209013-02	9/5/2012	Ammonia as N	<0.050	0.05	mg/L
Gerk1A	Tile Wetland	1209013-05	9/5/2012	Ammonia as N	<0.050	0.05	mg/L
Ache1A	Tile Wetland	1209013-07	9/5/2012	Ammonia as N	0.168	0.05	mg/L

Table A.11. Continued.

Sample Name	Site Category	Lab Number	Date Sampled	Analyte	Result	Report Limit	Units
Long1	Outfall, Tile	1204020-01	4/10/2012	Chlorophyll-a	3.31	0.4	ug/L
Long2	Outfall, Tile	1204020-02	4/10/2012	Chlorophyll-a	<0.40	0.4	ug/L
Long3	Outfall, Tile	1204020-03	4/10/2012	Chlorophyll-a	3.33	0.4	ug/L
Nels1	Outfall, tile	1205023-03	5/2/2012	Chlorophyll-a	9.47	0.4	ug/L
Dryl1	Outfall, Tile	1205023-01	5/2/2012	Chlorophyll-a	4.55	0.4	ug/L
Thor1	Outfall, Tile	1205023-02	5/2/2012	Chlorophyll-a	<0.40	0.4	ug/L
Long1	Outfall, Tile	1205023-07	5/2/2012	Chlorophyll-a	2.63	0.4	ug/L
Long2	Outfall, Tile	1205023-08	5/2/2012	Chlorophyll-a	<0.40	0.4	ug/L
Nels1	Outfall, tile	1206023-01	6/6/2012	Chlorophyll-a	26.3	0.4	ug/L
Hejo1	Outfall, Tile	1206023-02	6/6/2012	Chlorophyll-a	3.65	0.4	ug/L
Gerk1	Outfall, Tile	1206023-04	6/6/2012	Chlorophyll-a	62.4	0.4	ug/L
Long1	Outfall, Tile	1206023-06	6/6/2012	Chlorophyll-a	266	0.4	ug/L
Long2	Outfall, Tile	1206023-07	6/6/2012	Chlorophyll-a	116	0.4	ug/L
Ache1	Outfall, Tile	1206023-08	6/6/2012	Chlorophyll-a	10.8	0.4	ug/L
Wern1	Outfall, Tile	1206023-10	6/6/2012	Chlorophyll-a	11.5	0.4	ug/L
Pets1	Outfall, Tile	1207019-05	7/11/2012	Chlorophyll-a	48.6	0.4	ug/L
BUFO1	Reference	1205023-09	5/2/2012	Chlorophyll-a	5.64	0.4	ug/L
Lost1	Reference	1207019-09	7/11/2012	Chlorophyll-a	80.2	0.4	ug/L
Schaf1	Reference	1209013-01	9/5/2012	Chlorophyll-a	5.5	0.4	ug/L
Pitt1	Reference	1209013-04	9/5/2012	Chlorophyll-a	55.9	0.4	ug/L
Lost1	Reference	1209013-10RE1	9/5/2012	Chlorophyll-a	1420	4	ug/L
John1	Surface Wetland	1209013-03RE1	9/5/2012	Chlorophyll-a	195	0.8	ug/L
Rams1	Surface Wetland	1209013-06	9/5/2012	Chlorophyll-a	2.94	0.4	ug/L
2Petr1A	Surface Wetland	1209013-08RE1	9/5/2012	Chlorophyll-a	616	2	ug/L
2PetrA2	Surface Wetland	1209013-09RE1	9/5/2012	Chlorophyll-a	733	4	ug/L
Nels1A	Tile Wetland	1207019-01	7/11/2012	Chlorophyll-a	20.6	0.4	ug/L
Hejo1A	Tile Wetland	1207019-02	7/11/2012	Chlorophyll-a	16.9	0.4	ug/L
Long2A	Tile Wetland	1207019-07	7/11/2012	Chlorophyll-a	84.9	0.4	ug/L
Volk1	Tile Wetland	1207019-08	7/11/2012	Chlorophyll-a	58.8	0.4	ug/L
Nels1A	Tile Wetland	1209013-02RE1	9/5/2012	Chlorophyll-a	432	2	ug/L
Gerk1A	Tile Wetland	1209013-05	9/5/2012	Chlorophyll-a	38.1	0.4	ug/L
Ache1A	Tile Wetland	1209013-07	9/5/2012	Chlorophyll-a	59.5	0.4	ug/L

Table A.11. Continued.

Sample Name	Site Category	Lab Number	Date Sampled	Analyte	Result	Report Limit	Units
Long1	Outfall, Tile	1204020-01	4/10/2012	Chlorophyll-b	<0.40	0.4	ug/L
Long2	Outfall, Tile	1204020-02	4/10/2012	Chlorophyll-b	<0.40	0.4	ug/L
Long3	Outfall, Tile	1204020-03	4/10/2012	Chlorophyll-b	<0.40	0.4	ug/L
Nels1	Outfall, tile	1205023-03	5/2/2012	Chlorophyll-b	2.14	0.4	ug/L
Dryl1	Outfall, Tile	1205023-01	5/2/2012	Chlorophyll-b	2.33	0.4	ug/L
Thor1	Outfall, Tile	1205023-02	5/2/2012	Chlorophyll-b	<0.40	0.4	ug/L
Long1	Outfall, Tile	1205023-07	5/2/2012	Chlorophyll-b	<0.40	0.4	ug/L
Long2	Outfall, Tile	1205023-08	5/2/2012	Chlorophyll-b	<0.40	0.4	ug/L
Nels1	Outfall, tile	1206023-01	6/6/2012	Chlorophyll-b	2.64	0.4	ug/L
Hejo1	Outfall, Tile	1206023-02	6/6/2012	Chlorophyll-b	<0.40	0.4	ug/L
Gerk1	Outfall, Tile	1206023-04	6/6/2012	Chlorophyll-b	2.47	0.4	ug/L
Long1	Outfall, Tile	1206023-06	6/6/2012	Chlorophyll-b	1.47	0.4	ug/L
Long2	Outfall, Tile	1206023-07	6/6/2012	Chlorophyll-b	4.65	0.4	ug/L
Ache1	Outfall, Tile	1206023-08	6/6/2012	Chlorophyll-b	1.06	0.4	ug/L
Wern1	Outfall, Tile	1206023-10	6/6/2012	Chlorophyll-b	0.75	0.4	ug/L
Pets1	Outfall, Tile	1207019-05	7/11/2012	Chlorophyll-b	1.59	0.4	ug/L
BUFO1	Reference	1205023-09	5/2/2012	Chlorophyll-b	<0.40	0.4	ug/L
Lost1	Reference	1207019-09	7/11/2012	Chlorophyll-b	1.76	0.4	ug/L
Schaf1	Reference	1209013-01	9/5/2012	Chlorophyll-b	<0.40	0.4	ug/L
Pitt1	Reference	1209013-04	9/5/2012	Chlorophyll-b	5.39	0.4	ug/L
Lost1	Reference	1209013-10	9/5/2012	Chlorophyll-b	66.8	0.4	ug/L
John1	Surface Wetland	1209013-03	9/5/2012	Chlorophyll-b	39.7	0.4	ug/L
Rams1	Surface Wetland	1209013-06	9/5/2012	Chlorophyll-b	<0.40	0.4	ug/L
2Petr1A	Surface Wetland	1209013-08	9/5/2012	Chlorophyll-b	32.6	0.4	ug/L
2PetrA2	Surface Wetland	1209013-09	9/5/2012	Chlorophyll-b	36.8	0.4	ug/L
Nels1A	Tile Wetland	1207019-01	7/11/2012	Chlorophyll-b	1.75	0.4	ug/L
Hejo1A	Tile Wetland	1207019-02	7/11/2012	Chlorophyll-b	<0.40	0.4	ug/L
Long2A	Tile Wetland	1207019-07	7/11/2012	Chlorophyll-b	4.95	0.4	ug/L
Volk1	Tile Wetland	1207019-08	7/11/2012	Chlorophyll-b	28.8	0.4	ug/L
Nels1A	Tile Wetland	1209013-02RE1	9/5/2012	Chlorophyll-b	84.2	2	ug/L
Gerk1A	Tile Wetland	1209013-05	9/5/2012	Chlorophyll-b	7.05	0.4	ug/L
Ache1A	Tile Wetland	1209013-07	9/5/2012	Chlorophyll-b	19.8	0.4	ug/L

Table A.11 Continued.

Sample Name	Site Category	Lab Number	Date Sampled	Analyte	Result	Report Limit	Units
Long1	Outfall, Tile	1204020-01RE1	4/10/2012	Nitrate as N	10.4	0.05	mg/L
Long2	Outfall, Tile	1204020-02RE1	4/10/2012	Nitrate as N	9.16	0.05	mg/L
Long3	Outfall, Tile	1204020-03RE1	4/10/2012	Nitrate as N	10.4	0.05	mg/L
Nels1	Outfall, tile	1205023-03	5/2/2012	Nitrate as N	0.191	0.005	mg/L
Dryl1	Outfall, Tile	1205023-01RE1	5/2/2012	Nitrate as N	5.52	0.05	mg/L
Thor1	Outfall, Tile	1205023-02RE1	5/2/2012	Nitrate as N	1.66	0.025	mg/L
Long1	Outfall, Tile	1205023-07RE1	5/2/2012	Nitrate as N	10.6	0.05	mg/L
Long2	Outfall, Tile	1205023-08RE1	5/2/2012	Nitrate as N	11.3	0.05	mg/L
Nels1	Outfall, tile	1206023-01	6/6/2012	Nitrate as N	0.973	0.005	mg/L
Hejo1	Outfall, Tile	1206023-02RE1	6/6/2012	Nitrate as N	8.4	0.05	mg/L
Gerk1	Outfall, Tile	1206023-04RE1	6/6/2012	Nitrate as N	8.84	0.05	mg/L
Long1	Outfall, Tile	1206023-06	6/6/2012	Nitrate as N	1.19	0.05	mg/L
Long2	Outfall, Tile	1206023-07RE1	6/6/2012	Nitrate as N	15.9	0.1	mg/L
Ache1	Outfall, Tile	1206023-08RE1	6/6/2012	Nitrate as N	8.35	0.05	mg/L
Wern1	Outfall, Tile	1206023-10RE1	6/6/2012	Nitrate as N	11.9	0.05	mg/L
Reev1	Outfall, Tile	1207019-04RE1	7/11/2012	Nitrate as N	27.1	0.5	mg/L
Pets1	Outfall, Tile	1207019-05RE1	7/11/2012	Nitrate as N	13.1	0.5	mg/L
Long1	Outfall, Tile	1207019-06RE1	7/11/2012	Nitrate as N	11.6	0.5	mg/L
BUFO1	Reference	1205023-09	5/2/2012	Nitrate as N	< 0.005	0.005	mg/L
Lost1	Reference	1207019-09	7/11/2012	Nitrate as N	< 0.005	0.005	mg/L
Schaf1	Reference	1209013-01	9/5/2012	Nitrate as N	0.0149	0.005	mg/L
Pitt1	Reference	1209013-04	9/5/2012	Nitrate as N	< 0.005	0.005	mg/L
Lost1	Reference	1209013-10	9/5/2012	Nitrate as N	< 0.005	0.005	mg/L
John1	Surface Wetland	1209013-03	9/5/2012	Nitrate as N	< 0.005	0.005	mg/L
Rams1	Surface Wetland	1209013-06	9/5/2012	Nitrate as N	< 0.005	0.005	mg/L
2Petr1A	Surface Wetland	1209013-08	9/5/2012	Nitrate as N	< 0.005	0.005	mg/L
2PetrA2	Surface Wetland	1209013-09	9/5/2012	Nitrate as N	0.0117	0.005	mg/L
Nels1A	Tile Wetland	1207019-01RE1	7/11/2012	Nitrate as N	15.9	0.5	mg/L
Hejo1A	Tile Wetland	1207019-02RE1	7/11/2012	Nitrate as N	8.92	0.5	mg/L
Long2A	Tile Wetland	1207019-07RE1	7/11/2012	Nitrate as N	6.4	0.5	mg/L
Volk1	Tile Wetland	1207019-08	7/11/2012	Nitrate as N	< 0.005	0.005	mg/L
Nels1A	Tile Wetland	1209013-02	9/5/2012	Nitrate as N	< 0.005	0.005	mg/L
Gerk1A	Tile Wetland	1209013-05	9/5/2012	Nitrate as N	< 0.005	0.005	mg/L
Ache1A	Tile Wetland	1209013-07	9/5/2012	Nitrate as N	< 0.005	0.005	mg/L

Table A.11 Continued.

Sample Name	Site Category	Lab Number	Date Sampled	Analyte	Result	Report Limit	Units
Long1	Outfall, Tile	1204020-01	4/10/2012	Nitrite as N	0.00623	0.005	mg/L
Long2	Outfall, Tile	1204020-02	4/10/2012	Nitrite as N	< 0.005	0.005	mg/L
Long3	Outfall, Tile	1204020-03	4/10/2012	Nitrite as N	0.00504	0.005	mg/L
Nels1	Outfall, tile	1205023-03	5/2/2012	Nitrite as N	< 0.005	0.005	mg/L
Dryl1	Outfall, Tile	1205023-01	5/2/2012	Nitrite as N	0.0105	0.005	mg/L
Thor1	Outfall, Tile	1205023-02	5/2/2012	Nitrite as N	< 0.005	0.005	mg/L
Long1	Outfall, Tile	1205023-07	5/2/2012	Nitrite as N	< 0.005	0.005	mg/L
Long2	Outfall, Tile	1205023-08	5/2/2012	Nitrite as N	< 0.005	0.005	mg/L
Nels1	Outfall, tile	1206023-01	6/6/2012	Nitrite as N	< 0.005	0.005	mg/L
Hejo1	Outfall, Tile	1206023-02	6/6/2012	Nitrite as N	< 0.005	0.005	mg/L
Gerk1	Outfall, Tile	1206023-04	6/6/2012	Nitrite as N	< 0.005	0.005	mg/L
Long1	Outfall, Tile	1206023-06	6/6/2012	Nitrite as N	< 0.005	0.005	mg/L
Long2	Outfall, Tile	1206023-07	6/6/2012	Nitrite as N	0.0159	0.005	mg/L
Ache1	Outfall, Tile	1206023-08	6/6/2012	Nitrite as N	< 0.005	0.005	mg/L
Wern1	Outfall, Tile	1206023-10	6/6/2012	Nitrite as N	< 0.005	0.005	mg/L
Reev1	Outfall, Tile	1207019-04	7/11/2012	Nitrite as N	0.106	0.005	mg/L
Pets1	Outfall, Tile	1207019-05	7/11/2012	Nitrite as N	< 0.005	0.005	mg/L
Long1	Outfall, Tile	1207019-06	7/11/2012	Nitrite as N	0.0128	0.005	mg/L
BUFO1	Reference	1205023-09	5/2/2012	Nitrite as N	< 0.005	0.005	mg/L
Lost1	Reference	1207019-09	7/11/2012	Nitrite as N	< 0.005	0.005	mg/L
Schaf1	Reference	1209013-01	9/5/2012	Nitrite as N	< 0.005	0.005	mg/L
Pitt1	Reference	1209013-04	9/5/2012	Nitrite as N	0.0118	0.005	mg/L
Lost1	Reference	1209013-10	9/5/2012	Nitrite as N	0.0164	0.005	mg/L
John1	Surface Wetland	1209013-03	9/5/2012	Nitrite as N	0.0253	0.005	mg/L
Rams1	Surface Wetland	1209013-06	9/5/2012	Nitrite as N	< 0.005	0.005	mg/L
2Petr1A	Surface Wetland	1209013-08	9/5/2012	Nitrite as N	0.017	0.005	mg/L
2PetrA2	Surface Wetland	1209013-09	9/5/2012	Nitrite as N	0.0188	0.005	mg/L
Nels1A	Tile Wetland	1207019-01	7/11/2012	Nitrite as N	0.00753	0.005	mg/L
Hejo1A	Tile Wetland	1207019-02	7/11/2012	Nitrite as N	< 0.005	0.005	mg/L
Long2A	Tile Wetland	1207019-07	7/11/2012	Nitrite as N	< 0.005	0.005	mg/L
Volk1	Tile Wetland	1207019-08	7/11/2012	Nitrite as N	0.00768	0.005	mg/L
Nels1A	Tile Wetland	1209013-02	9/5/2012	Nitrite as N	0.0117	0.005	mg/L
Gerk1A	Tile Wetland	1209013-05	9/5/2012	Nitrite as N	0.00759	0.005	mg/L
Ache1A	Tile Wetland	1209013-07	9/5/2012	Nitrite as N	0.0092	0.005	mg/L

Note: ug/L = micrograms per liter, mg/L = milligrams per liter, QA/QC = quality assurance/quality control sample, < = less than the detection limit.

Table A.12. Anion concentrations measured by EPA R8 Laboratory in water samples from select study sites within Madison Wetland Management District, South Dakota, 2012.

Sample Name	Site Category	Lab Number	Date Sampled	Analyte	Result	ReportLimit	Units
Ache1	Outfall, Tile	1206023-08	6/6/2012	Chloride	3.8	0.5	mg/L
Long1	Outfall, Tile	1207019-06	7/11/2012	Chloride	5.1	0.5	mg/L
Long2	Outfall, Tile	1205023-08	5/2/2012	Chloride	5.4	1	mg/L
Long1	Outfall, Tile	1206023-06	6/6/2012	Chloride	5.5	0.5	mg/L
Gerk1	Outfall, Tile	1206023-04	6/6/2012	Chloride	6	0.5	mg/L
Long1	Outfall, Tile	1204020-01	4/10/2012	Chloride	6.6	2.5	mg/L
Long3	Outfall, Tile	1204020-03	4/10/2012	Chloride	6.6	2.5	mg/L
Nels1	Outfall, tile	1206023-01	6/6/2012	Chloride	7.6	0.5	mg/L
Pets1	Outfall, Tile	1207019-05	7/11/2012	Chloride	8	0.5	mg/L
Wern1	Outfall, Tile	1206023-10	6/6/2012	Chloride	9.5	0.5	mg/L
Long2	Outfall, Tile	1204020-02	4/10/2012	Chloride	10.1	2.5	mg/L
Dryl1	Outfall, Tile	1205023-01	5/2/2012	Chloride	11.2	5	mg/L
Hejo1	Outfall, Tile	1206023-02	6/6/2012	Chloride	12.4	0.5	mg/L
Reev1	Outfall, Tile	1207019-04	7/11/2012	Chloride	13.7	0.5	mg/L
Long2	Outfall, Tile	1206023-07	6/6/2012	Chloride	13.9	0.5	mg/L
Thor1	Outfall, Tile	1205023-02	5/2/2012	Chloride	16.3	1	mg/L
Nels1	Outfall, tile	1205023-03	5/2/2012	Chloride	16.9	1	mg/L
Long1	Outfall, Tile	1205023-07	5/2/2012	Chloride	18	2.5	mg/L
Schaf1	Reference	1209013-01	9/5/2012	Chloride	3	0.5	mg/L
Lost1	Reference	1207019-09	7/11/2012	Chloride	6.3	0.5	mg/L
Lost1	Reference	1209013-10	9/5/2012	Chloride	8	0.5	mg/L
Pitt1	Reference	1209013-04	9/5/2012	Chloride	9.4	0.5	mg/L
BUFO1	Reference	1205023-09	5/2/2012	Chloride	11.7	2	mg/L
2Petr1A	Surface Wetland	1209013-08	9/5/2012	Chloride	9.7	0.5	mg/L
2PetrA2	Surface Wetland	1209013-09	9/5/2012	Chloride	9.9	0.5	mg/L
Rams1	Surface Wetland	1209013-06	9/5/2012	Chloride	16.3	0.5	mg/L
John1	Surface Wetland	1209013-03	9/5/2012	Chloride	17.6	0.5	mg/L
Long2A	Tile Wetland	1207019-07	7/11/2012	Chloride	10.5	0.5	mg/L
Hejo1A	Tile Wetland	1207019-02	7/11/2012	Chloride	14.4	0.5	mg/L
Gerk1A	Tile Wetland	1209013-05	9/5/2012	Chloride	18.9	0.5	mg/L
Nels1A	Tile Wetland	1209013-02	9/5/2012	Chloride	22.3	0.5	mg/L
Ache1A	Tile Wetland	1209013-07	9/5/2012	Chloride	25.3	0.5	mg/L
Nels1A	Tile Wetland	1207019-01	7/11/2012	Chloride	29.3	0.5	mg/L
Volk1	Tile Wetland	1207019-08RE1	7/11/2012	Chloride	114	5	mg/L

Table A.12. Continued.

Sample Name	Site Category	Lab Number	Date Sampled	Analyte	Result	ReportLimit	Units
Ache1	Outfall, Tile	1206023-08	6/6/2012	Fluoride	0.2	0.2	mg/L
Nels1	Outfall, tile	1206023-01	6/6/2012	Fluoride	0.4	0.2	mg/L
Gerk1	Outfall, Tile	1206023-04	6/6/2012	Fluoride	0.5	0.2	mg/L
Long1	Outfall, Tile	1206023-06	6/6/2012	Fluoride	0.5	0.2	mg/L
Long2	Outfall, Tile	1206023-07	6/6/2012	Fluoride	0.5	0.2	mg/L
Thor1	Outfall, Tile	1205023-02	5/2/2012	Fluoride	0.5	0.4	mg/L
Wern1	Outfall, Tile	1206023-10	6/6/2012	Fluoride	0.5	0.2	mg/L
Hejo1	Outfall, Tile	1206023-02	6/6/2012	Fluoride	0.6	0.2	mg/L
Long1	Outfall, Tile	1207019-06	7/11/2012	Fluoride	0.9	0.2	mg/L
Pets1	Outfall, Tile	1207019-05	7/11/2012	Fluoride	0.9	0.2	mg/L
Long2	Outfall, Tile	1204020-02	4/10/2012	Fluoride	1	1	mg/L
Reev1	Outfall, Tile	1207019-04	7/11/2012	Fluoride	1.1	0.2	mg/L
Long1	Outfall, Tile	1205023-07	5/2/2012	Fluoride	1.8	1	mg/L
Long2	Outfall, Tile	1205023-08	5/2/2012	Fluoride	<0.4	0.4	mg/L
Nels1	Outfall, tile	1205023-03	5/2/2012	Fluoride	<0.4	0.4	mg/L
Long1	Outfall, Tile	1204020-01	4/10/2012	Fluoride	<1.0	1	mg/L
Long3	Outfall, Tile	1204020-03	4/10/2012	Fluoride	<1.0	1	mg/L
Dryl1	Outfall, Tile	1205023-01	5/2/2012	Fluoride	<2.0	2	mg/L
Pitt1	Reference	1209013-04	9/5/2012	Fluoride	0.3	0.2	mg/L
Schaf1	Reference	1209013-01	9/5/2012	Fluoride	0.3	0.2	mg/L
Lost1	Reference	1207019-09	7/11/2012	Fluoride	0.4	0.2	mg/L
Lost1	Reference	1209013-10	9/5/2012	Fluoride	0.4	0.2	mg/L
BUFO1	Reference	1205023-09	5/2/2012	Fluoride	<0.8	0.8	mg/L
Rams1	Surface Wetland	1209013-06	9/5/2012	Fluoride	0.2	0.2	mg/L
2Petr1A	Surface Wetland	1209013-08	9/5/2012	Fluoride	0.3	0.2	mg/L
2PetrA2	Surface Wetland	1209013-09	9/5/2012	Fluoride	0.3	0.2	mg/L
John1	Surface Wetland	1209013-03	9/5/2012	Fluoride	0.6	0.2	mg/L
Ache1A	Tile Wetland	1209013-07	9/5/2012	Fluoride	0.3	0.2	mg/L
Gerk1A	Tile Wetland	1209013-05	9/5/2012	Fluoride	0.3	0.2	mg/L
Hejo1A	Tile Wetland	1207019-02	7/11/2012	Fluoride	0.5	0.2	mg/L
Long2A	Tile Wetland	1207019-07	7/11/2012	Fluoride	0.5	0.2	mg/L
Volk1	Tile Wetland	1207019-08	7/11/2012	Fluoride	0.5	0.2	mg/L
Nels1A	Tile Wetland	1207019-01	7/11/2012	Fluoride	0.6	0.2	mg/L
Nels1A	Tile Wetland	1209013-02	9/5/2012	Fluoride	0.7	0.2	mg/L

Table A.12. Continued.

Sample Name	Site Category	Lab Number	Date Sampled	Analyte	Result	ReportLimit	Units
Nels1	Outfall, tile	1206023-01	6/6/2012	Hardness	530	1.3	mg CaCO3 / L
Ache1	Outfall, Tile	1206023-08	6/6/2012	Hardness	634	1.3	mg CaCO3 / L
Nels1	Outfall, tile	1205023-03	5/2/2012	Hardness	653	1.3	mg CaCO3 / L
Hejo1	Outfall, Tile	1206023-02	6/6/2012	Hardness	696	1.3	mg CaCO3 / L
Long1	Outfall, Tile	1206023-06	6/6/2012	Hardness	722	1.3	mg CaCO3 / L
Long3	Outfall, Tile	1204020-03	4/10/2012	Hardness	751	1.3	mg CaCO3 / L
Long1	Outfall, Tile	1204020-01	4/10/2012	Hardness	756	1.3	mg CaCO3 / L
Long1	Outfall, Tile	1207019-06	7/11/2012	Hardness	761	1.3	mg CaCO3 / L
Thor1	Outfall, Tile	1205023-02	5/2/2012	Hardness	764	1.3	mg CaCO3 / L
Long1	Outfall, Tile	1205023-07	5/2/2012	Hardness	767	1.3	mg CaCO3 / L
Pets1	Outfall, Tile	1207019-05	7/11/2012	Hardness	902	1.3	mg CaCO3 / L
Reev1	Outfall, Tile	1207019-04	7/11/2012	Hardness	983	1.3	mg CaCO3 / L
Long2	Outfall, Tile	1204020-02	4/10/2012	Hardness	1080	1.3	mg CaCO3 / L
Wern1	Outfall, Tile	1206023-10	6/6/2012	Hardness	1130	1.3	mg CaCO3 / L
Gerk1	Outfall, Tile	1206023-04	6/6/2012	Hardness	1290	1.3	mg CaCO3 / L
Long2	Outfall, Tile	1205023-08	5/2/2012	Hardness	1360	1.3	mg CaCO3 / L
Long2	Outfall, Tile	1206023-07	6/6/2012	Hardness	1390	1.3	mg CaCO3 / L
Dryl1	Outfall, Tile	1205023-01	5/2/2012	Hardness	1870	1.3	mg CaCO3 / L
Pitt1	Reference	1209013-04	9/5/2012	Hardness	686	1.3	mg CaCO3 / L
BUFO1	Reference	1205023-09	5/2/2012	Hardness	740	1.3	mg CaCO3 / L
Schaf1	Reference	1209013-01	9/5/2012	Hardness	995	1.3	mg CaCO3 / L
Lost1	Reference	1207019-09	7/11/2012	Hardness	1080	1.3	mg CaCO3 / L
Lost1	Reference	1209013-10	9/5/2012	Hardness	1350	1.3	mg CaCO3 / L
John1	Surface Wetland	1209013-03	9/5/2012	Hardness	461	1.3	mg CaCO3 / L
Rams1	Surface Wetland	1209013-06	9/5/2012	Hardness	1480	1.3	mg CaCO3 / L
2Petr1A	Surface Wetland	1209013-08	9/5/2012	Hardness	1830	1.3	mg CaCO3 / L
2PetrA2	Surface Wetland	1209013-09	9/5/2012	Hardness	1860	1.3	mg CaCO3 / L
Nels1A	Tile Wetland	1209013-02	9/5/2012	Hardness	331	1.3	mg CaCO3 / L
Hejo1A	Tile Wetland	1207019-02	7/11/2012	Hardness	486	1.3	mg CaCO3 / L
Nels1A	Tile Wetland	1207019-01	7/11/2012	Hardness	487	1.3	mg CaCO3 / L
Long2A	Tile Wetland	1207019-07	7/11/2012	Hardness	1040	1.3	mg CaCO3 / L
Ache1A	Tile Wetland	1209013-07	9/5/2012	Hardness	1440	1.3	mg CaCO3 / L
Gerk1A	Tile Wetland	1209013-05	9/5/2012	Hardness	1880	1.3	mg CaCO3 / L
Volk1	Tile Wetland	1207019-08	7/11/2012	Hardness	2590	1.3	mg CaCO3 / L

Table A.12. Continued.

Sample Name	Site Category	Lab Number	Date Sampled	Analyte	Result	ReportLimit	Units
Nels1	Outfall, tile	1206023-01	6/6/2012	Sulfate as SO4	175	1	mg/L
Nels1	Outfall, tile	1205023-03	5/2/2012	Sulfate as SO4	290	2	mg/L
Ache1	Outfall, Tile	1206023-08RE1	6/6/2012	Sulfate as SO4	301	2	mg/L
Thor1	Outfall, Tile	1205023-02	5/2/2012	Sulfate as SO4	327	2	mg/L
Long2	Outfall, Tile	1205023-08	5/2/2012	Sulfate as SO4	412	2	mg/L
Long1	Outfall, Tile	1206023-06RE1	6/6/2012	Sulfate as SO4	456	5	mg/L
Long1	Outfall, Tile	1204020-01	4/10/2012	Sulfate as SO4	459	5	mg/L
Hejo1	Outfall, Tile	1206023-02RE1	6/6/2012	Sulfate as SO4	463	5	mg/L
Long3	Outfall, Tile	1204020-03	4/10/2012	Sulfate as SO4	466	5	mg/L
Long1	Outfall, Tile	1207019-06RE1	7/11/2012	Sulfate as SO4	476	5	mg/L
Pets1	Outfall, Tile	1207019-05RE1	7/11/2012	Sulfate as SO4	556	5	mg/L
Reev1	Outfall, Tile	1207019-04RE1	7/11/2012	Sulfate as SO4	639	5	mg/L
Long2	Outfall, Tile	1204020-02	4/10/2012	Sulfate as SO4	802	5	mg/L
Wern1	Outfall, Tile	1206023-10RE1	6/6/2012	Sulfate as SO4	950	10	mg/L
Gerk1	Outfall, Tile	1206023-04RE1	6/6/2012	Sulfate as SO4	1100	10	mg/L
Long1	Outfall, Tile	1205023-07	5/2/2012	Sulfate as SO4	1150	5	mg/L
Long2	Outfall, Tile	1206023-07RE1	6/6/2012	Sulfate as SO4	1200	10	mg/L
Dryl1	Outfall, Tile	1205023-01	5/2/2012	Sulfate as SO4	1590	10	mg/L
BUFO1	Reference	1205023-09	5/2/2012	Sulfate as SO4	488	4	mg/L
Pitt1	Reference	1209013-04RE1	9/5/2012	Sulfate as SO4	621	5	mg/L
Schaf1	Reference	1209013-01RE1	9/5/2012	Sulfate as SO4	695	5	mg/L
Lost1	Reference	1207019-09RE1	7/11/2012	Sulfate as SO4	1090	5	mg/L
Lost1	Reference	1209013-10RE1	9/5/2012	Sulfate as SO4	1260	10	mg/L
John1	Surface Wetland	1209013-03	9/5/2012	Sulfate as SO4	87	1	mg/L
Rams1	Surface Wetland	1209013-06RE1	9/5/2012	Sulfate as SO4	1580	10	mg/L
2Petr1A	Surface Wetland	1209013-08RE1	9/5/2012	Sulfate as SO4	1880	10	mg/L
2PetrA2	Surface Wetland	1209013-09RE1	9/5/2012	Sulfate as SO4	1900	10	mg/L
Nels1A	Tile Wetland	1207019-01	7/11/2012	Sulfate as SO4	55.9	1	mg/L
Nels1A	Tile Wetland	1209013-02	9/5/2012	Sulfate as SO4	76.6	1	mg/L
Hejo1A	Tile Wetland	1207019-02	7/11/2012	Sulfate as SO4	171	1	mg/L
Long2A	Tile Wetland	1207019-07RE1	7/11/2012	Sulfate as SO4	771	5	mg/L
Ache1A	Tile Wetland	1209013-07RE1	9/5/2012	Sulfate as SO4	1260	10	mg/L
Gerk1A	Tile Wetland	1209013-05RE1	9/5/2012	Sulfate as SO4	1850	10	mg/L
Volk1	Tile Wetland	1207019-08RE1	7/11/2012	Sulfate as SO4	2360	10	mg/L

Table A.12. Continued.

Sample Name	Site Category	Lab Number	Date Sampled	Analyte	Result	ReportLimit	Units
Nels1	Outfall, tile	1206023-01	6/6/2012	Total Dissolved Solids	593	2	mg/L
Ache1	Outfall, Tile	1206023-08	6/6/2012	Total Dissolved Solids	793	2	mg/L
Hejo1	Outfall, Tile	1206023-02	6/6/2012	Total Dissolved Solids	881	2	mg/L
Wern1	Outfall, Tile	1206023-10	6/6/2012	Total Dissolved Solids	1400	2	mg/L
Gerk1	Outfall, Tile	1206023-04	6/6/2012	Total Dissolved Solids	1440	2	mg/L
Long2	Outfall, Tile	1206023-07	6/6/2012	Total Dissolved Solids	1550	2	mg/L
Long1	Outfall, Tile	1206023-06	6/6/2012	Total Dissolved Solids	7380	2	mg/L
Nels1	Outfall, tile	1205023-03	5/2/2012	Total Dissolved Solids	746	12	mg/L
Thor1	Outfall, Tile	1205023-02	5/2/2012	Total Dissolved Solids	861	12	mg/L
Long1	Outfall, Tile	1205023-07	5/2/2012	Total Dissolved Solids	915	12	mg/L
Long1	Outfall, Tile	1207019-06	7/11/2012	Total Dissolved Solids	916	2	mg/L
Pets1	Outfall, Tile	1207019-05	7/11/2012	Total Dissolved Solids	1040	2	mg/L
Reev1	Outfall, Tile	1207019-04	7/11/2012	Total Dissolved Solids	1160	2	mg/L
Long2	Outfall, Tile	1205023-08	5/2/2012	Total Dissolved Solids	1500	12	mg/L
Dryl1	Outfall, Tile	1205023-01	5/2/2012	Total Dissolved Solids	2060	12	mg/L
BUFO1	Reference	1205023-09	5/2/2012	Total Dissolved Solids	896	12	mg/L
Pitt1	Reference	1209013-04	9/5/2012	Total Dissolved Solids	916	2	mg/L
Schaf1	Reference	1209013-01	9/5/2012	Total Dissolved Solids	1150	2	mg/L
Lost1	Reference	1207019-09	7/11/2012	Total Dissolved Solids	1310	2	mg/L
Lost1	Reference	1209013-10	9/5/2012	Total Dissolved Solids	1640	2	mg/L
John1	Surface Wetland	1209013-03	9/5/2012	Total Dissolved Solids	562	2	mg/L
Rams1	Surface Wetland	1209013-06	9/5/2012	Total Dissolved Solids	1840	2	mg/L
2Petr1A	Surface Wetland	1209013-08	9/5/2012	Total Dissolved Solids	2180	2	mg/L
2PetrA2	Surface Wetland	1209013-09	9/5/2012	Total Dissolved Solids	2180	2	mg/L
Nels1A	Tile Wetland	1209013-02	9/5/2012	Total Dissolved Solids	438	2	mg/L
Hejo1A	Tile Wetland	1207019-02	7/11/2012	Total Dissolved Solids	601	2	mg/L
Nels1A	Tile Wetland	1207019-01	7/11/2012	Total Dissolved Solids	609	2	mg/L
Long2A	Tile Wetland	1207019-07	7/11/2012	Total Dissolved Solids	1200	2	mg/L
Ache1A	Tile Wetland	1209013-07	9/5/2012	Total Dissolved Solids	1790	2	mg/L
Gerk1A	Tile Wetland	1209013-05	9/5/2012	Total Dissolved Solids	2090	2	mg/L
Volk1	Tile Wetland	1207019-08	7/11/2012	Total Dissolved Solids	3220	2	mg/L

Note: mg/L = milligrams per liter, QA/QC = quality assurance/quality control sample, < = less than the detection limit.

Table A.13. Concentrations of elemental contaminants in water, sediments, and tissue samples submitted by the Analytical Control Facility to Envirosystems Incorporated, Madison Wetland Management District, South Dakota, 2012–2015.

Analysis	Sample ID	Sample Matrix	Percent Total Organic Carbon	Percent moisture
Catalog 6090084	AcheSE1	Sediments	7.9	59.8
Elemental Contaminants	AcheSE2	Sediments	8	61.8
Wetland Sediments	AcheSE3	Sediments	7.2	58.3
	AcheSE4	Sediments	15	79.9
	AcheSE5	Sediments	7.8	64.7
	Bols1	Sediments	5.8	73.3
	Bols2	Sediments	19	70.7
	Bols3	Sediments	6.7	59.2
	Bols4	Sediments	4	27.9
	Bols5	Sediments	6.3	55.9
	BuffSE1	Sediments	0.47	71.7
	BuffSE2	Sediments	0.36	72.3
	BuffSE3	Sediments	14	73.4
	BuffSE4	Sediments	11	74.8
	BuffSE5	Sediments	8.2	59.8
	CoteSE1	Sediments	6.1	60.1
	CoteSE2	Sediments	9.1	68.6
	CoteSE3	Sediments	13	73.7
	CoteSE4	Sediments	25	83.4
	CoteSE5	Sediments	5.7	87.4
	GerkSE1	Sediments	9.3	80
	GerkSE2	Sediments	0.35	72.1
	GerkSE3	Sediments	0.22	54.3
	GerkSE4	Sediments	10	68.4
	GerkSE5	Sediments	16	76.6
	HejoSE1	Sediments	15	75.2
	HejoSE2	Sediments	0.83	66.3
	HejoSE3	Sediments	1.9	76.2
	HejoSE4	Sediments	1.3	49.7
	HejoSE5	Sediments	2.1	70.2
	LongSE1	Sediments	1	20.5
	LongSE2	Sediments	0.19	19.3
	LongSE3	Sediments	0.33	31
	LongSE4	Sediments	3.9	47.4
	LongSE5	Sediments	3.6	54.2
	LostSE1	Sediments	15	60.9
	LostSE2	Sediments	12	51.4
	LostSE3	Sediments	15	77.7
	LostSE4	Sediments	4.6	71.1
	LostSE5	Sediments	3.2	49.3
	NelsSE1	Sediments	3.3	62.1
	NelsSE2	Sediments	0.78	38.7
	NelsSE3	Sediments	2.3	45.2
	NelsSE4	Sediments	1.1	26.3
	NelsSE5	Sediments	7.4	57.9
	PetrSE1	Sediments	12	61.1
	PetrSE2	Sediments	15	72.1
	PetrSE3	Sediments	9.3	51.9
	PetrSE4	Sediments	8.9	55.8
	PetrSE5	Sediments	19	68.9
	SeveSE1	Sediments	13	69.6
	SeveSE2	Sediments	18	78.7
	SeveSE3	Sediments	20	77.7
	SeveSE4	Sediments	11	67.8
	SeveSE5	Sediments	13	72.5

Table A.13. Continued.

Analysis	Sample ID	Sample Matrix	Date	Volume (ml)
Catalog 6090085	BolsW1	Water	7/26/2012	1,000
Elemental Contaminants	BolsW2	Water	7/26/2012	1,000
Wetland Water	BolsW3	Water	7/26/2012	1,000
	BolsW4	Water	7/26/2012	1,000
	BolsW5	Water	7/26/2012	1,000
	CoteW1	Water	7/25/2012	1,000
	CoteW2	Water	7/25/2012	1,000
	CoteW3	Water	7/25/2012	1,000
	CoteW4	Water	7/25/2012	1,000
	CoteW5	Water	7/25/2012	1,000
	GerkW1	Water	7/26/2012	1,000
	GerkW2	Water	7/26/2012	1,000
	GerkW3	Water	7/26/2012	1,000
	GerkW4	Water	7/26/2012	1,000
	GerkW5	Water	7/26/2012	1,000
	HejoW1	Water	7/25/2012	1,000
	HejoW2	Water	7/25/2012	1,000
	HejoW3	Water	7/25/2012	1,000
	HejoW4	Water	7/25/2012	1,000
	HejoW5	Water	7/25/2012	1,000
	NelsW1	Water	7/25/2012	1,000
	NelsW2	Water	7/25/2012	1,000
	NelsW3	Water	7/25/2012	1,000
	NelsW4	Water	7/25/2012	1,000
	NelsW5	Water	7/25/2012	1,000
	SeveW1	Water	7/25/2012	1,000
	SeveW2	Water	7/25/2012	1,000
	SeveW3	Water	7/25/2012	1,000
	SeveW4	Water	7/25/2012	1,000
	SeveW5	Water	7/25/2012	1,000

Analysis	Sample ID	Sample Matrix	Sample Mass (grams)	Percent moisture
Catalog 6090086	2Petr1ACF	Crayfish	40	84.2
Elemental Contaminants	2Petr1AMI	Aquatic macroinvertebrates	15	84.3
Invertebrates and	Ache1AMI	Aquatic macroinvertebrates	20	77.6
Sediements	Bols1AMI	Aquatic macroinvertebrates	10	85.8
	Hejo1AMI	Aquatic macroinvertebrates	20	84.4
	Nels1AMI	Aquatic macroinvertebrates	20	84.9
	Gerk1ASN	Snails	30	93.2
	Zieg1SN	Snails	30	93.4
	Sample ID	**Sample Matrix**	**Percent Total Organic Carbon**	**Percent moisture**
	John01	Sediments	1.67	53.9
	John02	Sediments	6.98	39.5
	John03	Sediments	3.07	36.7
	John04	Sediments	0.97	40
	John05	Sediments	1.48	45.2
	Mund01	Sediments	2.7	57.5
	Mund02	Sediments	2.24	80.6
	Mund03	Sediments	5.99	80.5
	Mund04	Sediments	7.23	67
	Mund05	Sediments	5.96	63.9
	Pett01	Sediments	3.14	44.2
	Pett02	Sediments	2.02	42.4
	Pett03	Sediments	1.79	43.5
	Pett04	Sediments	3.18	44.5
	Pett05	Sediments	3.25	42.3

Table A.13. Continued.

Analysis	Sample ID	Sample Matrix	Percent Total Organic Carbon	Percent moisture
Catalog 6090086	Pitt01	Sediments	4.14	74
Elemental Contaminants	Pitt02	Sediments	5.52	57.9
Invertebrates and	Pitt03	Sediments	7.61	62.2
Sediements	Pitt04	Sediments	0.41	67.6
	Pitt05	Sediments	7.58	70
	Rams01	Sediments	4.23	52.2
	Rams02	Sediments	4.83	66.2
	Rams03	Sediments	7.47	56.4
	Rams04	Sediments	4.53	69.1
	Rams05	Sediments	7.21	60.9
	Schae01	Sediments	3.02	65.9
	Schae02	Sediments	3.09	39.7
	Schae03	Sediments	3.52	59.5
	Schae04	Sediments	4.55	68.7
	Schae05	Sediments	5.28	63.8
	Schaf01	Sediments	7.41	73.3
	Schaf02	Sediments	1.56	70.9
	Schaf03	Sediments	5.33	79.8
	Schaf04	Sediments	4.35	64.4
	Schaf05	Sediments	1.88	82.1
	VolkSE1	Sediments	5.02	55.2
	VolkSE2	Sediments	6.01	63.8
	VolkSE3	Sediments	4.41	51.6
	VolkSE4	Sediments	4.24	42.8
	VolkSE5	Sediments	4.73	65.5
	Zieg01	Sediments	4.85	63.9
	Zieg02	Sediments	4.42	65.7
	Zieg03	Sediments	3.21	71.7
	Zieg04	Sediments	2.62	48.3
	Zieg05	Sediments	6.42	68.6

Analysis	Sample ID	Sample Matrix	Sample Mass	Percent moisture
Catalog 6090087	GerkN1E1	Duck Eggs	36	68.7
Elemental Contaminants	GerkN1E2	Duck Eggs	32	66.7
Avian Eggs, Invertebrates,	GerkN2E1	Duck Eggs	28	61.4
Sediments	GerkN2E2	Duck Eggs	31	67.9
and Wetland Plants	GerkN2E3	Duck Eggs	29	65.3
	WenkN1E1	Duck Eggs	34	69.9
	WenkN1E2	Duck Eggs	33	69.9
	WenkN1E3	Duck Eggs	32	70.4
	WenkN1E4	Duck Eggs	35	69.8
	WenkN1E5	Duck Eggs	35	68.9
	WenkN2E1	Duck Eggs	22	64.2
	WenkN2E2	Duck Eggs	29	67.3
	WenkN2E3	Duck Eggs	25	66
	WenkN2E4	Duck Eggs	21	62
	WenkN2E5	Duck Eggs	29	70.5
	WenkN3E1	Duck Eggs	33	62.4
	WenkN3E2	Duck Eggs	42	65.1
	WenkN4E1	Duck Eggs	26	70.8
	WenkN4E2	Duck Eggs	33	70.2
	WenkN4E3	Duck Eggs	31	71.7
	WenkN4E4	Duck Eggs	30	68.3
	WenkN5E1	Duck Eggs	30	70.4
	WenkN5E2	Duck Eggs	29	67.9
	WenkN5E3	Duck Eggs	27	87.4
	WenkN5E4	Duck Eggs	33	67.4

Table A.13. Continued.

Analysis	Sample ID	Sample Matrix	Sample Mass	Percent moisture
Catalog 6090087	BuffCF1	Crayfish	18	79.9
Elemental Contaminants	John1CF	Crayfish	12	82.9
Avian Eggs, Invertebrates,	Lost1CF1	Crayfish	23	80.5
Sediments	Nels1ACF1	Crayfish	17	82.2
and Wetland Plants	Nels1ACF2	Crayfish	28	83.5
	Zieg1CF1	Crayfish	25	73.6
	Bols1F1	Fish	11	77.1
	Hejo1AF	Fish	43	81.9
	Mund1F1	Fish	11	74.5
	Nels1AF2	Fish	28	78.4
	Nels1F1	Fish	13	78.5
	Pitt1F1	Fish	10	80.9
	PittF2	Fish	15	80.4
	Zieg1F1	Fish	14	83.6
	Schae1F1	Fish	10	78.4
	2Petr1AMI1	Aquatic macroinvertebrates	10	85.9
	Bols1MI	Aquatic macroinvertebrates	11	84.6
	BuffMI1	Aquatic macroinvertebrates	14	84.1
	Cote1MI1	Aquatic macroinvertebrates	16	82.8
	Hejo1AMI1	Aquatic macroinvertebrates	14	84.8
	John1MI1	Aquatic macroinvertebrates	12	83.3
	Lost1MI1	Aquatic macroinvertebrates	12	85.3
	Mund1MI1	Aquatic macroinvertebrates	8	80.4
	Pett1MI1	Aquatic macroinvertebrates	9	86.2
	Pitt1MI1	Aquatic macroinvertebrates	10	80.6
	RamsMI1	Aquatic macroinvertebrates	11	79.2
	Schae1MI1	Aquatic macroinvertebrates	10	86.8
	Schaf1MI1	Aquatic macroinvertebrates	17	81.7
	Zieg1MI1	Aquatic macroinvertebrates	11	84.4
	Bols1BukS1	Sediments	190	57.6
	Bols1BukS2	Sediments	191	56.4
	2Petr1ASN1	Snails	10	76.8
	Buff1SN1	Snails	15	86.1
	BuffSN2	Snails	15	85.5
	CoteSN1	Snails	17	85.7
	Gerk1ASN1	Snails	15	88.5
	GerkSN2	Snails	11	84.2
	Hejo1ASN1	Snails	35	91.4
	Hejo1SN2	Snails	37	87.9
	Mund1SN1	Snails	13	86.2
	PettSN1	Snails	13	85.9
	Pitt1SN1	Snails	13	86
	RamsSN1	Snails	11	84.3
	Schae1SN1	Snails	12	81.1
	Schaf1SN1	Snails	11	85
	Volk1SN1	Snails	13	83.5
	VolkSN2	Snails	31	86.9
	Zieg1SN1	Snails	15	86.3
	ZiegSN2	Snails	19	87.2

Table A.13. Continued.

Analysis	Sample ID	Sample Matrix	Sample Mass	Percent moisture
Catalog 6090087	2Petr1ADW1	Wetland Plants	86	93.6
Elemental Contaminants	2Petr1ADW2	Wetland Plants	117	94.1
Avian Eggs, Invertebrates,	Bols1ADW1	Wetland Plants	112	92
Sediments	Bols1DW2	Wetland Plants	121	91.8
and Wetland Plants	Buff1PW1	Wetland Plants	96	92.3
	BuffPW2	Wetland Plants	115	92.6
	GerkPS1	Wetland Plants	134	77.5
	Hejo1ADW1	Wetland Plants	105	91.4
	Hejo1ADW2	Wetland Plants	111	93.8
	John1DW	Wetland Plants	119	92.2
	John1DW1	Wetland Plants	79	92.5
	Lost1DW1	Wetland Plants	59	91.3
	LostDW2	Wetland Plants	118	93
	Mund1DW	Wetland Plants	120	91.7
	Nels1DW1	Wetland Plants	81	87.7
	Nels1DW2	Wetland Plants	118	92.6
	Pett1PW1	Wetland Plants	99	92.2
	PettPW2	Wetland Plants	117	95.8
	PittPW2	Wetland Plants	125	91.8
	RamsDW	Wetland Plants	111	92.2
	Volk1DW1	Wetland Plants	95	93.1
	VolkDW2	Wetland Plants	107	92.8
	Zieg1DW1	Wetland Plants	109	93
	ZiegDW2	Wetland Plants	118	92.8

Table A.14. Water samples analyzed by the Environmental Protection Agency Region 8 Laboratory for total metals and collected from select study sites within the Madison Wetland Management District, South Dakota, 2012 and 2015.

Sample Name	Site Category	Lab Number	Date Sampled	Method	Laboratory
Ache1	Tile Outfall	1206023-08	6/6/2012	200.8/6020	U.S. EPA, Region 8 Laboratory
AcheA	Tile Wetland	1209013-07	9/5/2012	200.8/6020	U.S. EPA, Region 8 Laboratory
Adam1	Tile Outfall	1505023-09	5/12/2015	200.8/6020	U.S. EPA, Region 8 Laboratory
Adam1	Tile Outfall	1507016-08	7/7/2015	200.8/6020	U.S. EPA, Region 8 Laboratory
Adam1	Tile Outfall	1509015-07	9/1/2015	200.8/6020	U.S. EPA, Region 8 Laboratory
Adam2	Tile Outfall	1508019-03	8/4/2015	200.8/6020	U.S. EPA, Region 8 Laboratory
Adam2	Tile Outfall	1509036-07	10/27/2015	200.8/6020	U.S. EPA, Region 8 Laboratory
Adam2	Tile Outfall	1507016-07	7/7/2015	200.8/6020	U.S. EPA, Region 8 Laboratory
Adam2	Tile Outfall	1506020-05	6/9/2015	200.8/6020	U.S. EPA, Region 8 Laboratory
Adam2	Tile Outfall	1505023-10	5/12/2015	200.8/6020	U.S. EPA, Region 8 Laboratory
Blks1A	Tile Wetland	1207019-03	7/11/2012	200.8/6020	U.S. EPA, Region 8 Laboratory
Blks1	Tile Outfall	1205023-04	5/2/2012	200.8/6020	U.S. EPA, Region 8 Laboratory
Bols1	Tile Outfall	1507016-09	7/7/2015	200.8/6020	U.S. EPA, Region 8 Laboratory
Bols1	Tile Outfall	1504029-09	4/17/2015	200.8/6020	U.S. EPA, Region 8 Laboratory
Bols1	Tile Outfall	1509036-10	10/28/2015	200.8/6020	U.S. EPA, Region 8 Laboratory
Bols1	Tile Outfall	1509015-02	9/1/2015	200.8/6020	U.S. EPA, Region 8 Laboratory
Bols1A	Tile Wetland	1504029-10	4/17/2015	200.8/6020	U.S. EPA, Region 8 Laboratory
Bufo1	Reference Wetland	1205023-09	5/2/2012	200.8/6020	U.S. EPA, Region 8 Laboratory
Dryl1	Tile Outfall	1205023-01	5/2/2012	200.8/6020	U.S. EPA, Region 8 Laboratory
Gerk1	Tile Outfall	1206023-04	6/6/2012	200.8/6020	U.S. EPA, Region 8 Laboratory
Gerk1	Tile Outfall	1507016-10	7/8/2015	200.8/6020	U.S. EPA, Region 8 Laboratory
Gerk1	Tile Outfall	1506020-06	6/9/2015	200.8/6020	U.S. EPA, Region 8 Laboratory
Gerk1A	Tile Wetland	1504029-12	4/17/2015	200.8/6020	U.S. EPA, Region 8 Laboratory
Gerk1A	Tile Wetland	1209013-05	9/5/2012	200.8/6020	U.S. EPA, Region 8 Laboratory
Habe1	Tile Outfall	1506020-07	6/9/2015	200.8/6020	U.S. EPA, Region 8 Laboratory
Habe1	Tile Outfall	1507016-11	7/8/2015	200.8/6020	U.S. EPA, Region 8 Laboratory
Habe1	Tile Outfall	1509015-01	9/1/2015	200.8/6020	U.S. EPA, Region 8 Laboratory
Hejo1	Tile Outfall	1509015-06	9/1/2015	200.8/6020	U.S. EPA, Region 8 Laboratory
Hejo1	Tile Outfall	1509036-06	10/27/2015	200.8/6020	U.S. EPA, Region 8 Laboratory
Hejo1	Tile Outfall	1508019-05	8/4/2015	200.8/6020	U.S. EPA, Region 8 Laboratory
Hejo1	Tile Outfall	1506020-04	6/9/2015	200.8/6020	U.S. EPA, Region 8 Laboratory
Hejo1	Tile Outfall	1507016-05	7/7/2015	200.8/6020	U.S. EPA, Region 8 Laboratory
Hejo1	Tile Outfall	1505023-08	5/12/2015	200.8/6020	U.S. EPA, Region 8 Laboratory
Hejo1	Tile Outfall	1206023-02	6/6/2012	200.8/6020	U.S. EPA, Region 8 Laboratory
Hejo1A	Tile Wetland	1207019-02	7/11/2012	200.8/6020	U.S. EPA, Region 8 Laboratory
Hejo1A	Tile Wetland	1504029-07	4/17/2015	200.8/6020	U.S. EPA, Region 8 Laboratory
Hejo2	Tile Outfall	1509015-05	9/1/2015	200.8/6020	U.S. EPA, Region 8 Laboratory
Hejo2	Tile Outfall	1506020-03	6/9/2015	200.8/6020	U.S. EPA, Region 8 Laboratory
Hejo2	Tile Outfall	1505023-07	5/12/2015	200.8/6020	U.S. EPA, Region 8 Laboratory
Hejo2	Tile Outfall	1507016-06	7/7/2015	200.8/6020	U.S. EPA, Region 8 Laboratory
Hejo2	Tile Outfall	1509036-05	10/27/2015	200.8/6020	U.S. EPA, Region 8 Laboratory

Table A.14. Continued.

Sample Name	Site Category	Lab Number	Date Sampled	Method	Laboratory
John1	Surface Wetland	1504029-06	4/17/2015	200.8/6020	U.S. EPA, Region 8 Laboratory
JohnA	Surface Wetland	1209013-03	9/5/2012	200.8/6020	U.S. EPA, Region 8 Laboratory
Long 1	Tile Outfall	1204020-01	4/10/2012	200.8/6020	U.S. EPA, Region 8 Laboratory
Long 2	Tile Outfall	1204020-02	4/10/2012	200.8/6020	U.S. EPA, Region 8 Laboratory
Long1	Tile Outfall	1206023-06	6/6/2012	200.8/6020	U.S. EPA, Region 8 Laboratory
Long1	Tile Outfall	1207019-06	7/11/2012	200.8/6020	U.S. EPA, Region 8 Laboratory
Long1	Tile Outfall	1205023-07	5/2/2012	200.8/6020	U.S. EPA, Region 8 Laboratory
Long2	Tile Outfall	1205023-08	5/2/2012	200.8/6020	U.S. EPA, Region 8 Laboratory
Long2	Tile Outfall	1206023-07	6/6/2012	200.8/6020	U.S. EPA, Region 8 Laboratory
Long2A	Tile Wetland	1207019-07	7/11/2012	200.8/6020	U.S. EPA, Region 8 Laboratory
Lost1	Reference Wetland	1207019-09	7/11/2012	200.8/6020	U.S. EPA, Region 8 Laboratory
LostA	Reference Wetland	1209013-10	9/5/2012	200.8/6020	U.S. EPA, Region 8 Laboratory
Mund1T	Tile Outfall	1509036-09	10/27/2015	200.8/6020	U.S. EPA, Region 8 Laboratory
Mund1T	Tile Outfall	1509015-04	9/1/2015	200.8/6020	U.S. EPA, Region 8 Laboratory
Mund1T	Tile Outfall	1505023-06	5/12/2015	200.8/6020	U.S. EPA, Region 8 Laboratory
Mund1T	Tile Outfall	1506020-02	6/9/2015	200.8/6020	U.S. EPA, Region 8 Laboratory
Mund1T	Tile Outfall	1507016-04	7/7/2015	200.8/6020	U.S. EPA, Region 8 Laboratory
Mund1T	Tile Outfall	1504029-05	4/17/2015	200.8/6020	U.S. EPA, Region 8 Laboratory
Mund1T	Tile Outfall	1508019-02	8/4/2015	200.8/6020	U.S. EPA, Region 8 Laboratory
Nels1	Tile Outfall	1506020-01	6/9/2015	200.8/6020	U.S. EPA, Region 8 Laboratory
Nels1	Tile Outfall	1206023-01	6/6/2012	200.8/6020	U.S. EPA, Region 8 Laboratory
Nels1	Tile Outfall	1205023-03	5/2/2012	200.8/6020	U.S. EPA, Region 8 Laboratory
Nels1	Tile Outfall	1508019-01	8/4/2015	200.8/6020	U.S. EPA, Region 8 Laboratory
Nels1	Tile Outfall	1505023-05	5/12/2015	200.8/6020	U.S. EPA, Region 8 Laboratory
Nels1	Tile Outfall	1509015-03	9/1/2015	200.8/6020	U.S. EPA, Region 8 Laboratory
Nels1A	Tile Wetland	1209013-02	9/5/2012	200.8/6020	U.S. EPA, Region 8 Laboratory
Nels1A	Tile Wetland	1207019-01	7/11/2012	200.8/6020	U.S. EPA, Region 8 Laboratory
2PetrA1	Surface Wetland	1209013-08	9/5/2012	200.8/6020	U.S. EPA, Region 8 Laboratory
2PetrA2	Surface Wetland	1209013-09	9/5/2012	200.8/6020	U.S. EPA, Region 8 Laboratory
Pets1	Tile Outfall	1207019-05	7/11/2012	200.8/6020	U.S. EPA, Region 8 Laboratory
Pitt1	Reference Wetland	1209013-04	9/5/2012	200.8/6020	U.S. EPA, Region 8 Laboratory
Rams1	Surface Wetland	1504029-11	4/17/2015	200.8/6020	U.S. EPA, Region 8 Laboratory
Rams1	Surface Wetland	1209013-06	9/5/2012	200.8/6020	U.S. EPA, Region 8 Laboratory
Reev1	Tile Outfall	1207019-04	7/11/2012	200.8/6020	U.S. EPA, Region 8 Laboratory
Scha1A	Reference Wetland	1209013-01	9/5/2012	200.8/6020	U.S. EPA, Region 8 Laboratory
Thor1	Tile Outfall	1205023-02	5/2/2012	200.8/6020	U.S. EPA, Region 8 Laboratory
Volk1A	Tile Wetland	1207019-08	7/11/2012	200.8/6020	U.S. EPA, Region 8 Laboratory
Wern1	Tile Outfall	1206023-10	6/6/2012	200.8/6020	U.S. EPA, Region 8 Laboratory
Zeig1	Surface Wetland	1504029-08	4/17/2015	200.8/6020	U.S. EPA, Region 8 Laboratory

Table A.15. Sediment chemistry results from WARD Laboratories for samples collected from study sites within the Madison Wetland Management District, South Dakota, 2013.

						Concentration in mg/kg (ppm)											
Site Category	Sample ID	Date Collected	1:1 Soil pH	1:1 S Salts mmho/cm	Matter LOI %	Nitrate	Potassium	Sulfate	Zinc	Iron	Manganese	Copper	Calcium	Magnesium	Sodium	CEC/Sum of Cations meq/100g	Paste SAR
Refernce Wetland	BUFF 151	8/12/2013	7.2	4.4	15.7	3.4	196	510	4.83	128.3	225	2.2	5225	1548	126	40.1	0.7
Refernce Wetland	BUFF 152	8/12/2013	7.8	3.14	18.7	2.3	136	349	2.24	70.7	175	0.6	4057	1049	96	29.8	0.7
Refernce Wetland	BUFF 153	8/12/2013	7.5	4.16	8.6	0.3	291	800	4.17	110.5	296	2.8	6041	1770	112	46.2	0.7
Refernce Wetland	COTE 151	8/13/2013	8.2	1.98	4.8	0.3	88	261	1.71	117.1	22	2.0	2756	1588	52	27.5	0.7
Refernce Wetland	COTE 252	8/13/2013	8.1	2.88	11.3	0.5	157	395	4.56	66.6	28	2.3	3848	1994	85	36.6	0.6
Refernce Wetland	COTE 353	8/13/2013	8.2	1.98	4.6	0.5	95	338	2.18	72.4	19	1.8	2781	1488	50	26.8	0.5
Refernce Wetland	LOST 151	8/12/2013	7.5	2.96	5.9	0.4	401	497	2.94	167.9	187	4.6	3935	1348	85	32.3	0.6
Refernce Wetland	LOST 152	8/12/2013	7.5	2.66	4.5	0.3	419	435	2.92	168.2	145	4.6	3582	1336	75	30.4	0.6
Refernce Wetland	LOST 153	8/12/2013	7.8	3.38	6.3	0.8	399	500	3.5	148.9	155	4.5	4208	1385	86	34	0.6
Refernce Wetland	PETT 151	8/12/2013	6.3	1.52	7.2	0.7	359	280	4.26	280.6	202	3.5	3036	874	46	25.7	0.4
Refernce Wetland	PETT 152	8/12/2013	6.3	1.68	5.4	1.2	398	272	3.43	233.3	136	3.6	2900	885	29	24	0.3
Refernce Wetland	PETT 153	8/12/2013	6.2	1.7	6	0.9	403	332	3.69	268.1	159	3.8	3122	870	41	25.9	0.4
Refernce Wetland	PITT 151	8/14/2013	7.8	2.04	9.7	0.5	308	258	4.78	52.9	124	4.4	3972	1553	59	33.8	0.6
Refernce Wetland	PITT 152	8/14/2013	7.9	2.38	10	0.3	233	225	4.52	89.3	119	3.0	4165	1463	66	33.9	0.6
Refernce Wetland	PITT 153	8/14/2013	7.8	2.16	11.4	0.4	240	279	4.2	69.2	163	3.5	4443	1277	61	33.7	0.5
Refernce Wetland	SCHAF 151	8/13/2013	8	1.98	7	1.1	177	247	2.84	97.2	22	3.1	3838	1601	78	33.3	0.6
Refernce Wetland	SCHAF 152	8/13/2013	8	2.36	9.4	0.6	195	313	2.96	128.3	26	2.6	3030	2001	79	32.7	0.6
Refernce Wetland	SCHAF 153	8/13/2013	7.7	1.78	8	1	192	181	3.09	94.5	14	2.9	2799	1828	84	30.1	0.7
Surface Wetland	2PETR 151	8/12/2013	7	4.5	12.8	0.3	371	775	4.68	170.4	327	2.9	7806	1647	245	54.8	1.6
Surface Wetland	2PETR 152	8/12/2013	6.1	4.4	11.5	0.2	378	1200	3.72	288	177	2.5	6957	1304	180	50.3	1.2
Surface Wetland	2PETR 153	8/12/2013	7.1	4.82	12.7	0.4	435	925	4.9	194.3	301	2.9	8134	1875	317	58.8	1.6
Surface Wetland	JOHN 151	8/13/2013	8.1	1.48	7	0.4	149	153	2.9	176	27	3.4	4055	792	35	27.4	0.4
Surface Wetland	JOHN 152	8/13/2013	8	1.12	2.6	0.4	166	53	0.65	163.1	54	5.3	3940	1013	27	28.7	0.4
Surface Wetland	JOHN 153	8/13/2013	8.1	1.34	3.5	0.4	189	82	0.55	107.5	25	4.3	3189	1232	28	26.8	0.4

Table A.15. Continued.

Site Category	Sample ID	Date Collected	1:1 Soil pH	1:1 S Salts mmho/cm	Matter LOI %	Concentration in mg/kg (ppm) Nitrate	Potassium	Sulfate	Zinc	Iron	Manganese	Copper	Calcium	Magnesium	Sodium	CEC/Sum of Cations meq/100g	Paste SAR
Surface Wetland	RAMS 151	8/12/2013	7.7	3.58	7.3	0.3	227	493	2.44	86.8	115	3.3	4572	1212	137	34.1	1
Surface Wetland	RAMS 152	8/12/2013	7.6	3.12	7.4	0.3	272	515	2.11	149.8	141	4.1	4324	1448	144	35	1.1
Surface Wetland	RAMS 153	8/12/2013	7.8	4.2	15.5	0.7	250	720	3.91	118.4	198	3.1	4637	1524	194	37.4	1.3
Surface Wetland	SCHAE 151	8/12/2013	8.1	2.86	7.1	0.7	362	11	4.72	148.8	107	4.3	3238	2042	185	34.9	1.8
Surface Wetland	SCHAE 152	8/12/2013	8	3.04	8.7	2.2	342	415	3.4	121.4	192	3.8	3436	2110	207	36.5	1.7
Surface Wetland	SCHAE 153	8/12/2013	8.1	2.34	8.5	0.6	315	348	3.54	165	182	4.5	3211	1785	196	32.6	1.5
Surface Wetland	ZIEG 151	8/14/2013	7.4	4.42	18.5	4.5	221	665	5.34	155.4	95	3.4	4645	1312	193	35.6	1.3
Surface Wetland	ZIEG 152	8/14/2013	7.5	4.18	15.7	5.6	222	565	4.41	186.4	49	2.9	4456	1089	150	32.6	1.1
Surface Wetland	ZIEG 153	8/14/2013	7.9	3.44	6.2	1.8	143	410	2.29	131.5	47	1.8	4259	897	91	29.5	0.8
Tile Wetland	ACHE 151	8/12/2013	7.9	3.92	17.6	0.3	205	620	4.06	171.9	123	2.2	4486	1782	265	39	1.8
Tile Wetland	ACHE 152	8/12/2013	7.9	3.78	24.7	0.4	207	590	4.49	172.8	153	2.1	4190	1919	257	38.6	1.7
Tile Wetland	ACHE 153	8/12/2013	7.8	4.64	12.3	0.4	269	815	3.83	181	172	3.8	4775	2183	287	44	2.1
Tile Wetland	BOLS 151	8/14/2013	7.6	3.92	6.7	0.2	278	605	2.67	147.6	250	5.5	2926	2267	432	36.1	3.6
Tile Wetland	BOLS 152	8/14/2013	7.8	4	4.9	0.2	268	630	2.7	102.6	158	5.0	2759	2044	362	33.1	3.4
Tile Wetland	BOLS 153	8/14/2013	8.1	3.42	5.5	0.4	208	388	2.56	104.3	337	4.6	3096	2052	388	34.8	2.6
Tile Wetland	GERK 151	8/12/2013	7.6	4.84	9	0.3	198	630	3.37	83.7	110	4.7	8620	1887	196	60.2	1.1
Tile Wetland	GERK 152	8/12/2013	6	4.92	13.1	0.4	263	1260	4.32	358.9	59	4.8	6918	2151	196	56.7	1
Tile Wetland	GERK 153	8/12/2013	7.6	4.08	6.9	0.9	287	452	3	52.6	97	4.8	5035	1706	141	40.7	0.9
Tile Wetland	HEJO 151	8/13/2013	7.5	2.68	13.8	1.2	158	353	4.32	165.9	32	4.3	5595	1299	59	39.5	0.4
Tile Wetland	HEJO 152	8/13/2013	7.7	2.6	11.6	1.1	177	338	4.36	166.9	24	4.4	5214	1369	62	38.2	0.4
Tile Wetland	HEJO 153	8/13/2013	7.7	2.38	13.1	1.3	131	330	3.92	120.6	18	3.2	5045	1139	42	35.2	0.3
Tile Wetland	MUND 151	8/13/2013	7.4	2.42	10.9	5.2	198	279	6.74	120.3	23	3.0	4277	943	41	29.9	0.3
Tile Wetland	MUND 152	8/13/2013	7.5	2.44	10	4.4	181	320	8.46	149.6	20	3.3	4548	916	38	31	0.3
Tile Wetland	MUND 153	8/13/2013	7.5	2.38	9.2	1	235	251	4.59	119.9	25	3.0	4291	1116	44	31.5	0.3
Tile Wetland	NELS 151	8/13/2013	8.1	0.78	1.6	0.5	145	76	0.82	137.7	69	2.3	4167	539	15	25.8	0.2
Tile Wetland	NELS 152	8/13/2013	8.1	1.1	2.4	0.5	90	100	1.74	79.1	53	1.8	3532	410	11	21.4	0.2
Tile Wetland	NELS 153	8/13/2013	8.1	0.96	3	1.4	111	80	1.58	87.3	23	1.9	3778	383	12	22.4	0.2
Tile Wetland	VOLK 151	8/12/2013	5.7	5.44	7.8	0.3	697	764	4.32	231.1	229	2.9	4771	1752	398	45.6	3.4
Tile Wetland	VOLK 152	8/12/2013	6.3	5.08	12.9	0.3	560	759	7.84	260.8	230	2.2	6109	1608	391	50.5	3
Tile Wetland	VOLK 153	8/12/2013	6	6	12.4	0.2	744	1390	7.35	238.5	244	2.6	4660	2318	610	50.1	4.7

Note: S salts = soluble salts, mmho/cm = millimho per centimeter, LOI% = percent loss on ignition, CEC = cation exchange capacity, SAR = sodium absorption ratio.

Table A.16. Concentrations of selenium in water samples from select study sites within Madison Wetland Management District, South Dakota, 2013–2014.

Laboratory	Lab ID	Site	Site Category	Date Collected	Selenium (ug/L)	LOQ	Method
SDAL	13S05172	2Petr1A	Surface wetland	5/21/2013	0.65	0.40	SM3500-(fluorometric)
SDAL	13S06143	2Petr1A	Surface wetland	6/10/2013	1.09	0.40	SM3500-(fluorometric)
SDAL	13S06800	2Petr1A	Surface wetland	6/27/2013	0.76	0.40	SM3500-(fluorometric)
SDAL	13S07376	2Petr1A	Surface wetland	7/10/2013	0.70	0.40	SM3500-(fluorometric)
SDAL	13S08228	2Petr1A	Surface wetland	7/22/2013	1.71	0.40	SM3500-(fluorometric)
SDAL	13S09666	2Petr1A	Surface wetland	8/12/2013	0.66	0.40	SM3500-(fluorometric)
SDAL	14S04185	2Petr1A	Surface wetland	5/7/2014	< 0.4	0.40	SM3500-(fluorometric)
SDAL	14S04770	2Petr1A	Surface wetland	5/19/2014	0.42	0.40	SM3500-(fluorometric)
SDAL	14S05693	2Petr1A	Surface wetland	6/10/2014	0.56	0.40	SM3500-(fluorometric)
SDAL	14S06141	2Petr1A	Surface wetland	6/23/2014	0.47	0.40	SM3500-(fluorometric)
SDAL	14S07246	2Petr1A	Surface wetland	7/9/2014	< 0.4	0.40	SM3500-(fluorometric)
SDAL	14S08006	2Petr1A	Surface wetland	7/28/2014	< 0.4	0.40	SM3500-(fluorometric)
SDAL	14S08787	2Petr1A	Surface wetland	8/12/2014	0.62	0.40	SM3500-(fluorometric)
SDAL	14S09762	2Petr1A	Surface wetland	8/25/2014	< 0.4	0.40	SM3500-(fluorometric)
SDAL	13S06144	Ache1	Tile Outfall	6/11/2013	10.40	0.40	SM3500-(fluorometric)
SDAL	13S06787	Ache1	Tile Outfall	6/27/2013	0.57	0.40	SM3500-(fluorometric)
SDAL	14S06143	Ache1	Tile Outfall	6/23/2014	11.50	0.40	SM3500-(fluorometric)
SDAL	13S05167	Ache1A	Tile Wetland	5/21/2013	< 0.4	0.40	SM3500-(fluorometric)
SDAL	13S06145	Ache1A	Tile Wetland	6/12/2013	< 0.4	0.40	SM3500-(fluorometric)
SDAL	13S07361	Ache1A	Tile Wetland	7/10/2013	0.47	0.40	SM3500-(fluorometric)
SDAL	13S08215	Ache1A	Tile Wetland	7/22/2013	0.71	0.40	SM3500-(fluorometric)
SDAL	13S09664	Ache1A	Tile Wetland	8/12/2013	< 0.4	0.40	SM3500-(fluorometric)
SDAL	14S07237	Adam1	Tile Outfall	7/8/2014	4.95	0.40	SM3500-(fluorometric)
SDAL	14S08795	Adam2	Tile Outfall	8/11/2014	16.70	0.40	SM3500-(fluorometric)
SDAL	13S04778	Bols1	Tile Outfall	5/3/2013	3.41	0.40	SM3500-(fluorometric)
SDAL	13S05156	Bols1	Tile Outfall	5/20/2013	4.22	0.40	SM3500-(fluorometric)
SDAL	13S06146	Bols1	Tile Outfall	6/10/2013	6.28	0.40	SM3500-(fluorometric)
SDAL	13S06793	Bols1	Tile Outfall	6/26/2013	2.35	0.40	SM3500-(fluorometric)
SDAL	13S07363	Bols1	Tile Outfall	7/10/2013	2.11	0.40	SM3500-(fluorometric)
SDAL	13S09677	Bols1	Tile Outfall	8/14/2013	1.93	0.40	SM3500-(fluorometric)
SDAL	14S04176	Bols1	Tile Outfall	5/6/2014	19.20	0.40	SM3500-(fluorometric)
SDAL	14S05684	Bols1	Tile Outfall	6/10/2014	3.67	0.40	SM3500-(fluorometric)
SDAL	14S06150	Bols1	Tile Outfall	6/23/2014	2.08	0.40	SM3500-(fluorometric)
SDAL	14S07240	Bols1	Tile Outfall	7/8/2014	1.34	0.40	SM3500-(fluorometric)
SDAL	14S08021	Bols1	Tile Outfall	7/30/2014	0.78	0.40	SM3500-(fluorometric)
SDAL	14S08784	Bols1	Tile Outfall	8/11/2014	1.14	0.40	SM3500-(fluorometric)
SDAL	14S09771	Bols1	Tile Outfall	8/25/2014	0.94	0.40	SM3500-(fluorometric)
SDAL	13S05157	Bols1A	Tile Wetland	5/20/2013	< 0.4	0.40	SM3500-(fluorometric)
SDAL	13S06147	Bols1A	Tile Wetland	6/10/2013	< 0.4	0.40	SM3500-(fluorometric)
SDAL	13S06794	Bols1A	Tile Wetland	6/26/2013	< 0.4	0.40	SM3500-(fluorometric)
SDAL	13S07362	Bols1A	Tile Wetland	7/10/2013	< 0.4	0.40	SM3500-(fluorometric)
SDAL	13S08216	Bols1A	Tile Wetland	7/24/2013	0.44	0.40	SM3500-(fluorometric)
SDAL	13S09678	Bols1A	Tile Wetland	8/14/2013	< 0.4	0.40	SM3500-(fluorometric)
SDAL	14S04177	Bols1A	Tile Wetland	5/6/2014	< 0.4	0.40	SM3500-(fluorometric)
SDAL	14S04777	Bols1A	Tile Wetland	5/19/2014	< 0.4	0.40	SM3500-(fluorometric)
SDAL	14S05685	Bols1A	Tile Wetland	6/10/2014	< 0.4	0.40	SM3500-(fluorometric)

Table A.16. Continued.

Laboratory	Lab ID	Site	Site Category	Date Collected	Selenium (ug/L)	LOQ	Method
SDAL	14S06151	Bols1A	Tile Wetland	6/23/2014	< 0.4	0.40	SM3500-(fluorometric)
SDAL	14S07251	Bols1A	Tile Wetland	7/9/2014	< 0.4	0.40	SM3500-(fluorometric)
SDAL	14S08022	Bols1A	Tile Wetland	7/30/2014	< 0.4	0.40	SM3500-(fluorometric)
SDAL	14S08785	Bols1A	Tile Wetland	8/11/2014	< 0.4	0.40	SM3500-(fluorometric)
SDAL	14S09772	Bols1A	Tile Wetland	8/25/2014	ND	0.40	SM3500-(fluorometric)
SDAL	13S05168	Buff1	Reference Wetland	5/21/2013	0.54	0.40	SM3500-(fluorometric)
SDAL	13S06148	Buff1	Reference Wetland	6/12/2013	< 0.4	0.40	SM3500-(fluorometric)
SDAL	13S06788	Buff1	Reference Wetland	6/27/2013	0.57	0.40	SM3500-(fluorometric)
SDAL	13S07364	Buff1	Reference Wetland	7/10/2013	< 0.4	0.40	SM3500-(fluorometric)
SDAL	13S08217	Buff1	Reference Wetland	7/22/2013	0.49	0.40	SM3500-(fluorometric)
SDAL	13S09662	Buff1	Reference Wetland	8/12/2013	< 0.4	0.40	SM3500-(fluorometric)
SDAL	14S04182	Buff1	Reference Wetland	5/7/2014	< 0.4	0.40	SM3500-(fluorometric)
SDAL	14S04773	Buff1	Reference Wetland	5/19/2014	< 0.4	0.40	SM3500-(fluorometric)
SDAL	14S05691	Buff1	Reference Wetland	6/10/2014	< 0.4	0.40	SM3500-(fluorometric)
SDAL	14S06146	Buff1	Reference Wetland	6/23/2014	< 0.4	0.40	SM3500-(fluorometric)
SDAL	14S07250	Buff1	Reference Wetland	7/9/2014	< 0.4	0.40	SM3500-(fluorometric)
SDAL	14S08010	Buff1	Reference Wetland	7/28/2014	< 0.4	0.40	SM3500-(fluorometric)
SDAL	14S08791	Buff1	Reference Wetland	8/12/2014	< 0.4	0.40	SM3500-(fluorometric)
SDAL	14S09766	Buff1	Reference Wetland	8/25/2014	< 0.4	0.40	SM3500-(fluorometric)
SDAL	14S06145	Buff1T	Tile Outfall	6/23/2014	25.50	0.40	SM3500-(fluorometric)
SDAL	13S09682	Clea2	Tile Outfall	8/14/2013	14.50	0.40	SM3500-(fluorometric)
SDAL	14S07248	Clea2	Tile Outfall	7/9/2014	12.20	0.40	SM3500-(fluorometric)
SDAL	14S08008	Clea2	Tile Outfall	7/28/2014	11.80	0.40	SM3500-(fluorometric)
SDAL	14S08789	Clea2	Tile Outfall	8/12/2014	13.10	0.40	SM3500-(fluorometric)
SDAL	14S09764	Clea2	Tile Outfall	8/25/2014	11.00	0.40	SM3500-(fluorometric)
SDAL	13S05169	Cote1	Reference Wetland	5/21/2013	< 0.4	0.40	SM3500-(fluorometric)
SDAL	13S06149	Cote1	Reference Wetland	6/11/2013	< 0.4	0.40	SM3500-(fluorometric)
SDAL	13S06781	Cote1	Reference Wetland	6/26/2013	< 0.4	0.40	SM3500-(fluorometric)
SDAL	13S07365	Cote1	Reference Wetland	7/10/2013	< 0.4	0.40	SM3500-(fluorometric)
SDAL	13S08218	Cote1	Reference Wetland	7/23/2013	0.55	0.40	SM3500-(fluorometric)
SDAL	13S09676	Cote1	Reference Wetland	8/13/2013	0.50	0.40	SM3500-(fluorometric)
SDAL	14S04166	Cote1	Reference Wetland	5/6/2014	ND	0.40	SM3500-(fluorometric)
SDAL	14S04780	Cote1	Reference Wetland	5/20/2014	< 0.4	0.40	SM3500-(fluorometric)
SDAL	14S05675	Cote1	Reference Wetland	6/10/2014	< 0.4	0.40	SM3500-(fluorometric)
SDAL	14S06155	Cote1	Reference Wetland	6/24/2014	< 0.4	0.40	SM3500-(fluorometric)
SDAL	14S07230	Cote1	Reference Wetland	7/8/2014	< 0.4	0.40	SM3500-(fluorometric)
SDAL	14S08018	Cote1	Reference Wetland	7/29/2014	< 0.4	0.40	SM3500-(fluorometric)
SDAL	14S08775	Cote1	Reference Wetland	8/11/2014	< 0.4	0.40	SM3500-(fluorometric)
SDAL	14S09777	Cote1	Reference Wetland	8/26/2014	< 0.4	0.40	SM3500-(fluorometric)
SDAL	14S07239	Dryl3	Tile Outfall	7/8/2014	74.00	0.40	SM3500-(fluorometric)
SDAL	14S09775	Dryl3	Tile Outfall	8/25/2014	72.40	0.40	SM3500-(fluorometric)
SDAL	13S04779	Gerk1	Tile Outfall	5/8/2013	26.70	0.40	SM3500-(fluorometric)
SDAL	13S06150	Gerk1	Tile Outfall	6/10/2013	31.50	0.40	SM3500-(fluorometric)
SDAL	13S06791	Gerk1	Tile Outfall	6/21/2013	28.70	0.40	SM3500-(fluorometric)
SDAL	13S04780	Gerk1A	Tile Wetland	5/8/2013	1.68	0.40	SM3500-(fluorometric)

Table A.16. Continued.

Laboratory	Lab ID	Site	Site Category	Date Collected	Selenium (ug/L)	LOQ	Method
SDAL	13S05158	Gerk1A	Tile Wetland	5/20/2013	2.51	0.40	SM3500-(fluorometric)
SDAL	13S06151	Gerk1A	Tile Wetland	6/10/2013	20.70	0.40	SM3500-(fluorometric)
SDAL	13S06792	Gerk1A	Tile Wetland	6/26/2013	18.00	0.40	SM3500-(fluorometric)
SDAL	13S09528	Gerk1A	Tile Wetland	7/10/2013	4.42	0.40	SM3500-(fluorometric)
SDAL	13S08219	Gerk1A	Tile Wetland	7/24/2013	2.13	0.40	SM3500-(fluorometric)
SDAL	13S09670	Gerk1A	Tile Wetland	8/12/2013	1.27	0.40	SM3500-(fluorometric)
SDAL	14S04179	Gerk1A	Tile Wetland	5/7/2014	0.64	0.40	SM3500-(fluorometric)
SDAL	14S04776	Gerk1A	Tile Wetland	5/19/2014	0.52	0.40	SM3500-(fluorometric)
SDAL	14S05688	Gerk1A	Tile Wetland	6/10/2014	6.22	0.40	SM3500-(fluorometric)
SDAL	14S06149	Gerk1A	Tile Wetland	6/23/2014	6.87	0.40	SM3500-(fluorometric)
SDAL	14S07242	Gerk1A	Tile Wetland	7/9/2014	0.76	0.40	SM3500-(fluorometric)
SDAL	14S08023	Gerk1A	Tile Wetland	7/30/2014	0.71	0.40	SM3500-(fluorometric)
SDAL	14S08794	Gerk1A	Tile Wetland	8/12/2014	0.99	0.40	SM3500-(fluorometric)
SDAL	14S09768	Gerk1A	Tile Wetland	8/25/2014	0.80	0.40	SM3500-(fluorometric)
SDAL	14S07243	Habe1	Tile Outfall	7/9/2014	107.00	0.40	SM3500-(fluorometric)
SDAL	14S09770	Habe1	Tile Outfall	8/25/2014	109.00	0.40	SM3500-(fluorometric)
SDAL	13S04781	Hejo1	Tile Outfall	5/7/2013	11.40	0.40	SM3500-(fluorometric)
SDAL	13S05159	Hejo1	Tile Outfall	5/20/2013	12.80	0.40	SM3500-(fluorometric)
SDAL	13S06152	Hejo1	Tile Outfall	6/11/2013	12.40	0.40	SM3500-(fluorometric)
SDAL	13S06797	Hejo1	Tile Outfall	6/26/2013	1.25	0.40	SM3500-(fluorometric)
SDAL	13S07368	Hejo1	Tile Outfall	7/10/2013	10.90	0.40	SM3500-(fluorometric)
SDAL	13S08221	Hejo1	Tile Outfall	7/23/2013	8.34	0.40	SM3500-(fluorometric)
SDAL	14S05681	Hejo1	Tile Outfall	6/10/2014	0.89	0.40	SM3500-(fluorometric)
SDAL	14S06161	Hejo1	Tile Outfall	6/24/2014	8.83	0.40	SM3500-(fluorometric)
SDAL	14S07234	Hejo1	Tile Outfall	7/8/2014	10.30	0.40	SM3500-(fluorometric)
SDAL	13S05160	Hejo1A	Tile Wetland	5/20/2013	1.46	0.40	SM3500-(fluorometric)
SDAL	13S06153	Hejo1A	Tile Wetland	6/11/2013	2.34	0.40	SM3500-(fluorometric)
SDAL	13S06798	Hejo1A	Tile Wetland	6/26/2013	6.49	0.40	SM3500-(fluorometric)
SDAL	13S07367	Hejo1A	Tile Wetland	7/10/2013	1.35	0.40	SM3500-(fluorometric)
SDAL	13S08220	Hejo1A	Tile Wetland	7/23/2013	0.81	0.40	SM3500-(fluorometric)
SDAL	13S09671	Hejo1A	Tile Wetland	8/13/2013	0.71	0.40	SM3500-(fluorometric)
SDAL	14S04173	Hejo1A	Tile Wetland	5/6/2014	0.50	0.40	SM3500-(fluorometric)
SDAL	14S04785	Hejo1A	Tile Wetland	5/20/2014	0.47	0.40	SM3500-(fluorometric)
SDAL	14S05682	Hejo1A	Tile Wetland	6/10/2014	11.20	0.40	SM3500-(fluorometric)
SDAL	14S06162	Hejo1A	Tile Wetland	6/24/2014	1.00	0.40	SM3500-(fluorometric)
SDAL	14S07235	Hejo1A	Tile Wetland	7/8/2014	0.89	0.40	SM3500-(fluorometric)
SDAL	14S08012	Hejo1A	Tile Wetland	7/29/2014	0.56	0.40	SM3500-(fluorometric)
SDAL	14S08781	Hejo1A	Tile Wetland	8/11/2014	0.61	0.40	SM3500-(fluorometric)
SDAL	14S09783	Hejo1A	Tile Wetland	8/26/2014	0.52	0.40	SM3500-(fluorometric)
SDAL	13S07369	Hejo2	Tile Outfall	7/10/2013	15.20	0.40	SM3500-(fluorometric)
SDAL	14S06163	Hejo2	Tile Outfall	6/24/2014	12.20	0.40	SM3500-(fluorometric)
SDAL	14S07236	Hejo2	Tile Outfall	7/8/2014	11.30	0.40	SM3500-(fluorometric)
SDAL	13S04782	John1	Surface wetland	5/7/2013	1.57	0.40	SM3500-(fluorometric)
SDAL	13S05161	John1	Surface wetland	5/20/2013	1.09	0.40	SM3500-(fluorometric)

Table A.16. Continued.

Laboratory	Lab ID	Site	Site Category	Date Collected	Selenium (ug/L)	LOQ	Method
SDAL	13S06155	John1	Surface wetland	6/11/2013	0.79	0.40	SM3500-(fluorometric)
SDAL	13S06779	John1	Surface wetland	6/26/2013	0.67	0.40	SM3500-(fluorometric)
SDAL	13S07371	John1	Surface wetland	7/10/2013	0.49	0.40	SM3500-(fluorometric)
SDAL	13S08222	John1	Surface wetland	7/23/2013	0.61	0.40	SM3500-(fluorometric)
SDAL	13S09672	John1	Surface wetland	8/13/2013	0.41	0.40	SM3500-(fluorometric)
SDAL	14S04172	John1	Surface wetland	5/6/2014	< 0.4	0.40	SM3500-(fluorometric)
SDAL	14S04784	John1	Surface wetland	5/20/2014	< 0.4	0.40	SM3500-(fluorometric)
SDAL	14S05680	John1	Surface wetland	6/10/2014	< 0.4	0.40	SM3500-(fluorometric)
SDAL	14S06160	John1	Surface wetland	6/24/2014	0.47	0.40	SM3500-(fluorometric)
SDAL	14S07233	John1	Surface wetland	7/8/2014	0.44	0.40	SM3500-(fluorometric)
SDAL	14S08013	John1	Surface wetland	7/29/2014	ND	0.40	SM3500-(fluorometric)
SDAL	14S08780	John1	Surface wetland	8/11/2014	< 0.4	0.40	SM3500-(fluorometric)
SDAL	14S09782	John1	Surface wetland	8/26/2014	< 0.4	0.40	SM3500-(fluorometric)
SDAL	14S07222	Long1	Tile Outfall	7/7/2014	8.49	0.40	SM3500-(fluorometric)
SDAL	14S07223	Long2	Tile Outfall	7/7/2014	14.50	0.40	SM3500-(fluorometric)
SDAL	13S05170	Lost1	Reference Wetland	5/21/2013	< 0.4	0.40	SM3500-(fluorometric)
SDAL	13S06154	Lost1	Reference Wetland	6/12/2013	1.00	0.40	SM3500-(fluorometric)
SDAL	13S06785	Lost1	Reference Wetland	6/27/2013	0.77	0.40	SM3500-(fluorometric)
SDAL	13S07370	Lost1	Reference Wetland	7/10/2013	0.45	0.40	SM3500-(fluorometric)
SDAL	13S08223	Lost1	Reference Wetland	7/22/2013	0.43	0.40	SM3500-(fluorometric)
SDAL	13S09667	Lost1	Reference Wetland	8/12/2013	< 0.4	0.40	SM3500-(fluorometric)
SDAL	14S04183	Lost1	Reference Wetland	5/7/2014	< 0.4	0.40	SM3500-(fluorometric)
SDAL	14S04771	Lost1	Reference Wetland	5/19/2014	< 0.4	0.40	SM3500-(fluorometric)
SDAL	14S05694	Lost1	Reference Wetland	6/10/2014	< 0.4	0.40	SM3500-(fluorometric)
SDAL	14S06142	Lost1	Reference Wetland	6/23/2014	0.42	0.40	SM3500-(fluorometric)
SDAL	14S07247	Lost1	Reference Wetland	7/9/2014	< 0.4	0.40	SM3500-(fluorometric)
SDAL	14S08007	Lost1	Reference Wetland	7/28/2014	< 0.4	0.40	SM3500-(fluorometric)
SDAL	14S08788	Lost1	Reference Wetland	8/12/2014	< 0.4	0.40	SM3500-(fluorometric)
SDAL	14S09763	Lost1	Reference Wetland	8/25/2014	ND	0.40	SM3500-(fluorometric)
SDAL	13S05162	Mund1	Tile Wetland	5/20/2013	0.59	0.40	SM3500-(fluorometric)
SDAL	13S06156	Mund1	Tile Wetland	6/11/2013	0.89	0.40	SM3500-(fluorometric)
SDAL	13S06784	Mund1	Tile Wetland	6/26/2013	0.73	0.40	SM3500-(fluorometric)
SDAL	13S07373	Mund1	Tile Wetland	7/10/2013	0.53	0.40	SM3500-(fluorometric)
SDAL	13S08225	Mund1	Tile Wetland	7/23/2013	0.55	0.40	SM3500-(fluorometric)
SDAL	13S09673	Mund1	Tile Wetland	8/13/2013	0.59	0.40	SM3500-(fluorometric)
SDAL	14S04170	Mund1	Tile Wetland	5/6/2014	0.54	0.40	SM3500-(fluorometric)
SDAL	14S04783	Mund1	Tile Wetland	5/20/2014	< 0.4	0.40	SM3500-(fluorometric)
SDAL	14S05679	Mund1	Tile Wetland	6/10/2014	< 0.4	0.40	SM3500-(fluorometric)
SDAL	14S06159	Mund1	Tile Wetland	6/24/2014	< 0.4	0.40	SM3500-(fluorometric)
SDAL	14S07232	Mund1	Tile Wetland	7/8/2014	0.41	0.40	SM3500-(fluorometric)
SDAL	14S08015	Mund1	Tile Wetland	7/29/2014	3.21	0.40	SM3500-(fluorometric)
SDAL	14S08779	Mund1	Tile Wetland	8/11/2014	< 0.4	0.40	SM3500-(fluorometric)
SDAL	14S09781	Mund1	Tile Wetland	8/26/2014	0.53	0.40	SM3500-(fluorometric)
SDAL	13S07372	Mund1T	Tile Outfall	7/10/2013	2.28	0.40	SM3500-(fluorometric)
SDAL	13S08224	Mund1T	Tile Outfall	7/23/2013	6.99	0.40	SM3500-(fluorometric)
SDAL	14S04171	Mund1T	Tile Outfall	5/6/2014	8.54	0.40	SM3500-(fluorometric)

Table A.16. Continued.

Laboratory	Lab ID	Site	Site Category	Date Collected	Selenium (ug/L)	LOQ	Method
SDAL	14S05678	Mund1T	Tile Outfall	6/10/2014	4.68	0.40	SM3500-(fluorometric)
SDAL	14S06158	Mund1T	Tile Outfall	6/24/2014	2.37	0.40	SM3500-(fluorometric)
SDAL	14S07231	Mund1T	Tile Outfall	7/8/2014	2.40	0.40	SM3500-(fluorometric)
SDAL	14S08014	Mund1T	Tile Outfall	7/29/2014	< 0.4	0.40	SM3500-(fluorometric)
SDAL	14S08778	Mund1T	Tile Outfall	8/11/2014	3.60	0.40	SM3500-(fluorometric)
SDAL	14S09780	Mund1T	Tile Outfall	8/26/2014	4.72	0.40	SM3500-(fluorometric)
SDAL	13S05163	Nels1	Tile Outfall	5/20/2013	0.96	0.40	SM3500-(fluorometric)
SDAL	13S06157	Nels1	Tile Outfall	6/11/2013	0.89	0.40	SM3500-(fluorometric)
SDAL	13S06795	Nels1	Tile Outfall	6/26/2013	1.08	0.40	SM3500-(fluorometric)
SDAL	13S07375	Nels1	Tile Outfall	7/10/2013	1.06	0.40	SM3500-(fluorometric)
SDAL	13S08227	Nels1	Tile Outfall	7/23/2013	4.25	0.40	SM3500-(fluorometric)
SDAL	14S04168	Nels1	Tile Outfall	5/6/2014	0.64	0.40	SM3500-(fluorometric)
SDAL	14S04782	Nels1	Tile Outfall	5/20/2014	0.80	0.40	SM3500-(fluorometric)
SDAL	14S05677	Nels1	Tile Outfall	6/10/2014	0.77	0.40	SM3500-(fluorometric)
SDAL	14S06157	Nels1	Tile Outfall	6/24/2014	0.77	0.40	SM3500-(fluorometric)
SDAL	14S07228	Nels1	Tile Outfall	7/8/2014	0.90	0.40	SM3500-(fluorometric)
SDAL	14S08777	Nels1	Tile Outfall	8/11/2014	0.97	0.40	SM3500-(fluorometric)
SDAL	14S09779	Nels1	Tile Outfall	8/26/2014	0.66	0.40	SM3500-(fluorometric)
SDAL	13S04783	Nels1A	Tile Wetland	5/7/2013	0.82	0.40	SM3500-(fluorometric)
SDAL	13S05164	Nels1A	Tile Wetland	5/20/2013	1.10	0.40	SM3500-(fluorometric)
SDAL	13S06158	Nels1A	Tile Wetland	6/11/2013	1.11	0.40	SM3500-(fluorometric)
SDAL	13S06796	Nels1A	Tile Wetland	6/26/2013	1.51	0.40	SM3500-(fluorometric)
SDAL	13S07374	Nels1A	Tile Wetland	7/10/2013	1.53	0.40	SM3500-(fluorometric)
SDAL	13S08226	Nels1A	Tile Wetland	7/23/2013	1.56	0.40	SM3500-(fluorometric)
SDAL	13S09674	Nels1A	Tile Wetland	8/13/2013	1.28	0.40	SM3500-(fluorometric)
SDAL	14S04169	Nels1A	Tile Wetland	5/6/2014	0.73	0.40	SM3500-(fluorometric)
SDAL	14S04781	Nels1A	Tile Wetland	5/20/2014	0.94	0.40	SM3500-(fluorometric)
SDAL	14S05676	Nels1A	Tile Wetland	6/10/2014	0.96	0.40	SM3500-(fluorometric)
SDAL	14S06156	Nels1A	Tile Wetland	6/24/2014	0.85	0.40	SM3500-(fluorometric)
SDAL	14S07227	Nels1A	Tile Wetland	7/8/2014	1.05	0.40	SM3500-(fluorometric)
SDAL	14S08016	Nels1A	Tile Wetland	7/29/2014	< 0.4	0.40	SM3500-(fluorometric)
SDAL	14S08776	Nels1A	Tile Wetland	8/11/2014	0.89	0.40	SM3500-(fluorometric)
SDAL	14S09778	Nels1A	Tile Wetland	8/26/2014	0.65	0.40	SM3500-(fluorometric)
SDAL	14S07224	Pets1	Tile Outfall	7/7/2014	30.30	0.40	SM3500-(fluorometric)
SDAL	13S05171	Pett1	Reference Wetland	5/20/2013	0.51	0.40	SM3500-(fluorometric)
SDAL	13S06159	Pett1	Reference Wetland	6/10/2013	< 0.4	0.40	SM3500-(fluorometric)
SDAL	13S06799	Pett1	Reference Wetland	6/26/2013	0.58	0.40	SM3500-(fluorometric)
SDAL	13S07377	Pett1	Reference Wetland	7/10/2013	< 0.4	0.40	SM3500-(fluorometric)
SDAL	13S08231	Pett1	Reference Wetland	7/24/2013	< 0.4	0.40	SM3500-(fluorometric)
SDAL	13S09668	Pett1	Reference Wetland	8/12/2013	< 0.4	0.40	SM3500-(fluorometric)
SDAL	14S04180	Pett1	Reference Wetland	5/7/2014	< 0.4	0.40	SM3500-(fluorometric)
SDAL	14S04774	Pett1	Reference Wetland	5/19/2014	< 0.4	0.40	SM3500-(fluorometric)
SDAL	14S05689	Pett1	Reference Wetland	6/10/2014	< 0.4	0.40	SM3500-(fluorometric)
SDAL	14S06147	Pett1	Reference Wetland	6/23/2014	< 0.4	0.40	SM3500-(fluorometric)
SDAL	14S07244	Pett1	Reference Wetland	7/9/2014	< 0.4	0.40	SM3500-(fluorometric)

Table A.16. Continued.

Laboratory	Lab ID	Site	Site Category	Date Collected	Selenium (ug/L)	LOQ	Method
SDAL	14S08011	Pett1	Reference Wetland	7/28/2014	< 0.4	0.40	SM3500-(fluorometric)
SDAL	14S08792	Pett1	Reference Wetland	8/12/2014	ND	0.40	SM3500-(fluorometric)
SDAL	14S09767	Pett1	Reference Wetland	8/25/2014	ND	0.40	SM3500-(fluorometric)
SDAL	13S04784	Pitt1	Reference Wetland	5/7/2013	0.43	0.40	SM3500-(fluorometric)
SDAL	13S05165	Pitt1	Reference Wetland	5/20/2013	< 0.4	0.40	SM3500-(fluorometric)
SDAL	13S06160	Pitt1	Reference Wetland	6/10/2013	< 0.4	0.40	SM3500-(fluorometric)
SDAL	13S06782	Pitt1	Reference Wetland	6/26/2013	< 0.4	0.40	SM3500-(fluorometric)
SDAL	13S07378	Pitt1	Reference Wetland	7/10/2013	< 0.4	0.40	SM3500-(fluorometric)
SDAL	13S08230	Pitt1	Reference Wetland	7/23/2013	< 0.4	0.40	SM3500-(fluorometric)
SDAL	13S09680	Pitt1	Reference Wetland	8/14/2013	< 0.4	0.40	SM3500-(fluorometric)
SDAL	14S04174	Pitt1	Reference Wetland	5/6/2014	ND	0.40	SM3500-(fluorometric)
SDAL	14S04786	Pitt1	Reference Wetland	5/20/2014	< 0.4	0.40	SM3500-(fluorometric)
SDAL	14S05683	Pitt1	Reference Wetland	6/10/2014	< 0.4	0.40	SM3500-(fluorometric)
SDAL	14S06153	Pitt1	Reference Wetland	6/23/2014	< 0.4	0.40	SM3500-(fluorometric)
SDAL	14S07238	Pitt1	Reference Wetland	7/8/2014	< 0.4	0.40	SM3500-(fluorometric)
SDAL	14S08019	Pitt1	Reference Wetland	7/30/2014	< 0.4	0.40	SM3500-(fluorometric)
SDAL	14S08782	Pitt1	Reference Wetland	8/11/2014	< 0.4	0.40	SM3500-(fluorometric)
SDAL	14S09774	Pitt1	Reference Wetland	8/25/2014	ND	0.40	SM3500-(fluorometric)
SDAL	13S04785	Rams1	Surface wetland	5/8/2013	< 0.4	0.40	SM3500-(fluorometric)
SDAL	13S05166	Rams1	Surface wetland	5/20/2013	< 0.4	0.40	SM3500-(fluorometric)
SDAL	13S06161	Rams1	Surface wetland	6/10/2013	< 0.4	0.40	SM3500-(fluorometric)
SDAL	13S06783	Rams1	Surface wetland	6/26/2013	< 0.4	0.40	SM3500-(fluorometric)
SDAL	13S07379	Rams1	Surface wetland	7/10/2013	< 0.4	0.40	SM3500-(fluorometric)
SDAL	13S08229	Rams1	Surface wetland	7/24/2013	0.54	0.40	SM3500-(fluorometric)
SDAL	13S09669	Rams1	Surface wetland	8/12/2013	< 0.4	0.40	SM3500-(fluorometric)
SDAL	14S04178	Rams1	Surface wetland	5/7/2014	ND	0.40	SM3500-(fluorometric)
SDAL	14S04775	Rams1	Surface wetland	5/19/2014	< 0.4	0.40	SM3500-(fluorometric)
SDAL	14S05687	Rams1	Surface wetland	6/10/2014	< 0.4	0.40	SM3500-(fluorometric)
SDAL	14S06148	Rams1	Surface wetland	6/23/2014	< 0.4	0.40	SM3500-(fluorometric)
SDAL	14S07241	Rams1	Surface wetland	7/9/2014	< 0.4	0.40	SM3500-(fluorometric)
SDAL	14S08024	Rams1	Surface wetland	7/30/2014	< 0.4	0.40	SM3500-(fluorometric)
SDAL	14S08793	Rams1	Surface wetland	8/12/2014	< 0.4	0.40	SM3500-(fluorometric)
SDAL	14S09769	Rams1	Surface wetland	8/25/2014	ND	0.40	SM3500-(fluorometric)
SDAL	13S09681	Reev1	Tile Outfall	8/14/2013	15.00	0.40	SM3500-(fluorometric)
SDAL	14S07226	Reev1	Tile Outfall	7/7/2014	13.90	0.40	SM3500-(fluorometric)
SDAL	13S06163	Schae1	Surface wetland	6/12/2013	0.51	0.40	SM3500-(fluorometric)
SDAL	13S06790	Schae1	Surface wetland	6/27/2013	0.58	0.40	SM3500-(fluorometric)
SDAL	13S07381	Schae1	Surface wetland	7/10/2013	0.51	0.40	SM3500-(fluorometric)
SDAL	13S08232	Schae1	Surface wetland	7/22/2013	0.72	0.40	SM3500-(fluorometric)
SDAL	13S09663	Schae1	Surface wetland	8/12/2013	0.48	0.40	SM3500-(fluorometric)
SDAL	14S04181	Schae1	Surface wetland	5/7/2014	< 0.4	0.40	SM3500-(fluorometric)
SDAL	14S04772	Schae1	Surface wetland	5/19/2014	< 0.4	0.40	SM3500-(fluorometric)
SDAL	14S05690	Schae1	Surface wetland	6/10/2014	< 0.4	0.40	SM3500-(fluorometric)
SDAL	14S06144	Schae1	Surface wetland	6/23/2014	< 0.4	0.40	SM3500-(fluorometric)
SDAL	14S07249	Schae1	Surface wetland	7/9/2014	< 0.4	0.40	SM3500-(fluorometric)

Table A.16. Continued.

Laboratory	Lab ID	Site	Site Category	Date Collected	Selenium (ug/L)	LOQ	Method
SDAL	14S08009	Schae1	Surface wetland	7/28/2014	< 0.4	0.40	SM3500-(fluorometric)
SDAL	14S08790	Schae1	Surface wetland	8/12/2014	< 0.4	0.40	SM3500-(fluorometric)
SDAL	14S09765	Schae1	Surface wetland	8/25/2014	< 0.4	0.40	SM3500-(fluorometric)
SDAL	13S04786	Schaf1	Reference Wetland	5/7/2013	< 0.4	0.40	SM3500-(fluorometric)
SDAL	13S05174	Schaf1	Reference Wetland	5/20/2013	< 0.4	0.40	SM3500-(fluorometric)
SDAL	13S06162	Schaf1	Reference Wetland	6/11/2013	< 0.4	0.40	SM3500-(fluorometric)
SDAL	13S06789	Schaf1	Reference Wetland	6/26/2013	< 0.4	0.40	SM3500-(fluorometric)
SDAL	13S07380	Schaf1	Reference Wetland	7/10/2013	< 0.4	0.40	SM3500-(fluorometric)
SDAL	13S08233	Schaf1	Reference Wetland	7/23/2013	< 0.4	0.40	SM3500-(fluorometric)
SDAL	13S09675	Schaf1	Reference Wetland	8/13/2013	0.49	0.40	SM3500-(fluorometric)
SDAL	14S04167	Schaf1	Reference Wetland	5/6/2014	ND	0.40	SM3500-(fluorometric)
SDAL	14S04779	Schaf1	Reference Wetland	5/20/2014	< 0.4	0.40	SM3500-(fluorometric)
SDAL	14S05674	Schaf1	Reference Wetland	6/10/2014	ND	0.40	SM3500-(fluorometric)
SDAL	14S06154	Schaf1	Reference Wetland	6/24/2014	< 0.4	0.40	SM3500-(fluorometric)
SDAL	14S07229	Schaf1	Reference Wetland	7/8/2014	< 0.4	0.40	SM3500-(fluorometric)
SDAL	14S08017	Schaf1	Reference Wetland	7/29/2014	1.29	0.40	SM3500-(fluorometric)
SDAL	14S08774	Schaf1	Reference Wetland	8/11/2014	< 0.4	0.40	SM3500-(fluorometric)
SDAL	14S09776	Schaf1	Reference Wetland	8/26/2014	< 0.4	0.40	SM3500-(fluorometric)
SDAL	14S07225	Thor1	Tile Outfall	7/7/2014	5.05	0.40	SM3500-(fluorometric)
SDAL	13S05175	Volk1	Tile Wetland	5/21/2013	4.10	0.40	SM3500-(fluorometric)
SDAL	13S06164	Volk1	Tile Wetland	6/12/2013	9.25	0.40	SM3500-(fluorometric)
SDAL	13S06786	Volk1	Tile Wetland	6/27/2013	5.83	0.40	SM3500-(fluorometric)
SDAL	13S07382	Volk1	Tile Wetland	7/10/2013	5.36	0.40	SM3500-(fluorometric)
SDAL	13S08234	Volk1	Tile Wetland	7/22/2013	4.30	0.40	SM3500-(fluorometric)
SDAL	13S09665	Volk1	Tile Wetland	8/12/2013	3.81	0.40	SM3500-(fluorometric)
SDAL	14S04184	Volk1	Tile Wetland	5/7/2014	2.95	0.40	SM3500-(fluorometric)
SDAL	14S04769	Volk1	Tile Wetland	5/19/2014	4.71	0.40	SM3500-(fluorometric)
SDAL	14S05692	Volk1	Tile Wetland	6/10/2014	7.87	0.40	SM3500-(fluorometric)
SDAL	14S06140	Volk1	Tile Wetland	6/23/2014	11.90	0.40	SM3500-(fluorometric)
SDAL	14S07245	Volk1	Tile Wetland	7/9/2014	6.66	0.40	SM3500-(fluorometric)
SDAL	14S08005	Volk1	Tile Wetland	7/28/2014	4.22	0.40	SM3500-(fluorometric)
SDAL	14S08786	Volk1	Tile Wetland	8/12/2014	4.56	0.40	SM3500-(fluorometric)
SDAL	14S09761	Volk1	Tile Wetland	8/25/2014	6.02	0.40	SM3500-(fluorometric)
SDAL	13S09683	Wenk1A	Tile Wetland	8/15/2013	2.33	0.40	SM3500-(fluorometric)
SDAL	13S05176	Zieg1	Surface wetland	5/21/2013	1.24	0.40	SM3500-(fluorometric)
SDAL	13S06165	Zieg1	Surface wetland	6/10/2013	0.56	0.40	SM3500-(fluorometric)
SDAL	13S06780	Zieg1	Surface wetland	6/26/2013	1.11	0.40	SM3500-(fluorometric)
SDAL	13S07383	Zieg1	Surface wetland	7/10/2013	0.65	0.40	SM3500-(fluorometric)
SDAL	13S08235	Zieg1	Surface wetland	7/23/2013	1.02	0.40	SM3500-(fluorometric)
SDAL	13S09679	Zieg1	Surface wetland	8/14/2013	0.59	0.40	SM3500-(fluorometric)
SDAL	14S04175	Zieg1	Surface wetland	5/6/2014	0.42	0.40	SM3500-(fluorometric)
SDAL	14S04778	Zieg1	Surface wetland	5/19/2014	0.53	0.40	SM3500-(fluorometric)
SDAL	14S05686	Zieg1	Surface wetland	6/10/2014	1.06	0.40	SM3500-(fluorometric)
SDAL	14S06152	Zieg1	Surface wetland	6/23/2014	0.75	0.40	SM3500-(fluorometric)
SDAL	14S07252	Zieg1	Surface wetland	7/9/2014	0.86	0.40	SM3500-(fluorometric)

Table A.16. Continued.

Laboratory	Lab ID	Site	Site Category	Date Collected	Selenium (ug/L)	LOQ	Method
SDAL	14S08020	Zieg1	Surface wetland	7/30/2014	0.46	0.40	SM3500-(fluorometric)
SDAL	14S08783	Zieg1	Surface wetland	8/11/2014	0.40	0.40	SM3500-(fluorometric)
SDAL	14S09773	Zieg1	Surface wetland	8/25/2014	< 0.4	0.40	SM3500-(fluorometric)
ESI	sample mea	Cote1	Reference Wetland	7/25/2012	< 1	1.00	ICP-MS
ESI	sample mea	Seve	Reference Wetland	7/25/2012	< 1	1.00	ICP-MS
ESI	sample mea	Bols1A	Tile Wetland	7/26/2012	< 1	1.00	ICP-MS
ESI	sample mea	Gerk1A	Tile Wetland	7/26/2012	< 1	1.00	ICP-MS
ESI	sample mea	Hejo1A	Tile Wetland	7/25/2012	< 1	1.00	ICP-MS
ESI	sample mea	Nels1A	Tile Wetland	7/25/2012	< 1	1.00	ICP-MS
EPA R8	1205023-09	BUFO1	Reference Wetland	5/2/2012	< 1	1.00	ICP-MS
EPA R8	1209013-04	Pitt1	Reference Wetland	9/5/2012	< 1	1.00	ICP-MS
EPA R8	1209013-01	Schaf1	Reference Wetland	9/5/2012	< 1	1.00	ICP-MS
EPA R8	1504029-06	John1	Surface Wetland	4/17/2015	< 1	1.00	ICP-MS
EPA R8	1504029-08	Zeig1	Surface Wetland	4/17/2015	< 1	1.00	ICP-MS
EPA R8	1509015-02	Bols1	Tile Outfall	9/1/2015	< 1	1.00	ICP-MS
EPA R8	1505023-05	Nels1	Tile Outfall	5/12/2015	< 1	1.00	ICP-MS
EPA R8	1509015-03	Nels1	Tile Outfall	9/1/2015	< 1	1.00	ICP-MS
EPA R8	1504029-10	Bols1A	Tile Wetland	4/17/2015	< 1	1.00	ICP-MS
EPA R8	1504029-07	Hejo1A	Tile Wetland	4/17/2015	< 1	1.00	ICP-MS
EPA R8	1207019-09	Lost1	Reference Wetland	7/11/2012	1.50	1.00	ICP-MS
EPA R8	1209013-10	Lost1	Reference Wetland	9/5/2012	1.50	1.00	ICP-MS
EPA R8	1209013-08	2Petr1A	Surface Wetland	9/5/2012	2.40	1.00	ICP-MS
EPA R8	1209013-09	2PetrA2	Surface Wetland	9/5/2012	2.40	1.00	ICP-MS
EPA R8	1209013-03	John1	Surface Wetland	9/5/2012	1.20	1.00	ICP-MS
EPA R8	1209013-06	Rams1	Surface Wetland	9/5/2012	1.30	1.00	ICP-MS
EPA R8	1504029-11	Rams1	Surface Wetland	4/17/2015	1.10	1.00	ICP-MS
EPA R8	1206023-08	Ache1	Tile Outfall	6/6/2012	4.90	1.00	ICP-MS
EPA R8	1509015-07	Adam1	Tile Outfall	9/1/2015	4.10	1.00	ICP-MS
EPA R8	1507016-08	Adam1	Tile Outfall	7/7/2015	3.20	1.00	ICP-MS
EPA R8	1505023-09	Adam1	Tile Outfall	5/12/2015	2.50	1.00	ICP-MS
EPA R8	1505023-10	Adam2	Tile Outfall	5/12/2015	14.70	1.00	ICP-MS
EPA R8	1506020-05	Adam2	Tile Outfall	6/9/2015	11.20	1.00	ICP-MS
EPA R8	1507016-07	Adam2	Tile Outfall	7/7/2015	10.90	1.00	ICP-MS
EPA R8	1509036-07	Adam2	Tile Outfall	10/27/2015	9.00	1.00	ICP-MS
EPA R8	1508019-03	Adam2	Tile Outfall	8/4/2015	1.60	1.00	ICP-MS
EPA R8	1205023-04	BLSK1	Tile Outfall	5/2/2012	25.90	1.00	ICP-MS
EPA R8	1509036-10	Bols1	Tile Outfall	10/28/2015	6.30	1.00	ICP-MS
EPA R8	1504029-09	Bols1	Tile Outfall	4/17/2015	3.30	1.00	ICP-MS
EPA R8	1507016-09	Bols1	Tile Outfall	7/7/2015	2.10	1.00	ICP-MS
EPA R8	1205023-01	Dryl1	Tile Outfall	5/2/2012	18.90	1.00	ICP-MS
EPA R8	1506020-06	Gerk1	Tile Outfall	6/9/2015	56.50	1.00	ICP-MS
EPA R8	1507016-10	Gerk1	Tile Outfall	7/8/2015	55.50	1.00	ICP-MS
EPA R8	1206023-04	Gerk1	Tile Outfall	6/6/2012	22.80	1.00	ICP-MS
EPA R8	1507016-11	Habe1	Tile Outfall	7/8/2015	144.00	1.00	ICP-MS
EPA R8	1506020-07	Habe1	Tile Outfall	6/9/2015	108.00	1.00	ICP-MS

Table A.16. Continued.

Laboratory	Lab ID	Site	Site Category	Date Collected	Selenium (ug/L)	LOQ	Method
EPA R8	1509015-01	Habe1	Tile Outfall	9/1/2015	99.90	1.00	ICP-MS
EPA R8	1206023-02	Hejo1	Tile Outfall	6/6/2012	14.90	1.00	ICP-MS
EPA R8	1505023-08	Hejo1	Tile Outfall	5/12/2015	14.20	1.00	ICP-MS
EPA R8	1507016-05	Hejo1	Tile Outfall	7/7/2015	12.80	1.00	ICP-MS
EPA R8	1506020-04	Hejo1	Tile Outfall	6/9/2015	12.30	1.00	ICP-MS
EPA R8	1508019-05	Hejo1	Tile Outfall	8/4/2015	11.60	1.00	ICP-MS
EPA R8	1509036-06	Hejo1	Tile Outfall	10/27/2015	10.30	1.00	ICP-MS
EPA R8	1509015-06	Hejo1	Tile Outfall	9/1/2015	9.60	1.00	ICP-MS
EPA R8	1509036-05	Hejo2	Tile Outfall	10/27/2015	14.60	1.00	ICP-MS
EPA R8	1505023-07	Hejo2	Tile Outfall	5/12/2015	13.60	1.00	ICP-MS
EPA R8	1507016-06	Hejo2	Tile Outfall	7/7/2015	13.60	1.00	ICP-MS
EPA R8	1506020-03	Hejo2	Tile Outfall	6/9/2015	12.90	1.00	ICP-MS
EPA R8	1509015-05	Hejo2	Tile Outfall	9/1/2015	8.50	1.00	ICP-MS
EPA R8	1207019-06	Long1	Tile Outfall	7/11/2012	7.20	1.00	ICP-MS
EPA R8	1204020-01	Long1	Tile Outfall	4/10/2012	7.10	1.00	ICP-MS
EPA R8	1205023-07	Long1	Tile Outfall	5/2/2012	6.70	1.00	ICP-MS
EPA R8	1206023-06	Long1	Tile Outfall	6/6/2012	6.40	1.00	ICP-MS
EPA R8	1206023-07	Long2	Tile Outfall	6/6/2012	10.90	1.00	ICP-MS
EPA R8	1205023-08	Long2	Tile Outfall	5/2/2012	10.00	1.00	ICP-MS
EPA R8	1204020-02	Long2	Tile Outfall	4/10/2012	6.80	1.00	ICP-MS
EPA R8	1507016-04	Mund1T	Tile Outfall	7/7/2015	7.40	1.00	ICP-MS
EPA R8	1506020-02	Mund1T	Tile Outfall	6/9/2015	7.10	1.00	ICP-MS
EPA R8	1505023-06	Mund1T	Tile Outfall	5/12/2015	7.00	1.00	ICP-MS
EPA R8	1509015-04	Mund1T	Tile Outfall	9/1/2015	6.40	1.00	ICP-MS
EPA R8	1508019-02	Mund1T	Tile Outfall	8/4/2015	6.30	1.00	ICP-MS
EPA R8	1509036-09	Mund1T	Tile Outfall	10/27/2015	5.60	1.00	ICP-MS
EPA R8	1504029-05	Mund1T	Tile Outfall	4/17/2015	3.10	1.00	ICP-MS
EPA R8	1508019-01	Nels1	Tile Outfall	8/4/2015	5.20	1.00	ICP-MS
EPA R8	1205023-03	Nels1	Tile Outfall	5/2/2012	1.20	1.00	ICP-MS
EPA R8	1206023-01	Nels1	Tile Outfall	6/6/2012	1.10	1.00	ICP-MS
EPA R8	1506020-01	Nels1	Tile Outfall	6/9/2015	1.00	1.00	ICP-MS
EPA R8	1207019-05	Pets1	Tile Outfall	7/11/2012	11.80	1.00	ICP-MS
EPA R8	1207019-04	Reev1	Tile Outfall	7/11/2012	8.30	1.00	ICP-MS
EPA R8	1205023-02	Thor1	Tile Outfall	5/2/2012	1.20	1.00	ICP-MS
EPA R8	1206023-10	Wern1	Tile Outfall	6/6/2012	11.20	1.00	ICP-MS
EPA R8	1209013-07	Ache1A	Tile Wetland	9/5/2012	2.00	1.00	ICP-MS
EPA R8	1207019-03	BLKS1A	Tile Wetland	7/11/2012	3.60	1.00	ICP-MS
EPA R8	1209013-05	Gerk1A	Tile Wetland	9/5/2012	2.00	1.00	ICP-MS
EPA R8	1504029-12	Gerk1A	Tile Wetland	4/17/2015	1.10	1.00	ICP-MS
EPA R8	1207019-02	Hejo1A	Tile Wetland	7/11/2012	7.30	1.00	ICP-MS
EPA R8	1207019-07	Long2A	Tile Wetland	7/11/2012	6.20	1.00	ICP-MS
EPA R8	1207019-01	Nels1A	Tile Wetland	7/11/2012	8.40	1.00	ICP-MS
EPA R8	1209013-02	Nels1A	Tile Wetland	9/5/2012	1.10	1.00	ICP-MS
EPA R8	1207019-08	Volk1	Tile Wetland	7/11/2012	9.70	1.00	ICP-MS

Note: ug/L = micrograms per liter, < = less than the detection limit.

Table A.17. Pesticide compounds registered in South Dakota for row-crop agricultural use that were not tested for in tile effluent discharged into wetland sites within Madison Wetland Management District, South Dakota, 2011–2014.

Pesticide Compound	Type	Use Notes
Difenoconazole	Fungicide	sweet corn only
Fluazinam	Fungicide	soybeans (foliar)
Fluoxastrobin	Fungicide	corn and soybeans
Mancozeb	Fungicide	corn
Metconazole	Fungicide	corn and soybeans
Penflufen	Fungicide	corn and soybeans
Prothioconazole	Fungicide	corn and soybeans
Pyraclostrobin	Fungicide	corn and soybeans seed treatments
Thiram	Fungicide	corn
Trifloxystrobin	Fungicide	corn and soybeans (foliar)
Aminopyralid	Herbicide	corn (Milestone)
Clopyralid	Herbicide	corn
Dicamba	Herbicide	corn
Ethalfluralin	Herbicide	soybean soil treatment
Fenoxaprop	Herbicide	soybeans (foliar)
Fluroxypyr	Herbicide	corn and soybeans
Imazamox	Herbicide	soybeans (foliar)
Mesotrione	Herbicide	corn
Nicosulfuron	Herbicide	corn
Paraquat	Herbicide	corn and soybeans
Quizalofop	Herbicide	soybeans (foliar Treatment)
Bifenthrin	Insecticide	corn
Chlorantraniliprole	Insecticide	corn and soybeans
Chlorpyrifos	Insecticide	corn and soybeans
Cyfluthrin	Insecticide	corn (Aztec)
Cyhalothrin	Insecticide	soybeans
Deltamethrin	Insecticide	corn
Esfenvalerate	Insecticide	corn and soybeans
Flubendiamide	Insecticide	corn and soybeans
Indoxacarb	Insecticide	sweet corn only
Lambda-Cyhalothrin	Insecticide	corn
Phorate	Insecticide	corn and soybeans
Spinetoram	Insecticide	corn and soybeans
Spinosad	Insecticide	corn and soybeans
Spiromesifen	Insecticide	corn
Thodicarb	Insecticide	soybeans

Table A.18. Exceedances of water quality benchmarks for elemental contaminants and anions in water grab samples collected in 2012 and 2015 from tile outfalls and wetlands sites within Madison Wetland Management District, South Dakota.

Laboratory	Site Cat	Site	Date Sampled	Analyte	Concentration (µg/L)	Acute Benchmark (µg/L)	Total Acute Exceedances	Chronic Benchmark (µg/L)	Total Chronic Exceedances
EPA Region 8	Tile Wetland	BLKS1A	7/11/2012	Aluminum	3,030	750[1]	5	87[2]	23
EPA Region 8	Tile Wetland	Hejo1A	7/11/2012	Aluminum	2,300				
EPA Region 8	Tile Outfall	Mund1T	8/4/2015	Aluminum	1,570				
EPA Region 8	Surface Wetland	John1	9/5/2012	Aluminum	1,130				
EPA Region 8	Tile Outfall	Gerk1	7/8/2015	Aluminum	838				
EPA Region 8	Tile Wetland	Volk1	7/11/2012	Aluminum	555				
EPA Region 8	Tile Outfall	Mund1T	4/17/2015	Aluminum	509				
EPA Region 8	Reference Wetland	Lost1	7/11/2012	Aluminum	441				
EPA Region 8	Tile Wetland	Nels1A	9/5/2012	Aluminum	420				
EPA Region 8	Tile Outfall	Nels1	8/4/2015	Aluminum	369				
EPA Region 8	Surface Wetland	John1	4/17/2015	Aluminum	316				
EPA Region 8	Tile Outfall	Mund1T	10/27/2015	Aluminum	270				
EPA Region 8	Surface Wetland	2Petr1A	9/5/2012	Aluminum	236				
EPA Region 8	Surface Wetland	2PetrA2	9/5/2012	Aluminum	236				
EPA Region 8	Tile Outfall	Hejo1	6/9/2015	Aluminum	225				
EPA Region 8	Tile Wetland	Long2A	7/11/2012	Aluminum	224				
EPA Region 8	Tile Outfall	Mund1T	9/1/2015	Aluminum	205				
EPA Region 8	Tile Outfall	Reev1	7/11/2012	Aluminum	178				
EPA Region 8	Tile Wetland	Hejo1A	4/17/2015	Aluminum	169				
EPA Region 8	Tile Outfall	Gerk1	6/9/2015	Aluminum	149				
EPA Region 8	Reference Wetland	Lost1	9/5/2012	Aluminum	147				
EPA Region 8	Tile Outfall	Nels1	5/12/2015	Aluminum	143				
ESI	Reference Wetland	Cote	7/25/2012	Aluminum	111				
EPA Region 8	Tile Wetland	Volk1	7/11/2012	Barium	194	110[3]	6	NA	NA
EPA Region 8	Surface Wetland	John1	9/5/2012	Barium	144				
EPA Region 8	Reference Wetland	Lost1	7/11/2012	Barium	142				
EPA Region 8	Reference Wetland	Pitt1	9/5/2012	Barium	121				
EPA Region 8	Tile Outfall	Adam1	7/7/2015	Barium	119				
EPA Region 8	Surface Wetland	Rams1	9/5/2012	Barium	114				
EPA Region 8	Tile Outfall	Dryl1	5/2/2012	Calcium	396,000	NA	NA	116,000[4]	67
EPA Region 8	Tile Outfall	Gerk1	6/9/2015	Calcium	368,000				
EPA Region 8	Tile Wetland	Volk1	7/11/2012	Calcium	368,000				
EPA Region 8	Tile Outfall	Gerk1	7/8/2015	Calcium	362,000				
EPA Region 8	Tile Outfall	Habe1	7/8/2015	Calcium	358,000				
EPA Region 8	Tile Outfall	Habe1	6/9/2015	Calcium	348,000				
EPA Region 8	Tile Outfall	Habe1	9/1/2015	Calcium	341,000				
EPA Region 8	Surface Wetland	2PetrA2	9/5/2012	Calcium	316,000				
EPA Region 8	Tile Wetland	Gerk1A	9/5/2012	Calcium	314,000				
EPA Region 8	Surface Wetland	2Petr1A	9/5/2012	Calcium	312,000				
EPA Region 8	Tile Outfall	Bols1	10/28/2015	Calcium	311,000				
EPA Region 8	Tile Outfall	Bols1	7/7/2015	Calcium	305,000				
EPA Region 8	Tile Outfall	Gerk1	6/6/2012	Calcium	285,000				
EPA Region 8	Tile Outfall	Long2	5/2/2012	Calcium	273,000				
EPA Region 8	Tile Outfall	Long2	6/6/2012	Calcium	270,000				
EPA Region 8	Surface Wetland	Rams1	4/17/2015	Calcium	263,000				
ESI	Tile Wetland	Gerk1A	7/26/2012	Calcium	240,000				
EPA Region 8	Tile Outfall	BLSK1	5/2/2012	Calcium	237,000				
EPA Region 8	Tile Outfall	Long2	4/10/2012	Calcium	236,000				
EPA Region 8	Tile Wetland	Long2A	7/11/2012	Calcium	236,000				

Table A.18. Continued.

Laboratory	Site Cat	Site	Date Sampled	Analyte	Concentration (µg/L)	Acute Benchmark (µg/L)	Total Acute Exceedances	Chronic Benchmark (µg/L)	Total Chronic Exceedances
EPA Region 8	Tile Outfall	Wern1	6/6/2012	Calcium	229,000				
EPA Region 8	Tile Wetland	Gerk1A	4/17/2015	Calcium	228,000				
EPA Region 8	Surface Wetland	Rams1	9/5/2012	Calcium	212,000				
EPA Region 8	Tile Outfall	Pets1	7/11/2012	Calcium	207,000				
EPA Region 8	Tile Outfall	Reev1	7/11/2012	Calcium	206,000				
EPA Region 8	Tile Outfall	Thor1	5/2/2012	Calcium	183,000				
EPA Region 8	Tile Outfall	Bols1	4/17/2015	Calcium	179,000				
EPA Region 8	Tile Outfall	Adam2	5/12/2015	Calcium	178,000				
EPA Region 8	Tile Outfall	Long1	5/2/2012	Calcium	172,000				
EPA Region 8	Tile Outfall	Long1	4/10/2012	Calcium	171,000				
EPA Region 8	Tile Outfall	Hejo2	10/27/2015	Calcium	163,000				
EPA Region 8	Tile Outfall	Long1	7/11/2012	Calcium	163,000				
EPA Region 8	Reference Wetland	BUFO1	5/2/2012	Calcium	162,000				
EPA Region 8	Tile Outfall	Hejo1	10/27/2015	Calcium	161,000				
EPA Region 8	Tile Outfall	Hejo1	9/1/2015	Calcium	160,000				
EPA Region 8	Tile Outfall	Long1	6/6/2012	Calcium	159,000				
EPA Region 8	Tile Outfall	Bols1	9/1/2015	Calcium	158,000				
EPA Region 8	Tile Outfall	Hejo1	6/6/2012	Calcium	158,000				
EPA Region 8	Tile Outfall	Adam2	10/27/2015	Calcium	156,000				
EPA Region 8	Tile Outfall	Nels1	5/2/2012	Calcium	154,000				
EPA Region 8	Tile Outfall	Ache1	6/6/2012	Calcium	153,000				
EPA Region 8	Tile Outfall	Hejo2	9/1/2015	Calcium	153,000				
EPA Region 8	Tile Outfall	Hejo1	8/4/2015	Calcium	151,000				
EPA Region 8	Tile Outfall	Hejo1	7/7/2015	Calcium	150,000				
EPA Region 8	Tile Wetland	Bols1A	4/17/2015	Calcium	150,000				
EPA Region 8	Tile Outfall	Hejo1	6/9/2015	Calcium	148,000				
EPA Region 8	Tile Outfall	Hejo2	7/7/2015	Calcium	147,000				
EPA Region 8	Surface Wetland	Zeig1	4/17/2015	Calcium	147,000				
EPA Region 8	Tile Outfall	Mund1T	4/17/2015	Calcium	146,000				
EPA Region 8	Tile Outfall	Hejo2	6/9/2015	Calcium	144,000				
ESI	Tile Wetland	Bols1A	7/26/2012	Calcium	143,200				
EPA Region 8	Tile Outfall	Mund1T	10/27/2015	Calcium	142,000				
EPA Region 8	Tile Outfall	Adam2	6/9/2015	Calcium	141,000				
EPA Region 8	Tile Outfall	Adam2	7/7/2015	Calcium	140,000				
EPA Region 8	Reference Wetland	Lost1	9/5/2012	Calcium	140,000				
EPA Region 8	Tile Outfall	Mund1T	8/4/2015	Calcium	138,000				
EPA Region 8	Tile Outfall	Mund1T	9/1/2015	Calcium	136,000				
EPA Region 8	Tile Outfall	Hejo1	5/12/2015	Calcium	135,000				
EPA Region 8	Tile Outfall	Hejo2	5/12/2015	Calcium	134,000				
EPA Region 8	Tile Outfall	Mund1T	6/9/2015	Calcium	130,000				
EPA Region 8	Tile Outfall	Mund1T	5/12/2015	Calcium	123,000				
EPA Region 8	Tile Outfall	Mund1T	7/7/2015	Calcium	123,000				
EPA Region 8	Tile Outfall	Nels1	6/6/2012	Calcium	122,000				
EPA Region 8	Tile Outfall	Adam1	7/7/2015	Calcium	120,000				
EPA Region 8	Tile Outfall	Adam1	9/1/2015	Calcium	120,000				
EPA Region 8	Tile Wetland	Hejo1A	7/11/2012	Calcium	118,000				
EPA Region 8	Tile Wetland	BLKS1A	7/11/2012	Iron	5,920	NA	NA	1,000[2]	5
EPA Region 8	Tile Wetland	Hejo1A	7/11/2012	Iron	2,530				
EPA Region 8	Tile Outfall	Mund1T	8/4/2015	Iron	1,810				

Table A.18. Continued.

Laboratory	Site Cat	Site	Date Sampled	Analyte	Concentration (µg/L)	Acute Benchmark (µg/L)	Total Acute Exceedances	Chronic Benchmark (µg/L)	Total Chronic Exceedances
EPA Region 8	Surface Wetland	John1	9/5/2012	Iron	1,330				
EPA Region 8	Tile Wetland	Nels1A	9/5/2012	Iron	1,020				
EPA Region 8	Tile Wetland	Volk1	7/11/2012	Magnesium	406,000	NA	NA	82,000[4]	38
EPA Region 8	Tile Outfall	Habe1	9/1/2015	Magnesium	310,000				
EPA Region 8	Tile Outfall	Habe1	7/8/2015	Magnesium	309,000				
EPA Region 8	Tile Outfall	Habe1	6/9/2015	Magnesium	297,000				
EPA Region 8	Tile Wetland	Ache1A	9/5/2012	Magnesium	283,000				
EPA Region 8	Surface Wetland	Rams1	4/17/2015	Magnesium	272,000				
EPA Region 8	Tile Wetland	Gerk1A	9/5/2012	Magnesium	265,000				
EPA Region 8	Surface Wetland	2PetrA2	9/5/2012	Magnesium	259,000				
EPA Region 8	Surface Wetland	2Petr1A	9/5/2012	Magnesium	256,000				
EPA Region 8	Reference Wetland	Lost1	9/5/2012	Magnesium	243,000				
EPA Region 8	Surface Wetland	Rams1	9/5/2012	Magnesium	231,000				
EPA Region 8	Reference Wetland	Schaf1	9/5/2012	Magnesium	221,000				
EPA Region 8	Tile Outfall	Dryl1	5/2/2012	Magnesium	213,000				
EPA Region 8	Tile Wetland	Gerk1A	4/17/2015	Magnesium	201,000				
ESI	Reference Wetland	Cote	7/25/2012	Magnesium	194,000				
EPA Region 8	Reference Wetland	Lost1	7/11/2012	Magnesium	192,000				
EPA Region 8	Tile Outfall	Gerk1	6/9/2015	Magnesium	187,000				
EPA Region 8	Tile Outfall	Gerk1	7/8/2015	Magnesium	175,000				
EPA Region 8	Tile Outfall	Long2	6/6/2012	Magnesium	173,000				
EPA Region 8	Tile Outfall	Long2	5/2/2012	Magnesium	164,000				
ESI	Tile Wetland	Gerk1A	7/26/2012	Magnesium	151,000				
EPA Region 8	Tile Outfall	Gerk1	6/6/2012	Magnesium	142,000				
EPA Region 8	Tile Outfall	Wern1	6/6/2012	Magnesium	137,000				
EPA Region 8	Reference Wetland	Pitt1	9/5/2012	Magnesium	127,000				
EPA Region 8	Tile Wetland	Bols1A	4/17/2015	Magnesium	127,000				
EPA Region 8	Tile Outfall	Bols1	7/7/2015	Magnesium	122,000				
EPA Region 8	Tile Outfall	Bols1	10/28/2015	Magnesium	122,000				
EPA Region 8	Tile Outfall	Long2	4/10/2012	Magnesium	119,000				
ESI	Tile Wetland	Bols1A	7/26/2012	Magnesium	118,200				
EPA Region 8	Tile Outfall	Reev1	7/11/2012	Magnesium	114,000				
EPA Region 8	Tile Wetland	Long2A	7/11/2012	Magnesium	111,000				
EPA Region 8	Tile Outfall	BLSK1	5/2/2012	Magnesium	101,000				
EPA Region 8	Tile Outfall	Pets1	7/11/2012	Magnesium	93,200				
EPA Region 8	Tile Outfall	Adam2	5/12/2015	Magnesium	92,200				
EPA Region 8	Tile Outfall	Adam2	6/9/2015	Magnesium	91,200				
EPA Region 8	Tile Outfall	Adam2	10/27/2015	Magnesium	89,500				
EPA Region 8	Surface Wetland	Zeig1	4/17/2015	Magnesium	89,000				
EPA Region 8	Tile Outfall	Long1	7/11/2012	Magnesium	86,100				
EPA Region 8	Surface Wetland	2Petr1A	9/5/2012	Manganese	2,810	2,300	1	NA	NA
EPA Region 8	Tile Wetland	Volk1	7/11/2012	Phosphorus	2,050	NA	NA	37.5[5]	21
EPA Region 8	Surface Wetland	2PetrA2	9/5/2012	Phosphorus	1,200				
EPA Region 8	Surface Wetland	2Petr1A	9/5/2012	Phosphorus	1,160				
EPA Region 8	Reference Wetland	Lost1	9/5/2012	Phosphorus	998				
EPA Region 8	Reference Wetland	BUFO1	5/2/2012	Phosphorus	989				
EPA Region 8	Surface Wetland	John1	9/5/2012	Phosphorus	542				
EPA Region 8	Tile Wetland	Nels1A	9/5/2012	Phosphorus	360				
EPA Region 8	Tile Outfall	Dryl1	5/2/2012	Phosphorus	326				

Table A.18. Continued.

Laboratory	Site Cat	Site	Date Sampled	Analyte	Concentration (µg/L)	Acute Benchmark (µg/L)	Total Acute Exceedances	Chronic Benchmark (µg/L)	Total Chronic Exceedances
EPA Region 8	Tile Wetland	BLKS1A	7/11/2012	Phosphorus	288				
EPA Region 8	Tile Wetland	Ache1A	9/5/2012	Phosphorus	257				
EPA Region 8	Tile Wetland	Gerk1A	9/5/2012	Phosphorus	248				
EPA Region 8	Reference Wetland	Lost1	7/11/2012	Phosphorus	246				
EPA Region 8	Reference Wetland	Pitt1	9/5/2012	Phosphorus	218				
EPA Region 8	Tile Wetland	Hejo1A	7/11/2012	Phosphorus	131				
EPA Region 8	Tile Outfall	Reev1	7/11/2012	Phosphorus	112				
EPA Region 8	Tile Outfall	BLSK1	5/2/2012	Phosphorus	99				
EPA Region 8	Tile Outfall	Nels1	6/6/2012	Phosphorus	89				
EPA Region 8	Tile Outfall	Gerk1	6/6/2012	Phosphorus	45				
EPA Region 8	Tile Outfall	Nels1	5/2/2012	Phosphorus	45				
EPA Region 8	Surface Wetland	Rams1	9/5/2012	Phosphorus	45				
EPA Region 8	Tile Outfall	Ache1	6/6/2012	Phosphorus	40				
EPA Region 8	Tile Wetland	Volk1	7/11/2012	Potassium	81,300			53,000[4]	1
EPA Region 8	Tile Outfall	Habe1	7/8/2015	Selenium	144	20[6]	7	1.5[2]	62
EPA Region 8	Tile Outfall	Habe1	6/9/2015	Selenium	108				
EPA Region 8	Tile Outfall	Habe1	9/1/2015	Selenium	100				
EPA Region 8	Tile Outfall	Gerk1	6/9/2015	Selenium	57				
EPA Region 8	Tile Outfall	Gerk1	7/8/2015	Selenium	56				
EPA Region 8	Tile Outfall	BLSK1	5/2/2012	Selenium	26				
EPA Region 8	Tile Outfall	Gerk1	6/6/2012	Selenium	23				
EPA Region 8	Tile Outfall	Dryl1	5/2/2012	Selenium	19				
EPA Region 8	Tile Outfall	Hejo1	6/6/2012	Selenium	15				
EPA Region 8	Tile Outfall	Adam2	5/12/2015	Selenium	15				
EPA Region 8	Tile Outfall	Hejo2	10/27/2015	Selenium	15				
EPA Region 8	Tile Outfall	Hejo1	5/12/2015	Selenium	14				
EPA Region 8	Tile Outfall	Hejo2	5/12/2015	Selenium	14				
EPA Region 8	Tile Outfall	Hejo2	7/7/2015	Selenium	14				
EPA Region 8	Tile Outfall	Hejo2	6/9/2015	Selenium	13				
EPA Region 8	Tile Outfall	Hejo1	7/7/2015	Selenium	13				
EPA Region 8	Tile Outfall	Hejo1	6/9/2015	Selenium	12				
EPA Region 8	Tile Outfall	Pets1	7/11/2012	Selenium	12				
EPA Region 8	Tile Outfall	Hejo1	8/4/2015	Selenium	12				
EPA Region 8	Tile Outfall	Adam2	6/9/2015	Selenium	11				
EPA Region 8	Tile Outfall	Wern1	6/6/2012	Selenium	11				
EPA Region 8	Tile Outfall	Adam2	7/7/2015	Selenium	11				
EPA Region 8	Tile Outfall	Long2	6/6/2012	Selenium	11				
EPA Region 8	Tile Outfall	Hejo1	10/27/2015	Selenium	10				
EPA Region 8	Tile Outfall	Long2	5/2/2012	Selenium	10				
EPA Region 8	Tile Wetland	Volk1	7/11/2012	Selenium	10				
EPA Region 8	Tile Outfall	Hejo1	9/1/2015	Selenium	10				
EPA Region 8	Tile Outfall	Adam2	10/27/2015	Selenium	9				
EPA Region 8	Tile Outfall	Hejo2	9/1/2015	Selenium	9				
EPA Region 8	Tile Wetland	Nels1A	7/11/2012	Selenium	8				
EPA Region 8	Tile Outfall	Reev1	7/11/2012	Selenium	8				
EPA Region 8	Tile Outfall	Mund1T	7/7/2015	Selenium	7				
EPA Region 8	Tile Wetland	Hejo1A	7/11/2012	Selenium	7				
EPA Region 8	Tile Outfall	Long1	7/11/2012	Selenium	7				
EPA Region 8	Tile Outfall	Long1	4/10/2012	Selenium	7				

Table A.18. Continued.

Laboratory	Site Cat	Site	Date Sampled	Analyte	Concentration (µg/L)	Acute Benchmark (µg/L)	Total Acute Exceedances	Chronic Benchmark (µg/L)	Total Chronic Exceedances
EPA Region 8	Tile Outfall	Mund1T	6/9/2015	Selenium	7				
EPA Region 8	Tile Outfall	Mund1T	5/12/2015	Selenium	7				
EPA Region 8	Tile Outfall	Long2	4/10/2012	Selenium	7				
EPA Region 8	Tile Outfall	Long1	5/2/2012	Selenium	7				
EPA Region 8	Tile Outfall	Long1	6/6/2012	Selenium	6				
EPA Region 8	Tile Outfall	Mund1T	9/1/2015	Selenium	6				
EPA Region 8	Tile Outfall	Bols1	10/28/2015	Selenium	6				
EPA Region 8	Tile Outfall	Mund1T	8/4/2015	Selenium	6				
EPA Region 8	Tile Wetland	Long2A	7/11/2012	Selenium	6				
EPA Region 8	Tile Outfall	Mund1T	10/27/2015	Selenium	6				
EPA Region 8	Tile Outfall	Nels1	8/4/2015	Selenium	5				
EPA Region 8	Tile Outfall	Ache1	6/6/2012	Selenium	5				
EPA Region 8	Tile Outfall	Adam1	9/1/2015	Selenium	4				
EPA Region 8	Tile Wetland	BLKS1A	7/11/2012	Selenium	4				
EPA Region 8	Tile Outfall	Bols1	4/17/2015	Selenium	3				
EPA Region 8	Tile Outfall	Adam1	7/7/2015	Selenium	3				
EPA Region 8	Tile Outfall	Mund1T	4/17/2015	Selenium	3				
EPA Region 8	Tile Outfall	Adam1	5/12/2015	Selenium	3				
EPA Region 8	Surface Wetland	2Petr1A	9/5/2012	Selenium	2				
EPA Region 8	Surface Wetland	2PetrA2	9/5/2012	Selenium	2				
EPA Region 8	Tile Outfall	Bols1	7/7/2015	Selenium	2				
EPA Region 8	Tile Wetland	Ache1A	9/5/2012	Selenium	2				
EPA Region 8	Tile Wetland	Gerk1A	9/5/2012	Selenium	2				
EPA Region 8	Tile Outfall	Adam2	8/4/2015	Selenium	2				
EPA Region 8	Reference Wetland	Lost1	7/11/2012	Selenium	2				
EPA Region 8	Reference Wetland	Lost1	9/5/2012	Selenium	2				
EPA Region 8	Tile Wetland	Volk1	7/11/2012	Sulfate as SO4	2,360	875 [7]	13	500[7]	20
EPA Region 8	Surface Wetland	2PetrA2	9/5/2012	Sulfate as SO4	1,900				
EPA Region 8	Surface Wetland	2Petr1A	9/5/2012	Sulfate as SO4	1,880				
EPA Region 8	Tile Wetland	Gerk1A	9/5/2012	Sulfate as SO4	1,850				
EPA Region 8	Tile Outfall	Dryl1	5/02/2012	Sulfate as SO4	1,590				
EPA Region 8	Surface Wetland	Rams1	9/5/2012	Sulfate as SO4	1,580				
EPA Region 8	Reference Wetland	Lost1	9/5/2012	Sulfate as SO4	1,260				
EPA Region 8	Tile Wetland	Ache1A	9/5/2012	Sulfate as SO4	1,260				
EPA Region 8	Tile Outfall	Long2	6/06/2012	Sulfate as SO4	1,200				
EPA Region 8	Tile Outfall	Long1	5/02/2012	Sulfate as SO4	1,150				
EPA Region 8	Tile Outfall	Gerk1	6/06/2012	Sulfate as SO4	1,100				
EPA Region 8	Reference Wetland	Lost1	7/11/2012	Sulfate as SO4	1,090				
EPA Region 8	Tile Outfall	Wern1	6/06/2012	Sulfate as SO4	950				
EPA Region 8	Tile Outfall	Long2	4/10/2012	Sulfate as SO4	802				
EPA Region 8	Tile Wetland	Long2A	7/11/2012	Sulfate as SO4	771				
EPA Region 8	Reference Wetland	Schaf1	9/5/2012	Sulfate as SO4	695				
EPA Region 8	Tile Outfall	Reev1	7/11/2012	Sulfate as SO4	639				
EPA Region 8	Reference Wetland	Pitt1	9/5/2012	Sulfate as SO4	621				
EPA Region 8	Tile Outfall	Pets1	7/11/2012	Sulfate as SO4	556				
EPA Region 8	Tile Outfall	BLSK1	5/2/2012	Sulfate as SO4	518				
EPA Region 8	Tile Outfall	Long1	6/6/2012	TDS	7,380	4,375[8]	1	2000[8]	2
EPA Region 8	Tile Wetland	Volk1	7/11/2012	TDS	3,220				

Note: 1 = national freshwater chronic aquatic life criteirion, 2 = national freshwater acute aquatic life criteirion, 3 = Tier II secondary acute value (Suter and Tsao 1996), 4 = lowest chronic value (Suter and Tsao 1996), 5 = National ambient water quality criteria recommendation (EPA 2000), 6 = South Dakota acute water quality criterion for aquatic life, 7 = South Dakota human health criterion, 8 = South Dakota aquatic life criterion.

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Table A.19. Summary statistics for concentrations of elemental contaminants in water from wetland site categories compared to background and toxicity threshold benchmarks, Madison Wetland Management District, 2013–2014.

	Tile Wetland			Surface Wetland			Reference Wetland			
		Concentration (ug/L)			Concentration (ug/L)			Concentration (ug/L)		Published Background or
Trace Element	N_D/N_A	Mean ± S.E.	Range	N_D/N_A	Mean ± S.E.	Range	N_D/N_A	Mean ± S.E.	Range	Threshold (mg/kg)
Aluminum	7 / 15	471 ± 236	< 100 – 3,030	4 / 7	295 ± 145	< 100 – 1,130	3 / 7	123 ± 56	< 100 – 441	87 [1], 750 [2]
Arsenic	11 / 15	8 ± 2	< 1 – 24	6 / 7	9 ± 3	< 1 – 17	6 / 7	7 ± 2	< 1 – 17	150 [1], 340 [2]
Barium	15 / 15	72 ± 11	24 – 194	7 / 7	71 ± 18	22 – 144	7 / 7	75 ± 17	23 – 142	4 [3], 110 [4]
Boron	7 / 15	73 ± 10	< 1 – 145	2 / 7	76 ± 17	< 1 – 146	2 / 7	86 ± 30	< 1 – 264	1.6 [3], 30 [4], 13,000 [5]
Calcium	15 / 15	155,313 ± 25,973	33,600 – 368,000	7 / 7	196,943 ± 40,737	61,800 – 316,000	7 / 7	97,029 ± 17,998	34,700 – 162,000	116,000 [6]
Copper	4 / 15	4 ± 0.3	< 2 – 5	0 / 7	NA	3 – 5	2 / 7	NA	< 2 – 5	9 [1], 13 [2]
Iron	12 / 15	767 ± 407	< 100 – 5,920	4 / 7	350 ± 172	< 100 – 1,330	4 / 7	139 ± 59	< 100 – 460	1,000 [1]
Lead	3 / 15	NA	< 1 – 2.2	2 / 7	0.7 ± 0.3	< 1 – 2.3	0 / 7	NA	NA	2.5 [1], 65 [2]
Magnesium	15 / 15	134,520 ± 28,275	38,000 – 406,000	7 / 7	176,871 ± 37,051	56,500 – 272,000	7 / 7	162,000 ± 25,427	75,400 – 243,000	82,000 [6]
Manganese	15 / 15	561 ± 138	15 – 1,490	7 / 7	976 ± 480	89 – 2,840	7 / 7	414 ± 183	145 – 1,440	120 [3],2,300 [4]
Molybdenum	5 / 15	NA	< 5 – 10	3 / 7	7 ± 2	< 5 – 15	0 / 7	NA	NA	370 [3], 16,000 [4], 120 [5]
Nickel	12 / 15	7 2	< 1 – 25	4 / 7	7 2	< 1 – 15	7 / 7	5 2	1 10	52 [1], 470 [2]
Phosphorus	7 / 8	421 ± 237	< 10 – 2050	4 / 7	737 ± 276	< 10 – 1200	5 / 5	496 ± 207	28 – 998	37.5
Potassium	8 / 8	20,068 ± 9488	2860 – 81,300	4 / 4	21,175 ± 4684	14200 – 35,000	5 / 5	22,380 ± 1099	19700 – 25,900	53,000 [6]
Selenium	9 / 15	3 ± 1	< 1 – 9.7	5 / 4	1 ± 0	< 1 – 2.4	2 / 7	NA	< 1 – 1.5	1.5 [1]
Sodium	15 / 15	68,143 ± 22,190	8,080 – 338,000	7 / 7	88,786 ± 22,979	13,300 – 153,000	7 / 7	55,429 ± 11,199	17,400 – 103,000	680,000 [6]
Strontium	15 / 15	886 ± 194	134 – 2,750	7 / 7	1141 ± 257	305 – 1,700	7 / 7	638 ± 169	121 – 1,330	1,500 [3], 15,000 [4]
Vanadium	4 / 12	NA	< 10 – 54	3 / 3	21 ± 6	5 – 30	4 / 7	13 ± 5	< 10 – 31	20 [3], 280 [4]
Zinc	1 / 15	NA	< 50 – 162	0 / 4	NA	NA	1 / 7	NA	< 50 – 2	120 [1], 120 [2]

Note: * = minimum Reporting Limit for EPA Region 8 Laboratory, 1 = national freshwater chronic aquatic life criteirion, 2 = national freshwater acute aquatic life criteirion, 3 = Tier II secondary chronic value (Suter and Tsao 1996), 4 = Tier II secondary acute value (Suter and Tsao 1996), 5 = toxicity threshold (USDOI 1998), 6 = lowest chronic value (Suter and Tsao 1996).

Table A.20. Summary statistics for concentrations of elemental contaminants in sediment from wetland site categories compared to background and toxicity threshold benchmarks, Madison Wetland Management District, 2013–2014.

		Tile Wetland			Surface Wetland			Reference Wetland			
			Dry Weight Concentration (mg/kg)			Dry Weight Concentration (mg/kg)			Dry Weight Concentration (mg/kg)		
Trace Element	MDL Range (mg/kg)	N_D/N_A	Mean ± S.E.		N_D/N_A	Mean ± S.E.		N_D/N_A	Mean ± S.E.		Published Background or Threshold (mg/kg)
Aluminum	2–40	40 / 40	7,220 ± 602	A	25 / 25	6,554 ± 625	A	35 / 35	5,970 ± 281	A	25,500 [1]
Antimony	0.1–0.2	10 / 10	0.40 ± 0.02	A	20 / 20	0.32 ± 0.03	B	15 / 15	0.28 ± 0.02	B	0.16 [2]
Arsenic	0.1–1	40 / 40	5.10 ± 0.37	A	25 / 25	4.42 ± 0.37	AB	35 / 35	3.92 ± 0.26	B	5.9[3]–33 [4]
Barium	0.4–8	40 / 40	139.89 ± 11.28	A	25 / 25	123.80 ± 13.14	A	35 / 35	114.99 ± 9.24	A	700 [2]
Beryllium	0.03–0.7	40 / 40	0.64 ± 0.06	A	10 / 25	NA	A	26 / 35	0.51 ± 0.04	A	1 [5]
Boron	0.2–4	40 / 40	21.54 ± 2.60	A	25 / 25	16.89 ± 2.32	A	35 / 35	20.81 ± 2.30	A	29 [5]
Cadmium	0.08–0.5	35 / 40	0.55 ± 0.03	A	25 / 25	0.40 ± 0.03	B	35 / 35	0.54 ± 0.03	A	0.6 [3]–4.98 [4]
Calcium	30–400	40 / 40	21,344 ± 1,853	A	25 / 25	23,158 ± 4,714	A	35 / 35	39,186 ± 5,881	A	24,000 [5]
Chromium	0.1–1	40 / 40	11.79 ± 0.91	A	25 / 25	9.84 ± 0.76	A	35 / 35	10.29 ± 0.52	A	7 - 13 [2], 43 [3]
Cobalt	0.1–1	40 / 40	5.79 ± 0.46	A	25 / 25	4.65 ± 0.38	AB	35 / 35	4.47 ± 0.30	B	10 [2]
Copper	0.2–4	40 / 40	16.99 ± 1.33	A	25 / 25	16.95 ± 2.03	A	35 / 35	16.77 ± 0.85	A	31.6 [3]
Iron	7–70	40 / 40	12,132 ± 871	A	25 / 25	11,261 ± 1,133	AB	35 / 35	9,626 ± 594	B	9,900–18,000 [2]
Lead	0.1–1	40 / 40	13.70 ± 1.05	A	25 / 25	11.39 ± 0.94	A	35 / 35	14.14 ± 0.81	A	4–17 [2], 36 [3]
Magnesium	30–400	40 / 40	5,718 ± 268	A	25 / 25	5,288 ± 361	A	35 / 35	6,021 ± 599	A	10,000 [5]
Manganese	0.2–4	40 / 40	596 ± 97	A	25 / 25	627 ± 180	A	35 / 35	672 ± 101	A	400 [2]
Mercury	0.01–0.02	31 / 40	0.03 ± 0.002	A	18 / 25	0.02 ± 0.004	B	35 / 35	0.03 ± 0.003	AB	0.18 [3]
Molybdenum	0.2–4	15 / 40	NA		22 / 25	0.89 ± 0.13	A	19 / 35	1.25 ± 0.19	A	1.1 [5]
Nickel	0.1–0.2	40 / 40	17.13 ± 1.32	A	25 / 25	13.36 ± 1.03	B	35 / 35	14.30 ± 0.88	AB	9.9 [2], 23 [3]
Potassium	10–20	10 / 10	1,596 ± 157	A	20 / 20	1,200 ± 89	A	15 / 15	1,386 ± 51	A	XD
Selenium	0.01–2	33 / 40	1.60 ± 0.14	A	24 / 25	0.89 ± 0.08	B	29 / 35	1.31 ± 0.15	AB	0.29 [2], 1–4 [6], 2 [7]
Sodium	10–300	34 / 40	341 ± 42	A	25 / 25	273 ± 32	A	35 / 35	189 ± 17	B	XD
Strontium	0.1–4	40 / 40	62 ± 5	A	25 / 25	69 ± 11	AB	35 / 35	112 ± 15	B	49 [2]
Thallium	0.1–0.5	10 / 40	NA	A	14 / 25	0.14 ± 0.01	A	15 / 35	NA	A	0.7 [8]
Tin	0.1–0.2	10 / 10	0.58 ± 0.14	A	20 / 20	0.32 ± 0.03	B	15 / 15	0.37 ± 0.02	B	1.2 [5]
Vanadium	0.1–2	40 / 40	25 ± 2	A	25 / 25	21 ± 2	A	35 / 35	22 ± 1	A	50 [2]
Zinc	2–10	40 / 40	59 ± 4	A	25 / 25	52 ± 5	AB	35 / 35	51 ± 3	B	7–38 [2], 121 [3]

Note: 1 = threshold effect level (Buchman 2008), 2 = background (Buchman 2008), 3 = Threshold Effects Concentration below which adverse effects are not expected to occur (McDonald *et al*. 2000), 4 = Probable Effect Concentration above which adverse effects are expected to occur more often than not (McDonald *et al* 2000), 5 = background Western United States (Shakette *et al*.1984), 6 = Level of Concern (USDOI 1998), 7 = ecological sediment guideline (Lemly 2002), 8 = average of earth's crust (Guberman 2010).

Table A.21. Toxicity benchmark exceedances of selenium in duck eggs, aquatic macroinvertebrates and aquatic vegetation in samples from Tile Wetland sites within the Madison Wetland Management District, 2013–2015.

Catalog Number	Collection Date	WPA Name	Sample Number	Site	Site Category	Sample Matrix	Selenium mg/kg dw
6090087	6/8/2015	Wenk	WenkN5E3	Wenk1	Tile Wetland	Avian Egg	8.8
6090087	6/8/2015	Wenk	WenkN2E1	Wenk1	Tile Wetland	Avian Egg	4.8
6090087	6/8/2015	Wenk	WenkN2E3	Wenk1	Tile Wetland	Avian Egg	4.8
6090087	6/8/2015	Wenk	WenkN5E1	Wenk1	Tile Wetland	Avian Egg	4.4
6090087	6/8/2015	Wenk	WenkN1E3	Wenk1	Tile Wetland	Avian Egg	4.3
6090087	6/8/2015	Wenk	WenkN1E1	Wenk1	Tile Wetland	Avian Egg	4.2
6090087	6/8/2015	Wenk	WenkN2E2	Wenk1	Tile Wetland	Avian Egg	4.1
6090087	6/8/2015	Wenk	WenkN2E5	Wenk1	Tile Wetland	Avian Egg	4.1
6090087	6/8/2015	Wenk	WenkN3E1	Wenk1	Tile Wetland	Avian Egg	4.1
6090087	6/8/2015	Wenk	WenkN5E2	Wenk1	Tile Wetland	Avian Egg	3.7
6090087	6/8/2015	Wenk	WenkN3E2	Wenk1	Tile Wetland	Avian Egg	3.7
6090087	6/8/2015	Wenk	WenkN1E2	Wenk1	Tile Wetland	Avian Egg	3.6
6090087	6/8/2015	Wenk	WenkN1E5	Wenk1	Tile Wetland	Avian Egg	3.6
6090087	6/8/2015	Wenk	WenkN1E4	Wenk1	Tile Wetland	Avian Egg	3.2
6090087	6/1/2015	Gerdink	GerkN1E1	Gerk1	Tile Wetland	Avian Egg	3.1
6090086	7/23/2013	Johnson II (H)	Hejo1AMI	Hejo1	Tile Wetland	Mixed Inverts	3.8
6090087	8/13/2014	Voelker II	Volk1SN1	Volk1	Tile Wetland	Snails	16.7
6090086	8/12/2013	Gerdink	Gerk1ASN	Gerk1	Tile Wetland	Snails	8.4
6090087	6/11/2015	Voelker II	VolkSN2	Volk1	Tile Wetland	Snails	4.7
6090087	7/8/2015	Gerdink	GerkSN2	Gerk1	Tile Wetland	Snails	4.2
6090087	8/13/2014	Voelker II	Volk1DW1	Volk1	Tile Wetland	Vegetation	3.5

Table A.22. Wetland Rapid Assessment Protocol (WRAP) scores for wetland sites within the Madison Wetland Management District, 2013–2015.

Site Name	Site Category	Mean ± S.E	Range
Pett1	Reference Wetland	73.6 ± 1.2	69.5 – 77.5
Cote1	Reference Wetland	73.0 ± 1.4	69 – 79
Schafer	Reference Wetland	71.2 ± 0.9	67.5 – 74
Pitt1	Reference Wetland	71.0 ± 1.0	68.5 – 75
Lost1	Reference Wetland	69.1 ± 0.9	66.5 – 71.5
Bufo1	Reference Wetland	68.0 ± 1.2	64 – 72.5
John1	Surface Wetland	65.3 ± 1.1	61.5 – 68
Volk1	Tile Wetland	64.2 ± 1.3	59 – 68.5
Hejo1A	Tile Wetland	63.2 ± 1.7	59 – 68.5
Rams1	Surface Wetland	63.0 ± 2.4	56.5 – 72.5
Zieg1	Surface Wetland	62.8 ± 1.9	56.5 – 70
Schae1	Surface Wetland	62.7 ± 1.8	57 – 67.5
2Pertr1A	Surface Wetland	61.6 ± 1.9	56.5 – 67.5
Mund1	Tile Wetland	61.1 ± 1.5	55 – 65
Bols1A	Tile Wetland	60.8 ± 0.9	57.5 – 63
Ache1A	Tile Wetland	60.3 ± 1.9	54 – 65
Gerk1A	Tile Wetland	54.7 ± 1.8	47.5 – 59.5
Nels1A	Tile Wetland	52.7 ± 1.1	49.5 – 56.5

Table A.23. Amphibian and reptile voucher specimens collected from the Madison Wetland Management District, 2013–2014.

Field #	Species	Common Name	County	Locality	Latitude	Longitude	Date Collected
DRD–0293	*Ambystoma mavortium*	Western Tiger Salamander	Minnehaha	Buffalo Lake WPA	43.8224	-97.0606	19-Jun-13
DRD–0294	*Ambystoma mavortium*	Western Tiger Salamander	Minnehaha	Buffalo Lake WPA	43.8224	-97.0606	19-Jun-13
DRD–0295	*Ambystoma mavortium*	Western Tiger Salamander	Minnehaha	Buffalo Lake WPA	43.8224	-97.0606	19-Jun-13
DRD–1122	*Ambystoma mavortium*	Western Tiger Salamander	Minnehaha	Buffalo Lake WPA	43.8224	-97.0606	18-Jun-14
DRD–1123	*Ambystoma mavortium*	Western Tiger Salamander	Minnehaha	Buffalo Lake WPA	43.8224	-97.0606	18-Jun-14
DRD–1124	*Ambystoma mavortium*	Western Tiger Salamander	Minnehaha	Buffalo Lake WPA	43.8224	-97.0606	18-Jun-14
DRD–1125	*Ambystoma mavortium*	Western Tiger Salamander	Minnehaha	Buffalo Lake WPA	43.8224	-97.0606	18-Jun-14
DRD–0582	*Ambystoma mavortium*	Western Tiger Salamander	Minnehaha	Buffalo Lake WPA	43.8227	-97.0605	19-Jun-13
DRD–1107	*Ambystoma mavortium*	Western Tiger Salamander	Deuel	Coteau Prairie WPA	44.8966	-96.7152	17-Jun-14
DRD–1108	*Ambystoma mavortium*	Western Tiger Salamander	Deuel	Coteau Prairie WPA	44.8966	-96.7152	17-Jun-14
DRD–1109	*Ambystoma mavortium*	Western Tiger Salamander	Deuel	Coteau Prairie WPA	44.8966	-96.7152	17-Jun-14
DRD–1110	*Ambystoma mavortium*	Western Tiger Salamander	Deuel	Coteau Prairie WPA	44.8966	-96.7152	17-Jun-14
DRD–1298	*Ambystoma mavortium*	Western Tiger Salamander	Brookings	Eriksrud WPA	44.2501	-97.0587	16-Jul-14
DRD–1299	*Ambystoma mavortium*	Western Tiger Salamander	Brookings	Eriksrud WPA	44.2501	-97.0587	16-Jul-14
DRD–1300	*Ambystoma mavortium*	Western Tiger Salamander	Brookings	Eriksrud WPA	44.2501	-97.0587	16-Jul-14
DRD–0836	*Ambystoma mavortium*	Western Tiger Salamander	Minnehaha	Lost Lake WPA	43.6773	-97.0574	20-Jun-13
DRD–0390	*Ambystoma mavortium*	Western Tiger Salamander	Minnehaha	Lost Lake WPA	43.6773	-97.0574	20-Jun-13
DRD–0583	*Ambystoma mavortium*	Western Tiger Salamander	Minnehaha	Lost Lake WPA	43.6773	-97.0574	4-Jul-13
DRD–0584	*Ambystoma mavortium*	Western Tiger Salamander	Minnehaha	Lost Lake WPA	43.6773	-97.0574	4-Jul-13
DRD–0585	*Ambystoma mavortium*	Western Tiger Salamander	Minnehaha	Lost Lake WPA	43.6773	-97.0574	4-Jul-13
DRD–0586	*Ambystoma mavortium*	Western Tiger Salamander	Minnehaha	Lost Lake WPA	43.6773	-97.0574	4-Jul-13
DRD–0587	*Ambystoma mavortium*	Western Tiger Salamander	Minnehaha	Lost Lake WPA	43.6773	-97.0574	4-Jul-13
DRD–0588	*Ambystoma mavortium*	Western Tiger Salamander	Minnehaha	Lost Lake WPA	43.6773	-97.0574	4-Jul-13
DRD–0712	*Ambystoma mavortium*	Western Tiger Salamander	Minnehaha	Lost Lake WPA	43.6773	-97.0574	4-Jul-13
DRD–0828	*Ambystoma mavortium*	Western Tiger Salamander	Minnehaha	Lost Lake WPA	43.6773	-97.0574	4-Jul-13
DRD–0409	*Ambystoma mavortium*	Western Tiger Salamander	Minnehaha	Lost Lake WPA	43.6773	-97.0574	8-Jul-13
DRD–0417	*Ambystoma mavortium*	Western Tiger Salamander	Deuel	Mundahl WPA	44.6759	-96.5483	18-Jul-13
DRD–0322	*Ambystoma mavortium*	Western Tiger Salamander	Minnehaha	Petri II WPA	43.6785	-97.0948	20-Jun-13
DRD–0323	*Ambystoma mavortium*	Western Tiger Salamander	Minnehaha	Petri II WPA	43.6785	-97.0948	20-Jun-13
DRD–0324	*Ambystoma mavortium*	Western Tiger Salamander	Minnehaha	Petri II WPA	43.6785	-97.0948	20-Jun-13
DRD–1117	*Ambystoma mavortium*	Western Tiger Salamander	Minnehaha	Petri II WPA	43.6792	-97.0946	19-Jun-14
DRD–0589	*Ambystoma mavortium*	Western Tiger Salamander	Minnehaha	Petri II WPA	43.6785	-97.0948	5-Jul-13
DRD–0153	*Ambystoma mavortium*	Western Tiger Salamander	Moody	Pettigrew WPA	44.092	-96.8502	13-May-13
DRD–0282	*Ambystoma mavortium*	Western Tiger Salamander	Moody	Pettigrew WPA	44.0926	-96.8502	18-Jun-13
DRD–0283	*Ambystoma mavortium*	Western Tiger Salamander	Moody	Pettigrew WPA	44.0926	-96.8502	18-Jun-13
DRD–0296	*Ambystoma mavortium*	Western Tiger Salamander	Moody	Pettigrew WPA	44.0926	-96.8502	21-Jun-13
DRD–0297	*Ambystoma mavortium*	Western Tiger Salamander	Moody	Pettigrew WPA	44.0926	-96.8502	21-Jun-13
DRD–0298	*Ambystoma mavortium*	Western Tiger Salamander	Moody	Pettigrew WPA	44.0926	-96.8502	21-Jun-13
DRD–0299	*Ambystoma mavortium*	Western Tiger Salamander	Moody	Pettigrew WPA	44.0926	-96.8502	21-Jun-13
DRD–0300	*Ambystoma mavortium*	Western Tiger Salamander	Moody	Pettigrew WPA	44.0926	-96.8502	21-Jun-13
DRD–0311	*Ambystoma mavortium*	Western Tiger Salamander	Moody	Pettigrew WPA	44.0926	-96.8502	21-Jun-13
DRD–1067	*Ambystoma mavortium*	Western Tiger Salamander	Moody	Pettigrew WPA	44.0926	-96.8502	16-Jun-14
DRD–1105	*Ambystoma mavortium*	Western Tiger Salamander	Moody	Pettigrew WPA	44.0926	-96.8502	18-Jun-14

Table A.23. Continued.

Field #	Species	Common Name	County	Locality	Latitude	Longitude	Date Collected
DRD–1106	*Ambystoma mavortium*	Western Tiger Salamander	Moody	Pettigrew WPA	44.0926	-96.8502	18-Jun-14
DRD–1132	*Ambystoma mavortium*	Western Tiger Salamander	Brookings	Pittenger WPA	44.3866	-96.9652	17-Jun-14
DRD–1093	*Ambystoma mavortium*	Western Tiger Salamander	Deuel	Schafer WPA	44.9155	-96.7169	17-Jun-14
DRD–1094	*Ambystoma mavortium*	Western Tiger Salamander	Deuel	Schafer WPA	44.9155	-96.7169	17-Jun-14
DRD–0508	*Ambystoma mavortium*	Western Tiger Salamander	Minnehaha	Voelker II WPA	43.7078	-97.1124	8-Jul-13
DRD–0509	*Ambystoma mavortium*	Western Tiger Salamander	Minnehaha	Voelker II WPA	43.7078	-97.1124	8-Jul-13
DRD–0510	*Ambystoma mavortium*	Western Tiger Salamander	Minnehaha	Voelker II WPA	43.7078	-97.1124	8-Jul-13
DRD–0432	*Anaxyrus americanus*	American Toad	Minnehaha	Acheson WPA	43.8028	-97.0597	17-Jul-13
DRD–1101	*Anaxyrus americanus*	American Toad	Minnehaha	Acheson WPA	43.8028	-97.0597	18-Jun-14
DRD–1111	*Anaxyrus americanus*	American Toad	Minnehaha	Acheson WPA	43.8028	-97.0597	25-Jun-14
DRD–0154	*Anaxyrus americanus*	American Toad	Minnehaha	Acheson WPA	43.8032	-97.061	16-May-13
DRD–0288	*Anaxyrus americanus*	American Toad	Minnehaha	Acheson WPA	43.8029	-97.0617	19-Jun-13
DRD–0384	*Anaxyrus americanus*	American Toad	Minnehaha	Buffalo Lake WPA	43.8224	-97.0606	19-Jun-13
DRD–1103	*Anaxyrus americanus*	American Toad	Minnehaha	Buffalo Lake WPA	43.8224	-97.0606	18-Jun-14
DRD–0143	*Anaxyrus americanus*	American Toad	Deuel	Coteau Prairie WPA	44.8966	-96.7152	14-May-13
DRD–0269	*Anaxyrus americanus*	American Toad	Deuel	Coteau Prairie WPA	44.8966	-96.7152	17-Jun-13
DRD–0272	*Anaxyrus americanus*	American Toad	Deuel	Coteau Prairie WPA	44.8966	-96.7152	17-Jun-13
DRD–1069	*Anaxyrus americanus*	American Toad	Deuel	Coteau Prairie WPA	44.8957	-96.7166	17-Jun-14
DRD–1084	*Anaxyrus americanus*	American Toad	Deuel	Coteau Prairie WPA	44.8966	-96.7152	17-Jun-14
DRD–0421	*Anaxyrus americanus*	American Toad	Brookings	Gerdink WPA	44.2002	-96.9561	16-Jul-13
DRD–1096	*Anaxyrus americanus*	American Toad	Brookings	Gerdink WPA	44.2029	-96.9559	16-Jun-14
DRD–0152	*Anaxyrus americanus*	American Toad	Brookings	Gerdink WPA	44.2	-96.9557	13-May-13
DRD–0275	*Anaxyrus americanus*	American Toad	Deuel	Johnson I WPA	44.6263	-96.5	17-Jun-13
DRD–1077	*Anaxyrus americanus*	American Toad	Deuel	Johnson I WPA	44.6263	-96.5	17-Jun-14
DRD–0150	*Anaxyrus americanus*	American Toad	Deuel	Johnson I WPA	44.6263	-96.5004	14-May-13
DRD–1288	*Anaxyrus americanus*	American Toad	Deuel	Johnson I WPA	44.6259	-96.4998	15-Jul-14
DRD–1289	*Anaxyrus americanus*	American Toad	Deuel	Johnson I WPA	44.6259	-96.4998	15-Jul-14
DRD–1290	*Anaxyrus americanus*	American Toad	Deuel	Johnson I WPA	44.6259	-96.4998	15-Jul-14
DRD–1291	*Anaxyrus americanus*	American Toad	Deuel	Johnson I WPA	44.6259	-96.4998	15-Jul-14
DRD–1076	*Anaxyrus americanus*	American Toad	Deuel	Johnson II WPA	44.5583	-96.4547	17-Jun-14
DRD–0434	*Anaxyrus americanus*	American Toad	Minnehaha	Lost Lake WPA	43.6773	-97.0574	17-Jul-13
DRD–1072	*Anaxyrus americanus*	American Toad	Minnehaha	Lost Lake WPA	43.6773	-97.0574	18-Jun-14
DRD–0273	*Anaxyrus americanus*	American Toad	Deuel	Mundahl WPA	44.6765	-96.55	17-Jun-13
DRD–0144	*Anaxyrus americanus*	American Toad	Deuel	Nelson WPA	44.9095	-96.6315	15-May-13
DRD–0278	*Anaxyrus americanus*	American Toad	Deuel	Nelson WPA	44.9095	-96.6315	18-Jun-13
DRD–1080	*Anaxyrus americanus*	American Toad	Deuel	Nelson WPA	44.9095	-96.6315	17-Jun-14
DRD–1325	*Anaxyrus americanus*	American Toad	Deuel	Nelson WPA	44.9095	-96.6315	15-Jul-14
DRD–0341	*Anaxyrus americanus*	American Toad	Minnehaha	Petri II WPA	43.6789	-97.0944	20-Jun-13
DRD–0921	*Anaxyrus americanus*	American Toad	Minnehaha	Petri II WPA	43.679	-97.0932	14-May-14
DRD–1116	*Anaxyrus americanus*	American Toad	Minnehaha	Petri II WPA	43.6789	-97.0944	19-Jun-14
DRD–0289	*Anaxyrus americanus*	American Toad	Minnehaha	Petri II WPA	43.6793	-97.0946	20-Jun-13
DRD–1292	*Anaxyrus americanus*	American Toad	Minnehaha	Petri II WPA	43.6794	-97.0933	16-Jul-14
DRD–0405	*Anaxyrus americanus*	American Toad	Minnehaha	Petri II WPA	43.6785	-97.0948	5-Jul-13

Table A.23. Continued.

Field #	Species	Common Name	County	Locality	Latitude	Longitude	Date Collected
DRD–0139	*Anaxyrus americanus*	American Toad	Moody	Pettigrew WPA	44.093	-96.8509	13-May-13
DRD–0140	*Anaxyrus americanus*	American Toad	Moody	Pettigrew WPA	44.093	-96.8509	13-May-13
DRD–1068	*Anaxyrus americanus*	American Toad	Brookings	Pittenger WPA	44.3872	-96.9653	16-Jun-14
DRD–1097	*Anaxyrus americanus*	American Toad	Brookings	Pittenger WPA	44.3861	-96.964	17-Jun-14
DRD–1091	*Anaxyrus americanus*	American Toad	Brookings	Pittenger WPA	44.3868	-96.9653	23-Jun-14
DRD–0277	*Anaxyrus americanus*	American Toad	Lake	Ramsey WPA	44.1922	-96.9654	18-Jun-13
DRD–1098	*Anaxyrus americanus*	American Toad	Lake	Ramsey WPA	44.1922	-96.9654	16-Jun-14
DRD–0284	*Anaxyrus americanus*	American Toad	Minnehaha	Schaefer WPA	43.8124	-97.0334	19-Jun-13
DRD–0285	*Anaxyrus americanus*	American Toad	Minnehaha	Schaefer WPA	43.8124	-97.0334	19-Jun-13
DRD–0286	*Anaxyrus americanus*	American Toad	Minnehaha	Schaefer WPA	43.8124	-97.0334	19-Jun-13
DRD–0287	*Anaxyrus americanus*	American Toad	Minnehaha	Schaefer WPA	43.8124	-97.0334	19-Jun-13
DRD–1104	*Anaxyrus americanus*	American Toad	Minnehaha	Schaefer WPA	43.8121	-97.0356	18-Jun-14
DRD–0271	*Anaxyrus americanus*	American Toad	Deuel	Schafer WPA	44.9155	-96.7169	17-Jun-13
DRD–1070	*Anaxyrus americanus*	American Toad	Deuel	Schafer WPA	44.9162	-96.7161	17-Jun-14
DRD–1071	*Anaxyrus americanus*	American Toad	Deuel	Schafer WPA	44.9162	-96.7161	17-Jun-14
DRD–1081	*Anaxyrus americanus*	American Toad	Deuel	Schafer WPA	44.9155	-96.7169	17-Jun-14
DRD–0919	*Anaxyrus americanus*	American Toad	Minnehaha	Voelker II WPA	43.7096	-97.1134	14-May-14
DRD–0281	*Anaxyrus americanus*	American Toad	Brookings	Ziegler WPA	44.3139	-96.9773	19-Jun-13
DRD–1099	*Anaxyrus americanus*	American Toad	Brookings	Ziegler WPA	44.3139	-96.9773	16-Jun-14
DRD–0136	*Chelydra serpentina*	Common Snapping Turtle	Deuel	Johnson I WPA	44.6259	-96.4998	14-May-13
DRD–0439	*Chelydra serpentina*	Common Snapping Turtle	Minnehaha	Lost Lake WPA	43.6773	-97.0574	8-Jul-13
DRD–0135	*Chrysemys picta*	Painted Turtle	Deuel	Johnson I WPA	44.6263	-96.5003	14-May-13
DRD–0903	*Chrysemys picta*	Painted Turtle	Minnehaha	Petri II WPA	43.679	-97.0932	8-May-14
DRD–1038	*Chrysemys picta*	Painted Turtle	Minnehaha	Schaefer WPA	43.8117	-97.0312	8-May-14
DRD–1301	*Chrysemys picta*	Painted Turtle	Minnehaha	Voelker II WPA	43.7077	-97.1123	16-Jul-14
DRD–0848	*Chrysemys picta*	Painted Turtle	Brookings	Ziegler WPA	44.3138	-96.9767	Jul-14
DRD–0385	*Pseudacris maculata*	Boreal Chorus Frog	Minnehaha	Buffalo Lake WPA	43.8224	-97.0606	19-Jun-13
DRD–1102	*Pseudacris maculata*	Boreal Chorus Frog	Minnehaha	Buffalo Lake WPA	43.8224	-97.0606	18-Jun-14
DRD–1083	*Pseudacris maculata*	Boreal Chorus Frog	Deuel	Coteau Prairie WPA	44.8966	-96.7152	17-Jun-14
DRD–1095	*Pseudacris maculata*	Boreal Chorus Frog	Brookings	Eriksrud WPA	44.2501	-97.0587	16-Jun-14
DRD–0132	*Pseudacris maculata*	Boreal Chorus Frog	Brookings	Gerdink WPA	44.2044	-96.9556	13-May-13
DRD–0391	*Pseudacris maculata*	Boreal Chorus Frog	Minnehaha	Lost Lake WPA	43.6773	-97.0574	20-Jun-13
DRD–0392	*Pseudacris maculata*	Boreal Chorus Frog	Minnehaha	Lost Lake WPA	43.6773	-97.0574	20-Jun-13
DRD–0393	*Pseudacris maculata*	Boreal Chorus Frog	Minnehaha	Lost Lake WPA	43.6773	-97.0574	20-Jun-13
DRD–0410	*Pseudacris maculata*	Boreal Chorus Frog	Minnehaha	Lost Lake WPA	43.6773	-97.0574	8-Jul-13
DRD–0915	*Pseudacris maculata*	Boreal Chorus Frog	Minnehaha	Lost Lake WPA	43.6773	-97.0572	14-May-14
DRD–4523	*Pseudacris maculata*	Boreal Chorus Frog	Minnehaha	Lost Lake WPA	43.6773	-97.0574	20-Jun-13
DRD–0290	*Pseudacris maculata*	Boreal Chorus Frog	Deuel	Mundahl WPA	44.6765	-96.55	17-Jun-13
DRD–1078	*Pseudacris maculata*	Boreal Chorus Frog	Deuel	Mundahl WPA	44.6765	-96.55	17-Jun-14
DRD–0279	*Pseudacris maculata*	Boreal Chorus Frog	Deuel	Nelson WPA	44.9095	-96.6315	18-Jun-13
DRD–1079	*Pseudacris maculata*	Boreal Chorus Frog	Deuel	Nelson WPA	44.9095	-96.6315	17-Jun-14
DRD–0291	*Pseudacris maculata*	Boreal Chorus Frog	Minnehaha	Petri II WPA	43.6789	-97.0944	20-Jun-13
DRD–0292	*Pseudacris maculata*	Boreal Chorus Frog	Minnehaha	Petri II WPA	43.6789	-97.0944	20-Jun-13

Table A.23. Continued.

Field #	Species	Common Name	County	Locality	Latitude	Longitude	Date Collected
DRD–0340	*Pseudacris maculata*	Boreal Chorus Frog	Minnehaha	Petri II WPA	43.6789	-97.0944	20-Jun-13
DRD–0917	*Pseudacris maculata*	Boreal Chorus Frog	Minnehaha	Petri II WPA	43.6795	-97.0932	14-May-14
DRD–0918	*Pseudacris maculata*	Boreal Chorus Frog	Minnehaha	Petri II WPA	43.6795	-97.0932	14-May-14
DRD–1114	*Pseudacris maculata*	Boreal Chorus Frog	Minnehaha	Petri II WPA	43.6789	-97.0944	19-Jun-14
DRD–0406	*Pseudacris maculata*	Boreal Chorus Frog	Minnehaha	Petri II WPA	43.6785	-97.0948	5-Jul-13
DRD–0148	*Pseudacris maculata*	Boreal Chorus Frog	Moody	Pettigrew WPA	44.092	-96.8499	13-May-13
DRD–0149	*Pseudacris maculata*	Boreal Chorus Frog	Moody	Pettigrew WPA	44.092	-96.8499	13-May-13
DRD–0327	*Pseudacris maculata*	Boreal Chorus Frog	Moody	Pettigrew WPA	44.0926	-96.8502	18-Jun-13
DRD–1232	*Pseudacris maculata*	Boreal Chorus Frog	Moody	Pettigrew WPA	44.0926	-96.8502	6-Jul-14
DRD–0151	*Pseudacris maculata*	Boreal Chorus Frog	Minnehaha	Schaefer WPA	43.8121	-97.0354	16-May-13
DRD–0270	*Pseudacris maculata*	Boreal Chorus Frog	Deuel	Schafer WPA	44.9155	-96.7169	17-Jun-13
DRD–0141	*Pseudacris maculata*	Boreal Chorus Frog	Minnehaha	Voelker II WPA	43.7062	-97.1114	15-May-13
DRD–1100	*Pseudacris maculata*	Boreal Chorus Frog	Brookings	Ziegler WPA	44.3139	-96.9773	16-Jun-14
DRD–0333	*Rana pipiens*	Northern Leopard Frog	Minnehaha	Acheson WPA	43.8028	-97.0597	19-Jun-13
DRD–0334	*Rana pipiens*	Northern Leopard Frog	Minnehaha	Acheson WPA	43.8028	-97.0597	19-Jun-13
DRD–0335	*Rana pipiens*	Northern Leopard Frog	Minnehaha	Acheson WPA	43.8028	-97.0597	19-Jun-13
DRD–0336	*Rana pipiens*	Northern Leopard Frog	Minnehaha	Acheson WPA	43.8028	-97.0597	19-Jun-13
DRD–0337	*Rana pipiens*	Northern Leopard Frog	Minnehaha	Acheson WPA	43.8028	-97.0597	19-Jun-13
DRD–0338	*Rana pipiens*	Northern Leopard Frog	Minnehaha	Acheson WPA	43.8028	-97.0597	19-Jun-13
DRD–0429	*Rana pipiens*	Northern Leopard Frog	Minnehaha	Acheson WPA	43.8028	-97.0597	17-Jul-13
DRD–0430	*Rana pipiens*	Northern Leopard Frog	Minnehaha	Acheson WPA	43.8028	-97.0597	17-Jul-13
DRD–0431	*Rana pipiens*	Northern Leopard Frog	Minnehaha	Acheson WPA	43.8028	-97.0597	17-Jul-13
DRD–0325	*Rana pipiens*	Northern Leopard Frog	Minnehaha	Buffalo Lake WPA	43.8224	-97.0606	19-Jun-13
DRD–0326	*Rana pipiens*	Northern Leopard Frog	Minnehaha	Buffalo Lake WPA	43.8224	-97.0606	19-Jun-13
DRD–0386	*Rana pipiens*	Northern Leopard Frog	Minnehaha	Buffalo Lake WPA	43.8224	-97.0606	19-Jun-13
DRD–0387	*Rana pipiens*	Northern Leopard Frog	Minnehaha	Buffalo Lake WPA	43.8224	-97.0606	19-Jun-13
DRD–0388	*Rana pipiens*	Northern Leopard Frog	Minnehaha	Buffalo Lake WPA	43.8224	-97.0606	19-Jun-13
DRD–0389	*Rana pipiens*	Northern Leopard Frog	Minnehaha	Buffalo Lake WPA	43.8224	-97.0606	19-Jun-13
DRD–0276	*Rana pipiens*	Northern Leopard Frog	Deuel	Coteau Prairie WPA	44.8966	-96.7152	17-Jun-13
DRD–1082	*Rana pipiens*	Northern Leopard Frog	Deuel	Coteau Prairie WPA	44.8966	-96.7152	17-Jun-14
DRD–1284	*Rana pipiens*	Northern Leopard Frog	Deuel	Coteau Prairie WPA	44.8966	-96.7152	15-Jul-14
DRD–1285	*Rana pipiens*	Northern Leopard Frog	Deuel	Coteau Prairie WPA	44.8966	-96.7152	15-Jul-14
DRD–0418	*Rana pipiens*	Northern Leopard Frog	Brookings	Gerdink WPA	44.2029	-96.9559	16-Jul-13
DRD–0419	*Rana pipiens*	Northern Leopard Frog	Brookings	Gerdink WPA	44.2029	-96.9559	16-Jul-13
DRD–0420	*Rana pipiens*	Northern Leopard Frog	Brookings	Gerdink WPA	44.2029	-96.9559	16-Jul-13
DRD–1092	*Rana pipiens*	Northern Leopard Frog	Brookings	Gerdink WPA	44.2029	-96.9596	23-Jun-14
DRD–0274	*Rana pipiens*	Northern Leopard Frog	Deuel	Johnson I WPA	44.6263	-96.5	17-Jun-13
DRD–0280	*Rana pipiens*	Northern Leopard Frog	Deuel	Johnson I WPA	44.6263	-96.5	17-Jun-13
DRD–0427	*Rana pipiens*	Northern Leopard Frog	Deuel	Johnson I WPA	44.6263	-96.5003	18-Jul-13
DRD–1287	*Rana pipiens*	Northern Leopard Frog	Deuel	Johnson I WPA	44.6256	-96.4998	15-Jul-14
DRD–1283	*Rana pipiens*	Northern Leopard Frog	Deuel	Johnson II WPA	44.559	-96.4549	15-Jul-14
DRD–0142	*Rana pipiens*	Northern Leopard Frog	Deuel	Johnson II WPA	44.5564	-96.4551	15-May-13
DRD–0914	*Rana pipiens*	Northern Leopard Frog	Deuel	Johnson II WPA	44.5599	-96.4542	13-May-14

Table A.23. Continued.

Field #	Species	Common Name	County	Locality	Latitude	Longitude	Date Collected
DRD–0433	*Rana pipiens*	Northern Leopard Frog	Minnehaha	Lost Lake WPA	43.6773	-97.0574	17-Jul-13
DRD–0902	*Rana pipiens*	Northern Leopard Frog	Minnehaha	Lost Lake WPA	43.6751	-97.0571	8-May-14
DRD–1286	*Rana pipiens*	Northern Leopard Frog	Deuel	Nelson WPA	44.9095	-96.6315	15-Jul-14
DRD–0339	*Rana pipiens*	Northern Leopard Frog	Minnehaha	Petri II WPA	43.6789	-97.0944	20-Jun-13
DRD–0342	*Rana pipiens*	Northern Leopard Frog	Minnehaha	Petri II WPA	43.6789	-97.0944	20-Jun-13
DRD–0448	*Rana pipiens*	Northern Leopard Frog	Minnehaha	Petri II WPA	43.6789	-97.0944	17-Jul-13
DRD–0449	*Rana pipiens*	Northern Leopard Frog	Minnehaha	Petri II WPA	43.6789	-97.0944	17-Jul-13
DRD–0450	*Rana pipiens*	Northern Leopard Frog	Minnehaha	Petri II WPA	43.6789	-97.0944	17-Jul-13
DRD–0451	*Rana pipiens*	Northern Leopard Frog	Minnehaha	Petri II WPA	43.6789	-97.0944	17-Jul-13
DRD–0916	*Rana pipiens*	Northern Leopard Frog	Minnehaha	Petri II WPA	43.6794	-97.0933	14-May-14
DRD–1115	*Rana pipiens*	Northern Leopard Frog	Minnehaha	Petri II WPA	43.6789	-97.0944	19-Jun-14
DRD–1293	*Rana pipiens*	Northern Leopard Frog	Minnehaha	Petri II WPA	43.6789	-97.0944	16-Jul-14
DRD–1295	*Rana pipiens*	Northern Leopard Frog	Minnehaha	Petri II WPA	43.679	-97.0934	16-Jul-14
DRD–1296	*Rana pipiens*	Northern Leopard Frog	Minnehaha	Petri II WPA	43.6793	-97.0946	16-Jul-14
DRD–1294	*Rana pipiens*	Northern Leopard Frog	Minnehaha	Petri II WPA	43.6789	-97.0944	16-Jul-14
DRD–0413	*Rana pipiens*	Northern Leopard Frog	Minnehaha	Petri II WPA	43.6785	-97.0948	5-Jul-13
DRD–0414	*Rana pipiens*	Northern Leopard Frog	Minnehaha	Petri II WPA	43.6785	-97.0948	5-Jul-13
DRD–0411	*Rana pipiens*	Northern Leopard Frog	Minnehaha	Petri II WPA	43.6785	-97.0948	5-Jul-13
DRD–0412	*Rana pipiens*	Northern Leopard Frog	Minnehaha	Petri II WPA	43.6785	-97.0948	5-Jul-13
DRD–0328	*Rana pipiens*	Northern Leopard Frog	Moody	Pettigrew WPA	44.0926	-96.8502	18-Jun-13
DRD–0329	*Rana pipiens*	Northern Leopard Frog	Moody	Pettigrew WPA	44.0926	-96.8502	18-Jun-13
DRD–0330	*Rana pipiens*	Northern Leopard Frog	Moody	Pettigrew WPA	44.0926	-96.8502	18-Jun-13
DRD–0331	*Rana pipiens*	Northern Leopard Frog	Moody	Pettigrew WPA	44.0926	-96.8502	18-Jun-13
DRD–0332	*Rana pipiens*	Northern Leopard Frog	Moody	Pettigrew WPA	44.0926	-96.8502	18-Jun-13
DRD–0440	*Rana pipiens*	Northern Leopard Frog	Moody	Pettigrew WPA	44.0926	-96.8502	21-Jun-13
DRD–0441	*Rana pipiens*	Northern Leopard Frog	Moody	Pettigrew WPA	44.0926	-96.8502	21-Jun-13
DRD–0442	*Rana pipiens*	Northern Leopard Frog	Moody	Pettigrew WPA	44.0926	-96.8502	21-Jun-13
DRD–0443	*Rana pipiens*	Northern Leopard Frog	Moody	Pettigrew WPA	44.0926	-96.8502	21-Jun-13
DRD–0444	*Rana pipiens*	Northern Leopard Frog	Moody	Pettigrew WPA	44.0926	-96.8502	21-Jun-13
DRD–0445	*Rana pipiens*	Northern Leopard Frog	Moody	Pettigrew WPA	44.0926	-96.8502	21-Jun-13
DRD–0312	*Rana pipiens*	Northern Leopard Frog	Moody	Pettigrew WPA	44.0924	-96.849	23-Jun-13
DRD–0435	*Rana pipiens*	Northern Leopard Frog	Moody	Pettigrew WPA	44.0926	-96.8502	19-Jul-13
DRD–0436	*Rana pipiens*	Northern Leopard Frog	Moody	Pettigrew WPA	44.0926	-96.8502	19-Jul-13
DRD–0437	*Rana pipiens*	Northern Leopard Frog	Moody	Pettigrew WPA	44.0926	-96.8502	19-Jul-13
DRD–0438	*Rana pipiens*	Northern Leopard Frog	Moody	Pettigrew WPA	44.0926	-96.8502	19-Jul-13
DRD–0422	*Rana pipiens*	Northern Leopard Frog	Lake	Ramsey WPA	44.1933	-96.9649	16-Jul-13
DRD–0423	*Rana pipiens*	Northern Leopard Frog	Lake	Ramsey WPA	44.1933	-96.9649	16-Jul-13
DRD–0428	*Rana pipiens*	Northern Leopard Frog	Minnehaha	Schaefer WPA	43.8124	-97.0334	17-Jul-13
DRD–0901	*Rana pipiens*	Northern Leopard Frog	Minnehaha	Schaefer WPA	43.8117	-97.0323	8-May-14
DRD–0446	*Rana pipiens*	Northern Leopard Frog	Minnehaha	Voelker II WPA	43.7073	-97.1117	17-Jul-13
DRD–0447	*Rana pipiens*	Northern Leopard Frog	Minnehaha	Voelker II WPA	43.7073	-97.1117	17-Jul-13
DRD–0138	*Thamnophis radix*	Plains garter snake	Moody	Pettigrew WPA	44.092	-96.8502	13-May-13
DRD–0920	*Thamnophis radix*	Plains garter snake	Deuel	Schafer WPA	44.916	-96.7163	14-May-14

Note: WPA = Waterfowl Production Area

Table A.24. Number of individual aquatic invertebrates collected from wetland sites within the Madision Wetland Management District, 2013–2014.

			Number of Inviduals						Number of Inviduals		
Class	Order	Family	Reference Wetlands	Surface Wetlands	Tile Wetlands	Class	Order	Family	Reference Wetlands	Surface Wetlands	Tile Wetlands
Arachnida	Hydracarina	–	149	215	312	Hexapoda	Hemiptera	Belostomatidae	12	15	3
Branchiopoda	Anostraca	–	1	0	0			Corixidae	2,295	5,570	2,421
Gastropoda	Prosobranchia	–	9,545	14,206	17,622			Gerridae	10	9	2
	Pulmonata	–	29,070	24,885	10,932			Hebridae	8	11	19
Hexapoda	Coleoptera	Curculionidae	66	44	550			Nepidae	0	13	3
		Dytiscidae	379	385	631			Notonectidae	567	880	308
		Gyrinidae	27	1	2			Pleidae	597	756	536
		Haliplidae	271	352	281			Veliidae	23	168	79
		Hydrophilidae	389	1,004	1,179		Lepidoptera	Pyralidae	7	7	13
		Lampyridae	1	3	13		Odonata	Aeshnidae	468	497	215
		Staphylinidae	2	3	8			Coenagrionidae	1,845	1,242	701
		–	2	1	1			Cordullidae	1	0	0
	Collembola	Isotomidae	94	22	242			Lestidae	1	0	0
		Poduridae	11	93	727			Libellulidae	64	83	29
		Sminthuridae	1	4	9		Trichoptera	Brachycentridae	1	1	2
	Diptera	Ceratopogonidae	139	91	440			Helicopsychidae	0	4	5
		Chaoboridae	125	12	22			Hydroptilidae	1	10	4
		Chironomidae	5,867	6,073	13,541			Lepidostomatidae	0	4	0
		Culicidae	93	81	51			Leptoceridae	0	0	1
		Dolichopodidae	4	2	5			Limnephilidae	56	13	4
		Ephydridae	93	116	363			Molannidae	0	1	0
		Psychodidae	203	169	151			Phryganeidae	1	0	0
		Simulidae	0	6	0	Hirudinea	–	–	115	178	631
		Stratiomyidae	362	282	725	Malacostraca	Amphipoda	–	569	2,282	1,040
		Syrphidae	3	8	27		Decapoda	Malacostraca	29	30	38
		Tipulidae	18	7	30		Isopoda	–	6	0	3
		–	23	30	51	Clitellata	Lumbriculida	Lubriculidae	133	289	467
	Ephemeroptera	Baetidae	12	62	32	Ostracoda	Podocopida	–	6,898	10,303	20,427
		Caenidae	399	863	270						
		Ephemeridae	1	0	0						
		Isonychiidae	673	669	369						

Note: total number of sweeps by site category were 3,020 (Reference Wetlands), 2,780 (Surface Wetlands), and 3,460 (Tile Wetlands).

APPENDIX B: ADDITIONAL FIGURES

Figure B.1. Acheson Waterfowl Production Area (WPA) site map. Note: red line is WPA boundary, yellow circle with dot marks a tile outfall (Ache1) and green triangle marks the wetland site (Ache1A) sampled. Imagery from Google Earth (March 2015).

Figure B.2. Buffalo Lake Waterfowl Production Area (WPA) site map. Note: red line is WPA boundary, green triangle marks the wetland site (Buff1) sampled. Imagery from Google Earth (March 2015).

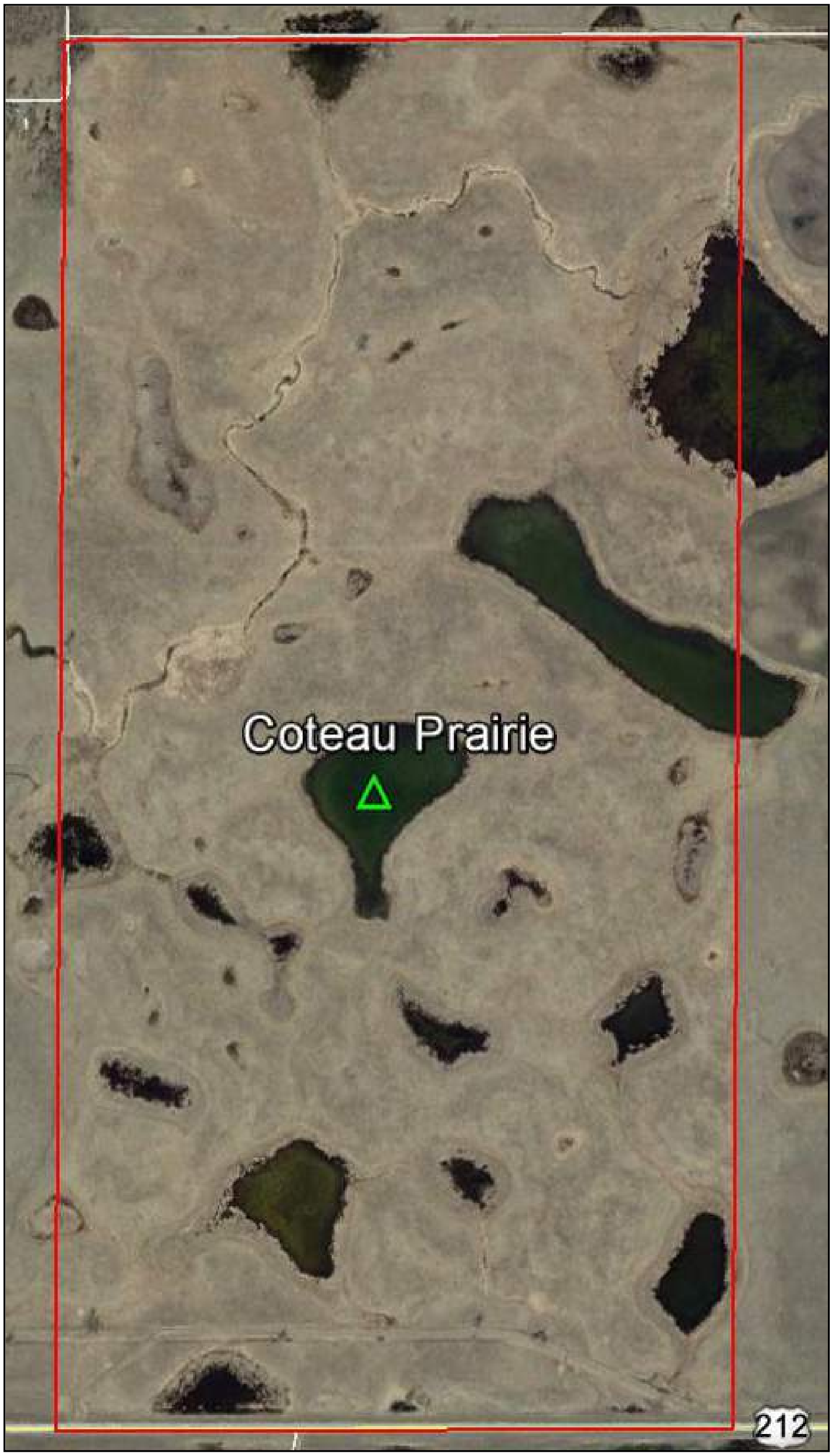

Figure B.3. Coteau Prairie Waterfowl Production Area (WPA) site map. Note: red line is WPA boundary, green triangle marks the wetland site (Cote1) sampled. Imagery from Google Earth (April 2014).

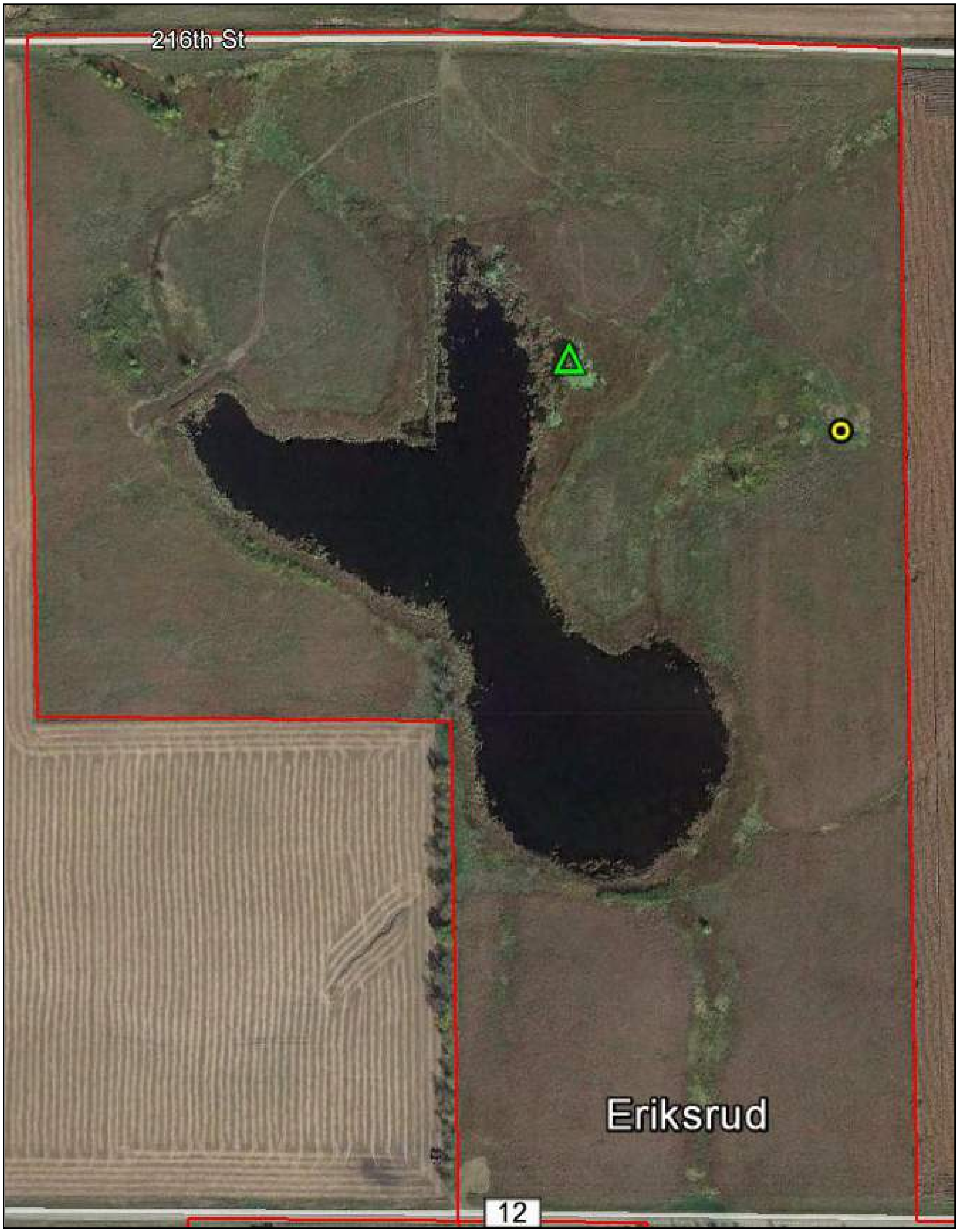

Figure B.4. Eriksrud Waterfowl Production Area (WPA) site map. Note: red line is WPA boundary, yellow circle with dot marks a tile outfall (Bols1) and green triangle marks the wetland site (Bols1A) sampled. Imagery from Google Earth (October 2014).

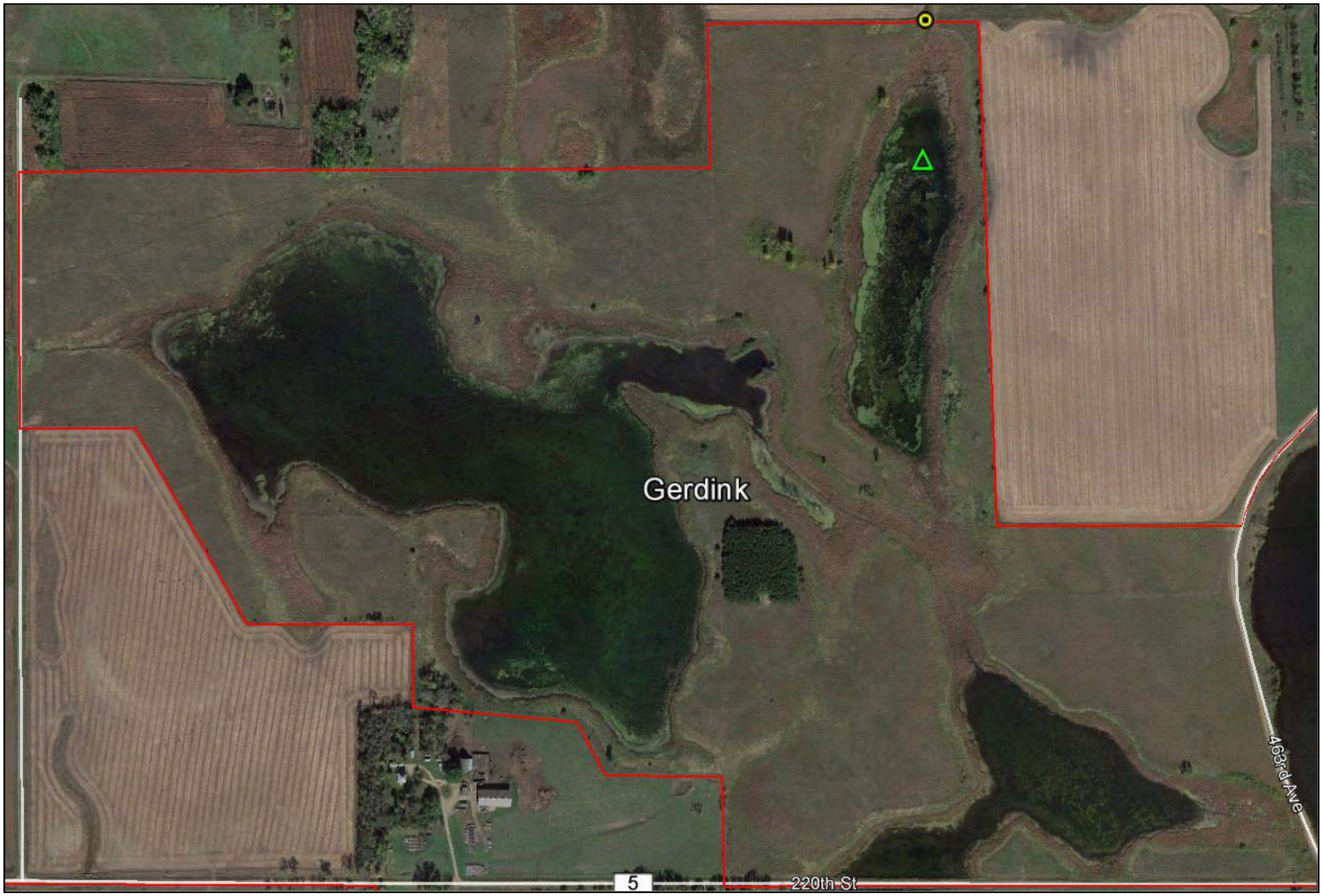

Figure B.5. Gerdink Waterfowl Production Area (WPA) site map. Note: red line is WPA boundary, yellow circle with dot marks a tile outfall (Gerk1) and green triangle marks the wetland site (Gerk1A) sampled. Imagery from Google Earth (October 2014).

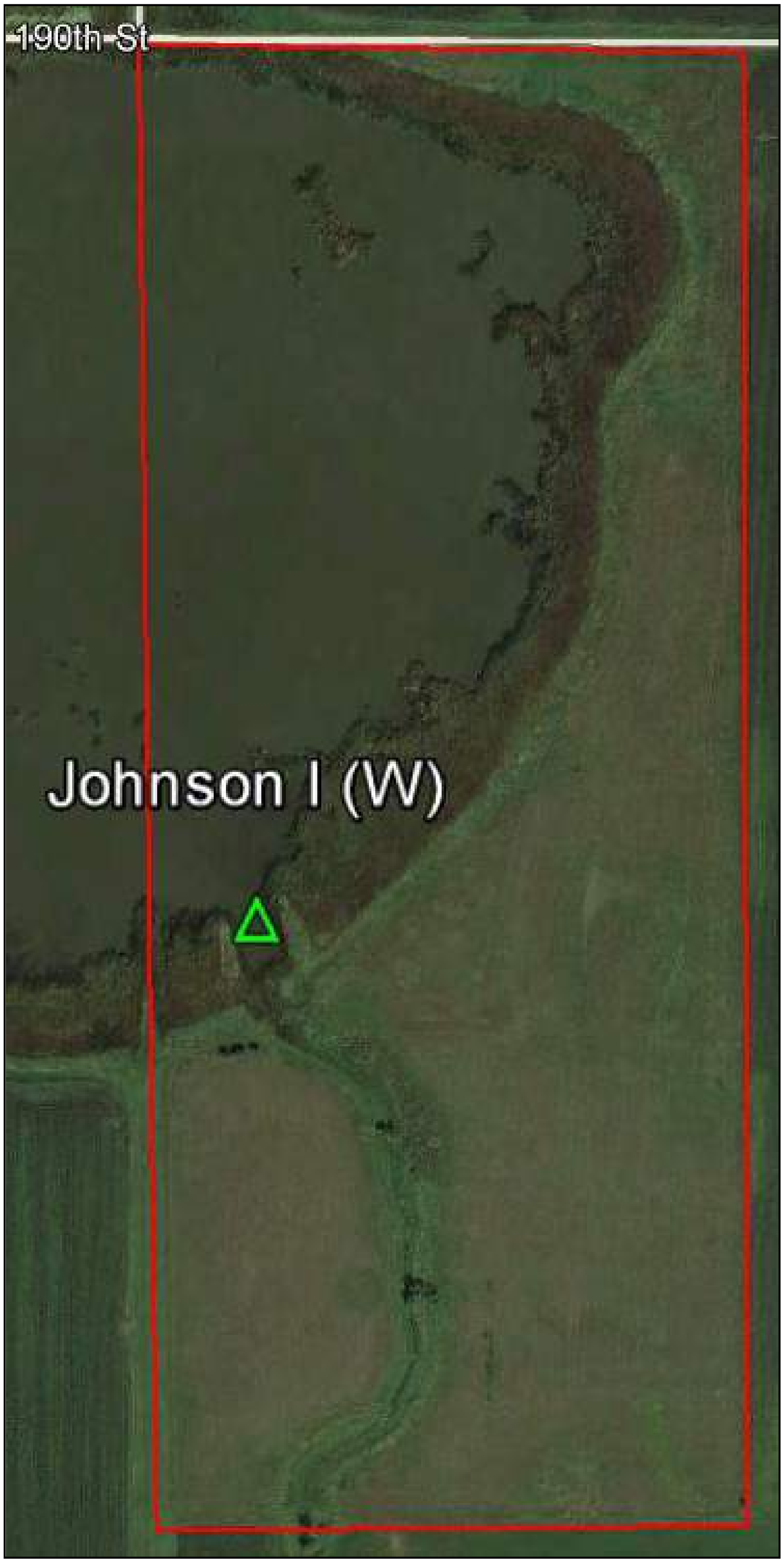

Figure B.6. Johnson I Waterfowl Production Area (WPA) site map. Note: red line is WPA boundary, green triangle marks the wetland site (John1) sampled. Imagery from Google Earth (September 2015).

Figure B.7. Johnson II Waterfowl Production Area (WPA) site map. Note: red line is WPA boundary, yellow circle with dot marks a tile outfall (Hejo1 and Hejo2) and green triangle marks the wetland site (Hejo1A) sampled. Imagery from Google Earth (September 2015).

Figure B.8. Lost Waterfowl Production Area (WPA) site map. Note: red line is WPA boundary, green triangle marks the wetland site (Lost1) sampled. Imagery from Google Earth (September 2015).

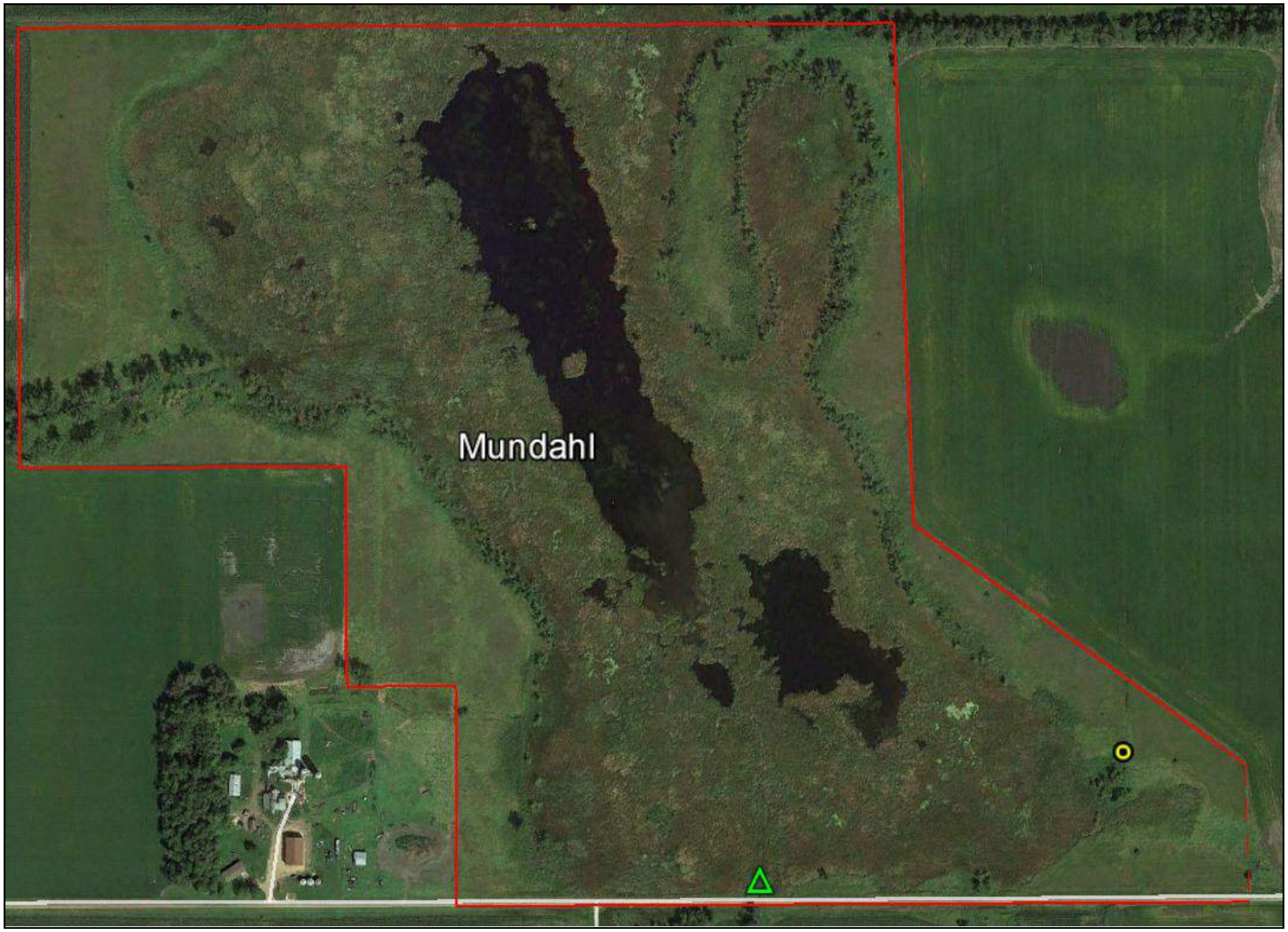

Figure B.9. Mundahl Waterfowl Production Area (WPA) site map. Note: red line is WPA boundary, yellow circle with dot marks a tile outfall (Mund1T) and green triangle marks the wetland site (Mund1) sampled. Imagery from Google Earth (September 2015).

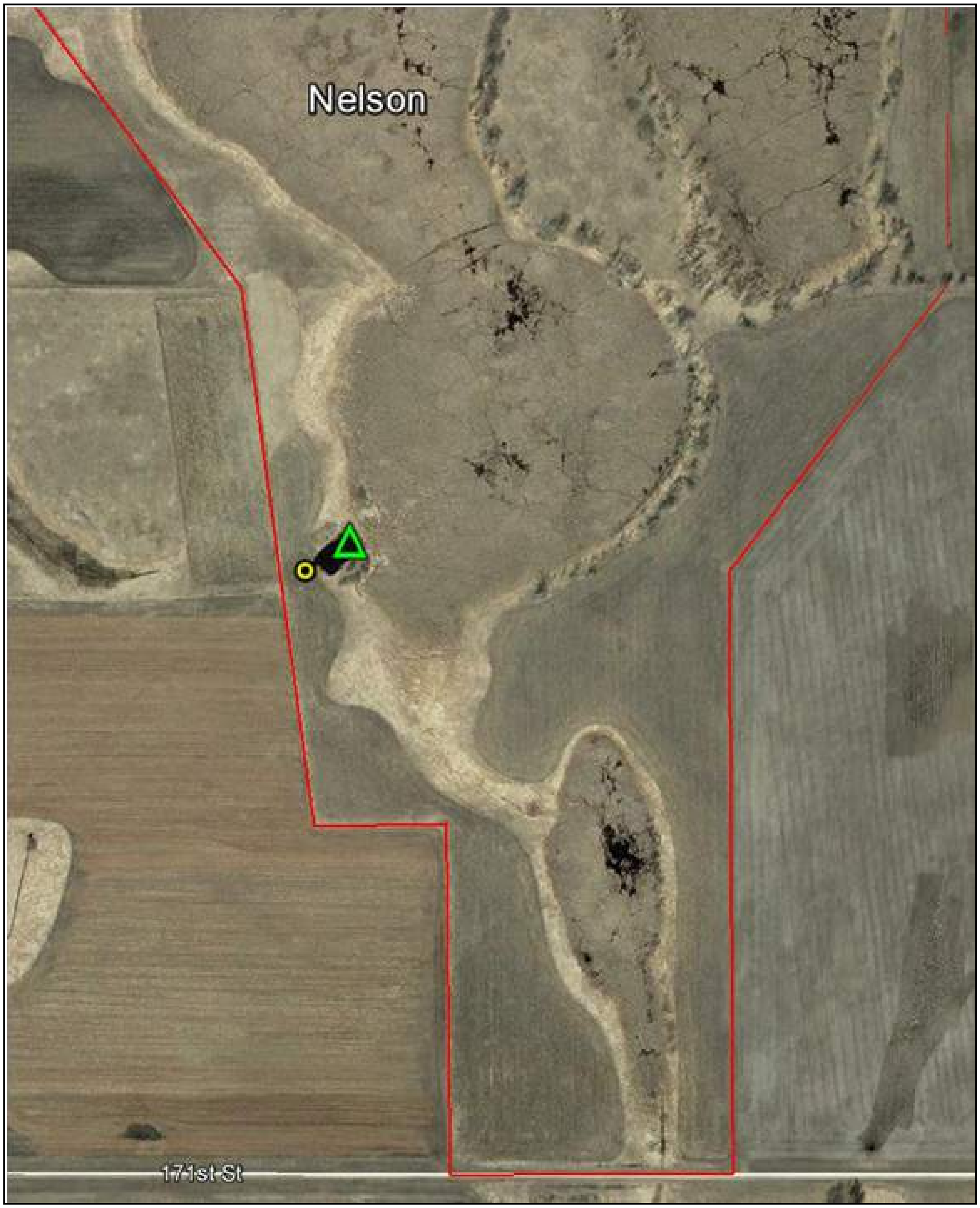

Figure B.10. Nelson Waterfowl Production Area (WPA) site map. Note: red line is WPA boundary, yellow circle with dot marks a tile outfall (Nels1) and green triangle marks the wetland site (Nels1A) sampled. Imagery from Google Earth (September 2015).

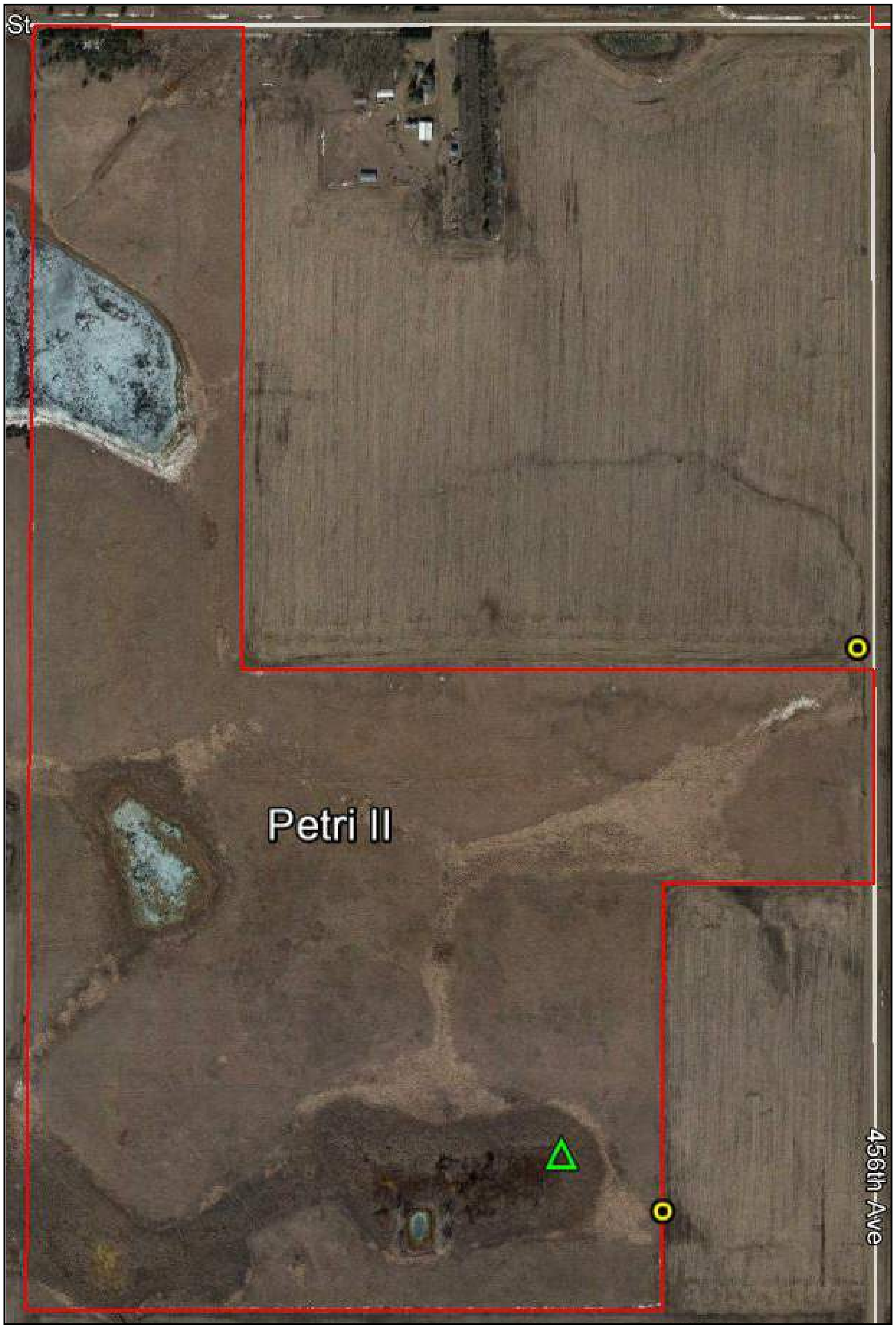

Figure B.11. Petri II Waterfowl Production Area (WPA) site map. Note: red line is WPA boundary, yellow circle with dot marks a tile outfall (2Petr1 and 2Petr2) and green triangle marks the wetland site (2Petr1A) sampled. Imagery from Google Earth (March 2015).

Figure B.12. Pettigrew Waterfowl Production Area (WPA) site map. Note: red line is WPA boundary and green triangle marks the wetland site (Pett1) sampled. Imagery from Google Earth (October 2014).

Figure B.13. Pittenger Waterfowl Production Area (WPA) site map. Note: red line is WPA boundary and green triangle marks the wetland site (Pitt1) sampled. Imagery from Google Earth (October 2014).

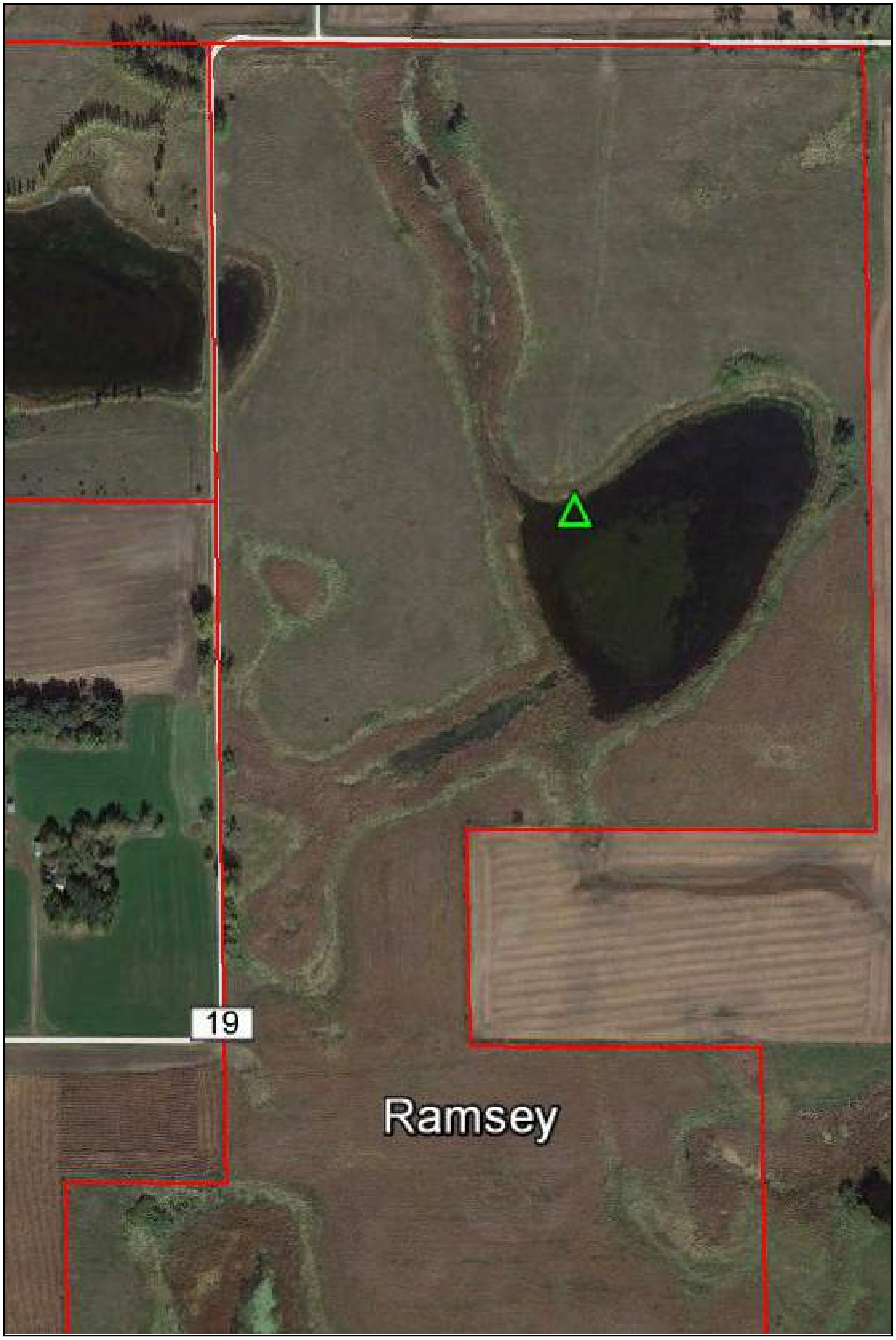

Figure B.14. Ramsey Waterfowl Production Area (WPA) site map. Note: red line is WPA boundary and green triangle marks the wetland site (Rams1) sampled. Imagery from Google Earth (October 2014).

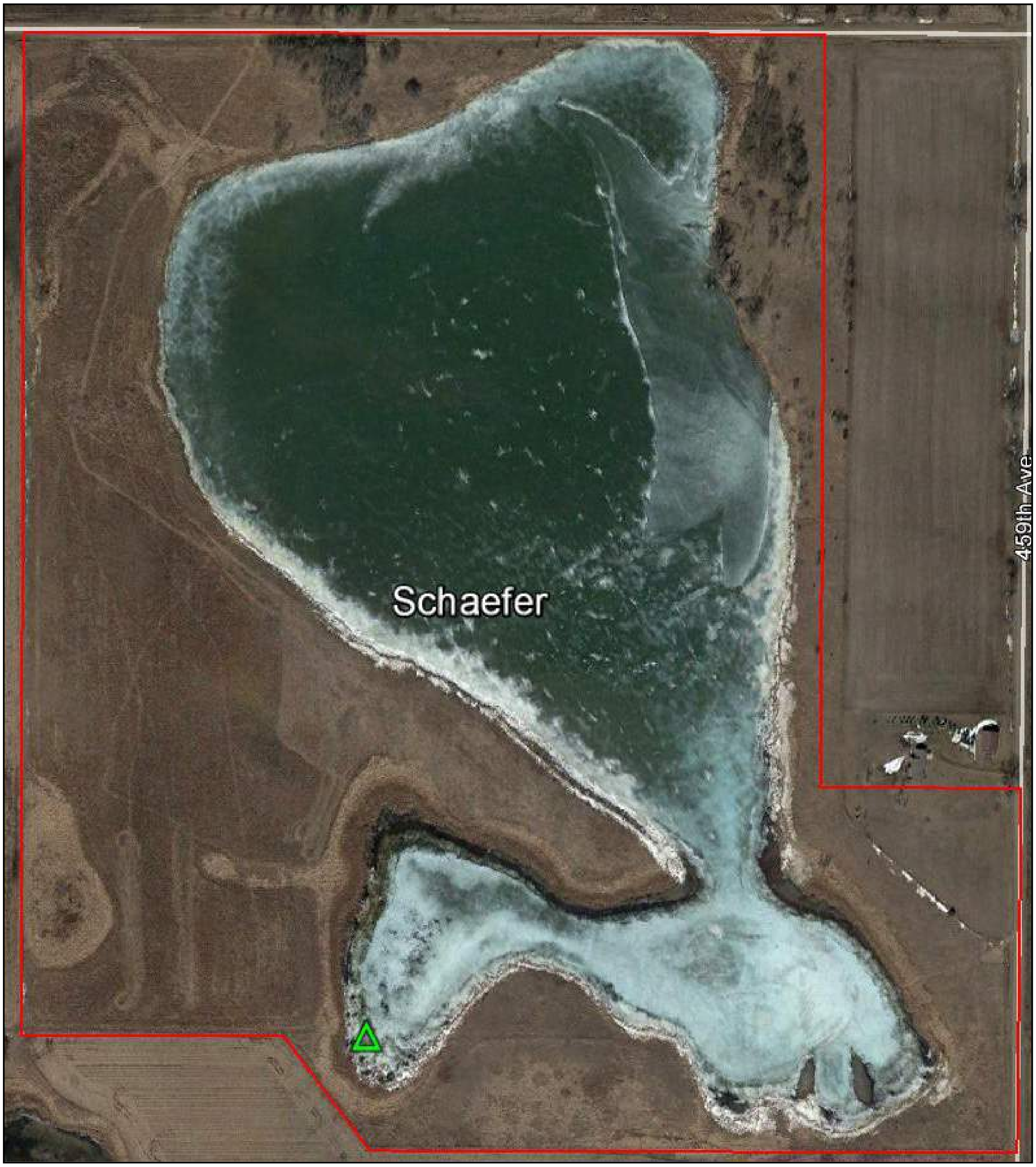

Figure B.15. Schaefer Waterfowl Production Area (WPA) site map. Note: red line is WPA boundary and green triangle marks the wetland site (Schae1) sampled. Imagery from Google Earth (March 2015).

Figure B.16. Schafer Waterfowl Production Area (WPA) site map. Note: red line is WPA boundary and green triangle marks the wetland site (Schaf1) sampled. Imagery from Google Earth (April 2014).

Figure B.17. Volker II Waterfowl Production Area (WPA) site map. Note: red line is WPA boundary and green triangle marks the wetland site (Volk1) sampled. Imagery from Google Earth (April 2014).

Figure B.18. Ziegler Waterfowl Production Area (WPA) site map. Note: red line is WPA boundary and green triangle marks the wetland site (Zieg1) sampled. Imagery from Google Earth (April 2014).

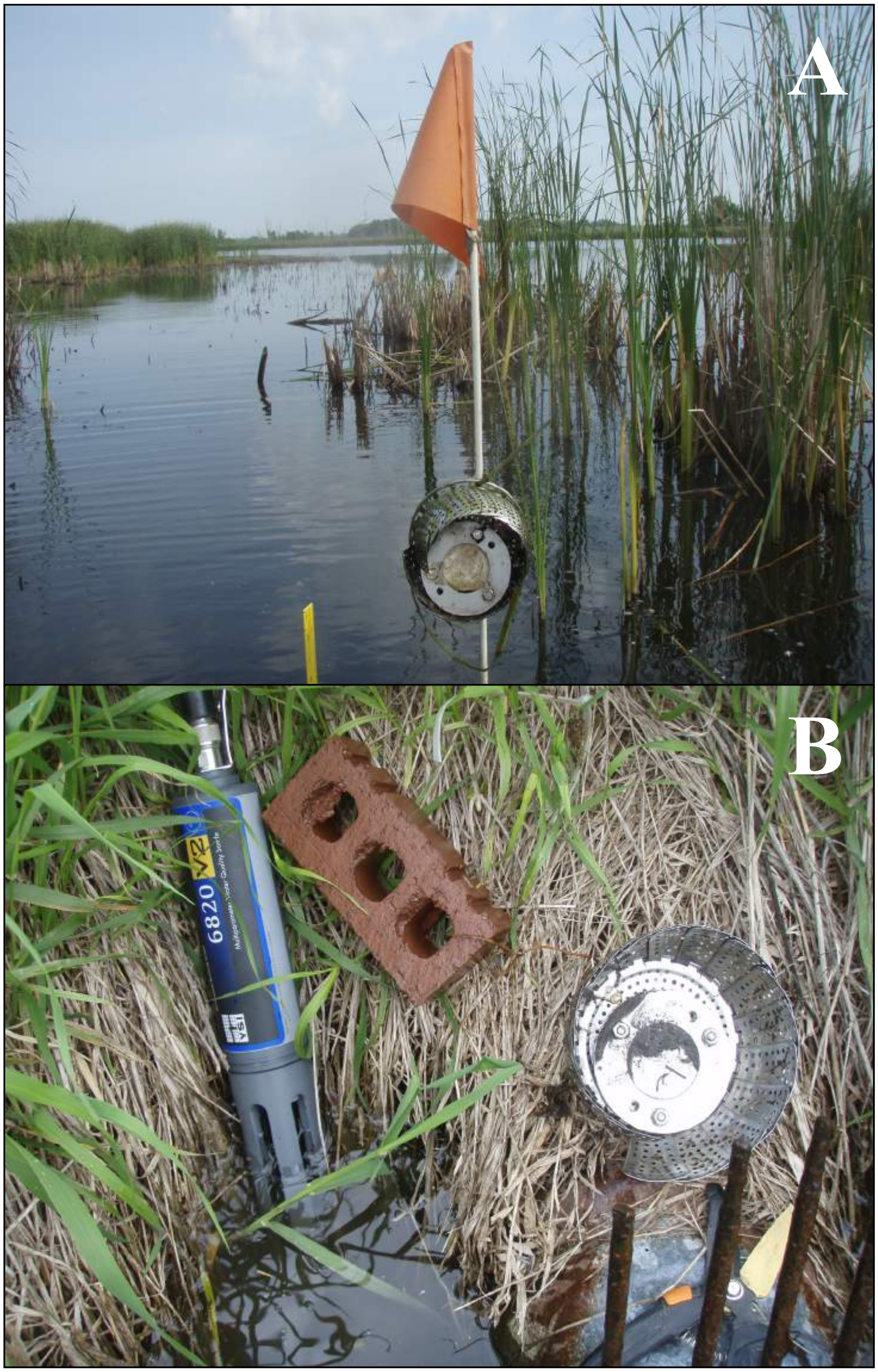

Figure B.19. Deployment of polar organic chemical integrative samplers (POCIS) by connecting to flag (A) or to a brick (B).

Figure B.20. Sediments from adjacent cornfield that buried Tile Outfall M3 (A) and extended past the fence onto Madison WPA (B) following a large rain event in June 2014. Note: red arrow points to edge of buried M3 outfall pipe.

Figure B.21. Crop duster plane observed over Pitt1 Reference Wetland on 15 May 2013, Brookings County, South Dakota.