KANSAS DEPARTMENT OF TRANSPORTATION WETLAND MITIGATION SITES—Analysis and Opportunity for Improving Success

September 1998

Kelly Kindscher*, Megan Mehaffey, Alexandra Fraser,
Kansas Biological Survey
and Ernie Pogge, Civil Engineering Department
The University of Kansas

MATC Project No. MATC KU 96-3
KDOT Project No. K-TRAN: KU 96-2

Mid-America Transportation Center
University of Nebraska-Lincoln
W333.2 Nebraska Hall
Lincoln, NE 68588-0530
Telephone 402-472-1974
Fax 402-472-0859

Sponsored by the

Kansas Department of Transportation
2300 SW Van Buren Street
Topeka, KS 66611-1195
Telephone 785-296-3576
Fax 785-296-6944

DISCLAIMER

This document is disseminated under the sponsorship of the Department of Transportation, University Transportation Centers of University Research Institutes Program, in the interest of information exchange.

REPORT DOCUMENTATION PAGE

Form Approved
OMB No. 0704-0188

1. AGENCY USE ONLY *(Leave Blank)*	2. REPORT DATE	3. REPORT TYPE AND DATES COVERED

4. TITLE AND SUBTITLE	5. FUNDING NUMBERS
Kansas Department of Transportation Wetland Mitigation Sites—Analysis and Opportunity for Improving Success	DTRS95-G-0007
6. AUTHOR(S)	
Kelly Kindscher, Megan Mehaffey, Alexandra Fraser, and Ernie Pogge	
7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES)	**8. PERFORMING ORGANIZATION REPORT NUMBER**
Mid-America Transportation Center University of Nebraska-Lincoln W333.2 Nebraska Hall Lincoln, NE 68588-0530	MATC KU96-3
9. SPONSORING /MONITORING AGENCY NAME(S) AND ADDRESS(ES	**10. SPONSORING /MONITORING NUMBER**
Kansas Department of Transportation 2300 Van Buren Street Topeka, KS 66611-1195	KTRAN/KU96-2
11. SUPPLEMENTARY NOTES	
12a. DISTRIBUTION/AVAILABILITY STATEMENT	**12b. DISTRIBUTION CODE**
This document is available to the public	

13. ABSTRACT ***(Maximum 200 words)***

In the last decade, efforts to create and restore wetlands have expanded in response to both increased awareness of wetland benefits and changes in governmental policy. By some estimates half of the United States' original wetlands have been destroyed (Mitch and Gosselink 1993). Remaining wetlands are valuable for floodwater management, water quality and wildlife habitat as well as aesthetic and educational benefits to humans (Hammer 1992). Section 404 of the Clean Water Act (U.S. Congress 1987) requires mitigation of wetlands that will be destroyed, and is enforced by the U.S. Army Corps of Engineers.

The objective of our study was to examine wetland status, success rate, and the potential for continued development as wetlands of six Kansas Department of Transportation wetland mitigations. The wetlands were constructed to compensate for impacts caused by KDOT road projects in accordance with the Army Corps of Engineers 404 permit process. At each mitigation the vegetation, soils, and hydrology were studied to assess the site's current and future ability to function as a wetland. Each site was monitored for the presence of wetland parameters, and the results were analyzed in the context of long term site goals and objectives.

14. SUBJECT TERMS	15. NUMBER OF PAGES
	52
	16. PRICE CODE

17. SECURITY CLASSIFICATION OF REPORT	18. SECURITY CLASSIFICATION OF THIS PAGE	19. SECURITY CLASSIFICATION OF ABSTRACT	20. LIMITATION OF ABSTRACT
Unclassified	Unclassified	Unclassified	

PREFACE

This research project was funded by the Kansas Department of Transportation K-TRAN research program and the Mid-America Transportation Center (MATC). The Kansas Transportation Research and New-Developments (K-TRAN) Research Program is an ongoing, cooperative and comprehensive research program addressing transportation needs of the State of Kansas utilizing academic and research resources from the Kansas Department of Transportation, Kansas State University and the University of Kansas. The projects included in the research program are jointly developed by transportation professionals in KDOT and the universities.

NOTICE

The authors, the State of Kansas and the Mid-America Transportation Center do not endorse products or manufacturers. Trade and manufacturers names appear herein solely because they are considered essential to the object of this report.

This information is also available in alternative accessible formats from the Kansas Department of Transportation. To obtain an alternative format, contact the Kansas Department of Transportation, Office of Public Information, 7th Floor, Docking State Office Building, Topeka, Kansas, 66612-1568 or phone (785) 296-3583 (voice) (TDD).

DISCLAIMER

The contents of this report reflect the views of the authors who are responsible for the facts and accuracy of the data presented herein. The contents to not necessarily reflect the views or the policies of the State of Kansas. This report does not constitute a standard, specification or regulation.

TABLE OF CONTENTS

INTRODUCTION

In the last decade, efforts to create and restore wetlands have expanded in response to both increased awareness of wetland benefits and changes in governmental policy. By some estimates half of the United States' original wetlands have been destroyed (Mitch and Gosselink 1993). Remaining wetlands are valuable for floodwater management, water quality and wildlife habitat as well as aesthetic and educational benefits to humans (Hammer 1992). Section 404 of the Clean Water Act (U.S. Congress 1987) requires mitigation of wetlands that will be destroyed, and is enforced by the U.S. Army Corps of Engineers. For any wetland to be developed, a dredge and fill permit must be obtained, and a wetland creation or enhancement must occur to compensate for the wetland to be impacted.

In national regulations for wetland delineation, the U.S. Army Corps of Engineers (Environmental Labs 1987) defines wetlands as: "Those areas that are inundated or saturated by surface or ground water at a frequency and duration sufficient to support, and that under normal circumstances do support, a prevalence of vegetation typically adapted for life in saturated soil conditions." In both delineating and restoring or creating wetlands, it is essential to focus on three parameters: hydrology, wetland soils, and wetland vegetation.

Monitoring of wetland mitigations is necessary to ensure that the wetlands' criteria are met and the wetland is functioning as planned. At the time of planning, mitigation goals should be set based on hydrological criteria, soil and vegetation. These criteria are best established when based on local wetland ecology and careful consideration of the impacted wetland. To ensure success, monitoring should be conducted from the time of construction until the mitigation goals and criteria are met.

Any site will support plant species adapted to localized conditions, therefore vegetation represents the integration of many site features, such as climate, soil type, and hydrology. A detailed look at the vegetation of wetland mitigations can determine its ability to sustain wetland status into the future. Measurement of soil characteristics can help determine the site's ability to maintain hydrology and the vegetation necessary for continued wetland development. The hydrology of each mitigation site should be analyzed based on mitigation project objectives. This does not infer a complete design type analysis, but instead a reconnaissance study of the existing hydrologic conditions over time and under a variety of weather conditions to determine if the mitigation is able to support the planned, long term objectives of each mitigation project.

The objective of our study was to examine wetland status, success rate, and the potential for continued development as wetlands of six Kansas Department of Transportation wetland mitigations. The wetlands were constructed to compensate for impacts caused by KDOT road projects in accordance with the Army Corps of Engineers 404 permit process. At each mitigation the vegetation, soils, and hydrology were studied to assess the site's current and future ability to function as a wetland. Each site was monitored for the presence of wetland parameters, and the results were analyzed in the context of long term site goals and objectives.

STUDY AREAS

The Enterprise mitigation was created in 1988 to mitigate for the loss of 1.7 acres of riparian wetlands by roadfill in an old oxbow 1/3 mile north of a new bridge over the Smoky Hill River (see maps for all sites in Appendix 1). A five-acre site near the new bridge was planted with native trees and is maintained by the Kansas Department of Wildlife and Parks (KDWP). A second site designed for wetland mitigation was excavated along the river channel. It was planted with a native plant mix and has been allowed to vegetative succession.

The 18-acre Emporia mitigation was constructed to mitigate for the loss of wetlands caused by the relocation and widening U.S. Highway 50. The site was created by sculpturing an existing waterway between two highway culverts. The waterway was widened and the channel elevation was lowered. The buffer area was seeded with grass to encourage vegetation establishment and prevent erosion, and the majority of the mitigation was covered with wetland top soil to introduce wetland vegetation.

The 60-acre Kingman mitigation was constructed in 1987 to mitigate for US-54 highway construction impacts on wetland meadows in drainages of the North Fork Ninnescah River. The impacts occurred between Kingman and Cunningham on U.S. Highway 54. A dike, shallow pond, and control outlets were constructed on 60 acres of Kansas Fish and Game Property adjacent to KDWP owned Kingman Wildlife Area. No apparent revegetation efforts were undertaken. This area is under management by KDWP.

The Santa Fe site in Lawrence was constructed in 1994 as part of a plan to mitigate for the loss of 13 acres of wetlands by the proposed South Lawrence Trafficway. A 2-foot berm was constructed around the perimeter of the 17-acre site, and two one-foot frog ponds were created to provide habitat for the formerly state-threatened northern crayfish frog (*Rana areolata circulosa*). The site was seeded with 42 species of native wetland plants, and plugs of root stock were transplanted from the nearby Baker-Haskell Wetlands. This site is owned by Douglas County and has been monitored by the Kansas Biological Survey since 1994.

The Medicine Lodge site consists of a 0.38 acre basin constructed to mitigate for 0.345 acres of permanent fill and 0.230 acres of temporary fill from the replacement of the Medicine Lodge River Bridge on U.S. 160. Wetland soils were transported from the impact site and plugs of vegetation were placed in the basin. Construction of this site was completed in December 1995.

The Wichita mitigation was constructed around 1985 to mitigate for the loss of 0.7 acres of wetlands and wildlife habitat by the construction of an interchange ramp on I-135. The area impacted is a manmade sand-pit now used as a fishing pond and recreational area. Although this site's exact location is unclear, an embankment was constructed on the impoundment to compensate for the area removed by the interchange.

SAMPLING METHODS

Vegetation Sampling and Analysis

The vegetation of each of the six wetland mitigation sites was sampled twice during the growing season, in June and October of both 1996 and 1997. For the three largest sites (Emporia, Kingman, and Lawrence), plant sampling transects were located in the lowest area and an area of slightly higher elevation (Appendix 3). For the Enterprise and Medicine Lodge sites (which are much smaller in size), sampling was located in the area that most accurately represents the typical site vegetation. Because of confusion surrounding the exact location of the Wichita site, no transect was sampled.

Each transect was 120 m long and consisted of 30 1m^2 plots at four meter intervals. Aerial percent cover of each species occurring within a plot was estimated to derive a measure of plant species composition. Species identifications were verified using keys, and all species names conform to nomenclature in the Flora of the Great Plains (Great Plains Flora Association, 1991). The combined cover of bare ground, litter, and water was also estimated. Total cover within a plot could exceed 100% because of overlapping plant canopies. In June, each plot was permanently marked with buried steel so later sampling would be exact. The plots were relocated at subsequent sampling dates with a metal detector.

All plant species found in the wetland mitigation plots were assigned one of five wetland values defined in the 1987 Wetland Delineation Manual (Environmental Lab 1987) and listed in the National List of Plant Species that Occur in Wetlands (Reed 1988):

1) *obligate wetland plants* (OBL) occur almost always (estimated probability > 99%) in wetlands, but occasionally are found in nonwetlands (estimated probability<1%);
2) *facultative wetland plants* (FACW) usually occur in wetlands (estimated probability 67% to 99%), but occasionally are found in nonwetlands (estimated probability 1% to 33%);
3) *facultative plants* (FAC) share an equal likelihood (estimated probability 33% to 67%) of occurring in either wetlands or nonwetlands;
4) *facultative upland plants* (FACU) usually occur in nonwetlands (estimated probability 67% to 99%), but occasionally are found in wetlands (estimated probability 1% to <33%); and
5) *obligate upland plants* (UPL) occur almost always (estimated probability >99%) in nonwetlands.

These categories were used to calculate average wetland values where 1=obligate, 2=facultative wetland, 3=facultative, 4=facultative upland, and 5=upland. Average wetland values and transect species composition by site (Appendix 2) were compiled using Quattro Pro database software (Borland 1993).

Soil Sampling and Analysis

Soil samples were collected from five of the six mitigation sites during the summer of 1996. A back saver hand probe was used to remove soil cores to a depth of 30 cm. Six cores were collected from each site. Visual observation of soil cores were made on site to determine presence of hydric soil indicators (i.e., mottling and ferrous oxide). The cores were then subdivided into two sections consisting of the top 10 cm and the bottom 20 cm. Each core section was placed in plastic bags to reduce moisture loss and packed in ice to slow microbial activity until drying could take place.

Once at the lab the two sections from each soil core were removed from the plastic bags, weighed on a top loading scale, placed in separate paper bags, and left on a drying rack for at least three days. The soil was then ground with a mortar and pestle and hand sieved. Bulk density was determined by drying a 10 g subsample at 105°C. Texture analyses was conducted using the hydrometer method (Day, 1965) and pH was determined on a 1:1 soil solution (McLean, 1965). An additional subsample was pulverized with a "Wig-L-Bug" (Cresant Dental M.G. Co.) for total carbon and nitrogen determination using an autoanalyzer with Dumas combustion (20 mg sample; Carlo Erba NA 1500). All results were expressed on a dry weight basis and are give in Appendix 3.

Hydrologic Investigation Methods

During an initial site visit, surface run off patterns, possible and apparent ground water sources, and manmade discharge structures were noted. Using a U.S.G.S. Topographic Map, tributary area for surface water runoff was determined. Available climatological, hydrological, and surficial geological information was collected and used in a preliminary assessment of groundwater conditions in site vicinities. Additional on-site observations were made during early and late spring and some periods immediately following substantial precipitation events. This verified assumed runoff patterns and amounts. During summer and early fall site visits, dry conditions were observed. Site visits fortunately coincided with a variety of hydrologic conditions which provided more information about overall conditions than available historic data.

RESULTS

Vegetation Results

The results of the vegetation surveys are attached in Appendix 2. These tables show the species, their percent cover, and the average wetland value for each transect. All transects sampled were dominated by wetland vegetation and their wetland values were less than 3.0. The Emporia, Kingman, and Santa Fe sites primarily support moderate to high quality wetland vegetation, especially when compared to the other sites. Generally, these sites are less weedy, with a greater abundance of perennial plant species. These sites also have better establishment of grasses and sedges, which is a regionally desirable trait. The average wetland values of these sites are, for the most part, lower than the other sites. Furthermore, these sites generally have higher species diversity. Unfortunately the Emporia site has some invasion by the undesirable sericea lespedeza (*Lespedeza cuneata*), and the Kingman site has woody encroachment. The Enterprise and Medicine Lodge sites support vegetation that is lower in quality. The plant species in these sites are more weedy, with relatively little perennial cover. Both sites have very high cover of bare ground. The Enterprise site is largely dominated by an annual smartweed (*Polygonum lapathifolium*) and cottonwood saplings. The Medicine Lodge site has transplanted plugs of bulrush (*Scirpus acutus*), which have survived and now comprise the dominant cover of the site. However, the site supports very little additional wetland vegetation, and other species at this site are unplanted weedy species.

Soil Results

All sites had the presence of wetland delineation indicators (see Appendix 2). The Santa Fe, Kingman and Emporia sites had greater amounts of mottling and ferrous oxide (hydric soil indicators) than the Enterprise and Medicine Lodge sites. Each of the five sites had different soil carbon and nitrogen pools. Both carbon and nitrogen were greater in the upper 10cm of the soil cores. As discussed below, the greatest amounts of C and N were found at the more hydric sites and sample locations. The Kingman site, which is the oldest site sampled, had large amounts of carbon and nitrogen in the soil. Enterprise and Emporia had the smallest total carbon and nitrogen pools. The Santa Fe and Medicine Lodge sites have similar carbon pools, but the nitrogen pool at Medicine Lodge is considerably lower resulting in the high carbon to nitrogen ratios. The Medicine Lodge and Enterprise sites had a greater amount of sand comprising the soil texture. Kingman had a more loamy texture, while the remaining two sites were composed of a more heavy clay texture. Bulk density followed soil texture for most sites. However, the sandy conditions at the Enterprise and Medicine Lodge did not allow for the collection of intact cores. Therefore, the estimated bulk density at these two sites does not accurately represent the soil texture conditions. The pH ranged between 5.36 and 7.88 for all sites. The most acid conditions were found at the Santa Fe site and the most basic at Enterprise and Medicine Lodge. The pH and bulk density did not seem to vary greatly with sample location or transect. However, pH became more basic and bulk density increased at the lower sampling depth.

Hydrology Results

At the Enterprise site, the wetland mitigation within the river channel receives limited surface water runoff (from a 0.5 acre watershed), but has a good water supply from riverbank seepage. During periods of high discharge the terrace on which the site is located is subject to inundation. The Emporia site was created by modifying the lower portion of a tributary of Beaver Creek upstream from Plymouth, Kansas. Because this tributary is located on the floodplain for the Cottonwood River, its total drainage area is hard to determine due to local drainage activity plus the effects of the highway and railroad. It does, however, drain almost 2,000 acres and receive an appreciable discharge during precipitation events. From on site observations, most of this run off flows throughout the wetland mitigation and west into Beaver Creek. The groundwater is near the surface and probably contributes to the deeper ponds during the dry season. The Kingman site has a good supply of surface runoff from a 550 acre drainage area to the south and the groundwater table in the area is quite close to the land surface. The retention of surface runoff and depth of water in the wetland is controlled by the two corrugated pipe outlets which have gates composed of two by six boards. The Santa Fe site was designed by a private consulting firm. Observation suggests that water retention at this site is good, but perhaps is high during the early growing season. During heavy precipitation the water depths are larger than desirable and the frog ponds which were designed to dry out to eliminate fish populations have continuously had water in them. The Medicine Lodge site has simple hydrology with runoff from the adjacent 2 acre rest area, which flows into the wetland via a culvert at the east end. This is a good source of water since much of the rest area is surfaced (100% runoff). The mitigation site is configured like a large bathtub with a pipe supplying the water and a restricted outlet. The hydrology is not going to be the determining factor in how well this mitigation achieves the functions of the impacted wetland. Erosion on the steep slopes is already allowing sandy soil to begin to fill the site.

DISCUSSION

The vegetative wetland values of less than 3.0 for all sites indicates a successful start in establishing wetland vegetation. The Kingman, Santa Fe and Emporia sites were superior to Enterprise and Medicine Lodge sites in their abundance and diversity of perennial wetland species. However, the Kingman and Emporia sites contain invasive species, which should be reduced in order to continue the establishment of more favorable vegetation. (As of Fall, 1997, it appears that Kansas Department of Wildlife and Parks is planning further management at the Kingman site, and KDOT staff is now working to control sericea lespedeza at the Emporia site. The high amount of bare ground and abundance of weedy annuals at the Enterprise and Medicine Lodge sites indicate poor vegetation establishment. Furthermore, both sites seem likely to become dominated by one species (i.e., cottonwood at Enterprise and bulrush at Medicine Lodge) which may impede wetland functions in the future. The value of having a diversity of species is that there is greater resistance to pests and disease, drought and other unusual weather patterns.

The evidence of anoxic (oxygen-free) conditions is a good indication of wetland type soils at each of the sites. However, the ability of each of the soils to sustain vegetation and hydrology depends on more than mottles and ferrous oxide. The greater carbon and nitrogen soil contents at the Kingman site, most likely due to the surrounding berm or the age of the site and its conditions prior to 1987, provided one of the best mediums for vegetation and hydrologic conditions. The Santa Fe site, which retained much of the nutrients and organic matter due to the minimal construction disturbance during site establishment, provides good soil conditions for continued wetland hydrology and vegetation development. Emporia's small carbon pools are a reflection of the recent site construction and initial flooding which most likely removed most of the top soil placed on site. The loss of top soil has resulted in crusting on the soil surface. This loss of soil structure makes establishment of good vegetation cover more difficult. The Enterprise site will continue to lose nutrients and organic matter due to leaching and river scouring resulting in only minimal support of plant diversity. The site with the lowest nitrogen pools, Medicine Lodge, had 15 feet of topsoil and subsoil removed in some areas in order to bring the exposed surface closer to the water table thereby meeting the hydrologic delineation criteria. This stripping of the upper soil layers makes for a site with a poor quality soil with a limited ability to support vegetation. An additional concerns about the Medicine Lodge site is that the extremely steep slopes of the site are eroding into the wetland area and will fill part of it over time.

Although inundation may be infrequent at the Enterprise site, the wetland could be destroyed during a flooding event because the soil is highly erosive silt and the wetland is located within the floodflow channel. Because the Emporia site is frequently subject to high flow rates, development of the wetland (as planned) may be retarded. The discharge from the Kingman wetland is controlled, and therefore some form of a management plan should be developed based on management objectives (which appear to now occurring, personal communication with Troy Davis, KDW&P). The high water levels occurring during heavy precipitation at the Santa Fe site could potentially impact the wetland structure. Fortunately, this site is intensively monitored and a water control structure has been installed to manage the water levels. However, without management objectives and an associated management plan, the control structure will accomplish nothing. The Kansas Biological Survey will be writing a management plan for the site during 1998.

These five wetland mitigation projects include considerable variation in size of the sites and tributary watersheds, and it is notable that the two smaller wetlands (Enterprise and Medicine Lodge) are less successful than the three larger sites (Emporia, Kingman, and Santa Fe). While a study of only five mitigation projects does not allow strong conclusions on the relationship of size and success, it would be advisable to make special consideration in planning and management based on the size of the mitigation. Because wetlands are complex ecosystems, the success of constructed or created wetlands depends on many factors, including soils, land forms, adjacent land use and vegetation.

Careful planning and management are the keys to wetland mitigation success, including provision and maintenance of a proper hydrologic budget. Areal size affects the hydrologic response of a watershed, and will impact the hydrologic budget of a mitigated wetland. An understanding of hydrology calls attention to two hydrologic response characteristics of a watershed based on areal size. First, hydrologic inputs (usually precipitation) and outputs (usually runoff) behave differently in watersheds of various sizes. For small watersheds, the extreme variation in magnitude and temporal and spatial distribution of the hydrologic inputs are passed through to the hydrologic outputs with little attenuation. In large watersheds the variation of inputs are reduced by a filtering effect of basin scale and the output (runoff) is less variable. Second, physical changes in the watershed, either natural or man-made, can have a strong effect on the input/output response of a small watershed, whereas in larger watersheds these impacts are mollified by basin scale and the hydrologic response is more stable.

These two size related characteristics are important because an understanding of them can reduce the amount of post-establishment management. Small wetland projects, which are expected to function on their own with little or no management, can be drastically impacted by changes such as alteration of a drainage ditch or plugging a small culvert, which would have a minimal effect on a large watershed. For the extreme variations in the hydrologic parameters of a wetland, the issue is more debatable. Larger and more diverse wetlands appear to be stimulated by variation of the hydrologic inputs. For extreme variations (extended floods and droughts) certain components of the structure of the wetland ecosystem are going to be adversely affected. Therefore a larger and more diverse wetland may be able to tolerate these variations, which could prove destructive to a smaller one. Under conditions of minimal management, areal size of wetland mitigation projects may be a factor in the success of establishment and survivability of a wetland. However, with proper planning, management and maintenance of the proper hydrologic budget, small, even tiny wetlands can be successful.

CONCLUSION

These mitigation sites should all be classified as wetlands based on the delineation techniques established by the U.S. Army Corps of Engineers. This was expected, since the guidelines must be followed by Kansas Department of Transportation upon establishment of the mitigations. However, the delineation procedures give only a minimal amount of information about current site conditions. By taking a more scientific look at the site's vegetation, soils and hydrology we were better able to determine their potential for continued functioning and development as wetlands. While all sites were highly varied, it is likely that those sites with the greatest diversity of vegetation, highest soil quality and best hydrology will continue to develop as wetlands in the future. The three mitigations most likely achieve the goal of replacement wetlands are the Santa Fe, Kingman, and Emporia sites. In part these three sites will continue to succeed as wetlands due to prior planning and continued follow up monitoring.

Unfortunately, records for most of the mitigations are unclear about finances and design implementation. Future wetland mitigations would benefit from improved record keeping on planning and construction. It would be very useful to know how much it cost to build these sites. Furthermore, the goals for each project should be carefully determined and clearly stated. Pre-construction planning and assessment should occur based on these goals. These improvements would be highly beneficial to improving the cost-effectiveness of Kansas wetland mitigations.

ACKNOWLEDGMENTS

This project was made possible with funding through the K-Trans Program from the Kansas Department of Transportation and the federal Mid-America Transportation Center in Lincoln, Nebraska. The assistance of Ken Herin and Mike Fletcher, Kansas Department of Transportation, is greatly appreciated for help related to previous work at these sites by KDOT. We are indebted for the help that we received in the field from: Jim Minnerath, U.S. Fish and Wildlife Service; Shaun Vickers, USDA, Natural Resource Conservation Service; and from several University of Kansas graduate students and staff--Todd Aschenbach, Caleb Morse, Shari Wilson, and Hillary Loring and Derek VanSchmus.

LITERATURE CITED

Borland International Inc. 1993. Quattro Pro for Windows.

Day, P.R. 1965. Particle fractionation and particle size analysis. Pages 545-567 In: C.A. Black, D.D. Evans, J.L. White, L.E. Ensminger, and F.E. Clark, editors, Methods of Soil Analysis. Part 1 Agronomy 9. American Society of Agronomists, Madison, Wisconsin, USA.

Environmental Lab. 1987. "Corps of Engineers Wetlands Delineation Manual," Technical Report Y-87-1, U.S. Army Corps of Engineers Waterways Experiment Station, Vicksburg, Miss.

Hammer, D.A. 1992. Creating Freshwater Wetlands, Lewis Publishers, Inc. Chelsea, Mich., 298p.

McLean, E.O. 1965. Soil pH and Lime Requirements. In: C.A. Black, D.D. Evans, J.L. White, L.E. Ensminger, and F.E. Clark, editors, Methods of Soil Analysis. Part 2 Agronomy 9. American Society of Agronomists, Madison, Wisconsin, USA.

Mitsch, W.J. and J.G. Gosselink. 1993. Wetlands. Van Nostrand and Reinhold, New York, NY.

Reed, P.B., Jr. 1988. National List of Plant Species that Occur in Wetlands: National Summary. U.S. Fish Wild. Surv. Biol. Rep. 88(24). 244 pp.

Improving the Success of Wetland Mitigation in Kansas

INTRODUCTION

Because the creation of wetlands is a new phenomenon, there are few guidelines on how to proceed. The lack of research and data on creating, restoring and enhancing wetlands makes the task of achieving successful mitigations even more difficult. Furthermore, because most engineers have little training in ecology and few ecologists are experienced in engineering design, failure to meet mitigation goals and objectives is often the end result.

In recent years, because of federal funding and increased public awareness, greater attention has been focused on trying to provide guidelines on how to achieve a successful mitigation. In 1996 the American Association of State Highway and Transportation Officials in cooperation with the Federal Highway Administration, produced a manual titled "Guidelines for the Development of Wetland Replacement Areas" (NCHRP Report 379, 1996). This manual is a comprehensive guide to wetland mitigation including current information and data on the process of wetland replacement.

The NCHRP report is highly recommended for those involved in mitigation research and construction. However, because the manual must address all types of wetland creation, it is fairly broad in its scope. Wetland mitigations from state to state, not to mention from site to site, are unique, and trying to glean the appropriate information from a large manual is a difficult task. The objective of this report is to provide a more narrowly focused set of guidelines and suggestions based on the available data and information, in order to improve the success of wetland mitigations in the state of Kansas.

Step 1: Setting Goals and Objectives

1.1 *Assessment of the Impacted Wetland*

Eliminating or reducing the impacts on a wetland should be the first priority in setting goals and objectives for any project. If after an investigation of alternatives, no other possibility exists but to impact a wetland area, the next step is a study of all major wetland functions and values. Wetland functions include the physical, chemical and biological processes of the ecosystem. For example sediment stabilization, nutrient cycling, fish and wildlife habitat, and water quality. Wetland values are goods and services that benefit human needs including the functions mentioned above, recreation, and green space. Accurate assessment of these functions and values is critical and may require professional evaluation. Depending on the type of wetland, needed expertise may include: terrestrial and wetland ecology, surface and ground water hydrology, soils, botany, and geology.

A number of assessment techniques and tools are available for determining function and values. However, they range widely in cost and time expenditures, as well as type of information provided. A comprehensive list of the techniques can be found in the NCHRP Report (Table 2, 1996). Other sources for information on techniques may be found in academic journals, government sponsored literature, and previous mitigation assessments by other agencies. Agencies that may be able to provide expertise and information on available assessment tools are: the Natural Resource Conservation Service (NRCS), Kansas Biological Survey (KBS), U.S. Fish and Wildlife Service (FWS), Environmental Protection Agency (EPA), and environmental consulting firms. The more familiar the wetland research team is with the selected techniques and the wetland type, the less time and money it will take for an accurate investigation.

1.2 *Deciding on the Type of Mitigation*

After finishing the wetland assessment process, the agencies involved in the project must decide on a type of mitigation. Specifically, the agency must determine if an in-kind or out-of-kind replacement is more appropriate for their situation. An in-kind wetland replacement, which is usually preferred, is one in which the goal is to duplicate the functions, values, and species found in the impacted wetland in the mitigation. While an out-of-kind replacement would entail a mitigation covering the lost acreage, but with differences in functions, values, and species than the impacted wetland. Once a decision is made between an in-kind or out-of-kind replacement there are three basic compensatory types to consider: restoration, enhancement, or creation.

1.2-1 Restoration: Restoration refers to the reestablishment of a degraded historic wetland. Disturbance of the historic wetland may have been the result of man made or natural events. If the site contains the necessary soil structure, restoration may be simply a matter of returning hydrology to the area. One benefit of restoration is that wetland functions may be established with low effort and cost, and a greater likelihood of success. The drawbacks are that often there are few, if any, preexisting wetlands near the project site, requiring the selection of a distant site. In general, greater distance means greater equipment, personnel time, and cost. Also if disturbance is severe, restoring the site may require the reestablishment of most of the lost wetland functions.

1.2-2 Enhancement: Enhancement refers to improving functions and values of an existing wetland. An example of this would be to increase productivity or habitat by changing topographic elevations in order to increase water retention in the area. However, tradeoffs are often the case in enhancement, because changes that are beneficial for one species are often detrimental to others. Enhancement is often less time consuming and costly since wetland functions are already present and improvement involves modification of an existing environmental parameter. However, when taken to extremes enhancement will result in an exchange of wetland types, rather then the goal of functional wetland improvement. An example of this would be a proposed enhancement involving increasing the depth and duration of the water level in a wetland. The increased water level would considerably alter the habitat by changing the plant species composition and the type of animals capable of using the area. Changes of this type are not always suitable and do not necessarily equate with a better or more enhanced wetland. Of course another problem with enhancement is that improvements made to a wetland may not be a fair exchange for the loss of an existing one.

1.2-3 Creation: The final option is creation of a new wetland. Creation usually entails the removal of upland soils to promote establishment of the necessary hydrology and soils to support wetland plant and animal species. Establishing the correct elevation and available water are critical in the establishment of these new wetlands. This type of mitigation is commonly associated with dredge and fill permits. The benefit to the agency is the low cost of land and abundance of available sites. However, because no previous wetland existed on these upland sites, establishment of functions and values are extremely difficult to achieve and take long periods of time and maintenance for successful establishment to occur.

Step 2: Selection of the Mitigation Site

2.1 *Site Criteria*

Site selection for the mitigation is the next step in the process. The type of mitigation and goals set forth will drive the selection of a site. Other considerations will include any permit stipulations that were mandated by other outside agencies, as well as, cost and ease of development. One way of reducing the time and cost involved is to look for sites that are close to the actual construction area, and close to the impacted wetlands. Another way to keep costs down and improve the success of a mitigation is to select a site that requires minimal engineering in order to establish or improve selected functions and values.

Ideally, the site of the replacement mitigation should be on-site rather than off-site. On-site mitigations are in the same locale or ecosystem of the impacted site. This usually entails restoring or creating the replacement wetland next to, or contiguous with, the impacted wetland. Unfortunately this type of on-site replacement is not always available, in which case the replacement wetland must be located off-site. Preferably the site should remain in the same watershed even if it cannot be placed next to the impacted wetland. An example of this type of mitigation would be the Santa Fe mitigation for the South Lawrence Trafficway. (Note: a review of this site and other KDOT wetland mitigations is available from KBS). The site is not directly connected to the wetland to be impacted but is adjacent to it and originally of the same ecosystem type. This type of on-site mitigation provides an ideal area for a replacement wetland because of ease of access and a nearby source for plant and animal species.

2.2 *Where to Find Help*

There are numerous sources of information for helping in the selection process. The Natural Resource Conservation Service can provide aerial photographs of the surrounding areas which may help in locating promising habitat or an historic wetland site. The U.S. Fish and Wildlife Service has National Wetland Inventory (NWI) maps which can be used to locate places that the government considers a wetland. However, recent studies of these maps indicate that over 50% of potential wetlands are not included on these maps. Using the NRCS soil surveys can help to locate possible wetland or hydric soil areas that are not found on the NWI maps. If a wetland area cannot be located, topography maps can provide insight into areas which may have the necessary hydrology given a minimal amount of engineering. Ownership and tax maps will be necessary for determining acreage, ownership, land use and land value. Other potential sources of information and data are: the KBS, EPA, local universities and environmental consulting firms.

2.3 *Survey of Potential Sites*

Once potential sites have been selected, the area must be surveyed to determine what type of changes will need to be made in order to achieve the goals and objectives of the mitigation. A team consisting of wetland and engineering specialists would be the best combination for conducting the survey. The initial review of the sites should be a quick assessment to eliminate those sites that are not good prospects for the mitigation. Items that might negate the use of a particular site are: insufficient hydrology, exceptional amount of engineering required to achieve desired goals, potential for influx of outside pollution (i.e., road runoff into site), presence of utilities or hazardous waste, presence of another important habitat type (i.e., native prairie, primary forest or riparian areas), insufficient land for the replacement wetland, and prohibitive purchase prices for the land.

Final site selection should be based on a more in-depth review of the sites vegetation, hydrology and soil. The site should be able to provide the functions and values set forth under the mitigation objectives and goals. This means that the site should show the potential for having sufficient hydrology during the growing season, so that the water is available for the selected plant species when needed. In order to determine these aspects, the relationship of the sites hydrologic position within the watershed must be established. Furthermore, it will be important to calculate a baseline for surface elevations and fluctuations. There should also be evidence of the correct soil type. Good indicators of this would be a hydric soil designation, presence of a clay lens, heavy clay texture, slow percolation, and an indication of past anoxic conditions. Anoxic conditions generally occur during a flooding event where oxygen levels become extremely low. Indicators of this would be mottling of the soil, especially around plant root systems and a sulfurous rotting smell. These factors can be established by a characterization of a few soil cores from within the site. Another factor to consider when determining an acceptable site is the presence of benchmark wetland vegetation. The presence of these benchmark plant species, such as those listed in Table 2, can give clues to seasonal water level changes and help reduce the need for extensive hydrological monitoring by establishing the elevations needed to support the desired wetland community. By getting botanical help from KBS and Kansas State University in determining the presence of these key parameters the survey team can help insure that replacement wetland construction is feasible as well as cost effective.

Step 3: Creating Replacement Wetlands

3.1 *Design Plans*

The design plans should remain as simple as possible, but provide the necessary information for implementation of the mitigation. The plans should include steps to be taken for isolating the mitigation from possible sources of disturbance and pollution including trash, road runoff, and erosion from nearby development. Criteria should also be set for hydrology, soils, and vegetation based on the desired functions and site characteristics determined in Steps 1 and 2.

3.1-1 Hydrology: The design plans should clearly indicate the expected water source and levels. The levels and timing of available water will be directly tied to the type of plant community type selected for the mitigation (i.e., in-kind vs. out-of-kind). If any water control structures are necessary, it should be stated if it will be an active or passive mechanism. A passive system is preferable in that cost is held down and there is little need for outside management. However, an active control structure may be the best means of providing the necessary seasonal inundation of water, but would require extra management and monitoring plans and increased cost. The establishment of hydrology should require only minimal earthwork if the site selection was done appropriately. The best plans would require the creation of a simple berm or gentle surrounding slopes between 1 and 3 percent in grade. A site which has a design plan requiring steeper slopes to provide some semblance of hydrology is a poor choice because their will be little shallow water and possible future erosion. In these cases an effort should be made to find an alternative mitigation location.

3.1-2 Soils: The plans should stipulate any soil removal or additions that will occur at the site and what will be done with the soil. If the project design calls for the removal of soil for fill, then there must be some plan for replacement of the lost organic matter or nutrients to the site. The best choice would be to stockpile the soil from the impacted wetland. This soil will already have the proper structure and texture for wetland establishment. If not stockpiled for long periods of time, the soil will retain much of the seed bank and microorganisms found at the original site. However, if bringing in soil from the impacted wetland is not a feasible option, the design should include stockpiling of the topsoil at the constructed mitigation and mixing it with soils from another wetland in the area.

The addition of fertilizer to the area is not recommended as a means of compensating for loss of top soil. Subsoil is often too heavy in texture and will not provide the necessary structure for vegetative establishment. The heavy clay will shrink and swell with water availability destroying the tender root system of young shoots. Also, the subsoil will often crust over on the surface making it impenetrable to seeds. Furthermore, the addition of fertilizer will likely stimulate the weed seed bank to grow vigorously, rather than the more desirable wetland seed bank.

3.1-3 Vegetation: Finally a plan for establishment of the appropriate vegetation is necessary for success of the mitigation. The design plan should include mention of any special considerations such as: area to be vegetated and its hydrology, planting time tables, preconditioning of materials (preadapting vegetation or seed), selected vegetation, and method of establishment. The type of vegetation and its establishment method will depend on the type of community to be established.

Vegetation should be selected which is best suited for the different available water depths at the mitigation site. Plant material could come from a number of sources: a seed bank in wetland soils, adult vegetation chunks from the impacted site or a nearby reference wetland, or seed or vegetation from a supplier. Seed banking or transportation of adult vegetation is the ideal choice for an in-kind replacement. However, it does require equipment and money to move the needed soil and vegetation to the site. Also, if the mitigation is being constructed prior to the destruction of the existing wetland area, such as in the case of the Santa Fe mitigation for the South Lawrence Trafficway, then an alternative source for the materials will need to be found. One possible source for vegetative materials could be from a selected reference wetland. A reference wetland is a site having similar functions and values, habitat, hydrology, and soil as the proposed mitigation. This will require that ownership and permission for removal of any material be established. If a nearby source of soil or vegetative material is not available, or if an out-of-kind replacement is the goal, seed and plant material can be purchased. Purchase of plant species which are native to the area is strongly recommended. However, there are few suppliers for these materials in the state of Kansas. If nursery stock is not available from a local agency, material would have to be purchased from outside the state. Often this type of material is not adapted to soil and climate conditions of Kansas making establishment difficult. Another problem to consider when seeding is its tendency to washout of the mitigation site when flooding occurs. Because establishment and purchase of the necessary vegetative material is difficult, the need to preserve any available wetland seed bank is of immense value to the mitigation.

Step 4: Monitoring and Management

4.1 *Maintaining Goals and Objectives*

While the design of the mitigation should be as low-maintenance as possible, upon completion of the project there will be some expected and unexpected management that will need to take place in the future. A monitoring plan should be written up for the implementation of anticipated maintenance and site surveys can be conducted on a routine basis. The three areas of greatest concern for monitoring and management are 1) soils - stabilization and erosion 2) vegetation - sustaining the designed habitat and 3) hydrology - adjustment of water flow and availability.

4.1-1 Hydrology: The hydrology will need to be maintained as set forth by the project goals and objectives. This means that if an active water control structure is present, it will need to be cleaned, repaired, and operated at set time periods to insure water flow and availability when desired. Other management that will most likely need to take place is the removal of unwanted animal structures, such as those constructed by beavers, and the building of drainage ditches for a site that is not draining properly.

4.1-2 Soils: From time to time the weather, humans or animals may result in the instability of soil, particularly in sloping areas. Gullies from water erosion will need to be mended either by regrading the slope, or by lining the eroded site with stones to reduce water flow impacts to the soil. Vandalism by animals or humans can be reduced by providing an exclusionary device and warning signs.

4.1-3 Vegetation: Sustaining the habitat is a more involved process and will require a more rigorous monitoring than the soil or hydrology, especially in the initial stages of development. Management of the vegetation may include things such as burning or mowing to eliminate invasive species and improve nutrient conditions, and replanting or reseeding areas of lost vegetation, watering during droughty time periods in order maintain particular species, and controlling disease and insects.

A continuous record of all monitoring trips, management practices, and expenses should be kept for each mitigation site for future reference. Photographs are also recommended as a good technique for documentation of progress. Included in the management and monitoring plan should be a list of people and/or agencies involved in the process. It is highly recommended that an effort be made to bring in individuals with an interest in seeing the wetland mitigation succeed. Including students from nearby universities and colleges to help with this part of the mitigation would reduce the time and cost to the agency. Participation by these types of groups could also provide a means of monitoring past the stipulated five years set forth by the U.S. Army Corps of Engineers increasing the odds of success of the mitigation.

The Mitigation Process

1. When possible avoid any and all impacts to existing wetlands.

2. If it is impossible to avoid impacts then the project objectives should be to minimize impact to the existing wetland.

3. Prior to impact, an assessment of the area to be impacted should be conducted. All potentially lost wetland functions and values should be noted.

4. In consultation with other agencies, goals and objectives of the mitigation are decided - including type of wetland (enhanced vs. restored vs. created, in-kind vs. out-of-kind, on-site vs. off-site) and functions and values necessary to achieving success.

5. A search for potential mitigation sites should be conducted using aerial photographs, soil surveys, topographic maps and other information sources.

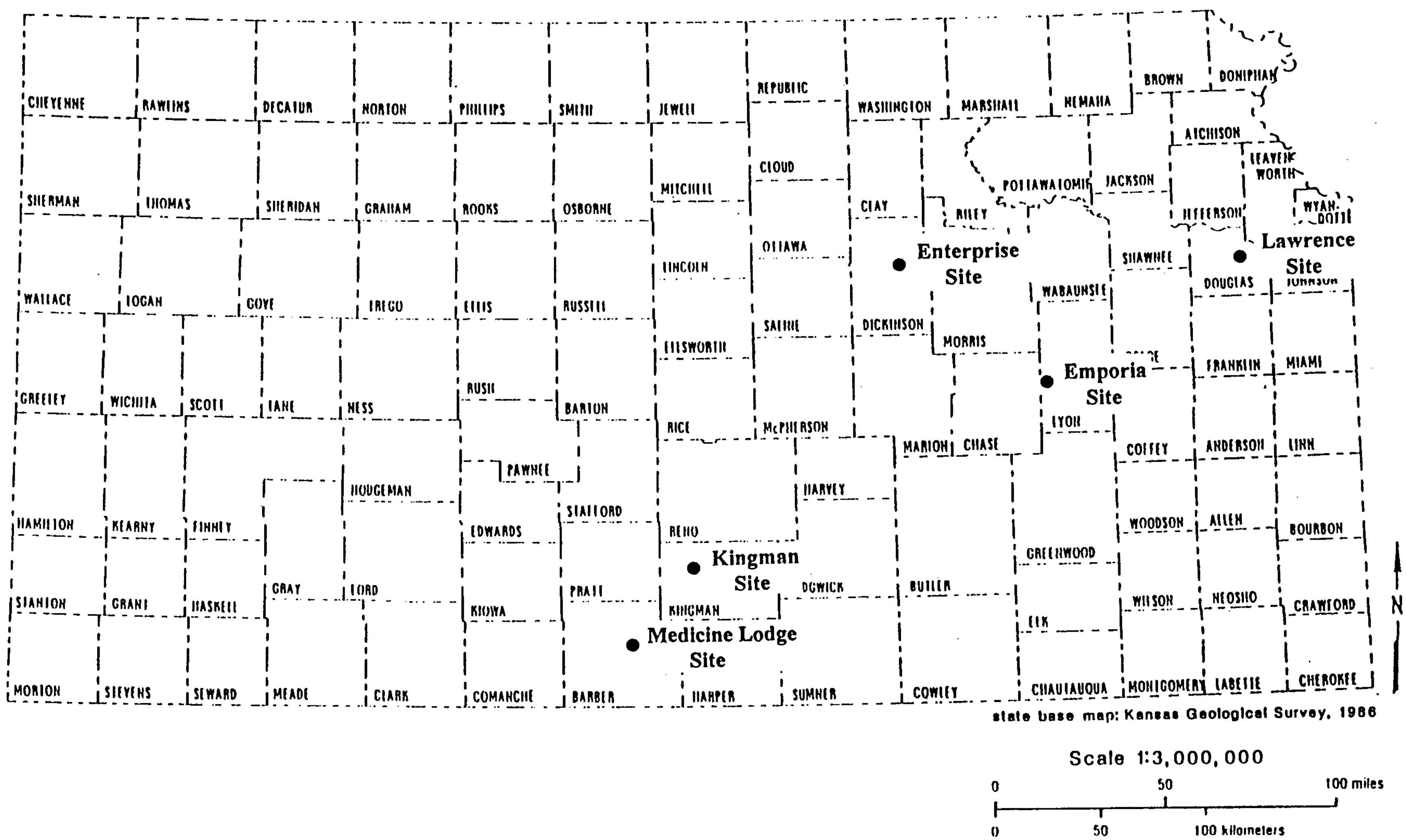
6. A team of specialists survey the selected sites to determine acceptability of hydrologic, soil, and vegetative conditions.

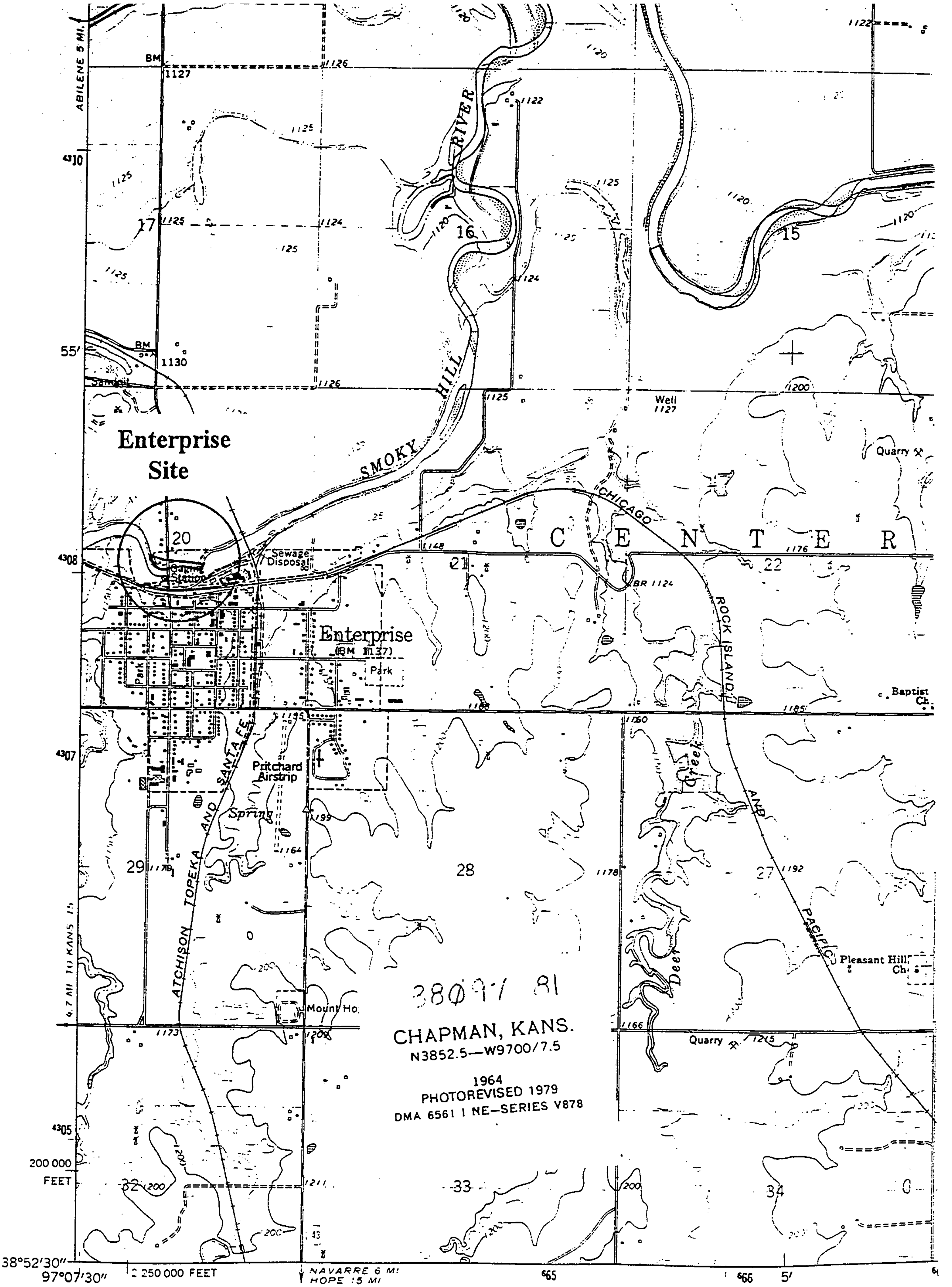
7. Design plans for the selected site should be drawn up. The plans should include any construction needed to achieve hydrologic conditions, movement of soil to or from the site, and source and steps required for vegetative establishment.

8. A monitoring and management plan for the next five years should be developed to insure the continued progress and eventual success of the mitigation.

Appendix 1

KDOT Mitigation Sites

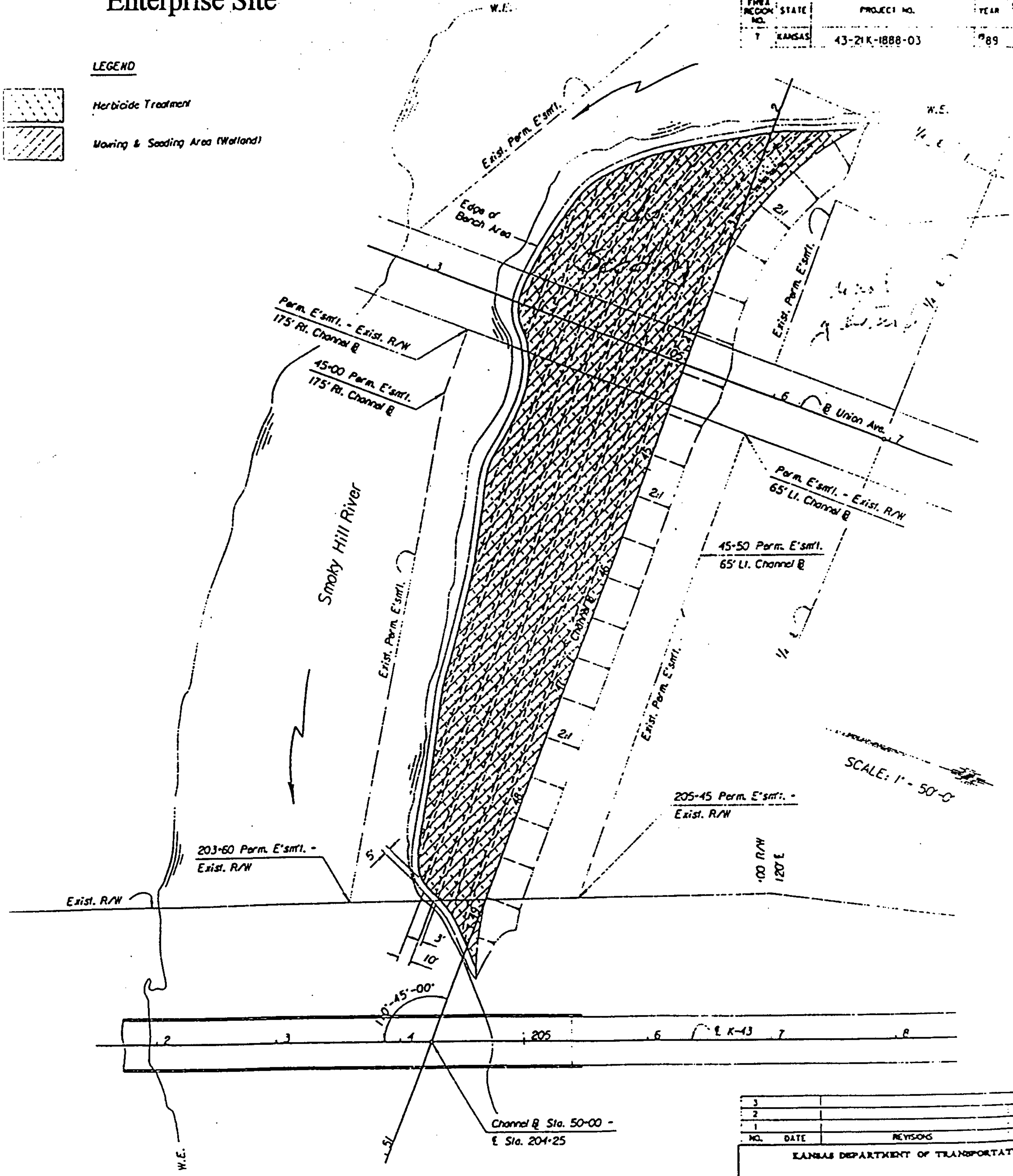




Enterprise
Site
Enterprise
SMOKY HILL RIVER
CENTER
CHICAGO ROCK ISLAND AND PACIFIC
ATCHISON TOPEKA AND SANTA FE
Sewage Disposal
Gaging Station
Pritchard Airstrip
Spring
Park
Quarry
Baptist Ch.
Pleasant Hill Ch
Mount Ho
Deer Creek
Well 1127
Sandpit
ABILENE 5 MI.
4.7 MI TO KANS 15
NAVARRE 6 MI
HOPE 15 MI
CHAPMAN, KANS.
N3852.5—W9700/7.5
1964
PHOTOREVISED 1979
DMA 6561 I NE—SERIES V878
38°52′30″
97°07′30″
250 000 FEET
200 000 FEET

Enterprise Site

FHWA REGION NO.	STATE	PROJECT NO.	YEAR	SHEET NO.	TOTAL SHEETS
7	KANSAS	43-21K-1888-03	'89	4	4



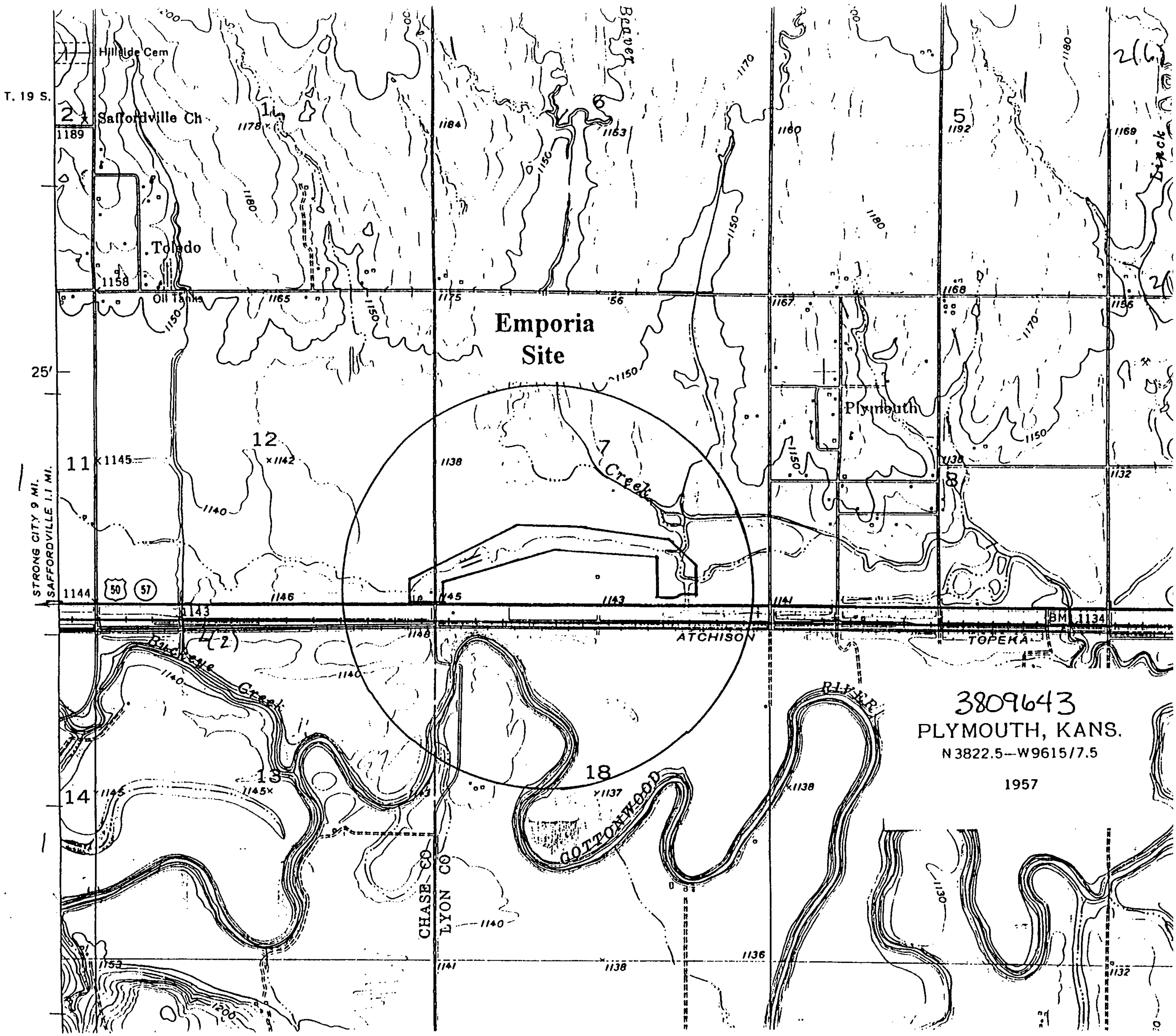
PLAN

NO.	DATE	REVISIONS	BY	APP
3				
2				
1				

KANSAS DEPARTMENT OF TRANSPORTATION

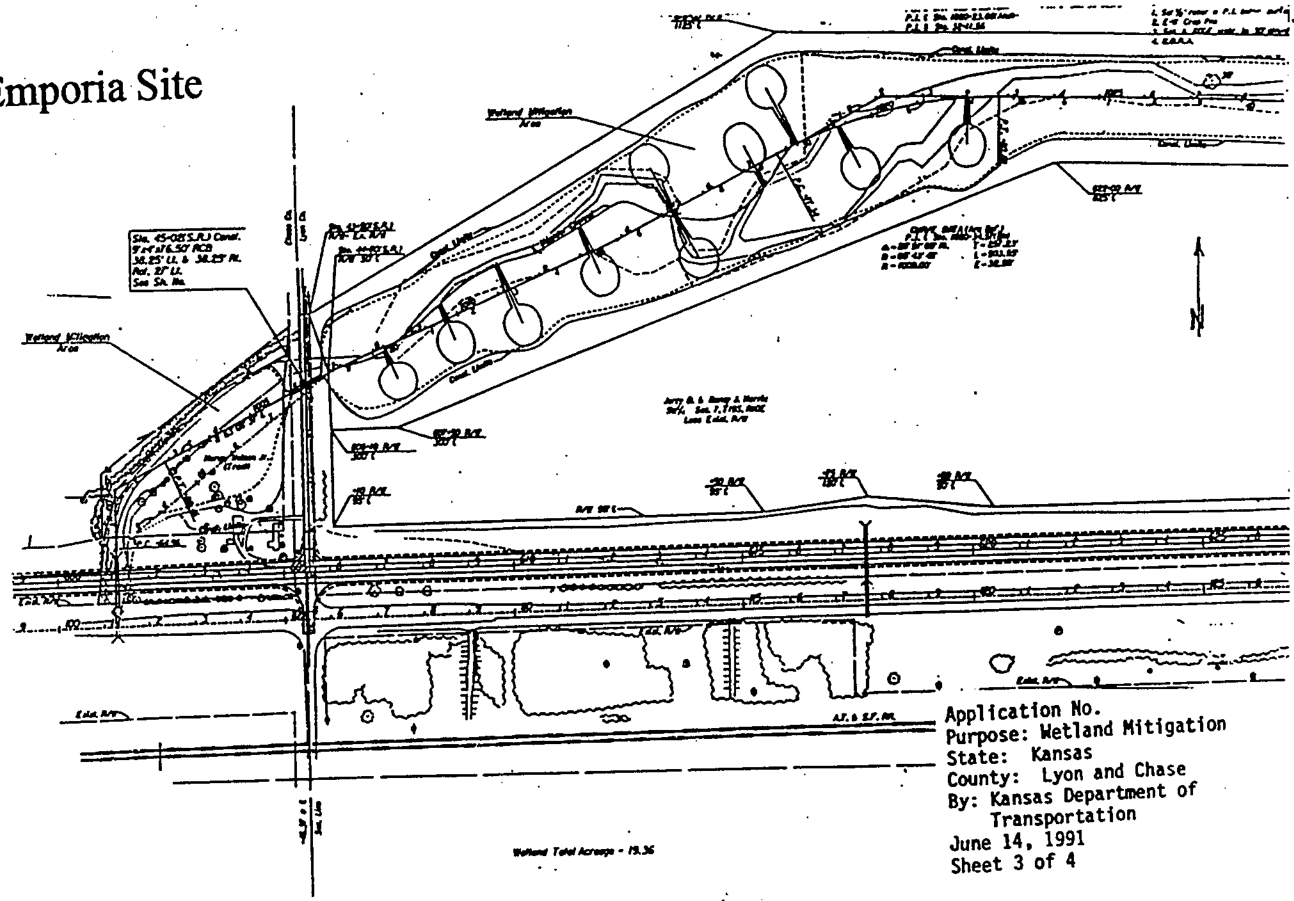
WETLAND SEEDING PLAN
GENERAL NOTE

Proj. No. 43-21K-1888-03 Dickinson C

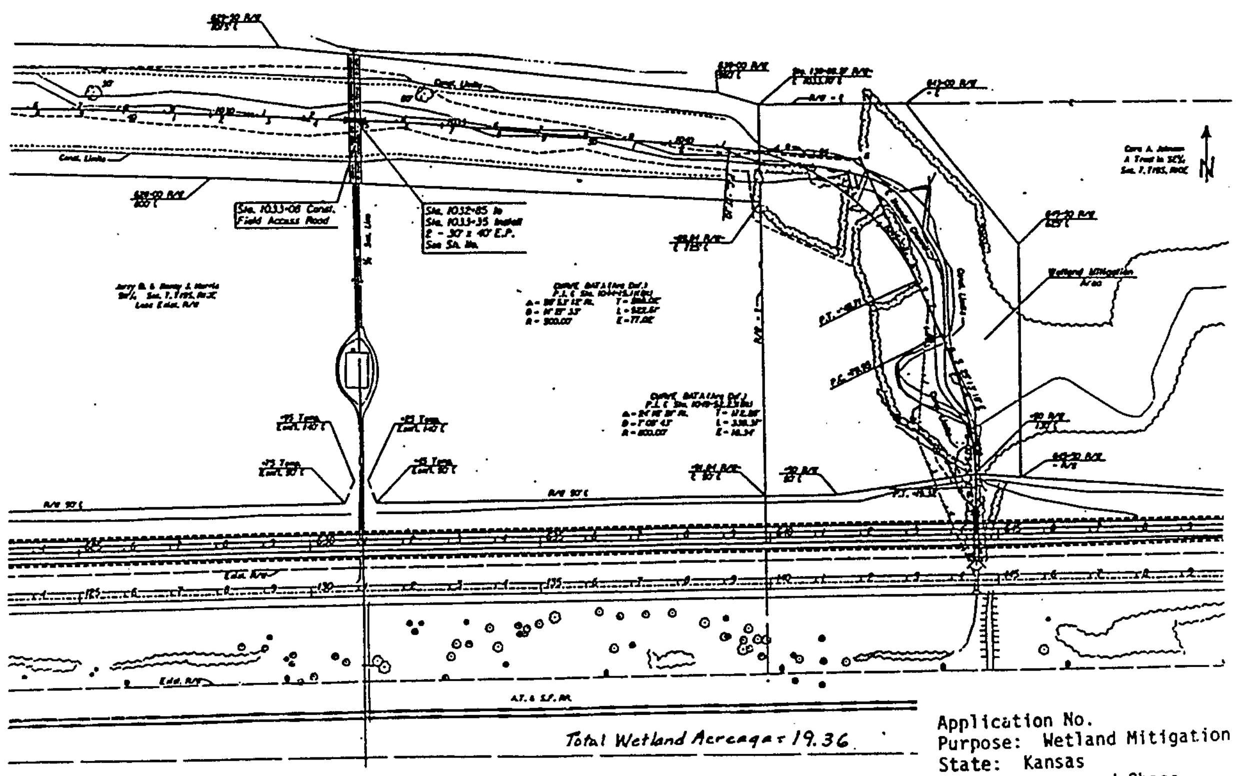


Emporia
Site
3809643
PLYMOUTH, KANS.
N 3822.5—W9615/7.5
1957
T. 19 S.
25'
STRONG CITY 9 MI.
SAFFORDVILLE 1.1 MI.
Hillside Cem
Saffordville Ch
Toledo
Oil Tanks
Plymouth
Beaver
Creek
ATCHISON
TOPEKA
COTTONWOOD
RIVER
CHASE CO
LYON CO
BM 1134

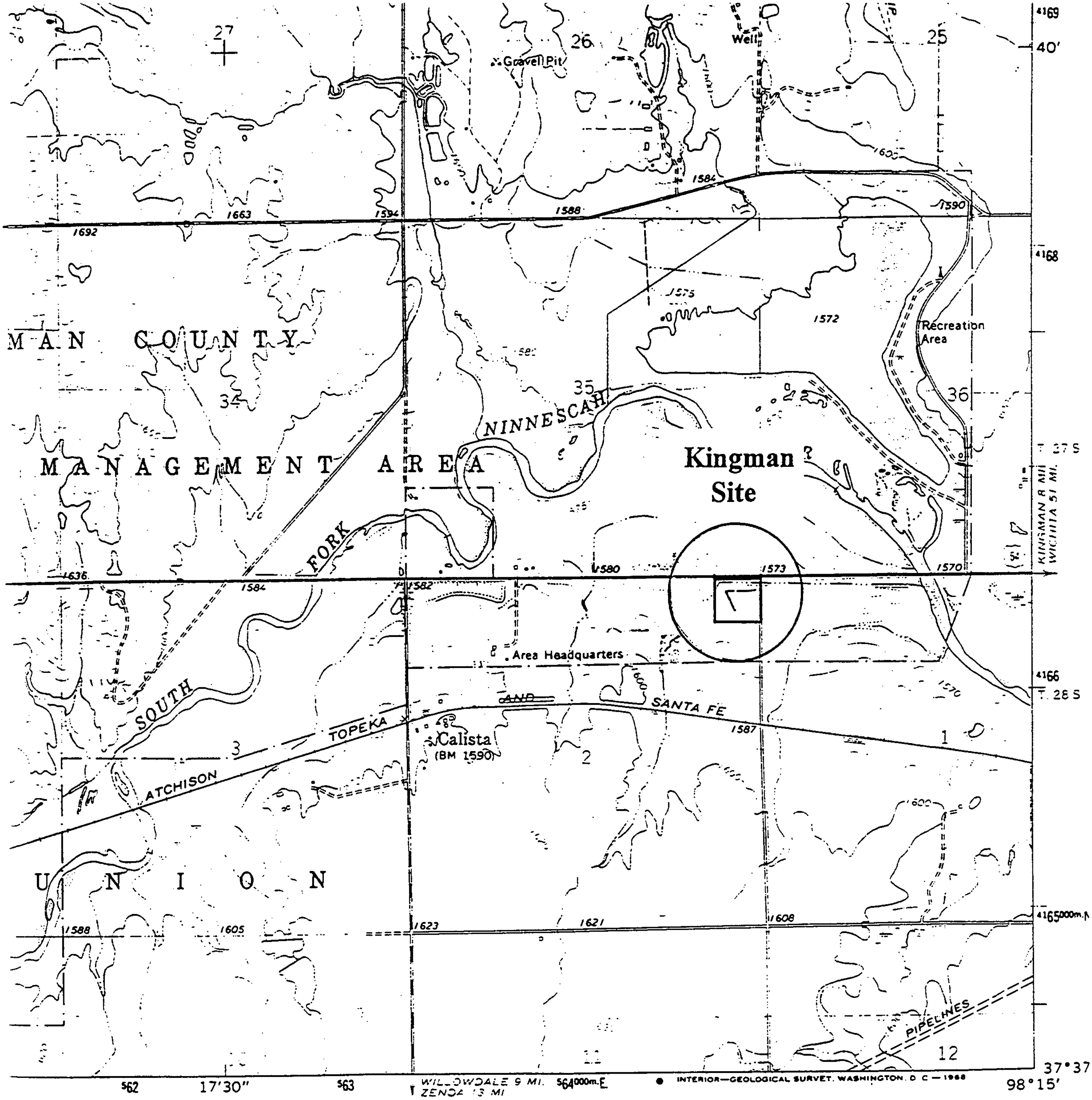
Emporia Site



Application No.
Purpose: Wetland Mitigation
State: Kansas
County: Lyon and Chase
By: Kansas Department of Transportation
June 14, 1991
Sheet 3 of 4



Application No.
Purpose: Wetland Mitigation
State: Kansas
County: Lyon and Chase
By: Kansas Department of Transportation
June 14, 1991
Sheet 4 of 4



1 MILE

6000 7000 FEET

1 KILOMETER

ROAD CLASSIFICATION

Heavy-duty .... Light-duty ....

Medium-duty .... Unimproved dirt ========

U. S. Route

KANSAS

QUADRANGLE LOCATION

DARDS
R WASHINGTON, D. C. 20242
ANSAS 66044
ABLE ON REQUEST

3769063

PENALOSA, KANS.
N3737.5—W9815/7.5

1967

AMS 6359 III NE—SERIES V878

Kingman Site

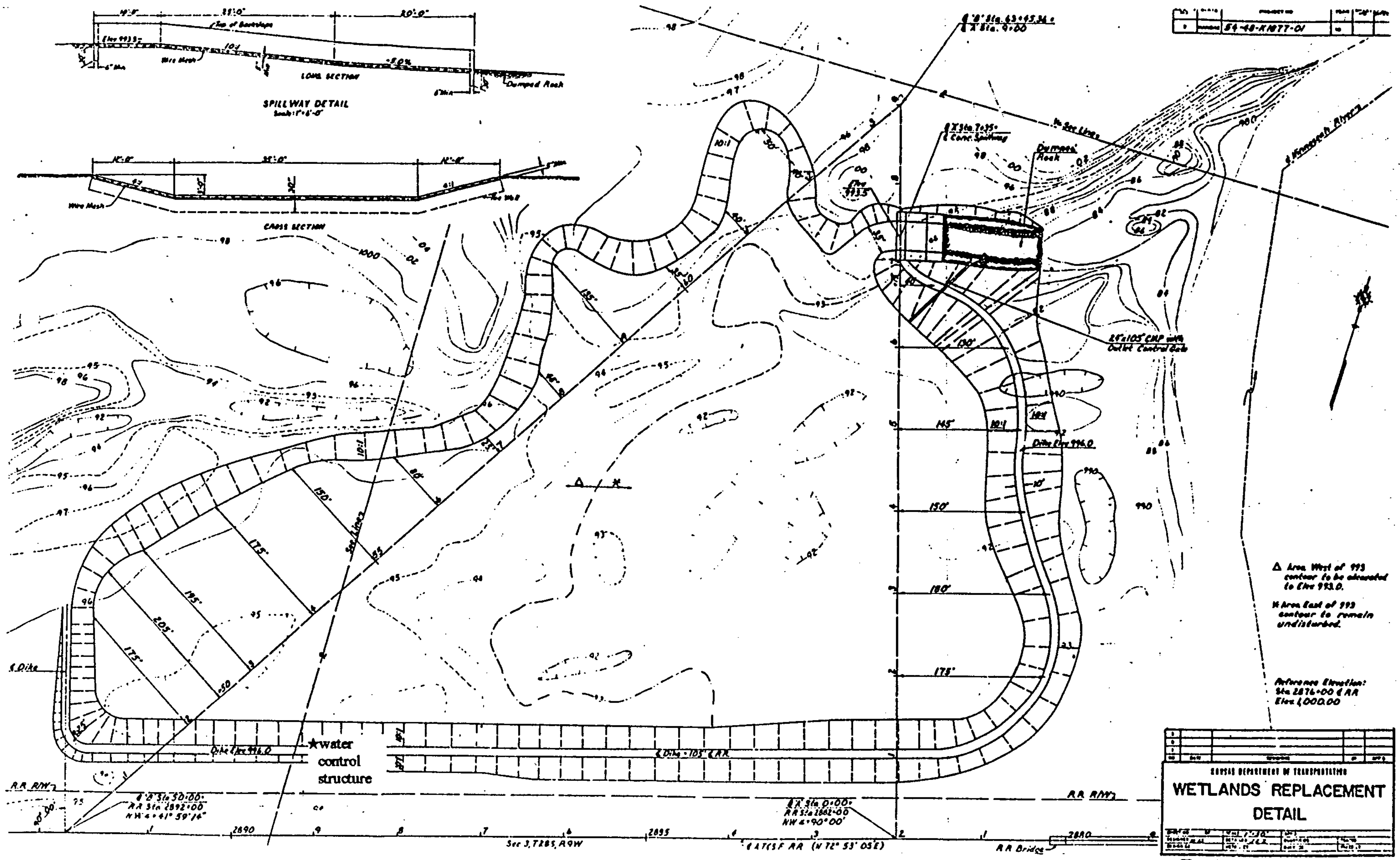
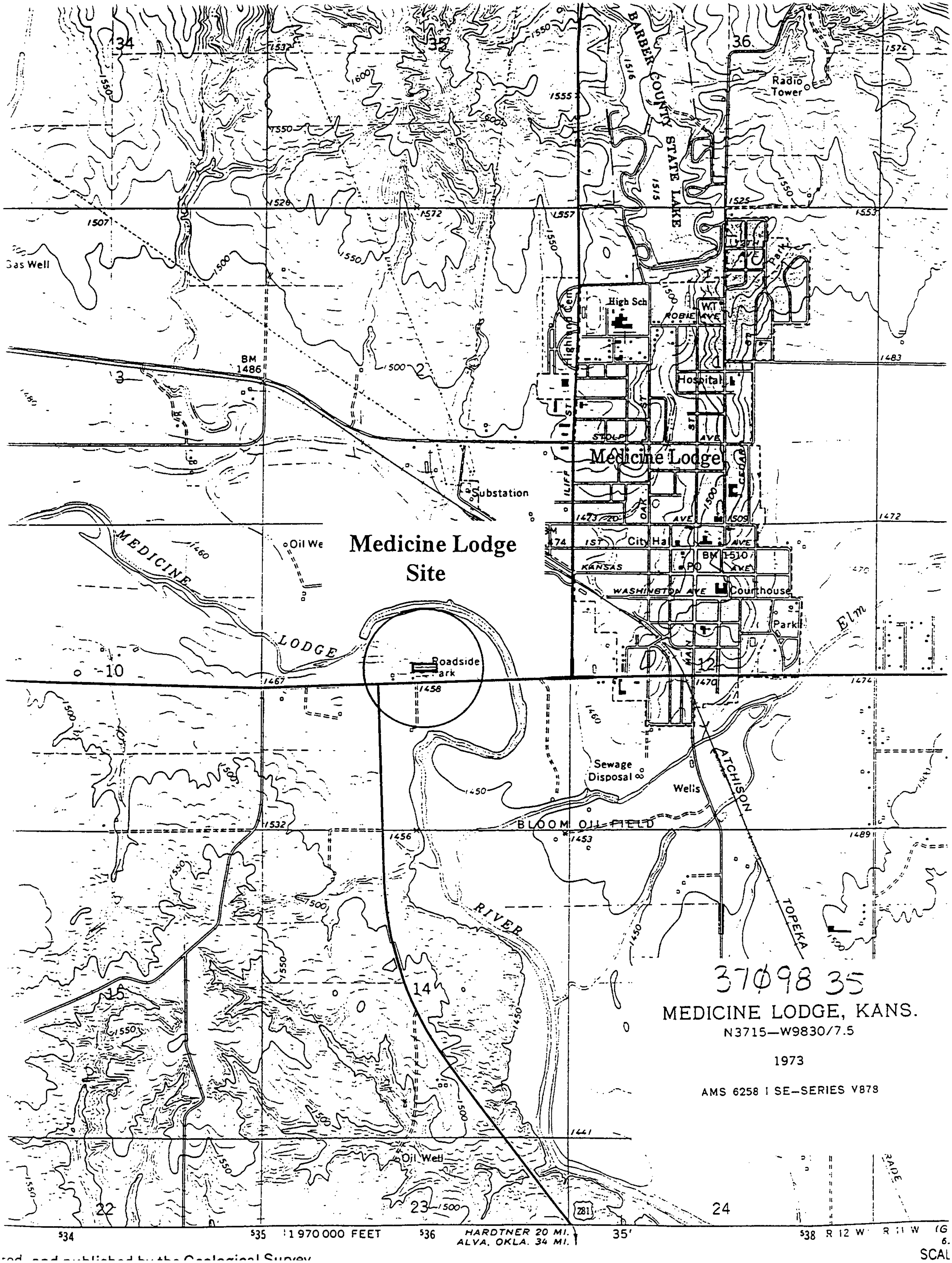
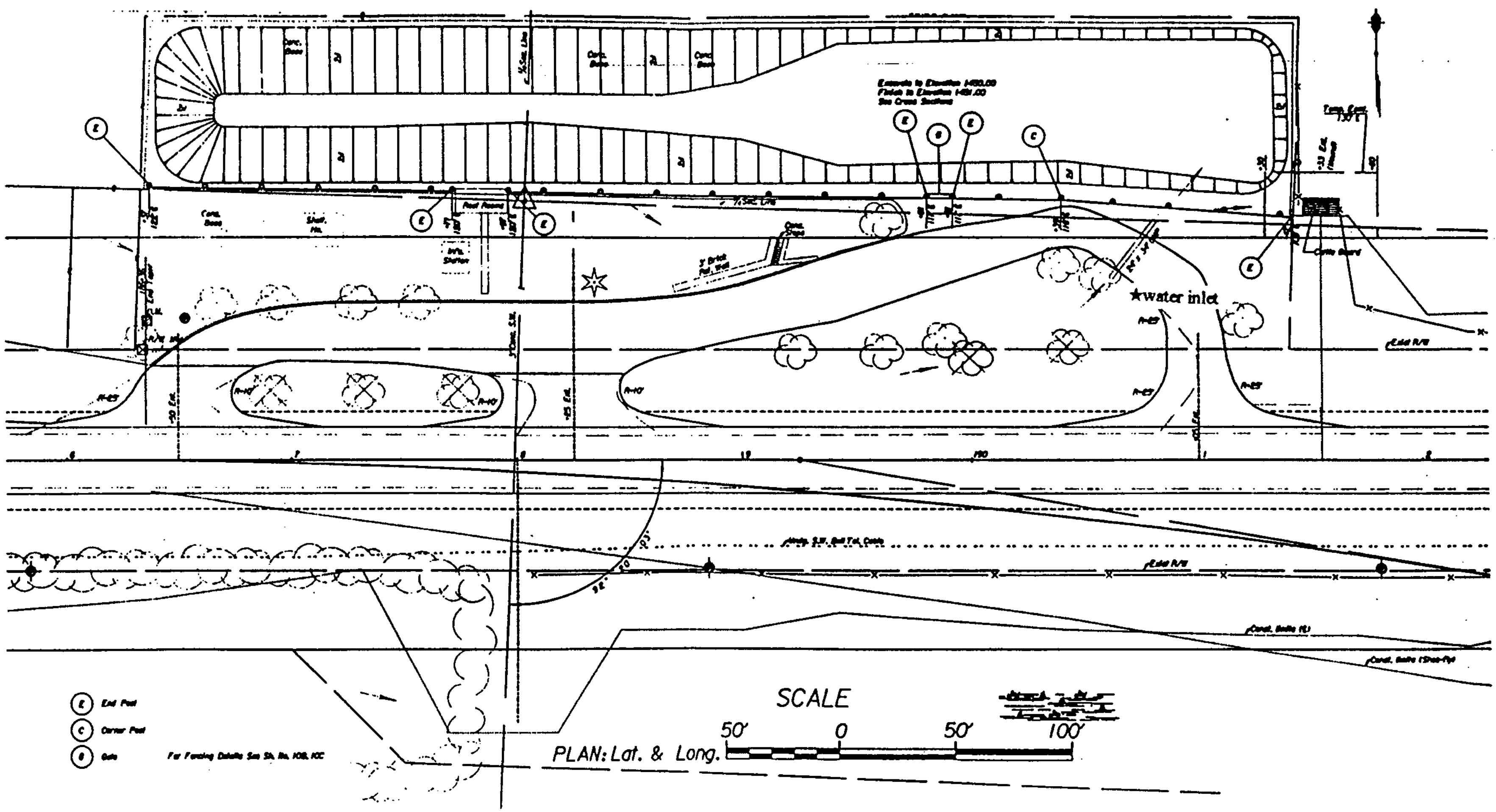
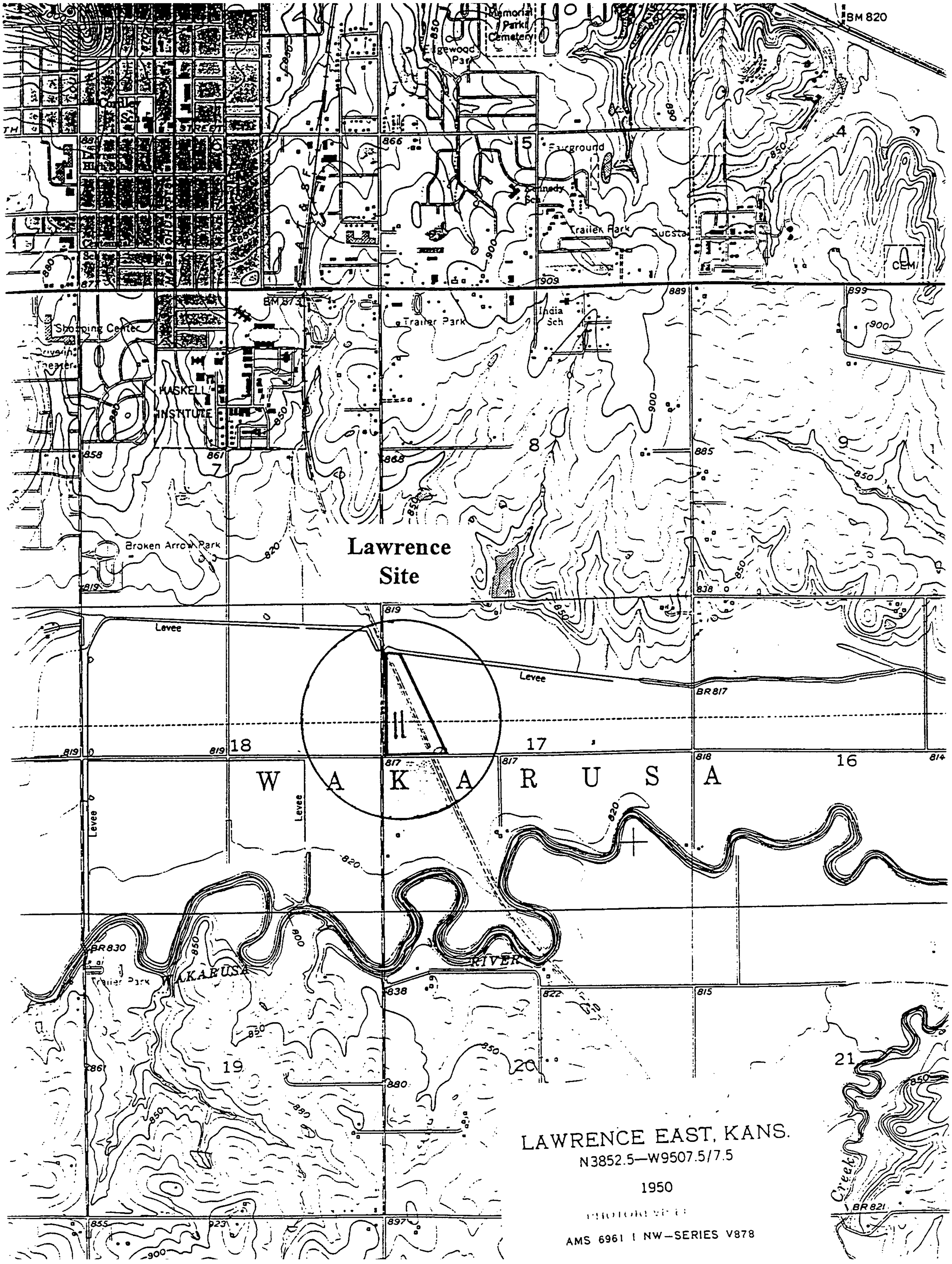


Exhibit C

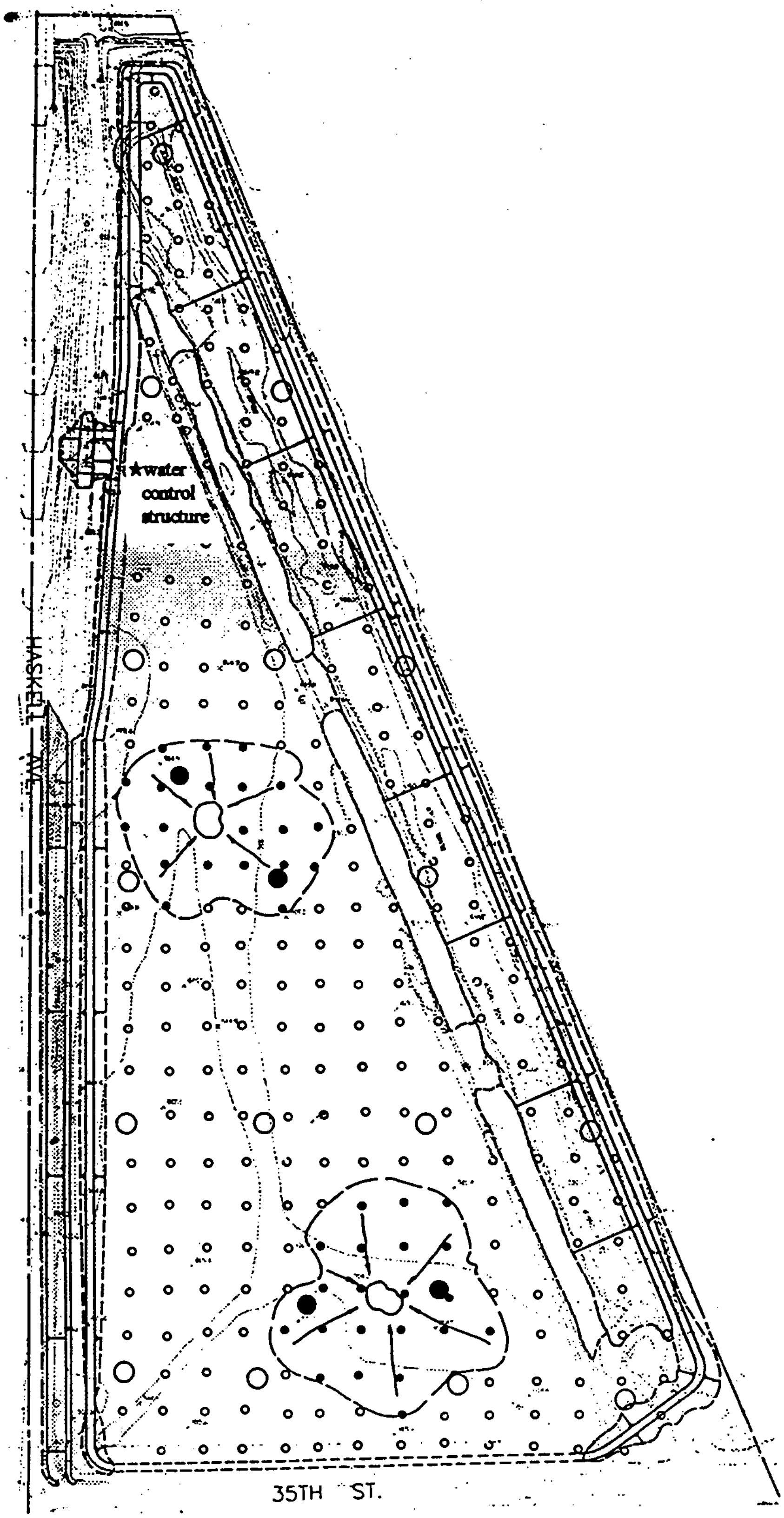

Medicine Lodge Site
Medicine Lodge
BARBER COUNTY STATE LAKE
Radio Tower
Gas Well
High Sch
ROBIE AVE
Hospital
STOLP
AVE
Substation
City Hall
1ST
AVE
KANSAS
AVE
PO
BM 1510
WASHINGTON AVE
Courthouse
Park
Elm
MEDICINE
LODGE
RIVER
Roadside Park
Oil Well
Sewage Disposal
Wells
BLOOM OIL FIELD
ATCHISON
TOPEKA
BM 1486
37098 35
MEDICINE LODGE, KANS.
N3715—W9830/7.5
1973
AMS 6258 I SE—SERIES V878
1 970 000 FEET
HARDTNER 20 MI.
ALVA, OKLA. 34 MI.
281
R 12 W
R 11 W

Medicine Lodge Site




Lawrence
Site
Memorial Park Cemetery
BM 820
Edgewood Park
Fairground
Kennedy Sch
Trailer Park
Substa
CEM
BM 873
Trailer Park
India Sch
Shopping Center
Drive-in Theater
HASKELL INSTITUTE
Broken Arrow Park
Levee
Levee
BR 817
18
17
16
W A K A R U S A
Levee
Levee
BR 830
Trailer Park
WAKARUSA
RIVER
19
20
21
Creek
BR 821
LAWRENCE EAST, KANS.
N3852.5—W9507.5/7.5
1950
AMS 6961 I NW—SERIES V878

Santa Fe Site in Lawrence



Appendix 2. Soil Characteristics for Two Transects at the Kingman Mitigation Site in Kansas.

Kingman Wet Transect Distance	Depth	% Moisture	Bulk Density	pH	gN/m2/cm	gC/m2/cm	C:N	Texture Sand	Slit	Clay	Classification
20	10	44.09	1.41	7.44	53.58	874.82	16				
	30	42.05	1.63	7.64	57.58	1395.90	24				
40	10	29.25	1.17	7.44	50.41	763.71	15	52	28	20	loam
	30	34.52	1.14	7.50	43.17	660.22	15	48	32	20	loam
60	10	25.58	0.91	7.53	38.44	580.00	15				
	30	27.16	1.67	7.56	44.30	794.65	18				
80	10	14.52	2.21	7.63	65.56	371.17	6	36	44	20	loam
	30	16.08	2.11	7.69	19.10	377.24	20	36	48	16	loam
100	10	12.84	1.49	7.70	14.51	473.26	33				
	30	14.42	1.90	7.75	15.73	617.40	39				
120	10	11.36	1.62	7.65	13.47	332.02	25	36	40	24	loam
	30	15.59	1.75	7.75	11.16	423.89	38	40	52	8	silt loam

Kingman Dry Transect Distance	Depth	% Moisture	Bulk Density	pH	gN/m2/cm	gC/m2/cm	C:N	Texture Sand	Slit	Clay	Classification
20	10	12.73	1.60	7.63	6.62	298.05	45				
	30	16.40	1.77	7.75	14.23	541.06	38				
40	10	16.04	1.23	7.69	23.49	521.96	22	40	44	16	loam
	30	17.51	1.64	7.77	16.75	627.80	37	36	40	24	loam
60	10	30.21	0.90	7.42	26.65	550.72	21				
	30	30.78	1.04	7.53	30.73	233.50	8				
80	10	31.67	1.19	7.28	42.58	610.75	14	48	32	20	loam
	30	27.97	1.66	7.44	26.27	472.04	18	44	40	16	loam
100	10	41.05	0.94	7.36	20.04	866.51	43				
	30	39.63	1.49	7.48	44.11	582.70	13				
120	10	44.97	1.05	7.34	25.81	965.35	37	60	29	11	sandy loam
	30	34.30	1.72	7.56	28.52	214.90	8	56	36	8	sandy loam

Appendix 2. Soil Characteristics for Two Transects at the Emporia Mitigation Site in Kansas.

Emporia Dry Transect Distance	Depth	% Moisture	Bulk Density	pH	gN/m2/cm	gC/m2/cm	C:N	Texture Sand	Slit	Clay	Classification
20	10	7.63	1.48	6.82	8.16	115.32	14				
	30	9.56	1.91	6.26	7.28	94.35	13				
40	10	7.93	1.42	6.51	5.20	77.51	15	24	44	32	clay loam
	30	10.88	1.68	6.35	4.41	63.63	14	28	48	24	loam
60	10	10.00	1.25	6.32	5.04	145.55	29				
	30	15.04	1.87	6.17	10.05	194.38	19				
80	10	8.20	1.34	6.36	7.62	143.95	19	20	52	28	silt loam
	30	12.47	1.89	6.02	14.12	263.67	19	16	36	48	clay
100	10	8.24	1.44	6.04	6.27	147.33	23				
	30	11.05	1.76	5.89	4.97	130.27	26				
120	10	8.61	1.73	6.27	8.37	158.43	19	20	48	32	clay loam
	30	13.01	1.81	6.01	11.16	252.28	23	20	46	34	clay loam

Emporia Wet Transect Distance	Depth	% Moisture	Bulk Density	pH	gN/m2/cm	gC/m2/cm	C:N	Texture Sand	Slit	Clay	Classification
20	10	8.00	1.79	7.12	10.68	185.29	17				
	30	11.78	1.89	6.93	17.63	226.14	13				
40	10	9.98	1.44	7.04	12.43	102.95	8	24	44	32	clay loam
	30	10.26	1.71	7.62	8.67	67.06	8	24	40	36	clay loam
60	10	7.46	2.25	6.82	11.68	128.92	11				
	30	14.54	2.14	6.71	14.65	156.34	11				
80	10	9.62	1.05	6.92	12.29	154.58	13	24	44	32	clay loam
	30	10.11	1.77	6.42	11.03	117.21	11	28	44	28	clay loam
100	10	8.93	1.79	6.65	13.18	168.46	13				
	30	9.52	2.27	6.67	7.11	119.74	17				
120	10	8.01	1.54	6.56	7.68	107.66	14	24	44	32	clay loam
	30	11.30	1.81	6.57	11.02	165.35	15	20	40	40	clay loam

Appendix 2. Soil Characteristics for Two Transects at the Santa Fe Mitigation Site in Kansas.

Lawrence Wet Transect Distance	Depth	% Moisture	Bulk Density	pH	gN/m2/cm	gC/m2/cm	C:N	Texture Sand	Slit	Clay	Classification
20	10	18.23	1.51	6.02	31.47	371.87	12				
	30	20.45	1.72	5.94	24.65	256.53	10				
40	10	21.19	1.67	6.13	35.72	386.77	11	20	32	48	clay
	30	21.30	1.67	6.20	24.86	256.56	10	28	24	48	clay
60	10	20.37	1.82	6.18	33.27	376.46	11				
	30	20.69	1.71	6.16	26.13	322.88	12				
80	10	19.41	1.69	6.10	31.64	371.56	12	20	32	48	clay
	30	21.17	1.82	6.25	23.21	275.72	12	16	28	56	clay
100	10	19.07	1.81	6.35	27.06	354.74	13				
	30	21.52	1.62	6.50	20.85	249.56	12				
120	10	18.44	1.60	6.32	25.45	318.40	13	28	24	48	clay
	30	21.01	1.78	6.77	16.86	241.83	14	20	24	56	clay

Lawrence Dry Transect Distance	Depth	% Moisture	Bulk Density	pH	gN/m2/cm	gC/m2/cm	C:N	Texture Sand	Slit	Clay	Classification
20	10	14.97	2.30	6.95	42.79	828.19	19				
	30	16.22	2.17	6.51	20.89	357.90	17				
40	10	19.26	1.88	6.58	21.49	358.18	17	28	36	36	clay loam
	30	19.39	2.12	5.82	28.58	469.14	16	24	32	44	clay
60	10	14.13	2.10	6.74	33.87	679.71	20				
	30	15.89	2.29	6.20	21.55	363.54	17				
80	10	10.90	1.80	6.48	27.25	399.50	15	20	36	44	clay
	30	17.80	2.26	6.40	29.03	505.26	17	32	24	44	clay
100	10	22.71	1.81	6.74	29.60	536.80	18				
	30	16.23	1.83	6.53	21.60	376.42	17				
120	10	19.42	1.79	5.36	23.81	406.13	17	28	24	48	clay
	30	17.29	1.73	6.60	16.86	277.98	16	22	22	56	clay

Appendix 2. Soil Characteristics at the Enterprise and Medicine Lodge Mitigation Sites in Kansas.

Enterprise

Distance	Depth	% Moisture	Bulk Density	pH	gN/m2/cm	gC/m2/cm	C:N	Texture Sand	Slit	Clay	Classification
20	10	15.14	2.06	7.64	4.38	106.24	24				
	30	18.38	1.98	7.44	1.98	108.81	55				
40	10	16.43	2.21	7.74	2.21	68.94	31	44	48	8	loam
	30	18.07	2.51	7.53	2.51	115.34	46	46	50	4	sandy loam
60	10	18.50	2.08	7.68	2.08	63.78	31				
	30	23.95	2.19	7.51	2.19	67.52	31				
80	10	18.96	1.68	7.73	3.46	63.77	18	48	51	1	silt loam
	30	18.14	1.85	7.62	3.64	81.58	22	44	44	12	loam
100	10	16.00	1.51	7.72	1.51	53.18	35				
	30	17.18	1.72	7.58	1.72	69.48	40				
120	10	9.14	1.63	7.88	1.63	49.76	30	64	32	4	sandy loam
	30	10.15	1.61	7.68	1.61	40.76	25	48	48	4	sandy loam

Medicine Lodge

Distance	Depth	% Moisture	Bulk Density	pH	gN/m2/cm	gC/m2/cm	C:N	Texture Sand	Slit	Clay	Classification
20	10	8.50	1.85	7.82	9.01	240.03	27				
	30	17.75	2.16	7.65	5.73	260.74	45				
40	10	7.60	1.71	7.52	5.59	267.78	48	56	24	20	sandy clay loam
	30	12.05	2.21	7.70	1.58	154.12	97	80	12	8	loamy sand
60	10	3.87	*	8.10	*	*	ERR				
	30	12.83	*	7.86	*	*	ERR				
80	10	13.94	1.79	7.37	23.02	408.89	18	68	24	8	sandy loam
	30	15.29	1.81	7.62	1.81	78.15	43	76	16	8	loamy sand
100	10	8.92	1.79	7.66	7.93	183.81	23				
	30	13.00	2.42	7.76	2.42	95.07	39				
120	10	6.23	2.05	7.66	2.05	245.35	120	64	24	12	sandy loam

Appendix 3

KDOT Enterprise Transect 1996

Genus	Species	Common Name	Wetland Index	Spring	Fall
Polygonum	*lapathifolium*	pale smartweed	1	8.7%	70.7%
Ranunculus	*sceleratus*	cursed buttercup	1	0.3%	T
Salix	*exigua*	interior sandbar willow	1	0.3%	0.8%
Salix	*nigra*	black willow	1	0.1%	0.2%
Amaranthus	*rudis*	water hemp	2	0.2%	3.4%
Aster	*simplex*	common willow-leaved aster	2	T	0.3%
Bidens	*frondosa*	devil's beggartick	2	0.6%	0.6%
Cyperus	*strigosus*	large nutsedge	2	T	0.1%
Echinochloa	*crusgalli*	common barnyardgrass	2	0.1%	0.1%
Muhlenbergia	*racemosa*	marsh muhly	2	0.0%	0.5%
Potentilla	*rivalis*	brook cinquefoil	2	0.2%	0.0%
Rorippa	*sinuata*	spreading yellowcress	2	2.6%	0.1%
Rumex	*crispus*	curly dock	2	T	0.0%
Salix	*amygdaloides*	peach-leaved willow	2	1.9%	0.3%
Teucrium	*canadense*	American germander	2	T	0.5%
Acer	*negundo*	violet boxelder	3	T	0.1%
Iva	*annua*	annual sumpweed	3	1.7%	0.0%
Lactuca	*serriola*	prickly lettuce	3	0.1%	0.0%
Morus	*alba*	white mulberry	3	T	0.1%
Panicum	*dichotomiflorum*	fall panicum	3	0.0%	1.9%
Populus	*deltoides*	plains cottonwood	3	7.5%	17.3%
Setaria	*glauce*	foxtail	3	0.5%	0.0%
Xanthium	*strumarium*	common cocklebur	3	0.0%	0.2%
Bromus	*japonicus*	Japanese brome	4	1.1%	0.0%
Conyza	*canadensis*	Canada horseweed	4	4.4%	0.3%
Digitaria	*sanguinalis*	hairy crabgrass	4	0.0%	2.0%
Euphorbia	*nutans*	eyebane	4	T	0.0%
Bromus	*inermis*	smooth brome	5	T	0.0%
Chenopodium	*berlandieri*	pitseed goosefoot	5	0.1%	0.0%
Physalis	*longifolia*	groundcherry	5	T	0.0%
Tridens	*flavus*	purpletop	5	0.0%	0.2%
Bare ground, litter, and water				69.4%	T
TOTAL				100.0%	100.0%
AVERAGE WETLAND VALUE				2.38	1.53

1 = Obligate Wetland Species; 2 = Facultative Wetland Species; 3 = Facultative Species;
4 = Facultative Upland Species; 5 = Upland Species.
T = trace species with less than 0.05% cover.

KDOT Emporia Wet Transect 1996

Genus	Species	Common Name	Wetland Index	Spring	Fall
Ammannia	*coccinea*	red toothcup	1	0.0%	T
Carex	*hyalinolepis*	Frank's sedge	1	0.1%	0.4%
Carex	*pellita*	sparse seed	1	0.0%	T
Carex	*sp.*	sedge	1	0.0%	T
Cephalanthus	*occidentalis*	buttonbush	1	0.1%	0.2%
Cyperus	*acuminatus*	tapeleaf sedge	1	1.0%	1.8%
Eleocharis	*erythropoda*	longstem spikesedge	1	35.4%	34.0%
Leersia	*oryzoides*	rice cutgrass	1	0.0%	T
Polygonum	*amphibium*	swamp smartweed	1	2.1%	1.5%
Sagittaria	*latifolia*	common arrowhead	1	0.1%	0.0%
Scirpus	*fluviatilis*	river bulrush	1	0.9%	0.2%
Veronica	*peregrina*	speedwell	1	0.1%	0.0%
Amaranthus	*rudis*	water hemp	2	0.3%	0.3%
Ambrosia	*trifida*	giant ragweed	2	T	0.7%
Aster	*praealtus*	common willow-leaved aster	2	1.3%	2.4%
Boltonia	*asteroides*	white boltonia	2	2.5%	20.5%
Echinochloa	*crusgalli*	common barnyardgrass	2	T	7.3%
Polygonum	*bicorne*	longstyle smartweed	2	3.2%	13.8%
Rorippa	*sinuata*	spreading yellowcress	2	0.2%	0.0%
Rumex	*crispus*	curly dock	2	0.2%	0.0%
Apocynum	*cannabinum*	hemp dogbane	3	T	0.0%
Carex	*brevior*	straw sedge	3	0.2%	0.1%
Ellisia	*nyctelea*	waterpod	3	T	0.0%
Elymus	*virginicus*	Virginia wildrye	3	0.3%	0.0%
Hordeum	*pusillum*	little barley	3	T	0.0%
Iva	*annua*	annual sumpweed	3	0.2%	1.4%
Juncus	*dudleyi*	inland rush	3	0.4%	0.0%
Lactuca	*serriola*	prickly lettuce	3	T	0.0%
Panicum	*dichotomiflorum*	fall panicum	3	0.0%	2.2%
Paspalum	*laeve*	field paspalum	3	0.0%	0.4%
Polygonum	*ramossissimum*	triangular; thin stalk	3	0.0%	0.2%
Populus	*deltoides*	plains cottonwood	3	0.3%	1.6%
Rumex	*altissimus*	pale dock	3	4.5%	0.0%
Setaria	*glauca*	foxtail	3	0.1%	0.0%
Viola	*pratincola*	meadow violet	3	T	0.1%
Aster	*pilosus*	hairy aster	4	0.1%	1.0%
Bromus	*japonicus*	Japanese brome	4	T	0.0%
Abutilon	*theophrasti*	velvet-leaf	5	T	0.0%
Chenopodium	*berlandieri*	goosefoot	5	0.0%	T
Descurainia	*pinnata*	tansy mustard	5	T	0.0%
Digitaria	*ischaemum*	smooth crabgrass	5	0.0%	T
Hibiscus	*trionum*	flower-of-an-hour	5	T	0.0%
Muhlenbergia	*cuspidata*	plains muhly	5	0.6%	0.8%
Oxalis	*stricta*	common wood sorrel	5	0.3%	0.2%
Physalis	*longifolia*	common groundcherry	5	0.0%	0.1%
Solanum	*carolinense*	Carolina horse nettle	5	T	0.0%
Bare ground, litter, and water				45.2%	8.3%
TOTAL				100.0%	100.0%
AVERAGE WETLAND VALUE				1.43	1.71

1 = Obligate Wetland Species; 2 = Facultative Wetland Species; 3 = Facultative Species;
4 = Facultative Upland Species; 5 = Upland Species.
T = trace species with less than 0.05% cover.

KDOT Emporia Dry Transect 1996

Genus	Species	Common Name	Wetland Index	Spring	Fall
Ammannia	*coccinea*	toothcup	1	0.0%	T
Carex	*hyalinolepis*	Frank's sedge	1	0.7%	0.9%
Cyperus	*acuminatus*	tapeleaf sedge	1	0.0%	2.1%
Eleocharis	*macrostachya*	longstem spikesedge	1	1.1%	1.1%
Marsilea	*vestita*	western water-clover	1	0.0%	T
Polygonum	*amphibium*	swamp smartweed	1	0.2%	0.1%
Scirpus	*fluviatilis*	river bulrush	1	T	0.0%
Amaranthus	*rudis*	water hemp	2	0.3%	0.8%
Ambrosia	*trifida*	giant ragweed	2	0.3%	0.4%
Aster	*praealtus*	common willow-leaved aster	2	3.7%	6.7%
Boltonia	*asteroides*	violet boltonia	2	0.7%	4.4%
Cyperus	*esculentus*	nutsedge	2	0.1%	0.3%
Echinochloa	*crusgalli*	common barnyardgrass	2	0.4%	27.5%
Polygonum	*bicorne*	longstyle smartweed	2	0.9%	3.3%
Rorippa	*sinuata*	spreading yellowcress	2	0.2%	0.0%
Rumex	*crispus*	curly dock	2	T	T
Apocynum	*cannabinum*	hemp dogbane	3	T	0.0%
Carex	*annectens*	yellowfruit sedge	3	0.3%	0.6%
Carex	*brevior*	straw sedge	3	0.6%	1.3%
Elymus	*virginicus*	Virginia wildrye	3	0.4%	0.1%
Eragrostis	*frankii*	sandbar lovegrass	3	0.0%	7.3%
Erigeron	*strigosus*	daisy fleabane	3	0.1%	0.0%
Iva	*annua*	annual sumpweed	3	0.5%	3.3%
Lactuca	*serriola*	prickly lettuce	3	T	0.0%
Lepidium	*densiflorum*	peppergrass	3	T	0.0%
Panicum	*capillare*	common witchgrass	3	T	0.0%
Panicum	*dichotomiflorum*	fall panicum	3	0.0%	17.6%
Paspalum	*laeve*	field paspalum	3	0.0%	0.1%
Polygonum	*ramosissimum*	bush knotweed	3	T	0.1%
Populus	*deltoides*	plains cottonwood	3	0.4%	0.8%
Portulaca	*oleracea*	common purslane	3	0.0%	T
Setaria	*glauca*	yellow foxtail	3	0.4%	4.1%
Allium	*canadense*	wild onion	4	0.1%	0.0%
Aster	*pilosus*	hairy aster	4	0.3%	5.6%
Bromus	*japonicus*	Japanese brome	4	0.4%	0.1%
Desmanthus	*illinoensis*	Illinois bundleflower	4	0.1%	0.8%
Euphorbia	*maculata*	spotted spurge	4	0.1%	0.0%
Euphorbia	*nutans*	eyebane	4	T	0.0%
Galium	*aparine*	catchweed bedstraw	4	T	0.0%
Geranium	*maculatum*	wild cranesbill	4	T	0.0%
Helianthus	*annuus*	common sunflower	4	0.1%	1.1%
Lespedeza	*stipulacea*	Korean lespedeza	4	T	0.0%
Sporobolus	*asper*	rough dropseed	4	0.4%	0.8%
Sporobolus	*vaginiflorus*	povertygrass	4	T	T
Abutilon	*theophrasti*	velvet-leaf	5	T	0.0%
Chenopodium	*berlandieri*	pitseed goosefoot	5	T	0.0%
Digitaria	*ischaemum*	smooth crabgrass	5	0.0%	0.2%
Euphorbia	*missurica*	Missouri spurge	5	T	0.0%
Hibiscus	*trionum*	flower-of-an-hour	5	T	T
Lespedeza	*virginica*	slender bush lespedeza	5	0.0%	T
Mirabilis	*nyctaginea*	wild four-o'clock	5	T	0.0%
Oxalis	*dillenii*	green wood sorrel	5	T	0.0%
Physalis	*longifolia*	common groundcherry	5	T	T
Bare ground, litter, and water				86.7%	8.1%
TOTAL				100.0%	100.0%
AVERAGE WETLAND VALUE				2.31	2.53

1 = Obligate Wetland Species; 2 = Facultative Wetland Species; 3 = Facultative Species;
4 = Facultative Upland Species; 5 = Upland Species.
T = trace species with less than 0.05% cover.

KDOT Kingman Wet Transect 1996

Genus	Species	Common Name	Wetland Index	Spring	Fall
Ammannia	*coccinea*	red toothcup	1	T	0.0%
Aster	*subulatus*	saltmarsh aster	1	0.0%	0.8%
Bidens	*cernua*	devil's beggartick	1	7.4%	16.5%
Carex	*hystericina*	sedge	1	0.1%	0.0%
Cyperus	*acuminatus*	nutsedge	1	0.0%	0.0%
Eleocharis	*erythropoda*	longstem spikesedge	1	0.2%	0.2%
Leersia	*oryzoides*	rice cutgrass	1	0.3%	1.1%
Lemna	*minor*	lesser duckweed	1	0.1%	0.1%
Lippia	*lanceolata*	lanceleaf frogfruit	1	11.5%	10.5%
Ludwigia	*peploides*	marsh seedbox	1	0.3%	T
Lycopus	*virginicus*	Virginia bugleweed	1	0.2%	0.8%
Polygonum	*amphibium*	swamp smartweed	1	0.2%	0.4%
Ranunculus	*sceleratus*	cursed buttercup	1	1.2%	0.0%
Sagittaria	*latifolia*	common arrowhead	1	1.0%	0.4%
Salix	*exigua*	western sandbar willow	1	0.5%	1.1%
Salix	*nigra*	black willow	1	0.3%	0.7%
Scirpus	*acutus*	hardstem bulrush	1	0.1%	0.0%
Sparganium	*eurycarpum*	giant bur-reed	1	0.3%	0.3%
Typha	*angustifolia*	narrow-leaved cattail	1	9.0%	3.7%
Typha	*latifolia*	common cattail	1	1.8%	2.3%
Veronica	*anagallis-aquatica*	water speedwell	1	T	0.0%
Conium	*maculatum*	poison hemlock	2	T	0.0%
Echinochloa	*crusgalli*	common barnyardgrass	2	1.3%	10.5%
Eclipta	*prostrata*	yerba de tajo	2	0.0%	T
Polygonum	*bicorne*	longstyle smartweed	2	0.0%	3.0%
Polygonum	*hydropipes*	mild water-pepper smartweed	2	14.0%	11.7%
Rumex	*crispus*	curly dock	2	0.0%	0.0%
Verbena	*hastata*	blue verbena	2	T	0.0%
Carex	*annectens*	yellowfruit sedge	3	8.1%	9.4%
Erechtites	*hieracifolia*	American burnweed	3	0.0%	4.2%
Geum	*canadense*	white avens	3	T	T
Iva	*annua*	annual sumpweed	3	1.2%	1.9%
Juncus	*interior*	inland rush	3	0.1%	T
Lactuca	*serriola*	prickly lettuce	3	T	0.1%
Panicum	*capillare*	common witchgrass	3	T	0.1%
Panicum	*virgatum*	switchgrass	3	1.9%	2.4%
Populus	*deltoides*	plains cottonwood	3	1.4%	2.9%
Rumex	*altissimus*	pale dock	3	0.0%	T
Xanthium	*strumarium*	common cocklebur	3	0.4%	8.3%
Acalypha	*virginica*	Virginia copperleaf	4	0.0%	0.0%
Conyza	*canadensis*	Canada horseweed	4	0.0%	0.1%
Galium	*aparine*	catchweed bedstraw	4	0.6%	0.0%
Solidago	*canadensis*	rough Canada goldenrod	4	0.1%	0.2%
Cirsium	*altissimum*	tall thistle	5	0.1%	0.5%
Stellaria	*media*	chickweed	5	0.0%	T
Bareground, litter and water				36.2%	6.0%
TOTAL				100.0%	100.0%
AVERAGE WETLAND VALUE				1.69	1.92

1 = Obligate Wetland Species; 2 = Facultative Wetland Species; 3 = Facultative Species;
4 = Facultative Upland Species; 5 = Upland Species.
T = trace species with less than 0.05% cover.

KDOT Kingman Dry Transect 1996

Genus	Species	Common Name	Wetland Index	Spring	Fall
Amorpha	*fruticosa*	false indigo	1	1.4%	0.8%
Aster	*subulatus*	saltmarsh aster	1	0.0%	0.7%
Bidens	*cernua*	devil's beggartick	1	13.4%	13.3%
Boehmeria	*cylindrica*	bog hemp	1	T	1.2%
Carex	*stipata*	owlfruit sedge	1	0.3%	1.0%
Eleocharis	*erythropoda*	spikerush	1	0.6%	0.0%
Eupatorium	*perfoliatum*	boneset	1	0.1%	0.7%
Leersia	*oryzoides*	rice cutgrass	1	1.8%	3.5%
Lippia	*lanceolata*	lanceleaf frogfruit	1	22.3%	16.3%
Lycopus	*virginicus*	Virginia bugleweed	1	0.1%	T
Polygonum	*hydropiperoides*	mild water-pepper smartweed	1	0.0%	0.3%
Ranunculus	*sceleratus*	cursed buttercup	1	1.0%	0.0%
Sagittaria	*latifolia*	common arrowhead	1	1.0%	0.0%
Salix	*exigua*	western sandbar willow	1	2.2%	3.9%
Salix	*nigra*	black willow	1	1.6%	0.6%
Scirpus	*acutus*	hardstem bulrush	1	1.7%	0.3%
Scirpus	*pungens*	hardstem bullrush	1	1.0%	0.1%
Scutellaria	*laterifolia*	blue skullcap	1	9.5%	0.3%
Typha	*angustifolia*	narrow-leaved cattail	1	0.0%	0.1%
Typha	*latifolia*	common cattail	1	16.1%	25.6%
Veronica	*anagallis-aquatica*	water speedwell	1	T	0.0%
Agalinis	*tenuifolia*	slender false-foxglove	2	0.0%	3.9%
Amaranthus	*rudis*	tall amaranth	2	T	0.0%
Ambrosia	*trifida*	giant ragweed	2	5.1%	7.5%
Aster	*praealtus*	common willow-leaved aster	2	0.0%	T
Conium	*maculatum*	poison hemlock	2	0.1%	0.0%
Echinochloa	*crusgalli*	common barnyardgrass	2	0.1%	0.1%
Eclipta	*prostrata*	yerba de tajo	2	0.0%	T
Polygonum	*pensylvanicum*	Pennsylvania smartweed	2	1.1%	0.8%
Rumex	*altissimus*	pale dock	2	1.0%	0.1%
Rumex	*crispus*	curly dock	2	0.0%	0.4%
Solidago	*gigantea*	giant goldenrod	2	0.0%	0.2%
Verbena	*hastata*	blue verbena	2	0.0%	0.9%
Cornus	*drummondii*	roughleaf dogwood	3	1.4%	0.2%
Haplopappus	*ciliatus*	wax goldenweed	3	0.0%	1.4%
Iva	*annua*	annual sumpweed	3	0.6%	2.4%
Juncus	*tenuis*	path rush	3	0.2%	0.2%
Lactuca	*serriola*	prickly lettuce	3	T	0.0%
Morus	*alba*	white mulberry	3	0.1%	T
Panicum	*capillare*	common witchgrass	3	0.0%	2.1%
Populus	*deltoides*	plains cottonwood	3	5.1%	5.8%
Vernonia	*fasciculata*	western ironweed	3	0.3%	0.3%
Vitis	*riparia*	wild grape	3	0.0%	T
Xanthium	*strumarium*	common cocklebur	3	0.0%	0.4%
Bromus	*japonicus*	Japanese brome	4	T	0.0%
Conyza	*canadensis*	Canada horseweed	4	T	0.2%
Galium	*aparine*	catchweed bedstraw	4	1.0%	0.0%
Geum	*canadense*	white avens	4	0.1%	0.1%
Juniperus	*virginiana*	red cedar	4	T	0.0%
Solidago	*canadensis*	Canada goldenrod	4	0.3%	0.3%
Cirsium	*altissimum*	tall thistle	5	T	0.0%
Stellaria	*media*	chickweed	5	0.0%	0.6%
Bare ground, litter, and water				9.6%	3.3%
TOTAL				100.0%	100.0%
AVERAGE WETLAND VALUE				1.28	1.46

1 = Obligate Wetland Species; 2 = Facultative Wetland Species; 3 = Facultative Species;
4 = Facultative Upland Species; 5 = Upland Species.
T = trace species with less than 0.05% cover.

KDOT Lawrence Wet Transect 1996

Genus	Species	Common Name	Wetland Index	Spring	Fall
Ammannia	*coccinea*	Red toothcup	1	0.0%	T
Cyperus	*acuminatus*	Tapeleaf sedge	1	10.8%	0.0%
Echinochloa	*muricata*	Prickly barnyardgrass	1	8.4%	15.1%
Eleocharis	*macrostachya*	Longstem spikesedge	1	0.4%	2.1%
Lemna	*minor*	Lesser duckweed	1	0.0%	9.0%
Lippia	*lanceolata*	Lanceleaf frogfruit	1	0.0%	0.2%
Rorippa	*palustris*	Bog yellowcress	1	6.9%	0.2%
Sagittaria	*latifolia*	Common arrowhead	1	4.1%	19.3%
Amaranthus	*rudis*	Water hemp	2	2.2%	0.0%
Bidens	*polylepis*	Beggar-ticks	2	0.1%	0.0%
Boltonia	*asteroides*	Violet boltonia	2	0.0%	1.2%
Cyperus	*strigosus*	False nutsedge	2	6.6%	1.1%
Polygonum	*pensylvanicum*	Pennsylvania smartweed	2	25.1%	11.6%
Rumex	*crispus*	Curly dock	2	0.3%	0.0%
Iva	*annua*	Annual sumpweed	3	2.1%	9.1%
Juncus	*tenuis*	Path rush	3	0.0%	0.7%
Panicum	*dichotomiflorum*	Fall panicum	3	0.0%	0.2%
Trifolium	*hybridum*	Alsike clover	4	0.4%	0.0%
Bare ground, water and litter				32.4%	30.3%
TOTAL				100.0%	100.0%
AVERAGE WETLAND VALUE				1.59	1.48

1 = Obligate Wetland Species; 2 = Facultative Wetland Species; 3 = Facultative Species;
4 = Facultative Upland Species; 5 = Upland Species.
T = trace species with less than 0.05% cover.

KDOT Lawrence Dry Transect 1996

Genus	Species	Common Name	Wetland Index	Spring	Fall
Ammannia	*coccinea*	Red toothcup	1	0.3%	3.6%
Cyperus	*acuminatus*	Tapeleaf sedge	1	0.1%	0.7%
Echinochloa	*muricata*	Prickly barnyardgrass	1	20.6%	33.3%
Eleocharis	*macrostachya*	Longstem spikesedge	1	0.1%	1.5%
Ipomoea	*lacunosa*	White morning-glory	1	0.1%	T
Leersia	*oryzoides*	Rice cutgrass	1	0.1%	0.0%
Lemna	*minor*	Lesser duckweed	1	0.0%	0.1%
Lindernia	*dubia*	Yellow false pimpernel	1	0.8%	0.3%
Ludwigia	*palustris*	Water purslane	1	0.0%	0.1%
Lythrum	*alatum*	Winged loosestrife	1	0.1%	0.0%
Penthorum	*sedoides*	Ditch stonecrop	1	0.0%	0.1%
Polygonum	*amphibium*	Swamp smartweed	1	2.8%	3.3%
Polygonum	*hydropiperoides*	Water-pepper smartweed	1	0.0%	T
Sagittaria	*latifolia*	Common arrowhead	1	3.3%	1.1%
Amaranthus	*rudis*	Water hemp	2	0.1%	0.0%
Bidens	*polylepis*	Beggar-ticks	2	42.6%	26.8%
Boltonia	*asteroides*	Violet boltonia	2	T	0.1%
Cyperus	*strigosus*	False nutsedge	2	4.8%	2.2%
Eclipta	*prostrata*	Yerba de tajo	2	0.0%	0.1%
Helenium	*autumnale*	Common sneezeweed	2	0.0%	0.1%
Polygonum	*pensylvanicum*	Pennsylvania smartweed	2	5.2%	5.3%
Rumex	*crispus*	Curly dock	2	3.5%	1.1%
Spartina	*pectinata*	Prairie cordgrass	2	0.0%	0.5%
Apocynum	*cannabinum*	Hemp dogbane	3	0.3%	0.4%
Carex	*annectens*	Yellowfruit sedge	3	0.0%	0.7%
Iva	*annua*	Annual sumpweed	3	0.9%	0.1%
Juncus	*tenuis*	Path rush	3	0.1%	0.0%
Panicum	*dichotomiflorum*	Fall panicum	3	0.0%	8.3%
Setaria	*glauca*	Yellow foxtail	3	0.2%	1.4%
Acalypha	*virginica*	Virginia copperleaf	4	0.1%	0.0%
Galium	*aparine*	Catchweed bedstraw	4	0.2%	0.4%
Helianthus	*annuus*	Common sunflower	4	0.8%	0.0%
Taraxacum	*officinale*	Common dandelion	4	0.1%	T
Trifolium	*hybridum*	Alsike clover	4	0.2%	0.4%
Oxalis	*dillenii*	Green wood sorrel	5	T	T
Bare ground, water and litter				12.6%	8.0%
TOTAL				100.00%	100.00%
AVERAGE WETLAND VALUE				1.72	1.66

1 = Obligate Wetland Species; 2 = Facultative Wetland Species; 3 = Facultative Species;
4 = Facultative Upland Species; 5 = Upland Species.
T = trace species with less than 0.05% cover.

KDOT Medicine Lodge Transect 1996

Genus	Species	Common Name	Wetland Index	Spring	Fall
Aster	*subulatus*	saltmarsh aster	1	0.1%	0.0%
Cyperus	*acuminatus*	tapeleaf sedge	1	T	0.0%
Scirpus	*pungens*	hardstem bulrush	1	15.9%	27.9%
Amaranthus	*graecizans*	prostrate pigweed	2	0.2%	0.0%
Ambrosia	*trifida*	giant ragweed	2	0.0%	1.5%
Bidens	*frondosa*	devil's beggartick	2	0.2%	0.0%
Cyperus	*strigosus*	false nutsedge	2	1.4%	0.0%
Echinochloa	*crusgalli*	common barnyardgrass	2	0.3%	0.0%
Eleocharis	*montevidiensis*	spikerush	2	T	0.0%
Fraxinus	*pennsylvanica*	green ash	2	T	0.0%
Polygonum	*bicome*	longstyle smartweed	2	2.7%	1.1%
Haplopappus	*ciliata*	wax goldenweed	3	0.7%	0.5%
Hordeum	*pusillum*	little barley	3	T	0.0%
Iva	*annua*	annual sumpweed	3	3.8%	0.0%
Juncus	*tenuis*	path rush	3	T	0.0%
Lactuca	*serriola*	prickly lettuce	3	0.4%	0.0%
Medicago	*lupulina*	black medick	3	0.1%	0.0%
Panicum	*capillare*	common witchgrass	3	T	0.0%
Polygonum	*ramosissimum*	bush knotweed	3	0.0%	4.2%
Rumex	*altissimus*	pale dock	3	0.2%	0.0%
Ambrosia	*artemisiifolia*	common ragweed	4	0.2%	0.0%
Bromus	*japonicus*	Japanese brome	4	3.0%	0.0%
Conyza	*canadensis*	Canada horseweed	4	8.2%	7.3%
Euphorbia	*maculata*	spotted spurge	4	T	0.0%
Euphorbia	*marginata*	snow-on-the-mountain	4	T	0.0%
Euphorbia	*nutans*	eyebane	4	T	0.0%
Geranium	*maculatum*	wild cranesbill	4	T	0.0%
Helianthus	*annuus*	common sunflower	4	0.8%	0.0%
Kochia	*scoparia*	summer cypress	4	0.2%	0.0%
Lespedeza	*stipulaceae*	Korean lespedeza	4	T	0.0%
Lolium	*perenne*	perennial ryegrass	4	T	0.0%
Oenothera	*biennis*	evening primrose	4	0.9%	0.0%
Plantago	*virginica*	pale-seeded plantain	4	0.1%	0.0%
Salsola	*iberica*	Russian thistle	4	3.3%	0.0%
Bromus	*inermis*	smooth brome	5	T	0.0%
Chenopodium	*berlandieri*	pitseed goosefoot	5	0.3%	0.0%
Euphorbia	*dentata*	toothed spurge	5	0.3%	0.0%
Haplopappus	*validus*	slender goldenweed	5	0.3%	0.0%
Lespedeza	*violaceae*	violet lespedeza	5	T	0.0%
Schedonnardus	*paniculatus*	tumblegrass	5	0.1%	0.0%
Solanum	*rostratum*	buffalo bur	5	0.1%	5.8%
Strophostyles	*leiosperma*	slick-seed bean	5	0.1%	0.0%
Bare ground, litter, and water				55.5%	51.5%
TOTAL				100.0%	100.0%
AVERAGE WETLAND VALUE				2.59	2.19

1 = Obligate Wetland Species; 2 = Facultative Wetland Species; 3 = Facultative Species;
4 = Facultative Upland Species; 5 = Upland Species.
T = trace species with less than 0.05% cover.

KDOT Enterprise Transect 1997

Genus	Species	Common Name	Wetland Index	Spring	Fall
Aster	*subulatus*	saltmarsh aster	1	0.7%	0.0%
Cephalanthus	*occidentalis*	buttonbush	1	T	0.0%
Ranunculus	*sceleratus*	cursed buttercup	1	0.1%	0.0%
Salix	*exigua*	sandbar willow	1	0.7%	0.2%
Salix	*nigra*	black willow	1	0.0%	2.0%
Veronica	*peregrina*	purslane speedwell	1	T	0.0%
Amaranthus	*rudis*	tall amaranth	2	0.1%	0.1%
Ambrosia	*trifida*	giant ragweed	2	6.5%	8.6%
Aster	*simplex*	panicled aster	2	7.1%	15.1%
Bidens	*frondosa*	devil's beggartick	2	2.4%	5.0%
Cyperus	*strigosus*	large nutsedge	2	0.0%	T
Echinochloa	*crusgalli*	barnyardgrass	2	0.6%	T
Fraxinus	*pennsylvanica*	green ash	2	0.0%	T
Muhlenbergia	*racemosa*	marsh muhly	2	0.7%	2.7%
Polygonum	*lapathifolium*	pale smartweed	2	22.0%	9.7%
Potentilla	*rivalis*	brook cinquefoil	2	0.1%	0.0%
Ranunculus	*abortivus*	early wood buttercup	2	T	0.0%
Rorippa	*sinuata*	spreading yellowcress	2	0.8%	0.4%
Rumex	*crispus*	curly dock	2	0.6%	T
Salix	*amygdaloides*	peach-leaved willow	2	5.1%	0.2%
Solidago	*gigantea*	late goldenrod	2	0.0%	0.5%
Teucrium	*canadense*	American germander	2	0.7%	0.9%
Lactuca	*serriola*	prickly lettuce	3	T	0.0%
Morus	*alba*	white mulberry	3	1.0%	0.3%
Panicum	*capillare*	common witchgrass	3	0.0%	0.2%
Panicum	*dichotomiflorum*	fall panicum	3	T	0.0%
Parthenocissus	*quinquefolia*	Virginia creeper	3	0.0%	T
Populus	*deltoides*	plains cottonwood	3	9.3%	8.7%
Setaria	*glauca*	yellow foxtail	3	0.3%	0.0%
Ulmus	*rubra*	slippery elm	3	0.1%	0.1%
Vitis	*riparia*	river-bank grape	3	0.0%	T
Xanthium	*strumarium*	common cocklebur	3	T	0.0%
Acalypha	*virginica*	Virginia three-seeded mercury	4	T	0.0%
Aster	*pilosus*	hairy aster	4	2.6%	0.0%
Conyza	*canadensis*	Canada horseweed	4	33.1%	38.6%
Erigeron	*annuus*	annual fleabane	4	0.1%	0.1%
Euphorbia	*nutans*	eyebane	4	T	0.1%
Geum	*canadense*	white avens	4	T	0.0%
Oenothera	*biennis*	evening primrose	4	0.8%	1.1%
Solidago	*canadensis*	Canada goldenrod	4	0.1%	0.0%
Sorgastrum	*nutans*	Indian grass	4	T	0.0%
Taraxacum	*officinale*	common dandelion	4	0.1%	T
Bromus	*inermis*	smooth brome	5	0.0%	T
Chenopodium	*berlandieri*	pitseed goosefoot	5	0.7%	1.8%
Sanicula	*canadensis*	black snakeroot	5	0.0%	T
Tridens	*flavus*	purpletop	5	0.0%	1.8%
Ulmus	*pumila*	Siberian elm	5	T	0.0%
Bareground				3.6%	1.7%
TOTAL				100.0%	100.0%
AVERAGE WETLAND VALUE				2.88	2.99

1 = Obligate Wetland Species; 2 = Facultative Wetland Species; 3 = Facultative Species;
4 = Facultative Upland Species; 5 = Upland Species.
T = trace species with less than 0.05% cover.

KDOT Emporia Wet Transect 1997

Genus	Species	Common Name	Wetland Index	Spring	Fall
Ammannia	*coccinea*	red toothcup	1	T	0.1%
Bidens	*cernua*	nodding beggar-ticks	1	0.0%	T
Carex	*hyalinolepis*	shoreline sedge	1	2.2%	2.0%
Carex	*pellita*	sedge	1	0.8%	T
Cephalanthus	*occidentalis*	buttonbush	1	0.7%	0.7%
Cyperus	*acuminatus*	tapeleaf sedge	1	7.3%	15.5%
Eleocharis	*macrostachya*	spikerush	1	42.6%	37.9%
Leersia	*oryzoides*	rice cutgrass	1	1.3%	1.5%
Marsilea	*vestita*	western water-clover	1	T	0.0%
Polygonum	*amphibium*	swamp smartweed	1	1.0%	0.7%
Sagittaria	*latifolia*	common arrowhead	1	0.9%	0.0%
Salix	*exigua*	sandbar willow	1	0.7%	0.0%
Salix	*nigra*	black willow	1	0.0%	0.1%
Scirpus	*validus*	bulrush	1	0.0%	0.6%
Veronica	*peregrina*	water speedwell	1	0.1%	0.0%
Amaranthus	*rudis*	tall amaranth	2	0.3%	T
Ambrosia	*trifida*	giant ragweed	2	T	0.1%
Aster	*praealtus*	willow-leaved aster	2	2.1%	1.2%
Boltonia	*asteroides*	violet boltonia	2	4.0%	5.2%
Echinochloa	*crusgalli*	barnyardgrass	2	1.7%	12.8%
Ipomoea	*lacunosa*	white morning-glory	2	0.0%	0.1%
Polygonum	*bicorne*	longstyle smartweed	2	1.1%	1.0%
Rumex	*crispus*	curly dock	2	0.2%	1.5%
Apocynum	*cannabinum*	Indian hemp dogbane	3	T	0.0%
Carex	*brevior*	fescue sedge	3	T	1.2%
Elymus	*virginicus*	Virginia wildrye	3	T	0.0%
Iva	*annua*	annual sumpweed	3	1.2%	4.1%
Juncus	*interior*	inland rush	3	0.2%	0.0%
Panicum	*dichotomiflorum*	fall panicum	3	0.0%	2.0%
Polygonum	*ramosissimum*	bush knotweed	3	0.0%	0.1%
Populus	*deltoides*	plains cottonwood	3	3.6%	5.0%
Rumex	*altissimus*	pale dock	3	4.1%	0.0%
Setaria	*glauca*	yellow foxtail	3	0.0%	0.2%
Viola	*pratincola*	meadow violet	3	0.1%	0.3%
Aster	*pilosus*	hairy aster	4	0.4%	0.1%
Desmanthus	*illinoensis*	Illinois bundleflower	4	T	0.1%
Euphorbia	*maculata*	spotted spurge	4	0.0%	T
Helianthus	*annuus*	common sunflower	4	T	1.7%
Abutilon	*theophrasti*	velvet-leaf	5	0.0%	T
Cuscuta	*glomerata*	dodder	5	0.3%	0.1%
Digitaria	*ischaemum*	smooth crabgrass	5	0.0%	0.7%
Euphorbia	*stictospora*	mat spurge	5	0.0%	T
Euphorbia	*corollata*	flowering spurge	5	0.0%	T
Lespedeza	*cuneata*	Chinese bush clover	5	0.0%	0.1%
Lespedeza	*sericeus*	bush clover	5	T	0.0%
Muhlenbergia	*cuspidata*	plains muhly	5	0.5%	0.9%
Oxalis	*stricta*	common wood sorrel	5	1.9%	T
Physalis	*longifolia*	common groundcherry	5	0.2%	0.2%
Solanum	*carolinense*	Carolina horse nettle	5	0.3%	0.1%
Bareground				20.0%	2.2%
TOTAL				100.0%	100.0%
AVERAGE WETLAND VALUE				1.53	1.63

1 = Obligate Wetland Species; 2 = Facultative Wetland Species; 3 = Facultative Species;
4 = Facultative Upland Species; 5 = Upland Species.
T = trace species with less than 0.05% cover.

KDOT Emporia Dry Transect 1997

Genus	Species	Common Name	Wetland Index	Spring	Fall
Carex	*hyalinolepis*	shoreline sedge	1	4.3%	0.3%
Cephalanthus	*occidentalis*	buttonbush	1	0.0%	T
Cyperus	*acuminatus*	tapeleaf sedge	1	1.5%	0.0%
Eleocharis	*macrostachya*	spikerush	1	2.3%	0.6%
Leersia	*oryzoides*	rice cutgrass	1	0.0%	T
Marsilea	*vestita*	western water-clover	1	0.0%	1.2%
Polygonum	*amphibium*	swamp smartweed	1	0.2%	1.1%
Sagittaria	*latifolia*	common arrowhead	1	0.0%	T
Salix	*exigua*	sandbar willow	1	0.0%	T
Salix	*nigra*	black willow	1	0.0%	0.1%
Veronica	*peregrina*	water speedwell	1	0.2%	0.0%
Amaranthus	*rudis*	tall amaranth	2	0.6%	0.0%
Ambrosia	*trifida*	giant ragweed	2	0.9%	0.0%
Aster	*praealtus*	willow-leaved aster	2	11.2%	0.0%
Boltonia	*asteroides*	violet boltonia	2	3.3%	0.0%
Echinochloa	*crusgalli*	barnyardgrass	2	2.7%	1.5%
Ipomoea	*lacunosa*	white morning-glory	2	T	11.0%
Polygonum	*bicorne*	longstyle smartweed	2	3.1%	2.2%
Rorippa	*sinuata*	spreading yellowcress	2	T	2.4%
Rumex	*crispus*	curly dock	2	0.1%	2.2%
Apocynum	*cannabinum*	Indian hemp dogbane	3	T	T
Carex	*annectens*	yellowfruit sedge	3	0.9%	0.0%
Carex	*brevior*	fescue sedge	3	2.1%	T
Elymus	*virginicus*	Virginia wildrye	3	0.6%	0.2%
Eragrostis	*frankii*	sandbar lovegrass	3	0.0%	2.3%
Hordeum	*pusillum*	little barley	3	T	0.3%
Iva	*annua*	annual sumpweed	3	17.3%	18.0%
Lactuca	*serriola*	prickly lettuce	3	0.1%	0.1%
Lepidium	*densiflorum*	peppergrass	3	0.4%	0.0%
Panicum	*capillare*	common witchgrass	3	0.1%	T
Paspalum	*laeve*	field paspalum	3	0.2%	T
Polygonum	*ramosissimum*	bush knotweed	3	0.2%	0.7%
Populus	*deltoides*	plains cottonwood	3	1.4%	0.6%
Rumex	*altissimus*	pale dock	3	T	0.2%
Setaria	*glauca*	yellow foxtail	3	0.0%	1.5%
Triodanis	*perfoliata*	Venus' looking glass	3	T	3.5%
Viola	*pratincola*	meadow violet	3	0.1%	0.3%
Allium	*canadense*	wild onion	4	T	0.0%
Aster	*pilosus*	hairy aster	4	6.6%	5.3%
Bromus	*japonicus*	Japanese brome	4	0.9%	0.4%
Conyza	*canadensis*	Canada horseweed	4	0.0%	T
Desmanthus	*illinoensis*	Illinois bundleflower	4	3.9%	6.3%
Erigeron	*annuus*	annual fleabane	4	0.1%	T
Euphorbia	*maculata*	spotted spurge	4	0.1%	0.1%
Helianthus	*annuus*	common sunflower	4	1.1%	0.6%
Poa	*pratensis*	Kentucky bluegrass	4	T	0.0%
Sorgastrum	*nutans*	Indian grass	4	0.2%	0.4%
Sporobolus	*asper*	rough dropseed	4	10.7%	6.1%
Sporobolus	*vaginiflorus*	povertygrass	4	T	7.3%
Chenopodium	*berlandieri*	pitseed goosefoot	5	T	0.0%
Cuscuta	*glomerata*	dodder	5	0.1%	0.1%
Digitaria	*ischaemum*	smooth crabgrass	5	0.1%	0.2%
Euphorbia	*cyathophora*	fire on the mountain	5	0.0%	T
Euphorbia	*dentata*	toothed spurge	5	T	0.0%
Euphorbia	*missurica*	Missouri spurge	5	T	0.0%
Euphorbia	*stictospora*	mat spurge	5	0.0%	T
Hibiscus	*trionum*	flower-of-an-hour	5	T	0.0%
Lespedeza	*cuneata*	Chinese bush clover	5	0.1%	0.0%
Lithospermum	*arvense*	puccoon	5	T	0.0%
Oenothera	*speciosa*	showy white evening primrose	5	0.1%	0.0%
Oxalis	*dillenii*	green wood sorrel	5	0.1%	0.0%
Physalis	*longifolia*	common groundcherry	5	T	T
Pyrrhopappus	*carolinianus*	false dandelion	5	T	0.0%
Silene	*antirrhina*	sleepy catchfly	5	T	2.2%
Solanum	*carolinense*	Carolina horse nettle	5	T	0.0%
Bareground				21.8%	14.0%
TOTAL				100.0%	100.0%
AVERAGE WETLAND VALUE				2.82	2.85

1 = Obligate Wetland Species; 2 = Facultative Wetland Species; 3 = Facultative Species;
4 = Facultative Upland Species; 5 = Upland Species.
T = trace species with less than 0.05% cover.

KDOT Lawrence Wet Transect 1997

Genus	Species	Common Name	Wetland Index	Spring	Fall
Ammannia	coccinea	red toothcup	1	0.0%	0.7%
Cyperus	acuminatus	tapeleaf sedge	1	0.0%	T
Echinochloa	muricata	prickly barnyardgrass	1	0.0%	15.0%
Echinodurus	rostratus	burhead	1	0.1%	0.0%
Eleocharis	macrostachya	longstem spikesedge	1	4.8%	2.8%
Geum	macrophylla	white avens	1	0.1%	0.0%
Lemna	minor	lesser duckweed	1	10.1%	0.0%
Lippia	lanceolata	lanceleaf frogfruit	1	0.3%	3.9%
Ludwigia	palustris	water purslane	1	0.2%	5.6%
Sagittaria	latifolia	common arrowhead	1	76.2%	7.8%
Alopecurus	virginianus	carolina foxtail	2	0.2%	0.0%
Amaranthus	rudis	water hemp	2	0.0%	0.4%
Cyperus	strigosus	false nutsedge	2	0.0%	17.2%
Hordeum	jubatum	foxtail barley	2	0.5%	0.0%
Ipomoea	lacunosa	white morning-glory	2	0.0%	0.1%
Polygonum	pensylvanicum	Pennsylvania smartweed	2	0.0%	0.7%
Solidago	gigantea	giant goldenrod	2	T	0.0%
Andropogon	gerardii	big bluestem	3	T	0.0%
Panicum	dichotomiflorum	fall panicum	3	0.0%	0.3%
Xanthium	strumarium	common cocklebur	3	0.0%	T
Melilotus	alba	white sweet clover	4	6.1%	0.0%
Bare ground, litter, and water				1.3%	45.5%
TOTAL				100.0%	100.0%
AVERAGE WETLAND VALUE				1.19	1.35

1 = Obligate Wetland Species; 2 = Facultative Wetland Species; 3 = Facultative Species;
4 = Facultative Upland Species; 5 = Upland Species.
T = trace species with less than 0.05% cover.

KDOT Lawrence Dry Transect 1997

Genus	Species	Common Name	Wetland Index	Spring	Fall
Ammannia	coccinea	red toothcup	1	T	0.5%
Cyperus	acuminatus	tapeleaf sedge	1	0.2%	0.3%
Echinochloa	muricata	prickly barnyardgrass	1	1.5%	3.6%
Eleocharis	macrostachya	longstem spikesedge	1	0.0%	1.7%
Eleocharis	obtusa	spikerush	1	9.6%	12.6%
Ipomoea	lacunosa	white morning-glory	1	0.0%	T
Leersia	oryzoides	rice cutgrass	1	1.8%	4.0%
Lemna	minor	lesser duckweed	1	3.7%	0.0%
Lindernia	dubia	yellow false pimpernel	1	0.0%	0.2%
Lippia	lanceolata	lanceleaf frogfruit	1	0.0%	0.1%
Ludwigia	palustris	water purslane	1	T	0.0%
Penthorum	sedoides	ditch stonecrop	1	0.0%	2.0%
Polygonum	amphibium	swamp smartweed	1	0.0%	0.8%
Polygonum	hydropiperoides	mild water-pepper smartweed	1	T	0.0%
Ranunculus	sceleratus	cursed buttercup	1	0.4%	0.0%
Rorippa	palustris	bog yellowcress	1	0.0%	T
Sagittaria	latifolia	common arrowhead	1	5.5%	0.0%
Scirpus	atrovirens	green bulrush	1	1.1%	0.6%
Veronica	peregrina	water speedwell	1	0.2%	0.0%
Alopecurus	carolinianus	Carolina foxtail	2	2.3%	0.3%
Amaranthus	rudis	water hemp	2	0.0%	T
Bidens	polylepis	beggarstick	2	42.3%	52.8%
Boltonia	asteroides	white boltonia	2	0.2%	3.3%
Cyperus	strigosus	false nutsedge	2	T	4.5%
Helenium	autumnale	common sneezeweed	2	0.1%	0.3%
Polygonum	pensylvanicum	Pennsylvania smartweed	2	1.7%	4.4%
Rumex	crispus	curly dock	2	1.4%	0.1%
Spartina	pectinata	prairie cordgrass	2	0.0%	0.7%
Apocynum	cannabinum	hemp dogbane	3	0.9%	0.0%
Carex	annectens	yellowfruit sedge	3	0.8%	1.6%
Iva	annua	annual sumpweed	3	0.1%	0.2%
Panicum	dichotomiflorum	fall panicum	3	T	4.4%
Panicum	virgatum	switchgrass	3	0.1%	T
Rumex	altissimus	pale dock	3	T	0.1%
Setaria	glauca	yellow foxtail	3	0.0%	T
Tripsacum	dactyloides	eastern gammagrass	3	0.0%	T
Acalypha	virginica	Virginia copperleaf	4	0.0%	0.1%
Acer	saccharum	sugar maple	4	T	T
Aster	pilosus	hairy aster	4	0.0%	T
Bromus	japonicus	Japanese brome	4	T	0.0%
Helianthus	annuus	common sunflower	4	T	0.0%
Sorghastrum	nutans	Indiangrass	4	T	0.0%
Trifolium	hybridum	Alsike clover	4	7.0%	0.0%
Trifolium	repens	white clover	4	0.0%	0.1%
Bareground				19.1%	0.6%
TOTAL				100.0%	100.0%
AVERAGE WETLAND VALUE				1.90	1.80

1 = Obligate Wetland Species; 2 = Facultative Wetland Species; 3 = Facultative Species;
4 = Facultative Upland Species; 5 = Upland Species.
T = trace species with less than 0.05% cover.

KDOT Kingman Wet Transect 1997

Genus	Species	Common Name	Wetland Index	Spring	Fall
Ammannia	*coccinea*	red toothcup	1	0.1%	0.1%
Aster	*subulatus*	saltmarsh aster	1	0.1%	0.2%
Bidens	*cemua*	devil's beggartick	1	17.2%	11.1%
Boehmeria	*cylindrica*	bog hemp	1	0.1%	0.0%
Carex	*stipata*	owl fruit sedge	1	13.1%	0.0%
Carex	*hystericina*	bottlebrush sedge	1	0.9%	16.1%
Eleocharis	*erythropoda*	spikerush	1	2.3%	3.5%
Epilobium	*coloratum*	purple-leaved willow herb	1	0.1%	T
Leersia	*oryzoides*	rice cutgrass	1	3.9%	5.8%
Lemna	*minor*	lesser duckweed	1	T	0.0%
Lippia	*lanceolata*	lanceleaf frogfruit	1	5.8%	7.7%
Ludwigia	*palustris*	water purslane	1	0.0%	1.7%
Ludwigia	*peploides*	marsh seedbox	1	2.4%	0.0%
Lycopus	*virginicus*	Virginia bugleweed	1	1.2%	0.3%
Polygonum	*amphibium*	swamp smartweed	1	0.2%	0.2%
Ranunculus	*sceleratus*	cursed buttercup	1	3.4%	0.1%
Sagittaria	*latifolia*	common arrowhead	1	8.2%	1.2%
Salix	*exigua*	sandbar willow	1	2.8%	0.3%
Salix	*nigra*	black willow	1	0.0%	0.2%
Sparganium	*eurycarpum*	giant bur-reed	1	1.3%	0.9%
Typha	*angustifolia*	narrow-leaved cattail	1	5.8%	5.8%
Typha	*latifolia*	common cattail	1	3.2%	4.0%
Agalinis	*tenuifolia*	slender false-foxglove	2	0.1%	0.0%
Ambrosia	*trifida*	giant ragweed	2	0.3%	0.1%
Aster	*praealtus*	willow-leaved aster	2	0.0%	0.6%
Aster	*simplex*	panicled aster	2	0.3%	0.0%
Conium	*maculatum*	poison hemlock	2	T	0.0%
Cyperus	*esculentus*	nutsedge	2	0.2%	0.3%
Echinochloa	*crusgalli*	barnyardgrass	2	1.8%	3.7%
Eclipta	*prostrata*	yerba de tajo	2	0.1%	0.1%
Hordeum	*jubatum*	foxtail barley	2	T	0.0%
Juncus	*torreyi*	Torrey's rush	2	0.1%	T
Polygonum	*bicome*	longstyle smartweed	2	1.0%	0.0%
Polygonum	*hydropiperoides*	pepper smartweed	2	7.2%	17.5%
Rumex	*crispus*	curly dock	2	0.4%	0.1%
Apocynum	*cannabinum*	Indian hemp dogbane	3	0.1%	0.4%
Erechtites	*hieracifolia*	American burnweed	3	0.1%	0.0%
Iva	*annua*	annual sumpweed	3	1.5%	0.5%
Juncus	*dudleyi*	Dudley's rush	3	0.1%	0.0%
Morus	*alba*	white mulberry	3	0.0%	T
Panicum	*capillare*	common witchgrass	3	0.1%	1.7%
Panicum	*dichotomiflorum*	fall panicum	3	0.0%	3.0%
Panicum	*virgatum*	switchgrass	3	1.6%	2.2%
Populus	*deltoides*	plains cottonwood	3	1.7%	1.0%
Xanthium	*strumarium*	common cocklebur	3	5.5%	0.2%
Bromus	*japonicus*	Japanese brome	4	0.1%	T
Conyza	*canadensis*	Canada horseweed	4	0.0%	T
Galium	*aparine*	catchweed bedstraw	4	2.7%	0.0%
Geum	*canadense*	white avens	4	T	0.0%
Polygonum	*scandens*	false buckwheat	4	0.8%	0.1%
Solidago	*canadensis*	Canada goldenrod	4	0.3%	0.5%
Carex	*sp.*	sedge	5	T	0.0%
Cirsium	*altissimum*	tall thistle	5	0.4%	0.1%
Bare ground				1.4%	8.8%
TOTAL				100.0%	100.0%
AVERAGE WETLAND VALUE				1.79	1.70

1 = Obligate Wetland Species; 2 = Facultative Wetland Species; 3 = Facultative Species;
4 = Facultative Upland Species; 5 = Upland Species.
T = trace species with less than 0.05% cover.

KDOT Kingman Dry Transect 1997

Genus	Species	Common	Wetland Index	Spring	Fall
Amorpha	*fruticosa*	false indigo	1	3.2%	1.6%
Aster	*subulatus*	saltmarsh aster	1	0.1%	0.7%
Bidens	*cernua*	nodding beggar-ticks	1	13.9%	16.5%
Boehmeria	*cylindrica*	bog hemp	1	3.7%	4.5%
Carex	*stipata*	owlfruit sedge	1	1.7%	0.2%
Cicuta	*maculata*	water hemlock	1	0.1%	0.1%
Cyperus	*acuminatus*	tapeleaf sedge	1	0.0%	T
Eleocharis	*erythropoda*	spikerush	1	1.0%	T
Epilobium	*coloratum*	purple-leaved willow herb	1	0.0%	2.7%
Eupatorium	*perfoliatum*	boneset	1	T	0.0%
Leersia	*oryzoides*	rice cutgrass	1	4.3%	6.8%
Leucospora	*multifida*	narrow-leaf paleseed	1	T	0.2%
Lippia	*lanceolata*	lanceleaf frogfruit	1	17.9%	16.4%
Ludwigia	*palustris*	water purslane	1	T	0.1%
Lycopus	*virginicus*	Virginia bugleweed	1	0.3%	0.3%
Ranunculus	*sceleratus*	cursed buttercup	1	3.0%	0.1%
Sagittaria	*latifolia*	common arrowhead	1	2.4%	0.2%
Salix	*exigua*	sandbar willow	1	4.2%	2.8%
Scirpus	*acutus*	hardstem bulrush	1	1.0%	0.6%
Scirpus	*pungens*	hardstem bulrush	1	0.4%	0.7%
Scutellaria	*lateriflora*	blue skullcap	1	0.0%	2.6%
Typha	*angustifolia*	narrow-leaved cattail	1	0.1%	0.4%
Typha	*latifolia*	common cattail	1	12.0%	9.4%
Agalinis	*tenuifolia*	slender false-foxglove	2	0.5%	0.4%
Amaranthus	*rudis*	tall amaranth	2	0.1%	T
Ambrosia	*trifida*	giant ragweed	2	12.7%	7.5%
Aster	*praealtus*	willow-leaved aster	2	T	0.0%
Cyperus	*esculentus*	nutsedge	2	0.0%	0.1%
Echinochloa	*crusgalli*	barnyardgrass	2	0.3%	2.2%
Eclipta	*prostrata*	yerba de tajo	2	0.0%	0.1%
Helianthus	*grosseserratus*	sawtooth sunflower	2	T	0.0%
Polygonum	*bicorne*	longstyle smartweed	2	0.9%	0.0%
Polygonum	*hydropiperoides*	pepper smartweed	2	0.1%	2.4%
Rorippa	*sinuata*	spreading yellowcress	2	T	0.0%
Rumex	*crispus*	curly dock	2	0.2%	2.0%
Solidago	*gigantea*	late goldenrod	2	0.2%	T
Verbena	*hastata*	blue verbena	2	T	0.0%
Carex	*blanda*	eastern woodland sedge	3	0.0%	0.4%
Cornus	*drummondii*	roughleaf dogwood	3	0.4%	0.2%
Iva	*annua*	annual sumpweed	3	1.5%	T
Juncus	*dudleyi*	Dudley's rush	3	0.2%	T
Juncus	*tenuis*	path rush	3	1.5%	0.2%
Lactuca	*ludoviciana*	western wild lettuce	3	0.0%	T
Lactuca	*serriola*	prickly lettuce	3	0.0%	T
Morus	*alba*	white mulberry	3	0.0%	T
Panicum	*capillare*	common witchgrass	3	0.1%	3.6%
Panicum	*virgatum*	switchgrass	3	0.0%	T
Parthenocissus	*quinquefolia*	Virginia creeper	3	0.0%	T
Populus	*deltoides*	plains cottonwood	3	4.3%	4.3%
Rumex	*altissimus*	pale dock	3	0.2%	0.1%
Sambucus	*canadensis*	elderberry	3	0.6%	1.0%
Ulmus	*rubra*	slippery elm	3	T	0.0%
Vernonia	*fasciculata*	western ironweed	3	0.2%	0.1%
Vitis	*riparia*	river-bank grape	3	T	T
Xanthium	*strumarium*	common cocklebur	3	0.1%	T
Bromus	*japonicus*	Japanese brome	4	0.2%	0.0%
Desmanthus	*illinoensis*	Illinois bundleflower	4	0.0%	T
Galium	*aparine*	catchweed bedstraw	4	0.8%	0.0%
Geum	*canadense*	white avens	4	0.1%	T
Helianthus	*annuus*	common sunflower	4	T	0.0%
Juniperus	*virginiana*	red cedar	4	T	T
Solidago	*canadensis*	Canada goldenrod	4	0.9%	1.5%
Toxicodendron	*radicans*	poison ivy	4	0.0%	T
Abutilon	*theophrasti*	velvet-leaf	5	0.0%	T
Carex	*sp.*	sedge	5	T	0.0%
Cirsium	*altissimum*	tall thistle	5	0.1%	0.1%
Helianthus	*maximilianii*	Maximillian sunflower	5	0.0%	0.3%
Torilis	*arvensis*	hedge parsley	5	0.1%	0.0%
Bareground				4.2%	6.6%
TOTAL				100.0%	100.0%
AVERAGE WETLAND VALUES				1.42	1.43

1 = Obligate Wetland Species; 2 = Facultative Wetland Species; 3 = Facultative Species;
4 = Facultative Upland Species; 5 = Upland Species.
T = trace species with less than 0.05% cover.

KDOT Medicine Lodge Transect 1997

Genus	Species	Common Name	Wetland Index	Spring	Fall
Ammania	*auriculata*	toothcup	1	T	4.2%
Aster	*subulatus*	saltmarsh aster	1	0.0%	2.2%
Cyperus	*acuminatus*	tapeleaf sedge	1	T	0.1%
Lippia	*lanceolata*	lanceleaf frogfruit	1	T	0.0%
Polygonum	*lapathifolium*	pale smartweed	1	0.0%	3.5%
Scirpus	*pungens*	hardstem bulrush	1	33.3%	85.3%
Aster	*simplex*	panicled aster	2	0.3%	0.0%
Cyperus	*strigosus*	large nutsedge	2	0.0%	1.4%
Echinochloa	*crusgalli*	barnyardgrass	2	0.0%	0.1%
Polygonum	*bicorne*	longstyle smartweed	2	0.4%	0.0%
Iva	*annua*	annual sumpweed	3	0.1%	0.1%
Panicum	*capillare*	common witchgrass	3	0.0%	T
Polygonum	*ramosissimum*	bush knotweed	3	0.9%	0.3%
Rumex	*altissimus*	pale dock	3	T	0.0%
Plantago	*virginica*	pale-seeded plantain	4	T	0.0%
Bareground				64.9%	2.9%
TOTAL				100.0%	100.0%
AVERAGE WETLAND VALUES				1.08	1.02

1 = Obligate Wetland Species; 2 = Facultative Wetland Species; 3 = Facultative Species;
4 = Facultative Upland Species; 5 = Upland Species.
T = trace species with less than 0.05% cover.