Ken Kaymeyer - CDOW
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DEPARTMENT OF THE INTERIOR
U.S. FISH AND WILDLIFE SERVICE
REGION 6

FY06 Environmental Contaminants Program
On-Refuge Investigations Sub-Activity

CO – Nutrients and Arapaho National Wildlife Refuge

Project ID: New
(filename:Arapaho Nutrients 05.doc)

by

Laura Archuleta
Environmental Contaminants Specialist

for

Susan Linner, Field Office Supervisor
Colorado Field Office
Lakewood, CO
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Congressional District #3

II. INTRODUCTION

II.A. Background and Justification

Refuge

Arapaho National Wildlife Refuge (Refuge) was created in 1967 to provide suitable nesting habitat for waterfowl, in part, to offset losses of nesting habitat for migratory birds in the prairie wetland region of the Midwest. The Refuge is located in an intermountain glacial basin south of Walden, Colorado in an area of the state known as "North Park" (Figure 1). North Park extends north into Wyoming and is bounded on the west by the Park Range, on the south by the Rabbit Ears Mountains, on the southeast by the Never-Summer Range, and on the east and northeast by the Medicine Bow Range. Numerous meandering streams are interspersed on the basin floor and eventually come together to form the headwaters of the North Platte River.

Encompassing approximately 23,267 acres and ranging in elevation from 8100 to 8700 feet, the Refuge is climactically classified as a cold desert. The Refuge consists of irrigated and sub-irrigated meadows, sagebrush grasslands, natural and manmade wetlands, riparian willow and stream habitats. Because the Refuge does not receive much rainfall (10-15 inches per year), water is diverted from the Illinois River through a complex ditch system to irrigate meadows and fill waterfowl brood ponds.

The Refuge is a major breeding and migratory stopping ground for a large number of migratory birds and waterfowl, making the area a popular bird watching destination. Over 200 species of birds have been documented on the Refuge including sage grouse, black-crowned night-heron, white pelican, prairie falcon, and golden eagle. Peregrine falcons and bald eagles, Federally listed threatened species, both occasionally occur on the Refuge. Greater sandhill cranes, a State species of special concern, nest in the area and are frequently observed on the Refuge. Refuge efforts to restore the Illinois River channel hydrology and areas of sagebrush uplands, and to effectively manage wetlands and meadows, contribute to the ecological integrity of the Refuge, North Park, and the overall North Platte River system.

In 2004 (US Fish and Wildlife Service), the Refuge completed a Comprehensive Conservation Plan (CCP) which will guide Refuge management for the next 15 years. Goals for the Refuge include a representative high mountain valley riparian community, a properly functioning river channel, managed wetlands, and irrigated meadows which will provide habitat for migratory birds, waterfowl, shorebirds, wading birds, sage grouse broods, and other wildlife. In addition, the Refuge established a Partners for Fish and Wildlife program to encourage habitat restoration on private lands, especially those impacting the Refuge.

Willows were historically removed, presumably to increase hay yield, along the Illinois River on the north end of the Refuge (US Fish and Wildlife Service 2004). Willow removal impacts riparian and aquatic habitats by destabilizing river banks, increasing sedimentation, decreasing shading and increasing water temperatures. Riparian plant communities are important for maintaining water quality and aquatic habitat, support distinct vegetative communities, and provide high-quality terrestrial wildlife habitat (Thomas et al. 1979; Windell et al. 1986; Naiman et al. 1993; Stocek 1994 as cited in US Fish and Wildlife Service 2004).

Several strategies are outlined in the CCP to meet Refuge goals including stream channel restoration; adjusting water management practices; restoring riparian habitat; monitoring vegetative, fishery, and wildlife responses to management actions; and enhance aquatic habitats and fishing opportunities.

North Park

Meandering streams crisscross North Park and flow toward the north-central part of the basin to form the North Platte River. Most of the floodplain is irrigated meadow that produces a single hay crop per year with sagebrush grasslands characterizing the adjacent low rises. North Park has a ranching heritage and it continues to dominate the area's culture. Beef cattle and nationally renowned mountain hay are major sources of income for ranchers in North

Park (United States Fish and Wildlife Service 2004).

In North Park, there are approximately 134,000 acres of irrigated pastures/hay meadows with nearly 15,000 acres located upstream of the Refuge (Figure 2). These hay meadows are regularly fertilized (G. Langer, D. Heeney, J. Jack, pers comm.) and may be contributing nitrogen and phosphorous to the Illinois River. Fertilizer is locally stockpiled in Walden (G. Langer pers. comm.) but data about its formulation are not available.

The Illinois River is on the State of Colorado's 303(d) list of impaired waters and 2 tributaries to the Illinois are on its Monitoring and Evaluation (M&E) List (Colorado Water Quality Control Division 2004). The M&E list is intended to identify stream segments where there is reason to suspect water quality problems, but uncertainty exists regarding one or more factors. About 70 miles of the Illinois River is not supporting its designated use of Aquatic Life Cold 1 (i.e. trout stream) due to impairment (Colorado Water Quality Control Division 2004). The Illinois River, at one sampling location on the Refuge, is not meeting water quality standards for several constituents; including iron and dissolved oxygen (Colorado Water Quality Control Division unpublished data). These data are the only water quality data available from the Refuge and they represent only one sampling location. Consequently, there is little known about water quality on the Refuge.

Nutrients and hay meadows

An essential component of western mountain valley cattle ranches are irrigated hay meadows. Jacobs and Kearl (1979) estimated that approximately 1,700,000 acres of irrigated hay meadows occur in the mountain and intermountain regions of California, Oregon, Idaho, Utah, Nevada, Montana, Colorado, and Wyoming. There are approximately **250,000 (verifying w/ CSU Ext)** acres of hay meadows in the mountains of Colorado (CSU Extension, pers. comm..) yielding about 1.3 tons per acre (Mortvedt et al. 1996).

Mountain meadows typically produce low forage yields and tend to have low soil fertility, but are capable of high productivity with fertilization and proper irrigation (Siemer 1984 as cited by White et al. 2003). Ludwick (1979) stated that high-elevation hay meadows can be expected to respond to fertilization because nitrogen (N) is generally deficient and must be applied annually. Mortvedt et al. (1996) state that N and phosphorous (P) are the primary nutrients limiting productivity of irrigated hay meadows. Although they are essential for maximum plant growth, surplus N and P can lead to nutrient runoff and degradation of surface waters (Sharpley et al. 1994; Turner and Haygarth 2000; Trachtenberg and Ogg 1994).

In addition to N, P may be a component of fertilizer used on North Park hay meadows. P from soils can impair water quality of streams and lakes (Haygarth et al. 1998; Turner and Haygarth 2000) as well as impact fish communities in low order streams when P exceeds background concentrations in water (Miltner and Rankin 1998).

Flood irrigation is commonly used throughout the western United States and is predominantly practiced in irrigated hay meadows (US Geological Survey 2000). Fertilizing irrigated hay meadows provides a potential source of pollutants (Donaldson and Swanson 2000) and overland flow from flood irrigation provides a transport pathway for nutrients to enter surface waters (White et al. 2003). Hay meadows dominated by organic soils that are flooded during part of the growing season may have lower responses to N fertilization (Mortvedt et al. 1996). Consequently, producers may over-apply N fertilizer if they have not considered soil type when determining N management and its economic impacts to their operation.

Why nutrients are potentially impacting the Refuge

In North Park, there are approximately 134,000 acres of irrigated hay meadows with nearly 15,000 acres located upstream of the Refuge (Figure 2). These hay meadows are regularly fertilized (G. Langer, D. Heeney, J. Jack, pers comm.) and may be contributing N and P to the Illinois River. Typically, fertilizer is applied to hay meadows in April as producers prepare fields for the irrigation season, which is from 1 May to 30 September (White et al. 2003). Water quality of irrigation runoff tends to be most affected by fertilizer applied in the spring just prior to irrigation (White et al. 2003). Further, potential exists for producers to over-apply N fertilizer given that many hay meadows in North Park are dominated by organic soils that are flooded during the growing season.

As mentioned earlier, the Illinois River is not meeting water quality standards for several constituents, including iron and dissolved oxygen, at one sampling location on the Refuge (Colorado Water Quality Control Division unpublished data). Sediment samples from two river and 2 impoundment sites on the Refuge had elevated (>16,000 ppm, dw) iron concentrations (Chirhart et al. 2003). Furthermore, plant tissue concentrations were elevated compared to sites from the San Luis Valley, CO (Archuleta and DeWeese 1992), suggesting that iron is bioavailable.

Anecdotal information suggests that algae growth occurs in the Illinois River on the Refuge at certain times of the year (A. Archuleta, K. Kehmeier, pers. comm.) and CFO EC staff have also observed these phenomena. Increased nutrient inputs into aquatic ecosystems may increase primary productivity (i.e. increased algal biomass) subject to nutrient limitation, which may impact benthic macroinvertebrate community structure (Kiffney and Richardson 2001). Kehmeir (1998) qualitatively (presence/absence) sampled benthic macroinvertebrates on the Refuge and found that the number of taxa decreased from upstream to downstream in the Illinois River and that benthic macroinvertebrate diversity was greatest in the impoundments. However, no data exist regarding benthic macroinvertebrate community structure in the Illinois River or impoundments on the Refuge.

The Illinois River supports aquatic vegetation including filamentous algae (US Fish and Wildlife Service 2004), but there are no data documenting primary productivity of the river or Refuge impoundments.

In 2004, Colorado Field Office (CFO) Environmental Contaminants (EC) staff conducted malformed amphibian surveys at the Refuge. Four malformations were observed and occurred in Refuge impoundments (CFO unpublished data). Johnson and Chase (2004) imply that eutrophication may be linked to amphibian malformations due to shifts in food web interactions. Amphibians are potentially exposed to fertilizer and manure runoff in pasture lands, but studies of potential interactions between levels of fertilizer contamination, anthropogenic habitat alteration, and amphibian declines do not exist (Bishop et al. 2003).

II.B. Scientific Objective(s)

1. Determine if nutrients from fertilization of upstream hay meadows are negatively impacting aquatic habitats on the Refuge.

2. Determine if primary productivity in the Illinois River and Refuge impoundments is affected by possible eutrophication.

3. Evaluate health of Illinois River and Refuge impoundments using benthic macroinvertebrate community data and fish population estimates.

   The CCP (US Fish and Wildlife Service 2004) states that quantitative sampling of benthic macroinvertbrates would assist in identifying problems in wetlands and the river (riparian areas) on the Refuge.

4. Make inferences about potential risks to fish and wildlife resources and potentially affected habitats from possible eutrophication.

II.C. Management Action(s)

<u>Direct Management Actions</u>:

1) By determining if nutrients are impacting aquatic habitats on the Refuge, the Refuge will be better able to:

- **prioritize irrigation changes to provide for a properly functioning channel in the Illinois River (CCP goal);**

- establish aquatic vegetation (algae) monitoring protocols and goals for post- river restoration evaluation
- establish pre-river restoration fish population estimates
- establish pre-river restoration invertebrate community indices

2) Data will be used to make recommendations to the Colorado Water Quality Control Commission regarding water quality standards and designated uses in the Illinois River.

3) The Service will use the data to determine if amphibians may be impacted by nutrients from upstream sources.

Indirect Management Actions:

1) Data will be provided to Partners for Fish and Wildlife, Colorado Division of Wildlife, Natural Resource Conservation Service, and Colorado State University Cooperative Extension to assist in providing technical assistance to willing landowners to implement Best Management Practices (BMPs) regarding nutrient and riparian management.

Although some BMPs regarding irrigated hay meadow management are available (Mortvedt et al. 1996; Jacobs et al. 1993), there is uncertainty related to implementation. Economic and agronomic considerations should provide the impetus for ranchers to successfully implement BMPs.

2) Data will be used, as appropriate, by the Refuge in meeting several CCP goals.

3) Data may be used to begin drafting a nutrient management plan for the Illinois River.

4) CDOW may use the data to refine fishery goals on the Illinois River.

III. METHODS

III.A. Data Collection and Analysis

The Illinois River, which flows across the refuge, and Refuge impoundments are the focus of this study. Two reference sites will be established, one on the Illinois River and the other on a similar stream in North Park. Both reference sites will be located upstream of potential nutrient sources. All sample site locations will be recorded using a global positioning system and entered into a GIS database.

During the first year of the investigation, biotic and abiotic samples will be collected at 10-12 sites in the Illinois River on the Refuge and at 2 reference sites. During year 2, biotic and abiotic samples will be collected from 10 -12 impoundment sampling sites on the Refuge. Year 3 biotic and abiotic sampling will be conducted to better define areas of impact. Water and sediments samples will be collected pre-, beginning, mid- and post-irrigation. Invertebrate and algae samples will be collected between mid- and post-irrigation . Fish populations will be sampled in both the river and impoundments. Timing of fish sampling will be at the discretion of the Colorado Division of Wildlife's (CDOW) fishery biologist.

Water quality, invertebrate, and algae sampling will be conducted according to USGS National Water Quality Assessment Program protocols (USGS 2005, Moulton II et al. 2002). Fish population sampling will be in accordance with CDOW protocols.

Sample collection for determination of:

Laboratory Analyses:
Major Ions (water, routine and anions, includes iron)
Nitrogen as nitrate, nitrite, and ammonia (water and sediments)
Orthophosphate and total P (water and sediments)
Chlorphyll *a* (algae)
Ash-free dry mass (algae)

Field Instrument Determinations
Conductivity/TDS/Salinity/Temperature (water – field measurement)
Dissolved Oxygen (water – field measurement)
pH (water – field measurement)

Sample identification

A unique sample identification code must be written on each sample container using a black Sharpie.

Data Analysis

Water quality data will be compared to Colorado water quality standards to determine if impairments are occurring on the Refuge. The Illinois River is on the State of Colorado's 303(d) list and approximately 70 miles of the Illinois River is not supporting its designated use of Aquatic Life Cold 1 (Colorado Water Quality Control Division 2004) due to impairment.

Primary productivity will be determined using algal data. In addition, algal data will be used to determine if aquatic habitats on the Refuge are impacted by nutrients.

Additionally, data will be compared to NAWQA data from other parts of the nation to determine the 'relative ranking' of nutrients in the Illinois River.

Invertebrate community data will be analyzed to determine if the community type is tolerant or intolerant of nutrients.

Fish population data will be compared to historic fish population data to evaluate current fishery health. Additionally, fishery data will be used to determine if the Illinois River on the Refuge is meeting its designated use or is impaired.

III.B. Proposed Schedule of Milestones

Sampling will begin in April 2006 and be completed by fall 2008. An interim report will be completed in 2006 and 2007. A final report will be prepared in 2009.

IV. INTERIM REPORT

IV.A. Results to Date

This is a new investigation proposal.

IV.B. Significant Changes to Previous Proposal

This is a new investigation proposal.

V. REFERENCES

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VI. ROLES, RESPONSIBILITIES, AND PARTNERSHIPS

VI.A. Roles and Responsibilities

Data collection, analyses, and interpretation will involve cooperation with the following entities:
US Fish and Wildlife Service - Colorado Field Office and Arapaho National Wildlife Refuge
US Geological Survey - National Water-Quality Assessment Program
Colorado Division of Wildlife
US Geological Survey - National Water Quality Laboratory
Colorado State University – Mountain Meadows Research Station

Colorado State University – Soil, Water, and Plant Testing Laboratory
US Environmental Protection Agency – Region 8 Laboratory

The principal investigator for this study is Ms. Laura Archuleta (CFO). The principal investigator will be responsible for coordination with the aforementioned agencies and institutions for sampling, sample analyses, data interpretation, and report writing. CFO EC staff will assist in sample collection, data analysis, interpretation, and report writing. Pam Johnson will be the primary Refuge contact and will provide technical assistance for sample collections.

VI.B. Partnerships

US Geological Survey - National Water-Quality Assessment Program/Water Resources
Rod DeWeese, Stephen Porter, Bill Battaglin, and Katy Walton-Day will provide technical assistance regarding sampling protocols for water, algae, sediments, and invertebrates. Some field assistance will also be provided. In addition, Mr. DeWeese, Dr. Porter, Mr. Battaglin, and Ms. Walton-Day will assist with data analyses and interpretation. Total estimated in-kind contribution: $16,000

Colorado Division of Wildlife (CDOW)
Ken Kehmeier, Fisheries Biologist, will provide an electorfishing crew and all necessary equipment for fish population sampling. Mr. Kehmeier sampled the Refuge in 1998 and will provide assistance by modeling fish population and community metrics including: biomass, species diversity, age, abundance, and sex ratio. Total estimated in-kind contribution: $12,000.

Colorado State University – Mountain Meadows Research Station
Dr. Joe Brummer will provide agricultural expertise for this investigation. Dr. Brummer will review the experimental design prior to data collection and will provide technical support and review of statistical analyses and interpretation. Total estimated in-kind contribution: $2,000.

US Environmental Protection Agency – Region 8 Laboratory
Richard Evans, aquatic ecologist, will provide entomological expertise for this investigation. Mr. Evans will process all benthic macroinvertebrate samples by identifying to species, if possible, and enumerating invertebrates in each sample. If possible, some field assistance may be provided. Mr. Evans will also provide technical support and review of analyses and interpretation of aquatic data. Total estimated in-kind contribution: $12,000.

VII. Budget

The proposed investigation is a collaboration of Federal and State entities, all of which are willing to contribute cost free expertise, equipment, and time.

VIII. REVIEW AND APPROVAL

Proposal Title: Nutrients and Arapaho National Wildlife Refuge

Project ID#: New

Submitted by: _____ Date: June 2005
Contaminant Specialist, Field Office

Reviewed by: _____ Date: _____
Refuge Manager, (required for On-Refuge Investigations)

Reviewed by: _____ Date: _____
Program Manager, ... e.g., Hatchery, Endangered Species, etc. (if appropriate)

Reviewed by: _____ Date: _____
Environmental Contaminants Coordinator

Approved by: _____ Date: _____
Regional Director

Scientific Peer Review Form (3/05)

1. Is the experimental design well thought out and scientifically valid? Please comment:

2. Is there a good probability of achieving the objectives of the investigation? Please comment:

3. Does the investigation integrate current information with accepted methodologies to close data gaps, and establish a cause and effect relationship? Please comment:

4. Are the costs well researched, clearly spelled out and defensible? Please comment:

5. Commensurate with investigation objectives, does the proposal describe or cite scientifically acceptable operating procedures that include QA/QC sufficient to ensure the integrity of the data? Please comment:

Please check one of the following:

___ Proposal is acceptable *as is* (no changes required) ___ Minor revisions required ___ Major revisions required

PROPOSAL TITLE _____
REVIEWER* _____ **TITLE** _____ **DATE** ___
*If peer reviewer is anonymous, EC coordinator should indicate such and initial the signature line.

2006 National Criteria Score Sheet

TITLE: _____

PROJECT I.D.: _____ REGION: ___ RO RANK: ____ TARGET STATES: _____

Pass/Fail Criteria
The investigation proposal ***DOES*** ___ ***DOES NOT*** ___ pass the minimum required standards of the Environmental

Contaminants Program.

Yes/No Proposal clearly identifies (1) an environmental problem related to anthropogenic contaminants and (2) site-specific management actions designed to resolve that problem. If not, explain:

Yes/No The proposal clearly identifies a level of biological impacts that must be investigated. Abiotic only sampling is clearly linked to an established threshold level of concern. If not, explain:

Yes/No At least one substantive peer review has been conducted and is attached. The proposal has been revised as appropriate. The study design is sufficient to meet the objectives of the proposal. If not, explain:

Yes/No The required surnames have been obtained. If not, explain:

Ranking Criteria

For the above referenced proposal, determine a score for each of the following criteria in accordance with the criteria definitions described in Chapter 5 of the investigations manual. Identify the location of the text that supports the score. If you disagree with a score previously provided, explain why.

*A. Threats to resources are **DOCUMENTED (20 pts) or SUSPECTED (15 pts).***

Field Office Supporting Text (**in bold**): Section _____, ¶ _____ Score: ____

Regional Office Supporting Text: Section _____, ¶ _____ Score: ____
Explanation (if scores differ):

Reviewer Supporting Text: Section _____, ¶ _____ Score: ____
Explanation (if scores differ):

*B. Management actions are **DIRECT (15 pts) or INDIRECT (10 pts).***

Field Office Supporting Text (**in bold**): Section _____, ¶ _____ Score: ____
Regional Office Supporting Text: Section _____, ¶ _____ Score: ____
Explanation (if scores differ):

Reviewer Supporting Text: Section _____, ¶ _____ Score: ____
Explanation (if scores differ):

*C.1. The study question(s) or hypotheses being addressed by the investigation **ARE (4 pts) or ARE NOT (0 pts)** clearly stated.*

Field Office Supporting Text (**in bold**): Section _____, ¶ _____ Score: ____

Regional Office Supporting Text: Section _____, ¶ _____ Score: ____
Explanation (if scores differ):

Reviewer Supporting Text: Section _____, ¶ _____ Score: ____
Explanation (if scores differ):

*C.2. The study design as described in the proposal **WILL (4) or WILL NOT (0 PTS) answer the study question(s)/hypotheses.***

Field Office Supporting Text (**in bold**): Section _____, ¶ _____ Score: ____

Regional Office Supporting Text: Section _____, ¶ _____ Score: ____
Explanation (if scores differ):

Reviewer Supporting Text: Section _____, ¶ _____ Score: ____
Explanation (if scores differ):

*C.3. The scope or complexity of impacts being addressed by the investigation **IS (4 pts) or IS NOT (0 pts)** appropriate.*

Field Office Supporting Text (**in bold**): Section _____, ¶ _____ Score: ____

Regional Office Supporting Text: Section _____, ¶ _____ Score: ____
Explanation (if scores differ):

Reviewer Supporting Text: Section _____, ¶ _____ Score: ____
Explanation (if scores differ):

*C4. The most severe type of biological impact addressed by the investigation is an **INDICATOR OF ADVERSE EFFECTS (4 pts) or ACTUAL ADVERSE EFFECTS (7 pts).***

Field Office Supporting Text (**in bold**): Section _____, ¶ _____ Score: ____
Regional Office Supporting Text: Section _____, ¶ _____ Score: ____
Explanation (if scores differ):

Reviewer Supporting Text: Section _____, ¶ _____ Score: ____
Explanation (if scores differ):

*C.5. Source of the contaminant **IS (3 pts) or IS NOT (0 pts)** sufficiently addressed.*

Field Office Supporting Text (**in bold**): Section _____, ¶ _____ Score: ____

Regional Office Supporting Text: Section _____, ¶ _____ Score: ____
Explanation (if scores differ):

Reviewer Supporting Text: Section _____, ¶ _____ Score: ____
Explanation (if scores differ):

*C.6. Pathway of the contaminant **IS (3 pts) or IS NOT (0 pts)** sufficiently addressed.*

Field Office Supporting Text (**in bold**): Section _____, ¶ _____ Score: ____

Regional Office Supporting Text: Section _____, ¶ _____ Score: ____
Explanation (if scores differ):

Reviewer Supporting Text: Section _____, ¶ _____ Score: ____

Explanation (if scores differ):

D. Final regional rank order is ___ of ___ proposals submitted. Score: ____

E1. Regional Performance Score Score: ____

E2. Total Partnership Effort

Field Office Supporting Text: Section _____, ¶ _____ Score: ____

Regional Office Supporting Text: Section _____, ¶ _____ Score: ____
Explanation (if scores differ):

Reviewer Supporting Text: Section _____, ¶ _____ Score: ____
Explanation (if scores differ):

General Reviewer Comments or Major Concerns: