U.S. Fish and Wildlife Service
Region 2
Contaminants Program

CONTAMINANTS INVESTIGATION OF BUFFALO LAKE NATIONAL WILDLIFE REFUGE (Interim Report) 1994

by

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INTRODUCTION

Buffalo Lake National Wildlife Refuge (BLNWR) is located in the Southern High Plains Region of the Texas Panhandle, in Randall County (Figure 1). Upon the completion of Umbarger Dam across Tierra Blanca Creek in 1939, Buffalo Lake was created. In 1941, the lake filled and overflowed the inadequately designed spillway and nearly destroyed the integrity of the dam. A minimum pool level was maintained while dam safety was considered. Meanwhile, the newly created lake, its vast shallow wetlands, and nearby agricultural crops attracted millions of waterfowl migrating along the Central Flyway. Buffalo Lake was also a valuable source of recreation in this semi-arid region. To better perpetuate the migratory bird resource, despite assuming liability for a defective dam, the U.S. Fish and Wildlife Service (Service) assumed trusteeship for Buffalo Lake National Wildlife Refuge by Secretarial Order 2843 on November 17, 1959.

Irwin and Dodson (1991) documented severe contamination at BLNWR during the initial contaminant survey in 1986. Watersheds upstream from BLNWR include numerous combined animal feedlots (CAFO). Approximately one million dry tons of manure are generated annually by an estimated 500,000 head of beef cattle within the 1,724 square mile watersheds of Tierra Blanca Creek and Frio Draw. Nutrients, salts, and other contaminants are possible pollutants of concern in the creek and could adversely impact the management and the natural resources of BLNWR. Nutrients, ammonia, and trace elements such as copper, strontium, and zinc were elevated in cattle waste lagoons, and were significantly higher in the creek and refuge influent water downstream of the feedlots compared with areas upstream of feedlots. Past fish kills, bacteriological contamination, and undesirable eutrophic conditions in the lake resulted from waste-laden water for Buffalo Lake.

Farming selected areas of the BLNWR dry lake bed has been practiced since 1988. Soil nutrients and contaminants will be reevaluated and compared with the 1987 study results to determine the nutrient uptake and contaminant removal efficiency of cropping.

Migratory waterfowl use of the BLNWR has declined in past years. Lack of available surface water is suspected as the primary reason for the decline in bird use. The development of five moist soil management units upstream from Stewart Dike is planned to increase migratory waterfowl use of BLNWR. The units flooded with pumped well water would also compensate for the contaminant nutrient loading received from upstream waters of Tierra Blanca Creek and improve aquatic and wetland habitat.

Objectives of this study include:

1. Stormwater monitoring To evaluate the extent of contamination in stormwater entering the refuge from Tierra Blanca Creek watershed and to determine if recent State regulations have beneficially affected cattle feedlot nonpoint source discharges.

2. Contaminant removal by farming - To evaluate the extent of contamination in Buffalo Lake soils and vegetation and evaluate the ability of crops grown in the dry lake bed to reduce soil contaminant concentrations.

3. Moist soil management unit monitoring - To evaluate and monitor contaminant levels in sediments, water, vegetation, and invertebrates before and after establishment of moist soil management units constructed upstream of Stewart Dike.

See Table/Figure

Figure 1. Location of Buffalo Lake National Wildlife Refuge.

This interim report discusses sample collection methods and preliminary results of water, soil, and plant samples collected from Tierra Blanca Creek and BLNWR. Final data evaluation and collection of samples will continue during FY 1995. A final report is projected to be completed in early FY 1996.

BACKGROUND

Cattle feedlot operations along Tierra Blanca Creek are required by the Texas Natural Resource Conservation Commission and the Environmental Protection Agency to contain pollutants in waste retention lagoons and prevent their discharge unless a rainfall of greater than 4.5 to 5.0 inches occurs during a 24-hour period, 25-year storm event. The current compliance schedule for CAFOs under 1,000 head extends into 1995.

A contaminant study of the Tierra Blanca Creek watershed including BLNWR was conducted by the Service's Arlington Ecological Services Field Office in 1987 (Irwin and Dodson 1991). The conclusions reached were:

1. Elevated concentrations of nutrients (nitrogen and phosphorus), salts, copper, strontium, and zinc were found in and downstream of CAFO retention pond soils;

2. Tierra Blanca Creek has degraded water quality, primarily associated with CAFOs and their nonpoint source discharges;

3. Nutrient concentrations in lake bed soils were elevated to the extent that inundation could create unacceptably high nutrient concentrations in the water; and,

4. The potential effects upon wildlife species that feed in or near CAFOs were unknown, but wildlife are likely burdened by the ingestion of poor quality water and sediments.

Recommendations in the 1991 report are to increase the regulations for CAFOs and their wastes, continue monitoring, and evaluate the effects of elevated nutrients and veterinary drugs on wildlife.

Over time, the water quality of Buffalo Lake deteriorated as a result of accumulated sediments and nutrients and inadequate inflows. During recent years, with the exception of major storms, little or no water flowed from Tierra Blanca Creek into the lake. Tierra Blanca Creek has changed from a perennial to an ephemeral stream. In 1985, the U. S. Bureau of Reclamation (Bureau) reported that while average rainfall remains consistent over time, trends in runoff data support the suggestion that the amount of precipitation required to produce significant runoff has increase since about 1960. This phenomenon may be partly due to the construction of check dams by farmers and pumping from deep wells resulting in a lower ground water table, thus increasing infiltration.

The water quality and subsequent closure of Buffalo Lake is discussed by Irwin and Dodson (1991). After Buffalo Lake was drained in 1978, the Service constructed a low level dike, Stewart Dike, to retain water in Stewart Marsh and develop moist soil management units for winter waterfowl use. Four small, circular ponds were also constructed in the dry lake bed to maintain water for wildlife. Replacement of Umbarger dam began soon after the Lake was drained in 1978. By 1993, Umbarger Dam was rebuilt.

METHODS AND MATERIALS

Twenty six study sites were selected along Tierra Blanca Creek and the BLNWR. Water, soil/sediments, vegetation, and biota samples were collected between August 1993 and June 1994 (Table 1). Stormwater was collected within a few hours after the start of the rain event at seven sites from Tierra Blanca Creek (Creek). After stormwater receded, water samples were collected from the Creek above Stewart Marsh, at Stewart Marsh, and the four constructed ponds on BLNWR. Additional water samples were also collected from the four ponds one year later. A groundwater sample was collected from one site on BLNWR. A 1-liter, precleaned polyethylene bottle was used to collect grab samples of stormwater, post stormwater, and groundwater. Samples were not filtered, but immediately acidified with 5 milliliters (ml) of concentrated nitric acid, frozen, and later refrigerated for future analyses. Simultaneously, 1-liter, glass bottles were filled, acidified with 5-mi concentrated sulfuric acid, refrigerated and submitted for analyses.

Composite soil samples were collected from three cropping treatments at the BLNWR's dry lake bed. Cropping treatments included wheat, sorghum (milo/sudan grass combination), and fallow fields. Four fields per cropping treatment were selected at random and two transects were selected at random for each field. Two composite soil samples were collected per transect. Soil samples were collected using a hand-held, polycarbonate WildCo core sampler to a depth of three inches, sifted with a stainless steel and brass sieve, placed in precleaned jars, and kept frozen until submitted for analyses. Four composite sediment samples were collected from each pond. Sediment samples were collected using a hand-held, polycarbonate WildCo core sampler to a depth of five inches, placed in whirlpaks and frozen for future analyses. Additional sediment samples were collected from ponds 1 and 2 and placed in foil and frozen for future analyzes.

Composite plant samples were collected concurrently with soil samples from the three cropping treatments and the Stewart Dike. Because the wheat crops failed, Kochia sp. was collected. Sudan grass was collected from sorghum fields and Kochia sp. was collected from fallow fields. Plants of uniform size were cut at the soil's surface and bagged without washing and refrigerated for analyses. In addition, composite aquatic plant samples were collected from ponds 1, 3, and 4. Aquatic plant species included Chara sp. (a submergent aquatic), pondweed (Potamogeton pusillus), and sedge (Cyperus sp.) seeds. Aquatic plants were rinsed with water from the site, placed in plastic bags, and frozen until submitted for analyses.

Composite grasshopper samples were collected with a dip-net from Stewart Dike and fields dominated by Kochia sp. or sorghum. Numerous individuals were bagged and frozen for future analyses.

Biota samples were collected from ponds 1, 3, and 4. Composite samples of damselfly nymphs were collected from ponds 1, 3 and 4. A composite tadpole sample was collected from pond 3. A mourning dove (Zenaidura macroura) and red-winged blackbird (Agelaius phoeniceus) fledgling and composite mourning dove and red-winged blackbird eggs were collected from pond 1. An unidentified species of avian fledgling was collected from pond 4. Damselfly and tadpole samples were collected by a dip net, placed in whirlpaks and frozen until submitted for analyses. Fledglings were collected by hand, euthanized, wrapped in plastic and frozen for future analyses. The bird eggs were collected by hand, contents removed, placed in foil, and frozen until submitted for analyses.

Table 1. Buffalo Lake National Wildlife Refuge collection locations and type of analyses for collected media, Texas, 1993. SW = stormwater, W = water, GW = groundwater, S = soil/sediment, P = plant, GH = grasshopper, DF = damselfly nymph, TP = tadpole, FL = fledgling, E = egg, and F = fish tissue.

Site Number	Station Location	Metalloids[sup]1	Nutrientsý	Organochlorine[sup]3
1	Tierra Blanca Creek at FM 1057	SW, W, S	S	
2	Tierra Blanca Creek at Holly Sugar Plant	SW, W, S	S	
3	Tierra Blanca Creek east of Hereford	SW, W. S	S	
4	Tierra Blanca Creek above TriState Feedyard	SW. W, S	S	

5	Tierra Blanca Creek below TriState Feedyard	SW, W, S	S, F, A	
6	Tierra Blanca Creek at Stewart Ranch	SW, W, S	S, F, A	
7	Tierra Blanca Creek above Stewart Marsh	SW, W, S	S, FL	
8	Stewart Marsh	W, P		
9	Grazing Unit #6	GW		
10	Moist Soil Management Unit	S, P, F	S	S, F, E
11	Pond 1	W, S, P, GH, DF, FL, E	W, S	S
12	Pond 2	W, S, P	W, S	S
13	Pond 3	W,S,DF,TP	W, S	
14	Pond 4	W, S, P, DF, FL	W, S	
15	Field 1 - Fallow	S, P	S	
16	Field 4 - Wheat	S, P	S	
17	Field 5 - Sorghum	S, P	S	
18	Field 6 - Sorghum	S, P, GH	S	
19	Field 7 - Wheat	S, P	S	
20	Field 10 - Sorghum	S, P, GH	S	
21	Field 11 - Wheat	S, P	S	
22	Field 12 - Fallow	S, P	S	
23	Field 13 - Wheat	S, P	S	
24	Field 19 - Sorghum	S, P, GH	S	
25	Field 21 - Fallow	S, P	S	
26	Field 25 - Fallow	S, P	S	

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[sup]1 Metalloids - include 14 elements (Al, As, Be, Cd, Cr, Cu, Fe, Hg, Mn, Ni, Pb, Se, Tl, Zn)
[sup]2 Nutrients - ammonia nitrogen, total Kjeldahl nitrogen, organic nitrogen, nitrate nitrogen, and total phosphate
[sup]3 Organochlorine pesticide scan (includes 20 pesticides and total PCBs)

Sediment, vegetation, and fish were collected from the moist soil management units. Data from this collection sequence will establish a contaminant baseline level for nutrients and metals at the moist soil units. Construction of all five units and a complete monitoring of moist soil units could not be completed in 1994 due to the abundance of water that flooded the area above Stewart Dike. One moist soil management unit was constructed during December 1994 and is now established. The remaining four moist soil management units will be constructed at a later date. Collection of water, sediments, plants, and biota from the established unit will be completed by August 1995. Composite sediment samples were collected from the five units. Two transects were randomly selected perunit and at random points along each transect two composite sediment samples were collected. Two additional composite sediment samples were collected at random points along one transect in unit 2. Sediment samples were collected using a hand-held, polycarbonate WildCo core sampler to a depth of three inches. The samples were placed in whirlpaks and the additional two samples in foil, frozen and submitted for future analyses.

Composite smartweed (Polygonum lapathifolium) samples were collected from one transect in each moist soil unit. Plants of uniform size were cut at the soils surface and placed in whirlpaks without washing and refrigerated until submitted for analyses.

Six composite black bullhead (Ameiurus melas) samples were collected from the moist soil management units. Four composite samples were placed in plastic bags, frozen, and later submitted for analyses. The remaining two composite samples were wrapped in foil, frozen, and later submitted for analyses.

Water (stormwater, post stormwater and groundwater), soil and sediment samples were analyzed for metalloids and nutrients (nitrogen and phosphorus). Plants, grasshopper, tadpole, fledgling, and fish samples were analyzed for metalloids. Sediments from the ponds and moist soil management units, eggs, and fish samples were analyzed for organochlorines including polychlorinated biphenyl (PCBs).

All samples were submitted through Patuxent Analytical Control Facility (PACF) to its designated contract laboratory. Metalloids, organochlorine pesticides (including PCBs), grain size, total organic carbon, and nutrient analyses were completed by Hazelton Environmental Services, Inc., Madison, Wisconsin. Arsenic and selenium concentrations in water, sediments, and biotic tissue were analyzed by graphite furnace and mercury by cold vapor atomic absorption. All other elements were analyzed by inductively coupled plasma spectroscopy. Organochlorine pesticides in sediments and soils were detected by Sonication extraction and in biotic tissues concentrations were detected by Soxhlet extraction. The PACF was responsible for assessing quality assurance and control (QA/QC) procedures for all contract labs and QA/QC met PACF standards.

RESULTS

Water

Metalloids - Because of the collection and preservation method of water samples, the metal concentration in the unfiltered, grab samples must be back-calculated to determine the dissolved concentration. The dissolved concentration can then be compared to Texas numerical chronic freshwater and other protective criteria to evaluate the sample quality. Cadmium, mercury, molybdenum, and selenium were not detected in stormwater samples. Concentrations of arsenic, copper, iron, manganese, and zinc in the stormwater samples from Tierra Blanca Creek exceeded the Environmental Protection Agency's (EPA) water quality criteria. Cadmium, mercury, and selenium were not detected in pond water samples. The pond water samples had elevated concentrations of arsenic, boron, copper, iron, manganese, and zinc. Groundwater samples from grazing unit #6 were relatively clean.

Concentrations of the cation elements (aluminum, arsenic barium, cadmium, chromium, copper, iron, magnesium, manganese, nickel, and zinc) recovered in stormwater samples fluctuate from site to site. Concentrations are high above Hereford; below the Holly sugar plant and waste water treatment facility concentrations decrease; concentrations begin to increase in water samples collected below TriState Feeds and Stewart Ranch; and as the Creek enters BLNWR concentrations again decrease.

Nutrients - Nitrogen compounds in the Creek stormwater samples are generally greater than reported by Irwin and Dodson (1991). Total kjeldahl nitrogen (TKN), ammonia nitrogen, and nitrate nitrogen concentrations in the Creek stormwater samples exceed the State's 85th percentile. The high concentrations of nitrate nitrogen are high enough to cause eutrophic conditions in perennial waters. Stormwater concentrations of phosphorus have decreased since 1987 (Irwin and Dodson 1991) and were below the State's 85th percentile.

Pond water samples had lower concentrations of TKN, ammonia-nitrogen, organic and nitrate nitrogen, and total phosphorus than the Creek samples. Concentrations of TKN, ammonia-nitrogen, and nitrate nitrogen exceeded the State's 85th percentile.

Soil/Sediment

Metalloids - Concentrations recovered in soil samples from the three different cropping treatments were within the background ranges for soils found in the western United States (Shacklette and Boerngen 1984). Concentrations of aluminum, chromium, copper, iron, and vanadium were significantly higher than the concentrations reported by Irwin and Dodson (1991).

Nutrients - Concentrations of ammonia nitrogen and total phosphorus were significantly higher than those reported by Irwin and Dodson (1991).

Organochlorine Pesticides - Organochlorine pesticides, including PCBs, were not detected in soil samples from the ponds and sediments from the moist soil management units.

Vegetation - Kochia collected from wheat fields had significantly higher concentrations of aluminum, iron, manganese, and vanadium compared to concentrations in the sudan and fallow fields. Plants collected from the sudan field had significantly lower concentrations of barium, boron, magnesium, and strontium; and significantly higher concentrations of molybdenum compared to concentrations in the wheat and fallow fields.

Biota

Grasshoppers did not have elevated metal concentrations. Concentrations of arsenic and molybdenum were significantly higher in grasshopper samples collected from sorghum planted fields than wheat planted fields. Aluminum, manganese, and vanadium concentrations were significantly lower in grasshoppers collected from sorghum fields than wheat fields. Organochlorines were not detected in mourning dove and red-winged black bird embryo samples. Concentrations of p,p'-DDE in fish tissue samples were below the National Academy of Sciences and National Academy of Engineering (1973) 1.0 ppm DDT and metabolites criterion established for protection of wildlife.

DISCUSSION AND CONCLUSIONS

Stormwater may be generally as polluted as it was in 1987. TriState has generally remained in compliance with their State wastewater discharge permit; however, mineralized nitrate appears to be leaching from their soils or from soils in the creek bed that were previously saturated with nitrogen components from their operations. The optimum goal would be to encourage the TNRCC to adopt TKN standards for surface waters and consider treating CAFO waste through waste water treatment plants or constructed wetlands. Perhaps, the Service should work with TNRCC to set up a program to educate the CAFOs operators about the problem.

Planting treatments have not drastically changed the concentration of inorganic contaminants in soils. For several elements, there may be an actual increase. At this time it is difficult to determine or explain the apparent increase. We have encountered problems in comparing our soil sample analyses with the data reported by Irwin and Dodson (1991). Soil samples from 1993 were collected along known transects at a 3-inch depth with a core-sampler. It is assumed that samples collected during 1986 were from a 6-inch depth. This assumption, however, is suspect, because no collection methodology was written and we are relying on the recollection of Jim Rogers, the technician who collected the samples. Jim Rogers, of the former Bureau of Reclamation office in Amarillo, Texas, was assigned the task of soil collection by Roy Irwin. In 1994, we collected soil samples at several depths to develop a regression equation and determine the likely concentrations at the 6 inch layer. In conclusion, the metal concentrations in soils from the dry lake bed at BLNWR are not at levels considered harmful to wildlife.

Nitrogen levels in soils are elevated but do not appear to be causing nitrogen toxicosis to animals that eat plants grown on these soils (Dr. Michael Hickey, Texas Tech, personal communication).

At Buffalo Lake NWR, nitrogen is mostly bound up in organic materials. There is no established level of concern for the protection of wildlife that ingest plants with elevated nitrogen.

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