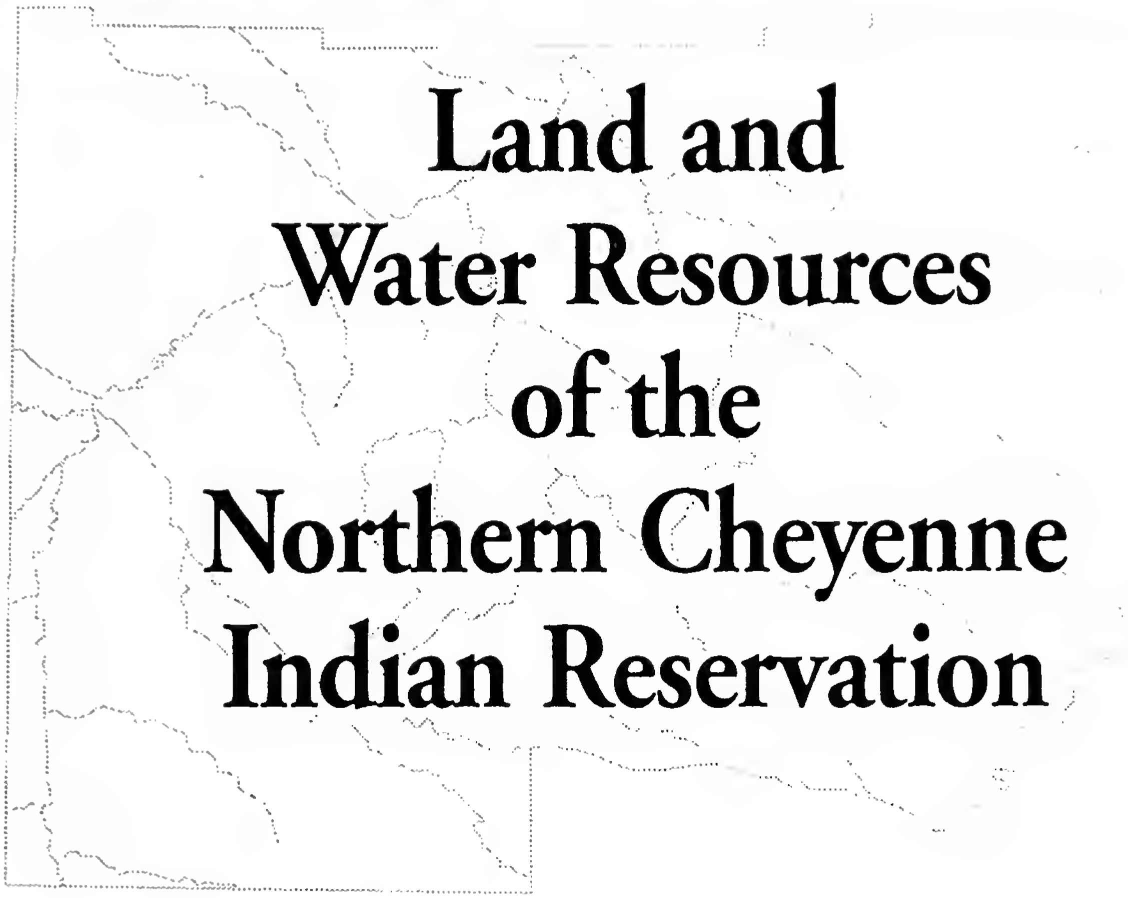

Land and Water Resources of the Northern Cheyenne Indian Reservation

STAFF REPORT

Presented to the

MONTANA RESERVED WATER RIGHTS COMPACT COMMISSION

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Marcia Beebe Rundle, Counsel/Program Manager

Susan Cottingham, Technical Team Leader

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This report contains memoranda prepared by the staff of the Montana Reserved Water Rights Compact Commission, evaluating the practicality of irrigation on the Northern Cheyenne Reservation. This evaluation is a necessary component of the quantification of the Tribe's reserved water right. The memoranda include analyses of arable land, water availability, economics, and engineering designs, all of which were performed independently of analyses by the Tribe or the federal government. The report also describes extensive data input to the Geographic Information System and computerized evaluations of the hydrology of the Reservation.

Staff members whose work is presented in this report include Arial Anderson, Soil Scientist; Craig Bacino, Geographer; Scott Freburg, GIS Specialist; Bill Greiman, Agricultural Engineer; Bob Levitan, Hydrologist; and Igor Suchomel, Hydrologist. Previous RWRCC or DNRC staff whose work was reviewed and, in some cases, incorporated into the report include Greg Ames, Lynda Saul, Steve Holnbeck, Nancy Granger, Glenn Smith and Earl Griffith. Susan Cottingham coordinated the research and analysis of technical issues described in this report.

My personal thanks for the patience, good humor, and skills of Mary Bertagnolli, Danette Hayek, and Marilyn Richardson, who typed drafts, redrafts, and final copies of these memos, to James Madden for his assistance and counsel, and to Carole Massman and Dan Vichorek for their editorial expertise. A separate document analyzes the legal and historical bases for the Northern Cheyenne claims.

Marcia Beebe Rundle
Counsel/Program Manager

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I. INTRODUCTION

In 1908, the U.S. Supreme Court first enunciated the doctrine of an implied reserved water right for Indian reservations. U.S. v. Winters, 207 U.S. 564 (1908). Not until much later, however, did the Supreme Court establish a standard by which to quantify the federal reserved water rights for Indian reservations. In 1963, the Supreme Court adopted the "practicably irrigable acreage" (PIA) standard for Indian reservations established for agricultural purposes. Arizona v. California, 373 U.S. 546 (1963). The PIA standard was most recently applied by the state courts of Wyoming and affirmed by the United States Supreme Court. Wyoming v. U.S., 109 S.Ct. 2994 (1989). The analyses employed by the staff of the Compact Commission, and reported in this document, constitute a modified PIA analysis, which we refer to as a feasibly irrigable lands (FIL) analysis.

A. Background of Negotiations

The Northern Cheyenne Tribe was among the first tribes in Montana to agree to participate in negotiations to settle water rights issues between the Tribe and the State. In a letter dated February 28, 1980, Allan Rowland, President of the Northern Cheyenne Tribal Council, informed Henry Loble, Chairman of the Compact Commission, that the Council had appointed a team of tribal council members and tribal attorneys to represent them in discussions with the Compact Commission.

At the time, federal courts had ruled that federal and Indian reserved rights in Montana were to be quantified in the state's adjudication-negotiation process. In 1975 the Northern Cheyenne Tribe had requested Montana's federal district court to adjudicate water rights in the Tongue River and Rosebud Creek[1]. The same year, the United States filed a federal suit on its own behalf and as fiduciary for the Tribe[2]. The cases were stayed pending the United States Supreme Court's determination whether Indian reserved rights were to be adjudicated in federal or state court. Colorado River Water Conservation District v. United States, 424 U.S. 800 (1976).

In 1979, based on Colorado River, Montana's federal district courts dismissed the Tribal suits in favor of the state forum. This ruling was ultimately upheld by the United States Supreme Court in Arizona v. San Carlos Apache Tribe, 463 U.S. 545 (1983)[3]. While San Carlos was pending, the Tribe and the BIA on behalf of the Tribe filed eleven claims for water rights with the Montana Water Court, although filing is statutorily suspended while negotiations are in progress. Section 85-2-217, Montana Code Annotated.

For over two years, discussions were held between the State and Tribe on a wide range of issues related to both the process of negotiations and the substantive issues involved in the Northern Cheyenne claims to water in the Tongue and Rosebud drainages of southeastern Montana. The Commission staff acquired a considerable amount of data and began analyses of the land and water resources of the reservation. At the same time, the United States Bureau of Reclamation and the Montana Department of Natural Resources and Conservation were engaged in feasibility studies for rehabilitating the Tongue River Dam.

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[1] Northern Cheyenne Tribe v. Tongue River Water Users' Ass'n, 484 F. Supp 31 (D. Mont. 1979).

[2] United States v. Tongue River Water Users' Ass'n, No. CV-75-20 (D. Mont. filed March 7, 1975.). The United States also filed suit on behalf of the Crow Tribe. United States v. Big Horn Low Line Canal, No. CV-75-34 (D. Mont. filed April 17, 1975).

[3] The supreme Court reversed and remanded to the Ninth Circuit, which had held in favor of the federal forum. Northern Cheyenne Tribe v. Adsit, 668 F.2d 1080 (9th Cir. 1982). On remand, the Ninth Circuit stayed all proceedings in the Montana federal actions pending the outcome of the state court proceedings. Northern Cheyenne Tribe v. Adsit, 721 F.2d 1187 (9th Cir. 1983).

For a comprehensive discussion of this issue, See MacIntyre, Quantification of Indian Reserved Water Right in Montana: State ex. rel. Greely in the Footsteps of San Carlos Apache Tribe, 8 Public Land Law Review 33 (1987). See also, MacIntyre, The Adjudication of Montana's Water—A Blueprint for Improving the Judicial Structure, 49 Mont. Law Rev. 211, 229 (1988).

While these technical studies were underway, the Commission focused its efforts on negotiations with the Assiniboine and Sioux Tribes of the Fort Peck Reservation. In May of 1985 the Fort Peck-Montana Compact was signed into law and the Commission again turned its attention to the Northern Cheyenne.

When the Compact Commission and the Northern Cheyenne met again in October of 1985, the attorneys for the Tribe agreed to draft a settlement proposal to submit to the Compact Commission. The Tribe's proposal for quantification of its reserved water rights was received in October of 1988. Meanwhile, in 1987, the legislature mandated that the Commission focus its work on negotiations in the Milk River Basin, to the maximum extent practicable. In 1989, the Commission obtained increased funding from the legislature and authorization for additional personnel on the staff of the Commission, so that the Commission could respond to the Northern Cheyenne proposal without neglecting the mandate to work on the Milk River Basin.

In March 1989, the RWRCC and Tribe agreed to try to have a water rights compact ready for ratification by the 1991 Montana Legislature. Ratification of water rights compacts is required by state statute. Section 85-2-702, Montana Code Annotated. In the spring and summer of 1989, the RWRCC resumed legal and historical analyses of the tribal claims. Initial responses to the Northern Cheyenne proposal on key issues of priority date and reservation purpose were sent to the Tribe in October.

As new technical staff members were hired and trained, the work of the former staff was reviewed and updated, additional background information was obtained, and plans for a comprehensive technical review were developed. The first four months of 1990 were devoted to intensive analyses of the land and water resources of the Northern Cheyenne Reservation. On May 1, 1990, the Reserved Water Rights Compact Commission responded to the Tribe's proposal with a counterproposal developed by the negotiating team with knowledge of the results of the technical work discussed in this report.

B. Summary of Technical Analyses

To estimate the amount of water necessary to fulfill the present and potential future agricultural needs of the Northern Cheyenne Reservation, the technical staff employed a four-part procedure: geographic data computerization, classification of soils and arable land, assessment of water availability, and engineering design of economically feasible irrigation systems.

The staff of the Compact Commission uses a Geographic Information System (GIS) for spatial analyses. Geographic Information Systems are used to store, retrieve, manipulate and analyze resource data (ie. soils, hydrologic, engineering, agricultural). A GIS enables the user to overlay separate types of resource data for a particular area. The user can then identify relationships between natural features and man-made developments, compare past, existing and potential conditions and model present conditions that could affect future management.

The initial evaluation began with a survey of available information from previous staff work, library sources and other agencies. Information on soils, land use and land ownership, along with other types of data, were entered into the GIS as base information for maps, overlays and statistics to aid decision-making.

The staff soils scientist evaluated soil types on the reservation and classified them as to whether they were physically capable of producing crops under sustained irrigation. The agricultural engineer then used this soil information to determine where irrigation would be feasible, based on engineering and economic criteria.

The staff hydrologist evaluated streamflow and groundwater data to determine the amount of water actually available in the relevant basins. Scenarios were developed for the different levels of irrigation that would result from different water use efficiencies.

On the Tongue River, the staff concluded that 4,027 acres could be irrigated on the Reservation, with a cost benefit ratio of 1:1 or better. RWRCC's negotiating team accepted this ratio as a criterion of an economically feasible irrigation system. The amount of water necessary to irrigate these projects was estimated to be 10,497 acre feet per year. Little of this acreage is being irrigated at the present.

On the Rosebud, a complete FIL analysis was not performed because sufficient water was not available. A preliminary engineering review determined that any currently nonirrigated land could only be served by partial service irrigation, which most likely would be uneconomical.

II. RWRCC GEOGRAPHIC INFORMATION SYSTEM

A. History of RWRCC Geographic Information System

The Compact Commission purchased its first land management system, a Linear Measurement Set (LMS), in 1982-83. The LMS consisted of an Apple II computer, color monitor, video camera, light table, linear measuring tablet and printer. This system analyzed aerial photography to determine geographic and hydrologic information concerning arable and irrigated lands.

In 1986 it became apparent to the RWRCC staff that the LMS was outdated and that a more accurate system would be required to effectively analyze natural resource information for the Compact Commission. After considerable research, a geographic information hardware/software system was selected that would enhance staff efficiency and functionality. This system has become known as the Reserved Water Rights Compact Commission Geographic Information System (RWRCC-GIS).

B. GIS Capabilities

As discussed in Chapter I, Geographic Information Systems (GIS) store, retrieve, manipulate and analyze resource data in a digital format. This type of system enables the RWRCC staff to relate different types of spatial data, to identify spatial relationships, model existing data for the interpretation of "what if..." scenarios and to compare past, present and potential conditions. The GIS can generate maps that provide concise visual representations of geographic information that are required when working in negotiation scenarios. This system also allows modeling and analyzing alternative assumptions before final decisions are made.

A large amount of data manipulation is required to provide RWRCC members with the most concise, accurate and up-to-date scenarios for making decisions in the negotiation of federal and Indian reserved water rights in Montana. The RWRCC has used a GIS since 1987 to analyze land and water resource information related to federal and Indian reservations.

The RWRCC-GIS was used to evaluate the reserved water rights for the Northern Cheyenne Reservation. Information compiled by the RWRCC or received from outside sources and stored in the RWRCC-GIS included polygonal data (such as soils and lakes), linear data (roads, streams and canals), and point data (wells, springs and stream gages).

C. Database

The database created for the Northern Cheyenne analysis was developed in sections and each section was based on 1:24,000 base topographic maps. The Northern Cheyenne Indian Reservation encompasses an area of approximately 445,000 acres and 27 sectional 1:24,000 quadrangles. Mylar maps were used to avoid the amount of distortion that is inherent in paper maps. This sectional design and scale provided easy data accessibility.

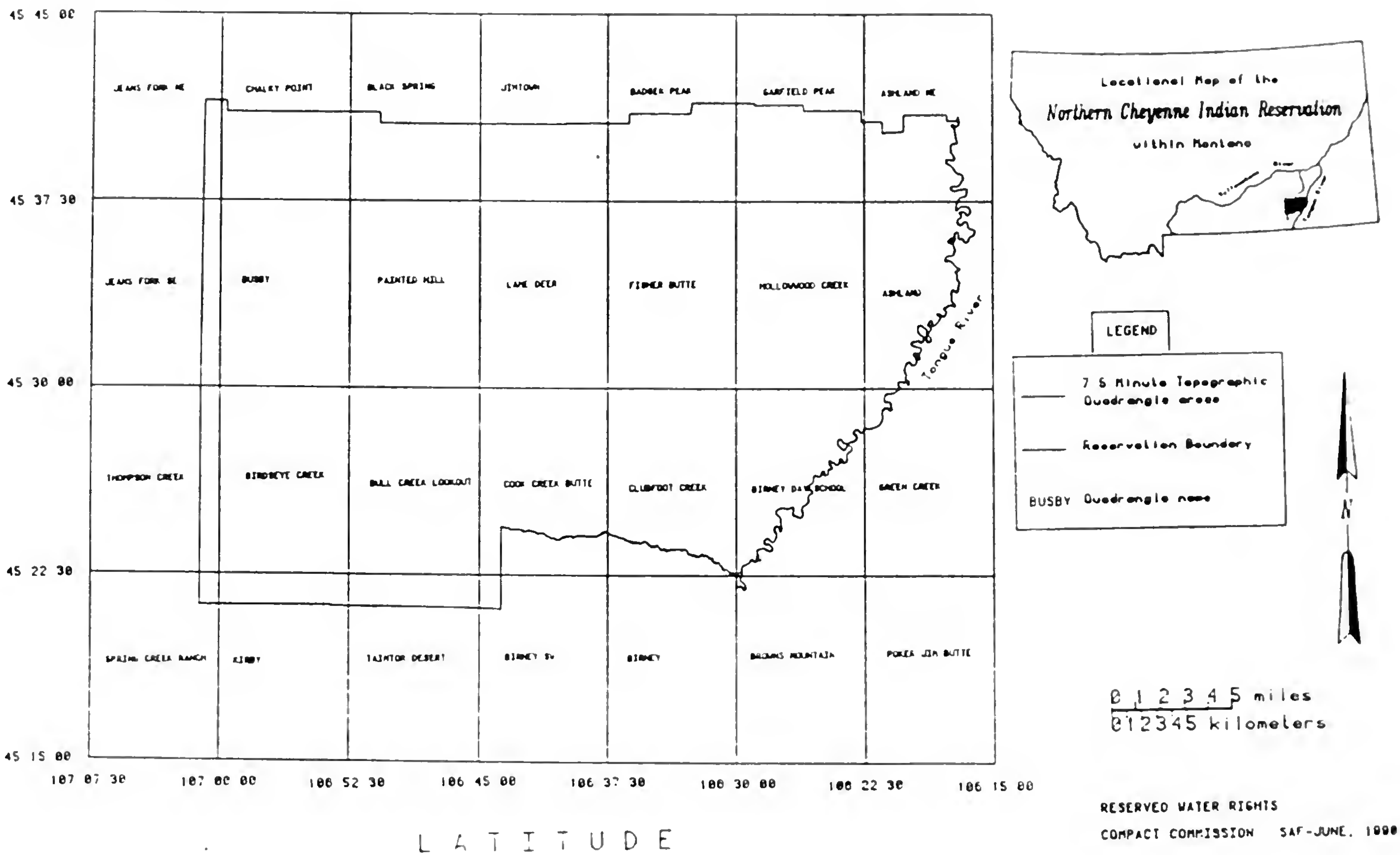
1. GIS Data

Geographic data compiled for use in Northern Cheyenne negotiations were divided into two categories: (1) data currently available within the RWRCC-GIS and (2) data on 9-track tape and available through conversion when necessary.

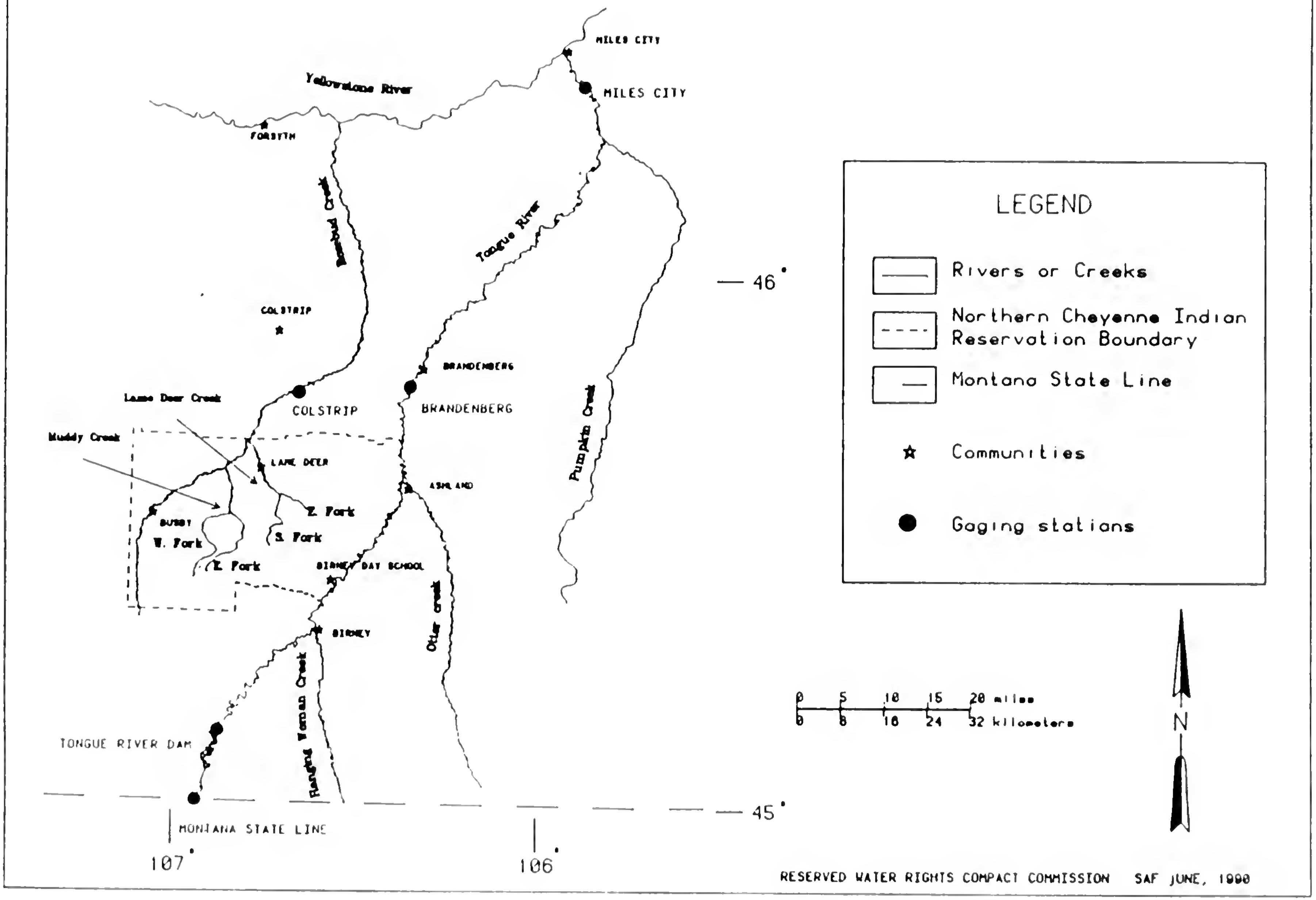
Readily available data were converted or digitized into the GIS for data analysis. The data currently in the RWRCC-GIS pertain to soils, political boundaries and elevation.

Soils units were previously digitized by the Bureau of Indian Affairs (BIA) using maps compiled by the Soil Conservation Service (SCS). Although this information was available, the RWRCC did not use it because the original field sheets were not geometrically corrected before the digitization process. This produced distortion errors that would have limited the accuracy of area calculations needed in a soil analysis of this size and importance. Through discussion with SCS staff members in Bozeman, it was agreed that SCS would re-compile the soil map units using topographic and orthophoto quadrangle maps. This recompilation created new soil maps that were then digi-

Northern Cheyenne Indian Reservation



TONGUE RIVER & ROSEBUD CREEK BASINS



tized by RWRCC staff and incorporated into the GIS. The SCS currently is in the process of updating many of its less accurate soil maps into corrected soil sheets. The Northern Cheyenne Reservation will be incorporated into a published soil report in the future, but is not available at this time.

Political boundaries digitized into the RWRCC-GIS included the Northern Cheyenne Reservation boundary and the Rosebud and Bighorn County boundaries within the reservation. The Northern Cheyenne Reservation boundary was entered into the GIS as depicted on 1:24,000 topographic maps.

HKM, Incorporated, an engineering firm in Billings, Montana, was hired for the Northern Cheyenne Tribe to perform various contracted services. One of those services was to identify 100 and 300 foot lift lines from both the Tongue River and Rosebud Creek. "Lift" denotes a specific elevation from a water source and is used primarily in agricultural engineering. This information, along with information pertaining to irrigated lands, dry arable lands and "prime and important" lands, was provided to the RWRCC and used as part of the RWRCC's soil, agricultural and hydrologic analyses.

Land resource information was obtained from the BIA Denver and Billings offices. These data were digitized by the BIA from 1:24,000 scale quadrangle maps and were completely compatible with our database. The data were not entered into the GIS, but stored on 9-track tape. Tape storage simplified the database by keeping non-essential data out of the GIS. This provided easier and quicker access to essential data. Data stored on tape and available if needed pertains to:

1) Farmland
2) Land Ownership
3) Roads
4) Range Water
5) Springs
6) Digital Elevation Models
7) Lakes and Reservoirs
8) Public Land Survey
9) Range Unit Boundaries
10) Soils
11) Streams

2. Maps Generated on the GIS

The RWRCC staff has prepared various types of maps identifying specific data relationships within the Northern Cheyenne reservation. The most important maps are summarized in Appendix A.

3. Other maps used in analysis

Maps compiled by the RWRCC in the early 1980s were used to a small degree in the current analyses. They also are listed in Appendix A.

4. Non-RWRCC maps

Maps available from other sources and used by RWRCC staff are also listed and described in Appendix A.

Glossary

Conversion	As used in this report, a computer process whereby a program or data file is changed so that it will run on a different computer.
Database	A collection of data organized for rapid search and retrieval (i.e. by a computer).
Digitization	The process whereby data is converted from map x,y points into a computer file of x,y points through use of a hardware equipment known as a "digitizer."
Map Distortion	The error produced when map and earth coordinates do not match within a specified error distance.
Geometrical Correction	A process whereby coordinates on a map are adjusted to correspond to their true geographic location on the earth.
GIS	Abbreviation for Geographic Information System; a system to efficiently store, retrieve, manipulate, analyze and display spatial data in a user specified format.
Topographic	Pertains to the configuration of the surface of the earth (i.e. elevation, natural and/or man-made features).

III. LAND RESOURCES

The Tongue River and Rosebud Creek drainages have four major physiographic soil areas. They are (1) floodplains and low terraces, (2) fans, terraces and uplands, (3) sedimentary uplands and (4) dissected sedimentary uplands. The elevation ranges from about 2,800 to 3,800 feet. The average annual precipitation in the river valleys ranges from 10 to 14 inches. The frost free period is 105 to 130 days. A more detailed description of these areas can be found in Appendix B.

A. Procedures for Land Classification

1. Definition and Purpose

Several agencies make soil surveys or land classifications to show the kinds of soil that occur in an area. After all the soil characteristics are known, a land classification guide is developed to categorize the soils into the appropriate land class for the intended use. Several agencies have developed guides for classifying soils for irrigation purposes. A brief explanation of the most widely-used methods is provided in Appendix C.

Land classification of arable lands for irrigation involves the systematic examination, description, appraisal and grouping of soils on the basis of physical and chemical characteristics affecting suitability for sustained crop production under irrigation. Selection of land for irrigation also involves prediction of the behavior of soils after development and application of irrigation water. All factors for an individual area are evaluated and delineations are made separating the land into different land classes.

The purpose of the land classification system developed by the RWRCC Soil Scientist is to determine the extent and degree of suitability of land for irrigation. Soil units are grouped into interpretative classes, based upon relative capability for sustained crop production under irrigation. This classification also provides an inventory of land characteristics and identifies potential problems that may occur with irrigation.

2. Land Classification

Land class indicates the general capability of land for irrigation use in its present state. Land classes are based upon the rating and assessment of the soil properties and topographic features that affect the suitability of the land for irrigation. Land within a land class is consistent, or nearly consistent, in its potential to be developed and in its response to a similar level of management. Land classes 1, 2 and 3 are arable and suitable for irrigation. Class 6 land is nonarable and not suited for irrigation. Classes 4 and 5 are not used in this report, since these lands are limited to rare or unique situations requiring special studies. The limitations or hazards become progressively greater from class 1 to class 6.

The land classification process depends on the experience and judgement of soil scientists, based on observations of land conditions and supported by laboratory data and field studies.

3. Land Classes

Class 1 - Arable: Land in this class is well suited for irrigated agriculture with few significant limitations. Class 1 land is capable of producing a high yield of a wide range of climatically adapted crops. The soils are of a medium texture, well drained, and hold adequate available moisture. Class 1 land is level to nearly level. This class is suitable for irrigation by gravity and sprinkler methods.

Class 2 - Arable: Land in this class is suited for irrigated agriculture with moderate limitations. Slightly more development and management may be required for Class 2 land than for Class 1 land, such as growing protective cover crops, contouring, and installing small drainage ditches. The land can be maintained or improved with proper management. The soils in this class may be slowly permeable due to fine texture or soil structure deterioration. The available water capacity may be lower due to coarse texture or limited soil depth. Drainage may be somewhat restricted. Class 2 land is level to gently sloping or undulating. Land in this class is suitable for irrigation by gravity or sprinkler methods.

Class 3 - Arable: Land in this class is suited for irrigated agriculture with severe limitations. The deficiencies may be due to a single condition or a combination of several conditions in soils and topographic features. The soils may be limited by excess salinity, sodicity, slow permeability or low water capacity. Surface or subsurface drainage may be restricted. A higher level of management is required, such as light, frequent irrigations or more intensive soil conservation and improvement practices (terracing and installation of extensive drainage facilities) than for Class 2 land. Class 3 land may be level to strongly sloping. Land in this class is suitable for irrigation by gravity (0 to 8 percent slopes) or sprinkler methods.

Class 6 - Nonarable: This land may be steep, dissected, eroded, or may have soils with very poor structure, coarse texture, excess salinity or sodicity, poor drainage, only a shallow thickness over sand and gravel or bedrock, or may have other deficiencies not feasible to improve. Class 6 land may surround areas of Class 1 to Class 3 land which cannot be separated due to the small size of the delineation at the scale used in mapping.

The arable land class for each mapping unit in the Tongue River and Rosebud Creek areas was determined by using the RWRCC Land Classification Specifications in Appendix D. The soil survey of Rosebud County Area and part of Big Horn County, Montana, completed in 1985 by the Soil Conservation Service, provided the basic data. Descriptions of individual soil mapping units are given in Appendix E.

B. Arable Lands

The amount of arable land in the Northern Cheyenne Indian Reservation was calculated for the Tongue River and Rosebud Creek areas. The Tongue River part was calculated for three areas: (1) within the seven USGS topographic maps encompassing the Tongue River (Ashland NE, Ashland, Green Creek, Garfield Peak, Hollowwood Creek, Clubfoot Creek, Birney Day School), (2) 300 foot vertical lift from the Tongue River and (3) 100 foot vertical lift from the Tongue River. The Rosebud Creek area was calculated for the 300 and 100 foot vertical lift. The 100 foot and 300 foot areas were delineated by HKM Associates on its Arable Lands map. Areas in other parts of the reservation were not calculated because the amount of water available was not enough to irrigate beyond the 300 foot lift distance from the Tongue River and Rosebud Creek.

The following acreages were generated by the RWRCC GIS from criteria established by the RWRCC staff. Data used for these calculations were received from SCS and BIA.

NORTHERN CHEYENNE INDIAN RESERVATION

Total soil acreage within the reservation = 445,482.
Total soil acreage within 7 quads on Tongue river = 130,705.
Total soil acreage within 300 foot lift of Tongue river = 49,025.

ARABLE LANDS ANALYSIS

Tongue River

	7 Quad area-Tongue River	300 Foot Lift distance line	100 Foot Lift distance line
RWRCC Class 1	2,493 AC.	1,821 AC.	1,798 AC.
RWRCC Class 2	8,427 AC.	5,905 AC.	4,243 AC.
RWRCC Class 3	15,033 AC.	6,982 AC.	2,556 AC.
Total Arable Lands	25,953 AC.	14,708 AC.	8,597 AC.

Rosebud Creek

	300 Foot Lift distance line	100 Foot Lift distance line
RWRCC Class 1	2,685 AC.	2,051 AC.
RWRCC Class 2	9,582 AC.	6,610 AC.
RWRCC Class 3	7,788 AC.	2,693 AC.
Total Arable Lands	20,325 AC.	11,254 AC.

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U.S. Department of Agriculture Soil Conservation Service in cooperation with Montana Agriculture Experiment Station. 1985. Soil Survey of Rosebud County Area and Part of Big Horn County, Montana. Lewis A. Daniels and others. Unpublished.

U.S. Bureau of Reclamation, 1982. Reclamation Instructions: Irrigation.

Anderson, Arial, January 18, 1990. Land Classification Specifications for Irrigation Suitability. Unpublished memo, 8pp. RWRCC, Helena, Montana.

Glossary

Alluvium	Material such as sand, silt, or clay deposited on land by streams.
Arable land	In this document, land that could provide enough income to warrant consideration for irrigation development. Land classes 1 through 3 are arable, class 6 is nonarable. Classes 4 and 5 are lands limited to rare or unique situations requiring special studies and are not used in this analysis.
Available water capacity [available moisture capacity]	The capacity of soils to hold water available for use by most plants. Commonly defined as the difference between the amount of soil water at field moisture capacity and the amount at wilting point and commonly expressed as inches of water per inch of soil. <u>Field moisture capacity</u> - the percentage of water remaining in the soil two or three days after having been saturated. <u>Wilting point</u> - the moisture content of soil, on an oven dry basis, at which a plant (specifically sunflower) wilts so much that it does not recover when placed in a humid dark chamber.
Bedrock	The solid rock that underlies the soil and other unconsolidated material or that is exposed at the surface.
Channery	Thin flat fragments of limestone, sandstone or schist up to 6 inches in diameter
Clay	A soil textural class containing more than 40 percent clay, less than 45 percent sand and less than 40 percent silt.
Colluvium	Soil, rock fragments, or both, moved by creep, slide, or local wash and deposited at the bases of steep slopes.
Complex soil	Two or more kinds of soil occurring in such an intricate pattern that they cannot be shown separately on a soil map.
Depth to rock	The distance from soil surface to bedrock.
Eolian	Material transported by wind. Includes earth materials ranging from dune sands to silty loess deposits and volcanic ash.
Flooding	The temporary covering of soil with water from overflowing streams or runoff from adjacent slopes. Average frequency and probable dates of occurrence are estimated. Frequency is expressed as rare, occasional, or frequent. Rare means that it floods less than once in ten years; occasional that it floods once in two to ten years; and frequent that it floods once every two years. Probable dates are expressed in months; May and June, for example, means that flooding can occur during this time.
Flood plain	A nearly level alluvial plain that borders a stream and is subject to flooding unless artificially protected.
Irrigable land	Arable land under a specific plan for which a water supply is or can be made available, and which is provided with, or planned to be provided with, irrigation, drainage, flood protection, and other facilities as necessary for sustained irrigation. (Bureau of Reclamation)

Parent material — The unconsolidated organic and mineral material from which soil forms.

Permeability — The quality of the soil that enables water to move downward through the profile. Permeability is measured as the number of inches per hour that water moves downward through the saturated soil. Terms describing permeability are: very slow [less than 0.06 inch], slow [0.06 to 0.2 inch], moderately slow [0.2 to 0.6 inch], moderate [0.6 to 2.0 inches], moderately rapid [2.0 to 6.0 inches], rapid [6.0 to 20 inches], and very rapid [more than 20 inches].

Residuum [residual soil material] — Unconsolidated, weathered or partly weathered mineral material that accumulated as consolidated rock disintegrated in place.

Sand — Soil mineral particles from 2.0 to 0.5 mm in diameter.

Sedimentary rock — Rock made up of particles deposited from suspension in water. The chief kinds of sedimentary rock are conglomerate, formed from gravel; sandstone, formed from sand; shale, formed from clay; and limestone, formed from soft masses of calcium carbonate. There are many intermediate types. Some wind-deposited sand is consolidated into sandstone.

Silt — Soil mineral particles 0.002 to 0.05 mm in diameter.

Slope — The degree of deviation of a surface from horizontal, measured in percent or degrees.

Sodicity — The degree to which a soil is affected by exchangeable sodium. Sodicity is expressed as a sodium absorption ratio (SAR) of a saturated extract.

Soil — Material at the earth's surface that is capable of supporting plants and has properties resulting from the effect of climate and living matter acting on earthy parent material over periods of time.

Soil Depth — The depth in inches from the surface to a root impeding layer in the soil. The following classes are used to express soil depth.

Deep...............more than 40 inches deep.
Moderately deep....20 to 40 inches deep.
Shallow...........10 to 20 inches deep.

Soil Profile — A vertical section of the soil extending through all its horizons and into the parent material.

Soil Series — A group of soils with profiles that are almost alike, except for differences in texture of the surface layer or of the underlying material. All the soils of a series have horizons that are similar in composition, thickness and arrangement.

Soil Structure — The arrangement of soil particles. Deterioration can result from too much water, compaction by heavy machinery, effect of heavy rain on bare soil and excess sodium.

Soil Texture — The relative proportions of sand, silt and clay particles, in a mass of soil. The basic textural classes, in order of increasing proportion of fine particles are sand, loamy sand, sandy loam, loam, silt, silt loam, sandy clay loam, clay loam, silty clay loam, sandy clay, silty clay and clay. The sand, loamy sand and sandy loam classes may be further divided by specifying "coarse," "fine," or "very fine."

Terrace — An old alluvial plain, ordinarily flat or undulating, bordering a river or a lake.

Upland — Land at a higher elevation, in general, than the alluvial plain or stream terrace; land above the lowlands along streams.

Vertical lift — Vertical distance from water source.

IV. WATER RESOURCES

A. Tongue River

1. Basin Characteristics

The Tongue River headwaters originate in Wyoming's Bighorn Mountains. Annual precipitation in the Bighorn Mountains at elevations around 13,000 feet averages over 25 inches and occurs primarily as winter snowfall and spring rainfall. Flows peak in May and June — the time of major snowmelt runoff (see Figure 1). Little of the discharge enters the river in Montana.

The Northern Cheyenne Reservation lies in Montana about 60 miles downstream (northeast) from the base of the Bighorn Mountains. The Tongue River forms the Reservation's 47-mile eastern boundary. Here, the river dissects plateaus and benches up to 4,400 feet in elevation. Annual precipitation in the Tongue River valley averages 12 to 14 inches. Seasonal and year-to-year variations are high. Prior to the construction of the Tongue River Dam, the river had summer flows near zero at its mouth on several occasions (Woessner et al. 1981). In contrast, the largest flood occurred at the end of May, 1978, with flows over 7,000 cubic feet per second. The Tongue River enters the Yellowstone River near Miles City.

The Tongue River Reservoir with a storage capacity of about 69,000 acre-feet, lies 37 river miles upstream from the Reservation. Since the 1978 flood, which damaged its spillway, it is operated at about 40,000 acre-feet storage capacity for safety reasons.

2. Streamflows

The USGS gage no. 06306300, at the Montana/Wyoming border, has been in operation since 1961. The river at this point drains about 1,480 square miles with about 64,300 irrigated acres and 15,000 acre-feet combined volume of small reservoirs (USGS, 1988). To come up with a representative set of data, synthetic streamflows for the 1929-1960 period (Systems Technology, 1984) were added to the existing record. The flows exceeded 50 and 80 percent of time during a water year are as follows (see also Figure 1):

Tongue River Percentile Flows

Month	50%	80%
October	14,500 af	10,200 af
November	13,149 af	11,126 af
December	11,000 af	8,610 af
January	10,393 af	7,700 af
February	9,934 af	7,800 af
March	14,944 af	9,700 af
April	20,289 af	15,767 af
May	64,452 af	43,726 af
June	88,100 af	42,700 af
July	23,124 af	11,193 af
August	8,300 af	4,100 af
September	9,300 af	4,900 af
Annual	287,485 af	177,522 af

On average, the flows leaving the dam (USGS gage no. 06307500) equal the flows at the state line during the period from October to January. From February to June, water is stored in the reservoir and released from July to September to supply irrigation needs (see Figure 2).

On the stretch of the river between the dam and Miles City (USGS gage no. 06308500), the flow is usually stable from October to December. During January to April, flows at Miles City exceed flows leaving the dam with biggest gains in March. Irrigation of about 21,000 acres (DNRC, 1981) and natural evapotranspiration account for net losses during the May to September period (see Figure 3).

In general, flows at Miles City are lower than the dam releases during the May to September irrigation period and higher from October to April (see Figure 4). The highest measured volume deficit (flows at Miles City minus flows leaving the dam) peaked at about 72,000 acre-feet during the 1959 and 1988 May to September irrigation seasons. On a probability basis, during the 1947-1988 period, 80 percent of the time the volume deficit did not exceed 56,000 acre-feet, and 8 percent of the time the flows at Miles City exceeded those leaving the dam during the irrigation season (Figure 5).

A comprehensive seepage run was conducted on the Tongue River between the dam and Miles City in November

Figure 1

Monthly Volumes at State Line, Tongue River
1929-1960 reconstituted flows, 1961-1988 measured flows

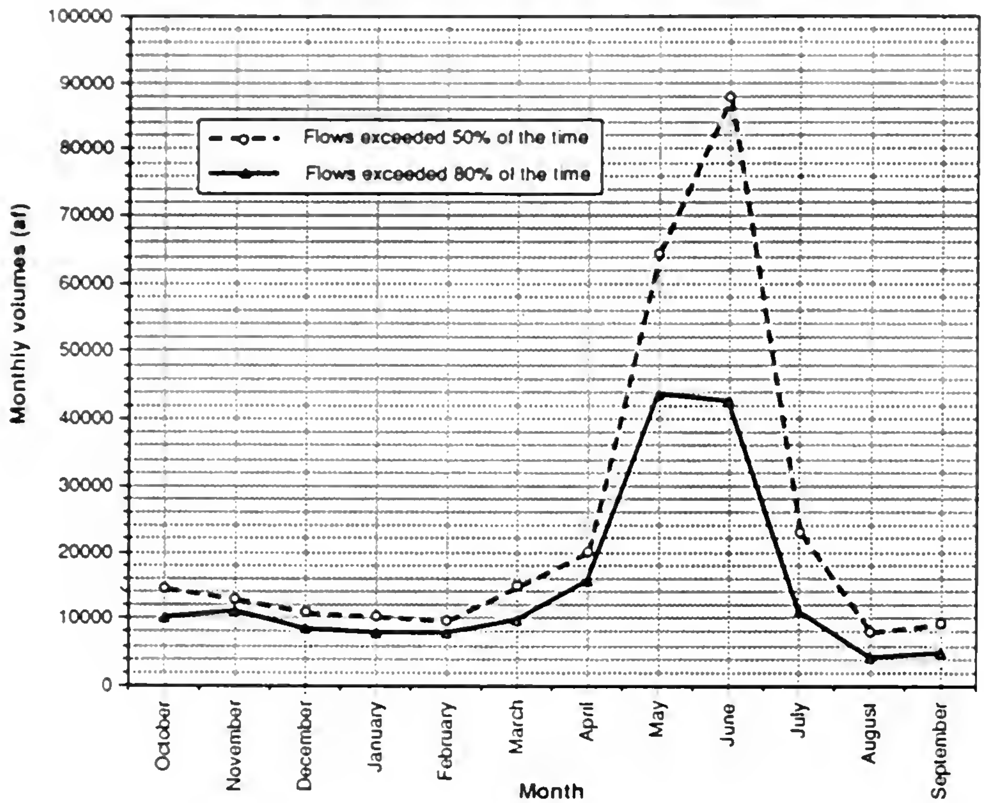


Figure 2

Monthly Volume Differences Between State Line and Dam, 1961-1988, Tongue River

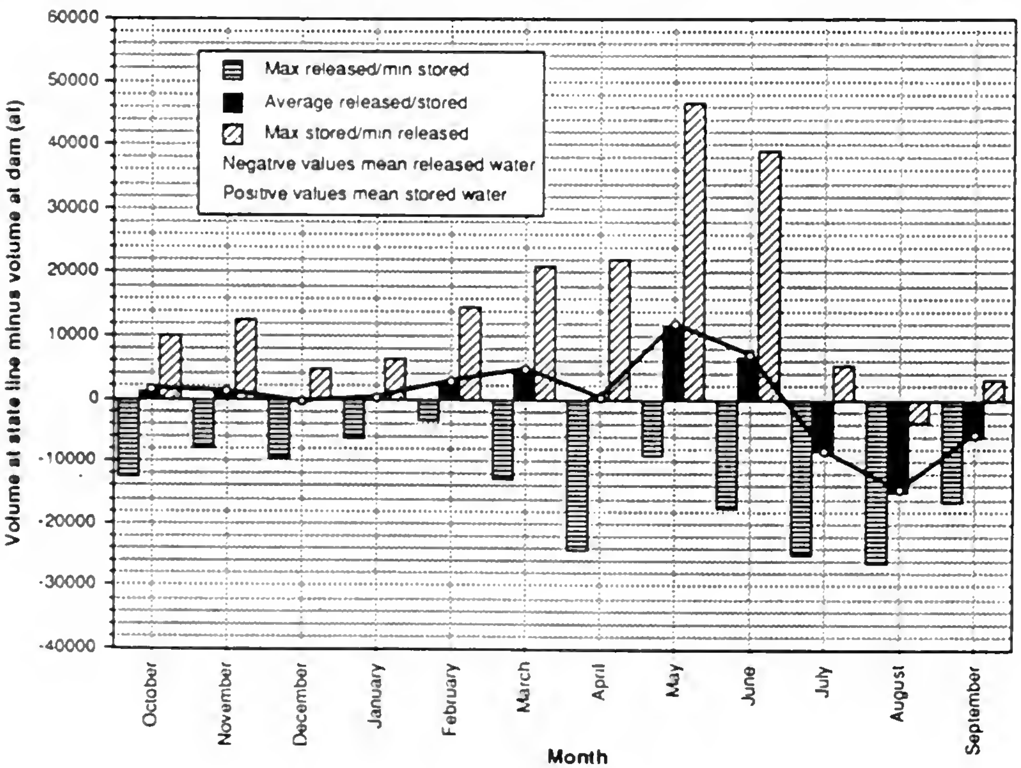


Figure 3

Monthly Volume Differences Between Miles City and Dam, 1947-1988, Tongue River

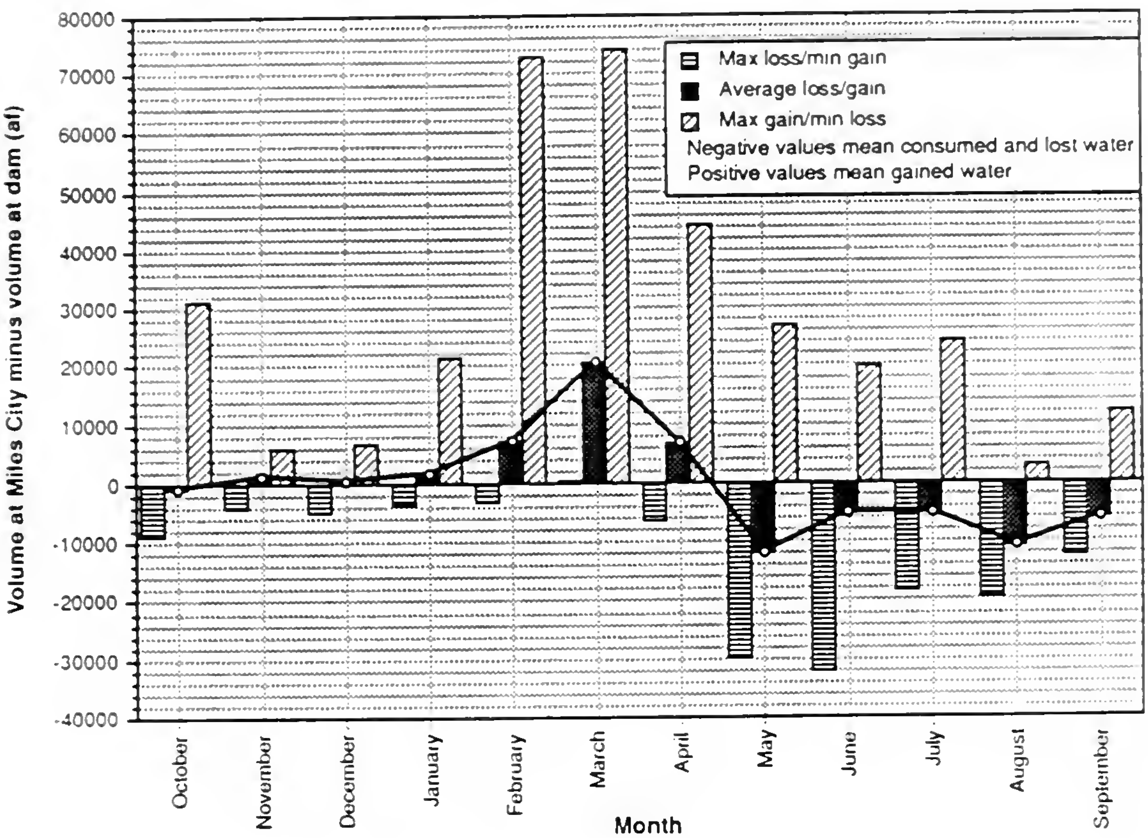


Figure 4

TWO SEASON VOLUME DIFFERENCES BETWEEN TONGUE RIVER DAM AND MILES CITY MAY THROUGH SEPTEMBER AND OCTOBER THROUGH APRIL

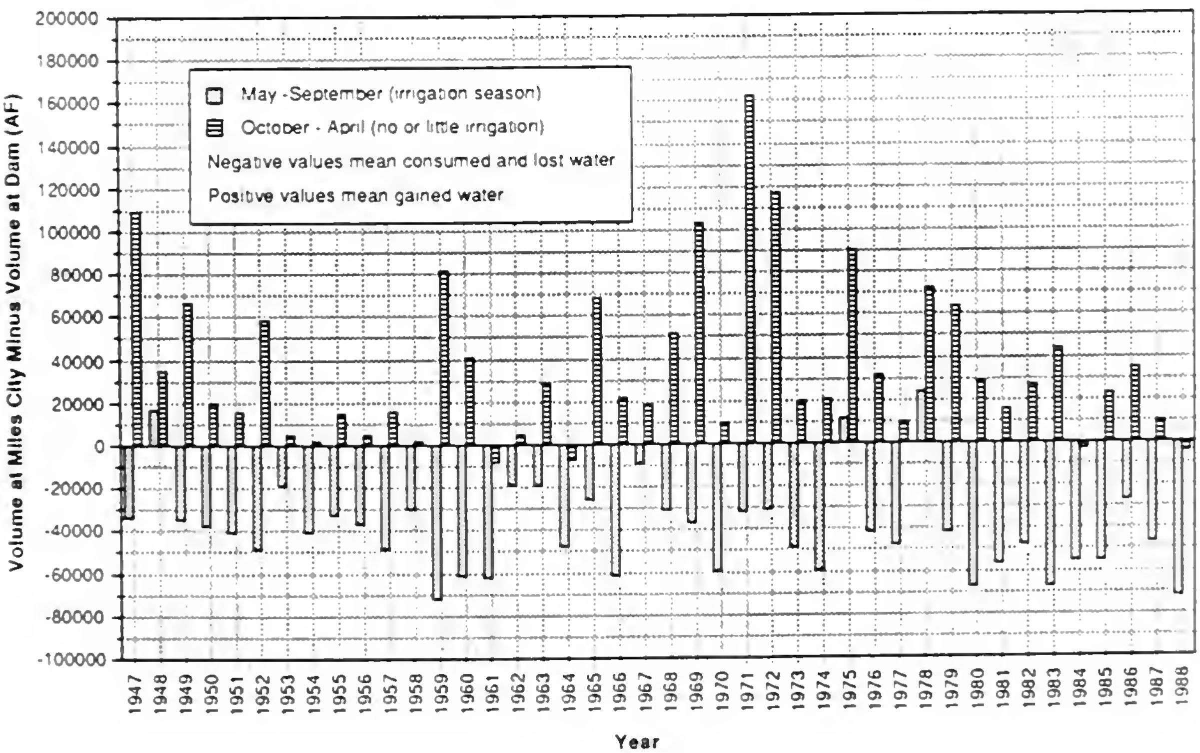
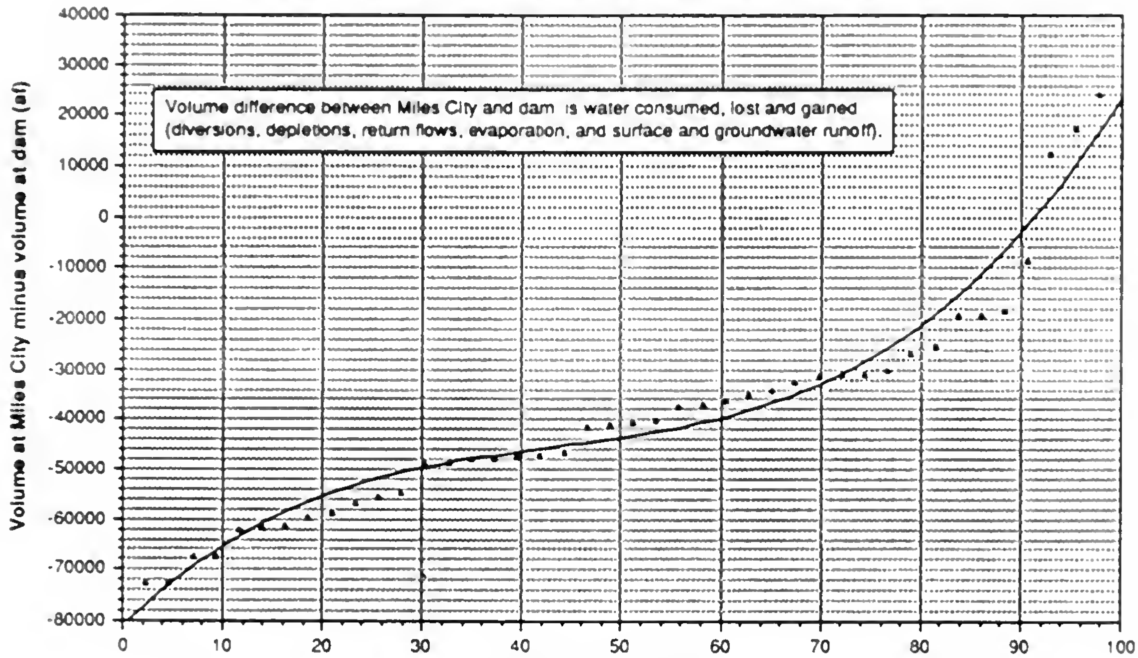


Figure 5

Probability Distribution of Water Volume Change Between Miles City and Dam Irrigation season May-September, 1947-1988, Tongue River

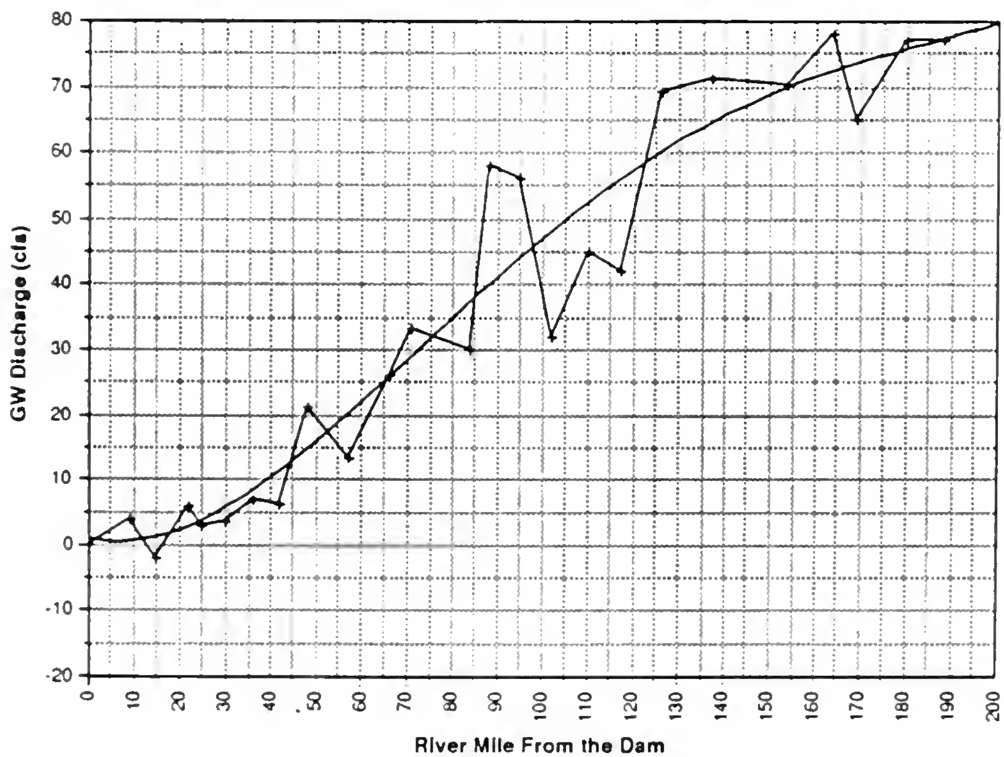


Percent of time volume of water consumed/lost equals or exceeds the given value.
(e.g., 92% of time there is a net loss; 8% of time net gain, and 20% of time net loss exceeds 56,000 af)

y = - 8.1715e+4 + 1957.5x - 38.949x^2 + 0.29845x^3 R^2 = 0.963

Figure 6

Tongue River - Groundwater Discharge into the River (Nov. 2-5, 1977)



River Mile From the Dam

y = 0.76962 - 0.15762x + 1.2873e-2x^2 - 8.3108e-5x^3 + 1.6272e-7x^4 R^2 = 0.928

1977 by Morrison Maierle Inc. (Woessner, et al. 1981). Groundwater discharge into the river during this baseflow period was about 75 cubic feet per second at Miles City (see Figure 6). However, since irrigation return flows were ignored, the natural groundwater discharge may be slightly less.

Two gaged off-reservation tributaries enter the Tongue River downstream from or on the boundary of the reservation: Hanging Woman Creek and Otter Creek. Both creeks sustain irrigated agriculture (mostly spring sub-irrigation and natural flooding), peak during the February to April period, and average close to zero flows during the July to August period.

3. The Tongue River Reservoir

The Tongue River Reservoir, in operation since 1939, regulates the streamflows for irrigation purposes. It is owned by the State of Montana and operated by the Tongue River Water Users Association (TRWUA). Recreation is an important secondary use. The reservoir has a capacity of 69,000 acre-feet and can store about 19 percent of the average annual inflow (Woessner, et al. 1981). Currently because of safety reasons, storage is limited to 40,000 acre-feet, 32,500 of which is obligated to downstream users other than the Tribe, mostly as supplemental irrigation water. The average annual evaporation from the reservoir is estimated to be around 10,000 acre-feet (Woessner, et al. 1981)

In 1978, the dam's spillway was severely damaged by a 7,000 cfs flow, although it was theoretically designed to handle flows up to 98,000 cfs. To evaluate the dam failure risk, the Department of Natural Resources and Conservation (DNRC) has commissioned a number of studies; the latest one calls for a labyrinth spillway construction and an increase in storage capacity to 80,300 acre-feet (Anderson, Bucher, 1990). This increase in storage capacity is crucial to satisfy the Northern Cheyenne reserved water right without adversely affecting existing water uses below the dam.

4. Groundwater

Several distinct aquifers underlie the Northern Cheyenne Reservation (Woessner, et al. 1981). In the Tongue River basin, only unconsolidated, quaternary alluvium and the deep Madison aquifer have yields high enough (10 to 700 and 70 to 2,000 gallons per minute respectively) for agricultural or industrial purposes. Withdrawal of any water from the alluvial aquifer would be reflected in the Tongue River streamflows. The Madison aquifer is about 6,000 feet below surface and its water has a high ion concentration and a temperature of about 180 degrees F (Woessner, et al. 1981.)

The other aquifers, composed primarily of cretaceous and tertiary sandstones, clinker, siltstones and shale, have yields varying from 1 to 80 gallons per minute (Woessner, et al. 1981). This is adequate for domestic and stock water use, but not enough for irrigation.

5. Water Rights and Existing Irrigation

The estimates of irrigated acreage below the dam range from 14,000 acres (DNRC, 1985) through 21,000 acres (DNRC, 1981) to 36,000 acres (USGS, 1988). Because irrigation diversions, depletions and return flows on the river are not measured, the Tongue River has not yet been adjudicated through the SB 76 process, and water rights claims have not been verified by the DNRC for the Water Court, quantification and timing of existing water use on the Tongue River is an imprecise process. Estimates of use can be based on monthly volume differences between upstream and downstream gages but this does not distinguish among diversions, depletions, return flows, evaporation, surface runoff and groundwater discharge. Alternatively, diversions, depletions and return flows can be calculated from known irrigated acreage, irrigation system efficiency, irrigation timing and crop irrigation requirements. The second option entails detailed field investigation and aerial photography interpretation.

Water in the Tongue River was first apportioned in 1914 in the Miles City Decree, which recognized rights totaling 419.17 cubic feet per second. Since then, the Tongue River Reservoir has inundated some of the decreed acreage. If 4.56 cubic feet per second for land which was flooded by the reservoir is subtracted, the total decreed amount comes to 125,368 acre-feet during the May to September irrigation season. The irrigation season flows exceeded 80 percent of the time at state line are 106,619 acre-feet. Assuming high irrigation return flow reuse, the total amount of the Miles City Decree usually can be satisfied from the direct flow of the Tongue River during May and June. The river is overappropriated during July and

August. The SB 76 water right claims total 5,709,376 acre-feet, 53-times more than the 80 percentile flows.

Currently, non-tribal irrigators have storage contracts to 32,500 acre-feet and Northern Cheyenne Tribe to 7,500 acre-feet of water from the Tongue River Reservoir. Also, 30 cubic feet per second (9,075 acre-feet from May to September) with a priority date of March 24, 1909 was allocated to the Northern Cheyenne Tribe in the Miles City Decree. However, the Tribe does not recognize the decree as a legitimate quantification of its water right. The Northern Cheyenne Reservation was established by an Executive Order issued on March 19, 1900; it is presumed by the RWRCC negotiating team that this would be the likely priority date assigned to the Tribe in an adjudication of its reserved right.

The present system with the reservoir works well for the other existing users primarily because the Tribe doesn't fully use its contract water or its share of the Miles City Decree water (around 500 acres are presently irrigated on the Reservation). Shortages are none or minimal even during the driest years (Mobley, 1990). If the irrigation season flow volume difference between the dam and Miles City is used as a surrogate for water demand, then 50 percent of the time water demand doesn't exceed 44,000 acre-feet and 80 percent of time it doesn't exceed 56,000 acre-feet (see Figure 5).

6. Water Availability and Modeling

The water availability issue on the Tongue River is complicated by the existence of the Yellowstone Compact, which apportions water between Montana and Wyoming. Under the terms of the Compact, Wyoming is entitled to 40 percent of the "unallocated flow" (the water left after servicing all Montana and Wyoming pre-1950 rights) at Miles City. Wyoming initially asserted a right to 26,900 acre-feet of "supplemental water" for its pre-1950 projects with partial irrigation service.

In 1984 Systems Technology, under a contract with the DNRC, developed a water allocation model and a project yield analysis model to determine Montana's share of allocable water and firm annual yield from the Tongue River Reservoir. The project yield analysis model was updated in 1990 to correspond to different scenarios of water allocation between the private water users represented by the Tongue River Water Users Association and the Northern Cheyenne Tribe.

Initial computer runs used a hypothetical scenario in which Wyoming used all of its allocable and claimed supplemental water (29,000 acre-feet), the existing Montana demand was estimated at 83,200 acre-feet, and the firm annual yield from the enlarged, 80,300 acre-feet reservoir was predicted to be around 55,000 acre-feet (Anderson, Bucher, 1990). The estimate of the existing demand was a high, worst-case scenario; the hypothetical demand of 83,200 acre-feet of water used in the model is higher than the 72,500 acre-feet highest recorded flow volume difference between the dam and Miles City. Eighty percent of the time the depletions do not exceed 56,000 acre-feet and it is improbable that Wyoming would develop all 29,000 acre-feet of its claimed water. Therefore, on a probability basis, more water would be available most of the time because of a lower demand.

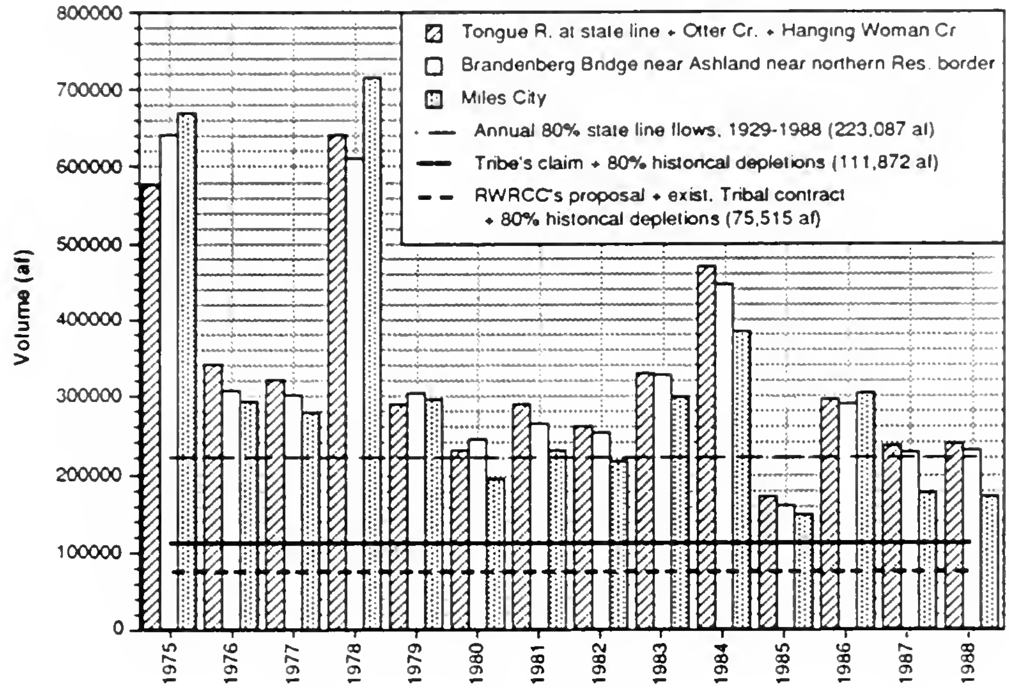
Wyoming's unused water could be available as well (see Figures 7 and 8). In a hypothetical scenario in which Wyoming does not use any of its claimed water and using 80th percentile depletions (56,000 acre-feet), the reservoir firm annual yield would significantly increase, depending on uses.

The firm annual yield also changes with different scenarios of water use; for example, a year-round industrial use puts less demand on the reservoir than agricultural use during a 5-month irrigation season (Anderson, Bucher, 1990). Subsequent computer analysis that used Wyoming's revised claim for supplemental depletions (18,700 acre-feet) and the highest recorded Montana irrigation demand of 72,500 acre-feet resulted in a new firm annual yield estimate of 62,200 acre-feet of water (McDonald, 1990). Use of 80 percentile flows and 80 percentile depletions in the calculations indicates a large water reserve (see Figure 7); however, it is not clear how much of that water would actually be available: not all of it can be stored, and timing and quantity of uses throughout the year can make significant differences. The analysis merely indicates that significantly more water may be available on a probability basis, depending on timing and kind of use.

In July, even the pre-1900 existing uses from the Miles City Decree exceed the 80th percentile state line flows by 4,686 acre-feet and by 11,779 acre-feet in August, even if a 35 percent irrigation reuse of return flows is assumed. Thus, there is no direct flow left for the Tribe during July and August if 1900 is used as a priority date for the Tribe. Only

Figure 7

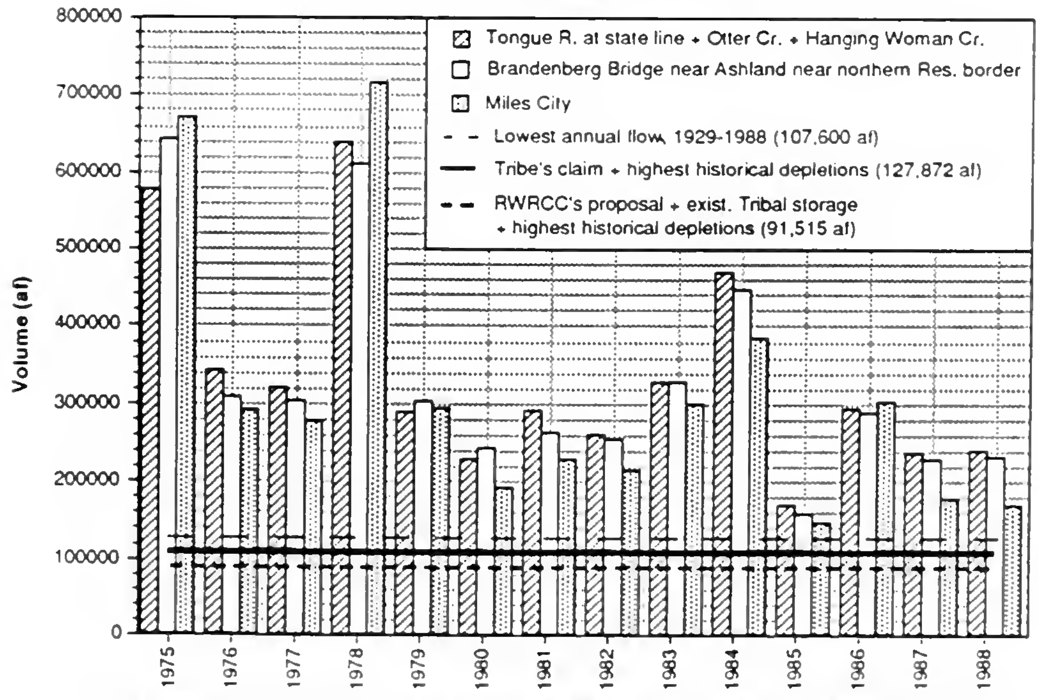
Annual Runoff, 80% Flow - Tongue River



It is assumed that 35 percent of the Tribe's agricultural claim of 70,315 af and 10 percent of the RWRCC's agricultural proposal of 13,300 af would be reused. No additional Wyoming depletions are considered.

Figure 8

Annual Runoff, Extremes - Tongue River



It is assumed that 35 percent of the Tribe's agricultural claim of 70,315 af and 10 percent of the RWRCC's agricultural proposal of 13,300 af would be reused. No additional Wyoming depletions are considered.

a pre-1886 priority date ensures a direct flow water right for anyone in July and August. (August 9, 1886 is the priority date for the Tongue and Yellowstone Irrigation District on the Tongue River. It operates a ditch, which irrigates approximately 9,000 acres of land in the lower Tongue River basin, with a decreed water right of 187.5 cubic feet per second.)

B. Rosebud Creek

1. Basin Characteristics

The headwaters of Rosebud Creek originate in the Wolf Mountains, a sedimentary upland with maximum elevation of 5,400 feet. The creek flows through the Northern Cheyenne Reservation for about 73 miles and then for about 132 miles through private land until it empties into the Yellowstone River.

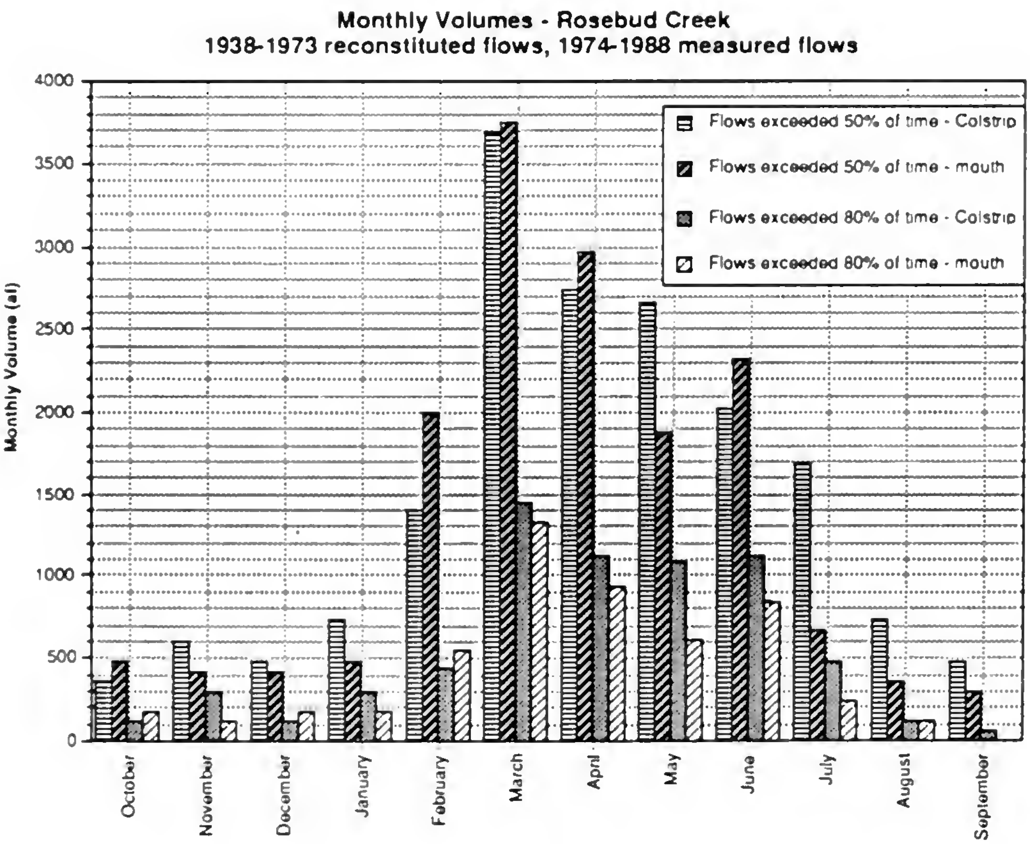
Rosebud Creek is a perennial, prairie stream. No significant snowpack develops in the Wolf Mountains. Runoff peaks usually during spring snowmelt in March and April. A second, lesser magnitude peak occurs in June during early summer rainfalls (see Figure 9). Baseflow conditions prevail through summer and early fall. Two principal tributaries, Lame Deer and Muddy creeks, enter the Rosebud on the Reservation. Their flows are usually near zero during late July and August.

The creek dissects a semi-arid rangeland and forms a valley approximately 0.6 miles wide. Average annual precipitation ranges from 12 to 17 inches. Alfalfa, hay and grain are major crops. Very few irrigation systems have been developed on Rosebud Creek; most of the crops receive subirrigation and natural flooding (Woessner, et al. 1981, Griffith, Holnbeck, 1982). No major reservoirs exist on the creek.

2. Streamflows

Most or all flow accumulates upstream from USGS gage no. 06295250 at Colstrip near the northern reservation boundary. Flow at the northern reservation boundary is

Figure 9



about 98 percent of the creek's flow at its mouth. Flow at the Colstrip gage is about 106 percent of that at the mouth (Woessner, et al. 1981, Saul, 1988). Consumption by irrigation and riparian vegetation and a lack of appreciable groundwater discharge into the creek downstream from Colstrip reduce streamflows by the time the creek reaches the Yellowstone River.

To develop a representative period of record, a 1938 to 1974 period of record was synthesized for the USGS gage no. 06295250 (drainage area 799 square miles) at Colstrip and added to measured streamflows from 1974 to 1988 (Holnbeck, 1981a, Saul, 1988). The same was done for the USGS gage no. 06296003 (drainage area 1,302 square miles) at the creek's mouth near Rosebud. The flows that were exceeded 50 and 80 percent of time are shown in the table below (also see Figure 9).

On average, the stretch of the Rosebud Creek between Colstrip and its mouth is a slightly losing reach. From October to April, the mean monthly flows at the two gages are roughly equal. During irrigation and growing season, May to September, significant losses occur.

Based on a seepage run conducted by Morrison Maierle Inc. in November 1977, there is significant groundwater discharge (about 0.14 cubic-feet per second per mile) into Rosebud Creek in the 32-mile upstream reach extending down to Busby (Woessner, et al. 1981). When effects of Muddy and Lame Deer Creeks were subtracted, the downstream reach from Busby to the mouth showed a slight loss. The higher elevation coal and clinker aquifers flanking Rosebud Creek and its tributaries in the southern portion of the Northern Cheyenne Reservation are the major contributors of the groundwater inflow.

3. Groundwater

As in the Tongue River basin, only the alluvial and the deep Madison aquifer can provide yield high enough to be used for irrigation (Woessner, et al. 1981). Because of its depth (around 6,000 feet), high temperature and high ion concentration, the Madison aquifer probably would not be an economical source for irrigation water. The alluvial aquifer could provide water for irrigation; however, withdrawal of water from the alluvium would reduce Rosebud Creek streamflows. An alluvial well used to supply water for an irrigation center pivot on the reservation may intercept the creek's flow after several days of pumping (Holnbeck, 1981b) and thus immediately lower surface water supply. Poor quality and low yield in late summer would probably restrict irrigation use of alluvial groundwater (Griffith, Holnbeck, 1982).

The clinker and coal aquifers, with maximum measured yield of 50 gallons per minute, (Woessner, et al. 1981) provide enough water for domestic and stock water use, but not enough for irrigation.

Rosebud Creek Percentile Flows

Month	50%	80% at Colstrip	50%	80% at mouth
October	363 af	121 af	484 af	182 af
November	595 af	298 af	417 af	119 af
December	484 af	121 af	424 af	182 af
January	726 af	303 af	484 af	182 af
February	1,403 af	444 af	1,998 af	553 af
March	3,691 af	1,452 af	3,751 af	1,331 af
April	2,737 af	1,131 af	2,975 af	940 af
May	2,662 af	1,089 af	1,876 af	605 af
June	2,023 af	1,131 af	2,321 af	883 af
July	1,694 af	484 af	666 af	242 af
August	726 af	121 af	363 af	121 af
September	476 af	60 af	298 af	0 af
Annual	17,620 af	6,753 af	16,054 af	5,291 af

4. Existing Irrigation

Review of 1980 aerial photographs, infrared photography and water resources data resulted in the following distinctions between lands on the Rosebud north of the Northern Cheyenne Reservation:

1. sprinkler irrigation;
2. surface irrigation, including all methods of application such as border dikes and ditches, which generally receive at least one application a year;
3. partial service irrigation which receives some water on an intermittent basis;
4. naturally subirrigated cropland, based on deep rooted crops (alfalfa);
5. naturally subirrigated riparian areas which are not cropped;
6. formerly irrigated cropland which has been irrigated in the past but is now in dryland crops; and
7. formerly irrigated lands now idle and not being used as cropland.

Irrigation occurring in 1980 was calculated at approximately the following levels for each of these categories:

1.	sprinkler irrigated	0 acres
2.	surface irrigation	1,960 acres
3.	partial-service irrigation	322 acres
4.	naturally subirrigated cropland	3,805 acres
5.	naturally subirrigated riparian areas	453 acres
6.	formerly irrigated cropland now in dryland crops	1,188 acres
7.	formerly irrigated, idle	0 acres

The method used to obtain these acreages does not give precise results, but does show the irrigation practices for this area in 1980. More accurate information could be obtained from detailed field work.

Because of low flows and poor quality of water during summer and fall, all irrigation in the Rosebud Creek basin is partial service. No one irrigates after mid-July. Irrigators cooperate and usually only three diversions operate simultaneously (Griffith, Holnbeck, 1982).

A field survey by former RWRCC staff members indicated about 1,900 acres were served by irrigation systems downstream from the northern Reservation boundary in 1981 (Griffith, Holnbeck, 1982). About one-third of these acres also benefited from natural flooding; most of them also benefited from natural sub-irrigation (high water table).

Around 1,600 acres received a second irrigation that year. Pumping was used 88 percent and gravity diversions 12 percent for the second irrigation. Reduced streamflows were the main reason for pumping (Griffith, Holnbeck, 1982). The first application consisted mostly of natural flooding upstream and from gravity diversion downstream from West Rosebud Creek. Acres totally dependent on natural sub-irrigation were not calculated.

The estimate of irrigated acreage south of the northern reservation boundary, both on and off the Reservation, ranges from 300 acres (Woessner, et al. 1981) to 543 acres (Water Resources Survey, 1947).

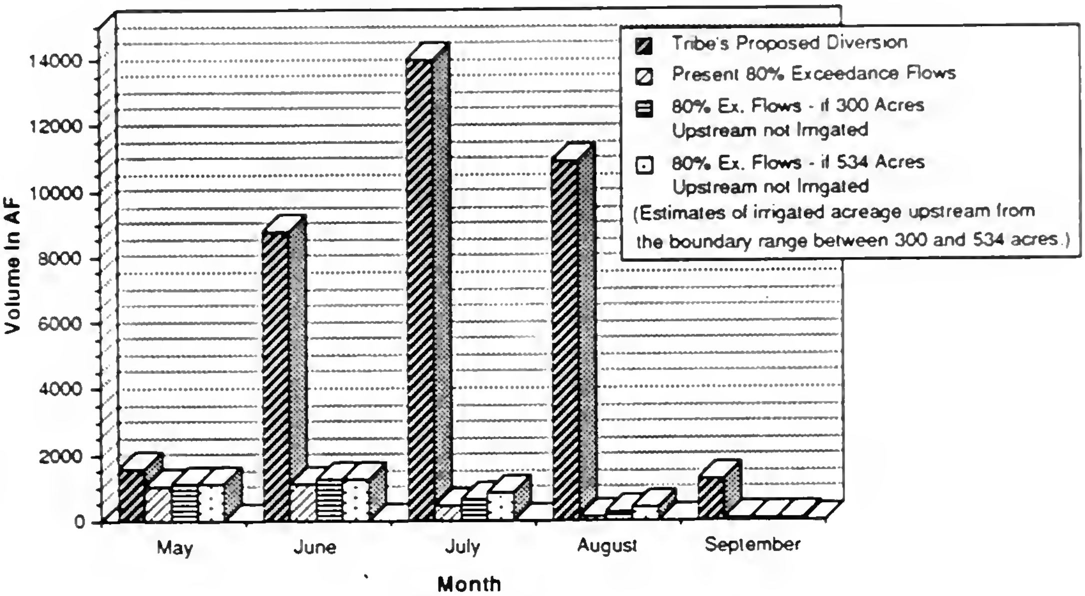
5. Water Availability

Rosebud Creek is almost a fully used system. In 1980 it supported partial service irrigation for about 6,000 acres, most of which are dependent on sub-irrigation. There is a very small amount of additional water available during March and April for early first irrigation applications. However, development of new irrigation systems just for one application probably would be economically infeasible (Greiman, 1990) and would reduce the flow, thus probably forcing some downstream irrigators to change their diversion structures. Any other irrigation development, potential reservoirs included, could adversely affect existing practices by stopping the natural flooding and changing the sub-irrigation water table (Golder, 1990).

Barring development of the Madison aquifer, Rosebud Creek basin does not have enough water for significant development of irrigation systems on the reservation, even if all off-Reservation irrigation south of the northern reservation boundary would cease (see Figure 10). The total flow of Rosebud Creek at the northern reservation boundary exceeded 80 percent of the time for the May to September irrigation season amounts to about 2,800 acre-feet.

Figure 10

PROPOSED DIVERSIONS AND 80% EXCEEDANCE FLOWS
ROSEBUD CREEK NEAR NORTHERN RESERVATION BOUNDARY



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Glossary

Evapotranspiration A water loss due to evaporation from a water surface and consumption by vegetation.

Exceedance flows Water flows, the quantity of which repeats or is exceeded a given percentage of the time. If 30 acre-feet is the May 80th percentile exceedance flow, then 30 acre-feet was met or exceeded 80 percent of the time in May during the period the flows were measured; if the period was 10 years, then the 30 acre-feet flows were met or exceeded 8 years (see percentile flows, probability flows).

Firm annual yield An estimate of the maximum volume of water than can be released from a reservoir every year. It depends on reservoir inflows and downstream direct flow demands.

Groundwater discharge Water entering a stream from its banks and bed.

Losing reach A stream reach with flows decreasing downstream.

Miles City Decree A 1914 district court adjudication of all existing water rights on the mainstem of the Tongue River.

Natural flooding A flooding caused by overflow of a stream channel. No diversion means are used.

Percentile flows (See exceedance flows)

Probability flows (See exceedance flows)

Reconstituted flows Statistically created streamflow records for streams with no or few flow measurements.

Return flow Excess irrigation water returning back to a stream.

SB76 Water right claims In 1979 Senate Bill 76 required the filing of all pre-1973 water rights claims with the DNRC by 1982. These claims are being adjudicated by the Montana Water Court.

Seepage run A method of measuring water leaving or entering a stream through its banks and bed. (see groundwater discharge).

Sub-irrigation Natural watering due to groundwater close to field surface. No diversion means are used.

Synthesized flows (See reconstituted flows).

Water year A year starting in October end ending in September. It represents water runoff and is used in hydrology.

V. ENGINEERING ANALYSIS

A. Tongue River

1. Feasibly Irrigable Land Analysis

DNRC's method of analyzing feasibly irrigable land (FIL) in the Missouri River Basin was adopted by the Reserved Water Rights Compact Commission (RWRCC) to determine FIL on Indian reservations in Montana. This method is documented in DNRC's "Methodology Manual for Conservation Districts Water Reservation Application" (DNRC, 1989).

The determination of RWRCC's FIL is based on a 1 to 1 benefit/cost (B/C) ratio. A 1:1 B/C ratio has been established by the courts as a means of determining tribal water rights for agricultural purposes. Wyoming v. U.S., 109 S. Ct. 2994 (1989). DNRC's method evaluates the probability that a project will generate a specific amount of net annual revenue.

Numerous conditions affect the economic feasibility of an irrigation development such as crops raised, yield, price, and production costs. Because alfalfa is the most widely raised crop in the study area, it is used to determine feasibility. The crops raised are the basis on which the other factors are determined.

Alfalfa yield is assumed to be directly related to its water consumption. Several regional studies (Bauer and others 1974, Hill 1981, USDI 1983, Wilcox 1978, and Wright 1981) have analyzed yields compared to consumption of water. While each study had slightly different results, a general relationship between the consumption of water and alfalfa's potential yield was established. This relationship was used to determine the peak per-acre yield for alfalfa on the Northern Cheyenne lands. The amount of water consumed by crops in the area was calculated to be 29.1 inches per irrigation season.

It was assumed that alfalfa would be grown with an 8-year rotation where alfalfa is grown for the first 7 years followed by 1 year of small-grain production. Alfalfa yields are low the first year, rapidly increase to a peak, and then gradually decline. These varying alfalfa yields were estimated by proportioning the yields reported in "Optimal Replacement of Alfalfa Stands: A Farm Level Decision Model" (Stauber and Goodman 1986) based on the calculated peak alfalfa yield. At the end of the seventh year, the stand of alfalfa is replaced with a small-grain crop. The following year alfalfa is planted and the cycle begins again. A 70-year planning period is used. The peak yield used in this study is 5.6 tons per acre with an average yield of 4.4 tons per acre.

Crop prices are then forecast and these forecasts are combined with yield to provide an estimate of gross revenue per acre. This price forecasting is based on a statistical relationship established between alfalfa prices and a number of variables including calf prices, wheat prices, state-wide alfalfa production, and precipitation. Forecast prices are based on this statistical relationship. Three hundred forecasts were made in order to encompass as many scenarios as possible.

Grain prices were also forecast because the stand is replaced by a grain crop in 1 out of 8 years. Grain yields are more constant than alfalfa, so an average yield of 70 bushels per-acre was used. In a year when alfalfa has been plowed under and grain planted, the gross revenue was calculated by multiplying the average grain yield by the forecast price of grain in that year.

Production costs also vary with yield. The production costs for establishing alfalfa, established alfalfa, and irrigated grain were based on a machinery costs computer program and a crop enterprise budget computer program (DNRC, 1989). When combined, these programs account for all production costs, except for the irrigation development and water application costs which are developed separately. These programs determine annual per-acre production costs based on farm size, cropping pattern, size and type of equipment, annual equipment use, fertilization, and projected crop yields.

The study uses the production costs established by DNRC's "Methodology Manual for Conservation Districts Water Reservation Application" (DNRC 1989). Using this production cost information, an alfalfa price of $64 per ton and an average yield of 4.4 tons per acre, the annual farm benefit was $154.35 per acre. This did not include any cost change for irrigation. This means that a positive B/C ratio can be obtained as long as the irrigation system and water delivery costs do not exceed that amount. The $154.35 per acre is

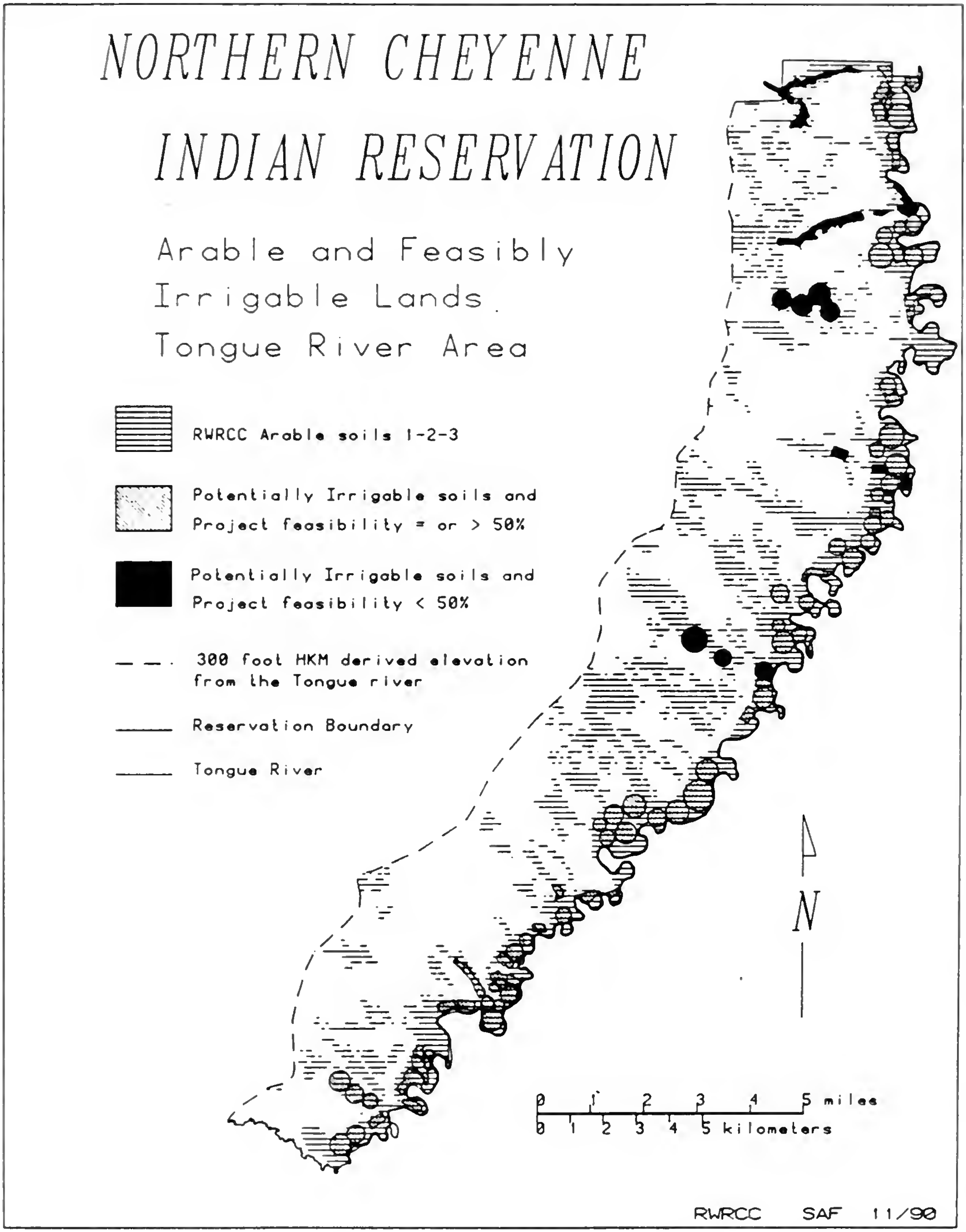
NORTHERN CHEYENNE
INDIAN RESERVATION
Arable and Feasibly
Irrigable Lands
Tongue River Area
RWRCC Arable soils 1-2-3
Potentially Irrigable soils and
Project feasibility = or > 50%
Potentially Irrigable soils and
Project feasibility < 50%
300 foot HKM derived elevation
from the Tongue river
Reservation Boundary
Tongue River
N
0 1 2 3 4 5 miles
0 1 2 3 4 5 kilometers
RWRCC SAF 11/90

Table 1. Northern Cheyenne Reservation FIL project descriptions.
Tongue River

PROJECT NUMBER	ANNUAL COST ($/Acre)	FEASIBILITY RATING (percentile)	COMMENTS
FEASIBLE PROJECTS			
NCR-1	$118	93	Two handlines and two wheellines (low lift).
NCR-2	$76	100	One pivot (low lift).
NCR-3	$131	85	Two wheellines (low lift).
NCR-4	$100	100	Five pivots and one wheelline.
NCR-7	$121	92	One pivot and two handlines.
NCR-9	$120	93	One wheelline and one pivot.
NCR-10	$83	100	Three pivots.
NCR-12	$112	96	Two pivots and one wheelline.
NCR-13	$125	91	Three pivots.
NCR-14	$90	100	Three pivots.
NCR-15	$116	94	Two pivots and one handline.
NCR-16	$95	100	Three pivots.
NCR-17	$104	99	Two pivots and two wheellines.
NCR-19	$82	100	Three pivots.
NCR-20	$101	100	Six pivots.
NCR-21	$149	62	Three handlines and one pivot.
NCR-22	$141	73	Five handlines, two pivots, and one wheelline.
NCR-23	$98	100	Four pivots.
NCR-24	$113	95	Two wheellines.
NCR-25	$124	91	Three pivots.
NCR-26	$108	97	Two pivots and one wheelline.
NCR-27	$109	97	Six flooded fields.
INFEASIBLE PROJECTS			
INCR-5	$230	0	Hand lines on Stebbins Cr. infeasible because of pipeline length vs. area irrigated
INCR-3	$242	0	Hand line on Reservation Cr. infeasible because of pipeline length vs. area irrigated.
INCR-2	$236	0	Same project area as INCR-3 with two additional handlines.
NCR-6	$157	42	Same project as INCR-5 with the last handline system eliminated.
NCR-8	$174	19	Four high (320') lift pivots. Infeasible because of lift and pipeline length vs area irrigated.
NCR-11	$178	15	Three wheellines. The last wheelline makes the project infeasible, but the first two wheellines would be feasible.
NCR-18	$163	33	Two high (300') lift pivots. Infeasible because of lift and pipeline length vs area irrigated.

equivalent to a 50th percentile feasibility rating which is discussed more completely in DNRC's methodology document.

2. Project Description

First, the soils along the Tongue River were classified for arability (see Soils section). Then site specific irrigation projects were designed on these lands to determine the economic feasibility of individual projects. (See Appendix F) Projects were designed on lands adjacent to the Tongue River and on contiguous lands away from the river until the B/C for a project went below 0.8. (See Appendix G) At this point, no further projects were designed. The following tables summarize the results of the projects evaluated in the FIL analysis of Northern Cheyenne Indian Reservation.

B. Rosebud Creek

1. Feasibly Irrigable Land Analysis

The amount of feasibly irrigable land on the Rosebud depends on the availability (amount and timing) of water, the suitability of the soils adjacent to the water source, and the economic variables used in the analysis, such as interest rate, crops raised, crop prices, and crop yield.

Rosebud Creek, like most eastern Montana creeks, has a high flow in the spring and little flow in late summer, fall, and winter. This means that full service irrigation is limited to the amount of flow in July and August (less than 2 cfs). The standard approach in full service irrigation design is to base the design acreage on the amount of water available 8 years out of 10 for the crop's peak use period. Therefore, the Rosebud would be able to support less than 150 acres of new irrigation.

The customary way to irrigate on these creeks is to spread water in the spring during high flow. This will generally provide enough water for one full cutting of hay. The Rosebud is a relatively flat meandering stream; land next to it is usually flooded by natural flows each year. Floodplain land is also partially sub-irrigated along the Rosebud which is an ideal way of using the Rosebud's water, from an economic point of view. Any increase in consumptive use from the current situation would adversely impact downstream users, both Indian and non-Indian.

Table 2. Northern Cheyenne Reservation
FIL projects summary.
Tongue River

PRJ #	FEASIBILITY RATING (%)	TOTAL ACRES IRR.	ACRE-FEET	TOTAL FLOW (CFS)
NCR-1	93	168.0	484	3.5
NCR-2	100	116.0	286	1.9
NCR-3	85	75.0	214	1.7
NCR-4	100	337.0	841	5.8
NCR-7	92	89.1	240	1.7
NCR-9	93	77.0	200	1.4
NCR-10	100	248.6	612	4.2
NCR-12	96	110.0	271	1.8
NCR-13	91	113.1	286	2.1
NCR-14	100	167.2	410	2.8
NCR-15	94	148.2	379	2.7
NCR-16	100	157.2	386	2.6
NCR-17	99	196.5	507	3.4
NCR-19	100	359.5	885	6.0
NCR-20	100	399.3	981	6.7
NCR-21	62	117.2	319	2.3
NCR-22	73	289.8	793	5.9
NCR-23	100	196.5	482	3.3
NCR-24	95	100.8	276	2.0
NCR-25	91	187.8	462	3.1
NCR-26	97	177.5	452	3.1
NCR-27	97	196.0	731	5.0
TOTAL FEASIBLE		4,027.3	10,497	73.0
INCR-5	0	247.0	707	8.6
INCR-3	0	66.0	190	1.6
INCR-2	0	184.0	528	4.4
NCR-6	42	78.0	225	2.0
NCR-8	19	301.4	741	5.0
NCR-11	15	90.0	258	2.0
NCR-18	33	159.3	392	2.7
TOTAL INFEASIBLE		1,125.7	3,041	23.6
TOTAL ANALYZED		5,153.0	13,538	96.6

Because of the natural flooding and sub-irrigation in the floodplain any "new" floodplain development would be redundant (it is in effect irrigated now). So, new water-spreading irrigation would require pumping water to leveled or contour diked systems outside the flood plain. According to the SCS, these systems generally cost between $300 to $600 per acre with an annual pumping cost of from $10 to $20 per acre. The expected yield for this type of development would vary, depending on the duration of the high flows and spring rain, from 1 to 3 tons per acre. The benefit/cost ratio of this type of system is decidedly less than 1:1, making them economically infeasible.

2. Current Agricultural Land Use on the Reservation

On July 6, 1990, members of the RWRCC staff flew the length of the Rosebud Creek drainage on the Northern Cheyenne Indian Reservation. A video record of this flight was made, and approximately 100 still photographs were taken of the valley floor.

Aerial photographs were borrowed from the Water Rights Bureau in Miles City and copied and were used to distinguish currently cropped lands into sub-irrigated, irrigated, and dry land categories. The video tape and the still photos were used to corroborate the following rough estimates of currently irrigated lands on the Reservation:

naturally sub-irrigated	- 1,311 acres
currently irrigated (man-made systems)	- 525 acres
	1,836 acres

More accurate estimates could be achieved by field investigations.

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APPENDIX A
REFERENCE MAPS

1) ARABLE LANDS - NORTHERN CHEYENNE INDIAN RESERVATION
   Scale: approximately 1:275,000.
   Produced: April, 1990 by RWRCC staff.

This map displays Arable Lands (SCS classes 2-3-4), Non-arable Lands (RWRCC defined), 100 and 300 foot lift distance lines delineated from the HKM map ARABLE LANDS, Northern Cheyenne boundary and potential development projects determined by RWRCC analysis along the Tongue River.

2) FEASIBLY IRRIGABLE LANDS ANALYSIS - NORTHERN CHEYENNE INDIAN RESERVATION
   Scale: approximately 1:275,000.
   Produced: April, 1990 by RWRCC staff.

This map depicts 100 and 300 foot lift distance lines delineated from the HKM map ARABLE LANDS, 100 and 300 foot contour map lines digitized from topographic maps—beginning at the juncture of the Tongue River and the south end of the reservation, feasibility of potential agricultural project developments along the Tongue River, and the Northern Cheyenne Reservation boundary.

3) FEASIBLY IRRIGABLE LANDS ANALYSIS - NORTHERN CHEYENNE INDIAN RESERVATION
   Scale: approximately 1:275,000.
   Produced: June, 1990 by RWRCC staff.

This map is a composite of the two previously defined maps and incorporates the major data themes from each map. See page 26.

4) LIFT DISTANCES - NORTHERN CHEYENNE INDIAN RESERVATION
   Scale: approximate 1:500,000.
   Produced: April, 1990 by RWRCC staff.

This map encompasses the 100 and 300 foot digitized contour lines, Northern Cheyenne boundary and 100 and 300 foot lift distance lines delineated from the HKM map ARABLE LANDS.

5) TONGUE RIVER AREA - NCIR
   Scale: approximately 1:100,000.
   Produced: June, 1990 by RWRCC staff.

This is a working map for the RWRCC which depicts 100 and 300 foot lift distance lines delineated from the HKM map ARABLE LANDS and SCS arable soil classes 2-3-4 over bedrock found within seven 1:24000 quads adjacent to the Tongue River.

6) NORTHERN CHEYENNE RESERVATION
   Scale: 1:63,000.
   Produced: 1981 by former RWRCC or DNRC staff personnel.

This map depicts the reservation boundary, public land survey and isolated tracts of arable lands along both the Tongue and Rosebud rivers. The tracts are divided into:

ARABLE LANDS	Tongue	Rosebud
Small Isolated Tracts	1518 ac.	4956 ac.
Isolated Lands on Divide	1986 ac.	2186 ac.
Along Intermittent Streams	2193 ac.	7585 ac.
Along Perennial Streams	3306 ac.	10,050 ac.
Active Floodplain	0 ac.	4643 ac.

7) ROSEBUD COUNTY - LAND CLASSIFICATION MAP
   Scale: one-half inch equal one mile (1:125,000).
   Produced: former RWRCC staff (1982-83).

This map encompasses Rosebud Creek from the Yellowstone River south to the Northern Cheyenne Border north of Lame Deer. Within one sectionized area of Rosebud creek, lands were classified into irrigable classes 1, 2, 3, 3c and presently irrigated lands.

8) TONGUE RIVER PROJECT - IRRIGATED ACRES

Scale: approximately 1:125,000.
Produced: former RWRCC staff (1982-83).

A series of six maps encompassing the Tongue River from the Tongue River Dam to its confluence with the Yellowstone River at Miles City. The maps depict tracts of irrigated lands as derived by former RWRCC staff analysis.

9) SEMI-DETAILED LAND CLASSIFICATION

Scale: approximately 1:5,000.
Produced: Bureau of Reclamation, 1972.

These series of maps depict SCS class 1-2-3 lands along the Tongue River, including topographic details and vegetation cover.

10) ARABLE LANDS

Scale: approximately 1:125,000.
Produced: HKM, Associates (for Tribe).

This map depicts the reservation boundary; major rivers, streams and creeks; 100 and 300 foot lift distance lines from both the Tongue River and Rosebud Creek; Prime and Important Farmland within the reservation and arable SCS soils within the lift distance lines on both the Tongue and Rosebud.

11) COUNTY ARABLE MAPS

Scale: 1:32,000.
Produced: DNRC staff (1970's).

These three maps encompass Custer, Rosebud and Bighorn counties. They depict the following data:

1. DNRC 1-2-3 arable lands
2. Currently irrigated lands
3. Public Land Survey lines
4. Major streams and creeks
5. Drainage basin boundaries
6. Stock watering ponds and reservoirs

APPENDIX B
SOILS IN THE TONGUE AND ROSEBUD DRAINAGES

1. Soils on floodplains and low terraces.

These deep, well-drained soils are on nearly level floodplains and low terraces along the Tongue River and Rosebud Creek. The major soil series include Glendive, Hanly, Harlem, Havre and Straw. They formed in alluvium. Some soils are excessively drained and underlain by coarse or moderately coarse alluvium. Slopes range from 0 to 2 percent.

2. Soils on fans, terraces and uplands.

These deep, well drained soils are on nearly level terraces, sloping fans and moderately steep uplands. They occur above the floodplain and adjacent to the valley floor of the Tongue river and Rosebud Creek. Landscape dissection is a common feature adjacent to the valleys. The major soil series include Birney, Cooers, Kremlin, Lonna, Shambo and Yamac. They formed in alluvium and colluvium. Slopes range from 0 to 25 percent.

3. Soils on sedimentary uplands.

These shallow to deep, well drained soils are on gently sloping to moderately steep uplands. The major soil series include Busby, Cabbart, Cambeth, Castner and Delpoint. They formed in colluvium and weakly consolidated loamy and sandy sedimentary beds. Slopes range from 2 to 25 percent.

4. Soils on dissected sedimentary uplands.

These shallow to deep, well drained soils are on strongly sloping to very steep dissected uplands. The major soil series include Bitton, Cabbart, Cambeth, Delpoint and Yawdim. The dissected landscape has barren side slopes, escarpments, narrow ridges, rock outcrops and deeply entrenched coulees. Geologic erosion is very active in the sedimentary beds. Slopes range from 8 to 70 percent.

APPENDIX C
METHODS OF LAND CLASSIFICATION

The USDA Soil Conservation Service uses a Land Capability classification which involves the grouping of kinds of soil into special units, subclasses, and classes according to their capability for intensive use and the treatments required for sustained use. Eight land classes are used. Arable soils are classes I through IV, classes V through VIII are nonarable. The classification is based on a 5-foot profile. Class I is not used in Montana due to climatic limitations.

The Bureau of Reclamation uses an Irrigation Suitability Land Classification. Its primary purpose is to characterize the lands suitable for sustained, profitable irrigation agriculture. Soil and related features must be correlated with economic factors. Soil investigations may be to a depth of 10 feet or more. Arable soils are classes 1 through 3, Class 6 is nonarable.

The Montana DNRC uses a Land Classification that has a format similar to the Bureau of Reclamation Land Classification. The specifications resemble those of the Soil Conservation Service Land Capability Guide. Arable soils are classes 1 through 3, Class 6 is nonarable.

The RWRCC Land Classification Specifications for Irrigated Land include some features of the other systems. It also includes additional soil properties and related features such as moist bulk density, surface and subsurface drainage, etc. It was designed to provide documented specifications for the classification of irrigated land and its suitability for sustained production under irrigated agriculture.

Class IV used by the Soil Conservation Service is very restrictive and will occur in Bureau of Reclamation, DNRC and RWRCC classes 3 and 6. There will also be some overlap in other classes when the different classification systems are used. This in part helps to explain the differences for arable and nonarable acres between the various systems.

APPENDIX D
RWRCC LAND CLASSIFICATION SPECIFICATIONS

When switching to next lower class, soil must satisfy all criteria for that class.

Land Characteristics	Class 1	Class 2	Class 3
Soils Surface texture for 8 inches[1]	Sandy loam through friable clay loam, SL, FSL, VFSL, L, SIL, SI, SCL, CL, and SICL.	Coarse sandy loam to permeable clay. COSL, SL, FSL, VFSL, L, SIL, SI, SCL, CL, SICL, SC, and C. May be gravelly.	Loamy sand through permeable clay. LS, LVFS, COSL, SL, VFSL, SIL, SI, SCL, CL, SICL, SC, SIC, and C. May be gravelly, cobbly, Class I stoniness.
Texture profile Coarse	Sand permitted below 40 inches.	Loamy coarse sand or sand permitted below 30 inches.	Loamy, coarse sand permitted below 18 inches.
Fine	No clay, silty clay or sandy clay in upper 36 inches.	Permeable clay permitted below 12 inches.	Entire profile may be permeable clay if infiltration rate is adequate for plant moisture requirements.
Depth to coarse sand, gravel or cobble material[2]	Minimum 48 inches	Minimum 36 inches.	Minimum 18 inches.
Depth to dense clay, sandstone, siltstone, or shale bedrock[3]	Minimum 84 inches.	Minimum 84 inches.	Minimum 84 inches.
Available water-holding capacity[4]	Six inches or more in upper 48 inches.	Greater than 4.5 inches in upper 48 inches.	Greater than 3 inches in upper 48 inches.
Permeability[5]	.2 inch to 6 inches per hour.	Greater .1 inch to 20 inches per hour.	Greater than .1 inch per hour.
Salinity in root zone[6]	Salt content can be maintained at a level not to exceed 4 millimhos per centimeter.	Salt content can be maintained at a level not to exceed 6 millimhos per centimeter.	Salt content can be maintained at a level not to exceed 8 millimhos per centimeter.
Sodicity in root zone[7]	Sodium Adsorption Ratio (SAR) less than 13, and no physical deterioration of soil.	Sodium Adsorption Ratio (SAR) less than 13, some physical deterioration of soil, and permeability somewhat impaired.	Sodium Adsorption Ratio (SAR) less than 20, physical deterioration of soil, and permeability impaired. Permeability must be 0.2 inch per hour in the top 24 inches.

1. All surface textures and soil depths are dependent upon water holding capacities. Gravelly - less than 35% gravel (less 3 inches) in diameter; cobbly - less 35% cobbles (3 to 10 inches) in diameter, stones (10 to 24 inches) in diameter. Class 1 stoniness - stones cover less than 0.01 percent of surface.
2. All surface textures and soil depths are dependent upon water holding capacities.
3. The underlying geologic materials linit or prevent root penetration and permeability is impaired.
4. Soils with available water holding capacities of less than 3 inches in the upper 48 inches are Class 6 land.
5. Soils with a permeability of less than .1 inch per hour in any significant layer of the root zone are Class 6 land.
6. Soils dominated by montmorillonite clay are more difficult to manage than those dominated by illite or kaolinite and respond to lower levels of salinity. If the soil exceeds 8 millimhos per centimeter it must have good permeability (.2 inch per hour or greater) throughout the root zone.
7. The physical deterioration of the soil is caused by the dispersion and swelling of clays. These interrelated phenomena both act to reduce permeability (hydraulic conductivity) of the soil. Type of mineralogy, and salinity must be taken into account. Sodium Adsorption Ratio (SAR) should be less than 10 in some fine (clay) textured soils but may range to 20 in coarse (sandy) textured soils with adequate drainage.

Land Characteristics	Class 1	Class 2	Class 3
Moist bulk density[8]	1.30 g/cm³ to 1.60 g/cm³ with overlapping of blocks then allowable densities would be less than 1.55 g/cm³.	Maximum allowable 1.60 g/cm³ with overlapping of blocks then allowable densities would be less than 1.55 g/cm³.	Maximum allowable 1.60 g/cm³, with overlapping of blocks then allowable densities would be less than 1.55 g/cm³.
Slope[9]	0 - 4%	4 - 6%	6 - 8% Gravity 15% Sprinkler
Drainage			
Class	Well and moderately well drained, water table below 60 inches	Moderately well though somewhat poorly drained, water table below 36 inches.	Somewhat excessively through poorly drained, water table below 18 inches.
Surface	Little or no surface drainage required.	Shallow surface drainage required.	Shallow surface drainage required. Occassional small depressions, shallow drainways, few complex slopes.
Subsurface	Well aerated, no limit to moisture movement or root development.	Well to moderately well aerated; moisture movement and root development somewhat impeded.	Moderately well aerated, moisture movement, and root development moderately restricted.
Barrier (soil and/or drainage factor)[10]			
Overflow (Flooding)[11]	None in summer. Rare in fall and winter.	Rare in summer. Occasional in fall, winter, and spring.	Occassional in summer. Frequent in fall, winter, and spring.
Growing season[12]	More than 105 days.	90 to 105 days.	Less than 90 day growing season, crops produced 7 out of 10 years.

Classes 1, 2, and 3 are arable. Class 6 is nonarable (lands which do not meet minimum requirements for arable land). The land class assigned to a given soil unit is dependent upon the best judgement of the soil scientist.

References Cited:

National Soils Handbook, SCS, USDA
National Soils Handbook Issue No. MT-2, SCS, USDA
Soil Survey Manual, Chapters 4 and 5, SCS, USDA
Land Classification Techniques and Standards BOR, USDI

8. Bulk density is used to express weight measurements on a volume basis. As bulk densities approach 1.5 to 1.6 g/cm³, depending on texture, root growth is impeded and both aeration and water movement may be too low for optimum growth.
9. Gravity-type irrigation should be mostly limited to slopes of 6 percent or less in general gradient, and sprinkler-type irrigation limited to slopes of 15 percent or less.
10. The general depth to very slowly permeable or impermeable material that is a barrier to subsurface water movement shall be 7 feet or greater. This includes dense clay and sandstone, siltstone, or shale bedrock. Permeability less than .1 inch per hour.
11. Definition of Flooding Frequency: Rare - Floods less than once in ten years; Occasional - Floods once in two to ten years; Frequent - Floods at least once every two years.
12. The growing season (frost-free season) must be long enough to produce crops on a long term basis, at least 7 out of 10 years. The base reference crop is spring wheat.

APPENDIX E
SOIL MAPPING UNITS

Soil map units below the 300 foot lift in the Tongue River and Rosebud Creek Areas have been grouped into three major parts, 1) soils on flood plains, terraces, fans and uplands, 2) soils on fans and uplands, 3) soils on highly dissected uplands.

1. Soils on flood plains, terraces, fans and uplands. This group consists of forty-six map units. Slope is 0 to 15 percent. It includes the arable soils in Tongue River and Rosebud Creek areas. Non-arable soils with slopes less than 15 percent are included.

SOIL LEGEND

Symbol	Name
18	Birney-Cooers-Kirby complex, 2 to 15 percent slopes
28	Bitton-Twin Creek-Ringling, dry, complex, 2 to 15 percent slopes
36	Borollic Camborthids-Ustic Torrifluvents complex, 0 to 8 percent slopes
46	Busby loam, 0 to 2 percent slopes
47	Busby-Rock outcrop complex, 8 to 15 percent slopes
56	Cambeth silt loam, 2 to 8 percent slopes
57	Cambeth silt loam, 8 to 15 percent slopes
58	Cambeth-Cabbart silt loams, 4 to 15 percent slopes
61	Castner-Shambo complex, 2 to 15 percent slopes
62	Chinook fine sandy loam, 2 to 8 percent slopes
64	Cooers loam, 2 to 8 percent slopes
65	Cooers-Birney complex, 2 to 8 percent slopes
66	Cooers-Yamac loams, 2 to 8 percent slopes
81	Floweree silt loam, 0 to 2 percent slopes
82	Floweree silt loam, 2 to 8 percent slopes
89	Gerdrum clay loam, 2 to 8 percent slopes
91	Gerdrum-Kobar silty clay loams, 2 to 8 percent slopes
95	Glendive loam, 0 to 2 percent slopes, occasionally flooded
96	Hanly-Glendive loams, occasionally flooded, 0 to 2 percent slopes
97	Harlem silty clay loam, occasionally flooded, 0 to 2 percent slopes
99	Havre loam, 0 to 2 percent slopes
100	Havre loam, occasionally flooded, 0 to 2 percent slopes
109	Kobar silty clay loam, 0 to 2 percent slopes
110	Kobar silty clay loam, 2 to 8 percent slopes
111	Kobar silty clay loam, 8 to 15 percent slopes
112	Kobar silty clay loam, gullied, 2 to 15 percent slopes
116	Kremlin loam, 0 to 2 percent slopes
117	Kremlin loam, 2 to 8 percent slopes
123	Lonna silt loam, 0 to 2 percent slopes
124	Lonna silt loam, 2 to 8 percent slopes
125	Lonna silt loam, 8 to 15 percent slopes
159	Savage silty clay loam, 0 to 2 percent slopes
161	Shambo loam, 0 to 2 percent slopes

162 Shambo loam, 2 to 8 percent slopes

168 Spang sandy loam, 2 to 8 percent slopes

169 Spang-Birney complex, 8 to 15 percent slopes

171 Spinekop silty clay loam, 0 to 2 percent slopes

190 Vanstel loam, 2 to 8 percent slopes

197 Yamac loam, 0 to 2 percent slopes

198 Yamac loam, 2 to 8 percent slopes

199 Yamac loam, 8 to 15 percent slopes

201 Yamac-Birney complex, 2 to 8 percent slopes

202 Yamac-Birney complex, 8 to 15 percent slopes

205 Yamac-Busby complex, 2 to 8 percent slopes

208 Yamac-Delpoint loams, 4 to 15 percent slopes

209 Yamac-Redcreek loams, 2 to 15 percent slopes

MAP UNIT DESCRIPTIONS

18 - Birney-Cooers-Kirby complex, 2 to 15 percent slopes. This map unit is on uplands. Slope is 2 to 15 percent.

This unit is about 40 percent Birney channery loam, 35 percent Cooers loam, and 25 percent Kirby channery loam. The Birney and Cooers soils formed in colluvium derived from baked sandstone. The Kirby soil formed in residuum derived from baked sandstone.

The Birney soil is deep and well drained. The surface layer is a channery loam about 5 inches thick. The substratum to a depth of 48 inches or more is extremely channery sandy loam. Permeability is moderate and available water capacity is about 3 inches in the upper 48 inches.

The Cooers soil is deep and well drained. The surface layer is a loam about 4 inches thick. The underlying material to a depth of 48 inches or more is a loam or channery loam. Permeability is moderate and available water capacity is about 8 inches in the upper 48 inches.

The Kirby soil is shallow over fractured baked sandstone. The surface layer is a channery loam about 5 inches thick. The underlying material to a depth of about 18 inches is a very channery loam. Below this, to a depth of 48 inches or more, is fractured baked sandstone. Permeability is rapid and available water capacity is mainly 1 to 2 inches in the upper 48 inches.

This map unit is poorly suited to irrigated crops because of the low available water capacity of the Birney and Kirby soils, and areas of rock outcrop. This map unit is class 6 irrigated.

28 - Bitton-Twin Creek-Ringling, dry, complex, 2 to 15 percent slopes. This map unit is on uplands and fans. Slope is 2 to 15 percent.

This unit is about 40 percent Bitton channery loam, 35 percent Twin Creek loam, and 25 percent Ringling channery loam. The Bitton soil is on side slopes, the Twin Creek soil is on side slopes and short fans, the Ringling soil is on knobs and ridges. The Bitton and Twin Creek soils formed in colluvium derived from baked sandstone and shale, the Ringling soil formed in residuum derived from baked sandstone and shale.

The Bitton and Twin Creek soils are deep, and the Ringling soil is shallow to fractured baked sandstone.

This map unit is poorly suited to irrigated crops because of the low available water capacity of the Bitton and Ringling soils and the shallow depth to fractured baked sandstone in the Ringling soil. This map unit is class 6 irrigated.

36 - Borollic Camborthids-Ustic Torrifluvents complex, 0 to 8 percent slopes. This map unit is on channeled fans, terraces and flood plains. Slope is 0 to 8 percent.

This unit is about 65 percent Borollic Camborthids and 35 percent Ustic Torrifluvents. The Borollic Camborthids are on fans and terraces, the Ustic Torrifluvents are on low terraces and flood plains.

This map unit is poorly suited to irrigated crops because the unit is dissected by stream channels and some areas contain a high percentage of coarse fragments. This map unit is class 6.

46 - Busby loam, 0 to 2 percent slopes. This deep, well drained soil is on stream terraces. It formed in alluvium. Slope is 0 to 2 percent.

The surface layer of this soil is a loam about 5 inches thick. The subsoil is a loam about 11 inches thick. The substratum to a depth of 48 inches or more is mainly a fine sandy loam.

Permeability is moderately rapid and available water capacity is about 6 inches in the upper 48 inches.

This soil is well suited to irrigated crops. This map unit is Class 1 irrigated.

47 - Busby-Rock outcrop complex, 8 to 15 percent slopes. This map unit is on uplands. Slope is 8 to 15 percent.

This unit is about 50 percent Busby fine sandy loam and 50 percent sandstone Rock outcrop. The Busby soil is on short fans, and the Rock outcrop is on knobs and ridges. The Busby soil formed in alluvium.

The Busby soil is deep.

This map unit is not suited to irrigated crops because of the areas of Rock outcrop. This map unit is class 6.

56 - Cambeth silt loam, 2 to 8 percent slopes. This moderately deep, well drained soil is on uplands. Slope is 2 to 8 percent.

The surface layer of this soil is a silt loam about 5 inches thick. The underlying soil material is a silt loam. Below this, to a depth of 48 inches or more, are loamy sedimentary beds.

Permeability is moderate, and available water capacity is about 5 inches. The effective rooting depth is limited by the sedimentary beds at a depth of 20 to 40 inches.

This soil is poorly suited to irrigated crops because of the moderate depth to the sedimentary beds. This map unit is class 6 irrigated.

57 - Cambeth silt loam, 8 to 15 percent slopes. This moderately deep, well drained soil is on uplands. Slope is 8 to 15 percent.

The surface layer of this soil is a silt loam about 4 inches thick. The underlying soil material is a silt loam. Below this, to a depth of 48 inches or more, are loamy sedimentary beds.

Permeability is moderate, and available water capacity is about 5 inches. The effective rooting depth is limited by the sedimentary beds at a depth of 20 to 40 inches.

This map unit is poorly suited to irrigated crops because of the moderate depth to sedimentary beds. This map unit is class 6 irrigated.

58 - Cambeth-Cabbart silt loams, 4 to 15 percent slopes. This map unit is on uplands. Slope is 4 to 15 percent.

This unit is about 65 percent Cambeth silt loam and 35 percent Cabbart silt loam. These soils formed in residuum from loamy sedimentary beds.

The Cambeth soil is moderately deep and well drained. The surface layer is a silt loam about 5 inches thick. The underlying soil material is a silty clay loam. Below this, to a depth of 48 inches or more, are loamy sedimentary beds. Permeability is moderate and available water capacity is about 5 inches. The effective rooting depth is limited by the sedimentary beds at a depth of 20 to 40 inches.

The Cabbart soil is shallow and well drained. The soil material is a silt loam. Below this, to a depth of 48 inches or more, are loamy sedimentary beds. Permeability is moderate and available water capacity is about 2 inches. The effective rooting depth is limited by the sedimentary beds at a depth of 10 to 20 inches.

This map unit is poorly suited to irrigated crops because of the shallow to moderate depth to sedimentary beds. This map unit is class 6 irrigated.

61 - Castner-Shambo complex, 2 to 15 percent slopes. This map unit is on uplands. Slope is 2 to 15 percent.

This unit is about 50 percent Castner channery loam and 50 percent Shambo loam. The Castner soil formed in residuum derived from sandstone. The Shambo soil formed in alluvium derived from loamy sedimentary beds.

The Castner soil is shallow and well drained. The soil material is a channery or very channery loam. Below this, to a depth of 48 inches or more, is hard sandstone. Permeability is moderate and available water capacity is about 2 inches. The effective rooting depth is limited by hard sandstone at a depth of 10 to 20 inches.

The Shambo soil is deep and well drained. The soil profile to a depth of 48 inches or more is a loam. Permeability is moderate and available water capacity is about 8 inches in the upper 48 inches.

The map unit is poorly suited to irrigated crops because of the shallow depth to hard sandstone of the Castner soil. This map unit is class 6 irrigated.

62 - Chinook fine sandy loam, 2 to 8 percent slopes. This deep, well drained soil is on fans and uplands. It formed in alluvium on fans and in eolian material on uplands. Slope is 2 to 8 percent.

The soil profile to a depth of 48 inches or more is a fine sandy loam.

Permeability is moderately rapid and available water capacity is about 6 inches in the upper 48 inches.

This soil is suited to irrigated crops. This map unit is class 3 irrigated.

64 - Cooers loam, 2 to 8 percent slopes. This deep, well drained soil is on fans and uplands. It formed in alluvium or in colluvium derived from baked sandstone and shale. Slope is 2 to 8 percent.

The surface layer of this soil is a loam about 5 inches thick. The underlying material to a depth of 48 inches or more is a loam.

Permeability is moderate, and available water capacity is about 8 inches in the upper 48 inches.

This soil is suited to irrigated crops. This map unit is class 2 irrigated.

65 - Cooers-Birney complex, 2 to 8 percent slopes. This map unit is on uplands. Slope is 2 to 8 percent.

This unit is about 60 percent Cooers loam and 30 percent Birney channery loam. The Cooers soil formed in alluvium. The Birney soil formed in colluvium, derived from baked sandstone and shale.

The Cooers soil is deep and well drained. The surface layer is a loam about 4 inches thick. The underlying material to a depth of 48 inches or more is a loam. Permeability is moderate and available water capacity is about 8 inches in the upper 48 inches.

The Birney soil is deep and well drained. The surface layer is a channery loam about 5 inches thick. The subsoil is a channery loam about 8 inches thick. The substratum to a depth of 48 inches or more is mainly an extremely channery loam. Permeability is moderate and available water capacity is about 3 inches in the upper 48 inches.

This map unit is poorly suited to irrigated crops because of low available water capacity of the Birney soil and inclusions of shallow soils over baked sandstone and shale. This map unit is class 6 irrigated.

66 - Cooers-Yamac loams, 2 to 8 percent slopes. This map unit is on fans and uplands. Slope is 2 to 8 percent.

This unit is about 50 percent Cooers loam and 50 percent Yamac loam. They formed in alluvium and colluvium derived from baked sandstone and shale from loamy sedimentary beds.

The Cooers soil is deep and well drained. The surface layer is a loam about 4 inches thick. The underlying material to a depth of 48 inches or more is a loam. Permeability is moderate and available water capacity is about 8 inches in the upper 48 inches.

The Yamac soil is deep and well drained. The surface layer is a loam about 5 inches thick. The underlying material to a depth of 48 inches or more is a loam that has strata of fine sandy loam and silt loam. Permeability is moderate and available water capacity is about 8 inches in the upper 48 inches.

These soils are suited to irrigated crops. This map unit is class 2 irrigated.

81 - Floweree silt loam, 0 to 2 percent slopes. This deep, well drained soil is on terraces. It formed in alluvium. Slope is 0 to 2 percent.

The soil profile to a depth of 48 inches or more is a silt loam.

Permeability is moderate and available water capacity is about 8 inches in the upper 48 inches.

The soil is suited to irrigated crops. This map unit is class 2 irrigated.

82 - Floweree silt loam, 2 to 8 percent slopes. This deep, well drained soil is on fans, terraces and uplands. It formed in alluvium. Slope is 2 to 8 percent.

The soil profile to a depth of 48 inches or more is a silt loam.

Permeability is moderate and available water capacity is about 8 inches in the upper 48 inches.

This soil is suited to irrigated crops. This map unit is class 2 irrigated.

89 - Gerdrum clay loam, 2 to 8 percent slopes. This deep, well drained, sodium and salt-affected soil is on fans and uplands. It formed in alluvium. Slope is 2 to 8 percent.

The surface layer of this soil is a clay loam about 7 inches thick. The subsoil is a clay about 6 inches thick. The substratum to a depth of 48 inches or more is mainly a silty clay or silty clay loam.

Permeability is slow and available water capacity is about 5 inches in the upper 48.inches.

The soil is not suited to irrigated crops because of slow permeability, sodicity and salinity in the root zone. This soil is class 6 irrigated.

91 - Gerdrum-Kobar silty clay loams, 2 to 8 percent slopes. This map unit is on fans and uplands. Slope is 2 to 8 percent.

This unit is about 55 percent Gerdrum silty clay loam and 45 percent Kobar silty clay loam. They formed in alluvium.

The sodium and salt affected Gerdrum soil is deep and well drained. The surface layer is a silty clay loam about 7 inches thick. The subsoil is a silty clay about 12 inches thick. The substratum to a depth of 48 inches or more is a silty clay loam. Permeability is slow and available water capacity is about 5 inches in the upper 48 inches.

The Kobar soil is deep and well drained. The soil profile to a depth of 48 inches or more is a silty clay loam. Permeability is slow and available water capacity is about 7 inches in the upper 48 inches.

This map unit is poorly suited to irrigated crops because of slow permeability, sodicity and salinity in the root zone of the Gerdrum soil. This map unit is class 6 irrigated.

95 - Glendive loam, 0 to 2 percent slopes, occasionally flooded. This deep, well drained, occasionally flooded soil is on flood plains and low terraces along the Tongue River. It formed in alluvium. Slope is 0 to 2 percent.

The surface layer of this soil is a loam about 10 inches thick. The underlying material to a depth of 48 inches or more is mainly a sandy loam that has strata of loam and loamy sand.

Permeability is moderately rapid and available water capacity is mainly 5 or 6 inches in the upper 48 inches. This soil is subject to occasional periods of flooding during spring and early in summer.

The soil is suited to irrigated crops. This map unit is class 2 irrigated.

96 - Hanly-Glendive loams, occasionally flooded, 0 to 2 percent slopes. This map unit is on low stream terraces along the Tongue River and Rosebud Creek. Slope is 0 to 2 percent.

This unit is about 55 percent Hanly loam and 45 percent Glendive loam. These occasionally flooded soils formed in alluvium.

The Hanly soil is deep and somewhat excessively drained. The surface layer is a loam about 7 inches thick. The underlying material to a depth of 48 inches or more is mainly stratified loamy sand, fine sandy loam and fine sand. Permeability is rapid and available water capacity is mainly 3 to 4 inches in the upper 48 inches.

The Glendive soil is deep and well drained. The surface layer is a loam about 8 inches thick. The underlying material to a depth of 48 inches or more is sandy loam with strata of loam and loamy sand. Permeability is moderately rapid and available water capacity is mainly 5 or 6 inches in the upper 48 inches.

These soils are subject to occasional periods of flooding during spring and early in summer.

They are suited to irrigated crops. This map unit is class 3 irrigated.

97 - Harlem silty clay loam, occasionally flooded, 0 to 2 percent slopes. This deep, well drained, occasionally flooded soil is on flood plains and low terraces along the Tongue River. It formed in alluvium. Slope is 0 to 2 percent.

The surface layer of this soil is a silty clay loam about 8 inches thick. The underlying material to a depth of 48 inches or more is a silty clay loam with strata of loam, silt loam and fine sandy loam in the lower part.

Permeability is slow, and available water capacity is mainly 7 or 8 inches in the upper 48 inches. This soil is subject to occasional periods of flooding during spring and early in summer.

This soil is suited to irrigated crops. This map unit is class 2 irrigated.

99 - Havre loam, 0 to 2 percent slopes. This deep, well drained, rarely flooded soil is on stream terraces along the Tongue River. It formed in alluvium. Slope is 0 to 2 percent.

The surface layer of this soil is a loam about 6 inches thick. The underlying material to a depth of 48 inches or more is a loam that has strata of fine sandy loam and silt loam.

Permeability is moderate and available water capacity is about 8 inches in the upper 48 inches. This soil is subject to rare periods of flooding during spring and early in summer.

This soil is well suited to irrigated crops. This map unit is class 1 irrigated.

100 - Havre loam, occasionally flooded, 0 to 2 percent slopes. This deep, well drained, occasionally flooded soil is on floodplains and low terraces along the Tongue River and Rosebud Creek. It formed in alluvium. Slope is 0 to 2 percent.

The surface layer of this soil is a loam about 10 inches thick. The underlying material to a depth of 48 inches or more is mainly very fine sandy loam or loam.

Permeability is moderate and available water capacity is about 8 inches in the upper 48 inches. This soil is subject to occasional periods of flooding during spring and early in summer.

This soil is suited to irrigated crops. This map unit is class 2 irrigated.

109 - Kobar silty clay loam, 0 to 2 percent slopes. This deep, well drained soil is on terraces. It formed in alluvium. Slope is 0 to 2 percent.

The soil profile to a depth of 48 inches or more is a silty clay loam.

Permeability is slow and available water capacity is about 7 inches in the upper 48 inches.

This soil is suited to irrigated crops. This map unit is class 3 irrigated.

110 - Kobar silty clay loam, 2 to 8 percent slopes. This deep, well drained soil is on fans and uplands. It formed in alluvium and colluvium. Slope is 2 to 8 percent.

The soil profile to a depth of 48 inches or more is a silty clay loam.

Permeability is slow and available water capacity is about 7 inches in the upper 48 inches.

The soil is suited to irrigated crops. This map unit is class 3 irrigated.

111 - Kobar silty clay loam, 8 to 15 percent slopes. This deep, well drained soil is on fans and uplands. It formed in alluvium and colluvium. Slope is 8 to 15 percent.

The soil profile to a depth of 48 inches or more is a silty clay loam.

Permeability is slow and available water capacity is about 7 inches in the upper 48 inches.

This map unit is poorly suited to irrigated crops because of slow permeability and inclusion of shallow soils on knobs and ridges. This map unit is class 6 irrigated.

112 - Kobar silty clay loam, gullied, 2 to 15 percent slopes. This deep, well drained soil is on dissected fans. It formed in alluvium. Slope is 2 to 15 percent.

The soil profile to a depth of 48 inches or more is a silty clay loam.

Permeability is slow and available water capacity is about 7 inches in the upper 48 inches.

This soil is poorly suited to irrigated crops because it is dissected by deep gullies. This map unit is class 6 irrigated.

116 - Kremlin loam, 0 to 2 percent slopes. This deep, well drained soil is on terraces. It formed in alluvium. Slope s 0 to 2 percent.

The soil profile to a depth of about 36 inches is a loam. Below this to a depth of 48 inches or more is fine sandy loam that has thin strata of loam.

Permeability is moderate and available water capacity is about 8 inches in the upper 48 inches.

This soil is suited to irrigated crops. This map unit is class 1 irrigated.

117 - Kremlin loam, 2 to 8 percent slopes. This deep, well drained soil is on fans and terraces. It formed in alluvium. Slope is 2 to 8 percent.

The soil profile to a depth of 48 inches or more is a loam.

Permeability is moderate and available water capacity is about 8 inches in the upper 48 inches.

This soil is suited to irrigated crops. This map unit is class 2 irrigated.

123 - Lonna silt loam, 0 to 2 percent slopes. This deep, well drained soil is on terraces. It formed in alluvium. Slope is 0 to 2 percent.

The soil profile to a depth of 48 inches or more is a silt loam.

Permeability is moderate and available water capacity is about 8 inches in the upper 48 inches.

This soil is suited to irrigated crops. This map unit is class 2 irrigated.

124 - Lonna silt loam, 2 to 8 percent slopes. This deep, well drained soil is on fans. It formed in alluvium. Slope is 2 to 8 percent.

The soil profile to a depth of 48 inches or more is a silt loam.

Permeability is moderate and available water capacity is about 8 inches in the upper 48 inches.

This soil is suited to irrigated crops. This map unit is class 2 irrigated.

125 - Lonna silt loam, 8 to 15 percent slopes. This deep, well drained soil is on fans. It formed in alluvium. Slope is 8 to 15 percent.

The soil profile to a depth of 48 inches or more is a silt loam.

Permeability is moderate and available water capacity is about 8 inches in the upper 48 inches.

This soil is suited to irrigated crops. This map unit is class 3 irrigated.

159 - Savage silty clay loam, 0 to 2 percent slopes. This deep, well drained soil is on terraces. It formed in alluvium. Slope is 0 to 2 percent.

The surface layer of this soil is a silty clay loam about 6 inches thick. The subsoil is a silty clay about 9 inches thick. The substratum to a depth of 48 inches or more is a silty clay loam.

Permeability is slow and available water capacity is about 8 inches in the upper 48 inches.

This soil is suited to irrigated crops. This map unit is class 2 irrigated.

161 - Shambo loam, 0 to 2 percent slopes. This deep, well drained soil is on terraces. It formed in alluvium. Slope is 0 to 2 percent.

The soil profile to a depth of 48 inches or more is a loam.

Permeability is moderate and available water capacity is about 8 inches in the upper 48 inches.

This soil is suited to irrigated crops. This map unit is class 1 irrigated.

162 - Shambo loam, 2 to 8 percent slopes. This deep, well drained soil is on fans and uplands. It formed in alluvium. Slope is 2 to 8 percent.

The soil profile to a depth of 48 inches or more is a loam.

Permeability is moderate and available water capacity is about 8 inches in the upper 48 inches.

This soil is suited to irrigated crops. This map unit is class 2 irrigated.

168 - Spang sandy loam, 2 to 8 percent slopes. This deep, well drained soil is on fans and uplands. It formed in alluvium or in colluvium derived from baked sandstone. Slope is 2 to 8 percent.

The surface layer of this soil is a sandy loam about 6 inches thick. The underlying material to a depth of about 40 inches is a sandy loam, below this, is a loamy sand.

Permeability is moderately rapid and available water capacity is about 5 inches in the upper 48 inches.

This soil is suited to irrigated crops. This map unit is class 3 irrigated.

169 - Spang-Birney complex, 8 to 15 percent slopes. This map unit is on uplands. Slope is 8 to 15 percent.

This unit is about 55 percent Spang sandy loam and 45 percent Birney channery loam. The Spang soil formed in alluvium or in colluvium derived from baked sandstone. The Birney soil formed in colluvium derived from baked sandstone and shale.

The Spang soil is deep and well drained. The surface layer is a sandy loam about 6 inches thick. The underlying material to a depth of 48 inches or more is a sandy loam. Permeability is moderately rapid and available water capacity is about 5 inches in the upper 48 inches.

The Birney soil is deep and well drained. The surface layer is a channery loam about 6 inches thick. The substratum to a depth of about 25 inches is a very channery sandy loam. Below this, to a depth of 48 inches or more is extremely channery sandy loam. Permeability is moderate and available water capacity is about 3 inches in the upper 48 inches.

This map unit is poorly suited to irrigated crops because of the low available water capacity of the Birney soil and the inclusions of shallow stony soils. This map unit is class 6 irrigated.

171 - Spinekop silty clay loam, 0 to 2 percent slopes. This deep, well drained soil is on terraces. It formed in alluvium. Slope is 0 to 2 percent.

The surface layer of this soil is a silty clay loam about 11 inches thick. The subsoil is a silty clay loam in the upper part and a loam in the lower part. The substratum to a depth of 48 inches or more is a loam with strata of fine sandy loam and clay loam.

Permeability is moderately slow and available water capacity is about 8 inches in the upper 48 inches.

The soil is well suited to irrigated crops. This map unit is class 2 irrigated.

190 - Vanstel loam, 2 to 8 percent slopes. This deep, well drained soil is on fans, terraces and uplands. It formed in alluvium. Slope is 2 to 8 percent.

The surface layer of this soil is a loam about 5 inches thick. The subsoil is a clay loam in the upper part and a loam in the lower part. It is about 19 inches thick. The substratum to a depth of 48 inches or more is a loam.

Permeability is moderate and available water capacity is about 8 inches in the upper 48 inches.

This soil is suited to irrigated crops. This map unit is class 3 irrigated.

197 - Yamac loam, 0 to 2 percent slopes. This deep, well drained soil is on terraces. It formed in alluvium. Slope is 0 to 2 percent.

The surface layer of this soil is a loam about 5 inches thick. The underlying material to a depth of 48 inches or more is a loam that has strata of fine sandy loam and silt loam.

Permeability is moderate and available water capacity is about 7 inches in the upper 48 inches.

This soil is well suited to irrigated crops. This map unit is class 2 irrigated.

198 - Yamac loam, 2 to 8 percent slopes. This deep, well drained soil is on fans and uplands. It formed in colluvium and alluvium derived from loamy sedimentary beds. Slope is 2 to 8 percent.

The soil profile to a depth of 48 inches or more is a loam.

Permeability is moderate and available water capacity is about 8 inches in the upper 48 inches.

This soil is suited to irrigated crops. This map unit is class 3 irrigated.

199 - Yamac loam, 8 to 15 percent slopes. This deep well drained soil is on fans and uplands. It formed in alluvium and in colluvium derived from loamy sedimentary beds.

The soil profile to a depth of 48 inches or more is a loam.

Permeability is moderate and available water capacity is about 8 inches in the upper 48 inches.

This map unit is poorly suited to irrigated crops because of inclusions of shallow soils over loamy sedimentary beds. This map unit is class 6 irrigated.

201 - Yamac-Birney complex; 2 to 8 percent slopes. This map unit is on fans and uplands. Slope is 2 to 8 percent.

This unit is about 60 percent Yamac loam and 40 percent Birney channery loam. The Yamac soil formed in alluvium and in colluvium. The Birney soil formed in colluvium derived from baked sandstone and shale.

The Yamac soil is deep and well drained. The surface layer is a loam about 4 inches thick. The underlying material to a depth of 48 inches or more is a loam. Permeability is moderate and available water capacity is about 8 inches in the upper 48 inches.

The Birney soil is deep and well drained. The surface layer is a channery loam about 5 inches thick. The subsoil is a channery loam about 6 inches thick. The substratum to a depth of 48 inches or more is a very channery loam. Permeability is moderate and available water capacity is about 3 inches in the upper 48 inches.

This map unit is suited to irrigated crops. Birney soils have low available water capacity. Shallow soils over baked sandstone and shale are included. This map unit is class 3 irrigated.

202 - Yamac-Birney complex, 8 to 15 percent slopes. This map unit is on uplands. Slope is 8 to 15 percent.

This map unit is about 55 percent Yamac loam and 45 percent Birney channery loam. The Yamac soil formed in alluvium and in colluvium derived from baked sandstone and shale.

The Yamac soil is deep and well drained. The surface layer is a loam about 4 inches thick. The underlying material to a depth of 48 inches or more is a loam. Permeability is moderate and available water capacity is about 8 inches in the upper 48 inches.

The Birney soil is deep and well drained. The surface layer is a channery loam about 4 inches thick. The subsoil is a channery loam about 8 inches thick. The substratum to a depth of 48 inches or more is a very channery loam. Permeability is moderate and available water capacity is about 3 inches in the upper 48 inches.

This map unit is poorly suited to irrigated crops because of low available water capacity of the Birney soil and inclusions of shallow soil over baked sandstone and shale. This map unit is class 6 irrigated.

205 - Yamac-Busby complex, 2 to 8 percent slopes. This map unit is on fans and uplands. Slope is 2 to 8 percent.

This unit is about 55 percent Yamac loam and 45 percent Busby fine sandy loam These soils formed in alluvium and in colluvium derived from loamy and sandy sedimentary beds.

The Yamac soil is deep and well drained. The surface layer is a loam about 3 inches thick. The underlying material to a depth of 48 inches or more is a loam. Permeability is moderate and available water capacity is about 8 inches in the upper 48 inches.

The Busby soil is deep and well drained. The soil profile to a depth of 48 inches or more is a fine sandy loam. Permeability is moderately rapid and available water capacity is about 5 inches in the upper 48 inches.

This map unit is poorly suited to irrigated crops because of inclusions of rock outcrop. This map unit is class 6 irrigated.

208 - Yamac-Delpoint loams, 4 to 15 percent slopes. This map unit is on uplands. Slope is 4 to 15 percent.

This unit is about 55 percent Yamac loam and 45 percent Delpoint loam. The Yamac soil formed in alluvium and in colluvium. The Delpoint soil formed in residuum derived from loamy sedimentary beds.

The Yamac soil is deep and well drained. The surface layer is a loam about 4 inches thick. The underlying material to a depth of 48 inches or more is a loam. Permeability is moderate and available water capacity is about 8 inches in the upper 48 inches.

The Delpoint soil is moderately deep and well drained. The surface layer is a loam about 6 inches thick. The underlying soil material is a loam. Below this, to a depth of 48 inches or more, are loamy sedimentary beds. Permeability is moderate and available water capacity is mainly 3 to 5 inches, depending on the depth to the loamy sedimentary beds.

This map unit is poorly suited to irrigated crops because of depth to loamy sedimentary beds. This map unit is class 6.

209 - Yamac-Redcreek loams, 2 to 15 percent slopes. This map unit is on uplands. Slope is 4 to 15 percent.

This unit is about 50 percent Yamac loam and 50 percent Redcreek loam. The Yamac soil formed in colluvium. The Redcreek soil formed in residuum derived from sandstone.

The Yamac soil is deep and well drained. The surface layer is a loam about 4 inches thick. The underlying material to a depth of 48 inches or more is a loam. Permeability is moderate and available water capacity is about 8 inches in the upper 48 inches.

The Redcreek soil is shallow and well drained. The soil material is loam. Below this, to a depth of 48 inches or more, is sandstone. Permeability is moderately rapid and available water capacity is about 2 inches. The effective rooting depth is limited by the sandstone at a depth of 10 to 20 inches.

This map unit is poorly suited to irrigated crops because of the shallow depth to sandstone of the Redcreek soil. This map unit is class 6 irrigated.

2. **Soils on fans and uplands.** This group consists of fifteen map units. Slope is 4 to 25 percent. Soils are shallow to deep. They formed in alluvium, colluvium, baked sandstone and shale, and residuum from loamy and sandy sedimentary beds.

These map units are not suited to irrigated crops due to one or more of the following: steepness of slope, shallow depth, to baked sandstone and shale, sedimentary beds and low available water capacity of the soils. These map units are class 6.

The following map units are in this group.

Symbol	Name
16	Birney channery loam, 15 to 25 percent slopes
19	Birney-Kirby channery loams, 4 to 25 percent slopes
20	Birney-Kirby-Cabbart complex, 15 to 25 percent slopes
22	Birney, moist-Birney-Kirby channery loams, 15 to 25 percent slopes
25	Bitton-Ringling, dry, channery loams, 8 to 25 percent slopes
49	Busby-Twilight-Blackhall, warm, fine sandy loams, 8 to 25 percent slopes

59 Cambeth-Cabbart complex, dissected, 8 to 25 percent slopes

73 Delpoint-Cabbart-Yamac loams, 8 to 25 percent slopes

76 Delpoint, moist-Delpoint-Cabbart loams, 15 to 25 percent slopes

115 Kobar-Cabbart-Yawdim complex, 8 to 25 percent slopes

132 Lonna-Cabbart-Yawdim complex, 8 to 25 percent slopes

170 Spang, moist-Birney complex, 8 to 25 percent slopes

203 Yamac-Birney complex, 15 to 25 percent slopes

204 Yamac-Birney-Cabbart complex, 15 to 25 percent slopes

207 Yamac-Cabbart loams, 8 to 25 percent slopes

3. Soils on highly dissected uplands. This group consists of seventeen map units. Slope is 15 to 70 percent. They formed in colluvium, baked sandstone and shale, residium from loamy sedimentary beds and shale. Most areas have barren side slopes, narrow ridges, rock outcrops and deeply entrenched coulees. These map units are not suited to irrigated crops due to one or more of the following: steepness of slope, shallow depth to baked sandstone and shale, sedimentary beds and rock outcrop. These map units are class 6.

The following map units are in this group.

Symbol Name

8 Armells-Delpoint-Cabbart complex, 25 to 70 percent slopes

9 Armells-Kirby complex, 25 to 70 percent slopes

10 Armells-Kirby-Cabbart complex, 25 to 70 percent slopes.

12 Badland

14 Barvon, dry-Doney-Cabba complex, 15 to 70 percent slopes

21 Birney, moist-Armells-Cabbart complex, 25 to 70 percent slopes

24 Bitton-Doney-Ringling, dry, complex, 25 to 70 percent slopes

29 Bitton, moist-doney-Cabba complex, 15 to 70 percent slopes

32 Bitton, moist-Ringling, dry-Cabba complex, 25 to 70 percent slopes

54 Cabbart-Armells-Rock outcrop complex, 25 to 70 percent slopes

55 Cabbart-Yawdim-Rock outcrop complex, 15 to 70 percent slopes

72 Delpoint-Cabbart loams, 25 to 70 percent slopes.

74 Delpoint-Cabbart-Yawdim complex, 25 to 70 percent slopes.

77 Delpoint, moist-Delpoint-Cabbart loams, 25 to 70 percent slopes.

108 Kirby-Cabbart-Rock outcrop complex, 25 to 70 percent slopes

121 Lamedeer, dry-Bitton, moist-Ringling, dry, channery loams, 25 to 70 percent slopes

183 Ustic Torriorthents, 15 to 35 percent slopes.

APPENDIX F
ENGINEERING PROGRAM DESCRIPTION

Individual projects are designed using the interactive computer programs developed by the DNRC for Missouri River water reservation applications. This method incorporates computer-aided design (AutoCAD) and spreadsheet (Lotus-123) software to design and calculate annual irrigation costs of potential irrigation sites.

With AutoCAD a user can draws points, lines, geometric objects, and freehand traces. These drawing components are referred to as entities. Using a digitizing tablet and a printer or plotter these entities are drafted and reproduced on a map at any desired scale. A digitizing tablet is a computer input device, like the keyboard, that allows the user to place information on the screen. A map is placed on the digitizing tablet and the tablet is calibrated to the map's scale. Then the user draws entities on the screen at a scale relative to the map. This procedure is used in the design of irrigation systems. Text and attribute information is entered to complete a drawing. An attribute is information that is associated with a drawing entity and is used to index and keep track of graphic drawings in the design. These drawing entities and their attributes are referred to as blocks.

To design an irrigation system a base map of the design area is calibrated to the tablet and irrigation system design information is entered by the designer. The AutoCAD LISP programs are design tools that will perform calculations and insert standard symbols at the designer's discretion. These programs are not 'intelligent'; they do not make design decisions. They do, however, make the design process easer, quicker, and more accurate. When the design is finished, the attribute information is transfered to a spreadsheet that performs the economic analysis and formats the information to be used in a report.

The irrigation design analysis (IDA) spreadsheet takes information that has been extracted for AutoCAD irrigation designs and determines the total, annual, and annual per acre costs of that system. The spreadsheet uses a keyboard macro to import the information from AutoCAD and insert the information into the appropriate locations in the spreadsheet. The identification (ID) range of the IDA spreadsheet imports AutoCAD design data on project number, owner name, legal land description, and designer's name. The ID range is used as a project identifier for all output. Other project data is imported to the system variable range of the IDA spreadsheet including: peak consumptive use, total consumptive use, net irrigation requirement, maximum soil intake rate, soil water holding capacity, and miles of required power line construction. This information is used to document the variables used in the AutoCAD design process and is used by the spreadsheet to calculate other variables.

The irrigation attribute range imports AutoCAD design data and determines the volume of water needed and the system cost for each irrigation attributes in the AutoCAD design. It then totals the number of acres irrigated, flow required, labor required, acre feet of water needed, and system costs for all the systems in the AutoCAD design.

The distribution system attributes range import data from the pipeline attribute blocks of the AutoCAD design. This range determine the class and per foot cost of the pipeline at each node and then calculates the total cost of the pipeline for each reach. The per foot cost of the pipe is found by searching the pipe cost table for the appropriate size and class of pipe. The range then calculates the total pipe line costs.

The pump attributes range imports data for the pump attribute information. The range calculates the diesel engine cost that would be required to drive each pump. These costs are compared to electrical motor costs and power line construction costs in the system variables range to determine the least cost pumping alternative.

The system constants range sets the value for the spreadsheet variables that are not dependent on the AutoCAD design and so remain constant from one design to the next.

The system variables range is the set of variables that is obtained from or calculated from the AutoCAD design and so change with the design. This set of variables is included in the print out of each design summary. The equipment cost variable is the sum of the pivot, wheel line, and hand line costs. Annual pumping costs are determined for the least cost method of pumping.

The irrigation costs table range of the IDA spreadsheet annualizes the cost of the irrigation equipment in the AutoCAD designed system. The table separates the on-farm irrigation equipment costs from the water delivery system costs. The engineering and contingency costs are based on the delivery system. The range determines the total cost for each item then calculates the operation and maintenance from the O&M column and adds this to the amortized cost. The amortized cost is calculated on a economic and financial basis. The amortized economic costs are based on the systems life from the life column and the real rate of return interest variable. The amortized financial costs are based on the fixed financial life and financial interest rate variables. The range sums these columns to determine the total annual economic and financial system costs.

APPENDIX G
IRRIGATION PROJECT DESIGNS

1

Project# :	NCR-1			TOPO: ASHLAND NE
Owner :	NCR			SOURCE: TONGUE R.
Location :	T2S	R44E	10	NW,NW,SE	16-Feb-90

IRRIGATION ATTRIBUTES

TYPE (system)	ID#	AREA (acres)	FLOW (gpm)	MIN-PR (ft)	HW-L (ft)	LABOR (hours)	WATER USE (a-f/yr)	PIVOT COST	LINE COST	FLOOD COST
WHLN	1	42	370	126	948	74	119		$8,888	
WHLN	2	44	425	126	1095	74	125		$9,770	
HLN	1	25	233	135	600	133	73		$2,400	
HLN	2	35	337	135	840	186	102		$3,360	
HLN	3	22	199	135	520	115	65		$2,080	
		168	1564			582	484		$26,498	

DISTRIBUTION SYSTEM ATTRIBUTES

ID (OUT)	EL (ft)	HEAD (ft)	FLOW (gpm)	SIZE (in)	LENGTH (ft)	PR-IN (ft)	NODE ID (IN)	PIPE CLASS	COST/ FT	TOTAL COST
	2880	126	425	8	2170	132	1	80	$3.41	$7,406
1	2880	132	795	10	1799	159	2	100	$6.05	$10,879
20	2870	137	337	6	1350	159	2	100	$2.70	$3,640
21	2860	150	233	6	2029	159	2	100	$2.70	$5,471
2	2860	159	1365	12	2580	168	3	125	$9.55	$24,628
3	2860	168	1564	12	661	181	4	125	$9.55	$6,310
					10,589					$58,333

PUMP ATTRIBUTES

ID	EL (ft)	HEAD (ft)	FLOW (gpm)	BHP	AC-FT (annual)	HRS	MOTOR SIZE	ELECTICAL COSTS POWER	PUMP	DIESEL COSTS FUEL	ENGINE
0											
POD	2850	181	1564	95	484	1679	100	$5,341	$13,564	$7,973	$8,325
				95			100	$5,341	$13,564	$7,973	$8,325

SOIL ATTRIBUTES

Peak consumptive use	0.3 "/day
Soil water holding capacity	9 "
Maximum intake rate	0.6 "/hr
Predominant soil (Map Unit # & land class #)	109 123
Acres of irrigable soils in project area	170 ac
# of acres of Class 6 soil in design area	ac

Project#	NCR-1			TOPO: ASHLAND NE	
Owner :	NCR			SOURCE: TONGUE R.	
Location :	T2S	R44E	10	NW,NW,SE	16-Feb-90

SYSTEM VARIABLES

Require power line const.	PLC	3.0 miles			
Total consumptive use	TCU	29.1 inches			
Net irrigation requirement	NIR	22.2 inches			
Total acres irrigated	TAI	168 ac			
Ac-ft of water needed	AFN	484 ac-ft	Total pump hp	THP	95
Total flow	TFL	1564 gpm	Hours of pumping	HOP	1679
Equipment costs	EQC	$26,498	Engine amort.	ENA	8.7%
Flood costs	FDC		Annual electrical cost		$7,502
Total pipe cost	TPC	$58,333	Annual diesel costs		$10,338
Total ditch cost	TDC		Pumping power	PPP	Electrical
Labor cost	ALC	$2,910	Ann. energy costs	AEC	$5,341
TR-21 weather station	WSTA	N. CHEYENNE RES.	Energy cost/ac	EAC	$31.79

IRRIGATION COSTS TABLE

ITEM	COST/ UNIT	# OF ITEMS	UNITS	T. COST $1	% O&M	O&M	LIFE	ECON ANN-COST TOTAL	FINAN. ANN-COST TOTAL
Flood					10.0%		20		
Line				$26,498	1.5%	$397	10	$3,763	$4,710
Pivot					3.0%		20		
Other					1.5%		10		
Other			unit		5.0%		10		
ON-FARM TOTALS				$26,498		$397		$3,763	$4,710
Pump		100	hp	$13,564	2.5%	$339	30	$1,182	$2,547
Engine			hp		5.5%		17		
Diversion	$2,000	3.5	cfs	$6,951	1.0%	$70	30	$501	$1,201
Pump controls		10%	p. cost	$1,356	1.0%	$14	20	$119	$234
Pipe	$58,333	110%		$64,166	0.5%	$321	50	$3,621	$10,764
Ditches		110%			5.0%		20		
Storage			ac-ft		1.0%		50		
Other			unit		2.0%		50		
SYSTEM TOTALS				$86,038		$743		$5,422	$14,745
Power dev.	$12,500	3.0	miles	$25,625			50	$1,318	$4,170
Engineering		15%	S. total	$12,906			50	$664	$2,100
Contingency		10%	S. total	$8,604			50	$442	$1,400
TOTAL				$159,670		$1,140		$11,609	$27,126

TOTAL ANNUAL COSTS	ECONOMIC TOTAL	ECONOMIC /AC	ECONOMIC /AC-FT	FINANCIAL TOTAL	FINANCIAL /AC	FINANCIAL /AC-FT
LABOR	$2,910	$17.32	$6.01			
ENERGY	$5,341	$31.79	$11.04			
EQUIPMENT	$11,609	$69.10	$23.99	$27,126	$161.46	$56.05
TOTAL annual costs	$19,861	$118.22	$41.03	$35,377	$210.58	$73.09

Feasibility rating (chance that revenues exceed costs)

NCR-1 93 percentile N. CHEYENNE RES.

Project# :	NCR-2				TOPO: ASHLAND NE
Owner :	NCR				SOURCE: TONGUE R.
Location :	T2S	R44E	15	SE,NE,NW	06-Mar-90

IRRIGATION ATTRIBUTES

TYPE (system)	ID#	AREA (acres)	FLOW (gpm)	MIN-PR (ft)	HW-L (ft)	LABOR (hours)	WATER USE (a-f/yr)	PIVOT COST	LINE COST	FLOOD COST
PIVOT	2	116	869	72	1168	86	286	$31,448		
		116	869			86	286	$31,448		

DISTRIBUTION SYSTEM ATTRIBUTES

ID (OUT)	EL (ft)	HEAD (ft)	FLOW (gpm)	SIZE (in)	LENGTH (ft)	PR-IN (ft)	NODE ID (IN)	PIPE CLASS	COST/ FT	TOTAL COST
	2870	72	869	10	1368	97	1	80	$5.25	$7,179
					1,368					$7,179

PUMP ATTRIBUTES

ID	EL (ft)	HEAD (ft)	FLOW (gpm)	BHP	AC-FT (annual)	HRS	MOTOR SIZE	ELECTICAL COSTS POWER	PUMP	DIESEL COSTS FUEL	ENGINE
0											
pod	2850	97	869	28	286	1785	30	$1,648	$6,669	$2,499	$3,992
				28			30	$1,648	$6,669	$2,499	$3,992

SOIL ATTRIBUTES

Peak consumptive use	0.3 "/day	
Soil water holding capacity	9 "	
Maximum intake rate	0.6 "/hr	
Predominant soil (Map Unit # & land class #)	109	123
Acres of irrigable soils in project area	170 ac	
# of acres of Class 6 soil in design area	ac	

Project# :	NCR-2			TOPO: ASHLAND NE	
Owner :	NCR			SOURCE: TONGUE R.	
Location :	T2S	R44E	15	SE,NE,NW	06-Mar-90

SYSTEM VARIABLES

Require power line const.	PLC	3.0 miles			
Total consumptive use	TCU	29.1 inches			
Net irrigation requirement	NIR	22.2 inches			
Total acres irrigated	TAI	116 ac			
Ac-ft of water needed	AFN	286 ac-ft	Total pump hp	THP	28
Total flow	TFL	869 gpm	Hours of pumping	HOP	1785
Equipment costs	EQC	$31,448	Engine amort.	ENA	9.1%
Flood costs	FOC		Annual electrical cost		$3,810
Total pipe cost	TPC	$7,179	Annual diesel costs		$3,663
Total ditch cost	TDC		Pumping power	PPP	Diesel
Labor cost	ALC	$430	Ann. energy costs	AEC	$2,812
TR-21 weather station	WSTA	N. Cheyenne Res.	Energy cost/ac	EAC	$24.24

IRRIGATION COSTS TABLE

ITEM	COST/ UNIT	# OF ITEMS	UNITS	T. COST $1	% O&M	O&M	LIFE	ECON ANN-COST TOTAL	FINAN. ANN-COST TOTAL
Flood					10.0%		20		
Line					1.5%		10		
Pivot				$31,448	3.0%	$943	20	$3,382	$6,061
Other					1.5%		10		
Other			unit		5.0%		10		
ON-FARM TOTALS				$31,448		$943		$3,382	$6,061
Pump		30	hp	$6,669	2.5%	$167	30	$581	$1,252
Engine		31	hp	$3,992	5.5%	$220	16	$582	$869
Diversion	$2,000	1.9	cfs	$3,862	1.0%	$39	30	$279	$667
Pump controls		10%	p. cost	$667	1.0%	$7	20	$58	$115
Pipe	$7,179	110%		$7,897	0.5%	$39	50	$446	$1,325
Ditches		110%			5.0%		20		
Storage			ac-ft		1.0%		50		
Other			unit		2.0%		50		
SYSTEM TOTALS				$23,088		$471		$1,946	$4,228
Power dev.	$12,500		miles				50		
Engineering		15%	S. total	$3,463			50	$178	$564
Contingency		10%	S. total	$2,309			50	$119	$376
TOTAL				$60,308		$1,415		$5,625	$11,229

TOTAL ANNUAL COSTS	ECONOMIC TOTAL	ECONOMIC /AC	ECONOMIC /AC-FT	FINANCIAL TOTAL	FINANCIAL /AC	FINANCIAL /AC-FT
LABOR	$430	$3.71	$1.50			
ENERGY	$2,812	$24.24	$9.83			
EQUIPMENT	$5,625	$48.49	$19.67	$11,229	$96.80	$39.26
TOTAL annual costs	$8,866	$76.44	$31.00	$14,471	$124.75	$50.60

Feasibility rating (chance that revenues exceed costs)

NCR-2 100 percentile N. Cheyenne Res.

Project# :	NCR-3			TOPO: ASHLAND NE
Owner :	NCR			SOURCE: TONGUE R.
Location :	T2S	R44E	22	NW,SW,NW	06-Mar-90

IRRIGATION ATTRIBUTES

TYPE (system)	ID#	AREA (acres)	FLOW (gpm)	MIN-PR (ft)	HW-L (ft)	LABOR (hours)	WATER USE (a-f/yr)	PIVOT COST	LINE COST	FLOOD COST
WHLN	3	45	472	130	1220	74	129		$10,520	
WHLN	4	30	292	128	740	74	85		$7,640	
		75	764			148	214		$18,160	

DISTRIBUTION SYSTEM ATTRIBUTES

ID (OUT)	EL (ft)	HEAD (ft)	FLOW (gpm)	SIZE (in)	LENGTH (ft)	PR-IN (ft)	NODE ID (IN)	PIPE CLASS	COST/ FT	TOTAL COST
1	2880	130	472	8	1800	137	2	100	$3.92	$7,063
2	2880	137	764	10	940	139	3	100	$6.05	$5,684
3	2880	139	764	10	940	172	4	125	$7.10	$6,675
					3,680					$19,422

PUMP ATTRIBUTES

ID	EL (ft)	HEAD (ft)	FLOW (gpm)	BHP	AC-FT (annual)	HRS	MOTOR SIZE	ELECTICAL COSTS POWER	ELECTICAL COSTS PUMP	DIESEL COSTS FUEL	DIESEL COSTS ENGINE
0											
POD	2850	172	764	44	214	1519	50	$2,302	$7,464	$3,342	$4,850
.											
				44			50	$2,302	$7,464	$3,342	$4,850

SOIL ATTRIBUTES

Peak consumptive use	0.3 "/day	
Soil water holding capacity	9 "	
Maximum intake rate	0.6 "/hr	
Predominant soil (Map Unit # & land class #)109		123
Acres of irrigable soils in project area	170 ac	
# of acres of Class 6 soil in design area	ac	

Project# :	NCR-3			TOPO: ASHLAND NE	
Owner :	NCR			SOURCE: TONGUE R.	
Location :	T2S	R44E	22	NW,SW,NW	06-Mar-90

SYSTEM VARIABLES

Require power line const.	PLC	3.0 miles			
Total consumptive use	TCU	29.1 inches			
Net irrigation requirement	NIR	22.2 inches			
Total acres irrigated	TAI	75 ac			
Ac-ft of water needed	AFN	214 ac-ft	Total pump hp	THP	44
Total flow	TFL	764 gpm	Hours of pumping	HOP	1519
Equipment costs	EQC	$18,160	Engine amort.	ENA	8.2%
Flood costs	FDC		Annual electrical cost		$4,411
Total pipe cost	TPC	$19,422	Annual diesel costs		$4,655
Total ditch cost	TDC		Pumping power	PPP	Electrical
Labor cost	ALC	$740	Ann. energy costs	AEC	$2,302
TR-21 weather station	WSTA	N. Cheyenne Res.	Energy cost/ac	EAC	$30.69

IRRIGATION COSTS TABLE

ITEM	COST/ UNIT	# OF ITEMS	UNITS	T. COST $1	% O&M	O&M	LIFE	ECON ANN-COST TOTAL	FINAN. ANN-COST TOTAL
Flood					10.0%		20		
Line				$18,160	1.5%	$272	10	$2,579	$3,228
Pivot					3.0%		20		
Other					1.5%		10		
Other			unit		5.0%		10		
ON-FARM TOTALS				$18,160		$272		$2,579	$3,228
Pump		50	hp	$7,464	2.5%	$187	30	$650	$1,401
Engine			hp		5.5%		18		
Diversion	$2,000	1.7	cfs	$3,396	1.0%	$34	30	$245	$587
Pump controls		10%	p. cost	$746	1.0%	$7	20	$65	$129
Pipe	$19,422	110%		$21,365	0.5%	$107	50	$1,206	$3,584
Ditches		110%			5.0%		20		
Storage			ac-ft		1.0%		50		
Other			unit		2.0%		50		
SYSTEM TOTALS				$32,970		$335		$2,166	$5,701
Power dev.	$12,500	3.0	miles	$32,000			50	$1,646	$5,208
Engineering		15%	S. total	$4,946			50	$254	$805
Contingency		10%	S. total	$3,297			50	$170	$537
TOTAL				$91,373		$607		$6,814	$15,478

TOTAL ANNUAL COSTS	ECONOMIC TOTAL	ECONOMIC /AC	ECONOMIC /AC-FT	FINANCIAL TOTAL	FINANCIAL /AC	FINANCIAL /AC-FT
LABOR	$740	$9.87	$3.46			
ENERGY	$2,302	$30.69	$10.76			
EQUIPMENT	$6,814	$90.86	$31.84	$15,478	$206.37	$72.33
TOTAL annual costs	$9,856	$131.42	$46.06	$18,520	$246.93	$86.54

Feasibility rating (chance that revenues exceed costs)

NCR-3 85 percentile N. Cheyenne Res.

Project# :	NCR-4				TOPO: ASHLAND NE	
Owner :	NCR				SOURCE. TONGUE R.	
Location :	T2S	R44E	27	NE,SW,NE		20-Feb-90

IRRIGATION ATTRIBUTES

TYPE (system)	ID#	AREA (acres)	FLOW (gpm)	MIN-PR (ft)	HW-L (ft)	LABOR (hours)	WATER USE (a-f/yr)	PIVOT COST	LINE COST	FLOOD COST
PIVOT	1	66.7	500	59	861	50	164	$24,234		
PIVOT	2	112.1	840	105	1146	84	276	$30,931		
PIVOT	3	46.5	349	79	703	34	114	$20,521		
PIVOT	4	49.5	371	54	728	37	122	$21,108		
PIVOT	5	30.2	226	66	547	22	74	$16,855		
WHLN	1	32	297	117	980	72	91		$9,080	
		337	2583			299	841	$113,648	$9,080	

DISTRIBUTION SYSTEM ATTRIBUTES

ID (OUT)	EL (ft)	HEAD (ft)	FLOW (gpm)	SIZE (in)	LENGTH (ft)	PR-IN (ft)	NODE ID (IN)	PIPE CLASS	COST/ FT	TOTAL COST
2	2920	105	840	10	2029	112	3	80	$5.25	$10,648
3	2920	112	1189	12	973	135	4	100	$8.03	$7,812
40	2900	114	297	6	3051	135	4	100	$2.70	$8,227
41	2900	108	500	8	1426	114	41	80	$3.41	$4,867
4	2900	135	1986	15	778	137	5	100	$11.60	$9,027
5	2900	137	2212	15	1447	141	6	100	$11.60	$16,790
6	2900	141	2583	15	1002	165	7	100	$11.60	$11,626
					10,706					$68,997

PUMP ATTRIBUTES

ID	EL (ft)	HEAD (ft)	FLOW (gpm)	BHP	AC-FT (annual)	HRS	MOTOR SIZE	ELECTICAL COSTS POWER	ELECTICAL COSTS PUMP	DIESEL COSTS FUEL	DIESEL COSTS ENGINE
0											
POD	2880	165	2583	144	841	1766	150	$8,406	$17,583	$12,715	$12,440
				144			150	$8,406	$17,583	$12,715	$12.440

SOIL ATTRIBUTES

Peak consumptive use	0.3 "/day	
Soil water holding capacity	7 "	
Maximum intake rate	0.5 "/hr	
Predominant soil (Map Unit # & land class #)	197	1
Acres of irrigable soils in project area	608 ac	
# of acres of Class 6 soil in design area	ac	

Project#	NCR-4			TOPO: ASHLAND NE	
Owner	NCR			SOURCE: TONGUE R.	
Location	T2S	R44E	27	NE,SW,NE	20-Feb-90

SYSTEM VARIABLES

Require power line const.	PLC	3.0 miles			
Total consumptive use	TCU	29.1 inches			
Net irrigation requirement	NIR	22.2 inches			
Total acres irrigated	TAI	337 ac			
Ac-ft of water needed	AFN	841 ac-ft	Total pump hp	THP	144
Total flow	TFL	2583 gpm	Hours of pumping	HOP	1766
Equipment costs	EQC	$122,728	Engine amort.	ENA	9.0%
Flood costs	FDC		Annual electrical cost		$10,501
Total pipe cost	TPC	$68,997	Annual diesel costs		$16,054
Total ditch cost	TDC		Pumping power	PPP	Electrical
Labor cost	ALC	$1,495	Ann. energy costs	AEC	$9,468
TR-21 weather station	WSTA	N. Cheyenne Res.	Energy cost/ac	EAC	$28.10

IRRIGATION COSTS TABLE

ITEM	COST/ UNIT	# OF ITEMS	UNITS	T. COST $1	% O&M	O&M	LIFE	ECON ANN-COST TOTAL	FINAN. ANN-COST TOTAL
Flood					10.0%		20		
Line				$9,080	1.5%	$136	10	$1,289	$1,614
Pivot				$113,648	3.0%	$3,409	20	$12,222	$21,905
Other					1.5%		10		
Other			unit		5.0%		10		
ON-FARM TOTALS				$122,728		$3,546		$13,511	$23,519
Pump		150	hp	$17,583	2.5%	$440	30	$1,532	$3,301
Engine			hp		5.5%		16		
Diversion	$2,000	5.7	cfs	$11,480	1.0%	$115	30	$828	$1,983
Pump controls		10%p.	cost	$1,758	1.0%	$18	20	$154	$304
Pipe	$68,997	110%		$75,897	0.5%	$379	50	$4,283	$12,731
Ditches		110%			5.0%		20		
Storage			ac-ft		1.0%		50		
Other			unit		2.0%		50		
SYSTEM TOTALS				$106,718		$951		$6,796	$18,319
Power dev.	$12,500	3.0	miles	$19,500			50	$1,003	$3,174
Engineering		15%S.	total	$16,008			50	$823	$2,605
Contingency		10%S.	total	$10,672			50	$549	$1,737
TOTAL				$275,625		$4,497		$22,683	$49,354

TOTAL ANNUAL COSTS	ECONOMIC TOTAL	ECONOMIC /AC	ECONOMIC /AC-FT	FINANCIAL TOTAL	FINANCIAL /AC	FINANCIAL /AC-FT
LABOR	$1,495	$4.44	$1.78			
ENERGY	$9,468	$28.10	$11.26			
EQUIPMENT	$22,683	$67.31	$26.97	$49,354	$146.45	$58.68
TOTAL annual costs	$33,646	$99.84	$40.01	$60,317	$178.98	$71.72

Feasibility rating (chance that revenues exceed costs)

NCR-4 100 percentile N. Cheyenne Res.

Project# :	NCR-6				TOPO: ASHLAND NE
Owner :	NCR				SOURCE: TONGUE R.
Location :	T2S	R44E	27	NE,SE,SW	20-Feb-90

IRRIGATION ATTRIBUTES

TYPE (system)	ID#	AREA (acres)	FLOW (gpm)	MIN-PR (ft)	HW-L (ft)	LABOR (hours)	WATER USE (a-f/yr)	PIVOT COST	LINE COST	FLOOD COST
HLN	1	65	765	136	2040	446	186		$8,160	
HLN	2	13	117	136	400	87	39		$1,600	
		78	882			533	225		$9,760	

PUMP ATTRIBUTES

ID	EL (ft)	HEAD (ft)	FLOW (gpm)	BHP	AC-FT (annual)	HRS	MOTOR SIZE	ELECTICAL COSTS POWER	ELECTICAL COSTS PUMP	DIESEL COSTS FUEL	DIESEL COSTS ENGINE
0											
POD	2880	225	882	66	225	1384	75	$3,233	$10,082	$4,566	$6,223
				66			75	$3,233	$10,082	$4,566	$6,223

SOIL ATTRIBUTES

Peak consumptive use	0.3 "/day	
Soil water holding capacity	7 "	
Maximum intake rate	0.5 "/hr	
Predominant soil (Map Unit # & Land class #)197		1
Acres of irrigable soils in project area	608 ac	
# of acres of Class 6 soil in design area	ac	

Project# :	NCR-6			TOPO: ASHLAND NE	
Owner :	NCR			SOURCE: TONGUE R.	
Location :	T2S	R44E	27	NE,SE,SW	20-Feb-90

SYSTEM VARIABLES

Require power line const.	PLC	3.0 miles			
Total consumptive use	TCU	29.1 inches			
Net irrigation requirement	NIR	22.2 inches			
Total acres irrigated	TAI	78 ac			
Ac-ft of water needed	AFN	225 ac-ft	Total pump hp	THP	66
Total flow	TFL	882 gpm	Hours of pumping	HOP	1384
Equipment costs	EQC	$9,760	Engine amort.	ENA	7.7%
Flood costs	FDC		Annual electrical cost		$5,363
Total pipe cost	TPC	$20,949	Annual diesel costs		$6,266
Total ditch cost	TDC		Pumping power	PPP	Electrical
Labor cost	ALC	$2,665	Ann. energy costs	AEC	$3,233
TR-21 weather station	WSTA	N. Cheyenne Res.	Energy cost/ac	EAC	$41.45

IRRIGATION COSTS TABLE

ITEM	COST/ UNIT	# OF ITEMS	UNITS	T. COST $1	% O&M	O&M	LIFE	ECON ANN-COST TOTAL	FINAN. ANN-COST TOTAL
Flood					10.0%		20		
Line				$9,760	1.5%	$146	10	$1,386	$1,735
Pivot					3.0%		20		
Other					1.5%		10		
Other			unit		5.0%		10		
ON-FARM TOTALS				$9,760		$146		$1,386	$1,735
Pump		75	hp	$10,082	2.5%	$252	30	$878	$1,893
Engine			hp		5.5%		20		
Diversion	$2,000	2.0	cfs	$3,920	1.0%	$39	30	$283	$677
Pump controls		10%	p. cost	$1,008	1.0%	$10	20	$88	$174
Pipe	$20,949	110%		$23,044	0.5%	$115	50	$1,300	$3,866
Ditches		110%			5.0%		20		
Storage			ac-ft		1.0%		50		
ROAD CROSSING	$5,000	1	unit	$5,000	2.0%	$100	50	$357	$914
SYSTEM TOTALS				$43,054		$517		$2,907	$7,523
Power dev.	$12,500	3.0	miles	$29,250			50	$1,504	$4,760
Engineering		15%	S. total	$6,458			50	$332	$1,051
Contingency		10%	S. total	$4,305			50	$221	$701
TOTAL				$92,828		$663		$6,350	$15,770

TOTAL ANNUAL COSTS	ECONOMIC TOTAL	ECONOMIC /AC	ECONOMIC /AC-FT	FINANCIAL TOTAL	FINANCIAL /AC	FINANCIAL /AC-FT
LABOR	$2,665	$34.17	$11.84			
ENERGY	$3,233	$41.45	$14.37			
EQUIPMENT	$6,350	$81.42	$28.22	$15,770	$202.18	$70.09
TOTAL annual costs	$12,248	$157.03	$54.44	$21,668	$277.80	$96.30

Feasibility rating (chance that revenues exceed costs)

NCR-6 42 percentile N. Cheyenne Res.

Project# :	NCR-7				TOPO: ASHLAND
Owner :	NCR				SOURCE: TONGUE R.
Location :	T2S	R44E	35	SW,SW,NW	20-Feb-90

IRRIGATION ATTRIBUTES

TYPE (system)	ID#	AREA (acres)	FLOW (gpm)	MIN-PR (ft)	HW-L (ft)	LABOR (hours)	WATER USE (a-f/yr)	PIVOT COST	LINE COST	FLOOD COST
PIVOT	1	38.1	285	52	626	28	93	$18,711		
HLN	1	30	296	130	880	195	88		$3,520	
HLN	2	21	194	130	600	133	59		$2,400	
		89 1	775			356	240	$18,711	$5,920	

DISTRIBUTION SYSTEM ATTRIBUTES

ID (OUT)	EL (ft)	HEAD (ft)	FLOW (gpm)	SIZE (in)	LENGTH (ft)	PR-IN (ft)	NODE ID (IN)	PIPE CLASS	COST/ FT	TOTAL COST
	2920	130	194	6	2091	156	1	100	$2.70	$5,638
1	2900	156	490	8	2853	168	2	125	$4.60	$13,119
2	2900	168	775	10	726	190	3	125	$7.10	$5,155
					5,670					$23,912

PUMP ATTRIBUTES

ID	EL (ft)	HEAD (ft)	FLOW (gpm)	BHP	AC-FT (annual)	HRS	MOTOR SIZE	ELECTICAL COSTS POWER	PUMP	DIESEL COSTS FUEL	ENGINE
0											
POD	2880	190	775	49	240	1680	50	$2,756	$7,475	$4,115	$5,143
				49			50	$2,756	$7,475	$4,115	$5,143

SOIL ATTRIBUTES

Peak consumptive use	0.3 "/day	
Soil water holding capacity	7.5 "	
Maximum intake rate	0.5 "/hr	
Predominant soil (Map Unit # & land class #)171		1
Acres of irrigable soils in project area	90 ac	
# of acres of Class 6 soil in design area	ac	

Project# :	NCR-7				TOPO: ASHLAND	
Owner :	NCR				SOURCE: TONGUE R.	
Location :	T2S	R44E	35	SW,SW,NW		20-Feb-90

SYSTEM VARIABLES

Require power line const.	PLC	1.0 miles			
Total consumptive use	TCU	29.1 inches			
Net irrigation requirement	NIR	22.2 inches			
Total acres irrigated	TAI	89 ac			
Ac-ft of water needed	AFN	240 ac-ft	Total pump hp	THP	49
Total flow	TFL	775 gpm	Hours of pumping	HOP	1680
Equipment costs	EQC	$24,631	Engine amort.	ENA	8.7%
Flood costs	FDC		Annual electrical cost		$3,549
Total pipe cost	TPC	$23,912	Annual diesel costs		$5,498
Total ditch cost	TDC		Pumping power	PPP	Electrical
Labor cost	ALC	$1,780	Ann. energy costs	AEC	$2,923
TR-21 weather station	WSTA	N. Cheyenne Res.	Energy cost/ac	EAC	$32.80

IRRIGATION COSTS TABLE

ITEM	COST/ UNIT	# OF ITEMS	UNITS	T. COST $1	% O&M	O&M	LIFE	ECON ANN-COST TOTAL	FINAN. ANN-COST TOTAL
Flood					10.0%		20		
Line				$5,920	1.5%	$89	10	$841	$1,052
Pivot				$18,711	3.0%	$561	20	$2,012	$3,606
Other					1.5%		10		
Other			unit		5.0%		10		
ON-FARM TOTALS				$24,631		$650		$2,853	$4,659
Pump		50	hp	$7,475	2.5%	$187	30	$651	$1,403
Engine			hp		5.5%		17		
Diversion	$2,000	1.7	cfs	$3,444	1.0%	$34	30	$248	$595
Pump controls		10%	p. cost	$748	1.0%	$7	20	$65	$129
Pipe	$23,912	110%		$26,303	0.5%	$132	50	$1,484	$4,412
Ditches		110%			5.0%		20		
Storage			ac-ft		1.0%		50		
			unit		2.0%		50		
SYSTEM TOTALS				$37,970		$360		$2,449	$6,540
Power dev.	$12,500	1.0	miles	$6,375			50	$328	$1,038
Engineering		15%	S. total	$5,696			50	$293	$927
Contingency		10%	S. total	$3,797			50	$195	$618
TOTAL				$78,469		$1,010		$6,118	$13,781

TOTAL ANNUAL COSTS	ECONOMIC TOTAL	ECONOMIC /AC	ECONOMIC /AC-FT	FINANCIAL TOTAL	FINANCIAL /AC	FINANCIAL /AC-FT
LABOR	$1,780	$19.98	$7.42			
ENERGY	$2,923	$32.80	$12.18			
EQUIPMENT	$6,118	$68.67	$25.49	$13,781	$154.67	$57.42
TOTAL annual costs	$10,821	$121.44	$45.09	$18,483	$207.45	$77.01

Feasibility rating (chance that revenues exceed costs)

NCR-7 92 percentile N. Cheyenne Res.

Project# .	NCR-8		TOPO: ASHLAND
Owner :	NCR		SOURCE: TONGUE R.
Location :	T3S R44E 3 NW,SW,SW		20-Feb-90

IRRIGATION ATTRIBUTES

TYPE (system)	ID#	AREA (acres)	FLOW (gpm)	MIN-PR (ft)	HW-L (ft)	LABOR (hours)	WATER USE (a-f/yr)	PIVOT COST	LINE COST	FLOOD COST
PIVOT	1	67.4	505	60	866	50	166	$24,351		
PIVOT	2	78.6	589	64	943	58	193	$26,161		
PIVOT	3	87.9	659	103	1003	65	216	$27,571		
PIVOT	4	67.5	505	75	867	50	166	$24,375		
		301.4	2258			223	741	$102,457		

DISTRIBUTION SYSTEM ATTRIBUTES

ID (OUT)	EL (ft)	HEAD (ft)	FLOW (gpm)	SIZE (in)	LENGTH (ft)	PR-IN (ft)	NODE ID (IN)	PIPE CLASS	COST/ FT	TOTAL COST
	3220	60	505	8	2054	89	1	80	$3.41	$7,010
1	3200	89	1094	12	2059	94	2	80	$6.88	$14,162
2	3200	103	1753	15	2004	127	3	80	$9.81	$19,650
3	3180	127	2258	15	6831	229	4	160	$16.79	$114,685
4	3100	229	2258	15	1240	423	5	STEEL	$16.26	$20,159
					14,188					$175,665

PUMP ATTRIBUTES

ID	EL (ft)	HEAD (ft)	FLOW (gpm)	BHP	AC-FT (annual)	HRS	MOTOR SIZE	ELECTICAL COSTS POWER	PUMP	DIESEL COSTS FUEL	ENGINE
0											
POD	2910	423	2258	321	741	1780	400	$18,848	$42,258	$28,569	$28,890
.											
				321			400	$18,848	$42,258	$28,569	$28,890

SOIL ATTRIBUTES

Peak consumptive use	0.3 "/day	
Soil water holding capacity	9 "	
Maximum intake rate	0.5 "/hr	
Predominant soil (Map Unit # & land class #)65		1
Acres of irrigable soils in project area	490 ac	
# of acres of Class 6 soil in design area	ac	

Project#	NCR-8		TOPO: ASHLAND	
Owner	NCR		SOURCE: TONGUE R.	
Location	T3S R44E 3	NW,SW,SW		20-Feb-90

SYSTEM VARIABLES

Require power line const.	PLC	2.0 miles			
Total consumptive use	TCU	29.1 inches			
Net irrigation requirement	NIR	22.2 inches			
Total acres irrigated	TAI	301 ac			
Ac-ft of water needed	AFN	741 ac-ft	Total pump hp	THP	321
Total flow	TFL	2258 gpm	Hours of pumping	HOP	1780
Equipment costs	EQC	$102,457	Engine amort.	ENA	9.1%
Flood costs	FDC		Annual electrical cost		$20,695
Total pipe cost	TPC	$175,665	Annual diesel costs		$36,460
Total ditch cost	TDC		Pumping power	PPP	Electrical
Labor cost	ALC	$1,115	Ann. energy costs	AEC	$19,830
TR-21 weather station	WSTA	N. Cheyenne Res.	Energy cost/ac	EAC	$65.79

IRRIGATION COSTS TABLE

ITEM	COST/ UNIT	# OF ITEMS	UNITS	T. COST $1	% O&M	O&M	LIFE	ECON ANN-COST TOTAL	FINAN. ANN-COST TOTAL
Flood					10.0%		20		
Line					1.5%		10		
Pivot				$102,457	3.0%	$3,074	20	$11,019	$19,748
Other					1.5%		10		
Other			unit		5.0%		10		
ON-FARM TOTALS				$102,457		$3,074		$11,019	$19,748
Pump		400	hp	$42,258	2.5%	$1,056	30	$3,681	$7,934
Engine			hp		5.5%		16		
Diversion	$4,000	5.0	cfs	$20,071	1.0%	$201	30	$1,447	$3,467
Pump controls		10%	p. cost	$4,226	1.0%	$42	20	$370	$730
Pipe	$175,665	110%		$193,232	0.5%	$966	50	$10,904	$32,414
Ditches		110%			5.0%		20		
Storage			ac-ft		1.0%		50		
ROAD CROSSING	$10,000	1	unit	$10,000	2.0%	$200	50	$714	$1,827
SYSTEM TOTALS				$269,787		$2,466		$17,117	$46,372
Power dev.	$12,500	2.0	miles				50		
Engineering		15%	S. total	$40,468			50	$2,081	$6,586
Contingency		10%	S. total	$26,979			50	$1,387	$4,391
TOTAL				$439,690		$5,539		$31,604	$77,097

TOTAL ANNUAL COSTS	ECONOMIC TOTAL	ECONOMIC /AC	ECONOMIC /AC-FT	FINANCIAL TOTAL	FINANCIAL /AC	FINANCIAL /AC-FT
LABOR	$1,115	$3.70	$1.50			
ENERGY	$19,830	$65.79	$26.76			
EQUIPMENT	$31,604	$104.86	$42.65	$77,097	$255.80	$104.04
TOTAL annual costs	$52,549	$174.35	$70.92	$98,042	$325.29	$132.31

Feasibility rating (chance that revenues exceed costs)

NCR-8 19 percentile N. Cheyenne Res.

Project#	NCR-9				TOPO: ASHLAND
Owner	NCR				SOURCE: TONGUE R
Location	T3S	R44E	10	SE,NW,SW	20-Feb-90

IRRIGATION ATTRIBUTES

TYPE (system)	ID#	AREA (acres)	FLOW (gpm)	MIN-PR (ft)	HW-L (ft)	LABOR (hours)	WATER USE (a-f/yr)	PIVOT COST	LINE COST	FLOOD COST
PIVOT	5	51	382	55	741	38	125	$21,414		
WHLN	2	26	262	117	860	72	75		$8,360	
		77	644			110	200	$21,414	$8,360	

DISTRIBUTION SYSTEM ATTRIBUTES

ID (OUT)	EL (ft)	HEAD (ft)	FLOW (gpm)	SIZE (in)	LENGTH (ft)	PR-IN (ft)	NODE ID (IN)	PIPE CLASS	COST/ FT	TOTAL COST
7	2920	55	382	8	1243	58	8	80	$3.41	$4,242
80	2900	74	262	6	722	58	8	80	$2.41	$1,738
81	2920	55	262	6	537	58	8	80	$2.41	$1,292
8	2920	117	644	8	900	143	9	100	$3.92	$3,532
					3,402					$10,804

PUMP ATTRIBUTES

ID	EL (ft)	HEAD (ft)	FLOW (gpm)	BHP	AC-FT (annual)	HRS	MOTOR SIZE	ELECTICAL COSTS POWER	ELECTICAL COSTS PUMP	DIESEL COSTS FUEL	DIESEL COSTS ENGINE
0											
POD	2900	143	644	31	200	1684	40	$1,748	$6,944	$2,611	$4,143
				31			40	$1,748	$6,944	$2,611	$4,143

SOIL ATTRIBUTES

Peak consumptive use	0.3 "/day	
Soil water holding capacity	9 "	
Maximum intake rate	0.5 "/hr	
Predominant soil (Map Unit # & land class #)65		1
Acres of irrigable soils in project area	490 ac	
# of acres of Class 6 soil in design area	ac	

Project# :	NCR-9			TOPO: ASHLAND	
Owner :	NCR			SOURCE: TONGUE R.	
Location :	T3S	R44E	10	SE,NW,SW	20-Feb-90

SYSTEM VARIABLES

Require power line const.	PLC	0.5 miles			
Total consumptive use	TCU	29.1 inches			
Net irrigation requirement	NIR	22.2 inches			
Total acres irrigated	TAI	77 ac			
Ac-ft of water needed	AFN	200 ac-ft	Total pump hp	THP	31
Total flow	TFL	644 gpm	Hours of pumping	HOP	1684
Equipment costs	EQC	$29,774	Engine amort.	ENA	8.7%
Flood costs	FDC		Annual electrical cost		$2,301
Total pipe cost	TPC	$10,804	Annual diesel costs		$3,806
Total ditch cost	TDC		Pumping power	PPP	Electrical
Labor cost	ALC	$550	Ann. energy costs	AEC	$1,945
TR-21 weather station	WSTA	N. Cheyenne Res.	Energy cost/ac	EAC	$25.26

IRRIGATION COSTS TABLE

ITEM	COST/ UNIT	# OF ITEMS	UNITS	T. COST $1	% O&M	O&M	LIFE	ECON ANN-COST TOTAL	FINAN. ANN-COST TOTAL
Flood					10.0%		20		
Line				$8,360	1.5%	$125	10	$1,187	$1,486
Pivot				$21,414	3.0%	$642	20	$2,303	$4,127
Other					1.5%		10		
Other			unit		5.0%		10		
ON-FARM TOTALS				$29,774		$768		$3,490	$5,613
Pump		40	hp	$6,944	2.5%	$174	30	$605	$1,304
Engine			hp		5.5%		17		
Diversion	$2,000	1.4	cfs	$2,862	1.0%	$29	30	$206	$494
Pump controls		10%	p. cost	$694	1.0%	$7	20	$61	$120
Pipe	$10,804	110%		$11,884	0.5%	$59	50	$671	$1,994
Ditches		110%			5.0%		20		
Storage			ac-ft		1.0%		50		
ROAD CROSSING	$15,000	1	unit	$15,000	2.0%	$300	50	$1,071	$2,741
SYSTEM TOTALS				$37,385		$569		$2,614	$6,653
Power dev.	$12,500	0.5	miles	$2,375			50	$122	$387
Engineering		15%	S. total	$5,608			50	$288	$913
Contingency		10%	S. total	$3,738			50	$192	$608
TOTAL				$78,880		$1,336		$6,707	$14,174

TOTAL ANNUAL COSTS	ECONOMIC TOTAL	ECONOMIC /AC	ECONOMIC /AC-FT	FINANCIAL TOTAL	FINANCIAL /AC	FINANCIAL /AC-FT
LABOR	$550	$7.14	$2.75			
ENERGY	$1,945	$25.26	$9.72			
EQUIPMENT -	$6,707	$87.10	$33.53	$14,174	$184.07	$70.87
TOTAL annual costs	$9,202	$119.50	$46.01	$16,668	$216.47	$83.34

Feasibility rating (chance that revenues exceed costs)

NCR-9 93 percentile N. Cheyenne Res.

Project# :	NCR-10		TOPO: ASHLAND	
Owner :	NCR		SOURCE: TONGUE R.	
Location :	T03S	R44E 15 NW,NE,NW		21-Feb-90

IRRIGATION ATTRIBUTES

TYPE (system)	ID#	AREA (acres)	FLOW (gpm)	MIN-PR (ft)	HW-L (ft)	LABOR (hours)	WATER USE (a-f/yr)	PIVOT COST	LINE COST	FLOOD COST
PIVOT 1		109.4	820	69	1131	82	269	$30,579		
PIVOT 2		94.5	708	72	1044	70	233	$28,534		
PIVOT 3		44.7	335	53	686	33	110	$20,121		
		248.6	1863			185	612	$79,234		

DISTRIBUTION SYSTEM ATTRIBUTES

ID (OUT)	EL (ft)	HEAD (ft)	FLOW (gpm)	SIZE (in)	LENGTH (ft)	PR-IN (ft)	NODE ID (IN)	PIPE CLASS	COST/ FT	TOTAL COST
	2940	72	708	8	2936	96	1	80	$3.41	$10,020
10	2960	59	335	6	2019	96	1	80	$2.41	$4,859
1	2940	96	1751	15	1231	138	2	100	$11.60	$14,284
					6,186					$29,163

PUMP ATTRIBUTES

ID	EL (ft)	HEAD (ft)	FLOW (gpm)	BHP	AC-FT (annual)	HRS	MOTOR SIZE	ELECTICAL COSTS POWER	PUMP	DIESEL COSTS FUEL	ENGINE
0											
POD	2900	138	1751	81	576	1784	100	$4,765	$13,751	$7,226	$7,273
				81			100	$4,765	$13,751	$7,226	$7,273

SOIL ATTRIBUTES

Peak consumptive use	0.3 "/day	
Soil water holding capacity	8 "	
Maximum intake rate	0.6 "/hr	
Predominant soil (Map Unit # & land class #)124		1
Acres of irrigable soils in project area	1814 ac	
# of acres of Class 6 soil in design area	ac	

Project# :	NCR-10			TOPO: ASHLAND	
Owner :	NCR			SOURCE: TONGUE R.	
Location :	T03S	R44E	15	NW,NE,NW	21-Feb-90

SYSTEM VARIABLES

Require power line const.	PLC	2.0 miles			
Total consumptive use	TCU	29.1 . inches			
Net irrigation requirement	NIR	22.2 inches			
Total acres irrigated	TAI	249 ac			
Ac-ft of water needed	AFN	612 ac-ft	Total pump hp	THP	81
Total flow	TFL	1863 gpm	Hours of pumping	HOP	1782
Equipment costs	EQC	$79,234	Engine amort.	ENA	9.1%
Flood costs	FDC		Annual electrical cost		$6,384
Total pipe cost	TPC	$29,163	Annual diesel costs		$9,484
Total ditch cost	TDC		Pumping power	PPP	Electrical
Labor cost	ALC	$925	Ann. energy costs	AEC	$5,529
TR-21 weather station	WSTA	N. Cheyenne Res.	Energy cost/ac	EAC	$22.24

IRRIGATION COSTS TABLE

ITEM	COST/ UNIT	# OF ITEMS	UNITS	T. COST $1	% O&M	O&M	LIFE	ECON ANN-COST TOTAL	FINAN. ANN-COST TOTAL
Flood					10.0%		20		
Line					1.5%		10		
Pivot				$79,234	3.0%	$2,377	20	$8,521	$15,272
Other					1.5%		10		
Other			unit		5.0%		10		
ON-FARM TOTALS				$79,234		$2,377		$8,521	$15,272
Pump		100	hp	$13,751	2.5%	$344	30	$1,198	$2,582
Engine			hp		5.5%		16		
Diversion	$2,000	4.1	cfs	$8,280	1.0%	$83	30	$597	$1,430
Pump controls		10%	p. cost	$1,375	1.0%	$14	20	$120	$238
Pipe	$29,163	110%		$32,079	0.5%	$160	50	$1,810	$5,381
Ditches		110%			5.0%		20		
Storage			ac-ft		1.0%		50		
LAND CLEARING	$50	124	unit	$6,215	2.0%	$124	50	$444	$1,136
SYSTEM TOTALS				$61,700		$725		$4,169	$10,766
Power dev.	$12,500	2.0	miles	$14,875			50	$765	$2,421
Engineering		15%	S. total	$9,255			50	$476	$1,506
Contingency		10%	S. total	$6,170			50	$317	$1,004
TOTAL				$171,234		$3,102		$14,249	$30,970

TOTAL ANNUAL COSTS	ECONOMIC TOTAL	ECONOMIC /AC	ECONOMIC /AC-FT	FINANCIAL TOTAL	FINANCIAL /AC	FINANCIAL /AC-FT
LABOR	$925	$3.72	$1.51			
ENERGY	$5,529	$22.24	$9.03			
EQUIPMENT	$14,249	$57.32	$23.28	$30,970	$124.58	$50.60
TOTAL annual costs	$20,702	$83.28	$33.83	$37,423	$150.54	$61.15

Feasibility rating (chance that revenues exceed costs)

NCR-10 100 percentile N. Cheyenne Res.

Project#	NCR-11			TOPO:	ASHLAND
Owner	NCR			SOURCE:	TONGUE R.
Location :	T03S	R44E	22	SE,NE,NW	02-Mar-90

IRRIGATION ATTRIBUTES

TYPE (system)	ID#	AREA (acres)	FLOW (gpm)	MIN-PR (ft)	HW-L (ft)	LABOR (hours)	WATER USE (a-f/yr)	PIVOT COST	LINE COST	FLOOD COST
WHLN	1	36	340	124	980	72	103		$9,080	
WHLN	2	27	280	123	800	72	77		$8,000	
WHLN	3	27	280	119	800	72	78		$8,000	
		90	900			216	258		$25,080	

DISTRIBUTION SYSTEM ATTRIBUTES

ID (OUT)	EL (ft)	HEAD (ft)	FLOW (gpm)	SIZE (in)	LENGTH (ft)	PR-IN (ft)	NODE ID (IN)	PIPE CLASS	COST/ FT	TOTAL COST
2	3000	124	340	6	4343	189	3	125	$3.08	$13,368
3	2970	189	620	8	3373	241	4	160	$5.40	$18,211
4	2940	241	900	10	1934	289	5	200	$9.81	$18,981
					9,650					$50,561

PUMP ATTRIBUTES

ID	EL (ft)	HEAD (ft)	FLOW (gpm)	BHP	AC-FT (annual)	HRS	MOTOR SIZE	ELECTICAL COSTS POWER	ELECTICAL COSTS PUMP	DIESEL COSTS FUEL	DIESEL COSTS ENGINE
0											
POD	2900	289	900	87	258	1553	100	$4,623	$12,900	$6,755	$7,715
				87			100	$4,623	$12,900	$6,755	$7,715

SOIL ATTRIBUTES

Peak consumptive use	0.3	"/day
Soil water holding capacity	8	"
Maximum intake rate	0.6	"/hr
Predominant soil (Map Unit # & land class #)	124	1
Acres of irrigable soils in project area	1814	ac
# of acres of Class 6 soil in design area		ac

Project# :	NCR-11			TOPO: ASHLAND	
Owner :	NCR			SOURCE: TONGUE R.	
Location :	T03S	R44E	22	SE,NE,NW	02-Mar-90

SYSTEM VARIABLES

Require power line const.	PLC	2.0 miles			
Total consumptive use	TCU	29.1 inches			
Net irrigation requirement	NIR	22.2 inches			
Total acres irrigated	TAI	90 ac			
Ac-ft of water needed	AFN	258 ac-ft	Total pump hp	THP	87
Total flow	TFL	900 gpm	Hours of pumping	HOP	1553
Equipment costs	EQC	$25,080	Engine amort.	ENA	8.3%
Flood costs	FDC		Annual electrical cost		$6,151
Total pipe cost	TPC	$50,561	Annual diesel costs		$8,942
Total ditch cost	TDC		Pumping power	PPP	Electrical
Labor cost	ALC	$1,080	Ann. energy costs	AEC	$4,623
TR-21 weather station	WSTA	N. Cheyenne Res.	Energy cost/ac	EAC	$51.37

IRRIGATION COSTS TABLE

ITEM	COST/ UNIT	# OF ITEMS	UNITS	T. COST $1	% O&M	O&M	LIFE	ECON ANN-COST TOTAL	FINAN. ANN-COST TOTAL
Flood					10.0%		20		
Line				$25,080	1.5%	$376	10	$3,561	$4,458
Pivot					3.0%		20		
Other					1.5%		10		
Other			unit		5.0%		10		
ON-FARM TOTALS				$25,080		$376		$3,561	$4,458
Pump		100	hp	$12,900	2.5%	$323	30	$1,124	$2,422
Engine			hp		5.5%		18		
Diversion	$2,000	2.0	cfs	$4,000	1.0%	$40	30	$288	$691
Pump controls		10%	p. cost	$1,290	1.0%	$13	20	$113	$223
Pipe	$50,561	110%		$55,617	0.5%	$278	50	$3,138	$9,329
Ditches		110%			5.0%		20		
Storage			ac-ft		1.0%		50		
ROAD CROSSING	$5,000	1	unit	$5,000	2.0%	$100	50	$357	$914
SYSTEM TOTALS				$78,807		$753		$5,021	$13,579
Power dev.	$12,500	2.0	miles	$14,125			50	$726	$2,299
Engineering		15%	S. total	$11,821			50	$608	$1,924
Contingency		10%	S. total	$7,881			50	$405	$1,283
TOTAL				$137,714		$1,130		$10,322	$23,542

TOTAL ANNUAL COSTS	ECONOMIC TOTAL	ECONOMIC /AC	ECONOMIC /AC-FT	FINANCIAL TOTAL	FINANCIAL /AC	FINANCIAL /AC-FT
LABOR	$1,080	$12.00	$4.19			
ENERGY	$4,623	$51.37	$17.94			
EQUIPMENT	$10,322	$114.69	$40.06	$23,542	$261.58	$91.37
TOTAL annual costs	$16,025	$178.05	$62.19	$29,245	$324.95	$113.50

Feasibility rating (chance that revenues exceed costs)

NCR-11 15 percentile N. Cheyenne Res.

Project# :	NCR-12				TOPO: ASHLANO
Owner :	NCR				SOURCE: TONGUE R.
Location :	T03S	R44E	22	SE,SW,NW	23-Feb-90

IRRIGATION ATTRIBUTES

TYPE (system)	ID#	AREA (acres)	FLOW (gpm)	MIN-PR (ft)	HW-L (ft)	LABOR (hours)	WATER USE (a-f/yr)	PIVOT COST	LINE COST	FLOOD COST
PIVOT	4	55.2	414	56	774	41	136	$22,189		
PIVOT	5	32.9	246	51	575	24	81	$17,513		
PIVOT	6	21.9	164	50	451	16	54	$14,599		
		110	824			81	271	$54,300		

DISTRIBUTION SYSTEM ATTRIBUTES

ID (OUT)	EL (ft)	HEAD (ft)	FLOW (gpm)	SIZE (in)	LENGTH (ft)	PR-IN (ft)	NODE ID (IN)	PIPE CLASS	COST/ FT	TOTAL COST
5	2940	56	414	8	1482	60	6	80	$3.41	$5,058
60	2940	55	246	6	1122	60	6	80	$2.41	$2,700
6	2940	60	824	10	663	102	7	80	$5.25	$3,479
					3,267					$11,238

PUMP ATTRIBUTES

ID	EL (ft)	HEAD (ft)	FLOW (gpm)	BHP	AC-FT (annual)	HRS	MOTOR SIZE	ELECTICAL COSTS POWER	PUMP	DIESEL COSTS FUEL	ENGINE
0											
POO	2900	102	824	28	271	1784	30	$1,647	$6,624	$2,497	$3,992
.											
				28			30	$1,647	$6,624	$2,497	$3,992

SOIL ATTRIBUTES

Peak consumptive use	0.3	"/day
Soil water holding capacity	8	"
Maximum intake rate	0.6	"/hr
Predominant soil (Map Unit # & land class #)124		1
Acres of irrigable soils in project area	1814	ac
# of acres of Class 6 soil in design area		ac

Project# :	NCR-12			TOPO: ASHLAND	
Owner :	NCR			SOURCE: TONGUE R.	
Location :	T03S	R44E	22	SE,SW,NW	23-Feb-90

SYSTEM VARIABLES

Require power line const.	PLC	2.0 miles			
Total consumptive use	TCU	29.1 inches			
Net irrigation requirement	NIR	22.2 inches			
Total acres irrigated	TAI	110 ac			
Ac-ft of water needed	AFN	271 ac-ft	Total pump hp	THP	28
Total flow	TFL	824 gpm	Hours of pumping	HOP	1784
Equipment costs	EQC	$54,300	Engine amort.	ENA	9.1%
Flood costs	FDC		Annual electrical cost		$3,164
Total pipe cost	TPC	$11,238	Annual diesel costs		$3,657
Total ditch cost	TDC		Pumping power	PPP	Electrical
Labor cost	ALC	$405	Ann. energy costs	AEC	$2,128
TR-21 weather station	WSTA	N. Cheyenne Res.	Energy cost/ac	EAC	$19.35

IRRIGATION COSTS TABLE

ITEM	COST/ UNIT	# OF ITEMS	UNITS	T. COST $1	% O&M	O&M	LIFE	ECON ANN-COST TOTAL	FINAN. ANN-COST TOTAL
Flood					10.0%		20		
Line					1.5%		10		
Pivot				$54,300	3.0%	$1,629	20	$5,840	$10,466
Other					1.5%		10		
Other			unit		5.0%		10		
ON-FARM TOTALS				$54,300		$1,629		$5,840	$10,466
Pump		30	hp	$6,624	2.5%	$166	30	$577	$1,244
Engine			hp		5.5%		16		
Diversion	$2,000	1.8	cfs	$3,662	1.0%	$37	30	$264	$633
Pump controls		10%	p. cost	$662	1.0%	$7	20	$58	$114
Pipe	$11,238	110%		$12,361	0.5%	$62	50	$698	$2,074
Ditches		110%			5.0%		20		
Storage			ac-ft		1.0%		50		
LAND CLEARING	$100	110	unit	$11,000	2.0%	$220	50	$786	$2,010
SYSTEM TOTALS				$34,310		$491		$2,382	$6,074
Power dev.	$12,500	2.0	miles	$21,500			50	$1,106	$3,499
Engineering		15%	S. total	$5,146			50	$265	$838
Contingency		10%	S. total	$3,431			50	$176	$558
TOTAL				$118,687		$2,120		$9,769	$21,435

TOTAL ANNUAL COSTS	ECONOMIC TOTAL	ECONOMIC /AC	ECONOMIC /AC-FT	FINANCIAL TOTAL	FINANCIAL /AC	FINANCIAL /AC-FT
LABOR	$405	$3.68	$1.49			
ENERGY	$2,128	$19.35	$7.85			
EQUIPMENT	$9,769	$88.81	$36.05	$21,435	$194.87	$79.10
TOTAL annual costs	$12,302	$111.84	$45.39	$23,969	$217.90	$88.45

Feasibility rating (chance that revenues exceed costs)

NCR-12 96 percentile N. Cheyenne Res.

Project# :	NCR-12			TOPO: ASHLAND	
Owner :	NCR			SOURCE: TONGUE R.	
Location :	T03S	R44E	22	SE,SW,NW	23-Feb-90

This project would require land clearing in old river channels.

Project# :	NCR-13	TOPO: ASHLAND	
Owner :	NCR	SOURCE: TONGUE R.	
Location :	T03S R44E 22 NE,SW,SW		21-Feb-90

IRRIGATION ATTRIBUTES

TYPE (system)	ID#	AREA (acres)	FLOW (gpm)	MIN-PR (ft)	HW-L (ft)	LABOR (hours)	WATER USE (a-f/yr)	PIVOT COST	LINE COST	FLOOD COST
PIVOT	7	39	292	52	635	29	96	$18,923		
PIVOT	9	57.1	428	56	789	42	140	$22,542		
WHLN	5	17	220	118	620	72	50		$6,920	
		113.1	940			143	286	$41,464	$6,920	

DISTRIBUTION SYSTEM ATTRIBUTES

ID (OUT)	EL (ft)	HEAD (ft)	FLOW (gpm)	SIZE (in)	LENGTH (ft)	PR-IN (ft)	NODE ID (IN)	PIPE CLASS	COST/ FT	TOTAL COST
7	2980	118	220	6	1081	141	8	100	$2.70	$2,915
8	2960	141	220	6	796	164	9	100	$2.70	$2,146
90	2970	129	428	8	1554	164	9	100	$3.92	$6,098
10	2940	164	940	10	848	208	11	160	$8.35	$7,082
					4,279					$18,242

PUMP ATTRIBUTES

ID	EL (ft)	HEAD (ft)	FLOW (gpm)	BHP	AC-FT (annual)	HRS	MOTOR SIZE	ELECTICAL COSTS POWER	PUMP	DIESEL COSTS FUEL	ENGINE
0											
pod	2900	208	940	66	286	1650	75	$3,665	$10,140	$5,446	$6,223
.											
				66			75	$3,665	$10,140	$5,446	$6,223

SOIL ATTRIBUTES

Peak consumptive use	0.3	"/day
Soil water holding capacity	8	"
Maximum intake rate	0.6	"/hr
Predominant soil (Map Unit # & land class #)124		1
Acres of irrigable soils in project area	1814	ac
# of acres of Class 6 soil in design area		ac

Project# :	NCR-13			TOPO: ASHLAND	
Owner :	NCR			SOURCE: TONGUE R.	
Location :	T03S	R44E	22	NE,SW,SW	21-Feb-90

SYSTEM VARIABLES

Require power line const.	PLC	2.0 miles			
Total consumptive use	TCU	29.1 inches			
Net irrigation requirement	NIR	22.2 inches			
Total acres irrigated	TAI	113 ac			
Ac-ft of water needed	AFN	286 ac-ft	Total pump hp	THP	66
Total flow	TFL	940 gpm	Hours of pumping	HOP	1650
Equipment costs	EQC	$48,384	Engine amort.	ENA	8.6%
Flood costs	FDC		Annual electrical cost		$5,156
Total pipe cost	TPC	$18,242	Annual diesel costs		$7,208
Total ditch cost	TDC		Pumping power	PPP	Electrical
Labor cost	ALC	$715	Ann. energy costs	AEC	$4,045
TR-21 weather station	WSTA	N. Cheyenne Res.	Energy cost/ac	EAC	$35.76

IRRIGATION COSTS TABLE

ITEM	COST/ UNIT	# OF ITEMS	UNITS	T. COST $1	% O&M	O&M	LIFE	ECON ANN-COST TOTAL	FINAN. ANN-COST TOTAL
Flood					10.0%		20		
Line				$6,920	1.5%	$104	10	$983	$1,230
Pivot				$41,464	3.0%	$1,244	20	$4,459	$7,992
Other					1.5%		10		
Other			unit		5.0%		10		
ON-FARM TOTALS				$48,384		$1,348		$5,442	$9,222
Pump		75	hp	$10,140	2.5%	$254	30	$883	$1,904
Engine			hp		5.5%		17		
Diversion	$2,000	2.1	cfs	$4,178	1.0%	$42	30	$301	$722
Pump controls		10%	p. cost	$1,014	1.0%	$10	20	$89	$175
Pipe	$18,242	110%		$20,066	0.5%	$100	50	$1,132	$3,366
Ditches		110%			5.0%		20		
Storage			ac-ft		1.0%		50		
LAND PREP.	$100	28	unit	$2,828	2.0%	$57	50	$202	$517
SYSTEM TOTALS				$38,225		$462		$2,608	$6,683
Power dev.	$12,500	2.0	miles	$16,750			50	$861	$2,726
Engineering		15%	S. total	$5,734			50	$295	$933
Contingency		10%	S. total	$3,823			50	$197	$622
TOTAL				$112,915		$1,810		$9,402	$20,186

TOTAL ANNUAL COSTS	ECONOMIC TOTAL	ECONOMIC /AC	ECONOMIC /AC-FT	FINANCIAL TOTAL	FINANCIAL /AC	FINANCIAL /AC-FT
LABOR	$715	$6.32	$2.50			
ENERGY	$4,045	$35.76	$14.14			
EQUIPMENT	$9,402	$83.13	$32.88	$20,186	$178.48	$70.58
TOTAL annual costs	$14,162	$125.22	$49.52	$24,946	$220.57	$87.22

Feasibility rating (chance that revenues exceed costs)

NCR-13 91 percentile N. Cheyenne Res.

Project# :	NCR-14			TOPO: ASHLANO	
Owner :	NCR			SOURCE: TONGUE R.	
Location :	T03S	R44E	28	SW,NW,NE	23-Feb-90

IRRIGATION ATTRIBUTES

TYPE (system)	ID#	AREA (acres)	FLOW (gpm)	MIN-PR (ft)	HW-L (ft)	LABOR (hours)	WATER USE (a-f/yr)	PIVOT COST	LINE COST	FLOOD COST
PIVOT	1	38.8	290	67	633	29	95	$18,876		
PIVOT	2	74.6	559	62	916	55	183	$25,526		
PIVOT	3	53.8	403	55	763	40	132	$21,931		
		167 2	1252			124	410	$66,332		

DISTRIBUTION SYSTEM ATTRIBUTES

IO (OUT)	EL (ft)	HEAD (ft)	FLOW (gpm)	SIZE (in)	LENGTH (ft)	PR-IN (ft)	NODE ID (IN)	PIPE CLASS	COST/ FT	TOTAL COST
2	2950	62	559	8	1835	71	3	80	$3.41	$6,262
30	2950	66	403	8	1799	71	3	80	$3.41	$6,140
31	2950	62	290	6	1504	71	3	80	$2.41	$3,620
3	2950	71	1139	12	465	93	4	80	$6.88	$3,198
					5,603					$19,220

PUMP ATTRIBUTES

ID	EL (ft)	HEAD (ft)	FLOW (gpm)	BHP	AC-FT (annual)	HRS	MOTOR SIZE	ELECTICAL COSTS POWER	PUMP	DIESEL COSTS FUEL	ENGINE
0											
POD	2930	93	1139	35	373	1776	40	$2,052	$7,439	$3,108	$4,352
.											
				35			40	$2,052	$7,439	$3,108	$4,352

SOIL ATTRIBUTES

Peak consumptive use	0.3	"/day
Soil water holding capacity	8	"
Maximum intake rate	0.6	"/hr
Predominant soil (Map Unit # & land class #)100		1
Acres of irrigable soils in project area	2079	ac
# of acres of Class 6 soil in design area		ac

Project#	NCR-14				TOPO: ASHLAND	
Owner	NCR				SOURCE: TONGUE R	
Location	T03S	R44E	28	SW,NW,NE		23-Feb-90

SYSTEM VARIABLES

Require power line const.	PLC	3.0 miles			
Total consumptive use	TCU	29.1 inches			
Net irrigation requirement	NIR	22.2 inches			
Total acres irrigated	TAI	167 ac			
Ac-ft of water needed	AFN	410 ac-ft	Total pump hp	THP	35
Total flow	TFL	1252 gpm	Hours of pumping	HOP	1776
Equipment costs	EQC	$66,332	Engine amort.	ENA	9.1%
Flood costs	FDC		Annual electrical cost		$4,218
Total pipe cost	TPC	$19,220	Annual diesel costs		$4,390
Total ditch cost	TDC		Pumping power	PPP	Electrical
Labor cost	ALC	$620	Ann. energy costs	AEC	$2,667
TR-21 weather station	WSTA	N. Cheyenne Res.	Energy cost/ac	EAC	$15.95

IRRIGATION COSTS TABLE

ITEM	COST/ UNIT	# OF ITEMS	UNITS	T. COST $1	% O&M	O&M	LIFE	ECON ANN-COST TOTAL	FINAN. ANN-COST TOTAL
Flood					10.0%		20		
Line					1.5%		10		
Pivot				$66,332	3.0%	$1,990	20	$7,134	$12,785
Other					1.5%		10		
Other			unit		5.0%		10		
ON-FARM TOTALS				$66,332		$1,990		$7,134	$12,785
Pump		40	hp	$7,439	2.5%	$186	30	$648	$1,397
Engine			hp		5.5%		16		
Diversion	$2,000	2.8	cfs	$5,564	1.0%	$56	30	$401	$961
Pump controls		10%	p. cost	$744	1.0%	$7	20	$65	$129
Pipe	$19,220	110%		$21,142	0.5%	$106	50	$1,193	$3,546
Ditches		110%			5.0%		20		
Storage			ac-ft		1.0%		50		
LAND CLEARING	$100	20	unit	$2,000	2.0%	$40	50	$143	$365
SYSTEM TOTALS				$36,889		$395		$2,450	$6,398
Power dev.	$12,500	3.0	miles	$33,125			50	$1,704	$5,391
Engineering		15%	S. total	$5,533			50	$285	$901
Contingency		10%	S. total	$3,689			50	$190	$600
TOTAL				$145,569		$2,385		$11,762	$26,075

TOTAL ANNUAL COSTS	ECONOMIC TOTAL	ECONOMIC /AC	ECONOMIC /AC-FT	FINANCIAL TOTAL	FINANCIAL /AC	FINANCIAL /AC-FT
LABOR	$620	$3.71	$1.51			
ENERGY	$2,667	$15.95	$6.51			
EQUIPMENT	$11,762	$70.35	$28.69	$26,075	$155.95	$63.60
TOTAL annual costs	$15,049	$90.01	$36.71	$29,363	$175.62	$71.62

Feasibility rating (chance that revenues exceed costs)

NCR-14 100 percentile N. Cheyenne Res.

Project# :	NCR-15			TOPO: ASHLAND
Owner :	NCR			SOURCE: TONGUE R.
Location :	T03S	R44E	32	SE,NW,NE	23-Feb-90

IRRIGATION ATTRIBUTES

TYPE (system)	ID#	AREA (acres)	FLOW (gpm)	MIN-PR (ft)	HW-L (ft)	LABOR (hours)	WATER USE (a-f/yr)	PIVOT COST	LINE COST	FLOOD COST
PIVOT	4	45.7	342	53	695	34	112	$20,333		
PIVOT	5	63.5	475	58	838	47	156	$23,693		
HLN	1	39	394	107	1760	187	111		$7,040	
		148.2	1211			268	379	$44,026	$7,040	

DISTRIBUTION SYSTEM ATTRIBUTES

ID (OUT)	EL (ft)	HEAD (ft)	FLOW (gpm)	SIZE (in)	LENGTH (ft)	PR-IN (ft)	NODE ID (IN)	PIPE CLASS	COST/ FT	TOTAL COST
4	3020	58	475	8	2997	99	5	80	$3.41	$10,228
5	2990	99	817	10	905	132	6	80	$5.25	$4,750
60	2960	130	394	8	827	132	6	80	$3.41	$2,822
61	2960	126	394	8	1382	130	61	80	$3.41	$4,716
62	2960	120	394	8	1931	126	62	80	$3.41	$6,590
6	2960	132	1211	12		152	7	100	$8.03	
					8,042					$29,106

PUMP ATTRIBUTES

ID	EL (ft)	HEAD (ft)	FLOW (gpm)	BHP	AC-FT (annual)	HRS	MOTOR SIZE	ELECTICAL COSTS POWER	ELECTICAL COSTS PUMP	DIESEL COSTS FUEL	DIESEL COSTS ENGINE
0											
P00	2940	152	1211	62	379	1698	75	$3,515	$10,411	$5,262	$5,958
.											
				62			75	$3,515	$10,411	$5,262	$5,958

SOIL ATTRIBUTES

Peak consumptive use	0.3	"/day
Soil water holding capacity	8	"
Maximum intake rate	0.6	"/hr
Predominant soil (Map Unit # & land class #)	100	1
Acres of irrigable soils in project area	2079	ac
# of acres of Class 6 soil in design area		ac

Project#	NCR-15				TOPO: ASHLAND	
Owner :	NCR				SOURCE: TONGUE R.	
Location :	T03S	R44E	32	SE,NW,NE		23-Feb-90

SYSTEM VARIABLES

Require power line const.	PLC	3.0 miles			
Total consumptive use	TCU	29.1 inches			
Net irrigation requirement	NIR	22.2 inches			
Total acres irrigated	TAI	148 ac			
Ac-ft of water needed	AFN	379 ac-ft	Total pump hp	THP	62
Total flow	TFL	1211 gpm	Hours of pumping	HOP	1698
Equipment costs	EQC	$51,066	Engine amort.	ENA	8.8%
Flood costs	FDC		Annual electrical cost		$5,692
Total pipe cost	TPC	$29,106	Annual diesel costs		$7,020
Total ditch cost	TDC		Pumping power	PPP	Electrical
Labor cost	ALC	$1,340	Ann. energy costs	AEC	$3,924
TR-21 weather station	WSTA	N. Cheyenne Res.	Energy cost/ac	EAC	$26.48

IRRIGATION COSTS TABLE

ITEM	COST/ UNIT	# OF ITEMS	UNITS	T. COST $1	% O&M	O&M	LIFE	ECON ANN-COST TOTAL	FINAN. ANN-COST TOTAL
Flood					10.0%		20		
Line				$7,040	1.5%	$106	10	$1,000	$1,251
Pivot				$44,026	3.0%	$1,321	20	$4,735	$8,486
Other					1.5%		10		
Other			unit		5.0%		10		
ON-FARM TOTALS				$51,066		$1,426		$5,734	$9,737
Pump		75	hp	$10,411	2.5%	$260	30	$907	$1,955
Engine			hp		5.5%		16		
Diversion	$2,000	2.7	cfs	$5,382	1.0%	$54	30	$388	$930
Pump controls		10%	p. cost	$1,041	1.0%	$10	20	$91	$180
Pipe	$29,106	110%		$32,017	0.5%	$160	50	$1,807	$5,371
Ditches		110%			5.0%		20		
Storage			ac-ft		1.0%		50		
ROAD CROSSING	$10,000	1	unit	$10,000	2.0%	$200	50	$714	$1,827
SYSTEM TOTALS				$58,851		$685		$3,907	$10,262
Power dev.	$12,500	3.0	miles	$29,750			50	$1,530	$4,842
Engineering		15%	S. total	$8,828			50	$454	$1,437
Contingency		10%	S. total	$5,885			50	$303	$958
TOTAL				$154,380		$2,111		$11,928	$27,236

TOTAL ANNUAL COSTS	ECONOMIC TOTAL	ECONOMIC /AC	ECONOMIC /AC-FT	FINANCIAL TOTAL	FINANCIAL /AC	FINANCIAL /AC-FT
LABOR	$1,340	$9.04	$3.54			
ENERGY	$3,924	$26.48	$10.35			
EQUIPMENT	$11,928	$80.49	$31.47	$27,236	$183.78	$71.86
TOTAL annual costs	$17,192	$116.00	$45.36	$32,499	$219.29	$85.75

Feasibility rating (chance that revenues exceed costs)

NCR-15 94 percentile N. Cheyenne Res.

Project#	NCR-16			TOPO: ASHLAND	
Owner	NCR			SOURCE: TONGUE R.	
Location	T04S	R44E	5	NE,NE,NW	23-Feb-90

IRRIGATION ATTRIBUTES

TYPE (system)	ID#	AREA (acres)	FLOW (gpm)	MIN-PR (ft)	HW-L (ft)	LABOR (hours)	WATER USE (a-f/yr)	PIVOT COST	LINE COST	FLOOD COST
PIVOT	6	87	652	68	998	65	214	$27,453		
PIVOT	7	39	292	52	635	29	96	$18,923		
PIVOT	8	31.2	233	51	557	23	76	$17,090		
		157 2	1177			117	386	$63,465		

DISTRIBUTION SYSTEM ATTRIBUTES

ID (OUT)	EL (ft)	HEAD (ft)	FLOW (gpm)	SIZE (in)	LENGTH (ft)	PR-IN (ft)	NODE ID (IN)	PIPE CLASS	COST/ FT	TOTAL COST
7	2960	51	233	6	1739	48	8	80	$2.41	$4,185
8	2970	68	885	10	1074	82	9	80	$5.25	$5,636
90	2960	77	292	6	705	82	9	80	$2.41	$1,697
9	2960	82	1177	12	529	103	10	80	$6.88	$3,638
					4,047					$15,157

PUMP ATTRIBUTES

ID	EL (ft)	HEAD (ft)	FLOW (gpm)	BHP	AC-FT (annual)	HRS	MOTOR SIZE	ELECTICAL COSTS POWER	ELECTICAL COSTS PUMP	DIESEL COSTS FUEL	DIESEL COSTS ENGINE
0											
POD	2940	103	1177	41	386	1779	50	$2,406	$7,877	$3,647	$4,680
				41			50	$2,406	$7,877	$3,647	$4,680

SOIL ATTRIBUTES

Peak consumptive use	0.3	"/day
Soil water holding capacity	8	"
Maximum intake rate	0.6	"/hr
Predominant soil (Map Unit # & land class #)100		1
Acres of irrigable soils in project area	2079	ac
# of acres of Class 6 soil in design area		ac

Project# :	NCR-16			TOPO: ASHLAND	
Owner :	NCR			SOURCE: TONGUE R.	
Location :	T04S	R44E	5	NE,NE,NW	23-Feb-90

SYSTEM VARIABLES

Require power line const.	PLC	3.0 miles			
Total consumptive use	TCU	29.1 inches			
Net irrigation requirement	NIR	22.2 inches			
Total acres irrigated	TAI	157 ac			
Ac-ft of water needed	AFN	386 ac-ft	Total pump hp	THP	41
Total flow	TFL	1177 gpm	Hours of pumping	HOP	1779
Equipment costs	EQC	$63,465	Engine amort.	ENA	9.1%
Flood costs	FDC		Annual electrical cost		$4,560
Total pipe cost	TPC	$15,157	Annual diesel costs		$5,014
Total ditch cost	TDC		Pumping power	PPP	Electrical
Labor cost	ALC	$585	Ann. energy costs	AEC	$2,990
TR-21 weather station	WSTA	N. Cheyenne Res.	Energy cost/ac	EAC	$19.02

IRRIGATION COSTS TABLE

ITEM	COST/ UNIT	# OF ITEMS	UNITS	T. COST $1	% O&M	O&M	LIFE	ECON ANN-COST TOTAL	FINAN. ANN-COST TOTAL
Flood					10.0%		20		
Line					1.5%		10		
Pivot				$63,465	3.0%	$1,904	20	$6,825	$12,233
Other					1.5%		10		
Other			unit		5.0%		10		
ON-FARM TOTALS				$63,465		$1,904		$6,825	$12,233
Pump		50	hp	$7,877	2.5%	$197	30	$686	$1,479
Engine			hp		5.5%		16		
Diversion	$2,000	2.6	cfs	$5,231	1.0%	$52	30	$377	$904
Pump controls		10%	p. cost	$788	1.0%	$8	20	$69	$136
Pipe	$15,157	110%		$16,673	0.5%	$83	50	$941	$2,797
Ditches		110%			5.0%		20		
Storage			ac-ft		1.0%		50		
LAND CLEARING	$100	50	unit	$5,000	2.0%	$100	50	$357	$914
SYSTEM TOTALS				$35,569		$440		$2,430	$6,229
Power dev.	$12,500	3.0	miles	$32,375			50	$1,665	$5,269
Engineering		15%	S. total	$5,335			50	$274	$868
Contingency		10%	S. total	$3,557			50	$183	$579
TOTAL				$140,301		$2,344		$11,378	$25,178

TOTAL ANNUAL COSTS	ECONOMIC TOTAL	ECONOMIC /AC	ECONOMIC /AC-FT	FINANCIAL TOTAL	FINANCIAL /AC	FINANCIAL /AC-FT
LABOR	$585	$3.72	$1.52			
ENERGY	$2,990	$19.02	$7.75			
EQUIPMENT	$11,378	$72.38	$29.48	$25,178	$160.16	$65 23
TOTAL annual costs	$14,953	$95.12	$38.74	$28,753	$182.91	$74.49

Feasibility rating (chance that revenues exceed costs)

NCR-16 100 percentile N. Cheyenne Res.

Project# :	NCR-17	TOPO: ASHLAND	
Owner :	NCR	SOURCE: TONGUE R.	
Location :	T04S R44E 5 NW,SW,SW		23-Feb-90

IRRIGATION ATTRIBUTES

TYPE (system)	ID#	AREA (acres)	FLOW (gpm)	MIN-PR (ft)	HW-L (ft)	LABOR (hours)	WATER USE (a-f/yr)	PIVOT COST	LINE COST	FLOOD COST
PIVOT	10	58.4	438	62	800	43	144	$22,800		
PIVOT	11	80.1	600	65	953	60	197	$26,396		
WHLN	1	34	260	119	740	72	97		$7,640	
WHLN	2	24	240	118	680	72	69		$7,280	
		196.5	1538			247	507	$49,196	$14,920	

DISTRIBUTION SYSTEM ATTRIBUTES

ID (OUT)	EL (ft)	HEAD (ft)	FLOW (gpm)	SIZE (in)	LENGTH (ft)	PR-IN (ft)	NODE ID (IN)	PIPE CLASS	COST/ FT	TOTAL COST
12	2990	119	260	6	3075	144	13	100	$2.70	$8,291
13	2980	144	860	10	1451	160	14	100	$6.05	$8,774
140	2980	146	240	6	780	160	14	100	$2.70	$2,103
141	2980	145	438	8	1267	160	14	100	$3.92	$4,972
14	2970	160	1538	12	780	183	15	125	$9.55	$7,446
					7,353					$31,586

PUMP ATTRIBUTES

ID	EL (ft)	HEAD (ft)	FLOW (gpm)	BHP	AC-FT (annual)	HRS	MOTOR SIZE	ELECTICAL COSTS POWER	PUMP	DIESEL COSTS FUEL	ENGINE
0											
POD	2950	183	1538	95	507	1788	100	$5,597	$13,538	$8,493	$8,325
				95			100	$5,597	$13,538	$8,493	$8,325

SOIL ATTRIBUTES

Peak consumptive use	0.3 "/day	
Soil water holding capacity	8 "	
Maximum intake rate	0.6 "/hr	
Predominant soil (Map Unit # & land class #)	100	1
Acres of irrigable soils in project area	2079 ac	
# of acres of Class 6 soil in design area	ac	

Project# :	NCR-17			TOPO: ASHLAND	
Owner :	NCR			SOURCE: TONGUE R.	
Location :	T04S	R44E	5	NW,SW,SW	23-Feb-90

SYSTEM VARIABLES

Require power line const.	PLC	3.0 miles			
Total consumptive use	TCU	29.1 inches			
Net irrigation requirement	NIR	22.2 inches			
Total acres irrigated	TAI	197 ac			
Ac-ft of water needed	AFN	507 ac-ft	Total pump hp	THP	95
Total flow	TFL	1538 gpm	Hours of pumping	HOP	1788
Equipment costs	EQC	$64,116	Engine amort.	ENA	9 1%
Flood costs	FDC		Annual electrical cost		$7,756
Total pipe cost	TPC	$31,586	Annual diesel costs		$10,888
Total ditch cost	TDC		Pumping power	PPP	Electrical
Labor cost	ALC	$1,235	Ann. energy costs	AEC	$6,065
TR-21 weather station	WSTA	N. Cheyenne Res.	Energy cost/ac	EAC	$30.87

IRRIGATION COSTS TABLE

ITEM	COST/ UNIT	# OF ITEMS	UNITS	T. COST $1	% O&M	O&M	LIFE	ECON ANN-COST TOTAL	FINAN. ANN-COST TOTAL
Flood					10.0%		20		
Line				$14,920	1.5%	$224	10	$2,119	$2,652
Pivot				$49,196	3.0%	$1,476	20	$5,291	$9,482
Other					1.5%		10		
Other			unit		5.0%		10		
ON-FARM TOTALS				$64,116		$1,700		$7,409	$12,134
Pump		100	hp	$13,538	2.5%	$338	30	$1,179	$2,542
Engine			hp		5.5%		16		
Diversion	$2,000	3.4	cfs	$6,836	1.0%	$68	30	$493	$1,181
Pump controls		10%	p. cost	$1,354	1.0%	$14	20	$119	$234
Pipe	$31,586	110%		$34,745	0.5%	$174	50	$1,961	$5,828
Ditches		110%			5.0%		20		
Storage			ac-ft		1.0%		50		
Other			unit		2.0%		50		
SYSTEM TOTALS				$56,472		$594		$3,.751	$9,785
Power dev.	$12,500	3.0	miles	$25,625			50	$1,318	$4,170
Engineering		15%	S. total	$8,471			50	$436	$1,379
Contingency		10%	S. total	$5,647			50	$290	$919
TOTAL				$160,331		$2,294		$13,205	$28,387

TOTAL ANNUAL COSTS	ECONOMIC TOTAL	/AC	/AC-FT	FINANCIAL TOTAL	/AC	/AC-FT
LABOR	$1,235	$6.28	$2.44			
ENERGY	$6,065	$30.87	$11.96			
EQUIPMENT	$13,205	$67 20	$26.04	$28,387	$144.46	$55.99
TOTAL annual costs	$20,505	$104.35	$40.44	$35,687	$181.61	$70.39

Feasibility rating (chance that revenues exceed costs)

NCR-17 99 percentile N. Cheyenne Res.

Project# :	NCR-18			TOPO: ASHLAND
Owner :	NCR			SOURCE: TONGUE R.
Location :	T04S	R44E	5	NW,SW,SW	23-Feb-90

IRRIGATION ATTRIBUTES

TYPE (system)	ID#	AREA (acres)	FLOW (gpm)	MIN-PR (ft)	HW-L (ft)	LABOR (hours)	WATER USE (a-f/yr)	PIVOT COST	LINE COST	FLOOD COST
PIVOT	9	50.5	379	69	737	37	124	$21,320		
PIVOT	12	108.8	816	84	1128	81	268	$30,508		
		159.3	1195			118	392	$51,828		

DISTRIBUTION SYSTEM ATTRIBUTES

ID (OUT)	EL (ft)	HEAD (ft)	FLOW (gpm)	SIZE (in)	LENGTH (ft)	PR-IN (ft)	NODE ID (IN)	PIPE CLASS	COST/ FT	TOTAL COST
12	2990	119	260	6	3075	144	13	100	$2.70	$8,291
15	3180	84	816	10	3547	116	16	80	$5.25	$18,615
16	3160	116	1195	12	5278	341	17	STEEL	$13.54	$71,457
					11,900					$98,364

PUMP ATTRIBUTES

ID	EL (ft)	HEAD (ft)	FLOW (gpm)	BHP	AC-FT (annual)	HRS	MOTOR SIZE	ELECTICAL COSTS POWER	PUMP	DIESEL COSTS FUEL	ENGINE
0											
POD	2950	341	1195	137	392	1779	150	$8,042	$16,195	$12,188	$11,819
				137			150	$8,042	$16,195	$12,188	$11,819

SOIL ATTRIBUTES

Peak consumptive use	0.3 "/day	
Soil water holding capacity	8 "	
Maximum intake rate	0.6 "/hr	
Predominant soil (Map Unit # & land class #)	100	1
Acres of irrigable soils in project area	2079 ac	
# of acres of Class 6 soil in design area	ac	

Project# :	NCR-18				TOPO: ASHLAND		
Owner :	NCR				SOURCE: TONGUE R.		
Location :	T04S	R44E	5	NW,SW,SW			23-Feb-90

SYSTEM VARIABLES

Require power line const.	PLC	3.0 miles			
Total consumptive use	TCU	29.1 inches			
Net irrigation requirement	NIR	22.2 inches			
Total acres irrigated	TAI	159 ac			
Ac-ft of water needed	AFN	392 ac-ft	Total pump hp	THP	137
Total flow	TFL	1195 gpm	Hours of pumping	HOP	1779
Equipment costs	EQC	$51,828	Engine amort.	ENA	9.1%
Flood costs	FDC		Annual electrical cost		$10,096
Total pipe cost	TPC	$98,364	Annual diesel costs		$15,321
Total ditch cost	TDC		Pumping power	PPP	Electrical
Labor cost	ALC	$590	Ann. energy costs	AEC	$8,539
TR-21 weather station	WSTA	N. Cheyenne Res.	Energy cost/ac	EAC	$53.60

IRRIGATION COSTS TABLE

ITEM	COST/ UNIT	# OF ITEMS	UNITS	T. COST $1	% O&M	O&M	LIFE	ECON ANN-COST TOTAL	FINAN. ANN-COST TOTAL
Flood					10.0%		20		
Line					1.5%		10		
Pivot				$51,828	3.0%	$1,555	20	$5,574	$9,990
Other					1.5%		10		
Other			unit		5.0%		10		
ON-FARM TOTALS				$51,828		$1,555		$5,574	$9,990
Pump		150	hp	$16,195	2.5%	$405	30	$1,411	$3,041
Engine			hp		5.5%		16		
Diversion	$2,000	2.7	cfs	$5,311	1.0%	$53	30	$383	$917
Pump controls		10%p. cost		$1,620	1.0%	$16	20	$142	$280
Pipe	$98,364	110%		$108,200	0.5%	$541	50	$6,105	$18,150
Ditches		110%			5.0%		20		
Storage			ac-ft		1.0%		50		
ROAD CROSSING	$5,000	1	unit	$5,000	2.0%	$100	50	$357	$914
SYSTEM TOTALS				$136,326		$1,115		$8,398	$23,302
Power dev.	$12,500	3.0	miles	$20,375			50	$1,048	$3,316
Engineering		15%S. total		$20,449			50	$1,052	$3,328
Contingency		10%S. total		$13,633			50	$701	$2,219
TOTAL				$242,610		$2,670		$16,773	$42,154

TOTAL ANNUAL COSTS	ECONOMIC TOTAL	ECONOMIC /AC	ECONOMIC /AC-FT	FINANCIAL TOTAL	FINANCIAL /AC	FINANCIAL /AC-FT
LABOR	$590	$3.70	$1.51			
ENERGY	$8,539	$53.60	$21.78			
EQUIPMENT	$16,773	$105.29	$42.79	$42,154	$264.62	$107.53
TOTAL annual costs	$25,902	$162.60	$66.08	$51,283	$321.92	$130.82

Feasibility rating (chance that revenues exceed costs)

NCR-18 33 percentile N Cheyenne Res.

Project# : NCR-19 TOPO: GREEN CREEK
Owner : NCR SOURCE: TONGUE R.
Location : T04S R43E 24 NE,NE,NE 28-Feb-90

IRRIGATION ATTRIBUTES

TYPE (system)	ID#	AREA (acres)	FLOW (gpm)	MIN-PR (ft)	HW-L (ft)	LABOR (hours)	WATER USE (a-f/yr)	PIVOT COST	LINE COST	FLOOD COST
PIVOT	1	96.8	725	73	1058	72	238	$28,863		
PIVOT	2	170.1	1275	72	1435	127	419	$39,660		
PIVOT	3	92.6	694	71	1033	69	228	$28,276		
		359 5	2694			268	885	$96,799		

DISTRIBUTION SYSTEM ATTRIBUTES

ID (OUT)	EL (ft)	HEAD (ft)	FLOW (gpm)	SIZE (in)	LENGTH (ft)	PR-IN (ft)	NODE ID (IN)	PIPE CLASS	COST/ FT	TOTAL COST
	3020	73	725	8	2707	116	1	80	$3.41	$9,238
10	3000	94	694	8	2623	116	1	80	$3.41	$8,952
1	3000	116	2694	18	1550	148	2	100	$17.04	$26,406
					6,880					$44,596

PUMP ATTRIBUTES

ID	EL (ft)	HEAD (ft)	FLOW (gpm)	BHP	AC-FT (annual)	HRS	MOTOR SIZE	ELECTICAL COSTS POWER	ELECTICAL COSTS PUMP	DIESEL COSTS FUEL	DIESEL COSTS ENGINE
0											
pod	2970	148	2694	135	885	1782	150	$7,933	$17,694	$12,027	$11,643
.											
				135			150	$7,933	$17,694	$12,027	$11,643

SOIL ATTRIBUTES

Peak consumptive use	0.3 "/day	
Soil water holding capacity	10 "	
Maximum intake rate	0.6 "/hr	
Predominant soil (Map Unit # & land class #)99		1
Acres of irrigable soils in project area	359 ac	
# of acres of Class 6 soil in design area	ac	

Project#	NCR-19			TOPO: GREEN CREEK
Owner	NCR			SOURCE: TONGUE R.
Location :	T04S	R43E	24	NE,NE,NE	28-Feb-90

SYSTEM VARIABLES

Require power line const.	PLC	4.0 miles			
Total consumptive use	TCU	29.1 inches			
Net irrigation requirement	NIR	22.2 inches			
Total acres irrigated	TAI	360 ac			
Ac-ft of water needed	AFN	885 ac-ft	Total pump hp	THP	135
Total flow	TFL	2694 gpm	Hours of pumping	HOP	1782
Equipment costs	EQC	$96,799	Engine amort.	ENA	9.1%
Flood costs	FDC		Annual electrical cost		$10,736
Total pipe cost	TPC	$44,596	Annual diesel costs		$15,266
Total ditch cost	TDC		Pumping power	PPP	Electrical
Labor cost	ALC	$1,340	Ann. energy costs	AEC	$8,875
TR-21 weather station	WSTA	N. Cheyenne Res.	Energy cost/ac	EAC	$24.69

IRRIGATION COSTS TABLE

ITEM	COST/ UNIT	# OF ITEMS	UNITS	T. COST $1	% O&M	O&M	LIFE	ECON ANN-COST TOTAL	FINAN. ANN-COST TOTAL
Flood					10.0%		20		
Line					1.5%		10		
Pivot				$96,799	3.0%	$2,904	20	$10,410	$18,657
Other					1.5%		10		
Other			unit		5.0%		10		
ON-FARM TOTALS				$96,799		$2,904		$10,410	$18,657
Pump		150	hp	$17,694	2.5%	$442	30	$1,541	$3,322
Engine			hp		5.5%		16		
Diversion	$2,000	6.0	cfs	$11,973	1.0%	$120	30	$863	$2,068
Pump controls		10%	p. cost	$1,769	1.0%	$18	20	$155	$306
Pipe	$44,596	110%		$49,056	0.5%	$245	50	$2,768	$8,229
Ditches		110%			5.0%		20		
Storage			ac-ft		1.0%		50		
LAND CLEARING	$100	75	unit	$7,500	2.0%	$150	50	$536	$1,371
SYSTEM TOTALS				$87,993		$975		$5,864	$15,295
Power dev.	$12,500	4.0	miles	$33,125			50	$1,704	$5,391
Engineering		15%	S. total	$13,199			50	$679	$2,148
Contingency		10%	S. total	$8,799			50	$453	$1,432
TOTAL				$239,914		$3,879		$19,109	$42,924

TOTAL ANNUAL COSTS	ECONOMIC TOTAL	ECONOMIC /AC	ECONOMIC /AC-FT	FINANCIAL TOTAL	FINANCIAL /AC	FINANCIAL /AC-FT
LABOR	$1,340	$3.73	$1.51			
ENERGY	$8,875	$24.69	$10.03			
EQUIPMENT	$19,109	$53.15	$21.59	$42,924	$119.40	$48.50
TOTAL annual costs	$29,323	$81.57	$33.13	$53,139	$147.81	$60.04

Feasibility rating (chance that revenues exceed costs)

NCR-19 100 percentile N. Cheyenne Res.

Project# :	NCR-20			TOPO: BIRNEY DAY SCHOOL
Owner :	NCR			SOURCE: TONGUE
Location :	T04S	R43E	23	SW,NW,SE	28-Feb-90

IRRIGATION ATTRIBUTES

TYPE (system)	ID#	AREA (acres)	FLOW (gpm)	MIN-PR (ft)	HW-L (ft)	LABOR (hours)	WATER USE (a-f/yr)	PIVOT COST	LINE COST	FLOOD COST
PIVOT	2	74	555	87	913	55	182	$25,456		
PIVOT	3	99.2	743	90	1072	74	244	$29,192		
PIVOT	4	57.9	433	56	795	43	142	$22,683		
PIVOT	5	35.6	267	52	602	26	87	$18,147		
PIVOT	7	87.4	655	73	1000	65	215	$27,500		
PIVOT	8	45.2	339	58	692	33	111	$20,262		
		399.3	2992			296	981	$143,239		

DISTRIBUTION SYSTEM ATTRIBUTES

ID (OUT)	EL (ft)	HEAD (ft)	FLOW (gpm)	SIZE (in)	LENGTH (ft)	PR-IN (ft)	NODE ID (IN)	PIPE CLASS	COST/ FT	TOTAL COST
5	3060	90	743	10	1249	93	6	80	$5.25	$6,555
60	3060	89	822	10	1037	93	6	80	$5.25	$5,442
61	3060	80	267	6	1748	89	61	80	$2.41	$4,207
6	3060	93	1565	12	2222	124	7	80	$6.88	$15,283
70	3040	117	994	10	1246	124	7	80	$5.25	$6,539
71	3040	101	339	6	1902	117	71	80	$2.41	$4,578
71	3040	116	433	8	2192	124	7	80	$3.41	$7,481
7	3040	124	2992	18	109	184	8	125	$20.58	$2,243
					11,705					$52,328

PUMP ATTRIBUTES

ID	EL (ft)	HEAD (ft)	FLOW (gpm)	BHP	AC-FT (annual)	HRS	MOTOR SIZE	ELECTICAL COSTS POWER	PUMP	DIESEL COSTS FUEL	ENGINE
0											
POD	2980	184	2992	185	981	1778	200	$10,855	$22,992	$16,450	$16,208
				185			200	$10,855	$22,992	$16,450	$16,208

SOIL ATTRIBUTES

Peak consumptive use	0.3	"/day
Soil water holding capacity	9	"
Maximum intake rate	0.6	"/hr
Predominant soil (Map Unit # & land class #)123		1
Acres of irrigable soils in project area	475	ac
# of acres of Class 6 soil in design area		ac

Project# :	NCR-20				TOPO: BIRNEY DAY SCHOOL	
Owner :	NCR				SOURCE: TONGUE	
Location :	T04S	R43E	23	SW,NW,SE		28-Feb-90

SYSTEM VARIABLES

Require power line const.	PLC	5.0 miles			
Total consumptive use	TCU	29.1 inches			
Net irrigation requirement	NIR	22.2 inches			
Total acres irrigated	TAI	399 ac			
Ac-ft of water needed	AFN	981 ac-ft	Total pump hp	THP	185
Total flow	TFL	2992 gpm	Hours of pumping	HOP	1778
Equipment costs	EQC	$143,239	Engine amort	ENA	9.1%
Flood costs	FDC		Annual electrical cost		$14,309
Total pipe cost	TPC	$52,328	Annual diesel costs		$20,814
Total ditch cost	TDC		Pumping power	PPP	Electrical
Labor cost	ALC	$1,480	Ann. energy costs	AEC	$12,208
TR-21 weather station	WSTA	N. Cheyenne Res.	Energy cost/ac	EAC	$30.57

IRRIGATION COSTS TABLE

ITEM	COST/ UNIT	# OF ITEMS	UNITS	T. COST $1	% O&M	O&M	LIFE	ECON ANN-COST TOTAL	FINAN. ANN-COST TOTAL
Flood					10.0%		20		
Line					1.5%		10		
Pivot				$143,239	3.0%	$4,297	20	$15,404	$27,609
Other					1.5%		10		
Other			unit		5.0%		10		
ON-FARM TOTALS				$143,239		$4,297		$15,404	$27,609
Pump		200	hp	$22,992	2.5%	$575	30	$2,003	$4,317
Engine			hp		5.5%		16		
Diversion	$2,000	6.6	cfs	$13,298	1.0%	$133	30	$959	$2,297
Pump controls		10%p.	cost	$2,299	1.0%	$23	20	$201	$397
Pipe	$52,328	110%		$57,561	0.5%	$288	50	$3,248	$9,656
Ditches		110%			5.0%		20		
Storage			ac-ft		1.0%		50		
ROAD C. & LAND P.			unit	$20,000	2.0%	$400	50	$1,429	$3,655
SYSTEM TOTALS				$116,150		$1,419		$7,840	$20,321
Power dev.	$12,500	5.0	miles	$39,375			50	$2,025	$6,408
Engineering		15%S.	total	$17,422			50	$896	$2,835
Contingency		10%S.	total	$11,615			50	$597	$1,890
TOTAL				$327,801		$5,716		$26,763	$59,064

TOTAL ANNUAL COSTS	ECONOMIC TOTAL	ECONOMIC /AC	ECONOMIC /AC-FT	FINANCIAL TOTAL	FINANCIAL /AC	FINANCIAL /AC-FT
LABOR	$1,480	$3.71	$1.51			
ENERGY	$12,208	$30.57	$12.44			
EQUIPMENT	$26,763	$67.02	$27.28	$59,064	$147.92	$60.21
TOTAL annual costs	$40,450	$101.30	$41.23	$72,751	$182.20	$74.16

Feasibility rating (chance that revenues exceed costs)

NCR-20 100 percentile N. Cheyenne Res.

Project# :	NCR-21			TOPO: BIRNEY DAY SCHOOL
Owner :	NCR			SOURCE: TONGUE
Location :	T04S	R43E	34	NE,NE,NW	28-Feb-90

IRRIGATION ATTRIBUTES

TYPE (system)	ID#	AREA (acres)	FLOW (gpm)	MIN-PR (ft)	HW-L (ft)	LABOR (hours)	WATER USE (a-f/yr)	PIVOT COST	LINE COST	FLOOD COST
PIVOT	10	46.2	346	54	700	34	113	$20,450		
HLN	1	14	119	135	320	71	41		$1,280	
HLN	2	34	337	135	840	186	99		$3,360	
HLN	3	23	216	140	560	124	66		$2,240	
		117.2	1018			415	319	$20,450	$6,880	

DISTRIBUTION SYSTEM ATTRIBUTES

ID (OUT)	EL (ft)	HEAD (ft)	FLOW (gpm)	SIZE (in)	LENGTH (ft)	PR-IN (ft)	NODE ID (IN)	PIPE CLASS	COST/ FT	TOTAL COST
8	3080	140	216	6	2251	188	9	125	$3.08	$6,929
90	3040	177	456	8	2820	188	9	125	$4.60	$12,967
91	3040	175	119	6	1510	177	91	125	$3.08	$4,648
91	3040	169	346	6	2089	188	9	125	$3.08	$6,430
9	3040	188	1018	10	84	228	10	160	$8.35	$702
					8,754					$31,675

PUMP ATTRIBUTES

ID	EL (ft)	HEAD (ft)	FLOW (gpm)	BHP	AC-FT (annual)	HRS	MOTOR SIZE	ELECTICAL COSTS POWER	PUMP	DIESEL COSTS FUEL	ENGINE
0											
POD	3000	228	1018	78	319	1700	100	$4,426	$13,018	$6,629	$7,056
				78			100	$4,426	$13,018	$6,629	$7,056

SOIL ATTRIBUTES

Peak consumptive use	0.3 "/day	
Soil water holding capacity	9 "	
Maximum intake rate	0.6 "/hr	
Predominant soil (Map Unit # & land class #)123		1
Acres of irrigable soils in project area	475 ac	
# of acres of Class 6 soil in design area	ac	

Project# :	NCR-21			TOPO: BIRNEY DAY SCHOOL
Owner :	NCR			SOURCE: TONGUE
Location :	T04S	R43E	34	NE,NE,NW	28-Feb-90

SYSTEM VARIABLES

Require power line const.	PLC	5.0 miles			
Total consumptive use	TCU	29.1 inches			
Net irrigation requirement	NIR	22.2 inches			
Total acres irrigated	TAI	117 ac			
Ac-ft of water needed	AFN	319 ac-ft	Total pump hp	THP	78
Total flow	TFL	1018 gpm	Hours of pumping	HOP	1700
Equipment costs	EQC	$27,330	Engine amort.	ENA	8.8%
Flood costs	FDC		Annual electrical cost		$7,947
Total pipe cost	TPC	$31,675	Annual diesel costs		$8,771
Total ditch cost	TDC		Pumping power	PPP	Electrical
Labor cost	ALC	$2,075	Ann. energy costs	AEC	$4,612
TR-21 weather station	WSTA	N. Cheyenne Res.	Energy cost/ac	EAC	$39.35

IRRIGATION COSTS TABLE

ITEM	COST/ UNIT	# OF ITEMS	UNITS	T. COST $1	% O&M	O&M	LIFE	ECON ANN-COST TOTAL	FINAN. ANN-COST TOTAL
Flood					10.0%		20		
Line				$6,880	1.5%	$103	10	$977	$1,223
Pivot				$20,450	3.0%	$614	20	$2,199	$3,942
Other					1.5%		10		
Other			unit		5.0%		10		
ON-FARM TOTALS				$27,330		$717		$3,176	$5,165
Pump		100	hp	$13,018	2.5%	$325	30	$1,134	$2,444
Engine			hp		5.5%		16		
Diversion	$2,000	2.3	cfs	$4,524	1.0%	$45	30	$326	$782
Pump controls		10%	p. cost	$1,302	1.0%	$13	20	$114	$225
Pipe	$31,675	110%		$34,843	0.5%	$174	50	$1,966	$5,845
Ditches		110%			5.0%		20		
Storage			ac-ft		1.0%		50		
LAND CLEARING	$150	50	unit	$7,500	2.0%	$150	50	$536	$1,371
SYSTEM TOTALS				$61,187		$708		$4,076	$10,666
Power dev.	$12,500	5.0	miles	$52,750			50	$2,713	$8,585
Engineering		15%	S. total	$9,178			50	$472	$1,494
Contingency		10%	S. total	$6,119			50	$315	$996
TOTAL				$156,564		$1,425		$10,752	$26,905

TOTAL ANNUAL COSTS	ECONOMIC TOTAL	ECONOMIC /AC	ECONOMIC /AC-FT	FINANCIAL TOTAL	FINANCIAL /AC	FINANCIAL /AC-FT
LABOR	$2,075	$17.70	$6.50			
ENERGY	$4,612	$39.35	$14.46			
EQUIPMENT	$10,752	$91.74	$33.70	$26,905	$229.56	$84.34
TOTAL annual costs	$17,439	$148.80	$54.67	$33,592	$286.62	$105.30

Feasibility rating (chance that revenues exceed costs)

NCR-21 62 percentile N. Cheyenne Res.

Project# : NCR-22 TOPO: BIRNEY DAY SCHOOL
Owner : NCR SOURCE: TONGUE
Location : T05S R43E 4 SE,SE,NW 28-Feb-90

IRRIGATION ATTRIBUTES

TYPE (system)	ID#	AREA (acres)	FLOW (gpm)	MIN-PR (ft)	HW-L (ft)	LABOR (hours)	WATER USE (a-f/yr)	PIVOT COST	LINE COST	FLOOD COST
PIVOT	11	30.3	227	51	548	22	74	$16,878		
PIVOT	12	55.5	416	56	777	41	136	$22,260		
WHLN	1	34	334	131	851	74	97		$8,306	
HLN	4	22	199	135	520	115	62		$2,080	
HLN	5	49	487	135	1160	257	139		$4,640	
HLN	6	19	167	135	440	97	55		$1,760	
HLN	7	16	135	135	360	79	46		$1,440	
HLN	8	64	696	140	1560	346	184		$6,240	
		289.8	2661			1031	793	$39,138	$24,466	

DISTRIBUTION SYSTEM ATTRIBUTES

ID (OUT)	EL (ft)	HEAD (ft)	FLOW (gpm)	SIZE (in)	LENGTH (ft)	PR-IN (ft)	NODE ID (IN)	PIPE CLASS	COST/ FT	TOTAL COST
10	3140	140	696	8	4292	214	11	160	$5.40	$23,173
11	3100	214	696	8	1594	247	12	160	$5.40	$8,606
12	3080	247	831	10	1360	251	13	160	$8.35	$11,359
13	3080	251	998	10	1154	277	14	200	$9.81	$11,326
140	3050	282	842	10	1434	277	14	200	$9.81	$14,074
141	3050	276	426	8	1644	282	141	200	$6.34	$10,415
142	3040	279	199	6	2388	276	142	200	$4.06	$9,699
14	3060	277	2174	15	421	319	15	200	$20.08	$8,454
15	3060	131	334	6	1679	164	16	100	$2.70	$4,527
					15,966					$101,633

PUMP ATTRIBUTES

ID	EL (ft)	HEAD (ft)	FLOW (gpm)	BHP	AC-FT (annual)	HRS	MOTOR SIZE	ELECTICAL COSTS POWER	PUMP	DIESEL COSTS FUEL	ENGINE
0											
POD	3020	319	2174	233	654	1632	300	$12,832	$32,174	$19,009	$20,970
				233			300	$12,832	$32,174	$19,009	$20,970

SOIL ATTRIBUTES

Peak consumptive use	0.3	"/day
Soil water holding capacity	9	"
Maximum intake rate	0.6	"/hr
Predominant soil (Map Unit # & land class #)123		1
Acres of irrigable soils in project area	475	ac
# of acres of Class 6 soil in design area		ac

Project# :	NCR-22				TOPO: BIRNEY DAY SCHOOL	
Owner :	NCR				SOURCE: TONGUE	
Location :	T05S	R43E	4	SE,SE,NW		28-Feb-90

SYSTEM VARIABLES

Require power line const.	PLC	5.0 miles			
Total consumptive use	TCU	29.1 inches			
Net irrigation requirement	NIR	22.2 inches			
Total acres irrigated	TAI	290 ac			
Ac-ft of water needed	AFN	793 ac-ft	Total pump hp	THP	233
Total flow	TFL	2661 gpm	Hours of pumping	HOP	1616
Equipment costs	EQC	$63,604	Engine amort.	ENA	8.5%
Flood costs	FDC		Annual electrical cost		$16,547
Total pipe cost	TPC	$101,633	Annual diesel costs		$24,748
Total ditch cost	TDC		Pumping power	PPP	Electrical
Labor cost	ALC	$5,155	Ann. energy costs	AEC	$13,184
TR-21 weather station	WSTA	N. Cheyenne Res.	Energy cost/ac	EAC	$45.49

IRRIGATION COSTS TABLE

ITEM	COST/ UNIT	# OF ITEMS	UNITS	T. COST $1	% O&M	O&M	LIFE	ECON ANN-COST TOTAL	FINAN. ANN-COST TOTAL
Flood					10.0%		20		
Line				$24,466	1.5%	$367	10	$3,474	$4,349
Pivot				$39,138	3.0%	$1,174	20	$4,209	$7,544
Other					1.5%		10		
Other			unit		5.0%		10		
ON-FARM TOTALS				$63,604		$1,541		$7,683	$11,892
Pump		300	hp	$32,174	2.5%	$804	30	$2,803	$6,041
Engine			hp		5.5%		17		
Diversion	$2,000	5.9	cfs	$11,827	1.0%	$118	30	$853	$2,043
Pump controls		10%	p. cost	$3,217	1.0%	$32	20	$282	$556
Pipe	$101,633	110%		$111,797	0.5%	$559	50	$6,308	$18,753
Ditches		110%			5.0%		20		
Storage			ac-ft		1.0%		50		
ROAD CROSSING			unit	$10,000	2.0%	$200	50	$714	$1,827
SYSTEM TOTALS				$169,015		$1,714		$10,960	$29,220
Power dev.	$12,500	5.0	miles	$33,375			50	$1,716	$5,432
Engineering		15%	S. total	$25,352			50	$1,304	$4,126
Contingency		10%	S. total	$16,901			50	$869	$2,751
TOTAL				$308,247		$3,255		$22,533	$53,421

TOTAL ANNUAL COSTS	ECONOMIC TOTAL	ECONOMIC /AC	ECONOMIC /AC-FT	FINANCIAL TOTAL	FINANCIAL /AC	FINANCIAL /AC-FT
LABOR	$5,155	$17.79	$6.50			
ENERGY	$13,184	$45.49	$16.63			
EQUIPMENT	$22,533	$77.75	$28.41	$53,421	$184.34	$67.37
TOTAL annual costs	$40,872	$141.04	$51.54	$71,760	$247.62	$90.49

Feasibility rating (chance that revenues exceed costs)

NCR-22 73 percentile N Cheyenne Res.

Project# :	NCR-23		TOPO: BIRNEY DAY SCHOOL
Owner :	NCR		SOURCE: TONGUE
Location :	T05S R43E 9	SE,NW,NW	28-Feb-90

IRRIGATION ATTRIBUTES

TYPE (system)	ID#	AREA (acres)	FLOW (gpm)	MIN-PR (ft)	HW-L (ft)	LABOR (hours)	WATER USE (a-f/yr)	PIVOT COST	LINE COST	FLOOD COST
PIVOT	13	85.4	640	67	988	64	210	$27,218		
PIVOT	14	33.8	253	51	584	25	83	$17,724		
PIVOT	15	53	397	55	757	39	130	$21,790		
PIVOT	16	24.3	182	50	480	18	59	$15,280		
		196.5	1472			146	482	$82,012		

DISTRIBUTION SYSTEM ATTRIBUTES

ID (OUT)	EL (ft)	HEAD (ft)	FLOW (gpm)	SIZE (in)	LENGTH (ft)	PR-IN (ft)	NODE ID (IN)	PIPE CLASS	COST/ FT	TOTAL COST
16	3060	67	640	8	1639	78	17	80	$3.41	$5,593
170	3060	73	397	8	1491	78	17	80	$3.41	$5,088
171	3080	52	253	6	1144	78	17	80	$2.41	$2,753
17	3060	78	1472	12	720	111	18	80	$6.88	$4,952
					4,994					$18,387

PUMP ATTRIBUTES

ID	EL (ft)	HEAD (ft)	FLOW (gpm)	BHP	AC-FT (annual)	HRS	MOTOR SIZE	ELECTICAL COSTS POWER	PUMP	DIESEL COSTS FUEL	ENGINE
0											
POO	3030	111	1472	55	482	1776	60	$3,224	$9,972	$4,884	$5,510
				55			60	$3,224	$9,972	$4,884	$5,510

SOIL ATTRIBUTES

Peak consumptive use	0.3 "/day
Soil water holding capacity	9 "
Maximum intake rate	0.6 "/hr
Predominant soil (Map Unit # & land class #)123	1
Acres of irrigable soils in project area	475 ac
# of acres of Class 6 soil in design area	ac

Project# :	NCR-23				TOPO: BIRNEY DAY SCHOOL	
Owner :	NCR				SOURCE: TONGUE	
Location :	T05S	R43E	9	SE,NW,NW		28-Feb-90

SYSTEM VARIABLES

Require power line const.	PLC	5.0 miles			
Total consumptive use	TCU	29.1 inches			
Net irrigation requirement	NIR	22.2 inches			
Total acres irrigated	TAI	197 ac			
Ac-ft of water needed	AFN	482 ac-ft	Total pump hp	THP	55
Total flow	TFL	1472 gpm	Hours of pumping	HOP	1776
Equipment costs	EQC	$82,012	Engine amort.	ENA	9.1%
Flood costs	FDC		Annual electrical cost		$6,704
Total pipe cost	TPC	$18,387	Annual diesel costs		$6,555
Total ditch cost	TDC		Pumping power	PPP	Diesel
Labor cost	ALC	$730	Ann. energy costs	AEC	$5,632
TR-21 weather station	WSTA	N. Cheyenne Res.	Energy cost/ac	EAC	$28.66

IRRIGATION COSTS TABLE

ITEM	COST/ UNIT	# OF ITEMS	UNITS	T. COST $1	% O&M	O&M	LIFE	ECON ANN-COST TOTAL	FINAN. ANN-COST TOTAL
Flood					10.0%		20		
Line					1.5%		10		
Pivot				$82,012	3.0%	$2,460	20	$8,820	$15,807
Other					1.5%		10		
Other			unit		5.0%		10		
ON-FARM TOTALS				$82,012		$2,460		$8,820	$15,807
Pump		60	hp	$9,972	2.5%	$249	30	$869	$1,872
Engine		61	hp	$5,510	5.5%	$303	16	$802	$1,200
Diversion	$2,000	3.3	cfs	$6,542	1.0%	$65	30	$472	$1,130
Pump controls		10%p.	cost	$997	1.0%	$10	20	$87	$172
Pipe	$18,387	110%		$20,226	0.5%	$101	50	$1,141	$3,393
Ditches		110%			5.0%		20		
Storage			ac-ft		1.0%		50		
LAND CLEARING	$100	20	unit	$2,000	2.0%	$40	50	$143	$365
SYSTEM TOTALS				$45,248		$769		$3,514	$8,133
Power dev.	$12,500		miles				50		
Engineering		15%S.	total	$6,787			50	$349	$1,105
Contingency		10%S.	total	$4,525			50	$233	$736
TOTAL				$138,571		$3,229		$12,916	$25,781

TOTAL ANNUAL COSTS	ECONOMIC TOTAL	ECONOMIC /AC	ECONOMIC /AC-FT	FINANCIAL TOTAL	FINANCIAL /AC	FINANCIAL /AC-FT
LABOR	$730	$3.72	$1.51			
ENERGY	$5,632	$28.66	$11.68			
EQUIPMENT	$12,916	$65.73	$26.80	$25,781	$131.20	$53.49
TOTAL annual costs	$19,277	$98.10	$39.99	$32,143	$163.58	$66.69

Feasibility rating (chance that revenues exceed costs)

NCR-23 100 percentile N. Cheyenne Res.

Project# :	NCR-24			TOPO: BIRNEY DAY SCHOOL
Owner :	NCR			SOURCE: TONGUE
Location :	T05S	R43E	8 SE,NW,NE	28-Feb-90

IRRIGATION ATTRIBUTES

TYPE (system)	ID#	AREA (acres)	FLOW (gpm)	MIN-PR (ft)	HW-L (ft)	LABOR (hours)	WATER USE (a-f/yr)	PIVOT COST	LINE COST	FLOOD COST
PIVOT	14	33.8	253	51	584	25	83	$17,724		
WHLN	2	33	315	126	799	74	95		$7,994	
WHLN	4	34	315	126	802	74	98		$8,012	
		100.8	883			173	276	$17,724	$16,006	

DISTRIBUTION SYSTEM ATTRIBUTES

ID (OUT)	EL (ft)	HEAD (ft)	FLOW (gpm)	SIZE (in)	LENGTH (ft)	PR-IN (ft)	NODE ID (IN)	PIPE CLASS	COST/ FT	TOTAL COST
18	3090	126	315	6	2002	140	19	100	$2.70	$5,398
19	3090	140	630	8	2107	184	20	125	$4.60	$9,689
					4,109					$15,087

PUMP ATTRIBUTES

ID	EL (ft)	HEAD (ft)	FLOW (gpm)	BHP	AC-FT (annual)	HRS	MOTOR SIZE	ELECTICAL COSTS POWER	PUMP	DIESEL COSTS FUEL	ENGINE
0											
P00	3060	184	630	39	193	1662	40	$2,177	$6,930	$3,240	$4,569
				39			40	$2,177	$6,930	$3,240	$4,569

SOIL ATTRIBUTES

Peak consumptive use	0.3 "/day	
Soil water holding capacity	9 "	
Maximum intake rate	0.6 "/hr	
Predominant soil (Map Unit # & land class #)123		1
Acres of irrigable soils in project area	475 ac	
# of acres of Class 6 soil in design area	ac	

Project# :	NCR-24			TOPO: BIRNEY DAY SCHOOL	
Owner :	NCR			SOURCE: TONGUE	
Location :	T05S	R43E	8	SE,NW,NE	28-Feb-90

SYSTEM VARIABLES

Require power line const.	PLC	5.0 miles			
Total consumptive use	TCU	29.1 inches			
Net irrigation requirement	NIR	22.2 inches			
Total acres irrigated	TAI	101 ac			
Ac-ft of water needed	AFN	276 ac-ft	Total pump hp	THP	39
Total flow	TFL	883 gpm	Hours of pumping	HOP	1695
Equipment costs	EQC	$33,730	Engine amort.	ENA	8.8%
Flood costs	FDC		Annual electrical cost		$5,571
Total pipe cost	TPC	$15,087	Annual diesel costs		$4,496
Total ditch cost	TDC		Pumping power	PPP	Diesel
Labor cost	ALC	$865	Ann. energy costs	AEC	$3,396
TR-21 weather station	WSTA	N. Cheyenne Res.	Energy cost/ac	EAC	$33.69

IRRIGATION COSTS TABLE

ITEM	COST/ UNIT	# OF ITEMS	UNITS	T. COST $1	% O&M	O&M	LIFE	ECON ANN-COST TOTAL	FINAN. ANN-COST TOTAL
Flood					10.0%		20		
Line				$16,006	1.5%	$240	10	$2,273	$2,845
Pivot				$17,724	3.0%	$532	20	$1,906	$3,416
Other					1.5%		10		
Other			unit		5.0%		10		
ON-FARM TOTALS				$33,730		$772		$4,179	$6,261
Pump		40	hp	$6,930	2.5%	$173	30	$604	$1,301
Engine		43	hp	$4,569	5.5%	$251	17	$652	$995
Diversion	$2,000	2.0	cfs	$3,924	1.0%	$39	30	$283	$678
Pump controls		10%	p. cost	$693	1.0%	$7	20	$61	$120
Pipe	$15,087	110%		$16,595	0.5%	$83	50	$936	$2,784
Ditches		110%			5.0%		20		
Storage			ac-ft		1.0%		50		
Other			unit		2.0%		50		
SYSTEM TOTALS				$32,712		$554		$2,536	$5,877
Power dev.	$12,500		miles				50		
Engineering		15%	S. total	$4,907			50	$252	$799
Contingency		10%	S. total	$3,271			50	$168	$532
TOTAL				$74,619		$1,325		$7,136	$13,469

TOTAL ANNUAL COSTS	ECONOMIC TOTAL	ECONOMIC /AC	ECONOMIC /AC-FT	FINANCIAL TOTAL	FINANCIAL /AC	FINANCIAL /AC-FT
LABOR	$865	$8.58	$3.13			
ENERGY	$3,396	$33.69	$12.30			
EQUIPMENT	$7,136	$70.79	$25.85	$13,469	$133.63	$48.80
TOTAL annual costs	$11,397	$113.06	$41.29	$17,730	$175.90	$64.24

Feasibility rating (chance that revenues exceed costs)

NCR-24 95 percentile N. Cheyenne Res.

Project# : NCR-25 TOPO: BIRNEY DAY SCHOOL
Owner : NCR SOURCE: TONGUE R.
Location : T05S R43E 19 SE,NW,NW 28-Feb-90

IRRIGATION ATTRIBUTES

TYPE (system)	ID#	AREA (acres)	FLOW (gpm)	MIN-PR (ft)	HW-L (ft)	LABOR (hours)	WATER USE (a-f/yr)	PIVOT COST	LINE COST	FLOOD COST
PIVOT	1	83.2	623	81	973	62	205	$26,866		
PIVOT	2	57.8	433	71	795	43	142	$22,683		
PIVOT	3	46.8	350	69	705	35	115	$20,568		
		187.8	1406			140	462	$70,116		

DISTRIBUTION SYSTEM ATTRIBUTES

ID (OUT)	EL (ft)	HEAD (ft)	FLOW (gpm)	SIZE (in)	LENGTH (ft)	PR-IN (ft)	NODE ID (IN)	PIPE CLASS	COST/ FT	TOTAL COST
	3220	81	623	8	1974	133	1	80	$3.41	$6,737
1	3180	133	1056	10	1712	183	2	125	$7.10	$12,156
2	3140	183	1406	12	2168	262	3	160	$11.35	$24,601
					5,854					$43,494

PUMP ATTRIBUTES

ID	EL (ft)	HEAD (ft)	FLOW (gpm)	BHP	AC-FT (annual)	HRS	MOTOR SIZE	ELECTICAL COSTS POWER	PUMP	DIESEL COSTS FUEL	ENGINE
0											
POD	3070	262	1406	124	462	1782	125	$7,288	$15,706	$11,050	$10,691
.											
				124			125	$7,288	$15,706	$11,050	$10,691

SOIL ATTRIBUTES

Peak consumptive use	0.3	"/day	
Soil water holding capacity	9	"	
Maximum intake rate	0.6	"/hr	
Predominant soil (Map Unit # & land class #)	198		123
Acres of irrigable soils in project area	187.8	ac	
# of acres of Class 6 soil in design area		ac	

Project# :	NCR-25			TOPO: BIRNEY DAY SCHOOL	
Owner :	NCR			SOURCE: TONGUE R.	
Location :	T05S	R43E	19	SE,NW,NW	28-Feb-90

SYSTEM VARIABLES

Require power line const.	PLC	3.0 miles			
Total consumptive use	TCU	29.1 inches			
Net irrigation requirement	NIR	22.2 inches			
Total acres irrigated	TAI	188 ac			
Ac-ft of water needed	AFN	462 ac-ft	Total pump hp	THP	124
Total flow	TFL	1406 gpm	Hours of pumping	HOP	1782
Equipment costs	EQC	$70,116	Engine amort.	ENA	9.1%
Flood costs	FDC		Annual electrical cost		$9,395
Total pipe cost	TPC	$43,494	Annual diesel costs		$13,977
Total ditch cost	TDC		Pumping power	PPP	Electrical
Labor cost	ALC	$700	Ann. energy costs	AEC	$7,949
TR-21 weather station	WSTA	N. Cheyenne Res.	Energy cost/ac	EAC	$42.32

IRRIGATION COSTS TABLE

ITEM	COST/ UNIT	# OF ITEMS	UNITS	T. COST $1	% O&M	O&M	LIFE	ECON ANN-COST TOTAL	FINAN. ANN-COST TOTAL
Flood					10.0%		20		
Line					1.5%		10		
Pivot				$70,116	3.0%	$2,103	20	$7,540	$13,514
Other					1.5%		10		
Other			unit		5.0%		10		
ON-FARM TOTALS				$70,116		$2,103		$7,540	$13,514
Pump		125	hp	$15,706	2.5%	$393	30	$1,368	$2,949
Engine			hp		5.5%		16		
Diversion	$2,000	3.1	cfs	$6,249	1.0%	$62	30	$451	$1,079
Pump controls		10%	p. cost	$1,571	1.0%	$16	20	$137	$271
Pipe	$43,494	110%		$47,844	0.5%	$239	50	$2,700	$8,026
Ditches		110%			5.0%		20		
Storage			ac-ft		1.0%		50		
ROAD CROSSING			unit	$5,000	2.0%	$100	50	$357	$914
SYSTEM TOTALS				$76,369		$810		$5,013	$13,239
Power dev	$12,500	3.0	miles	$22,000			50	$1,131	$3,580
Engineering		15%	S. total	$11,455			50	$589	$1,864
Contingency		10%	S. total	$7,637			50	$393	$1,243
TOTAL				$187,577		$2,914		$14,667	$33,441

TOTAL ANNUAL COSTS	ECONOMIC TOTAL	/AC	/AC-FT	FINANCIAL TOTAL	/AC	/AC-FT
LABOR	$700	$3.73	$1.52			
ENERGY	$7,949	$42.32	$17.20			
EQUIPMENT	$14,667	$78.10	$31.75	$33,441	$178.07	$72.38
TOTAL annual costs	$23,316	$124.15	$50.47	$42,089	$224.12	$91.10

Feasibility rating (chance that revenues exceed costs)

NCR-25 91 percentile N. Cheyenne Res.

Project# :	NCR-26		TOPO: BIRNEY DAY SCHOOL
Owner :	NCR		SOURCE: TONGUE R.
Location :	T05S R43E 19	NW,SW,NW	28-Feb-90

IRRIGATION ATTRIBUTES

TYPE (system)	ID#	AREA (acres)	FLOW (gpm)	MIN-PR (ft)	HW-L (ft)	LABOR (hours)	WATER USE (a-f/yr)	PIVOT COST	LINE COST	FLOOD COST
PIVOT	4	81.5	611	65	963	61	201	$26,631		
PIVOT	5	61	457	57	819	45	150	$23,247		
WHLN	2	35	337	125	859	74	101		$8,354	
		177.5	1405			180	452	$49,877	$8,354	

DISTRIBUTION SYSTEM ATTRIBUTES

ID (OUT)	EL (ft)	HEAD (ft)	FLOW (gpm)	SIZE (in)	LENGTH (ft)	PR-IN (ft)	NODE ID (IN)	PIPE CLASS	COST/ FT	TOTAL COST
3	3090	65	611	8	1884	76	4	80	$3.41	$6,430
4	3090	76	1068	10	1545	85	5	80	$5.25	$8,108
5	3090	125	1405	12	2140	153	6	100	$8.03	$17,181
					5,569					$31,719

PUMP ATTRIBUTES

ID	EL (ft)	HEAD (ft)	FLOW (gpm)	BHP	AC-FT (annual)	HRS	MOTOR SIZE	ELECTICAL COSTS POWER	PUMP	DIESEL COSTS FUEL	ENGINE
0											
POD	3070	153	1405	72	452	1745	75	$4,166	$10,605	$6,282	$6,633
				72			75	$4,166	$10,605	$6,282	$6,633

SOIL ATTRIBUTES

Peak consumptive use	0.3 "/day
Soil water holding capacity	9 "
Maximum intake rate	0.6 "/hr
Predominant soil (Map Unit # & land class #)197	123
Acres of irrigable soils in project area	35 ac
# of acres of Class 6 soil in design area	ac

Project# :	NCR-26				TOPO: BIRNEY DAY SCHOOL	
Owner :	NCR				SOURCE: TONGUE R.	
Location :	T05S	R43E	19	NW,SW,NW		28-Feb-90

SYSTEM VARIABLES

Require power line const.	PLC	3.0 miles			
Total consumptive use	TCU	29.1 inches			
Net irrigation requirement	NIR	22.2 inches			
Total acres irrigated	TAI	178 ac			
Ac-ft of water needed	AFN	452 ac-ft	Total pump hp	THP	72
Total flow	TFL	1405 gpm	Hours of pumping	HOP	1745
Equipment costs	EQC	$58,231	Engine amort.	ENA	8 9%
Flood costs	FDC		Annual electrical cost		$6,290
Total pipe cost	TPC	$31,719	Annual diesel costs		$8,164
Total ditch cost	TDC		Pumping power	PPP	Electrical
Labor cost	ALC	$900	Ann. energy costs	AEC	$4,642
TR-21 weather station	WSTA	N. Cheyenne Res.	Energy cost/ac	EAC	$26.15

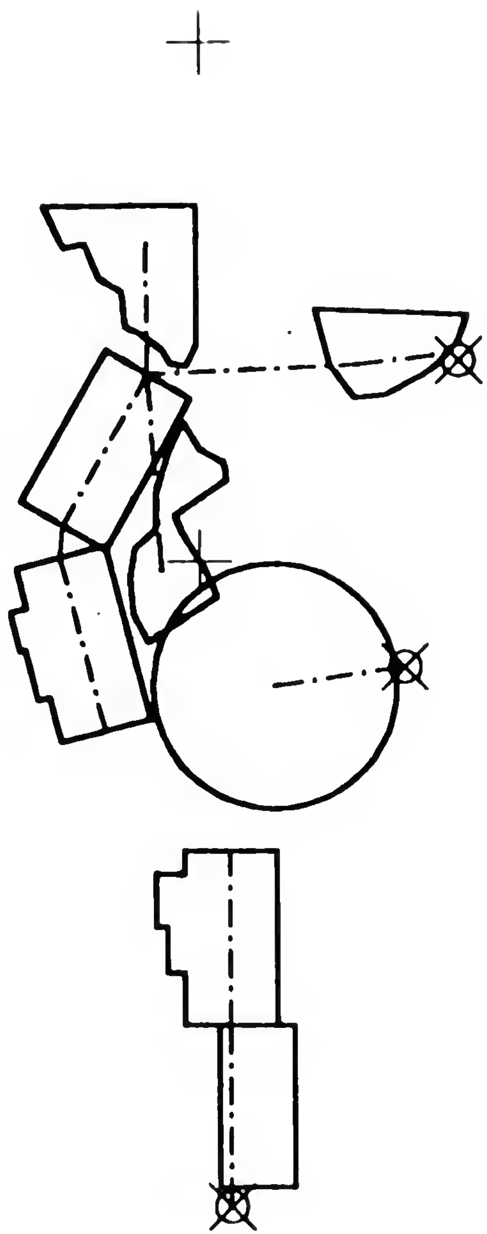
IRRIGATION COSTS TABLE

ITEM	COST/ UNIT	# OF ITEMS	UNITS	T. COST $1	% O&M	O&M	LIFE	ECON ANN-COST TOTAL	FINAN. ANN-COST TOTAL
Flood					10.0%		20		
Line				$8,354	1.5%	$125	10	$1,186	$1,485
Pivot				$49,877	3.0%	$1,496	20	$5,364	$9,614
Other					1.5%		10		
Other			unit		5.0%		10		
ON-FARM TOTALS				$58,231		$1,622		$6,550	$11,098
Pump		75	hp	$10,605	2.5%	$265	30	$924	$1,991
Engine			hp		5.5%		16		
Diversion	$2,000	3.1	cfs	$6,244	1.0%	$62	30	$450	$1,079
Pump controls		10%p.	cost	$1,061	1.0%	$11	20	$93	$183
Pipe	$31,719	110%		$34,891	0.5%	$174	50	$1,969	$5,853
Ditches		110%			5.0%		20		
Storage			ac-ft		1.0%		50		
LAND CLEARING	$200	89	unit	$17,750	2.0%	$355	50	$1,268	$3,244
SYSTEM TOTALS				$70,551		$868		$4,704	$12,350
Power dev.	$12,500	3.0	miles	$28,500			50	$1,466	$4,638
Engineering		15%S.	total	$10,583			50	$544	$1,722
Contingency		10%S.	total	$7,055			50	$363	$1,148
TOTAL				$174,920		$2,489		$13,627	$30,957

TOTAL ANNUAL COSTS	ECONOMIC TOTAL	ECONOMIC /AC	ECONOMIC /AC-FT	FINANCIAL TOTAL	FINANCIAL /AC	FINANCIAL /AC-FT
LABOR	$900	$5.07	$1.99			
ENERGY	$4,642	$26 15	$10.27			
EQUIPMENT	$13,627	$76.77	$30.15	$30,957	$174.40	$68.49
TOTAL annual costs	$19,168	$107 99	$42.41	$36,498	$205.63	$80.75

Feasibility rating (chance that revenues exceed costs)

NCR-26 97 percentile N. Cheyenne Res.



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Twn: T2S
Rng: R44E
Sec: 10

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NCR

SOURCE: TONGUE R. — BG
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Twn: T2S
Rng: R44E
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NCR

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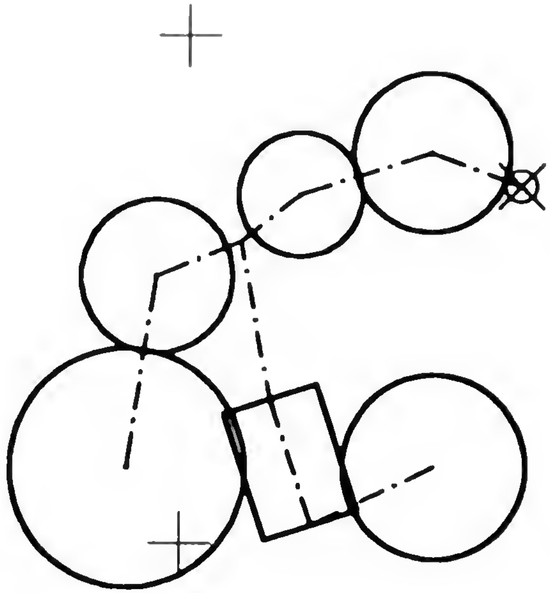
TOPO: ASHLAND NE
Twn: T2S
Rng: R44E
Sec: 22



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Rng: R44E
Sec: 27

BG

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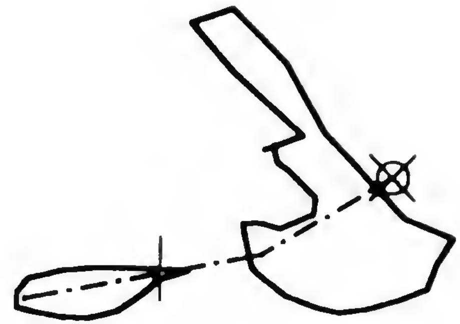
Twn: T2S
Rng: R44E
Sec: 22

BG



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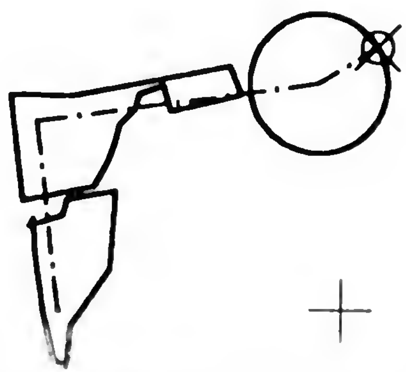
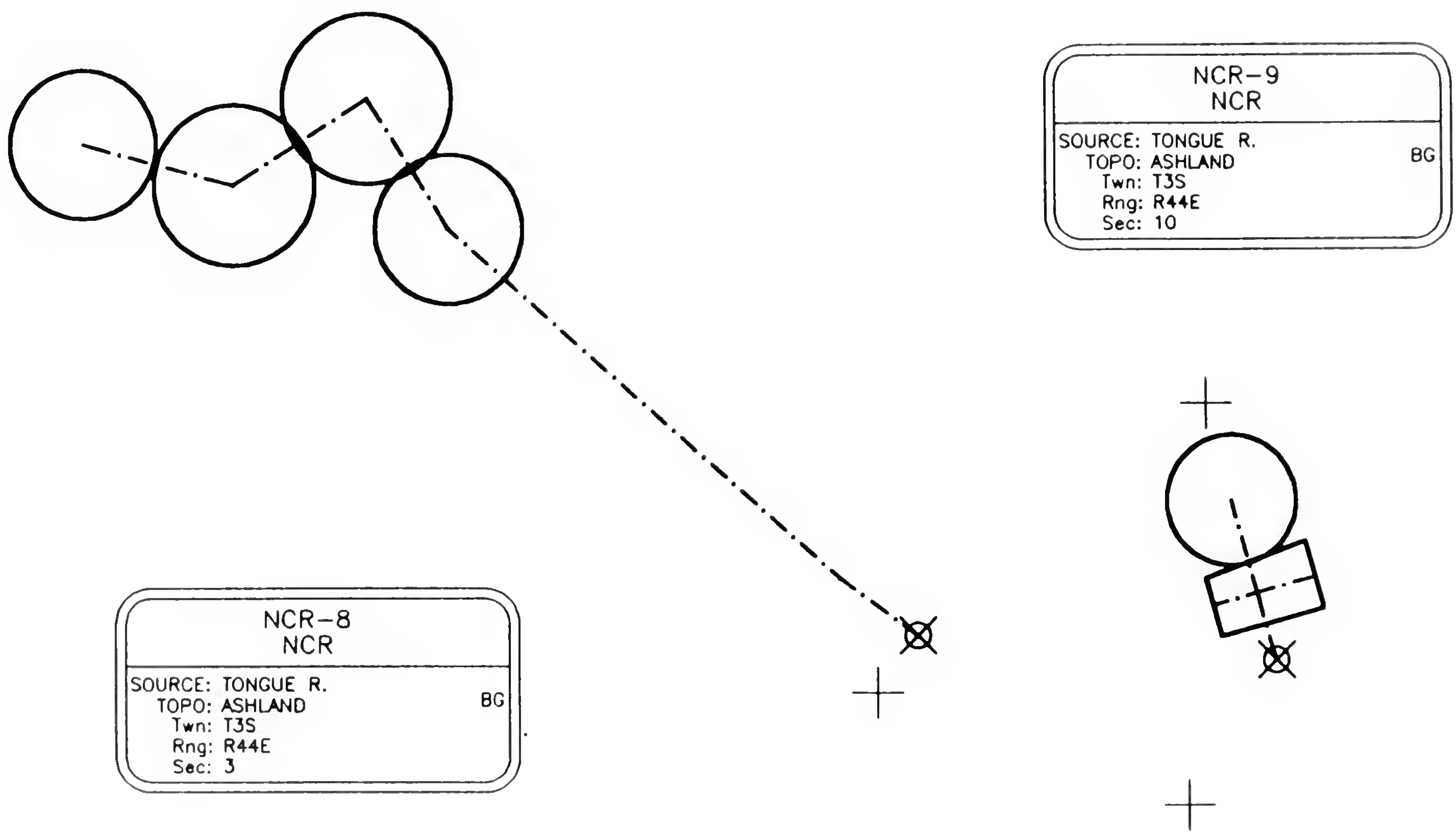
Sec: 35

BG

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Sec: 3
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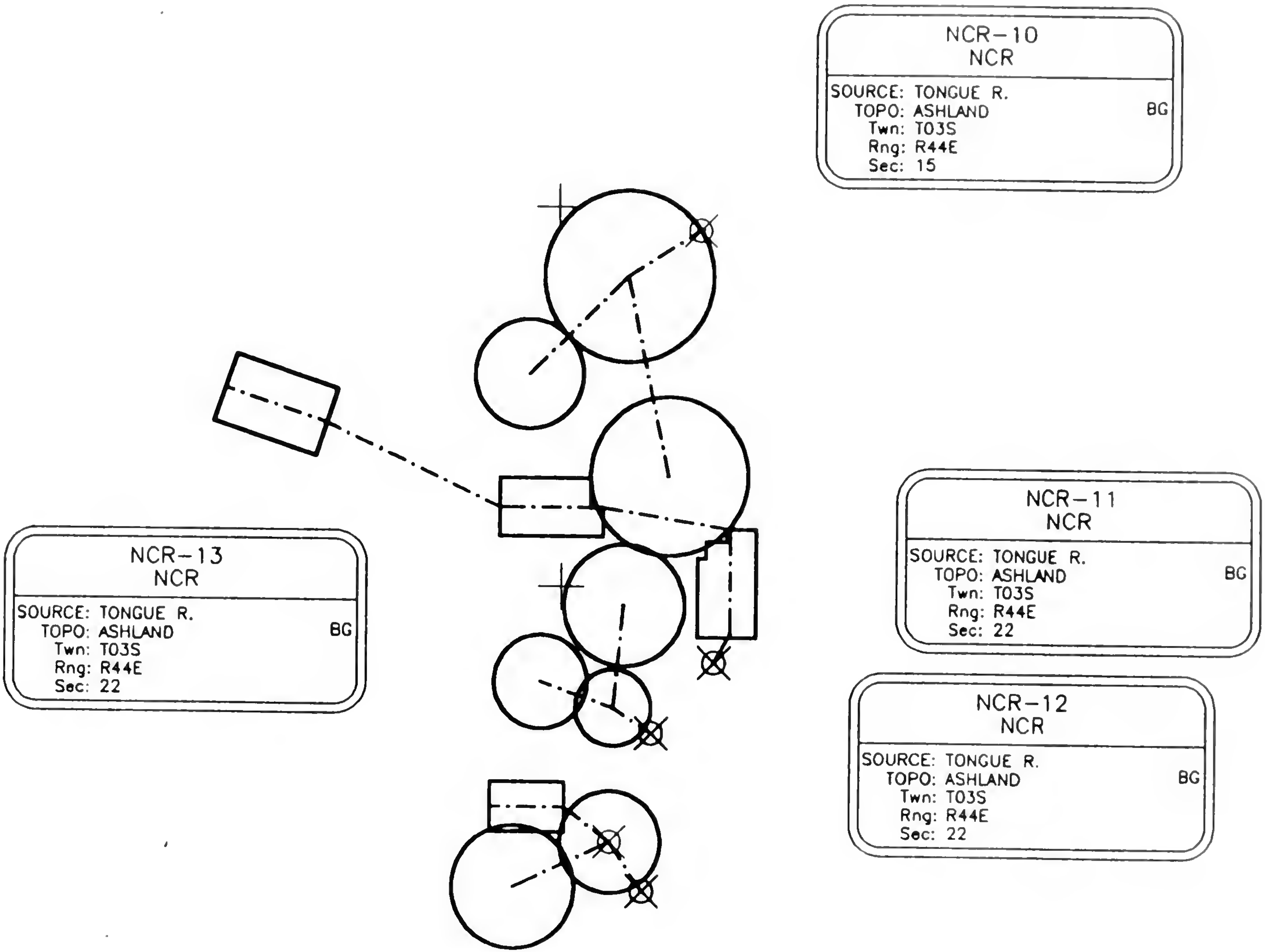
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Twn: T03S
Rng: R44E
Sec: 22
BG
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TOPO: ASHLAND
Twn: T03S
Rng: R44E
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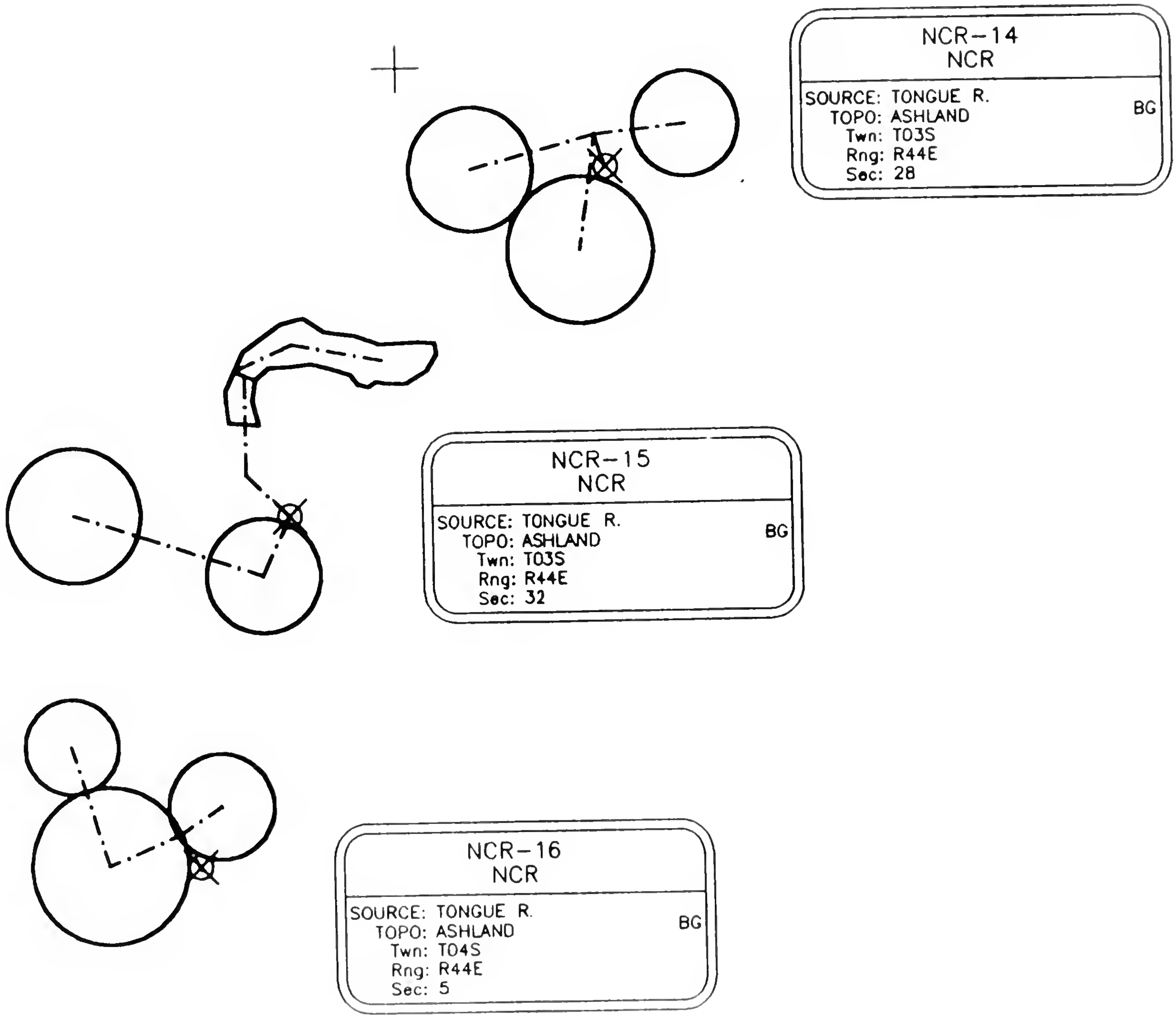
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Rng: R44E
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Sec: 5
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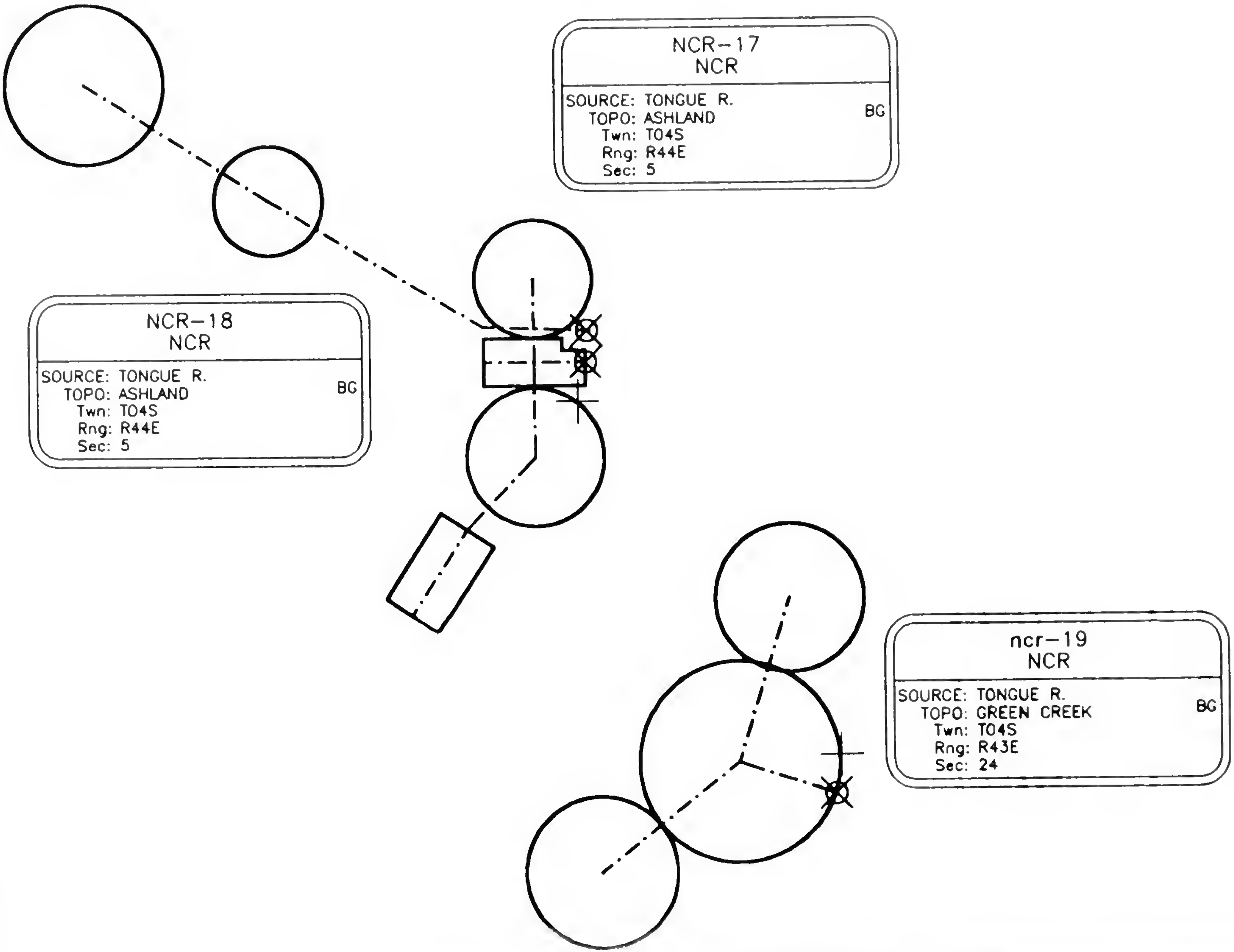
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Rng: R44E
Sec: 5
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SOURCE: TONGUE R.
TOPO: ASHLAND
Twn: T04S
Rng: R44E
Sec: 5
BG
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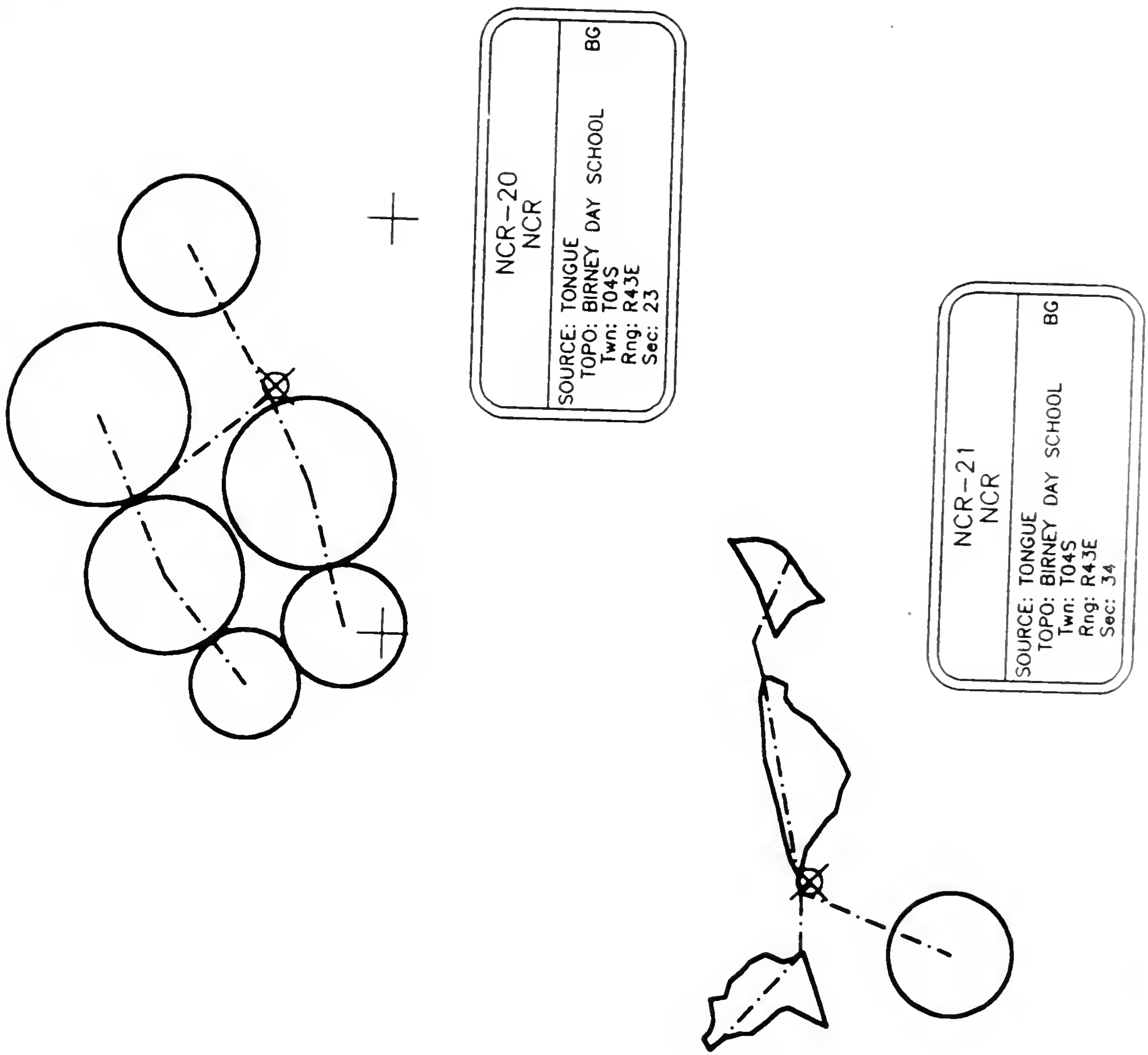
TOPO: GREEN CREEK
Twn: T04S
Rng: R43E
Sec: 24
BG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Twn: T04S
Rng: R43E
Sec: 23
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Twn: T04S
Rng: R43E
Sec: 34
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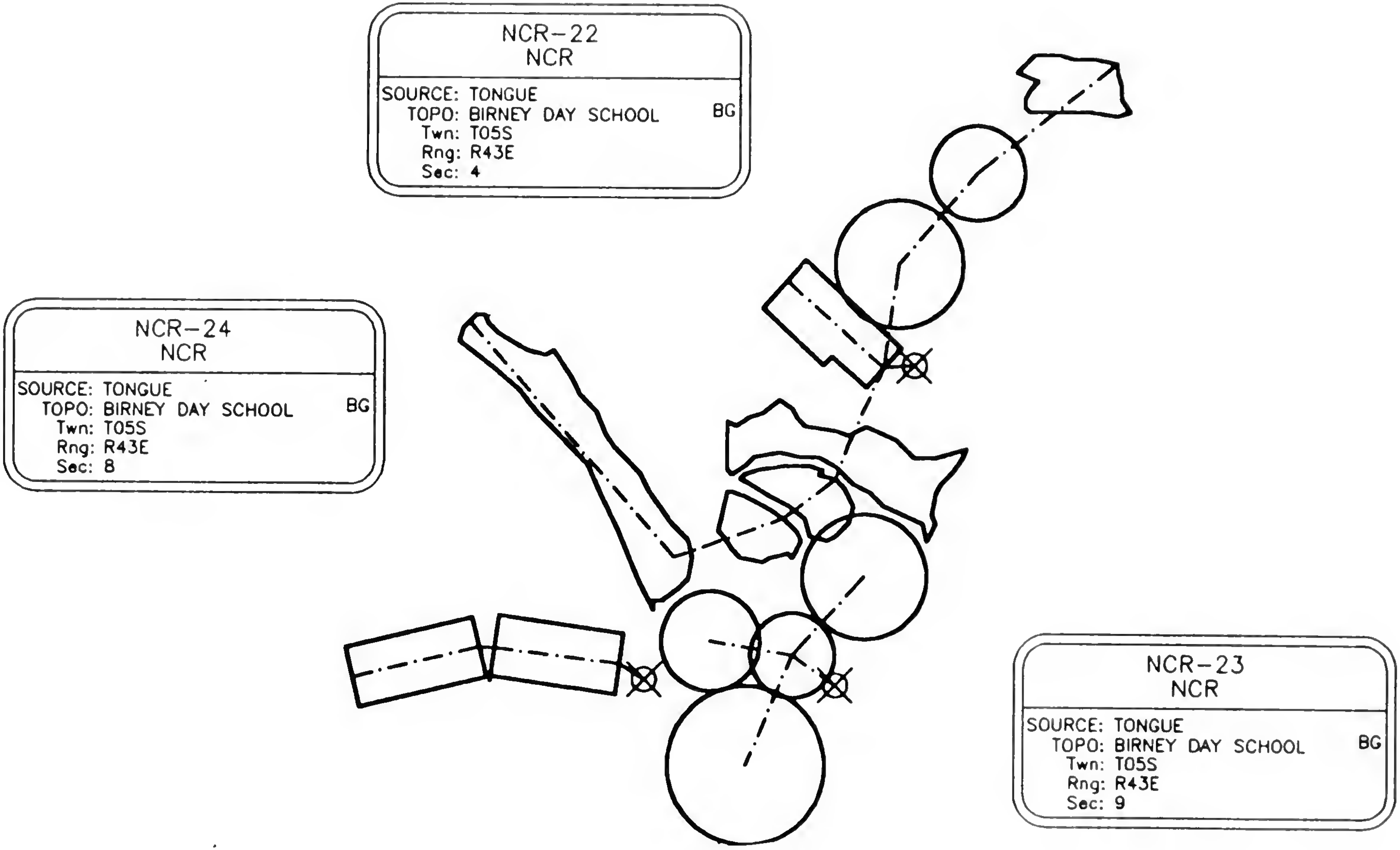
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Rng: R43E
Sec: 4
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SOURCE: TONGUE
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BG
Twn: T05S
Rng: R43E
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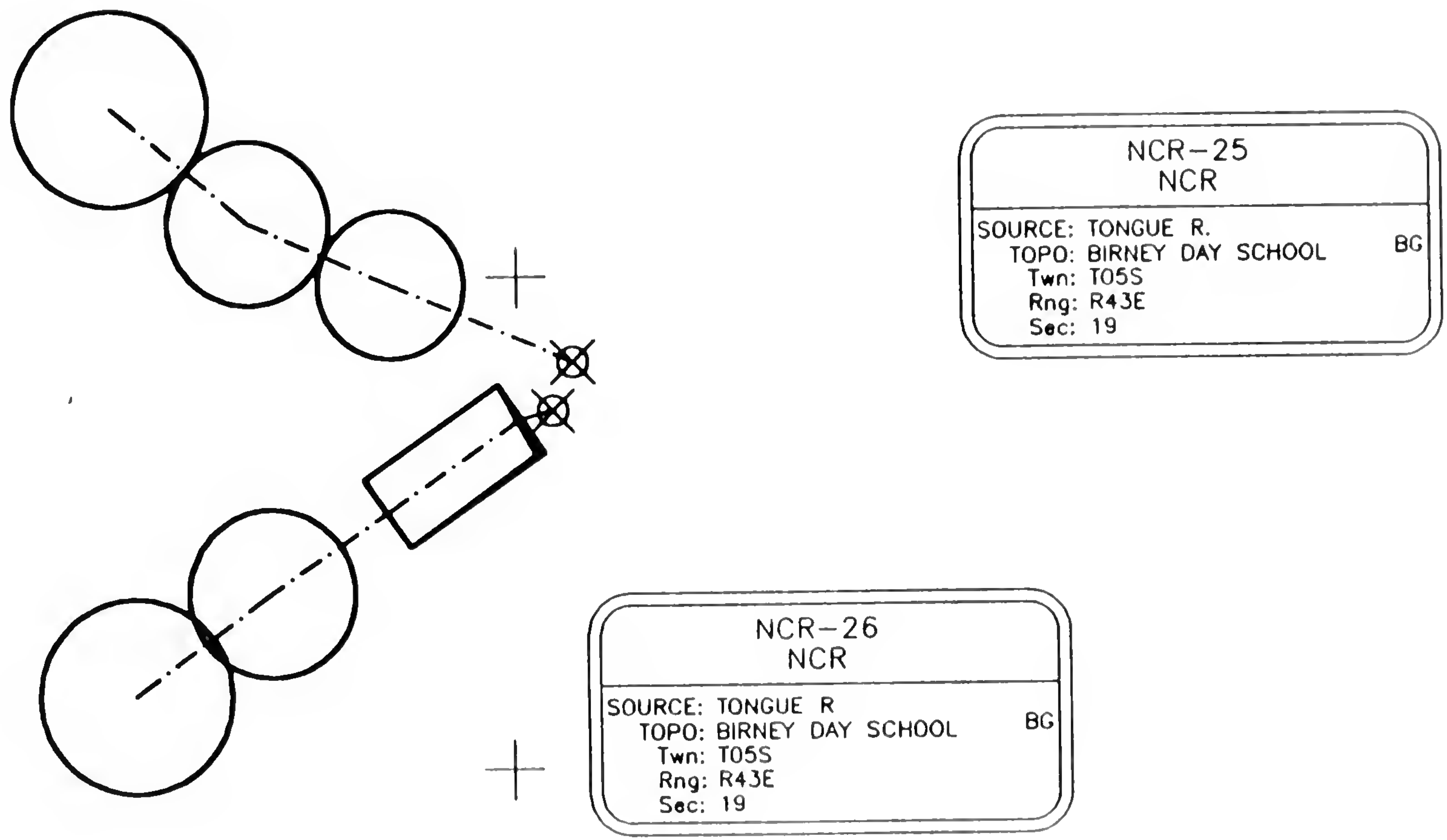
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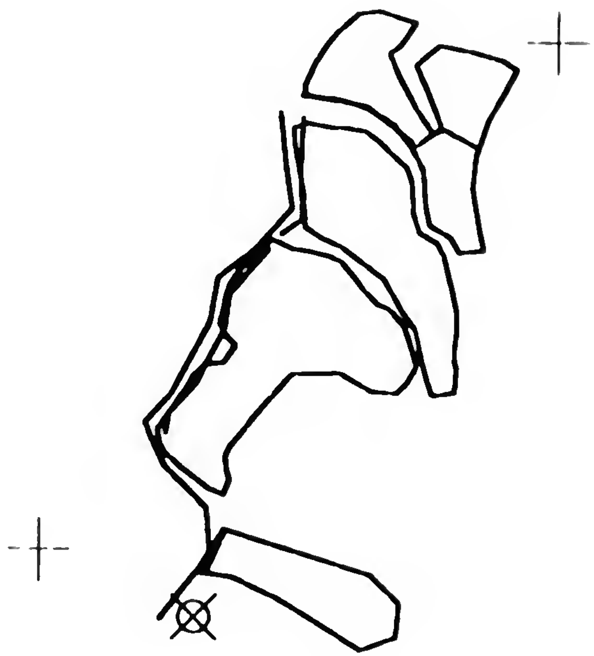

NCR-27
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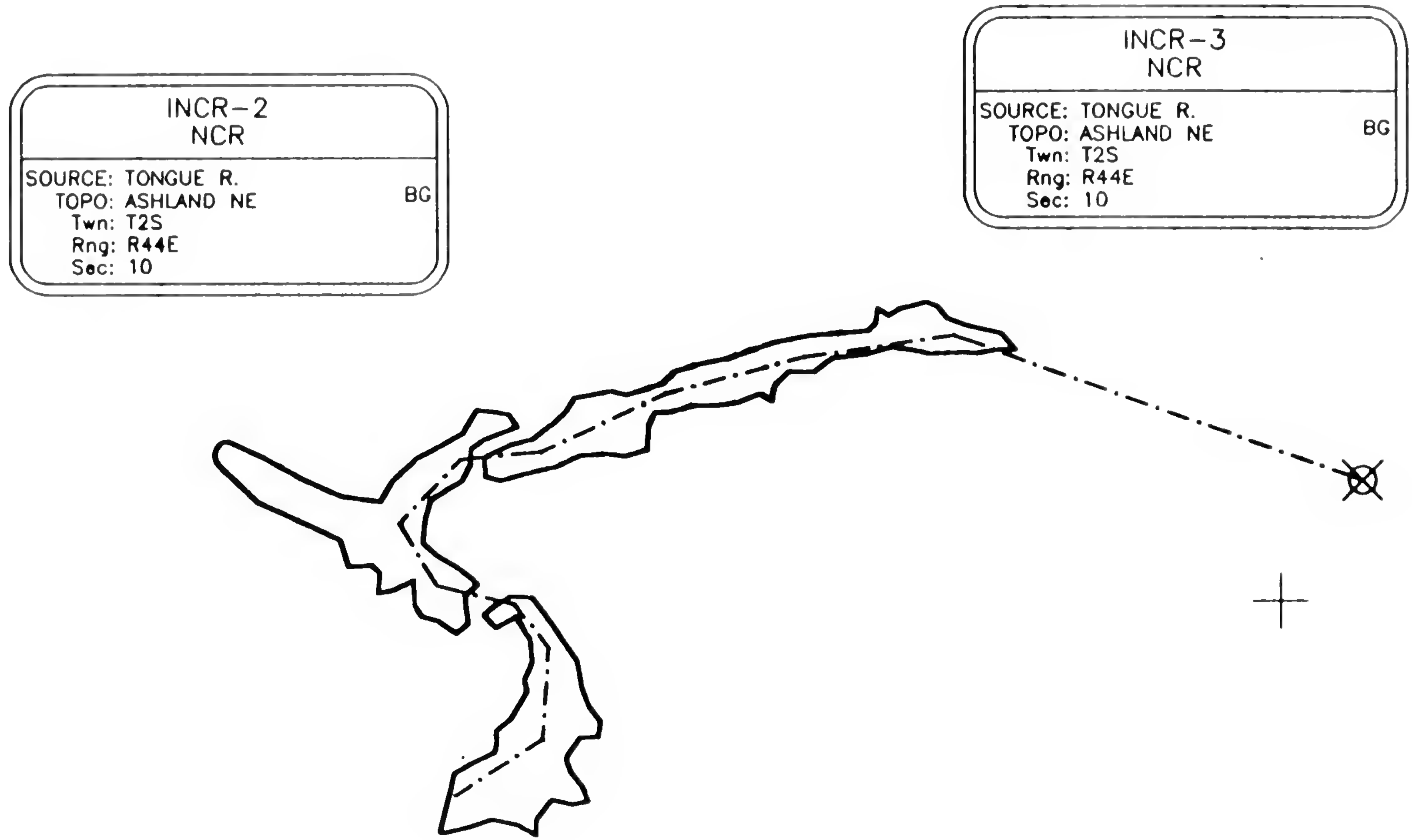
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Rng: R44E
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Sec: 10
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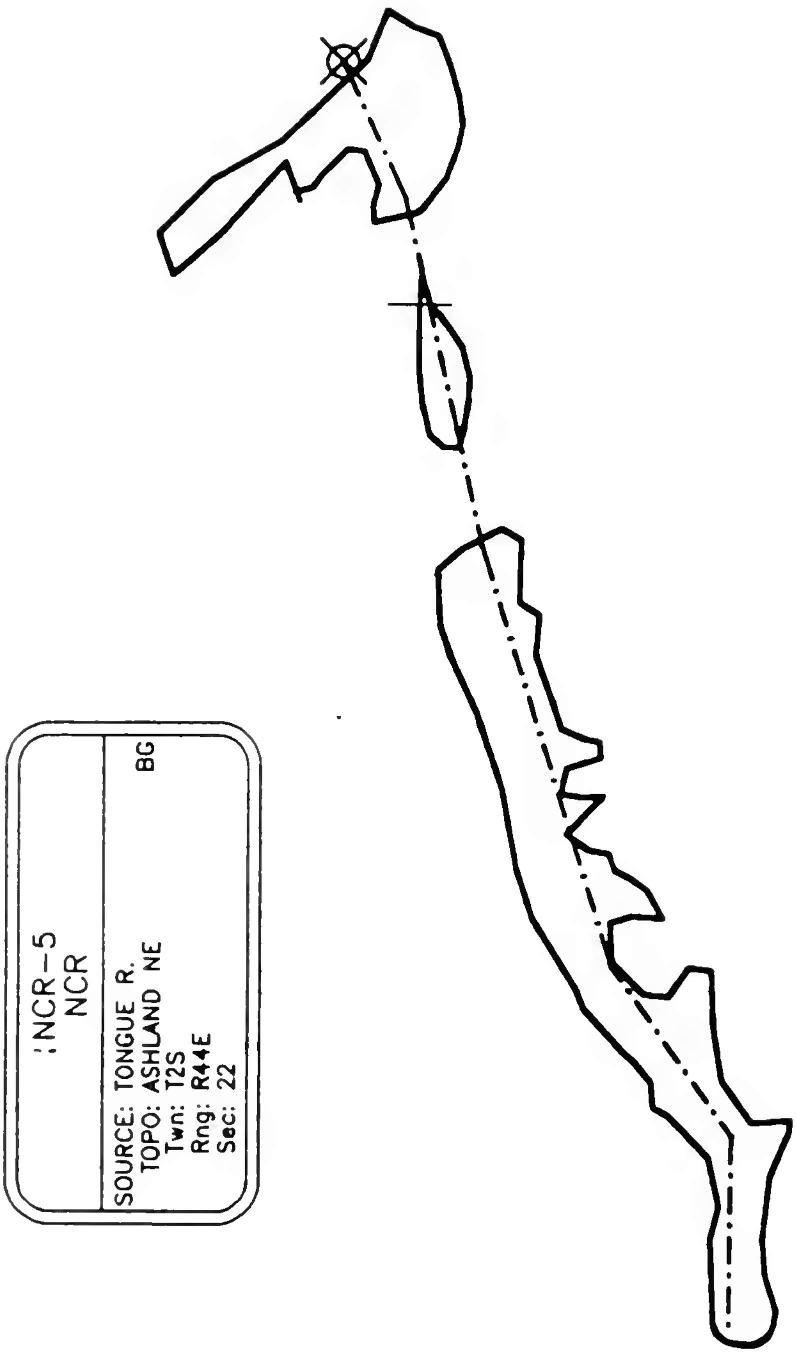
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