EXISTING WATER QUALITY CONDITIONS IN THE PLATTE RIVER

JULY 2000

Technical Report of the Platte River EIS Team
U.S. Department of the Interior
Bureau of Reclamation
Fish and Wildlife Service

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INTRODUCTION

This report is divided into seven chapters. Chapter I provides a general overview of the water quality conditions in the Platte River Valley. It summarizes the most noteworthy information that is presented in more detail in chapters II through VII. Chapter I is divided into the following subsections:

- Summary of Existing Studies—a list of studies done on the Platte River to date

- Water Quality—a description of water quality in the Platte River

- Ground Water Quality—a description of groundwater quality in the Platte River Valley (not including the ground water mound)

- Sediment Quality— a description of potential contaminants in the sediment in the Platte River Valley

- Fish and Bird Data—description of results from fish and bird egg studies done on the Platte River to date

- Trends and Causes of Changes—description of possible trends in the water and ground water quality

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CHAPTER I

Water Quality

This report focuses on water quality as it affects fish and wildlife resources and describes existing water and sediment quality conditions and trends to compare against future changes/improvements in habitat and species status. However, many water quality standards are related to human health issues, and need to be extrapolated. The following sections summarize results from existing studies and reports; describe the contaminants of concern in the surface water, ground water, and sediment; summarize the results from fish tissue studies and bird egg data to relate the contaminants to fish and wildlife resources; and discuss trends and recommend monitoring parameters to determine the future effects of water quality concerns on fish and wildlife.

SUMMARY OF EXISTING STUDIES

Surface water data and ground water data were taken from the Environmental Protection Agency's (EPA's) STORET data base.

The U.S. Geological Survey (USGS), under their National Water Quality Assessment (NAWQA) Program, conducted a study in the Central Platte Basin in Nebraska between 1992 and 1995 (Frenzel, et al.,1998).   Major water quality concerns identified in the NAWQA study included excessive concentrations of nitrates (greater than the 10 milligrams per liter [mg/L] drinking water maximum contaminant level [MCL]), along with the triazine herbicides, atrazine, and cyanazine, in ground water. Surface water concerns were mainly focused on physical habitat factors as having a great effect on aquatic life. Herbicides were also listed as a major factor in the water quality degradation of wetlands.

The Clean Water Act (Public Law.[P.L.] 95-217, Section 305(b)) requires the States to report on the status of their water quality every 2 years. The reports and a subsequent Section 303(d) list of impaired waters (Nebraska Department of Environmental Quality [NDEQ], 1998) delineate water quality problems by river reach. The reports also include an assessment of ground water quality. The most recent 305(b) report by the State of Nebraska, which includes the Central Platte, was prepared in 1996 (NDEQ, 1996).

The river reach in NDEQ (1996) of concern to this report is identified as the Middle Platte River, Nebraska. This reach extends from the confluence of the North and South Platte rivers to just beyond the mouth of the Loup River. NDEQ (1996) indicates that irrigation and power project diversions and return flows have a tremendous impact on streamflows in the Platte River. However, the causes of nonsupport[1] of the assigned use classification in two segments of the Middle Platte are pesticides, pathogens, and unionized ammonia; the sources are identified as municipal point source discharges (pathogens and ammonia) and agriculture (pesticides).

WATER QUALITY

Water quality standards in Nebraska are based on stream classifications for beneficial uses. The beneficial uses are assigned by stream segment. The mainstem of the Platte River includes seven stream segments in three sub-basins from the confluence of the North and South Platte rivers to its mouth at the Missouri River. On the mainstem, there are two sub-basins in the Middle Platte and one in the Lower Platte. All the segments share the same use classifications, which include agricultural water supply, recreation, and aquatic life support. In general, the water is alkaline (pH greater than [>] 7) and relatively clear.

AMMONIA

The amount of ammonia in surface water depends on the water's temperature and pH. The standards comparison for ammonia is based on USGS monitoring data, and ammonia did not exceed standards in the 149 observations at Overton or in the 215 observations at Grand Island. As ammonia standard was not exceeded, ammonia does not appear to threaten aquatic life.

BACTERIA

Fecal coliform bacteria, an indicator of potential pathogenic contamination, are used as the gauge for water safety for primary contact recreation. The standard is based on recreation use and does not relate to any wildlife concerns. Fecal coliform counts exceed the standards between 25 and 50 percent of the time. The NDEQ (1998) notes that the river is impaired from excessive pathogens based on the fecal coliform data.

TOTAL DISSOLVED SOLIDS/SPECIFIC CONDUCTANCE

Specific conductance is a measure of the ability of water to conduct an electrical current. Conductivity is related to the number of types of chemical ions or dissolved solids in solution. Conductance is thus a way to measure dissolved solids.

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[1] The nonsupport is based on violations of the water quality standards.

Specific conductance and total dissolved solids (TDS) are increasing, which usually indicates that water use, particularly for agriculture, is increasing. The TDS of the Platte River is about the same as the North Platte (median TDS of 600 mg/L at the State line), and much lower than the South Platte (median TDS of 1,500 mg/L at the State line). The drinking water standard (secondary MCL) for TDS is 500 mg/L which is approximately a specific conductance of 750 micromhos per centimeter (µmho/cm). While the Platte River is not classified for use as a drinking water source, it is classified for agricultural use. The agricultural standard for specific conductance is 2,000 µmho/cm, which is about 1,400 mg/L.

ATRAZINE

The State of Nebraska (NDEQ, 1996, 1998) lists pesticides as a major water quality problem on the 303(d) list (which lists stream segments that do not comply with the Clean Water Act) and require actions to improve water quality. Atrazine is the most heavily used herbicide in Nebraska and, thus, can indicate pesticide contamination. The primary source for atrazine in the Platte River is ground water, and atrazine is by far the most frequently detected pesticide in ground water in Nebraska (University of Nebraska-Lincoln [UNL], 1994).

The acute aquatic life criterion for atrazine (170 µg/L = (parts per billion [ppb]) has not been exceeded, but the chronic criterion for aquatic life (1 µg/L) was exceeded about 20 percent of the time at Grand Island. The standard was exceeded 87 percent of the time at the Duncan gauge, where 33 percent of these samples are over 5 µg/L (Yahnke, 2000). This indicates that atrazine contamination is greater upstream.

METALS

Aluminum, cadmium, and silver have exceeded their respective standards in a small percentage of samples based on USGS monitoring data in the Platte Basin. As aluminum exceeded its standard in 20 percent of the samples collected at Grand Island, it may be a concern in the critical habitat reach. Lead exceeds its standard in more than 50 percent of a very limited number of samples at Overton and Grand Island. Lead exceeds its standards less than 50 percent of the time at Duncan and Louisville, where there are more lead samples. Based on these samples, there could be a problem of lead contamination from Overton to the mouth of the Platte River. Lead should be monitored to determine the extent and cause of any exceedences.

TEMPERATURE

Elevated water temperatures harm various fish species in the Middle Platte. There have been a number of fish kills in the Platte River mainstem (Nebraska Game and Parks Commission [NGPC], 1996), many of these were attributed to low flows and excessive temperatures. The survival of the diverse, endemic populations of fish species plays a critical role in the interior least tern's diet.

Long term trends were determined from the USGS temperature and water quality data that was collected from the Overton gauge between 1950 and 1994 and the Grand Island gauge between 1964 and 1994. These are periodic measurements (about 6–10 a year) that coincide with water quality sample collection. Based on the USGS data, water temperatures in the Platte River have been increasing, with river temperatures warming significantly at Grand Island in the summer, as well as on a year-round basis.

Comparisons for temperature standards in the summer were determined from the U.S. Fish and Wildlife Service (FWS) data. The FWS' temperature data are based on continuous measurements from recording thermograph data (see for example Dinan, 1992). EPA indicates that elevated water temperatures negatively impact the survival of various fish species in the Middle Platte. The survival of the diverse, endemic populations of these fish species, many of which are small minnow species, play a critical role in the diet of the endangered interior least tern (EPA, 1998). According to EPA (1998), the FWS data show that the water quality standard for temperature (32 degrees Centigrade [°C] or 90 degrees Fahrenheit [°F]) is exceeded as much as 40 percent of the time near Grand Island (on about 40 percent of the days during the summer at a site near Grand Island).

The Environmental Protection Agency (EPA, 1998) proposed adding temperature to the list of water quality measures that are causes of nonsupport of the aquatic life beneficial use in the Central Platte Basin. The NDEQ (letter of August 9, 1999) indicated that the temperature standard was limited to situations where the heat was added from a point source discharge. Under this interpretation, temperatures above 32 °C due to solar radiation do not constitute exceedences of the temperature criterion. In their letter of December 7, 1999, EPA deferred to the State's interpretation of the water quality standard for temperature and withdrew its inclusion of the Middle Platte on the State's 303(d) list based on exceedences of the temperature standard.

GROUND WATER QUALITY

TDS/SPECIFIC CONDUCTANCE

Specific conductance in the ground water on the north side of the river is nearly twice that of the river itself, while the specific conductance on the south side ground water is about the same as the river. If ground water is used for irrigation, this specific conductance would increase further, as ground water recharge would be reduced by evapotranspiration, yet still carry the same amount of salts into the aquifer.

NITRATE

Excessive nitrate (as measured by amounts of nitrogen) in ground water is a documented problem throughout the valley, but more so to the north of the river. The maximum observed nitrate concentrations in ground water samples are well above the drinking water standard of 10 mg/L. There is measurable nitrate (greater than the detection limit) in virtually all of the ground water in the Middle Platte Valley. On the south side, the percentage of samples that exceed the standard is much lower; and maximum total nitrate concentrations are less than 50 mg/L. On the north side of the river, about 20 to 35 percent of the ground water samples exceed the drinking water standard, with the total nitrate concentration greater than 80 mg/L.

ATRAZINE

Atrazine is the only herbicide that exceeds its drinking water standard in the ground water. Atrazine is present in measurable concentrations in nearly all of the wells sampled to the north of the river, and about 3 percent of these samples exceeded the drinking water standard. Gosselin et al.(1996) found that nitrate and atrazine contamination were statistically associated, and that shallower wells were more likely to be contaminated than deeper wells. They did not find a difference between levels of nitrates and atrazine between 1984-89 and 1994-95.

TEMPERATURE

The median temperatures of the ground water on both sides of the river and the surface water are about the same (13-14 °C). However, the ground water's minimum temperatures are much higher, and the maximum temperatures are much lower than those of the river. The maximum temperature of the ground water is well below the surface water temperature standard.

SEDIMENT QUALITY

As there are no sediment quality standards comparable to water quality standards, other bases for evaluating sediment were used. The National Irrigation Water Quality Program (NIWQP) uses the Western Soils baseline (Shacklette and Boerngen, 1984) to evaluate potential sediment contamination. This assumes that stream sediment is derived from soil erosion. Crustal abundance values (CAV) from Fortescue (1992) are another basis for evaluating sediments. The CAV is based on average concentrations of the elements in various rocks. Exploration geochemistry, for example, uses these values to identify potential ore bearing sediments. Enrichment (concentrations three or more times the CAV) could indicate contamination.

Four elements are above the Western Soils baseline: selenium, chromium, manganese, and uranium. Of these four, selenium and chromium would be considered potential toxins for aquatic life and waterfowl.

- **Selenium.**–The Platte River samples were 2.6 and 2.1 parts per million (ppm) at Overton and Grand Island, respectively, while the Western Soils baseline concentration in the sediments is 0.4–1.4 ppm. Selenium concentrations of less than 1 ppm have been associated with reproductive effects in birds nesting in terminal wetlands (NIWQP, 1998). There may be a concern for sediment selenium in environments where selenium could be concentrated. The only analogous wetlands in the Central Platte Basin would be those that are only filled seasonally by overbank flows.

  A seleniferous area in the North Platte Basin was identified in the 1930s. The upper basin could be the source of selenium, but Glendo Reservoir and Lake McConaugh between the source and the study area should trap all, or nearly all, of the sediment from the North Platte. The South Platte basin is more likely the source of selenium.

- **Chromium.**–The Platte River samples were 42 and 37 ppm at Overton and Grand Island, respectively, while baseline concentration is 28 ppm. On the basis of the CAV, contamination would be indicated at 105 ppm. The samples are well below this value. Thus, results do not indicate chromium contamination.

- **Manganese.**– Manganese was equal to the upper limit of the Western Soils baseline (1,500 ppm) in Overton and slightly above in the Grand Island samples (1,600 ppm). It was not above three times the CAV (3,180 ppm). Manganese is not particularly toxic.

- **Uranium.**–The uranium concentration at Grand Island is 6 ppm, less than three times the CAV (6.9 ppm), and between the Western Soils baseline range of 0.1

to 11.2 ppm. Thus, sediment samples are not considered elevated in uranium. The source of uranium is likely to be the same as the source for the selenium.

FISH AND BIRD DATA

FISH TISSUE SAMPLES

The State of Nebraska maintains monitoring sites to collect fish and analyze fish tissue samples for priority pollutants (NDEQ 1996). Fish tissue data were provided by Mike Callum of the NDEQ (Personal communication, NDEQ, 2000). To date, all fish sampled have been over 5 inches long, yet the least tern consumes small fish (1.5 inches long) during nesting. Thus, a certain amount of extrapolation is needed to evaluate the effects on breeding terns. If there is a relationship between fish size and contaminant concentration, the threat may be more or less than analyses indicate. Statistical analysis of the NDEQ data showed that length and sample types were positively correlated with weight, mercury, and selenium and that larger fish have generally higher concentrations of mercury and selenium than smaller fish. This indicates a somewhat reduced threat to least terns from inorganic contaminants than the results from the NDEQ samples would indicate.

The NIWQP has developed guidelines for evaluating the potential toxicity of selected substances, including fish tissue where sufficient studies are available. These guidelines have three tiers:

- **No effect level.**–Concentrations below this level should have no adverse effects (equivalent to EPA’s No Observed Adverse Effects Level (NOAEL))
- **Level of concern.**–Concentrations where some toxicity may occur, particularly for sensitive individuals
- **Toxicity threshold.**–The concentration at which toxicity has been known to occur.

Potential inorganic contaminants include: arsenic, barium, cadmium, chromium, copper, lead, mercury, nickel, selenium, and zinc. Of these, the only elements that exceeded toxicity thresholds are mercury and selenium.

There was a decreasing trend in both barium and chromium. Neither of these trace elements are of particular concern. Arsenic and copper did not exceed any of the levels of concern and would not pose a threat for fish consumption.

Most of the cadmium, lead, and zinc samples exceeded the no effect level for fish. Cadmium and zinc do not exceed toxicity thresholds for waterfowl food items and thus apparently pose only a minimal threat to predatory birds. There is no toxicity threshold for lead, which is not included in the NIWQP guidelines.

Mercury

Mercury is listed as the primary inorganic contaminant of concern in Nebraska (NDEQ, 1996). Mercury needs to be further evaluated for potential effects on breeding birds, as about 47 percent of the fish samples exceeded the bird dietary mercury toxicity threshold. As regional background levels are above the demonstrated no effect level, interpretations of mercury levels in this area are complicated. Although many of the NDEQ analyses exceeded the no effect level for mercury, none exceeded the background concentrations or the toxicity threshold for fish. Recent research has indicated that the predominant source of mercury is atmospheric (Porcella, 1994). As fish from the North and South Platte show significantly higher levels of mercury than those from the Platte mainstem, the mercury source would be to the west.

Selenium

Selenium could also inhibit the recovery of the least tern population in the Platte River, as about 9 percent of the fish samples exceeded the bird dietary toxicity threshold for selenium, which is based on reproductive impairment. Most of the selenium samples exceeded the no effect level for fish.

Fish from the South Platte have significantly higher levels of selenium than those from either the North Platte or the Platte mainstem. This may indicate that the selenium source is in the South Platte basin. The sediment results also support this hypothesis.

Organic

NDEQ samples showed that levels of DDT, DDD, and DDE were well below the NIWQP thresholds for levels of effect. Organic contaminants in the NDEQ dataset appear to be below the normal background levels for the United States as determined by the National Pesticide Monitoring Program (NPMP). Also, five of the monitored organic contaminants have been decreasing significantly (*cis*-chlordane, *trans*-nonachlor, hexachlorobenzene, heptachlor epoxide, and PCB-1254).

BIRD EGG DATA

The Fish and Wildlife Service sampled bird eggs from the Platte River near Grand Island during 1991–93, with one additional sample collected in 1994. The 1991 samples were analyzed for 19 elements. Half of the 1992 samples were analyzed for the full suite of 19 analytes, while the other half were only analyzed for arsenic, mercury, and selenium only. In 1993, samples were analyzed only for arsenic, mercury, and selenium. This limited number of samples over a short time frame does not provide enough data for determining trends in the biological contaminants in bird eggs on the Platte River

The number and type of bird eggs sampled varied in these three years, with corresponding variations in detection limits. For example, most of the 1991 samples were tern eggs with a detection limit of 0.1 ppm for cadmium, while most 1992 samples were piping plover eggs with a detection limit of 0.04 ppm. This dichotomy of sampled species and detection limits caused statistical differences in cadmium concentrations between the tern and plover eggs.

However, we can compare these egg data to the NIWQP guidelines (discussed in the previous section) and draw some inferences.

Copper is a nutrient and thus was present in measurable quantities in all of the eggs. Levels in all of the tern and plover eggs were below the no effect level. Copper does not appear to be a major threat to the reproduction of endangered birds.

The elements of concern for breeding birds in the study area are:

- **Mercury.**–Ninety percent of the tern eggs and 13 percent of the piping plover eggs fell within the level of concern for mercury.

- **Selenium.**–Eighty-seven percent of the tern eggs and 94 percent of the plover eggs fell within the level of concern for selenium. None of the tern eggs exceeded the selenium toxicity threshold, but about 29 percent of the plover eggs did.

- **Zinc.**–Sixty-three percent of the tern eggs and 50 percent of the plover eggs exceeded the no effect level, and zinc is thus within the level of concern. The NIWQP did not recommend a toxicity threshold for zinc as zinc is physiologically controlled.

Based on the above, mercury, selenium, and zinc in bird eggs should be monitored in the future.

TRENDS AND CAUSES OF CHANGES

The sediment analysis included only two samples and the bird egg analysis contained at most 3 years of data. Thus these studies provided insufficient data for trend analyses.

SURFACE WATER QUALITY

The surface water quality data were analyzed to determine emerging trends. Table I-1 summarizes these results.

Table I-1.—Summary of Emerging Trends

Measure of Water Quality	Trend in Surface Water
Atrazine	No change
Turbidity	No change
Nitrate	Increasing
Ammonia	Increasing
Flows	Increasing, particularly summer flows at Grand Island
Specific Conductance/TDS	Specific conductance is increasing over time, indicating that the TDS concentrations are growing.
Temperature	Warming, particularly around Grand Island in the summer.
Bacteria	Decreasing
Inorganics	Levels of cadmium, mercury, and selenium are increasing over time. Chromium and barium are decreasing over time.
Organics	Five organic contaminants have been decreasing significantly.

GROUND WATER

Unlike the surface water, trends in ground water quality are more difficult to define, primarily due to the lack of long-term monitoring data. There are few wells with more than 10 years of data and even fewer with more than 10 observations. Fifteen wells with more than 10 years of data were used for the analysis. However, only 5 of these had more than 10 observations, 10 had 6 observations, and 1 had 7. The data are not evenly distributed throughout the total monitoring period, although most of the 10 wells with

6 observations were sampled every other year and do have a relatively uniform spread. Trends in temperature, EC, and NO_3-N were evaluated.

While two of the three wells with more than 25 years of observations showed increasing temperatures over time, a larger number of measurements over a relatively long period is needed to show any trend. The lack of a trend in the other wells may be due to the data base, or there may be no trend to find. Several of the wells show decreases over time, but this was not statistically significant. What this does indicate, in the absence of better data, is that any trend toward increasing temperature of the ground water is probably localized.

All five of the wells with more than 10 observations and four of the wells with only 6 observations showed increases in specific conductance, which indicates an increase in TDS. Because most of the wells show an increasing trend in specific conductance, it seems safe to conclude that the specific conductivity in the ground water has been increasing over the last 25 years or so that the data represent.

The number of nitrate observations is much smaller than observations for temperature and specific conductance. These data bases are too small to use for a meaningful analysis.

FISH TISSUES

Although fish have been sampled for inorganic and organic contaminants since 1983, samples were not collected to evaluate the effects of elevated levels of contaminants on the least tern, which eats only very small fish. Results must therefore be extrapolated. Further, over the years, samples have included increasingly larger fish, and an increasing proportion of fillet samples, as opposed to whole fish. As concentrations are often related to fish size and tissue samples, these trends could confound results related to trends in contaminants.

Cadmium, mercury, and selenium have been increasing. Cadmium and mercury were elevated in 89 and 44 percent of the samples respectively. Selenium exceeded the level of concern in 78 percent of the samples. However, as mercury and selenium are related to fish size, the trend may be an artifact of the increasingly larger fish in the samples.

Barium and chromium have been decreasing. Neither of these trace elements are of particular concern, and the decreasing trend would further reduce any concern that did exist.

Organic contaminants have been decreasing. Since most of the organics are chlorinated hydrocarbons that have been banned for further use in the U.S., this decline is expected.

IRRIGATION

Expanding irrigation and the corresponding increase in ground water use may be responsible for the trends in flows, temperature, and specific conductance/TDS. An increase in TDS usually indicates that water use, particularly for agriculture, is increasing. Both active wells and irrigated acreage have seen a substantial increase since 1950, as shown in figure I-1, indicating that agriculture is using ground water rather than surface water.

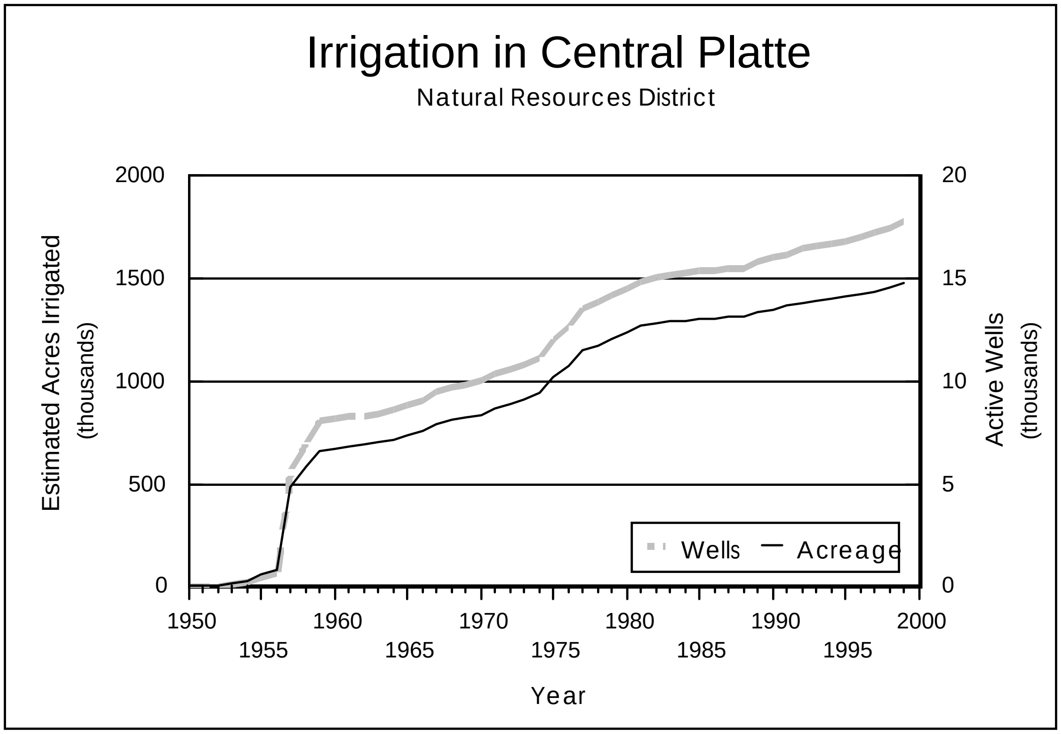

Figure I-1.—Irrigation in Central Platte.

Increasing flows could be caused by the natural progression of water years or it could be influenced by increased return flows from irrigation. Cooler ground water, which used to seep into the river, is now removed for agriculture first and now enters the river as warmer return flows. While the ground water is much cooler than the river, ground water would be warmed as it was applied to croplands. How much warming would occur is not known; however, if such warming occurred, it could influence the river temperature, particularly if the returns constituted a relatively large percentage of the river flow.

If return flows from ground water irrigation were a greater proportion of the river flow and other irrigation were not significantly changed, then the specific conductance of the river would increase. As a further consequence, the river would become warmer.

LEAD

There is no toxicity threshold for lead, which is not included in the NIWQP (1998) guidelines. In a review of studies of lead intake by aquatic birds, Irwin et al., (1997) found that most studies focused on lead shot. Since lead shot has been banned, concentrations of lead should decrease.

MONITORING PARAMETERS

The summary in table I-2 shows the recommended analytes to monitor in surface water, ground water, sediment, fish tissue, bird eggs, concern to evaluate existing water quality conditions. The data evaluated indicate that at least two of the contaminants of concern, mercury and selenium, are bioaccumulating through the food chain. Other contaminants may also be bioaccumulating, but there are not enough data on the environmental matrices to evaluate different trophic levels for contaminants. For this reason, wherever it is possible, any contaminant monitored in one environmental medium, should be monitored in all of the media.

Table I-2.—Summary of Recommended Monitoring Parameters for Water Quality to Determine the Effects on Habitat and Endangered Species

Media	Analyte	Method of Analysis	Notes
Surface water	Ammonia	Critical habitat reach and downstream to mouth	Potential fish toxins; concern for sturgeon
	Aluminum, arsenic, cadmium, lead, and silver		
	Atrazine and 2,4-D	Emphasize the river upstream from Duncan.	There are few data on atrazine upstream from Grand Island and essentially no data on 2,4-D upstream from North Bend.
Ground water	Specific conductance, nitrate-nitrogen (NO_3-N), atrazine	Focus on alluvial wells, primarily related to wet meadows.	Major water quality issues in ground waterMedia

Table I-2.—Summary of Recommended Monitoring Parameters for Water Quality to Determine the Effects on Habitat and Endangered Species (continued)

Media	Analyte	Method of Analysis	Notes
Sediment Media	Arsenic, cadmium, chromium, copper, lead, mercury, nickel, silver, and zinc	Use EPA (1990) digestion and analytical proce-dures, evaluate results against the Corps of Engineers sediment quality criteria for aquatic life.	While manganese, uranium, selenium, and chromium levels were exceeded, only chromium and selenium would be considered potential toxins for aquatic wildlife and fowl
	Selenium, uranium	Compare with work done on other sites with irrigation return flows and selenium contamination.	
	Total DDT and total PNAs	Undertake detailed analysis, if concentrations exceed criteria.	If totals do not exceed the cri-teria, components are unlikely to be elevated.
Fish tissue	Atrazine	Monitor atrazine concentrations in fish tissue.	There are no data on atrazine concentrations in fish.
	Cadmium, mercury, selenium, zinc and lead.	Monitor contami-nant levels in least tern prey (smaller fish)	There are no data available on fish < 1½ inches and contaminants vary depending on size and lifetime accumulation in larger fish.
Bird eggs	Mercury, selenium, and zinc	Monitor in the future Evaluate embryos before chemical analysis. Survey nests to determine hatchling health.	While these ele-ments were ele-vated, the bird egg analysis did not include data on the state of the eggs or the embryos within, so actual effects cannot be confirmed.
Aquatic invertebrates	Organic and inorganic contaminants	Monitor contaminant levels in piping plover prey (aquatic invertebrates).	As no data are available on aquatic invertebrates, a wider suite of analytes should be considered.

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One potentially important environmental medium has not been evaluated. There are no data on contaminants in aquatic invertebrates in the Platte River system. Aquatic invertebrates are either an important link in the food chain for the least tern or an important food source for nesting plovers. Aquatic invertebrates should be added as an essential medium for monitoring environmental contaminants.

There are a number of recommendations in table 1-2 that it is not possible to monitor in all media. For example, ammonia and nitrate are both chemical forms of nitrogen. Organisms are composed numerous forms of nitrogen, particularly in amino acids. To evaluate contamination, physiologically abnormal concentrations of nitrogen species would have to be determined. To determine all forms of nitrogen in organisms would be prohibitively expensive. This would probably also be true of the organic fraction of sediment samples. Consequently, nitrogen monitoring should be confined to the toxic aqueous species ammonia and nitrate nitrogen.

Trace elements (metals and metalloids) and pesticides may concentrate in the food chain. Consequently, to evaluate this potential, these contaminants should be monitored in each of the environmental media shown in table I-2. This may be somewhat idealistic. In all cases budgetary constraints may necessitate modification of these recommendations. In that case several indicators could be selected to follow potential bioaccumulation. At a minimum these should include mercury and selenium, each of which appears to have the greatest potential to exceed toxicity thresholds and have adverse effects on the recovery of the endangered birds.

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CHAPTER II

Water Quality in the Central Platte River Basin

The U.S. Geological Survey (USGS), under their National Water Quality Assessment (NAWQA) Program, conducted a study in the Central Platte Basin in Nebraska between 1992 and 1995 (Frenzel et al.,1998). Major water quality concerns identified in the NAWQA study included excessive concentrations of nitrates (greater than the 10 milligrams per liter [mg/L] drinking water MCL [maximum contaminant level]), along with the triazine herbicides, atrazine, and cyanazine in ground water. Surface water concerns were mainly focused on physical habitat factors as having a great effect on aquatic life. Herbicides were also listed as a major factor in the water quality degradation of wetlands.

The Clean Water Act (Public Law [P.L.] 95-217, Section 305(b)) requires the States to report on the status of their water quality every 2 years. The reports and a subsequent Section 303(d) list of impaired waters (Nebraska Department of Environmental Quality (NDEQ), 1998) delineate water quality problems by river reach. The reports also include an assessment of ground water quality. The most recent 305(b) report by the State of Nebraska, which includes the Central Platte, was prepared in 1996 (NDEQ, 1996A).

The river reach in NDEQ (1996A) of concern to this report is identified as the Middle Platte River, Nebraska. This reach extends from the confluence of the North and South Platte rivers to just beyond the mouth of the Loup River. NDEQ (1996A) indicates that irrigation and power project diversions and return flows have a tremendous impact on streamflows in the Platte River. However, the causes of nonsupport[1] of the assigned use classification in two segments of the Middle Platte are pesticides, pathogens, and unionized ammonia; the sources are identified as municipal point source discharges (pathogens and ammonia) and agriculture (pesticides).

The Environmental Protection Agency (EPA), (EPA, 1998) has proposed adding temperature to the list of water quality measures that are causes of nonattainment of the aquatic life beneficial use in the Central Platte Basin. The EPA indicates that elevated water temperatures negatively impact the survival of various fish species in the Middle Platte. The survival of the diverse, endemic populations of these fish species, many of which are small minnow species, plays a critical role in the diet of the endangered interior least tern (EPA, 1998). According to EPA (1998), the water quality standard for temperature (32 degrees Centigrade [°C] or 90 degrees Fahrenheit [°F]) has been

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[1] The nonsupport is based on violations of the water quality standards.

exceeded as much as 40 percent of the time in the vicinity of Grand Island. The NDEQ (letter of August 9, 1999) indicated that the temperature standard ws limited to situations where the heat was added from a point source discharge. Under this interpretation, temperatures above 32 °C, due to solar radiation, do not constitute exceedences of the temperature criterion. In their letter of December 7, 1999, EPA deferred to the State's interpretation of the water quality standard for temperature and withdrew its inclusion of the Middle Platte on the State's 303(d) list, based on its exceedence of the temperature standard.

SURFACE WATER QUALITY

Table II-1 presents a summary of selected USGS water quality data for two gages in the Middle Platte River. The data from the Overton gage were collected between 1950 and 1994, while the Grand Island data were collected between 1964 and 1994.

In general the water is alkaline (pH greater than [>] 7). The total dissolved solids (TDS) of the Middle Platte River is much lower than the South Platte (median TDS of 1,500 mg/L at the Colorado-Nebraska State line) and approximately the same as the North Platte (median TDS of 600 mg/L at the Wyoming-Nebraska State line). The turbidity data indicate that in general the water is relatively clear. The median turbidity has been 10 JTU (Jackson Turbidity Units) at the upstream station and 18 JTU at the lower end of the river reach (table II-1); for comparison, clear pond water would have an average turbidity of less than 25 JTU (McKee and Wolf, 1963).

It was noted by the NDEQ (1998) that the river is impaired due to excessive pathogens. Fecal coliform bacteria are an indicator of potential pathogenic contamination. The fecal coliform standard is used as a gauge of the safety of water for primary contact recreation (e.g., swimming and is based on both an average and an instantaneous population level) (i.e., 200 and 400 colonies per 100 milliliters [mL], respectively). The comparison shown in table II-1 is based on the instantaneous maximum of 400 colonies per 100 mL, since the water quality data are all instantaneous measurements. These data indicate that the fecal coliform counts exceed the standard between 25 and 35 percent of the time at the two sites.

There are three different forms of nitrogen shown in table II-1. Nitrate was noted earlier as a problem in ground water, which is frequently used for drinking water. The drinking water standard for nitrate is 10 mg/L. As can be seen in table II-1, the maximum observed nitrate concentrations (NO_2+NO_3) at each of the gages is well below the drinking water standard. There are two different forms of ammonia shown in in table 2A, the total of the ionized (NH_4^{+1}) and unionized (or gaseous) ammonia (NH_3). The ammonia standard varies with temperature and pH, so a single value cannot be

Table II-1.—Summary of Selected Water Quality Data at two Sites in the Central Platte Basin

Site		Water Temperature (°C)	E. C. at 25 °C (µmho/cm)	TDS Diss. 180 °C (mg/L)	TDS Sum (mg/L)	Turbidity (JTU)	pH (S.U.)
Overton	Minimum	-0.1	421	270	487	4	7.1
	Median	13.0	901	595	591	10	8.1
	Maximum	32.5	1235	776	731	80	9.0
	No. of Obs.	347	211	45	69	23	219
	No. > Std.	2					0
Grand Island	Minimum	0	462	443	435	3	7.2
	Median	14.0	879	597	582	18	8.2
	Maximum	30.6	1220	834	817	140	9.0
	No. of Obs.	239	221	52	112	86	234
	No. > Std.	0					0

		NO_2 & NO_3 N-Diss (mg/L)	NH_3+NH_4^{+1} N-Diss (mg/L)	Un-ionzed NH_3-N (mg/L)	Fecal Coli. M-FC Agar (#/100 mL)	Fecal Strep MFKF Agar (#/100 mL)	Atrazine Diss. (ppb)
Overton	Minimum	0.02	0.01	< 0.0001	0	0	0.37
	Median	1.15	0.04	0.0020	190	340	0.37
	Maximum	2.70	0.39	0.0240	190,000	128,000	0.37
	No. of Obs.	164	34	149	128	135	1
	No. > Std.	0		0	45		0
Grand Island	Minimum	0.00	0.01	< 0.0001	1	15	0.17
	Median	0.50	0.02	0.0020	150	220	0.58
	Maximum	2.50	0.54	0.0390	12,000	12,000	4.76
	No. of Obs.	113	25	215	154	146	24
	No. > Std.	0		0	42		5

delineated. However, none of the unionized ammonia concentrations in the USGS data set exceeded the aquatic life criterion that was calculated based on the method from EPA (1986).

Atrazine, the most heavily used herbicide on crops in Nebraska, is by far the most frequently detected pesticide in ground water in Nebraska (University of Nebraska-Lincoln [UNL], 1994). Atrazine data are included in table II-1 to represent pesticide contamination. The chronic aquatic life criterion for surface water in Nebraska is 1 µg/L (parts per billion [ppb]); the acute criterion is 170 µg/L (NDEQ, 1996B). The acute criterion for atrazine has not been exceeded, but the chronic criterion has been exceeded in 5 of 24 samples or about 20 percent of the time (table II-1).

The temperature data in table II-1 indicate that the temperature standard was exceeded only twice at Overton and was not exceeded at Grand Island. The above referenced EPA assessment, which indicated that the temperature standard was exceeded often, was based on data collected by the Fish and Wildlife Service during the summers of 1988–95. Those data show that the standard has been exceeded on about 40 percent of the days during the summer at a site near Grand Island.

CONCLUSION

Those daily data are a much better indicator and will be discussed in more detail later. **(Need conclusion.)**

GROUND WATER

Table II-2 presents a summary of ground water data from wells located in Dawson, Buffalo, and Hall counties on the north side of the Platte River and from Gosper, Phelps, and Kearney counties on the south side of the river. Table II-2 includes data on water temperature, EC (a surrogate measure of dissolved solids), three measures of nitrate, and four triazine herbicides.

The EC of the ground water on the north side of the river is nearly twice that of the water to the south (table II-2). The ground water to the north is also higher in EC than the river water, while the EC of ground water to the south is lower than that of the river (compare tables II-1 and II-2). There is no drinking water standard for EC, but the drinking water standard for TDS is 500 mg/L, which is approximately an EC of 750 µmho/cm. The median EC of the ground water to the north of the river is greater than the drinking water equivalent, while that of the ground water to the south of the river is lower (table II-2).

The median temperature of the ground water to the north and south of the river (table II-2) is about the same (13 and 14 °C). The median ground water temperatures are approximately the same as the median temperatures of the river (compare to table II-1). There is, however, a large difference in the minimum and maximum temperatures of the surface water and the ground water. The ground water has a much greater minimum

Table II-2.—Summary of Selected Ground Water Quality Data

Area		**Water Temp. (˚C)**	**E.C. at 25˚C (μmho/cm)**	**NO_3-N TOTAL (mg/L)**	**NO_2 & NO_3 N-total (mg/L)**	**NO_2 & NO_3 N-diss (mg/L)**
North	Minimum	8.0	260	< 0.05	< 0.05	0.01
	Median	13.0	1,140	5.70	4.50	2.85
	Maximum	20.5	2,820	83.0	84.0	71.0
	No. of Obs.	1,183	220	382	1,337	292
	No. > D.L.	-----	-----	382	1,331	272
	No. > Std.	-----	-----	85	462	54
South	Minimum	10.0	170	< 0.1	0.01	< 0.01
	Median	14.0	657	2.7	4.25	2.90
	Maximum	24.0	1,970	47.0	17.0	14.0
	No. of Obs.	180	258	61	44	83
	No. > D.L.	-----	-----	61	43	83
	No. > Std.	-----	-----	3	3	4

Area		Atrazine Whole Sample (μg/L)	Atrazine Diss. (ppb)	Cyanazine Whole Water (μg/L)	Propazine Diss. (μg/L)	Simazine Whole Water (μg/L)
North	Minimum	< 0.05	< 0.05	0.02	0.05	0.01
	Median	0.70	0.05	0.10	0.05	0.05
	Maximum	8.55	0.19	0.84	0.05	0.70
	No. of Obs.	885	9	83	9	882
	No. > D.L.	874	4	1	0	101
	No. > Std.	23	0	0	0	0
South	Minimum	0.04	-----	0.10	-----	0.05
	Median	0.10	-----	0.40	-----	0.05
	Maximum	1.0	-----	0.4	-----	0.1
	No. of Obs.	42	0	42	0	42
	No. > D.L.	17	-----	0	-----	2
	No. > Std.	0	-----	0	-----	0
	Standard	3	3	1	20 or 200	4

temperature and a much lower maximum temperature than the surface water (compare tables II-1 and II-2). The maximum temperature of the ground water is well below the surface water temperature standard (table II-2).

There are three measures of nitrate (NO_3) shown in table II-2. Two of those include nitrite (NO_2), which is usually a transitory form that is in low to unmeasurable concentrations. For this reason the $NO_2 + NO_3$ measures can usually be considered equivalent to NO_3. The inclusion of the $NO_2 + NO_3$ data expands the data base for NO_3 considerably; EPA gives a drinking water standard for $NO_2 + NO_3$, which is the same as that for nitrate alone.

There is measurable nitrate (i.e., > the detection limit or D.L.) in virtually all of the ground water in the Middle Platte Valley (table II-2). The data indicate that around 20 percent to as many as 35 percent (total $NO_2 + NO_3$) of the ground water samples on the north side of the river exceed the drinking water standard. This amount is similar to the exceedence percentage that Gosselin *et al.* (1996) reported in domestic wells in the Platte Valley. The percentage of samples that exceed the nitrate standard on the south side of the river is much lower (table II-2). Another great difference in the nitrate concentrations to the north and south of the river are in the maxima. Maximum nitrates to the north are greater than 80 mg/L for the total concentrations, but less than 50 and 20 mg/L for the total NO_3 and $NO_2 + NO_3$ respectively to the south. Excessive nitrate in ground water appears to be a problem throughout the valley, but more so to the north of the river.

Aquatic life criteria are applicable to surface water, but the most restrictive use of ground water, from a water quality perspective, is for domestic purposes. The aquatic life criterion for atrazine was given above as 1 µg/L; the drinking water standard is 3 µg/L. Drinking water standards for the other triazine herbicides shown in table II-2 are also shown at the bottom of the table. The only one of the herbicides that exceeds its drinking water standard in the Platte Valley is atrazine, which is present in measurable concentrations in nearly 100 percent of the wells sampled to the north of the river (table II-2). About 3 percent of the samples exceeded the drinking water standard.

Gosselin et al., (1996) compared nitrate data from 1984–89 and 1994–95. They found no significant difference between either nitrates or atrazine between the two periods. They did find a positive statistical association between nitrate contamination and atrazine contamination. They also found an association between the depth of the well and the degree of contamination; shallower wells were more likely to be contaminated than deeper wells.

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CHAPTER III

Water Quality Standards

Water quality standards in Nebraska are based on stream classifications for beneficial uses. The beneficial uses are assigned by stream segment. The mainstem of the Platte River includes seven stream segments in three sub-basins from the confluence of the North and South Platte rivers to its mouth at the Missouri River. There are two sub-basins in the Middle Platte and one in the Lower Platte. All the segments share the same use classifications, which include agricultural water supply, recreation, and aquatic life support.

The standards to be evaluated in this section are summarized in table III-1A. The standards have an effective date of March 6, 1996. The majority of the standards (13 of 15) are based on aquatic life support. There is one each based on agricultural water supply (conductivity) and recreation (fecal coliform bacteria). Several of the aquatic life standards have a sample specific basis. In the case of ammonia, the standard is calculated on the basis of the temperature and pH of the water sample. Consequently, the standard will vary from sample to sample. To reflect this, the range of unionized ammonia nitrogen (NH_3–N) standards is shown in table III-1A. A number of the metals standards (cadmium, chromium, copper, lead, and zinc) shown in table III-1A are based on the hardness concentration in a water sample. The range of the hardness-based calculated standards is also shown in table III-1A.

Table III-1B summarizes a comparison between historic data collected by the USGS at six gage sites in the mainstem of the Platte River and the water quality standards shown in table III-1A. The comparisons are based on samples collected since 1975. The 1975 cutoff is based primarily on the selenium data. The analytical procedure used by the USGS for selenium prior to 1975 has been found to produce incorrect results, and the pre–1975 data are therefore suspect.

A summary of all of the USGS monitoring data for the six sites in the mainstem of the Platte River, except for pre-1975 selenium analyses, is presented in tables III-2 through III-4. The complete period of record for each site is also shown in tables III-2 through III-4. The summaries include the first and third quartiles (25th and 75th percentiles), the median (the 50th percentile), the minimum, maximum, and the number of observations. These are key parameters in the cumulative frequency distribution of the water quality data.

The data in tables III-2 through III-4 are presented primarily to point out some of the complications in making the standards comparisons. The tables also include several water quality constituents for which there are no standards. These are either potential

Table III-1.—Water Quality Standards Summary

A. Water quality standards in the mainstem of the Platte River

		Water Temperature (˚C)	Conductivity at 25˚C (μmho/cm)	pH (S.U.)	Un-ionzed NH_3-N (mg/L)	Fecal Coliforms (#/100 mL)
Standard	Minimum	N/A	N/A	6.5	0.037	N/A
	Maximum	32	2000	9.0	0.614	400
Use category for standard		Aquatic Life	Agriculture	Aquatic Life	Aquatic Life	Recreation

B. Comparison to water quality standards at six sites in the mainstem of the Platte River

Location		Water Temperature	Conductivity	pH	Un-ionzed NH_3-N	Fecal Coliforms
Brady	No. > Std.	0	0	0	0	0
	No. of Obs.	9	21	21	3	0
	% > Std.	0	0	0	0	---
Overton	No. > Std.	2	0	0	0	45
	No. of Obs.	198	188	196	149	128
	% > Std.	1	0	0	0	35
Grand Island	No. > Std.	0	0	0	0	42
	No. of Obs.	207	195	202	201	154
	% > Std.	0	0	0	0	27
Duncan	No. > Std.	1	0	0	0	22
	No. of Obs.	237	213	220	124	101
	% > Std.	0	0	0	0	22
North Bend	No. > Std.	0	0	0	0	60
	No. of Obs.	185	161	164	166	149
	% > Std.	0	0	0	0	40
Louisville	No. > Std.	0	2	14	0	74
	No. of Obs.	451	358	364	266	149
	% > Std.	0	1	4	0	50

Table III-1.—Water Quality Standards Summary (Continued)

A. Water quality standards in the mainstem of the Platte River

		Aluminum Al, diss. (μg/L)	Arsenic As, diss. (μg/L)	Cadmium Cd, diss. (μg/L)	Chromium Cr, total (μg/L)	Copper Cu, diss. (μg/L)	Lead Pb, diss. (μg/L)
Standard	Minimum	87	1.4	2.4	217.0	25.2	< 0.1
	Maximum	87	1.4	20.3	262.8	162.9	1.0
Use category for standard		Aquatic Life	Aquatic Life	Aquatic Life	Aquatic Life	Aquatic Life	Aquatic Life

B. Comparison to water quality standards at six sites in the mainstem of the Platte River

Location		Aluminum Al, diss.	Arsenic As, diss.	Cadmium Cd, diss.	Chromium Cr, total	Copper Cu, diss.	Lead Pb, diss.
Brady	No. > Std.	0	0	0	0	0	0
	No. of Obs.	0	1	1	0	1	1
	% > Std.	---	0	0	---	0	0
Overton	No. > Std.	0	11	0	0	0	5
	No. of Obs.	0	11	8	30	11	8
	% > Std.	---	100	0	0	0	63
Grand Island	No. > Std.	11	20	0	0	0	13
	No. of Obs.	56	21	20	10	21	19
	% > Std.	20	95	0	0	0	68
Duncan	No. > Std.	2	51	0	0	0	10
	No. of Obs.	46	52	51	18	53	52
	% > Std.	4	98	0	0	0	19
North Bend	No. > Std.	0	24	1	0	0	11
	No. of Obs.	0	24	23	23	24	23
	% > Std.	---	100	4	0	0	48
Louisville	No. > Std.	2	57	1	0	0	20
	No. of Obs.	47	58	58	48	59	57
	% > Std.	4	98	2	0	0	35

Table III-1.—Water Quality Standards Summary (Continued)

A. Water quality standards in the mainstem of the Platte River

		Selenium Se,diss (µg/L)	Silver Ag,diss (µg/L)	Zinc Zn,diss (µg/L)	Atrazine Diss. (ppb)	2,4-D Whole Sample (µg/L)
Standard	Minimum	N/A	N/A	555	N/A	N/A
	Maximum	5	0.78	3540	1.0	0.07
Use category for standard		Aquatic Life	Aquatic Life	Aquatic Life	Aquatic Life	Aquatic Life

B. Comparison to water quality standards at six sites in the mainstem of the Platte River

Location		Selenium Se,diss	Silver Ag,diss	Zinc Zn,diss	Atrazine Diss.	2,4-D Whole Sample
Brady	No. > Std.	0	0	0	0	0
	No. of Obs.	0	0	1	2	6
	% > Std.	---	---	0	0	0
Overton	No. > Std.	0	0	0	0	0
	No. of Obs.	11	11	11	1	0
	% > Std.	0	0	0	0	---
Grand Island	No. > Std.	0	0	0	5	0
	No. of Obs.	21	21	21	24	0
	% > Std.	0	0	0	21	---
Duncan	No. > Std.	0	3	0	13	0
	No. of Obs.	64	64	53	15	2
	% > Std.	0	5	0	87	0
North Bend	No. > Std.	0	0	0	0	2
	No. of Obs.	24	22	24	0	7
	% > Std.	0	0	0	---	29
Louisville	No. > Std.	0	6	0	69	3
	No. of Obs.	69	63	58	162	14
	% > Std.	0	10	0	43	21

Table III-2.—Summary of Water Quality Data at Six Sites in the Mainstem of the Platte River in the Central Platte Basin

Location	Period of Record		Stream Flow (ft^3/s)	Water Temp. (°C)	Conductivity at 25 °C (µmho/cm)	TDS (mg/L)
Brady	From:	Minimum	4	11.0	401	270
	10/23/56	25th Percentile	82	16.0	656	455
	To:	Median	184	20.0	793	539
	07/27/94	75th Percentile	605	23.0	1,840	1,312
		Maximum	3,720	29.5	1,900	1,520
		No. of Obs.	22	9	21	18
Overton	From:	Minimum	61	-0.1	421	270
	02/01/50	25th Percentile	500	4.0	840	550
	To:	Median	1,105	13.0	902	592
	09/13/94	75th Percentile	2,165	21.0	966	646
		Maximum	23,700	32.5	1,235	776
		No. of Obs.	436	347	210	96
Grand Island	From:	Minimum	25	0.0	462	435
	09/17/64	25th Percentile	773	2.0	818	551
	To:	Median	1,430	14.0	879	582
	09/26/94	75th Percentile	2,660	22.0	954	628
		Maximum	19,200	30.6	1,220	834
		No. of Obs.	241	239	220	146
Duncan	From:	Minimum	3	0.0	236	171
	11/08/45	25th Percentile	574	5.0	780	509
	To:	Median	1,350	16.0	845	566
	08/02/94	75th Percentile	2,460	22.0	916	616
		Maximum	16,900	37.0	1,140	815
		No. of Obs.	352	374	362	262
North Bend	From:	Minimum	120	0.0	192	133
	09/18/64	25th Percentile	2,950	1.4	398	247
	To:	Median	5,000	13.8	480	299
	09/07/89	75th Percentile	8,300	22.6	575	364
		Maximum	73,600	71.0	880	560
		No. of Obs.	233	232	192	101
Louisville	From:	Minimum	390	0.0	100	168
	02/26/71	25th Percentile	3,120	8.0	484	347
	To:	Median	5,600	18.5	623	409
	03/17/95	75th Percentile	9,500	24.0	745	474
		Maximum	110,000	32.0	2,250	995
		No. of Obs.	505	516	356	168

Table III-2.—Summary of Water Quality (Basis of Nonsupport) at Six Sites in the Mainstem of the Platte River in the Central Platte Basin (Continued)

Location		pH SU	NH_3+NH_4^{-1} N Diss. (mg/L)	NH_3+NH_4^{-1} N TOTAL (mg/L)	Un-ionized NH_3-N (mg/L)	Un-ionized NH_3-NH_3 (mg/L)	Fecal Coliforms (#/100 mL)
Brady	Minimum	7.30	0.02	- - -	0.0008	0.001	- - -
	25th Percentile	7.60	0.03	- - -	0.0009	0.001	- - -
	Median	7.70	0.03	- - -	0.0010	0.001	- - -
	75th Percentile	8.10	0.03	- - -	0.0015	0.002	- - -
	Maximum	8.40	0.03	- - -	0.0020	0.003	- - -
	No. of Obs.	21	3	0	3	3	0
	No. < D.L.	---	0	0	0	0	—
Overton	Minimum	7.10	< 0.01	< 0.01	< 0.0001	< 0.0001	0
	25th Percentile	7.90	0.02	0.04	0.0009	0.001	61
	Median	8.12	0.04	0.08	0.0020	0.002	190
	75th Percentile	8.42	0.07	0.12	0.0040	0.004	700
	Maximum	8.98	0.39	0.42	0.0240	0.03	190,000
	No. of Obs.	218	34	138	149	149	128
	No. < D.L.	---	3	14	3	3	—
Grand Island	Minimum	7.20	0.01	< 0.01	< 0.0001	< 0.0001	1
	25th Percentile	8.10	0.02	0.03	0.0006	0.0008	59
	Median	8.20	0.02	0.06	0.0020	0.0020	150
	75th Percentile	8.40	0.03	0.10	0.0040	0.0050	430
	Maximum	8.95	0.54	0.36	0.0390	0.0470	12,000
	No. of Obs.	234	25	192	215	215	154
	No. < D.L.	---	0	25	0	0	—
Duncan	Minimum	6.80	< 0.01	< 0.01	< 0.0001	< 0.0001	2
	25th Percentile	7.80	0.02	0.03	0.0004	0.0005	30
	Median	8.10	0.04	0.05	0.0010	0.0020	93
	75th Percentile	8.35	0.07	0.08	0.0030	0.0030	340
	Maximum	8.93	0.32	0.33	0.0380	0.0460	5,900
	No. of Obs.	366	122	76	141	141	101
	No. < D.L.	---	8	5	8	8	—
North Bend	Minimum	6.90	0.01	< 0.01	< 0.0001	< 0.0001	10
	25th Percentile	7.70	0.01	0.04	0.0005	0.0006	100
	Median	8.00	0.03	0.08	0.0010	0.0020	260
	75th Percentile	8.30	0.13	0.16	0.0040	0.0045	1000
	Maximum	8.90	0.59	0.81	0.0630	0.0770	280,000
	No. of Obs.	199	23	180	183	183	149
	No. < D.L.	---	6	16	6	6	—
Louisville	Minimum	6.05	< 0.01	< 0.01	< 0.001	< 0.001	10
	25th Percentile	7.97	0.02	0.04	0.001	0.001	140
	Median	8.28	0.04	0.10	0.002	0.002	370
	75th Percentile	8.60	0.11	0.22	0.004	0.005	1600
	Maximum	10.00	0.58	1.10	0.043	0.052	290,000
	No. of Obs.	369	195	147	270	270	149
	No. < D.L.	—	14	11	14	14	—

Table III-3.—Summary of Inorganic Contaminants at Six Sites in the Mainstem of the Platte River in the Central Platte Basin

Location		Arsenic As, diss. (µg/L)	Cadmium Cd, diss. (µg/L)	Chromium Cr, total (µg/L)	Copper Cu, diss. (µg/L)	Lead Pb, diss. (µg/L)
Brady	Minimum	< 1	< 1	- - -	< 1	< 1
	25th Percentile	- - -	- - -	- - -	- - -	- - -
	Median	< 1	< 1	- - -	< 1	< 1
	75th Percentile	- - -	- - -	- - -	- - -	- - -
	Maximum	< 1	< 1	- - -	< 1	< 1
	No. of Obs.	1	1	0	1	1
	No. < D.L.	1	1	0	1	1
Overton	Minimum	< 1	< 1	< 10	< 1	< 1
	25th Percentile	4	< 1	< 10	2	1
	Median	5	< 1	< 10	3	4
	75th Percentile	6	1	10	8	5
	Maximum	30	2	30	20	13
	No. of Obs.	14	10	31	15	11
	No. < D.L.	1	7	20	2	1
Grand Island	Minimum	< 1	< 1	10	< 1	< 1
	25th Percentile	3	< 1	10	2	2
	Median	4	< 1	10	2	2
	75th Percentile	5	2	10	4	6
	Maximum	6	3	100	40	32
	No. of Obs.	24	23	10	25	22
	No. < D.L.	1	19	7	8	3
Duncan	Minimum	1	< 1	< 1	< 1	< 1
	25th Percentile	3	< 1	< 1	2	< 1
	Median	4	< 1	< 1	3	< 1
	75th Percentile	4	1	10	6	4
	Maximum	10	3	20	110	19
	No. of Obs.	53	67	21	71	53
	No. < D.L.	0	40	8	3	29
North Bend	Minimum	< 1	< 1	< 1	< 1	< 1
	25th Percentile	4	< 1	< 5	4	< 1
	Median	6	< 2	15	6	2
	75th Percentile	8	2	20	11	3
	Maximum	10	6	70	40	8
	No. of Obs.	29	28	27	29	28
	No. < D.L.	0	17	12	1	8
Louisville	Minimum	1	< 1	< 1	< 1	< 1
	25th Percentile	4	1	< 10	3	< 1
	Median	6	1	< 10	5	< 2
	75th Percentile	7	2	20	6	5
	Maximum	12	20	50	20	80
	No. of Obs.	59	59	49	60	58
	No. < D.L.	0	42	29	2	32

Table III-3.—Summary of Inorganic Contaminants at Six Sites in the Mainstem of the Platte River in the Central Platte Basin (Continued)

Location		Silver Ag, diss. (µg/L)	Aluminum Al, diss. (µg/L)	Lithium Li, diss. (µg/L)	Selenium Se, diss. (µg/L)	Zinc Zn, diss. (µg/L)
Brady	Minimum	- - -	- - -	- - -	- - -	20
	25th Percentile	- - -	- - -	- - -	- - -	- - -
	Median	- - -	- - -	- - -	- - -	20
	75th Percentile	- - -	- - -	- - -	- - -	- - -
	Maximum	- - -	- - -	- - -	- - -	20
	No. of Obs.	0	0	0	0	1
	No. < D.L.	0	0	0	0	0
Overton	Minimum	< 1	< 1	10	< 1	< 1
	25th Percentile	< 1	25	15	2	6
	Median	< 1	50	20	2	8
	75th Percentile	< 1	75	25	2	20
	Maximum	1	100	30	3	930
	No. of Obs.	13	2	2	13	15
	No. < D.L.	6	1	0	1	2
Grand Island	Minimum	< 1	< 1	- - -	< 1	< 1
	25th Percentile	< 1	10	- - -	1	7
	Median	< 1	20	- - -	2	20
	75th Percentile	< 1	30	- - -	3	20
	Maximum	2	100	- - -	8	80
	No. of Obs.	23	58	0	23	25
	No. < D.L.	19	11	0	1	8
Duncan	Minimum	< 1	< 1	18	< 1	< 1
	25th Percentile	1	< 10	30	2	3
	Median	1	10	34	2	8
	75th Percentile	1	20	37	2	20
	Maximum	2	200	53	4	42
	No. of Obs.	65	48	47	65	71
	No. < D.L.	54	18	0	3	9
North Bend	Minimum	< 1	- - -	3	< 1	< 1
	25th Percentile	< 1	- - -	- - -	1	3
	Median	< 1	- - -	3	1	10
	75th Percentile	< 1	- - -	- - -	2	20
	Maximum	2	- - -	3	6	340
	No. of Obs.	25	0	1	28	29
	No. < D.L.	19	0	1	1	12
Louisville	Minimum	< 1	< 10	13	< 1	< 1
	25th Percentile	< 1	< 10	21	1	4
	Median	< 1	20	24	2	9
	75th Percentile	< 1	30	28	2	17
	Maximum	4	610	51	5	35
	No. of Obs.	63	47	47	70	59
	No. < D.L.	53	12	0	3	16

Table III-4.—Summary of Organic Contaminants (Commonly Used Herbicides) at Six Sites in the Mainstem of the Platte River in the Central Platte Basin

Location		Simazine Diss. Water Rec. (µg/L)	Cyanazine Diss. Water Rec. (µg/L)	Atrazine Diss. (ppb)	2,4-D Whole Sample (µg/L)
Brady	Minimum	< 0.05	< 0.05	0.07	< 0.01
	25th Percentile	< 0.05	< 0.05	0.09	< 0.01
	Median	< 0.05	< 0.05	0.10	< 0.01
	75th Percentile	< 0.05	0.05	0.12	< 0.01
	Maximum	< 0.05	0.05	0.13	< 0.01
	No. of Obs.	2	2	2	6
	No. < D.L.	2	1	0	6
Overton	Minimum	- - -	- - -	0.37	- - -
	25th Percentile	- - -	- - -	- - -	- - -
	Median	- - -	- - -	0.37	- - -
	75th Percentile	- - -	- - -	- - -	- - -
	Maximum	- - -	- - -	0.37	- - -
	No. of Obs.	0	0	1	0
	No. < D.L.	0	0	0	0
Grand Island	Minimum	< 0.05	< 0.05	0.17	- - -
	25th Percentile	< 0.05	< 0.05	0.22	- - -
	Median	< 0.05	< 0.05	0.58	- - -
	75th Percentile	< 0.05	0.06	0.80	- - -
	Maximum	0.09	2.28	4.76	- - -
	No. of Obs.	24	24	24	0
	No. < D.L.	19	18	0	0
Duncan	Minimum	< 0.05	< 0.05	0.23	< 0.01
	25th Percentile	< 0.05	< 0.05	1.72	< 0.01
	Median	0.06	0.09	3.71	< 0.01
	75th Percentile	0.14	0.14	6.99	< 0.01
	Maximum	0.24	0.41	19.03	< 0.01
	No. of Obs.	15	15	15	4
	No. < D.L.	6	6	0	4
North Bend	Minimum	- - -	- - -	- - -	< 0.01
	25th Percentile	- - -	- - -	- - -	0.02
	Median	- - -	- - -	- - -	0.07
	75th Percentile	- - -	- - -	- - -	0.07
	Maximum	- - -	- - -	- - -	0.12
	No. of Obs.	0	0	0	10
	No. < D.L.	0	0	0	1
Louisville	Minimum	< 0.005	< 0.01	< 0.05	< 0.01
	25th Percentile	0.026	0.05	0.18	< 0.01
	Median	0.041	0.41	0.76	< 0.01
	75th Percentile	0.050	2.65	3.00	< 0.01
	Maximum	0.230	30.00	30.00	0.80
	No. of Obs.	91	91	162	14
	No. < D.L.	29	12	8	11

contaminants that are commonly used in the area (simazine and cyanazine) or are related to other constituents (the various measures of ammonia [NH_3–N] and ammonium [NH_4^{-1}–N]). The major complicating factor in making the comparisons is the detection limit for constituents such as arsenic and lead. The detection limit has varied over time. The main problem that this creates in a statistical summary is that some actual measured data are lower than earlier (or sometimes later) detection limits. This results in an intermingling of measured and unmeasurable results. An even greater difficulty arises when the standard is below the detection limit; this is a particular problem with lead. To avoid complications with the detection limit, the data were checked for flags in the data that indicate that the value was less than a detection limit. Any values that were flagged as being less than the detection limit were assumed to meet the standard without checking further. These types of values may or may not meet the standard, but there is no way to evaluate that for sure.

Table III-1B shows a comparison between the water quality standards and data collected since 1975. Based on the percent of the time that standards are exceeded, the greatest water quality problems in the mainstem of the Platte River are due to fecal coliform bacteria, arsenic, lead, and atrazine.

The fecal coliforms exceed the standard between 20 and 50 percent of the time depending on the monitoring site (table III-1B). As can be seen from table III-2, fecal coliform counts in the hundreds of thousands have been observed at three of the five sites for which there are data. The coliform standard is based on recreation use and does not relate to any of the endangered species or any other form of wildlife.

The arsenic standard shown in table III-1A is one of three different arsenic standards in Nebraska. It is shown in the table because it is the only one of the three that is not specific to a certain form of arsenic. The 1.4 µg/L standard is an aquatic life criterion based on the protection of human health; the standard is meant to assure that bioaccumulation to concentrations that are associated with an estimated 10^{-5} probability of cancer in human consumers of fish does not occur. The standard has nothing to do with the health of the fish themselves.

The chronic aquatic life standards are 190 µg/L for As^{III} (arsenite) and 48µg/L for As^{V} (arsenate). These are not shown in Table III-1A because the monitoring data are not speciated. However, the maximum concentration of dissolved arsenic is 30 µg/L; this would be the total of the As^{III}, As^{V}, and As^{-3} (arsenide), although the presence of all three forms at once is chemically unlikely. Nevertheless, it is obvious that the chronic standard for the individual arsenic species have not been exceeded by any of the monitoring results. There does not appear to be any risk to aquatic life due to arsenic contamination.

Lead exceeds its standard in more than ½ of the samples at both Overton and Grand Island (table III-1B). However, there are a very limited number of samples (i.e., < 10 at

Overton and < 20 at Grand Island). The highest median lead concentration is at Overton at 4 µg/L. The median lead concentration is below the detection limit of 1 µg/L at Duncan and the detection limit of 2 at Louisville (table III-2). The calculated standards based on hardness range from < 0.1 to 1 µg/L (table III-1A). The exceedences of the standard at sites with the largest number of lead samples (i.e., Duncan and Louisville) are less than 50 percent but still represent a significant percentage of the total (table III-1B). Based on the above, there appears to be a significant problem of lead contamination in the Platte River from Overton to its mouth. However, a closer inspection of the data indicates that there may really be no problem at all, at least under current conditions. Samples collected during the last several years of the record, the last of which was in 1991, were all below the detection limit, as indicated by the "<" symbol above the concentration. Although the detection limit may be well above the standard, the result would be assumed to meet the standard. There is no way to tell if it did not. The recent data would seem to indicate that the standard is met. A single exceedence would not be a violation. The standards are written such that a single exceedence may not actually violate a standard. The standards are evaluated by averaging a set samples over a specified period. Unless a sample shows a very high concentration, the average of several samples would not cause a violation.

Figure III-1 shows a plot of the lead data against the maximum lead standard (used for example). The problem with lead may extend farther upstream, but there are not enough data between Overton and the North and South Platte confluence to make a valid assessment. For example, only one sample has been collected at Brady (tables III-1 and III-2).

Aluminum, cadmium, and silver have exceeded their respective standards in a small percentage of samples (table III-1B). Silver exceeded its standard in one sample each at North Bend and Louisville (table III-1B). Aluminum exceeded its standard in two samples each at Duncan and Louisville; however, the aluminum standard was exceeded in 20 percent of the samples collected at Grand Island (table III-1B). Based on this, aluminum may be a concern in the habitat reach.

Mercury is not included in the previous tables. Mercury presents a special case in that the standard is well below the detection limit that is usually obtained by the analytical techniques that are most often used. The current standard analytical technique for mercury is by cold vapor atomic absorption spectrophotometry, which has a detection limit of 0.1 (or sometimes as high as 0.5) µg/L. The mercury standard, based on the chronic warm water aquatic life criterion is 0.012 µg/L or about ⅛ the minimum detection limit. (The mercury standard is so low because it is based on the very high bioaccumulation potential of mercury.) In evaluating the data against the standard, it is assumed that any datum that is less than the detection limit is also less than the standard. This obviously may or may not be true; however, there is no way to determine otherwise.

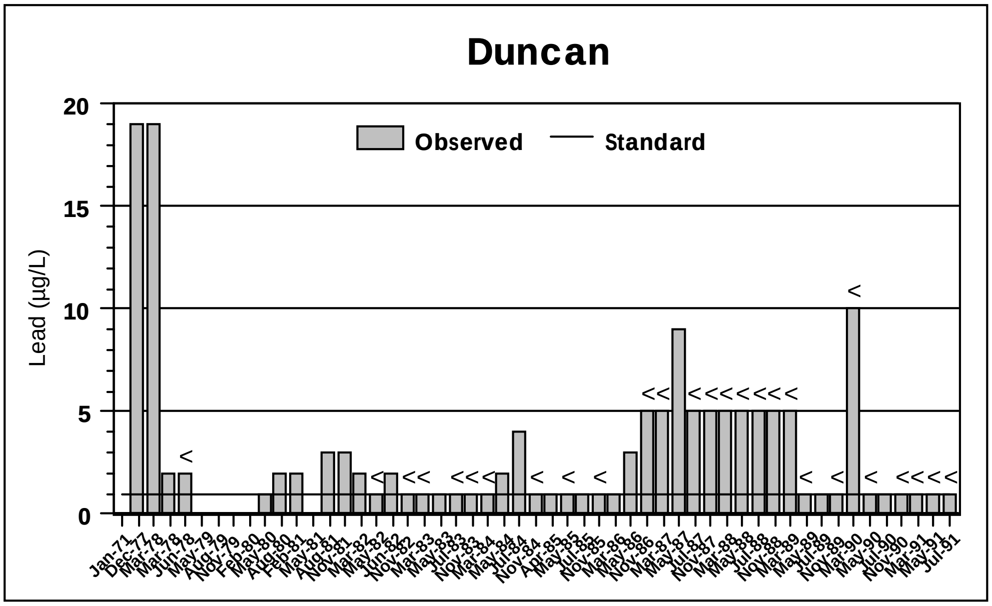

Figure III-1.—Comparison Between Lead Concentrations and the Maximum Lead Standard.

Alternatively a comparison to the detection limit will also suffice as a comparison to the standard, *i.e.* any sample that exceeds the detection limit will exceed the standard.

As can be seen in the data summary in table III-5, the available data consist of dissolved or total mercury. There are also a few suspended mercury analyses, but the most recent of these date from 20 years ago and are not being used. The mercury standard is for total recoverable mercury. The total recoverable analysis is based on a dilute acid digestion of the sample that is meant to break down particles that would be digested by an aquatic organism. It is meant to simulate biologically available mercury. The total mercury shown in table III-5 is from a strong acid digestion and would be expected to be somewhat higher than what would be obtained from the dilute acid digestion. However, in practice the total recoverable concentration is near the dissolved concentration. In this evaluation, both the dissolved and total mercury data will be evaluated against the standard.

The comparison of the dissolved mercury data to the standard indicate that there are a considerable number of samples that have exceeded the standard (table III-5A). The greatest on a percentage basis is at Overton, but that gage has the fewest samples of the sites shown None of the samples from Grand Island exceeded the standard, but the detection limit was always at 0.5µg/L. Consequently it seems likely that some of the samples would have exceeded 0.1 µg/L. At the three sites downstream from the habitat reach, roughly 20 percent of the samples have exceeded the standard.

Table 5.—Dissolved and Total Mercury at Five Sites in the Platte River Basin

A. Dissolved Mercury

	Overton	Grand Island	Duncan	North Bend	Louisville
Median (µg/L)	< 0.1	< 0.5	< 0.1	< 0.1	< 0.1
Maximum (µg/L)	0.7	< 0.5	0.4	0.5	1.0
No. of Obs.	11	23	54	29	58
No. > Std.	4	0	10	4	12
No. < D.L.	7	23	44	25	46
Begin Year	1978	1973	1971	1973	1974
End Year	1981	1981	1991	1981	1991

B. Total Mercury

	Overton	Grand Island	Duncan	North Bend	Louisville
Median (µg/L)	< 0.1	< 0.1	0.1	0.3	< 0.1
Maximum (µg/L)	6.0	0.1	1.2	0.7	1.5
No. of Obs.	38	28	18	31	46
No. > Std.	20	6	13	13	21
No. < D.L.	18	22	5	18	25
Begin Year	1978	1973	1977	1973	1974
End Year	1989	1984	1982	1984	1989

Another problem with the mercury data for the Platte Basin is that there is little in the way of mercury samples in recent years. The most recent data are from the Duncan and Louisville gages consist of dissolved mercury samples collected in 1991 (table III-5A). The most recent sample that exceeded the 0.1 µg/L detection limit was in 1988 at Duncan and in 1989 at Louisville.

A much greater percentage of the total mercury samples have exceeded the standard than was true of the dissolved fraction alone, based on the comparison to the detection limit (table III-5B). This is to be expected. This indicates that there was additional mercury present when the samples were collected, but there is no way to tell how much of it was biologically available. However, based on the biological data presented elsewhere, mercury is a problem in the Platte River.

The State of Nebraska (1996; 1998) list pesticides as a major cause of nonsupport for beneficial uses in the Platte River mainstem. Table III-1 indicates that its standard is exceeded a large percentage of the time by atrazine, particularly in the lower reaches of the river. Figures III-2 and III-3 show histograms of atrazine monitoring data at three sites in the lower Platte mainstem in comparison to the water quality standard. These data, unlike the lead data, show definitively the frequency with which the standard is exceeded. The data for Grand Island show that the standard is exceeded occasionally, but not by a great amount. The maximum concentration is less than 5 µg/L. There are fewer data at the Duncan gage than at Grand Island (table III-4), but the percentage of samples that exceeds the standard is much larger (87 and 21 percent, respectively—table III-1), with 33 percent of the Duncan samples greater than 5 µg/L.

There are many more atrazine samples from the Louisville gage (162) than from either of the upstream gages (table III-4). Of the 162 samples from the Louisville gage, 69 exceed the 1 µg/L standard. This translates to 43 percent, which is about ½ the percentage at the Duncan gage. From this perspective it would seem that there is some improvement in water quality relative to atrazine contamination in the river at the farthest downstream station. Alternatively, although the frequency of exceeding the standard decreases, the magnitude of the peak concentration of atrazine increased (compare figures III-2 and III-3). The maximum atrazine concentration has been 19 µg/L at Duncan, but it has been as high as 30 µg/L at the Louisville gage.

TEMPERATURE STANDARD

There have been a number of fish kills over the years in the Platte River mainstem (NGPC, 1996). Ninety-two percent of these were in the Middle Platte between Cozad and Columbus (*ibid.*). Many of these fish kills were attributed to low flows and excessive temperatures. These fish kills included species that are known to provide forage for nesting least terns. For this reason the temperature issue is a significant concern for the recovery of the tern in the Middle Platte Basin.

Between 1988 and 1995, the Fish and Wildlife Service monitored temperature at up to five sites in the Platte River. The data and a comparison to the Nebraska water quality standard for temperature in the Platte River (32˚C or 90˚F) for each year and each site are presented in table III-6. The number of days shown in table III-6 represents the total between the initiation of monitoring (June 1) and the last day of the monitoring period.

The last day during the years 1988 through 1993 was August 31. The end of the monitoring period was extended to the first or second week in September in 1994 and 1995; so the number of days in the monitoring period increased in those years. The number of observations represents the number of days within the total that monitoring actually occurred. This latter has the potential to affect the results, in that the days when

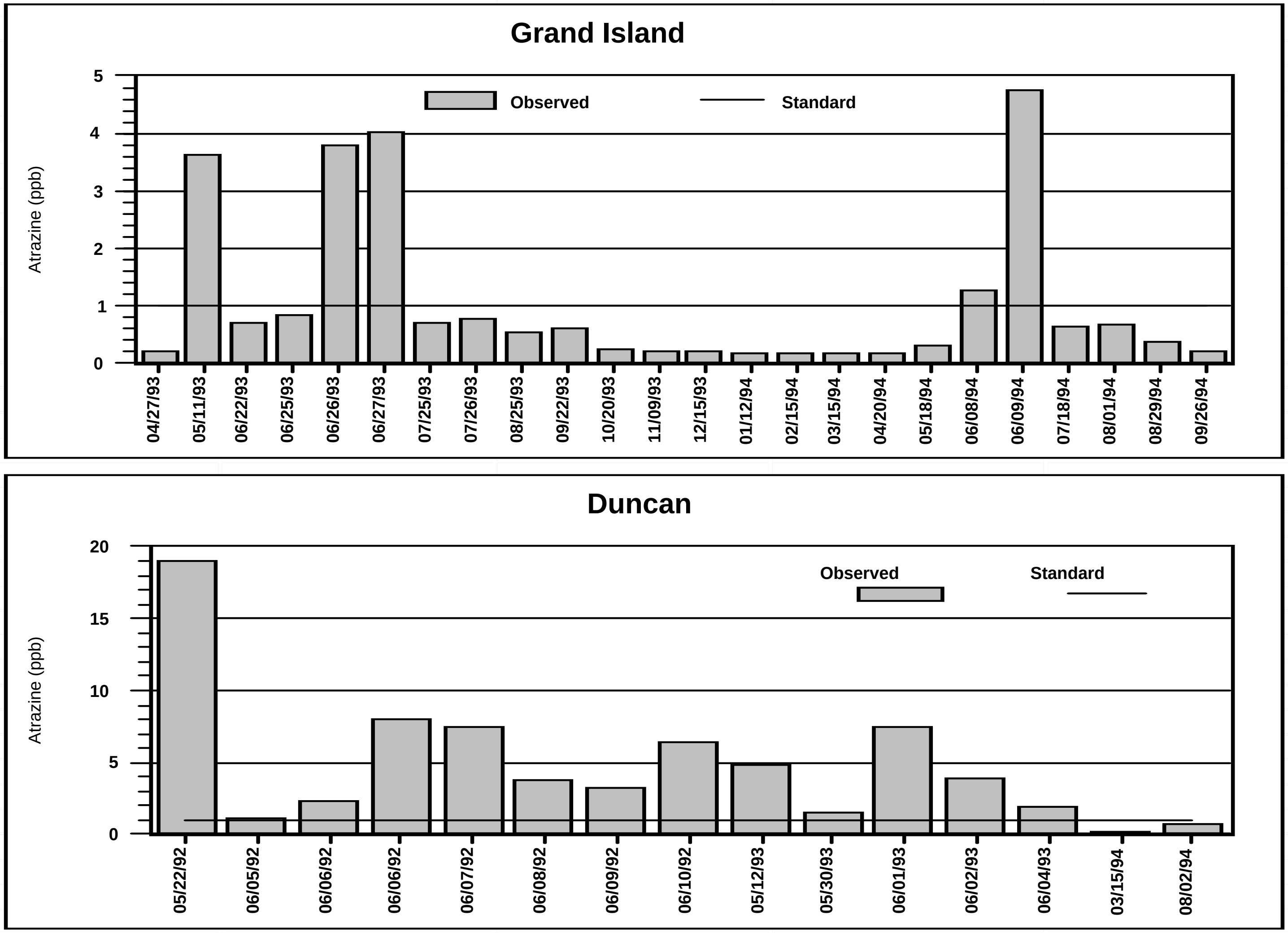

Figure III-2.—Comparison of Atrazine Concentrations in the Platte River at the Grand Island and Duncan Gages and the Atrazine Aquatic Life Standard.

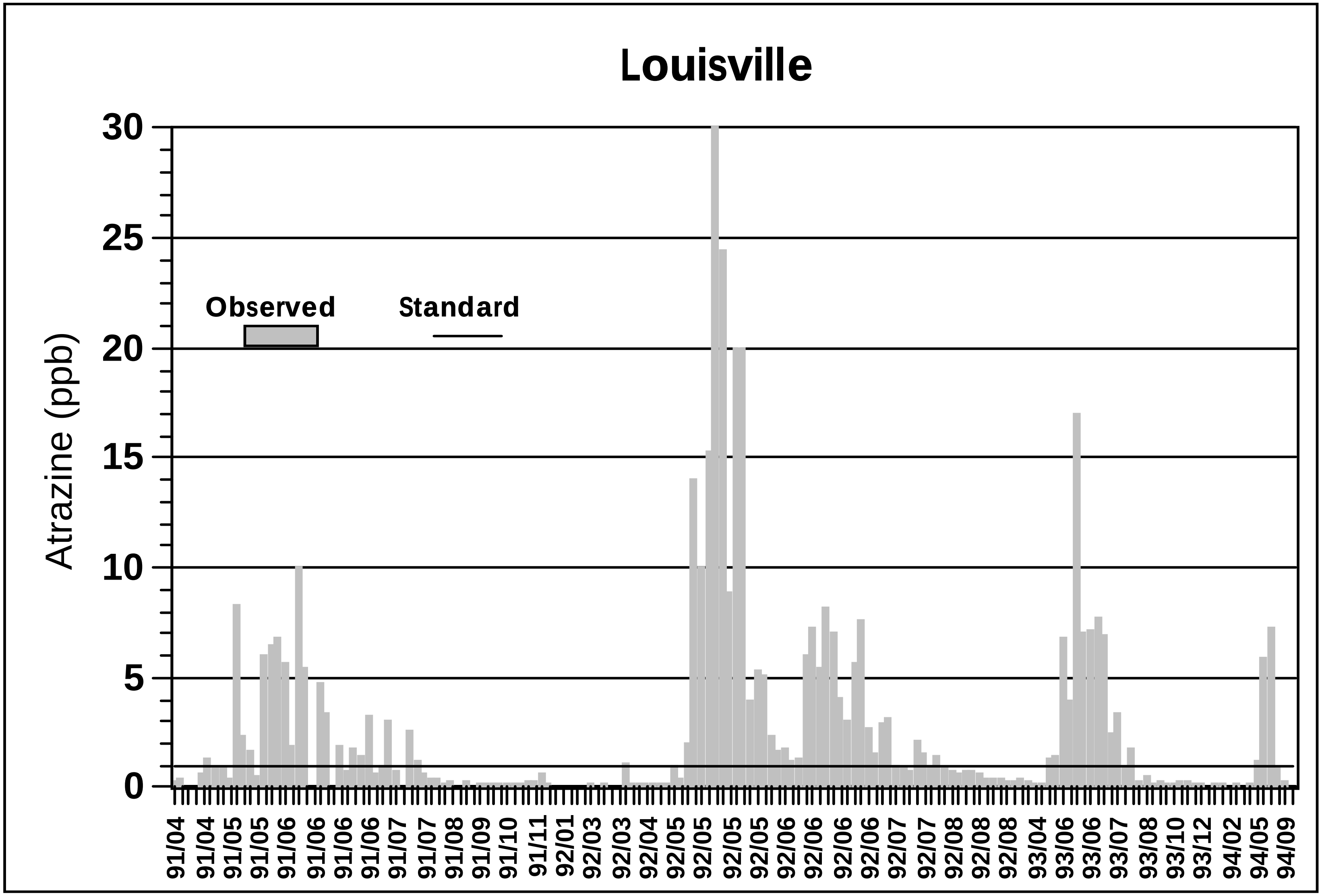

Figure III-3.—Comparison of Atrazine Concentrations in the Platte River at the Louisville Gage and the Atrazine Aquatic Life Standard.

Table III-6.—Summary of Temperature Data and Comparison to the Nebraska Temperature Standard at Five Sites in the Platte River

Site	Year	No. of Days	No. of Obs.	No. > Std.	% > Std.
Overton	1988	92	0	0	No Data
	1989	92	20	0	0.0%
	1990	92	77	3	3.9%
Ave. % > Std. = 2.8%	1991	92	88	1	1.1%
	1992	92	85	0	0.0%
	1993	92	82	1	1.2%
	1994	104	91	12	13.2%
	1995	101	35	0	0.0%
Odessa	1988	92	0	0	No Data
	1988	92	83	13	15.7%
	1990	92	63	12	19.0%
Ave. % > Std. = 9.5%	1991	92	75	12	16.0%
	1992	92	69	1	1.4%
	1993	92	85	0	0.0%
	1994	104	91	10	11.0%
	1995	101	32	1	3.1%
Kearney	1988	92	0	0	No Data
	1989	92	38	6	15.8%
	1990	92	86	30	34.9%
Ave. % > Std. = 19.2%	1991	92	92	36	39.1%
	1992	92	68	5	7.4%
	1993	92	85	4	4.7%
	1994	104	90	29	32.2%
	1995	99	4	0	0.0%
Mormon Island	1988	92	43	28	65.1%
	1989	92	0	0	No Data
	1990	92	65	42	64.6%
Ave. % > Std. = 37.5%	1991	92	90	53	58.9%
	1992	92	70	6	8.6%
	1993	92	85	16	18.8%
	1994	93	74	24	32.4%
	1995	93	71	10	14.1%
Phillips	1988	92	0	0	No Data
	1989	92	81	39	48.1%
	1990	92	82	50	61.0%
Ave. % > Std. = 34.5%	1991	92	69	48	69.6%
	1992	92	56	12	21.4%
	1993	92	84	9	10.7%
	1994	104	92	28	30.4%
	1995	101	6	0	0.0%

the monitors were not operating could be ones on which the standard was exceeded. For this reason, the percentage shown in the last column is a more representative measure of the exceedence of the standard than the number of days per year on which the standard is exceeded.

Table III-7 shows annualized values for the exceedences of the temperature standard in the Platte River. The data in table III-7 indicate that the exceedences of the standard increase in a downstream direction. They are the most frequent at the lower end of the critical habitat reach of the Platte River.

Table III-7.—Annual Average Exceedence of the Temperature Standard at Five Sites in the Critical Habitat Reach of the Platte River

Site	No. of Days	No. of Obs.	No. > Std.	% > Std.
Overton	95	68	2	3.6%
Odessa	95	71	7	9.8%
Kearney	95	66	16	23.8%
Mormon Island	92	71	26	35.9%
Phillips	95	67	27	39.6%

There is some controversy over the cause and best way to control temperature in the Middle Platte. Dinan (1992) simulated temperatures in the Platte River and found that the frequency and duration of lethal temperatures for fish could be reduced if flows were increased. This study was critiqued by Miller (1994) who maintained that the air temperature was the major factor in bringing about excessive water temperature and developed a series of regression relationships to evaluate the relationships between air temperature, water temperature, and flow. Zander (1996) also evaluated the relationships using several statistical techniques and reaffirmed Dinan's earlier findings. At about the same time Miller (1996), following a further evaluation of the air and water temperature and flow interrelationships, reiterated that it was extremely unlikely to change water temperature with flow manipulations alone.

The problem with all of this is that the there is no real difference in the findings. Neither Dinan (1992) nor Zander (1996) was recommending flows for temperature control. In both cases they found that any increase in flow would result in less warming of the water. Consequently at the higher summer flows anticipated as a result of the preferred alternative from the ESA consultation, there should be less frequent exceedences of the temperature standard as a side benefit.

The FWS (1997) in the Biological Opinion for Kingsley Hydroelectric Relicensing relied on a hydrodynamic temperature model (Sinokrot, et al., 1997) to evaluate the relationship between flow and temperature. The conclusion there was that the increase in the frequency of flows above 1,200 ft³/s if the preferred alternative were implemented would decrease the frequency of exceeding the temperature standard at Grand Island significantly and improve habitat conditions for the fish community.

Zander (1996) looked at the probability of exceeding the 32 °C temperature standard at various flows. That approach has been taken here as well. Using the temperature data for the two sites at which the standard was exceeded in the 1988-95 data sets, a series of cumulative frequency distributions were developed for various increments of flow at the USGS Grand Island gage (figure III-4). The flow increments were sized to include a minimum of 25 observations would be included in each frequency distribution. This leads to an unequal distributions of flows across each interval. The flow intervals were also determined to some extent by the goal of developing 12 frequency distributions. The probability of exceeding 32 °C at the Mormon Island and Phillips sites at different flows are shown on figure III-5. There is also a line shown on figure III-5. This is a polynomial (actually a quadratic) regression fit of the probabilities with the flow at the center of each interval. The coefficients of determination (R^2) of the regressions of the probability of exceeding the temperature standard as a function of flow is also shown on each of the plots in figure III-5; the regressions explain 80 percent or more of the variation in the probability—flow distributions.

The probability—flow distribution for the Mormon Island monitoring site indicates the the probability of exceeding the temperature standard during the months of June to September is greater than 60 percent at flows less than 100 ft³/s, around 50 percent at flows between 100 and 500 ft³/s, 30 percent at flows between 500 and 1,500 ft³/s, and so forth (figure III-5A). This does illustrate that there is a lower probability of exceeding the water quality standard at higher flows. However, the upper end of each of the probability distributions still show that at even the highest flows, there is a possibility of exceeding the temperature standard in the vicinity of Grand Island.

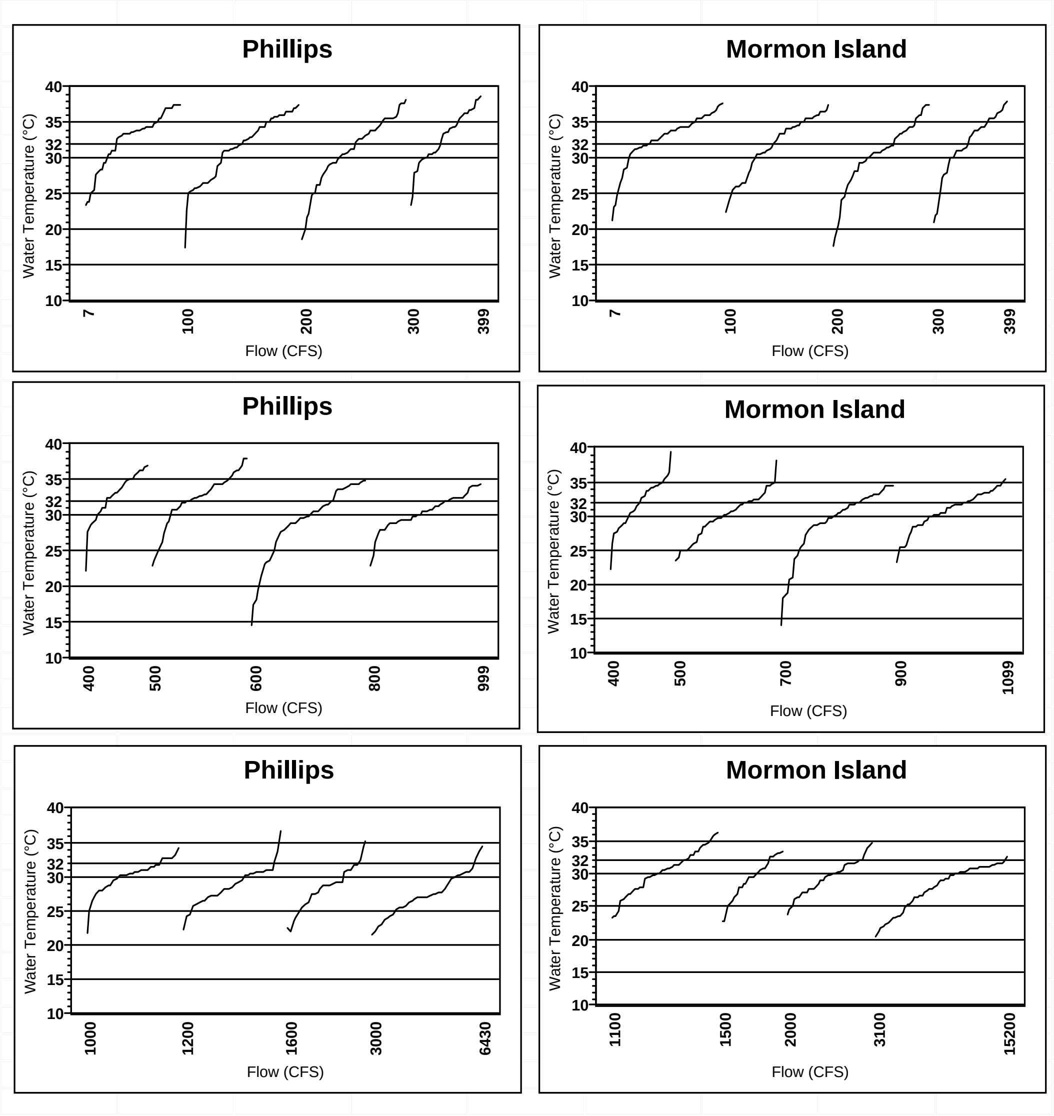

Figure III-4.—Cumulative Frequency Distributions of Maximum Water Temperatures Within Various Interval of Flow at the Grand Island Gage with a Comparison to the Water Quality Standard for Temperature.

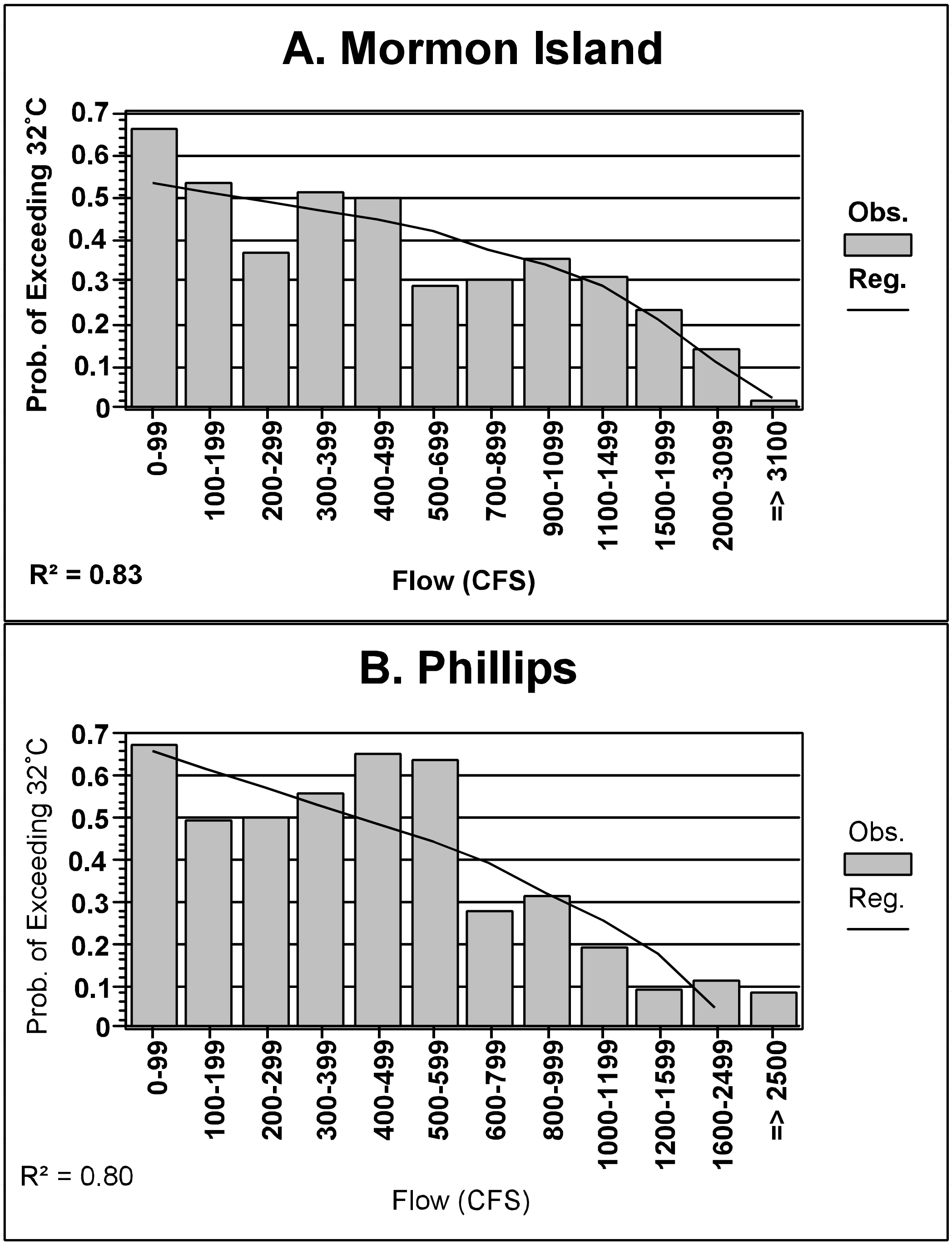

Figure III-5.—Flow Versus Probability Histograms for Platte River Temperatures.

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CHAPTER IV

Water Quality Trends in the Middle Platte River

The surface water data described above have been analyzed for trends over time. A summary of the results are shown in table IV-1. Spearman correlations were chosen to evaluate trends since they evaluate relationships based on the order of two variables when ranked from low to high. To evaluate a trend, the independent variable has to be some measure of a chronological sequence. Table IV-1 includes an evaluation of the variable relative to the sample year and a sequential sample number that is assigned as 1 through n, which sets the rank of the data against time. The differences in the correlations result from the effect of multiple years which are treated as ties and randomly ordered within the year. This has the effect of de-emphasizing seasonal effects.

Table IV-1.—Spearman Correlation Matrix – Trends Over Time for Various Measures of Water Quality

		Year	Probability		Trend	Probability
Temperature	r	0.153	< 0.05	r	0.163	< 0.05
	n	239		n	239	
Turbidity	r	-0.124	n.s.	r	-0.103	n.s.
	n	86		n	86	
Atrazine	r	-0.339	n.s.	r	-0.315	n.s.
	n	24		n	24	
Specific conductance	r	0.296	< 0.01	r	0.280	< 0.01
	n	221		n	221	
Dissolved Solids (sum)	r	0.286	< 0.01	r	0.263	< 0.01
	n	112		n	112	
Dissolved Solids (residue)	r	0.017	n.s.	r	0.011	n.s.
	n	52		n	52	
Fecal Coliforms	r	-0.235	< 0.05	r	-0.218	< 0.05
	n	154		n	154	
Fecal Streptococci	r	-0.266	< 0.01	r	-0.270	< 0.01
	n	146		n	146	
Flow	r	0.151	< 0.05	r	0.140	< 0.05
	n	241		n	241	
NH_3-N	r	0.465	< 0.001	r	0.469	< 0.001
	n	215		n	215	
$NH_3 + NH_4^{+1}$	r	0.045	n.s.	r	-0.118	n.s.
	n	25		n	25	
$NO_2 + NO_3$	r	0.214	< 0.05	r	0.188	n.s.
	n	113		n	113	
Temperature	r	0.153	< 0.05	r	0.163	< 0.05
	n	239		n	239	

The only variables that do not show any trend over time, *i.e.* do not show a significant correlation (designated by n.s. (not significant [probability >0.05]). in the probability column), are turbidity, atrazine, and $NH_3 + NH_4^{+1}$. $NO_2 + NO_3$ shows a correlation with year, but not with the trend line (or sequence number). Both of the bacterial measures shown in table IV-1 show a significant downward trend, indicating that concentrations have been decreasing over time, i.e., water quality is improving. The streptococcus decrease is the more significant of the two trends.

The correlations in table IV-1 indicate that the water temperature of the Platte River has been increasing over time. This is further illustrated in figure IV-1. Of particular interest to this study are the summer temperatures. When only the months of June through August are considered, the Spearman's r for the correlation between temperature and year and temperature and the trend line are both 0.27, which is also statistically significant in both cases. A regression of temperature against the trend line using the June through August data shows that the slope of the regression line is also statistically significant (t = 2.51, probability of a greater t = 0.014), further indicating the statistical significance of the increase in summer water temperature in the Platte River near Grand Island. In other words there is a significant trend toward warming of the river at Grand Island in the summer, as well as on a year-round basis.

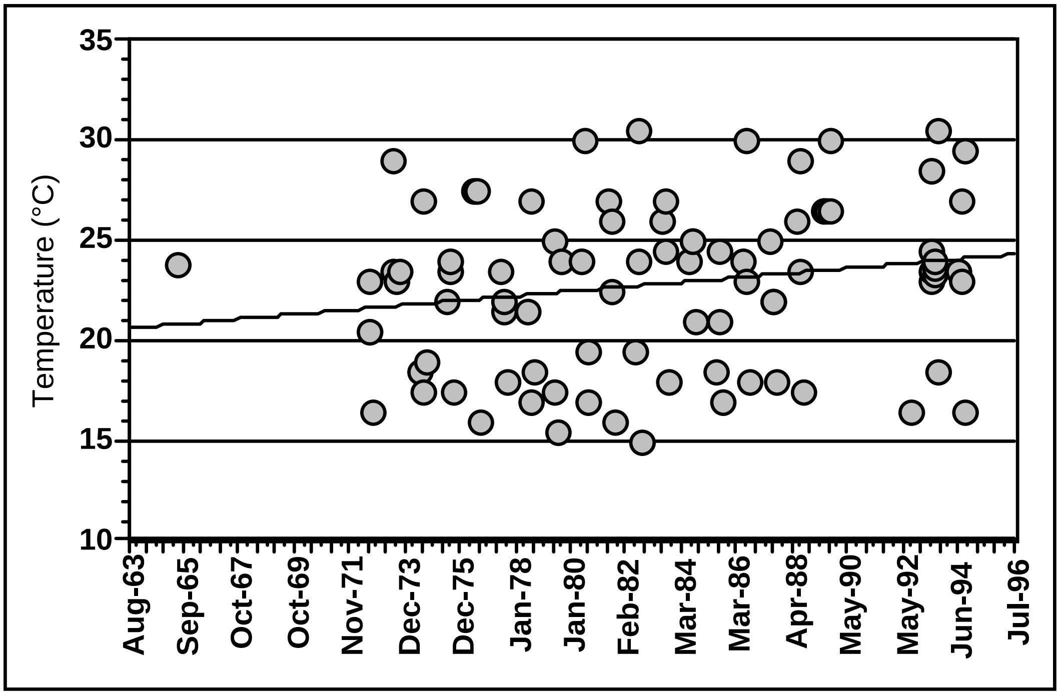


Figure IV-1.—Water Temperature at the USGS Grand Island Gage on the Platte River.

Table IV-1 also shows a significant trend toward increasing EC (specific conductance) and TDS. This is further illustrated in figure IV-2, which shows the trend of EC over time. Although several of the parameters discussed above indicate improving water quality, the TDS would indicate otherwise. An increase in TDS (or EC) is usually an indication that water use, particularly for agriculture, is increasing.

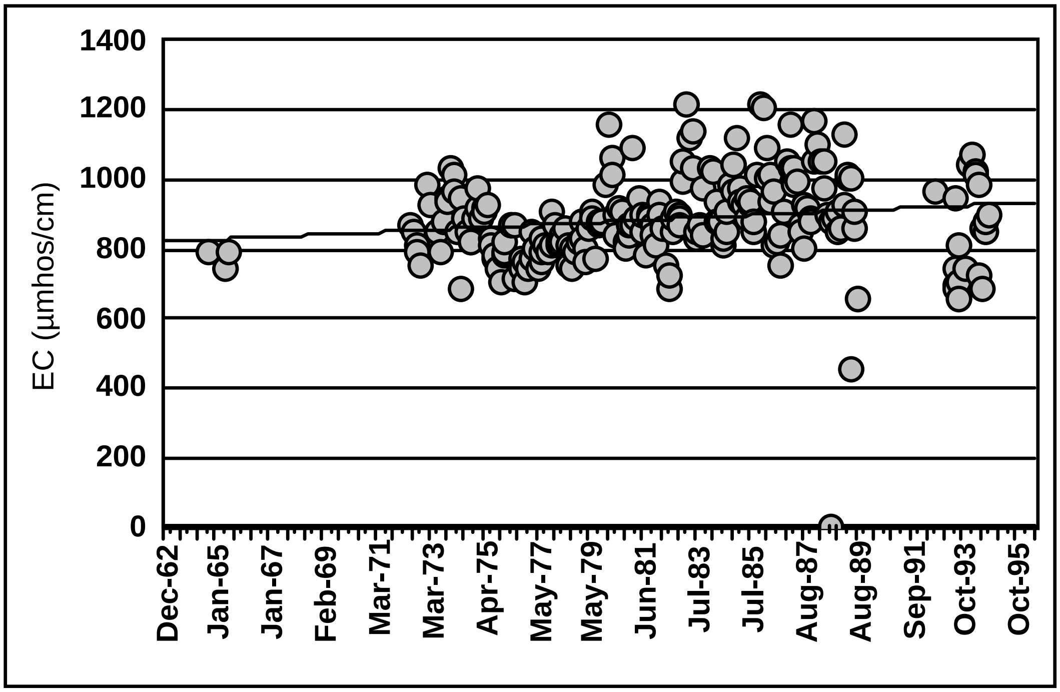


Figure IV-2.–Specific Conductance (EC) at the Grand Island Gage.

Table IV-1 also shows a significant positive correlation with flow, indicating that flows at the Grand Island gage have been increasing over time. Table IV-2 summarizes the statistics associated with the regression. Figure 3 shows the mean annual flow at the Grand Island gage for the entire period of record (1934 through 1998). The data in figure IV-3 indicate that the high flow years of 1983 and 1984 have an undue influence on the regression. Since this was apparently due to the very large volume of spring runoff and spills throughout the North Platte reservoir system, the summer flows alone could provide a better indicator of any trend, because the influence of spring runoff should be removed.

Figure IV-4 shows the trend for summer flows (June through August) only; table IV-2 includes the statistics for the summer flow trend. The relationship using only summer flows is not as significant as the regression for the average annual flows. The trend line has a t-value that also has a reduced significance level (probability) than that of the slope

Table IV-2.—Summary of Regressions of Average Annual Flow on Year

Flow condition	r	F	Probability of a greater F	t (slope)	Probability of a greater t
Average annual flow	0.401	11.514	0.001228	3.393	0.00123
Average summer flow	0.320	7.175	0.009416	2.679	0.00942
log Average summer flow	0.414	12.850	0.000665	3.584	0.00066

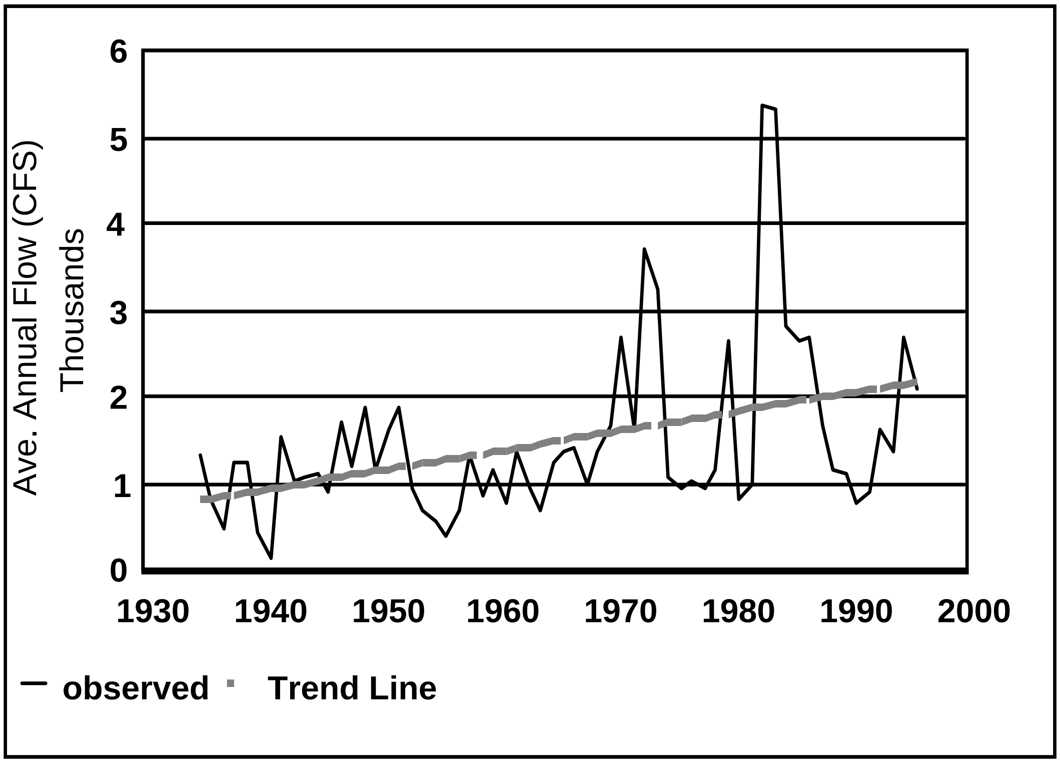


Figure IV-3.—Trend in Average Annual Flow of the Platte River at Grand Island.

of the average annual flow regression (table IV-2). However, although the summer flow in 1984 is much reduced, 1983 still appears to have a great influence on the regression. The regression output indicates that 1983 is an outlier, but does not indicate that it exerts undue leverage on the relationship.

A common method of normalizing or removing the skew in a numeric flow distribution is to evaluate the data after undertaking a log transformation. Table IV-2 shows the

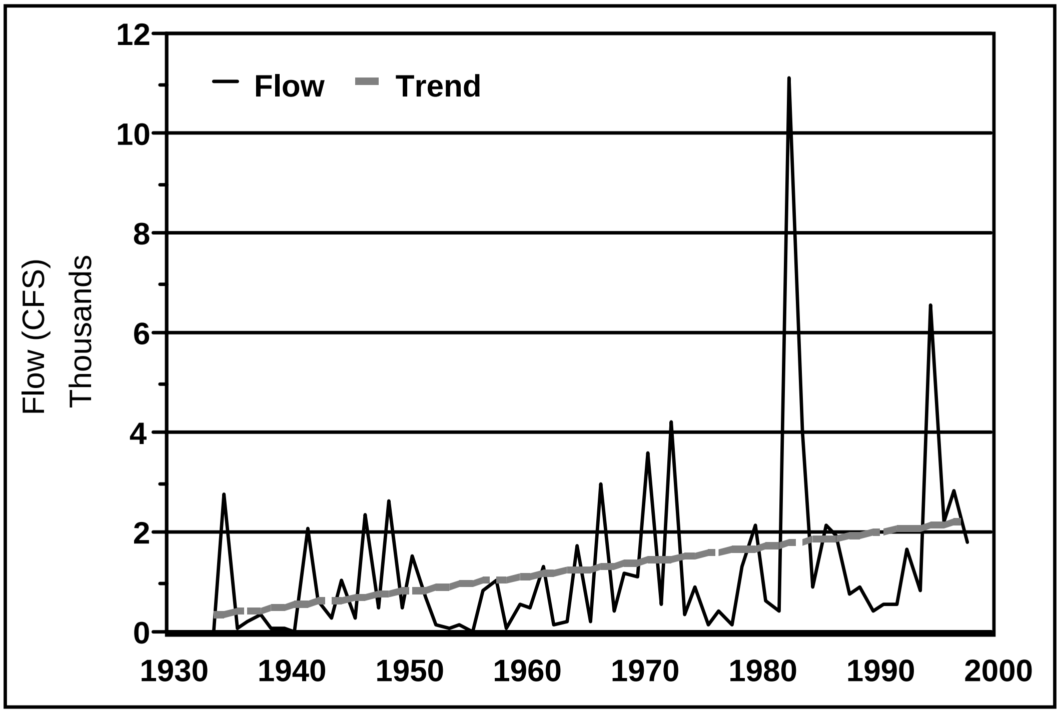


Figure IV-4.—Trend in Average Annual Summer (June through August) Flows in the Platte River at the Grand Island Gage.

statistics associated with the log-transformed flow regression. After the log-transformation, 1983 is no longer an outlier (figure IV-5). The log-transformation also removes the no-flow year of 1934 from the data set (the log of 0 is mathematically undefined). However, the average summer regression based on the log-transformed data shows the most significant trend of any of the three regressions of flow on year (table IV-2). Based on this result, one would have to conclude that the trend is real. The cause may still be the natural progression of water years.

An alternative explanation for the effect on summer flows could be the influence of return flows from an expansion of irrigation with ground water with its consequent addition of return flows. The trends in the Central Platte Natural Resources District (NRD) are shown on figure IV-6. The increase in the number of wells and irrigated acreage is presumptive evidence for an increase in the use of ground water for irrigation. This would also yield an increase in return flows from irrigation.

The hypothesis is further supported by the trends in EC and temperature, both of which have also shown an increasing trend over time. The ground water on the north side of the river has an EC that is somewhat greater than that of the river itself, while that on the south side of the river is approximately the same as the river. The EC would be further increased by evapotranspiration if used for irrigation. An increased proportion of river

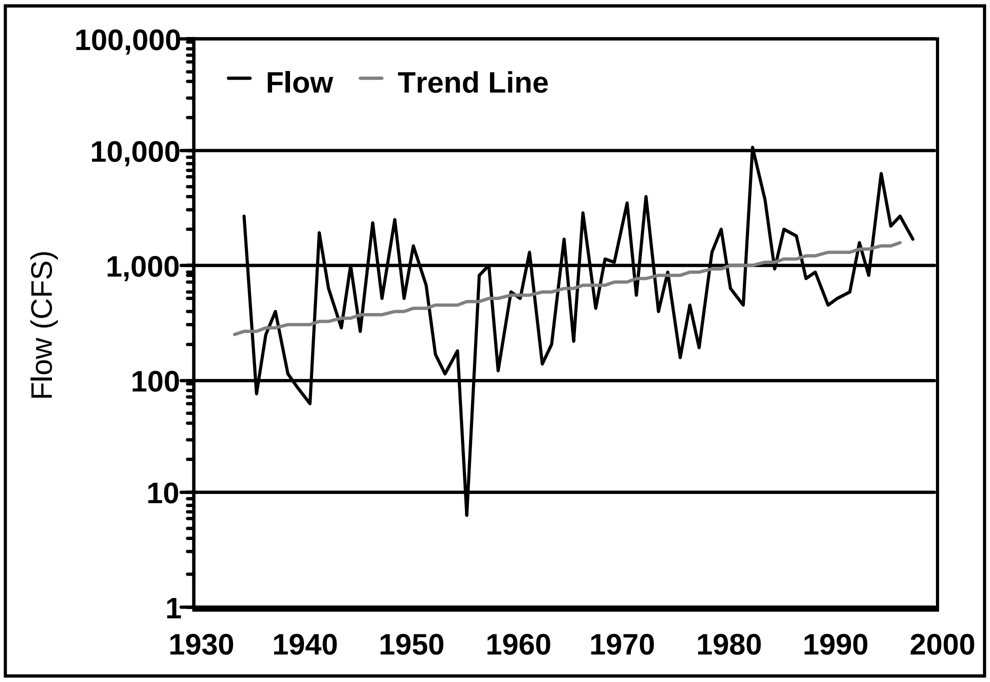


Figure IV-5.—Trend in Log-Transformed Average Annual Summer (June Through August) Flows in the Platte River at the Grand Island Gage.

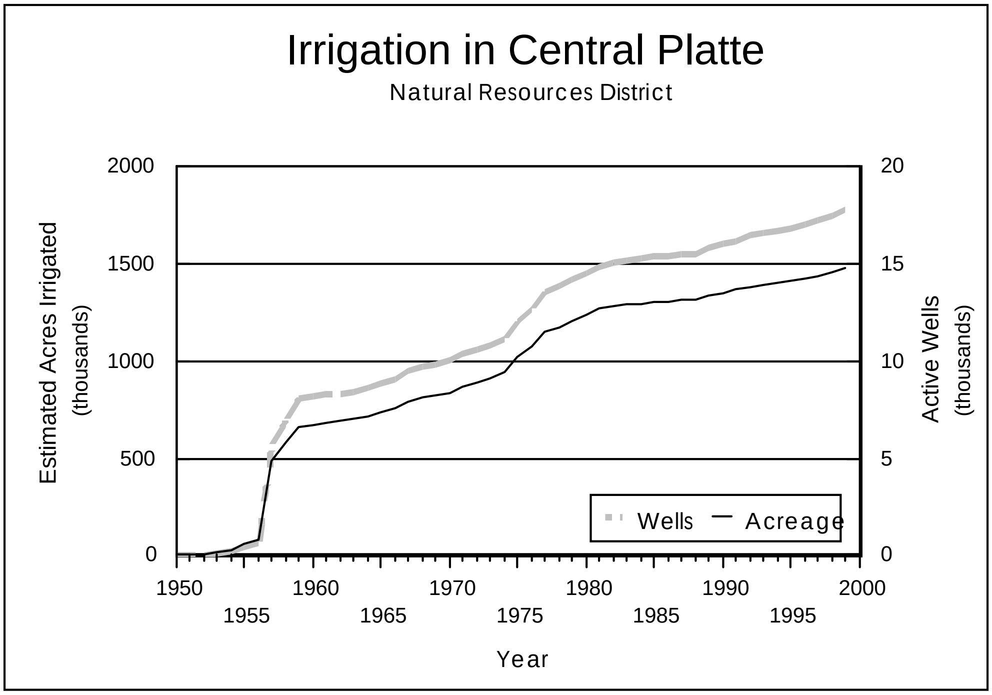


Figure IV-6.—Trend in Well Development and Irrigation in the Central Platte NRD.

flows that consist of returns from ground water irrigation would show an increase in the EC of the river if all other irrigation were not significantly changed. The effect on temperature could be somewhat similar. Although the temperature of the ground water along the river is much lower than that of the river, water would be warmed during application on croplands. How much it would be warmed is unknown, but if such warming occurred, it could influence the river temperature, particularly if the returns constitute a relatively large percentage of the total river flow.

GROUND WATER QUALITY

Unlike those for surface water, trends in ground water quality are more difficult to define, primarily because of a lack of long-term monitoring data. As was noted in the ground water quality discussion, there is a rather large body of EC data for the alluvial wells to the north of the river, but little data to the south. However, there are few wells with more than 10 years of data and even fewer with more than 10 observations. These were used in the initial screening to select wells for trend analysis. These screening criteria yielded a total of 5 wells, none of them to south of the river. There is a rather large number of wells with more than 10 observations, but the data only span a period of 2 to 3 years. This is too short of a period to define trends. A second screening was conducted to select any well that had an EC record spanning 10 or more years no matter what the number of observations. This provided an additional 11 wells, 10 of which had 6 observations and 1 with 7; one of these wells was to the south of the river. These were added to the initial data set. Trends in temperature, EC, and NO_3-N were evaluated.

The trend analysis was conducted using nonparametric Spearman correlations. For this type of correlation, the chronological data for each well was assigned a sequential number from 1 through n. The data are then sorted by the dependent variable. A ranking from 1 through n is then assigned to each dependent variables. The correlations are then calculated between the chronological sequence numbers and the dependent variable ranking. The results, along with the number of observations for each of the three variables and the total number of years in the monitoring record are shown in table IV-3. It should be noted that the data are not evenly distributed throughout the total monitoring period, although most of the wells with six observations were sampled every other year and do have a relatively uniform spread.

There are only two significant correlations between temperature and year. Both of the wells with the significant correlations have more than 20 observations over a 25-year period. Because of this, the trend is probably real, but may need a larger number of measurements over a relatively long period to show any trend. None of the other wells has as many observations and only one other well extends over a 25-year period (table IV-3). The lack of a trend in the other wells may be due to the data base, or there may be no trend to find. It should be noted that several of the wells show inverse, but nonsignificant, correlation coefficients in table IV-3. None of these have more than seven observations, but the indication is that the temperature has been decreasing over time, although not significantly. What this does indicate, in the absence of better data, is that any trend toward increasing temperature of the ground water is probably localized.

All 5 of the wells with more than 10 observations and 4 of the wells with only 6 observations show a significant increasing trend in EC over time. Some of these correlations are extremely good. By way of an example, two of the better ones are shown on figure IV-7. The upper plot is the best of the correlations shown in table IV-3. This would be as definitive as a trend could be even with an excellent data base. In the case of the lower plot, there is about a 5-year gap between 1986 and 1981. After the sampling was resumed, there is a somewhat greater spread in the data. Nevertheless, the trend is obvious. Because the majority of the wells show an increasing trend in EC, it seems safe to conclude that the EC in the ground water has been increasing over the last 25 years or so that the data represent.

The data base for NO_3-N is much smaller than those for temperature and EC (table IV-3). There are four significant correlations between NO_3-N and time. Two of these are based on wells with only three correlations, and the remaining two have six observations. These data bases are too small to use for a meaningful analysis.

There is only one well in table IV-3 that is located south of the river. That is the well located in township 6N (shown at the bottom of the table). It is also the well in the data base that is south of the river and has more than five EC observations. Not surprisingly, none of the correlations are significant. To attempt an analysis for the wells to the south of the river, the aggregated data were correlated. This creates something of a hodge-podge of data. For example, a large spread in EC would be expected among the various wells. Nevertheless, in the absence of any other data, the correlations were calculated and the ones for EC and temperature are shown in table IV-4.

The correlations between EC and time are significant for the data from Phelps and Kearney. Although they are significant, the r-values for the correlations are not particularly high. To illustrate what the data look like, the EC data are plotted against year on figure IV-8. The data appear to be in three groups for periods in the late-40's, the late-60's to early 70's, and then between 1980 and 1990. These clumps do show a general upward trend in both counties. The spread within each clump is quite a bit larger in the Phelps County well EC data (note the y-axis scales). Despite this, the Phelps data show the better correlation between EC and year. From the appearance of Figure 8, the trends appear to be real.

Only one of the county data sets shows a significant correlation between temperature and time (table IV-4). This is once again Phelps County. However, in this case the correlation does appear to be affected by the sampling pattern. The earlier data were taken over a cross-section of months from June through October. The measurements during the 1980's were almost exclusively made during the month of August. The seasonal difference in the temperature measurements seems a likely cause for the resulting trend.

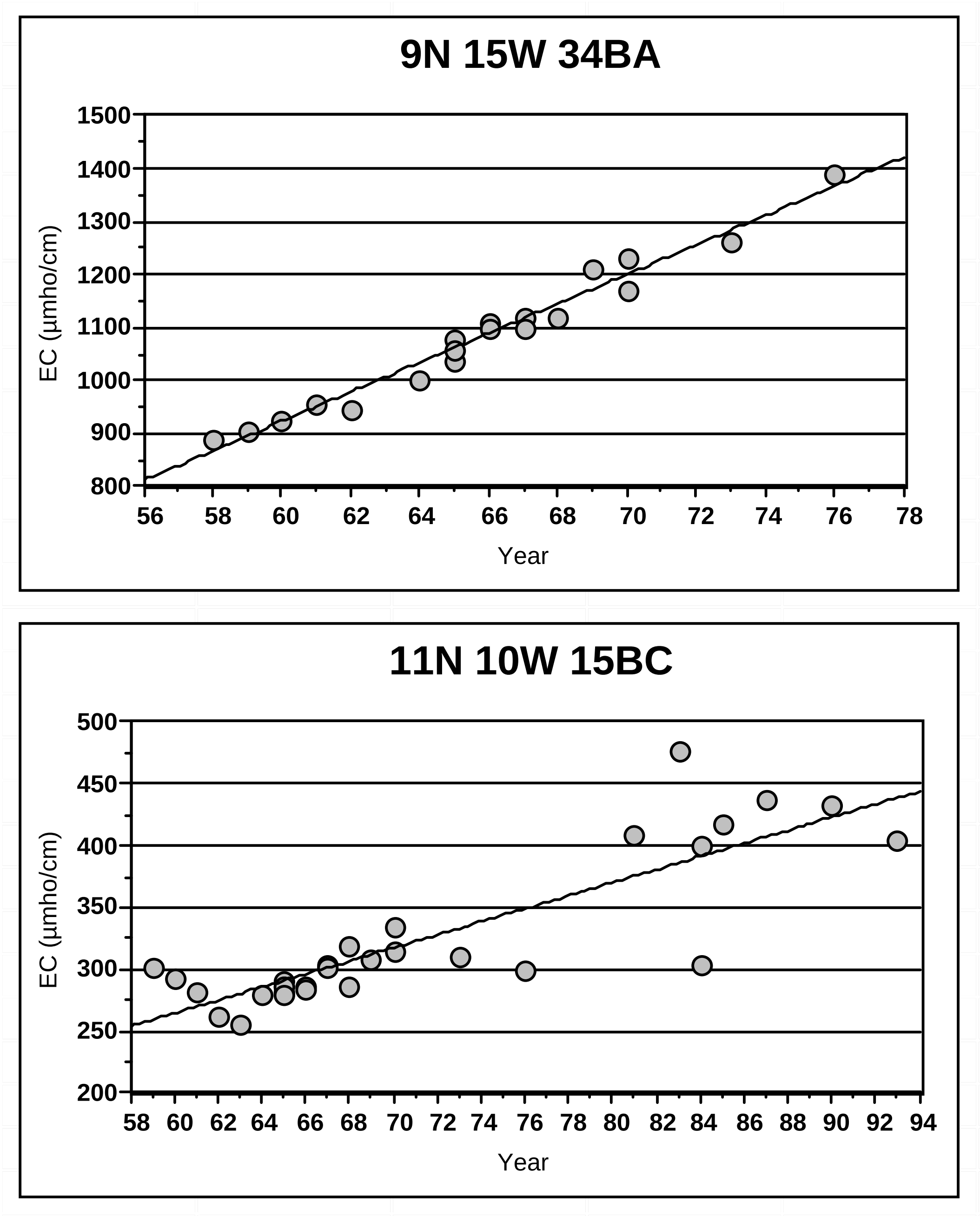


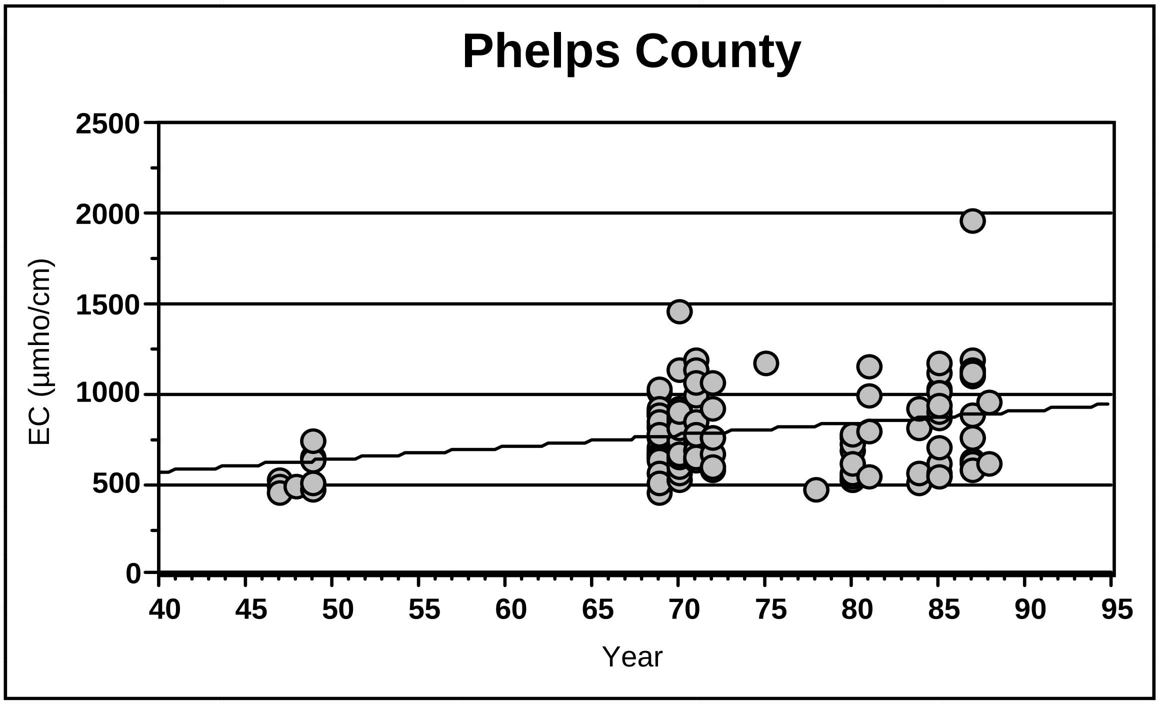
Figure IV-7.—Scattergrams and Trend Line for Electrical Conductivity in Two Wells Adjacent to the Platte River in Central Nebraska.

Table IV-3.—Spearman Correlations - Dependent Variable as Shown with Year

Well Location		Water Temperature	EC	$NO_2 + NO_3$	#of Years
9N 13W 10	r	0.657143	0.828571 *	-0.231908	12
	n	6	6	6	
9N 15W 34BA	r	0.347814	0.986792 **	1.000000 **	26
	n	17	19	3	
10N 10W 5BC	r	0.000000	1.000000 **	0.828571 *	12
	n	6	6	6	
10N 10W 30AD	r	-0.492805	-0.559065	-0.405840	12
	n	6	6	6	
10N 11W 19BD	r	0.394665	0.463817	0.067612	12
	n	6	6	6	
10N 11W 19CA	r	0.438031 *	0.516741 **	1.000000 **	25
	n	21	24	3	
11N 10W 15BC	r	0.706807 **	0.821786 **	-0.016667	25
	n	27	30	9	
11N 11W 35BC	r	0.231908	0.828571 *	-0.400000	12
	n	6	6	4	
11N 12W 24AA	r	0.492805	0.142857	-0.130931	12
	n	6	6	6	
11N 12W 34BC	r	0.676123	0.885714 *	0.985611 **	12
	n	6	6	6	
11N 9W 27BC	r	0.392388	0.504427 **	.	10
	n	16	16	0	
12N 11W 34BB	r	-0.318874	0.371429	-0.654654	12
	n	6	6	6	
12N 12W 24AB	r	-0.128489	0.392857	0.400892	10
	n	7	7	7	
12N 12W 34AB	r	-0.637748	0.666737	0.771429	12
	n	6	6	6	
12N 9W 11CC	r	0.204956	0.715343 **		16
	n	14	17	2	
6N 14W 6CB	r	-0.820783	0.257143	0.085714	10
	n	5	6	6	

** Probability of a greater "r" < 0.01.

* Probability of a greater "r" < 0.05.



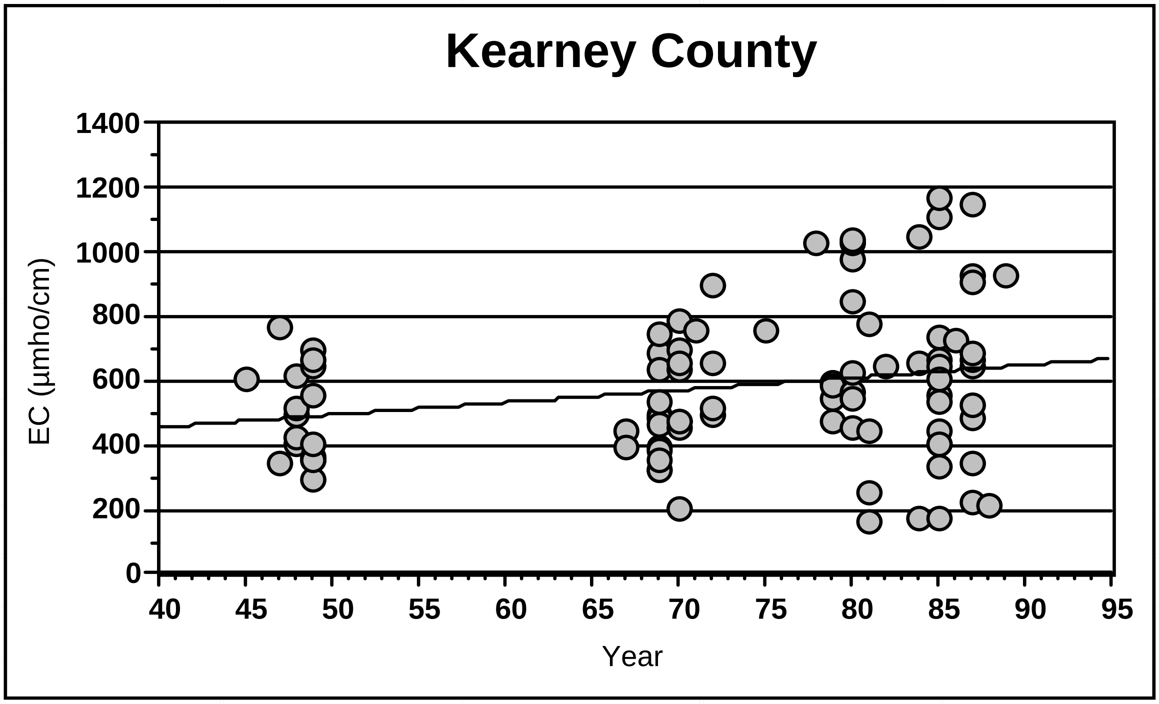


Figure IV-8.—Scattergrams and Trend Lines for the Statistically Significant County-Wide Correlations Between EC in Ground Water in the Central Platte Basin and Time

Table IV-4.—Correlations for Wells South of the River Grouped by County

County	No. of Years	EC Correlations			Temperature Correlations		
		r	n	Significance	r	n	Significance
Gosper	40	0.0644	42	n.s.	0.2109	39	n.s.
Phelps	41	0.2901	119	< 0.01	0.5441	65	< 0.01
Kearney	44	0.2254	91	< 0.05	0.1708	70	n.s.

CHAPTER V

Platte River Sediment Composition

The USGS collected sediment samples for chemical analysis in the Platte River at the Overton and Grand Island gages during September 1993. These data have been retrieved from EPA's STORET database. There are no sediment quality standards comparable to water quality standards at present. Consequently another basis for evaluating sediments for potential contamination is necessary. Table V-1 presents various baseline concentrations for elements in soils and rocks. The Department of the Interior's National Irrigation Water Quality Program (NIWQP) uses the Western Soils baseline (Shacklette and Boerngen, 1984) to evaluate potential sediment contamination on the assumption that stream sediment is derived from soil erosion and that such a database would provide a reasonable basis for comparison (Severson, et al., 1991). The soils baseline is based on the geometric mean ± 2 geometric deviations of samples collected throughout the 17 Western States.

Table V-1 also shows baseline concentrations in various rocks. The first is based on crustal abundance values (CAV) from Fortescue (1992). CAV's are used in exploration geochemistry to identify potential ore-bearing sediments; enrichment is defined by concentrations 3 or more times the CAV (Church *et al.*, 1997). Enrichment could also define contamination. The CAV is based on average concentrations of the elements in various rocks assuming the composition of the earth's crust to be that of Clarke, i.e., 95 percent igneous, 4 percent shale, 0.75 percent sandstone, and 0.25 percent limestone (Parker, 1967). The average concentrations of the elements in various sedimentary rocks from Parker (1967) are also included in table V-1 to illustrate the variability of their concentration in different natural sources.

The concentrations of 41 elements in two Platte River sediment samples are shown in table V-2. For the most part there is remarkably little difference between concentrations of the various elements in the twp samples. For the most part the variation between the two samples is much less than that shown for the various sedimentary rocks shown in table V-1. This would indicate that the sediments at the two sites are from a common source upstream from the Overton site.

A comparison of the two Platte River samples to the upper 95 percent confidence limit of the elemental data base for Western Soils shows that three are elevated at the Overton gage and four are elevated at the Grand Island gage. Those elements that are elevated relative to the baseline at both sample sites include chromium, selenium, and uranium (table V-2). Manganese is slightly elevated in the Grand Island sample only. However, the difference between the Overton and Grand island samples is less than 10 percent, but the soils baseline value is equal to the Overton concentration (tables V-1 and V-2).

Table V-1.—Various Baselines for Comparison to Platte River Sediment Data

							--------Western States-------- Baseline		
Element	Units	CAV {Clarke}	Clays and shales	Shales	Sandstones	Carbonate rocks	Geometric Mean	Lower C.I.	Upper C.I.
Antimony	Sb PPM-S	0.2	2	1.5	< 1	< 1			
Arsenic	As PPM-S	1.8	6.6	13	1	1	5.5	1.2	22
Beryllium	Be PPM-S	2.0	3	3	< 1	< 1	580	200	1,700
Bismuth	Bi PPM-S	0.0	0.01				0.68	0.13	3.6
Boron	B PPM-S	9.0	100	100	35	20	23	5.8	91
Cadmium	Cd PPM-S	0.16	0.3	0.3	< 0.1	0.035			
Cerium	Ce PPM-S	66.4	50	59	92	11.5	65	22	190
Chromium	Cr PPM-S	122	100	90	35	11	7.1	1.8	28
Cobalt	Co PPM-S	29	20	19	0.3	0.1	41	8.5	200
Copper	Cu PPM-S	68	57	45	< 1	4	21	4.9	90
Europium	Eu PPM-S	2.1	1	1	1.6	0.2			
Gallium	Ga PPM-S	19	30	19	12	4	16	5.7	45
Gold	Au PPM-S	0.004	0.001	< 0.01	< 0.01	< 0.01			
Holmium	Ho PPM-S	1.3	1	1.2	2	0.3	1.8	0.38	3.2
Iron	Fe %-S	6.2	3.33	4.7	1.0	0.4			
Lanthanum	La PPM-S	34.6	40	92	30	< 1			
Lead	Pb PPM-S	13	20	20	7	9	17	5.2	55
Lithium	Li PPM-S	18.0	60	66	15	5			
Magnesium	Mg %-S	2.8	1.34	1.5	0.7	4.7	0.74	0.15	3.6
Manganese	Mn PPM-S	1060	670	850	< 100	1,100	380	97	1,500
Mercury	Hg PPM-S	0.086	0.4	0.4	0.03	0.04	0.046	0.0085	0.25
Molybdenum	Mo PPM-S	1.2	2	2.6	0.2	0.4	0.85	0.18	4.0
Neodymium	Nd PPM-S	39.6	23	24	37	4.7	36	12	110
Nickel	Ni PPM-S	99	95	68	0.2	20	15	3.4	66
Niobium	Nb PPM-S	20	20	11	< 0.1	0.3			
Phosphorus	P %-S	0.112	0.077	0.1	0.02	0.04	0.032	0.0059	0.17
Potassium	K %-S	1.8	2.28	2.7	1.1	0.3			
Scandium	Sc PPM-S	25	10	13	1	1	8.2	2.7	25
Selenium	Se PPM	0.05	0.6	0.6	0.05	0.08	0.23	0.039	1.4
Silver	Ag PPM-S	0.08	0.1	0.07	< 0.1	< 0.1	< 0.5	----	----
Sodium	Na %-S	2.3	0.66	1.0	0.3	0.0			
Strontium	Sr PPM-S	384	450	300	20	610	200	43	930
Sulfur	S PPM-S	340	3,000	2,400	240	1,200			
Tantalum	Ta PPM-S	1.7	3.5	0.8	< 0.1	< 0.1			
Thorium.	Th PPM-S	8.1	11	12	1.7	1.7	9.1	4.1	20
Tin	Sn PPM-S	2.1	10	6	< 1	< 1			
Uranium	U PPM-S	2.3	3.2	3.7	0.45	2.2	2.5	1.2	5.3
Vanadium	V PPM-S	136	130	130	20	20	70	18	270
Yttrium	Y PPM-S	31	30	26	40	30	22	8	60
Zinc	Zn PPM-S	76	80	95	16	20	2.6	0.98	6.9
Zirconium	Zr PPM-S	162	200	160	220	19	55	17	180

Table V-2.—Total Concentrations of Various Elements in Sediments from the Platte River at Two USGS Gages during September 1993

Element	Units	Overton	Grand Island
Antimony	Sb PPM-S	0.5	0.5
Arsenic	As PPM-S	5.2	5.2
Beryllium	Be PPM-S	1	1
Bismuth	Bi PPM-S	< 10	< 10
Cadmium	Cd PPM-S	0.6	0.6
Boron	B PPM-S	9.3	11
Cerium	Ce PPM-S	59	57
Chromium	Cr PPM-S	42*	37*
Cobalt	Co PPM-S	11	12
Copper	Cu PPM-S	20	22
Europium	Eu PPM-S	32	30
Gallium	Ga PPM-S	13	13
Gold	Au PPM-S	< 8	< 8
Holmium	Ho PPM-S	< 4	< 4
Iron	Fe %-S	2.1	2
Lanthanum	La PPM-S	32	30
Lead	Pb PPM-S	23	26
Lithium	Li PPM-S	20	20
Magnesium	Mg %-S	0.86	0.9
Manganese	Mn PPM-S	1,500	1,600*
Mercury	Hg PPM-S	0.03	< 0.02
Molybdenum	Mo PPM-S	< 2	< 2
Neodymium	Nd PPM-S	28	27
Nickel	Ni PPM-S	20	20
Niobium.	Nb PPM-S	8	8
Phosphorus	P %-S	0.14	0.16
Potassium	K %-S	1.4	1.3
Scandium	Sc PPM-S	6	6
Selenium	Se PPM-S	2.6*	2.1*
Silver	Ag PPM-S	0.2	0.4
Sodium	Na %-S	0.54	0.47
Strontium	Sr PPM-S	420	500
Sulfur	S PPM-S	0.39	0.34
Tantalum	Ta PPM-S	< 40	< 40
Thorium	Th PPM-S	10	11
Tin	Sn PPM-S	< 10	< 10
Uranium	U PPM-S	8.1*	6*
Vanadium	V PPM-S	61	58
Yttrium	Y PPM-S	17	16
Zinc	Zn PPM-S	2	2
Zirconium	Zr PPM-S	82	81

* elevated relative to Western Soils Baseline

The chromium concentrations in the Platte River sediments are 42 and 37 ppm at Overton and Grand Island respectively (table V-2). The upper confidence limit for western soils is 28 ppm (table V-1), which is exceeded by both samples. However, the average chromium concentration in sandstones is 35 ppm, which is not much different from the Platte River sample concentrations. The results are well below either the CAV or the average concentration in shales (compare tables V-1 and V-2). Based on this and the factor of 3 rule-of-thumb for enrichment, the results do not indicate chromium contamination.

Manganese is equal to the upper limit of the Western soils baseline in the Overton sample and exceeds it slightly in the Grand Island sample. Pais and Jones (1997) show a baseline for soils of the world that presents somewhat higher concentrations than the Western soils baseline. Pais and Jones show a mean of 545 ppm with a normal range of 200-3,000 ppm in soils. Based on this, the manganese results are not unusually high.

Selenium exceeded the upper limit of the western soils baseline in both of the Platte River sediment samples (tables V-1 and V-2). The selenium concentration in the sediments also exceeded the factor of three rule-of-thumb enrichment indicator. The NIWQP developed reference concentrations for selenium in sediments (NIWQP, 1998). The background concentration for selenium in selenium-normal environments was 0.1-2.0 ppm, which is the same as that of Pais and Jones (1997) for soils. However, selenium concentrations < 1 ppm have been associated with reproductive effects in birds nesting in shallow terminal ponds (NIWQP, 1998). Alternatively an EC_{10}[1] of 2.5 ppm of selenium was estimated for fish and birds in a variety of freshwater habitats (NIWQP, 1998).

The existence of a seleniferous area in the North Platte Basin has been known for a long time (PHS, 1951; Rosenfield and Beath, 1964; Crist, 1974). The upper basin is a possible source of the seleniferous sediments. However, there are two large reservoirs (Glendo Reservoir and Lake McConaughy) between that source area and the study area. The reservoirs should trap all, or nearly all, of the sediment that originates from the North Platte River in Wyoming. The sediments in Lake McConaughy are reportedly elevated in selenium (cite!!).

There are outcrops of the Pierre Shale in the South Platte Basin in Colorado (Anderson *et al.* (1961). In the Central Platte Basin, the Pierre Shale forms bedrock well below the ground surface (Peckenpaugh *et al.*, 1987; Peckenpaugh and Dugan, 1983) and on this basis would be an unlikely source of seleniferous sediments. Pierre Shale is known to be locally seleniferous (Rosenfield and Beath, 1964), although samples from the South Platte River showed only a maximum of 2 ppm of selenium (Anderson et al. (1961). Frenzel *et al.* (1998) noted that there were higher concentrations of selenium in upstream sediments in the Central Platte River than in those farther downstream. Table V-2 shows a somewhat higher concentration of selenium in the Overton sample than in the one from Grand Island. This would indicate that the source is either upstream in the Platte or the South Platte or possibly both. However, because the geologic formations from which the selenium is most likely derived are at depth in the Platte Basin, the more likely source is the South Platte. The reduction at the downstream (Grand Island) site would be due to dilution by uncontaminated sediments from tributary inflows, similar to that which occurs in water. No matter what the source, there may be a concern for sediment selenium in the type of environment where selenium effects are favored, e.g. terminal wetlands. The only wetlands in the Central Platte Basin that would be possibly analogous to these would be those that are only filled seasonally by overbank flows.

The one other element in table V-2 that exceeded the upper confidence limit of the Western soils baseline is uranium. Elevated uranium is often associated with elevated selenium, so much so that selenium indicator plants have been used in uranium

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[1] The EC_{10} is the effective concentration at which 10 percent of the exposed population exhibit a particular effect or response. In the case of selenium the effect would be on avian reproduction (birth defects) and sublethal effects to adult fish along with reproductive effects.

prospecting (Cannon, 1960). Based on this association. the source of uranium is likely to be the same as the source of selenium. Uranium is also higher at Overton than at Grand Island indicating an upstream origin. High uranium concentrations have been reported in the alluvium in Morgan, Logan, and Boulder counties in eastern Colorado (CDPHE, 1999). All three counties are in the South Platte Basin.

The uranium concentration at Grand Island is 6 ppm, which is less than 3 times the CAV. On this basis, those sediments would not be considered enriched relative to the CAV. Alternatively, Pais and Jones (1997) give a baseline for soils that ranges from 0.1 to 11.2 ppm; on this basis, neither of the sediment samples would be considered elevated in uranium.

Uranium has not been found to be particularly toxic. For example, there is no EPA aquatic life criterion for uranium. Recent work on the reproductive effects of uranium in mice found effects (reduced litter size and increase number of stillbirths) only at the very highest doses (25-80 mg/Kg [ppm] per day of body weight: Corbella and Domingo, 1996). Similar results are reported for dogs and rats in EPA's IRIS (Integrated Risk Information System) database (EPA, 1989). Sediment uranium does not seem elevated enough to warrant particular concern in the Central Platte Basin.

TRENDS

There are only two samples included in the analysis above. This is an insufficient data base for a trend analysis.

RECOMMENDATIONS FOR FUTURE MONITORING

There were 4 elements in the above evaluation that exceeded what would be an uncontaminated background concentration. These include chromium, manganese, selenium, and uranium. Of these chromium and selenium would be considered potential toxins for aquatic life and waterfowl.

Recently there has been an emphasis on developing sediment quality criteria. The Corps of Engineers has developed criteria for 9 inorganic contaminants and a variety of organic compounds. Freshwater criteria are under development. The data available for Platte River are for inorganic elements only. The criteria apply to concentrations based on a different method of digestion from what is currently available. A more appropriate analysis for purposes of evaluating potential toxic effects to fish and wildlife would be to use the EPA (1990) digestion and analytical procedures. The results could then be evaluated against the sediment quality criteria for aquatic life. The inorganic contaminants for which there are criteria include arsenic, cadmium, chromium, copper, lead, mercury, nickel, silver, and zinc. All of these should be included in any future sediment evaluation. Because selenium and uranium were also elevated in comparison to background concentrations, they should also be included in any group of analytes. Although sediment criteria are not available for these potential contaminants, work done on the San Joaquin Valley and other sites associated with irrigation return flows and selenium contamination should provide data for the development of criteria for this program.

There are a large number of organic contaminants for which there are sediment quality criteria. The only ones that may be of concern on the Middle Platte, at least initially, would be for total DDT and total PAH's (polynuclear aromatic hydrocarbons [also known as PNA's]). If these were to exceed their criteria, then a more detailed analysis for individual compounds could be undertaken. Alternatively if the totals do not exceed the criteria, then it is unlikely that any of the components would be elevated. Therefore, it is recommended that any future sediment samples include total DDT and PAH among the analytes.

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CHAPTER VI

Contaminants in Platte River Fish

The State of Nebraska maintains a network of monitoring sites where fish tissue samples are collected and analyzed for priority pollutants (Nebraska Department of Environmental Quality [NDEQ], 1996). The fish tissue data collected between 1983 and 1997 were provided to Reclamation by Mike Callum of the NDEQ (personal communication to Jim Yahnke, Bureau of Reclamation, February 3, 2000). According to NDEQ (1996), when human health is the prime consideration, fish fillets are analyzed, and when aquatic life impacts are the prime consideration, whole fish samples are analyzed. The data provided include both types of samples.

The primary concern of this program is the potential for harm to endangered birds, particularly to the least tern and piping plover during reproduction. The least tern is piscivorus. In the study area, it consumes only small fish, i.e. < 3.8 cm or 1.5 in. (Wilson et al., 1993). None of the NDEQ samples is anywhere near that small; the smallest fish in the NDEQ data set is just under 5 inches. In order to evaluate the fish data relative to potential toxicity to breeding terns, a certain amount of extrapolation will be necessary.

INORGANIC CONTAMINANTS

The NDEQ samples have been analyzed for a total of 10 inorganic contaminants. The data, including the length, weight, and the number of fish per sample, are summarized in table VI-1. The analyses were performed on composite samples consisting of between 1 and 11 fish, with a median sample size of 5. Not all of the contaminants are analyzed in every sample, and in certain cases there a very few analyses. The most analyses are for mercury and the fewest are for nickel. Mercury is listed as the primary inorganic contaminant of concern in Nebraska (NDEQ, 1996).

The National Irrigation Water Quality Program (NIWQP) was formed by the Department of the Interior after wildlife were poisoned by irrigation drain water in the Central Valley of California in 1985. The NIWQP (1998) has developed guidelines for interpreting contaminants data in a variety of life forms. The guidelines consist of a "no effect" level and a toxicity threshold; intermediate concentrations between these two are labeled as being at a "level of concern." These guidelines will be used where possible to evaluate whether there is a potential problem involving the various contaminants for which there are data in the NDEQ data set.

Table VI-1.—Summary Data for Inorganic Contaminants in Platte River Basin Fish (All in PPM Wet Weight [ww], Unless Otherwise noted)

	Length (in.)	Weight (lb.)	Number of fish	Arsenic	Cadmium	Chromium	Barium
Minimum	4.9	0.3	1	0.011	0.05	0.03	0.06
Median	15.7	2.0	5	0.075	0.08	0.34	1.64
Maximum	26.3	8.1	11	0.190	0.33	0.64	4.50
# of Obs.	62	62	66	14	18	18	14

	Lead	Copper	Mercury	Nickel	Selenium	Zinc
Minimum	0.15	0.73	0.020	0.27	0.52	17.0
Median	0.32	0.94	0.095	0.48	1.41	64.4
Maximum	0.71	1.33	0.358	0.94	4.73	84.3
# of Obs.	5	7	68	4	23	7

The NIWQP guidelines include only 7 trace elements, two of which include no data in the NDEQ data set. Alternative evaluation criteria that were used in the NIWQP were the 85th percentile of the National Contaminants Biomonitoring Program (NCBP). The 85th percentile value or lower was assumed to be normal background, while values higher than the 85th percentile were assumed to represent a potentially contaminated situation. The 85th percentile concentrations from the NCBP have been published by Schmitt and Brumbaugh (1990). These will be used to supplement the NIWQP (1998) criteria where necessary.

The "no effect levels" and toxicity thresholds used to evaluate the fish contaminants data are shown in table VI-2. A summary of the comparison between the data and the evaluation criteria is also shown in table VI-2.

None of the arsenic nor copper samples exceeded their respective "no effect level." Alternatively, a majority of the cadmium, lead, selenium, and zinc samples exceeded the lower level of concern (table VI-2A). The NCBP had 2 sites on the Platte River in the study area. The results for cadmium and selenium were above the 85th percentile in samples collected during 1978-79 and in 1980-81 (Lowe *et al.*, 1985), while several of the samples were above the 85th percentile during the 1984 sampling (Schmitt and Brumbaugh, 1990). A large percentage of the mercury analyses also exceeded the "no effect level," although none of the NCBP samples collected were above the 85th percentile concentration. The NCBP 85th percentile mercury concentration is 0.18 ppm,

Table VI-2.—Comparison of Inorganic Contaminants in Platte River Basin Fish to Levels of Concern

A. NIWQP No Effect Levels (or NCBP 85th Percentile)

	Arsenic	Cadmium	Lead	Copper	Mercury	Selenium	Zinc
NOAEL (ppm)	0.25[1]	0.05[2]	0.22[2]	2.45[1]	0.11[1]	0.75[1]	34.2[2]
Number > NOAEL	0	16	3	0	30	18	6
Total Observations	14	18	5	7	68	23	7
% > NOAEL	0	88.9	60.0	0	44.1	78.3	85.7

B. NIWQP Toxicity thresholds (various - see notes)

	Arsenic	Cadmium	Lead	Copper	Mercury	Selenium	Zinc
Threshold (ppm)	3[1]	0.5[3]	NA	3.325[1]	1.0[1]	1.0[1]	80[4]
Number > threshold	0	0	NA	0	0	14	0
Total Observations	14	14	5	7	68	23	7
% > threshold	0	0	NA	0	0	60.9	0.0

[1] NIWQP (1998) no observed adverse effect level (NOAEL) or toxicity threshold. NOTE - all of the levels attributed to NIWQP (1998), which is a literature review, are derived form other sources; see NIWQP (1998) for individual references.

[2] Schmitt and Brumbaugh (1990) 85th percentile concentration.

[3] Toxicity threshold for waterfowl food consumption (Irwin et al., 1997).

[4] Toxicity threshold for waterfowl food consumption (NIWQP, 1998 - Table 37).

ww, which is somewhat greater than the no effect level shown in table VI-2A. The frequency with which the NCBP 85th percentile would be exceeded would be less than that for the "no effect level."

Table VI-2B shows toxicity thresholds for the elements. The toxicity thresholds shown in table VI-2B for copper, mercury, and selenium are for fish, not for waterfowl, which will be discussed later. The thresholds for cadmium and zinc are for waterfowl; no thresholds for fish could be located. There is no toxicity threshold for lead, which is not included in the NIWQP (1998) guidelines. In a review of studies of lead intake by aquatic birds, Irwin et al. (1997) found that the majority studies focused on lead shot, followed by wastes, such as lead-base paints either in cans or on discarded materials.

Only selenium exceeds any toxicity threshold among the elements shown in table VI-2B. Nevertheless, the elements that exceed the NOAEL, but not the toxicity threshold, fall within the level of concern as defined by NIWQP (1998). Consequently future monitoring should continue to evaluate those elements as well as selenium.

Although only selenium is indicated as having a threat for widespread effects on fish, the real goal of this evaluation is to look at the potential toxicity to predators of fish, specifically to the least tern. For this purpose any toxicity threshold that is lower than the ones evaluated in table VI-2B needs to be reviewed. Since the toxicity thresholds for cadmium and zinc shown in table VI-2B are not exceeded, those will not be evaluated further. They apparently pose only a minimal threat to predatory birds.

The selenium threshold for water bird food items in NIWQP (1998) is 3-8 ppm ww. The lowest of these is three times the fish threshold shown in table VI-2B. Consequently selenium would be expected to be somewhat less of a threat to consumers of the fish than it would be to the fish themselves. A comparison of the selenium concentrations of selenium in the fish samples to the bird food dietary threshold of 3 ppm shows that about 9 percent of the fish samples exceeded it. The selenium threshold shown above is based on reproductive impairment, which is obviously a major concern for least terns. Based on this result, selenium would have the potential to inhibit the recovery of the least tern population in the Platte River.

The bird dietary threshold for mercury is 0.10 ppm ww. This is lower than the 0.11 ppm NOAEL for fish. Consequently mercury needs to be further evaluated for potential effects on breeding birds. The comparison of the mercury concentration in the fish samples to the bird dietary mercury threshold shows that about 47 percent exceeded it. This is about the same percentage as exceeded the NOAEL for fish (table VI-2A), which is no surprise since the levels of concern are about the same as well.

Neither arsenic nor copper exceeded any of the levels of concern shown in table VI-2. The toxicity thresholds for bird food items for arsenic and copper are 7.5 and 200 ppm respectively (NIWQP, 1998). Since these are much higher than the levels of concern for the fish shown in table VI-2, these elements would be considered to pose no threat to consumers of the fish.

One further factor in evaluating the potential threat to least terns due to potential toxicity of dietary levels of inorganic contaminants concerns the food items themselves. As was noted above, least terns prey on fish that are much smaller than those in the samples being evaluated. If there is a relationship between the size of the fish and the concentration of the contaminant in question, the threat may be more or less than the

Table VI-3.—Correlations Among Element Concentrations, Physical Variables, and Time - Trends in Sampling and Content

Variable		Species	Length	Weight	No. of fish	Year
Species	r	——	-0.187373	-0.304958	0.002369	0.024033
	Prob. > r	——	0.144757	0.015949	0.985419	0.845758
	n	68	62	62	62	68
Sample type	r	0.280678	0.274788	0.161902	-0.238471	0.669748
	Prob. > r	0.020426	0.030661	0.208685	0.061966	< 0.000001
	n	68	62	62	62	68
Length	r	-0.187373	——	0.853971	-0.191782	0.466427
	Prob. > r	0.144757	——	< 0.000001	0.135370	0.000133
	n	62	62	62	62	62
Weight	r	-0.304958	0.853971	——	-0.246429	0.336790
	Prob. > r	0.015949	< 0.000001	——	0.053510	0.007437
	n	62	62	62	62	62
No. of fish	r	0.002369	-0.191782	-0.246429	——	-0.365753
	Prob. > r	0.985419	0.135370	0.053510	——	0.003463
	n	62	62	62	62	62
Arsenic	r	-0.422495	0.512793	0.459654	0.140189	0.303094
	Prob. > r	0.132333	0.060782	0.098209	0.632645	0.292167
	n	14	14	14	14	14
Cadmium	r	-0.192455	0.142719	0.145846	0.225909	0.618580
	Prob. > r	0.444216	0.584768	0.576479	0.383291	0.006207
	n	18	17	17	17	18
Chromium	r	0.538811	-0.130275	-0.246378	0.061859	-0.541419
	Prob. > r	0.021044	0.618232	0.340453	0.813551	0.020311
	n	18	17	17	17	18
Barium	r	No Data	-0.378885	-0.221539	-0.261998	-0.605649
	Prob. > r		0.181566	0.446554	0.365539	0.021709
	n	14	14	14	14	14
Lead	r	0.350247	0.124524	0.009284	-0.232760	0.799020
	Prob. > r	0.563345	0.841861	0.988179	0.706339	0.104837
	n	5	5	5	5	5
Copper	r	-0.578335	-0.256640	-0.153942	0.747626	0.401531
	Prob. > r	0.173779	0.623492	0.770911	0.087502	0.371935
	n	7	6	6	6	7
Mercury	r	0.298597	0.355210	0.303746	-0.090179	0.572206
	Prob. > r	0.013385	0.004611	0.016394	0.485777	< 0.000001
	n	68	62	62	62	68
Nickel	r	0.869832	-0.662147	-0.604824	0.285231	-0.438236
	Prob. > r	0.130168	0.539291	0.586487	0.815859	0.561764
	n	4	3	3	3	4
Selenium	r	-0.213082	0.428737	0.347939	0.256749	0.509749
	Prob. > r	0.328971	0.046490	0.112567	0.248735	0.012965
	n	23	22	22	22	23
Zinc	r	-0.880156	0.216331	0.119587	0.250775	0.538405
	Prob. > r	0.008944	0.680566	0.821475	0.631724	0.212476
	n	7	6	6	6	7

evaluation above would indicate. The relationship among the various contaminants and physical characteristics of the fish sampled was evaluated by correlation analysis. The results are shown in table VI-3. Significant correlations are highlighted for emphasis.

The physical variables included in table VI-3 include the species of fish, the length and weight of the fish in the sample, and the number of fish that were composited. This latter is somewhat related to the size variables in that more fish tend to be composited when the fish are smaller. The species breakdown is whether the sample was composed of carp (species = 1) or not (other species = 2). As was noted above, a significant portion of the inorganic contaminants samples were from carp (81 percent); data presented by Wilson et al. (1993) indicate that carp are a minor component of the diet of nesting least terns. These variables along with the sample type are also evaluated by correlation analysis with each other (table VI-3). Sample type was coded as whole fish = 1 and fillet = 2; it correlates positively with species, fish length, and year, the last of which will be discussed separately below. This indicates that in general fillets came from species other than carp and from larger fish.

Chromium and mercury are positively correlated and zinc is negatively correlated with species (table VI-3). This indicates that carp are generally lower in both mercury and chromium, but higher in zinc, than the other species.

Length, in addition to sample type, is positively correlated with weight, mercury, and selenium. This indicates that larger fish have generally higher concentrations of mercury and selenium than smaller fish. An increase in the mercury concentration as fish age is commonly observed (Sorensen, 1991). From the perspective of nesting terns, this would indicate a somewhat reduced threat from inorganic contaminants than would be indicated by the above analysis of body burdens alone. Weight correlates only with length and mercury and does not add any additional insight over that gained from the length correlations.

The number of fish per sample does not correlate with any of the variables. This indicates that the size of the composite is not a factor that affects the results.

Year was included in the correlation analysis to enable a simple trend analysis. The sample set extends over a 14-year inclusive period from 1983 through 1997. A significant correlation with year would indicate either an increasing or decreasing trend in the concentration of the contaminant or—in the case of sample, length, weight, and number of fish—the samples themselves. All of these latter variables are correlated with year, indicating that other species than carp have gained in importance in later years, larger fish have become more prevalent in the samples as time goes on, and the samples are composed of fewer fish in the more recent samples.

Cadmium, mercury, and selenium are positively correlated with year (table VI-3). This is particularly important in that any threat posed by these contaminants would be increasing over time. This could mean that such a threat would be increasingly important in the future. The opposite would be true of chromium and barium, although there is no indication of any threat from either of these trace elements.

The correlation analysis indicated that there were trends associated with the composition and type of the fish contaminant samples collected. This is further evaluated in table VI-4 as it relates to mercury and selenium.

Table VI-4.—Comparison of the distribution of mercury and selenium between fish species and sample types

A. Mercury in fish

Analysis of Variance			Species - Mean (ppm)		Sample type - Mean	
Source	F-ratio	Prob. > F	Carp	Others	Whole fish	Fillet
Species	5.224	0.026	0.114	0.166	0.087	0.194
Sample type	22.494	< 0.001				
Sp. X sample	15.734	< 0.001				

B. Selenium in fish

Analysis of Variance			Species - Mean (ppm)		Sample type - Mean	
Source	F-ratio	Prob. > F	Carp	Others	Whole fish	Fillet
Species	0.599	0.449	1.543	1.026	1.285	1.285
Sample type	0.000	1.000				
Sp. X sample	0.052	0.822				

Table VI-4 indicates that the mercury concentration varies between species. Species other than carp are generally higher in mercury than carp (table VI-4A) on the average. The results also indicate that fillets tend to be higher in mercury than whole fish samples. However, there is also a significant interaction effect between species and sample type (Sp. X sample in table VI-4). This would indicate that the any relationship between the mercury and species changes with sample type; that effect may warrant further investigation.

The distribution of mercury in fish tissues is related to the form of the mercury ingested and the time since ingestion (Sorensen, 1991), with methyl mercury (CH_3Hg^{+1}) predominantly in the skeletal muscle with increasing time from ingestion. The fish samples are collected any time between May and September (NDEQ, 1996). Whether this has an effect on the results is unknown. Most of the NDEQ data only include the year, not the date sampled.

Unlike mercury, there is no significant difference in selenium between species or sample type. This would indicate that any conclusions can be taken at face value.

The fish samples include those from the North Platte, South Platte, and Platte mainstem rivers in Nebraska. The data were also evaluated for differences in mercury and selenium in the three rivers based on Fisher's Least Significant Difference (LSD) Test. There were not enough observations for the other trace elements to make a statistical comparison, which could indicate a general source of the two elements. For example, the results shown in table VI-5 indicate that fish from the North and South Platte Rivers are significantly higher in mercury than those from the Platte and that the fish from the South Platte are significantly higher in selenium than those from either the North Platte or the Platte mainstem. This may indicate that the source of selenium is in the South Platte basin. Alternatively, recent research has indicated that the predominant source of mercury in fish is atmospheric (Porcella, 1994). If the differences among the three basins reflect proximity to the source, then it would be to the west.

Table VI-5.—Comparison of Mercury and Selenium Concentrations in Fish from the North Platte, South Platte, and Platte Rivers

Mercury (ppm)		**Fisher's LSD**		**Probability**	
Site	**LS Mean**	**N. Platte**	**Platte**	**N. Platte**	**Platte**
N. Platte	0.135				
Platte	0.077	-0.0579		0.0168	
S. Platte	0.159	0.0233	0.0812	0.3364	0.0007
Selenium (ppm)		**Fisher's LSD**		**Probability**	
Site	**LS Mean**	**N. Platte**	**Platte**	**N. Platte**	**Platte**
N. Platte	1.022				
Platte	1.183	0.1610		0.7383	
S. Platte	2.160	1.1379	0.9769	0.0265	0.0460

ORGANIC CONTAMINANTS

A summary of the organic contaminants data is presented in table VI-6. As is shown by the length and weight data, there are 82 samples; however, the most analyses for any individual contaminant is 66 for DDE, followed by 44 analyses for dieldrin and 42 for each of two PCB isomers. The emphasis reflects the NDEQ (1996) statement that dieldrin and PCB's were the toxic pollutants of greatest concern in the State, based on fish tissue data. The majority of fish consumption advisories in Nebraska are for

Table VI-6.—Summary Data for Organic Contaminants in Platte River Basin Fish (All in PPM WQ Unless Otherwise Noted)

	LENGTH (in.)	**WEIGHT (lb.)**	**Chlordane**	**Gamma Chlordane**	**Penta Chloroanisole**
Minimum	5.00	0.67	0.00	0.01	0.00007
Median	17.96	2.97	0.09	0.01	0.00037
Maximum	24.80	6.04	0.80	0.01	0.00120
# of Obs.	82	82	17	1	8
	Pentachloro benzene	*cis*-Chlordane	*trans*-Chlordane	*cis*-Nonachlor	*trans*-Nonachlor
Minimum	0.0003	0.0017	0.0018	0.0020	0.002
Median	0.0003	0.0034	0.0035	0.0035	0.004
Maximum	0.0003	0.0370	0.1800	0.1800	0.042
# of Obs.	1	35	27	15	32
	Oxychlordane	Heptachlor	Hexachloro benzene	Heptachlor Epoxide	Aldrin
Minimum	0.0023	0.01	0.0003	0.0014	0.01
Median	0.0050	0.18	0.0011	0.0035	0.01
Maximum	0.0050	0.18	0.0060	0.0120	0.06
# of Obs.	4	4	8	13	4
	Dieldrin	*p,p'*DDT	*p,p'*DDD	*p,p'*DDE	Aroclor®-1248
Minimum	0.002	0.002	0.01	0.003	0.10
Median	0.011	0.009	0.01	0.032	0.10
Maximum	0.180	0.140	0.06	1.380	0.10
# of Obs.	42	14	15	66	1
	PCB-1254	PCB-1242	PCB-1260	Trifluralin	
Minimum	0.02	0.02	0.01	0.01	
Median	0.05	0.09	0.04	0.02	
Maximum	0.71	0.10	0.32	0.10	
# of Obs.	43	4	44	12	

excessive PCB's. However, the fish consumption advisories are based on a $1*10^{-5}$ cancer risk in two consecutive samples based on EPA's Risk Assessment Method (NDEQ, 1996) and do not reflect the potential for toxicity to birds.

NIWQP (1998) only includes information on DDT and its degradation products, DDD and DDE. All of the dietary thresholds for DDT, DDD, and DDE were related to eggshell thinning and egg breakage. The NIWQP (1998) thresholds were all well in excess of the maxima shown in table VI-6, i.e., minimum threshold of 2.5 ppm (DDE) ww, which produced 20-percent eggshell thinning in one experiment and 10-percent egg cracking in another.

The other contaminants included in table VI-6 do not have dietary thresholds (or NOAEL's) that were found. This evaluation will not attempt to relate the concentrations of any of the organic contaminants to dietary thresholds. The screening will simply done by comparing the data to an ambient background for fish. The background being used is simply the geometric mean of the data gathered by the Fish and Wildlife Service's National Pesticide Monitoring Program (NPMB).

The NPMP geometric means and a comparison to the NDEQ data are shown in table VI-7. The rationale for the comparison is that if the Platte River data are near the average for the U.S., then about one-half the samples will be greater than the NPMP geometric mean. If the percentage exceeding the NPMP average is much greater than 50 percent, then there would be a potential threat and more in-depth investigation would be recommended.

Table VI-7.—Comparison to Geometric Wet Weight Mean Concentrations for 1976-81 of the National Pesticide Monitoring Program (Schmitt et al., 1985)

	***cis*-Chlordane**	***trans*-Chlordane**	***cis*-Nonachlor**	***trans*-Nonachlor**	**Oxychlordane**
NPMP Ave. (ppm *ww*)	0.053	0.023	0.020	0.040	0.010
Number > Ave.	0	4	3	2	0
Total Observations	35	27	15	32	4
% > Ave.	0.0	14.8	20	6.3	0
	Heptachlor	Dieldrin	*p,p'*DDT	*p,p'*DDD	*p,p'*DDE
NPMP Ave. (ppm *ww*)	0.013	0.047	0.047	0.083	0.240
Number > Ave.	2	3	1	0	4
Total Observations	4	42	14	15	66
% > Ave.	50	7.1	7.1	0.0	6.1
	Aroclor®-1248	PCB-1254	PCB-1260		
NPMP Ave. (ppm *ww*)	0.130	0.393	0.330		
Number > Ave.	0	1	0		
Total Observations	1	43	44		
% > Ave.	0	2.3	0.0		

None of the organic contaminants in the NDEQ data set has 50 percent of the samples greater than the NPMP geometric mean. Two of four heptachlor samples (or 50 percent exactly) were greater than the NPMP benchmark. Of all of the other organic contaminants, 20 percent or less were above the NPMP benchmark. Based on this result, the organic contaminants in the NDEQ data set are below the average for a normal background data set. This would indicate that organic contaminants are not likely to be anything more than an extremely isolated threat, if any at all, in the Platte River basin.

A correlation analysis was also performed on the organic contaminants data like that for the inorganic data. The results are shown in table VI-8. Length only correlates with weight, while weight only correlates with length and percent lipids (fats). This only confirms the obvious, i.e. longer fish weigh more and heavier fish contain more fat. However, percent lipids does correlate with heptachlor epoxide (inverse) and two of the DDT congeners, *p,p'*DDT and *p,p'*DDD. Since organochlorine pesticides tend to correlate with fat content (NIWQP, 1998), this should come as no surprise either. However, they also indicate that DDT correlates with fish age and length. The NDEQ samples do not show the latter correlation, indicating that accumulation is not occurring in the Platte basin.

The 4th set of correlations in table VI-8 is a trend analysis based on year. As was the case with the inorganic contaminants, there are significant positive correlations between length and weight and year. It should be noted that the fish in the inorganic contaminants data set are not necessarily the same as those in the organic data set. There are 82 observations in the organic data sets for length and weight (table VI-8), while there are only 62 in the inorganic data set for length and weight (table VI-3). The results are still the same, i.e., r-values of around 0.4 and an indication that the size of the fish sampled has increased over time.

There are five significant correlations between organic contaminant concentrations in fish and year (table VI-8). All five are negative. As a matter of fact, when the nonsignificant correlations between year and organic contaminant concentration are considered, only one is positive, the near-zero correlation with *p,p'*DDD. In other words, the concentrations of organic contaminants have been decreasing over time, some significantly, some not. This is no surprise; the use of nearly all organochlorine pesticides has been banned in the U.S. since about the beginning of the monitoring period. Furthermore the use of the nonpesticde organochlorines in the data set, i.e., PCB's, has also been phased out over the years.

The only non-organochlorine included in table VI-8—trifluralin, a trifluoro, dinitroaniline herbicide—is considered of low toxicity to birds. The dietary LC_{50} is >5,000 ppm in both quail and mallard (Ahrens, 1994). Trifluralin also has a negative r-value, although it is not statistically significant.

TRENDS

Fish samples for inorganic and organic contaminants have been collected since 1983 and analyzed for a variety of inorganic and organic contaminants by the NDEQ. Data for the years 1983 through 1997 have been provided to Reclamation for this evaluation. It should be noted that the samples have been collected for a completely different purpose than this application. This does affect the results somewhat.

Table VI-8.—Correlations among Concentrations of Organic Contaminants, Physical Variables, and Time—Trends in Sampling and Content

		Length	Weight	% Lipids	Year
Length	r	——	0.840094	0.349912	0.494449
	Prob. > r	——	< 0.000001	0.183987	0.000002
	n	82	82	16	82
Weight	r	0.840094	——	0.645199	0.417626
	Prob. > r	< 0.000001	——	0.006955	0.000095
	n	82	82	16	82
Chlordane	r	-0.044601	-0.113274	-0.287316	-0.460820
	Prob. > r	0.865033	0.665113	0.391620	0.062655
	n	17	17	11	17
Chloroanisol	r	-0.122774	0.023134	No Data	-0.556437
	Prob. > r	0.772101	0.956640	——	0.152033
	n	8	8	0	8
cis-Chlordane	r	-0.141857	-0.309192	-0.294073	-0.444146
	Prob. > r	0.416287	0.070708	0.329434	0.007521
	n	35	35	13	35
trans-Chlordane	r	-0.098599	-0.202351	0.099744	-0.340151
	Prob. > r	0.631796	0.321514	0.770450	0.089082
	n	26	26	11	26
cis-Nonachlor	r	-0.114737	-0.307105	-0.258810	-0.348640
	Prob. > r	0.696112	0.285506	0.575196	0.221835
	n	14	14	7	14
trans-Nonachlor	r	0.005054	-0.183411	-0.141952	-0.361694
	Prob. > r	0.978472	0.323331	0.643652	0.045572
	n	31	31	13	31
Hexachlorobenzene	r	0.006532	0.025634	No Data	-0.877330
	Prob. > r	0.987752	0.951958	——	0.004201
	n	8	8	0	8
Heptachlor Epoxide	r	-0.435346	-0.490074	-0.970851	-0.597403
	Prob. > r	0.157209	0.105789	0.029149	0.040246
	n	12	12	4	12
Dieldrin	r	-0.046809	-0.140415	-0.28197	-0.115473
	Prob. > r	0.774256	0.387481	0.498661	0.477994
	n	40	40	8	40
*p,p'*DDT	r	0.047906	-0.004572	0.999998	-0.253146
	Prob. > r	0.882467	0.988748	0.001337	0.427275
	n	12	12	3	12
*p,p'*DDD	r	-0.055715	-0.084603	0.794399	0.050951
	Prob. > r	0.849955	0.773687	0.010543	0.862668
	n	14	14	9	14

Table VI-8.—Correlations among Concentrations of Organic Contaminants, Physical Variables, and Time—Trends in Sampling and Content (continued)

		Length	Weight	% Lipids	Year
*p,p'*DDE	r	0.034522	0.074779	0.074010	-0.099661
	Prob. > r	0.786536	0.557024	0.785315	0.425936
	n	64	64	16	66
PCB-1254	r	-0.277396	-0.288737	-0.824650	-0.489560
	Prob. > r	0.075311	0.063672	0.382745	0.001000
	n	42	42	3	42
PCB-1260	r	0.017286	-0.026784	-0.829863	-0.188009
	Prob. > r	0.911323	0.862979	0.082059	0.221655
	n	44	44	5	44
Trifluralin	r	0.175660	-0.159522	No Data	-0.404289
	Prob. > r	0.585010	0.620444	——	0.192405
	n	12	12	0	12
% Lipids	r	0.349912	0.645199	——	-0.201575
	Prob. > r	0.183987	0.006955	——	0.454078
	n	16	16	16	16

Over the years there has been a trend toward an increasing percentage of fillet samples as opposed to whole fish. The latter are more appropriate for an evaluation of the potential effects on predatory wildlife. There has also been a trend toward increasingly larger fish in terms of both length and weight. The focus of this evaluation is related to food items for the least tern, which takes only very small fish as food. These trends have the potential to confound results related to trends in contaminants in that their concentrations are often related to the size of the fish and the tissue being sampled.

The samples consist of composites of between 1 and 11 fish. There has been a significant trend toward a decreasing number of fish per composite sample. This is consistent with an increase in the size of the fish being sampled. This in and of itself should not affect the results.

Among the inorganic analytes, there has been an increasing trend in cadmium, mercury, and selenium (table VI-3). Both mercury and selenium are correlated with fish size. Consequently, the trend may be an artifact of the trend toward larger fish in the samples. The data do not allow for an evaluation of this.

There was a decreasing trend in both barium and chromium. Neither of these trace elements are of particular concern. The decreasing trend would further reduce any concern that did exist.

Five of the organic contaminants showed significant trends over time. All were decreasing trends and included *cis*-chlordane, *trans*-nonachlor, hexachlorobenzene, heptachlor epoxide, and PCB-1254. Actually, all but one of the nonsignificant trends are also negative. Since most of the organics are chlorinated hydrocarbons that have been banned for further use in the United States, the decline should be expected.

RECOMMENDATIONS FOR FUTURE MONITORING

Seven of the 10 inorganic analytes were compared to levels of concern (see table VI-2). Of the 7, 5 exceeded a presumed no effect level. These included cadmium, lead, mercury, selenium, and zinc. There were fewer than 10 samples of lead and zinc, but over 50 percent of the samples that were available exceeded their respective levels of concern. Because of the high percentage and the paucity of samples, additional data on both lead and zinc appear necessary. Lead, along with cadmium and mercury are known as the “big three” among heavy metal poisons (Manahan, 1989). Cadmium and mercury are also elevated in 89 and 44 percent of the samples respectively. There are more analyses for mercury than for any other element. The remaining element that exceeded its level of concern is selenium, which was the only element to also exceed its toxicity threshold. Selenium exceeded the level of concern in 78 percent of the samples. All five of these elements are recommended for future monitoring.

The samples analyzed to data by the NDEQ are made up of larger fish. As was noted above, all of the samples consisted of fish that are much larger than those suitable as prey for least terns. Consequently, any future monitoring should focus on smaller fish, i.e. < 1.5 inches. In addition, there are no samples of the type of food items taken by piping plovers. This gap in data could be filled by also collecting samples of aquatic invertebrates for contaminants analysis. Analytes of concern would, at a minimum, consist of the five elements listed above. However, since there are no data available on the contaminants in aquatic invertebrates, a wider suite of analytes could be considered.

All of the organic analytes were present in concentrations that appear to be consistent with an uncontaminated background. Because all are showing decreasing trends over time as well, none of these appear to constitute a threat to breeding birds.

Atrazine has exceeded its water quality standard in a significant percentage of the samples that have been collected in recent years. For this reason, it is considered a potential contaminant in fish. There are no data on atrazine concentrations in fish. Consequently, it is recommended that future monitoring for contaminants in fish also include atrazine among the analytes.

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CHAPTER VII

Biological Contaminants in Bird Eggs from the Platte River

The Fish and Wildlife Service sampled bird eggs from the Platte River near Grand Island during 1991 through 1993, with one additional sample collected during 1994. A breakdown of the samples by species and by year is included in Table 1. In addition to the samples summarized in table VII-1, there were two killdeer eggs and four unidentified eggs collected in 1991, two American kestrel eggs collected in 1992, and three peregrine falcon eggs collected in 1993. This report will only address the analyses of the least tern and piping plover eggs.

Table VII-1.—Summary of Egg Samples Collected from the Platte River

	1991	1992	1993	1994	Total
Least Tern	10	21	6	1	38
Piping Plover	2	23	39	0	64
Total	18	44	45	1	108

The samples collected during 1991 were analyzed for 19 elements, including aluminum, arsenic, barium, beryllium, boron, cadmium, chromium, copper, iron, lead, magnesium, manganese, mercury, molybdenum, nickel, selenium, strontium, vanadium, and zinc. During 1992, ½ the samples were analyzed for the full suite of analytes, while the other ½ were only analyzed for arsenic, mercury, and selenium. The 1993 samples were only analyzed for the latter three elements. The 1994 sample was once again analyzed for the full suite of elements. In addition to the elements listed above, sample weight and percent moisture were also reported for most of the samples, i.e., 95 of 102.

The least tern and piping plover egg data are summarized in table VII-2. Part A of the table summarizes the least tern data and Part B summarizes the piping plover data. The data are presented separately because there are many interspecific differences in the measured variables. The differences are evaluated in table VII-3, based on Mann-Whitney tests. The Mann-Whitney test is a nonparametric equivalent of a simple t-test.

Mercury shows the most significant difference between the species. However, from the data in table VII-3, the species with the higher value cannot be readily determined. The data in table VII-2 do not readily show the difference. For example, the minimum

Table VII-2.—Summary of Platte River Endangered Species Egg Contaminants Data—All in mg/Kg Dry Weight (or ppm) Unless Otherwise Noted)

A. Least Tern

	Weight (gm)	Moisture (%)	Aluminum	Arsenic	Boron	Barium	Beryllium
N of cases	37	37	19	36	19	16	18
Minimum	1.73	2.68	3.0	0.1	0.5	0.68	0.01
Maximum	17.96	79.80	91.9	0.3	7.0	11.00	1.00
Median	5.10	74.90	19.6	0.2	2.0	3.55	0.06
No. < D.L.	-----	-----	7	34	14	6	17

	Cadmium	Chromium	Copper	Iron	Mercury	Magnesium	Manganese
N of cases	19	19	19	19	30	19	19
Minimum	0.01	0.10	2.00	70.7	0.23	254	1.06
Maximum	0.88	1.99	4.37	206.0	4.40	832	116.00
Median	0.10	0.50	3.60	128.0	1.55	411	4.19
No. < D.L.	18	14	0	0	0	0	0

	Molybdenum	Nickel	Lead	Selenium	Strontium	Vanadium	Zinc
N of cases	19	19	19	38	19	19	19
Minimum	0.5	0.05	0.034	1.10	1.50	0.3	16.3
Maximum	4.0	4.49	1.100	7.79	28.00	1.0	82.1
Median	0.8	0.50	0.300	4.90	6.94	0.5	60.6
No. < D.L.	18	16	17	0	0	18	0

B. Piping Plover

	Weight (gm)	Moisture (%)	Aluminum	Arsenic	Boron	Barium	Beryllium
N of cases	56	56	15	61	15	14	14
Minimum	1.48	52.30	3	0.20	0.5	2.7	0.02
Maximum	7.70	76.10	55	0.67	10.0	15.2	0.10
Median	5.00	71.30	6	0.20	2.0	6.8	0.02
No. < D.L.	-----	-----	9	57	11	1	14

	Cadmium	Chromium	Copper	Iron	Mercury	Magnesium	Manganese
N of cases	14	14	14	14	59	14	14
Minimum	0.04	0.1	2.6	68.0	0.08	311.0	1.0
Maximum	0.10	0.5	4.2	172.0	4.60	588.0	3.8
Median	0.04	0.1	3.3	86.5	0.25	392.5	1.8
No. < D.L.	14	11	0	0	0	0	0

	Molybdenum	Nickel	Lead	Selenium	Strontium	Vanadium	Zinc
N of cases	14	14	14	60	13	14	14
Minimum	0.5	0.1	0.3	2.7	4.3	0.3	33.0
Maximum	2.0	0.5	2.0	15.0	31.0	0.7	85.7
Median	1.0	0.1	0.6	5.3	12.3	0.3	51.6
No. < D.L.	14	11	14	0	0	14	0

Table VII-3.—Comparison of Egg Data by Species Based on the Mann-Whitney U Test

Variable	Tern n	Plover n	X^2	U	Probability
Weight	36	56	0.0270	1028.5	0.869380
Moisture (%)	36	56	10.4243	1411.5	0.001244 **
Aluminum	18	15	1.5696	169.0	0.210265
Arsenic	35	61	0.2753	1015.5	0.599799
Boron	18	15	1.6846	100.0	0.194309
Barium	15	14	8.0391	40.5	0.004578 **
Beryllium	17	14	5.7912	170.0	0.016107 *
Cadmium	18	14	5.6619	179.0	0.017338 *
Chromium	18	14	4.5421	178.0	0.033072 *
Copper	18	14	5.5663	188.0	0.018310 *
Iron	18	14	9.3613	206.5	0.002216 **
Mercury	29	59	44.7102	1608.5	< 0.000001 ***
Magnesium	18	14	1.2987	156.0	0.254451
Manganese	18	14	10.1968	210.0	0.001407 **
Molybdenum	18	14	3.6405	77.5	0.056389
Nickel	18	14	4.5821	178.0	0.032307 *
Lead	18	14	5.4784	73.5	0.019253 *
Selenium	37	60	1.1764	964.0	0.278100
Strontium	18	13	4.9393	61.5	0.026253 *
Vanadium	18	14	1.6006	157.0	0.205820
Zinc	18	14	1.3426	156.5	0.246576

Asterisks flag statistically significant tests as follows: * probability of greater $X^2 < 0.05$; ** prob. < 0.01; *** prob. < 0.001. Of the 21variables tested, 12 show statistically significant differences.

mercury concentrations are 0.23 and 0.08 ppm in the least tern and piping plover egg data respectively. The maximum mercury concentrations in the two sets of egg data are nearly equal at 4.4 and 4.6 ppm. However, the median mercury concentrations are very different and reflect the distributions of the data being evaluated, and they show the difference very well. A plot of the data will also illustrate the difference. As can be seen from figure VII-1, there is very little overlap in the two data sets. The minima and maxima are about the only points at which there is any near-coincidence of the data. Between those two points, the least tern distribution shows a somewhat linear increase, while the piping plover distribution is extremely concave. Consequently, the medians diverge considerably and reflect the statistical difference.

There are also highly significant differences (probability < 0.01) in the concentrations of several of the variables, including percent moisture, barium, iron, and manganese. It should be noted that the minimum moisture content in the tern eggs was less than

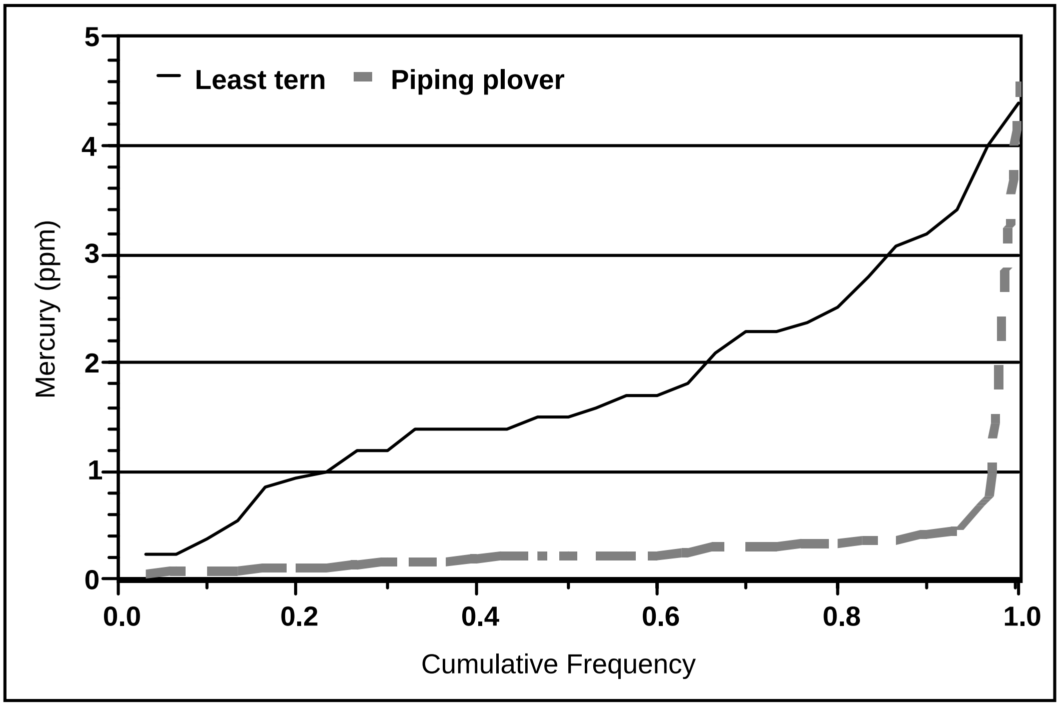

Figure VII-1.—Cumulative Frequency Distributions of Mercury in the Least Tern and Piping Plover Egg Data Sets from 1991-94.

3 percent; this would represent a desiccated egg that would probably not constitute a representative sample. However, it was not discarded. One outlier would not be a significant factor in the nonparametric analysis, wherein outliers have no more influence than any other single observation.

There are also seven elements that show significant differences (probability < 0.05). These include beryllium, cadmium, chromium, copper, nickel, lead, and strontium. The results for the majority of these elements are below the detection limits (table VII-2). The exceptions are copper and strontium. The reason for the differences between species relates to the variation in detection limits between years that coincides with a variation in sample species composition between years as well. These differences are more a difference due to sampling bias than a real difference between species.

The effect of the change in detection limit on the results can be illustrated using the cadmium data. Only one sample had a measurable cadmium concentration (table VII-2), a least tern collected in 1991. The complete cadmium data set for 1991 and 1992 is shown in figure VII-2. The plot includes the data for other species (unidentified, kestrels, and killdeer) collected in the 2 years. There was no measurable cadmium in any of those samples.

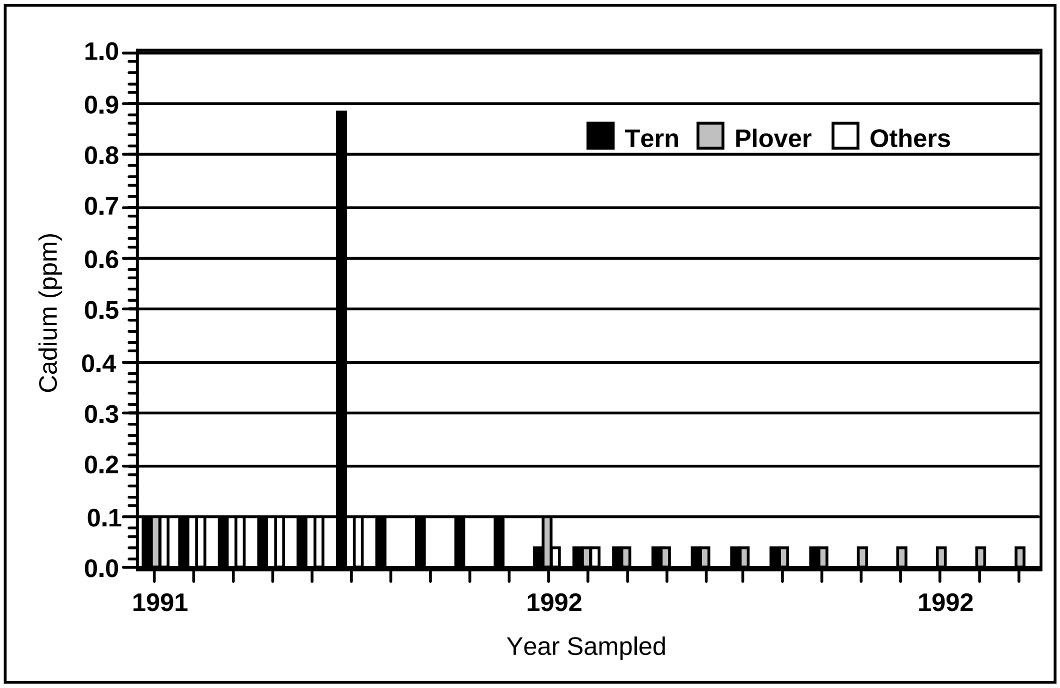

Figure VII-2.—Cadmium Concentrations in All Samples Collected in 1991 and 1992.

The majority of samples collected in 1991 were tern eggs with a detection limit of 0.1 ppm (figure VII-2). The majority of samples collected in 1992 were piping plover eggs with a detection limit of 0.04 ppm. This dichotomy of sampled species and detection limits appears to cause the difference in the cadmium concentration between the tern and plover eggs. It is also the primary control on the other trace elements, including (with their respective 1991 and 1992 detection limits): barium (5 and 0.1-0.4 ppm), beryllium (0.1 and 0.02 ppm), chromium (0.5 and 0.1-0.4 ppm), nickel (0.5 and 0.1-0.4 ppm), and lead (0.3 and 0.6 ppm). For the trace elements that are mostly below detection limits, there is little concern over potential toxicity.

The detection limits also varied between years for most of the other elements, but as long as the results were in the quantifiable range, this has no effect on the results. These are the elements that can be evaluated for potential toxicity.

The Department of the Interior has sponsored the National Irrigation Water Quality Program (NIWQP) since 1985. This program has been concerned with the potential effects of toxic irrigation return flows. In the course of the program, guidelines for evaluating the potential toxicity of selected substances have been developed (NIWQP, 1998). Guidelines have been developed for water, sediment, and a variety of tissues from organisms ranging from plants to mammals. The guidelines also include bird egg concentrations where sufficient studies are available.

The guidelines consist of three tiers of evaluation. The first is a "no effect" level below which there should be no adverse effects; this would be equivalent to EPA's NOAEL (No Observed Adverse Effects Level) for water quality standards. The upper tier is the toxicity threshold, which defines the concentration at which toxicity is a virtual certainty. The concentrations between the lower and upper tiers are within what is labeled the "level of concern." Within the level of concern some toxicity is likely, particularly to sensitive individuals.

The elements for which there are NIWQP (1998) guidelines that relate to the Platte River egg samples are compared in Table 4. Of the elements shown in table VII-4, a very high percentage of the arsenic (94%), boron (74%), and molybdenum (97%) are below their respective laboratory reporting limits. None of these elements exceeds its NOAEL (table VII-4).

Table VII-4.—Comparison of Contaminants Data to No Observed Adverse Effects Level [NOAEL] Taken from NIWQP (1998)

Element	NOAEL [ppm dw]	Species	Year	% > NOAEL
Arsenic	1.3	Least Tern	1991-93	0.0%
		Piping Plover	1991-93	0.0%
Boron	52	Least Tern	1991-92	0.0%
		Piping Plover	1991-92	0.0%
Copper	5.5	Least Tern	1991-92	0.0%
		Piping Plover	1991-92	0.0%
Mercury	0.4	Least Tern	1991-93	90.0%
		Piping Plover	1992-93	13.1%
Molybdenum	13	Least Tern	1991-92	0.0%
		Piping Plover	1991-92	0.0%
Selenium	3.0	Least Tern	1991-93	86.8%
		Piping Plover	1991-93	93.5%
Zinc	50	Least Tern	1991-92	63.2%
		Piping Plover	1991-92	50.0%

Cadmium -	Furness (1996) indicates that Cd is almost always low in bird eggs (usually < D.L. by AA)
Lead - - - -	Pain (1996) indicates that blood, liver, and kidney concentra-tions are primary indicators of contamination

Copper was present in measurable quantities in all of the eggs (table VII-2). All of the least tern and plover eggs were below the NOAEL (table VII-4). However, one of the killdeer eggs had a copper concentration of 5.53 ppm, which is in reality approximately equal to the NOAEL. However, the eggs of the other species as a group do not differ significantly in their copper content from either the tern or the plover eggs ($X^2 = 0.85$ and 2.26 respectively for the Mann-Whitney tests). Copper does not appear to be a major threat to the reproduction of endangered birds based on these egg data.

A very high percentage of the least tern eggs had a mercury concentration in excess of the NOAEL. A relatively small percentage of the plover eggs had mercury levels that were above the NOAEL. This reflects the above mentioned interspecific difference in the mercury concentration in the eggs. It should be noted that the NOAEL used for comparison may be extremely conservative. For example, Thompson (1996) recommended a no effect threshold of 2.5 ppm dw. About 23 percent of the least tern eggs exceeded that level, while less than 2 percent of the plover eggs were greater than Thompson's no effect threshold.

The NIWQP (1998) recommended a toxicity threshold for mercury of 3.4 ppm in bird eggs. About 7 percent of the tern eggs exceeded the toxicity threshold. The same plover eggs that exceeded Thompson's no effect threshold also exceeded the NIWQP (1998) toxicity threshold.

The intermediate zone between the NOAEL and the toxicity threshold is labeled the level of concern by NIWQP (1998). This is a level at which some effects on embryonic birds could be expected, particularly to sensitive individuals. The vast majority of the tern eggs fall within the level of concern. Consequently mercury should be labeled a concern for breeding birds in the study area.

A majority of both the least tern and plover eggs exceeded the NIWQP (1998) NOAEL for selenium (table VII-4). Unlike that for mercury, a greater percentage of the plover eggs exceeded the NOAEL than did the tern eggs, although in this case the difference is small. There was no interspecific difference in the selenium content of the eggs. Like the NIWQP (1998) NOAEL for mercury, the one for selenium may also be very conservative. Heinz (1996) recommended a no effect level for selenium in eggs of 3 ppm ww (or approximately 12 ppm dw assuming a moisture content of 75 percent). This latter resource is greater than the toxicity threshold for selenium recommended by the NIWQP of 6 ppm dw. The difference in the various recommendations may reflect the basis for the recommendations. Heinz's (1996) recommendation is based on controlled feeding studies, while the NIWQP (1998) toxicity threshold is based on field data. In the case of field studies, the toxicity may reflect either the synergistic effect of other contaminants or the effect of some other contaminant. Alternatively field studies do reflect the real world where confounding effects would be the rule rather than the exception.

The comparison of the egg data to the NIWQP (1998) selenium toxicity threshold showed that none of the tern eggs exceeded it, but about 29 percent of the plover eggs did. In either case the majority of the eggs were within the level of concern.

Consequently selenium would have to be added to the list of contaminants of concern for both least tern and piping plover reproduction in the Platte River.

A significant percentage of both tern and plover eggs exceeded the NOAEL of zinc (table VII-4). NIWQP (1998) did not recommend a toxicity threshold for zinc. The rationale for this was that zinc toxicity thresholds are not well established because zinc concentrations are homeostatically regulated (NIWQP, 1998). Nevertheless, no matter what such a threshold might be, under the definition of the "level of concern," the zinc data would fall within it. On the basis of this rationale, zinc should also be added to the list of contaminants of concern.

TRENDS

There are only 2 years of available data for most constituents, and 3 at most for several others. This is an insufficient data base for a trend analysis.

RECOMMENDATIONS FOR FUTURE MONITORING

Eggs of terns and plovers were collected during the years 1991-93. In 1991 and 1992 (about ½ the samples in 1992), the eggs were analyzed for their content of aluminum, arsenic, barium, beryllium, boron, cadmium, chromium, copper, iron, lead, magnesium, manganese, mercury, molybdenum, nickel, selenium, strontium, vanadium, and zinc. The remaining eggs in 1992 and those collected in 1993 were analyzed for arsenic, mercury, and selenium only.

Mercury, selenium, and zinc were elevated in a large percentage of the eggs. A small percentage of the eggs exceeded the toxicity threshold for mercury. There are no data on the state of the eggs or the embryos within; so actual effects cannot be confirmed. However, samples that are in excess of the no effect level may or may not exhibit adverse effects. Since one of the eggs was extremely desiccated (% moisture < 3), some cause of mortality was present. The desiccated egg did exceed the no effect level for selenium, although not the toxicity threshold. Nevertheless, all three elements are within the level of concern for potential embryonic toxicity and should be monitored in the future.

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