WILLISTON TIE PROJECT

Basin Electric Power Cooperative

Application to the North Dakota Public Service Commission for a Waiver of Procedures and Timelines, and Consolidated Certificate of Corridor Compatibility and Route Permit

PU-11-692

January 2012

BASIN ELECTRIC POWER COOPERATIVE

A Touchstone Energy® Cooperative

Williston Tie Project

Application to the North Dakota Public Service Commission for a Waiver of Procedures and Timelines, and Consolidated Certificate of Corridor Compatibility and Route Permit

Williams County, North Dakota

PU-11-692

Prepared For:

Basin Electric Power Cooperative
1717 East Interstate Avenue
Bismarck, ND

Prepared By:

HDR Engineering, Inc.

701 Xenia Avenue South

Suite 600

Minneapolis, MN 55416

Contents

Tables

Exhibits

Figures

Appendices

1 Introduction

Basin Electric Power Cooperative (Basin Electric) is a regional wholesale electric and transmission cooperative owned and controlled by its member cooperatives. Basin Electric includes 135 rural electric systems operated by member cooperatives and is one of the largest electric generation and transmission cooperatives in the U.S. Basin Electric serves approximately 2.8 million customers in 540,000 square miles covering portions of nine states: Colorado, Iowa, Minnesota, Montana, Nebraska, New Mexico, North Dakota, South Dakota, and Wyoming.

Basin Electric submits this Application for Waiver of Procedures and Timelines, and Consolidated Certificate of Corridor Compatibility (Corridor Certificate) and Route Permit for the Williston Tie Project (PU-11-692). The Williston Tie Project (Project) is an approximately 3.7 mile portion of the larger approximately 200 mile Antelope Valley Station to Neset 345-kV Transmission Project (PU-11-696) that Basin Electric is currently developing. The Williston Tie Project is located in Williams County North Dakota.

The Project proposes to string and energize approximately 2.1 miles of 230-kV and approximately 1.6 miles of 345-kV overhead electrical transmission line. The majority of the Williston Tie Project will be designed, constructed, and operated as a double circuit configuration. The 230-kV and 345-kV transmission lines will double circuit with a Mountrail Williams Electric Cooperative (MWEC) 115 kV transmission line (Figure 1.1). MWEC is a Class C member of Basin Electric. The MWEC 115-kV transmission line will be constructed and energized in the summer of 2012. The construction of the 115-kV structures will at a minimum include the davit arms for Basin Electric 230-kV and 345-kV transmission lines. MWEC will construct, own, and operate the Judson 115-kV distribution substation located adjacent to Basin Electric's proposed Judson 345-kV substation. Basin Electric's 230 and 345-kV transmission lines may be strung at the time MWEC constructs their 115-kV system. However the 230 and 345-kV lines will not be energized until all permits and approvals are obtained for the larger approximately 200-mile Antelope Valley Station to Neset 345-kV Transmission Project. The Project will consist of three transmission line segments connected to the future Basin Electric Judson 345-kV Substation. The Judson 345 kV Substation is not a part of this permit application and will be included in the North Dakota Public Service Commission (PSC) permit application for the larger 200 mile Antelope Valley Station to Neset 345-kV Transmission Project.

The three transmission line segments are described as follows (Figure 1.2):

Line segment A of the project is a 345/115 kV double circuit transmission line traveling south for approximately 1.62 miles from a 345/115 kV transmission line structure located in T154N, R102W Section 15 to the future Judson 345- kV Substation, which is not part of this project.

Transmission line segment B is a 230/115 kV double circuit transmission line which is approximately 1.9 miles in length and will travel east from the Judson 345-kV Substation to a 230/115 kV structure located in T154N, R102W, Section 24.

At the point where the 115-kV separates from the 230- kV, a single circuit, single pole transmission line will turn north and travel approximately 0.16 miles and finally turning eastward and traveling 0.04 miles interconnecting to Western Area Power Administration's Williston Substation (Segment C). The North Dakota Energy Conversion and Transmission Facility Siting Act requires an application for a Corridor Certificate and a Route Permit to meet the criteria set forth in North Dakota Century Code (NDCC) 49-22.

The siting of a transmission facility is to be made in an orderly manner compatible with environmental preservation and the efficient use of resources (NDCC 49-22-02).

To the extent available, Basin Electric has presented information required by the North Dakota Energy Conversion and Transmission Facility Siting Act. Basin Electric has considered exclusion areas, avoidance areas, the selection criteria, and the policy criteria in the design of the Route. In addition, sufficient transmission line design and technical information has been provided for a thorough evaluation of the reasonableness of the Corridor /Route studied. Basin Electric's policy is to locate and design the proposed transmission line by minimizing environmental impacts and utilizing existing corridors.

Table 1.2-1 and Table 1.3-1 outline the information required to fulfill the requirements for a Corridor Certificate and Route Permit with the PSC using the PSC Guidelines and identifying where these requirements are addressed in this document.

1.1 Provisions Requested to be Waived and Minimal Adverse Effect

Basin Electric submits this Application for a Waiver of Procedures and Time Schedules and consolidated applications for a Corridor Certificate and Route Permit (collectively, Application). By this Application, Basin Electric requests that the PSC, pursuant to NDCC Section 49-22-07.2, waive the following requirements:

1. That the PSC hold a single consolidated hearing on this waiver request for a Certificate of Corridor Compatibility and Route Permit, rather than separate hearings as may be required by NDCC Sections 49-22-08 & -08.1, 49-22-13, and North Dakota Administrative Code (NDAC) Section 69-06-01-02. Basin Electric also requests that the PSC shorten the three-month period specified in NDCC Section 49-22-08(5) and the six-month period specified in NDCC Section 49-22-08.1(5).
2. That the PSC waive the requirements of NDCC Section 49-22-08 and NDCC Section 49-22-08.1 insofar as these sections may require the separate filing of applications for a Corridor Certificate and a Route Permit, and insofar as they require the publication of notices of filing applications.
3. That the PSC waive the requirements from NDCC 69-06-04-02, which states that the width of the Corridor must be 10 percent of the length of the line, not less than 1 mile, and not more than 6 miles in width.
4. That the PSC waive requirements for Mylar maps and stereo-pair aerial photographs as set forth in the PSC's Application Guidelines for a Corridor Certificate and a Route Permit. Geographic Information System (GIS) developed maps are provided in the Application.

The PSC's Application Guidelines for Waiver of Procedures and Time Schedules require a facility description, need for, cost of, and justification for the request for waiver, together with evidence that the project will produce minimal adverse effects. As demonstrated in the Application, and as summarized below, Basin Electric's Waiver Request and the issuance of a Corridor Certificate and Route Permit is justified, as the proposed facility is of such design, location, and purpose that it will produce minimal adverse effects.

1.1.1 Description of Project

1.1.1.1 Type

Basin Electric is proposing a 3.7 mile transmission project. The project consists of 0.2 miles of single circuit 230-kV, 2.1 miles of 230-kV double circuit and 1.62 miles of 345-kV double circuit transmission line build out. Figure 1.2 shows the location of the potential 230-kV single circuit, the 230/115-kV double circuit and the 345/115-kV double circuit transmission lines.

1.1.1.2 Product

Electrical energy will be transported over the proposed transmission line to the electrical grid system serving the rapidly increasing electrical load requirements in northwestern North Dakota. In addition to voltage level improvements, the Project will also improve the reliability of service into the area.

1.1.1.3 Size and Design

The structures would be placed approximately 800 feet apart (with a maximum span of 1,020 feet). The height of the new structures would vary from 70 to 145 feet above ground, depending on terrain and structure type.

1.1.1.4 Location

The Williston Tie Project is located in Williams County North Dakota.

1.1.1.5 Geographical Service Area

The general area to be served by the transmission line is an area in northwestern North Dakota. The increased reliability provided by the line will serve all northwestern North Dakota.

1.1.1.6 Time Schedule

The in-service date is dependent upon permitting approvals and construction:

- Project construction is expected to begin in the spring of 2012 subject to road restrictions and weather. Total construction of the project will take approximately 3 months.
- MWEC will perform system testing of the 115-kV segment in the fall of 2012.The expected in-service date of MWEC's 115-kV is anticipated to be fall of 2012.
- The 230-kV and 345-kV portion of the project is anticipated to be interconnected and energized with Western's Williston Substation in late 2015 or early 2016.

1.1.1.7 Future Plans

Basin Electric is currently in the Environmental Review process for the larger Antelope Valley to Neset 345-kV Transmission Project. The remaining portion of the approximately 200 mile 345-kV project including the Judson 345-kV Substation will be addressed in a separate Siting Application (PU-11-696).

1.2 Need for Facility

Basin Electric has identified the need for additional electric transmission capacity in northwestern North Dakota as a result of increased demand and to meet reliability and system stability requirements for the region. Investigations and analyses conducted for the overall power delivery systems found that without improvements, the flow of power along existing lines may result in local line overloads, especially in the vicinity of Williston, North Dakota.

Load Forecast

The demand for electricity creates a stress on existing generation and transmission facilities. The August 2011 Basin Electric load forecast indicates an acceleration of growth in the northwestern North Dakota area that is mainly a result of the development related to the Bakken oil field. Much of the short-term load growth in this area is associated with provision of electrical service to support the rapid expansion of the number of facilities for oil and natural gas production as well as the supporting infrastructure and services. This relatively rapid upswing in development activity in recent years is due to new exploration and extraction technology and the potential for oil recovery from the Bakken Formation.

The Bakken Formation is a thin, widespread geologic formation consisting of oil-generating shale and sandstone layers that extends through portions of Montana, North Dakota, and the Canadian Provinces of Saskatchewan and Manitoba (USGS, 2008). While there are 17 oil-producing counties in North Dakota, all of which are located in the western third of the state, the top-producing counties in 2010 included Mountrail, McKenzie, Dunn, and Williams in northwestern North Dakota (NDPC, 2011). Oil production in North Dakota increased from 62.8 million barrels of oil in 2008 to 79.7 million barrels in 2009 (27% increase) and 113 million barrels in 2010 (40% increase) (NDPC, 2011). Production is expected to continue to increase with an estimated 1,100 to 2,700 new wells per year in western North Dakota and 26,000 new wells over the next 10 to 20 years (NDDMR, 2011).

Infrastructure development related to the expanding oil and gas industry activity in the region includes pipelines, rail, natural gas plants, homes, businesses, roads, and transmission/distribution line development. Pipeline infrastructure is being developed to transport crude oil out of the Bakken to refinery and marketing hubs, such as the U.S. Gulf Coast, as well as to transport natural gas, fracking water, and salt water. Crude oil is being transported by rail out of the Bakken oil field, and expansion of rail infrastructure and associated loading and unloading facilities is under development. Natural gas plants are expanding to process natural gas for consumer use. Local transmission lines for distribution have recently been constructed or are in development in western North Dakota to support the expanding drilling activity and supporting infrastructure.

In the Williston/Tioga region, the preliminary load forecast for northwestern North Dakota is noted in Table 1.2-1. It is projected that the load is increasing in the regions adjacent to Williston/Tioga in a similar manner.

Table 1.2-1.
Load Forecast for Transmission Lines in the Williston/Tioga Region

Year	Load (MW*)	Increase
2011	280	--
2012	390	39
2013	454	16
2014	481	6
2015	509	6
2016	538	6

**MW = mega watts*

An analysis of transmission line capacity indicates by the year 2016 the load will have increased beyond the load serving capacity of the existing system for the Williston/Tioga region and a new transmission line is required to provide additional capacity. The closest strong transmission system support is associated with the electrical power generation at the Antelope Valley Station, located near Beulah. This system is operated at 345-kV and extends west, south and east from Beulah. A new 345-kV transmission line from the Beulah area to the northwest that connects directly to the 230-kV system in the Williston/Tioga area would provide an increase in the load serving capacity to accommodate the projected load growth and maintain acceptable reliability of the regional transmission system. If this new 345-kV transmission line is not added, then the load growth will be capped at the projected 2015 load level and no new load growth could be accommodated. This would limit the future potential development activities in the Bakken oil field and any other load requirements in this service region.

Reliability Issues

The existing high voltage system in the Williston/Tioga region consists of 230-kV and 115-kV systems that connect to: Saskatchewan, Canada; eastern Montana; central North Dakota; and western North Dakota. Outage of any of these paths could cause low voltage criteria violations and overload adjacent transmission lines in the Williston/Tioga region.

Cost

The cost of construction for the 345/115-kV and 230/115-kV lines is estimated to be approximately four million dollars ($4,000,000). This cost estimate is for the 345-kV and 230-kV line, conductors and pole structures. The cost to procure and install the 115/25-kV portion of the project has been omitted from this cost estimate as it is outside of the Commission's siting jurisdiction.

1.2.1 Alternatives

The corridor/route was selected using the Commission's criteria in addition to other constraints such as engineering, cost, and landowner participation. The location of avoidance and exclusion areas was considered to develop the corridor/route. Section 2 discusses the corridor/route criteria evaluated in determing the final route.

Basin Electric focused on providing reliable power to support the rapid growth experienced due to the growing oil and gas industry in the area.

1.2.2 Ten-Year Plan

Basin Electric filed a Ten-Year Plan with the Commission on June 28, 2011. This Project is consistent with the Ten-Year Plan on file with the Commission.

1.2.2.1 Waiver Request

Waivers of timelines and procedures are needed in order to prevent potentially significant delays in this project. As set forth in Section 1.6 of the Application, The 115-kV project needs to be constructed and energized by the summer 2012 to ensure reliable power is being provided to the MWEC members. Basin Electric worked with MWEC to double circuit in an effort to minimize creating additional transmission line corridors in the area. Double circuiting the MWEC 115-kV transmission line with the Basin Electric 230-kV and 345-kV transmission lines is anticipated to produce minimal adverse effects. Section 49-22-07.2 of the Act provides that the PSC may waive procedures and time schedules upon a finding that "the proposed

facility is of such length, design, location, or purpose that it will produce minimal adverse effects." Based upon the thorough investigation and analysis set forth in the Application, waivers are appropriate because the proposed facility will produce minimal adverse effects.

In determining whether the proposed facility will result in adverse impacts on the environment, Basin Electric evaluated the transmission line using the criteria set forth in the Act, the Rules, and the PSC's Guidelines for Energy Conversion and Transmission Facility Siting (Guidelines). Basin Electric evaluated the impacts of the transmission line considering the siting criteria laid out in NDAC 69-06-08 (Section 2.0 of the Application) and the factors to be considered in NDCC Section 49-22-09 (Section 7.0 of the Application). Impacts associated with the transmission line are summarized in Section 4.18 of the Application. Based upon this evaluation and the factors set forth in the Energy Conversion and Transmission Facility Siting Act and PSC Guidelines, it is clear that the proposed facility will produce minimal adverse effects.

State and Federal agencies were consulted to provide input on potential impacts of the proposed Corridor and Route and, in general, concluded that the proposed facility would produce minimal adverse effects. Their findings are summarized in Section 4.0 of the Application.

Also, Basin Electric's proposal takes into consideration all state and Federal agency concerns and thereby further mitigates any adverse effects associated with the proposed facilities. The designated state agencies and officers listed in NDAC 69-06-01-05 were notified about the proposed project in June 2011, through a public notice prepared by Western regarding the MWEC 115 kV transmission line project. The public notice included the approximately 3.7 miles of transmission line as described in this application.

Basin Electric submits and believes the evidence demonstrates that it has taken all feasible and prudent actions to minimize and mitigate to the greatest extent possible all known or potential adverse impacts. In addition, Basin Electric believes that environmental impact will be further minimized by double circuiting MWEC's 115-kV. As a result, the proposed facilities will produce minimal adverse effects. Accordingly, Basin Electric respectfully requests that the PSC grant the requested waivers and render an expeditious decision.

1.3 Certificate of Corridor Compatibility

Table 1.3-1 outlines the information required in the North Dakota Century Code Title 49, Chapter 22, Section 08- 09: Energy Conversion and Transmission Facility Siting Act.

Table 1.3-1.
Corridor Certificate Completion Checklist

State Authority	Description	Section
Chapter 49-22-08	**PSC Guidelines:** **Energy Conversion and Transmission Facility Siting**	
Section A	**Description**	1.0
1.	Type: Describe the type of transmission facility addressed in this application. The description shall include the purpose of the facility and the technology to be employed	1.1.1
2.	Product: Describe the type, source, and final destination of the product to be transmitted by the proposed facility.	
3.	Size and Design:	1.1.1.3

State Authority	Description	Section
a.	Provide a description of the size and design of the ELECTRICAL facility including, but not limited to, the following:	Table 2.5-1
1.	Width of right of way;	
2.	Estimated span lengths;	
3.	Anticipated type of structure;	Exhibit 2.5-1 through Exhibit 2.5-3
4.	Approximate length of facility;	
5.	Voltage; and	
6.	The requirement for a general location of any new associated facilities.	1.1.1
b.	Provide a description of the size and design of the pipeline facility including, but not limited to, the following:	N/A
4.	Time Schedule: Provide the anticipated time schedule for the accomplishment of the following events:	1.6
a.	Certificate of Corridor Compatibility;	
b.	Route Application;	
c.	Route Permit;	
d.	Construction start date;	
e.	Construction complete; and	
f.	In-service date.	
Section B	**Studies**	Appendix A
Section C	**Need for Facility**	
1.	An analysis of the need for the proposed facility based on present and projected demand for the product to be transmitted by the facility, including the most recent system studies supporting the analysis of the need.	1.2
2.	A description of any feasible alternative methods of serving the need.	1.2.1
3.	A statement justifying any deviations from the most recent Ten-Year Plan which the proposed facility may present.	1.2.2
Section D	**Location**	
1.	Select a study area, which includes the proposed corridor, of sufficient width to enable the PSC to evaluate the factors addressed in Section 49-22-09, NDCC.	Figure 1.2, 1.5.2
2.	Identify and map the criteria that led to the proposed corridor location within the study area.	Figure 4.1, 4.5, & 2.0
3.	Discuss the relative value of each criteria and how the proposed corridor location was selected giving consideration to all criteria.	2.0
4.	The criteria to be evaluated shall include at a minimum all of the following which are within the study area:	
a.	Exclusion areas;	2.1
b.	Avoidance areas;	2.2
c.	Selection criteria;	2.3
d.	Policy criteria;	2.4
e.	Design and construction limitations; and	2.5, Exhibit 2.5-1 through Exhibit 2.5-3

State Authority	Description	Section
f.	Economic considerations.	2.6
5.	Discuss the general mitigative measures that will be taken to minimize adverse impacts which result from a route location in the proposed corridor.	4.2.3, 4.3.3, 4.4.3, 4.5.3, 4.6.3, 4.7.3, 4.8.3, 4.9.3, 4.10.3, 4.11.3, 4.12.3, 4.13.3, 4.14.3, 4.15.3, 4.16.3, 4.17.3, & Table 4.18-1.
6.	List the qualifications of the people in the various disciplines that contributed to the corridor location study	9.0
7.	Maps	Figures
a.	Map the criteria within the study area showing the proposed corridor. Several different criteria may be shown on each map, depending on the map scale and the density and nature of the criteria. Minimum map scale shall be ½ inch = 1 mile. All maps shall be at the same scale unless otherwise specified.	
b.	Furnish one set of Mylar maps, separate from the application, of the same scale as the criteria maps and showing the same basic features as the criteria maps, including the study area, but not the proposed facility location.	
Chapter 49-22-09	**Factors to be considered in evaluating applications and designation of sites, corridors, and routes.**	7.0
1.	Available research and investigations relating to the effects of the location, construction, and operation of the proposed facility on public health and welfare, natural resources, and the environment.	4.0, 7.1, & Appendix A
2.	The effects of new energy conversion and transmission technologies and systems designed to minimize adverse environmental effects.	7.2
3.	The potential for beneficial uses of waste energy from a proposed energy conversion facility	7.3
4.	Adverse direct and indirect environmental effects which cannot be avoided should the proposed site or route be designated.	7.4
5.	Alternatives to the proposed site, corridor, or route which are developed during the hearing process and which minimize adverse effects.	7.5
6.	Irreversible and irretrievable commitments of natural resources should the proposed site, corridor, or route be designated.	7.6
7.	The direct and indirect economic impacts of the proposed facility	7.7
8.	Existing plans of the state, local government, and private entities for other developments at or in the vicinity of the proposed site, corridor, or route.	7.8
9.	The effect of the proposed site or route on existing scenic areas, historic sites and structures, and paleontological or archaeological sites.	7.9
10.	The effect of the proposed site or route on areas which are unique because of biological wealth or because they are habitats for rare and endangered species	7.10
11.	Problems raised by federal agencies, other state agencies, and local entities	7.11

1.4 Route Permit Application

The table below outlines the information required in the PSC Guidelines dated November 1979 for a Route Permit. Information regarding easements for transmission lines per NDCC 49-22-08.1(f) is also included in the Application in Section 1.5.1.

Table 1.4-1.
Route Permit Completion Checklist

State Authority	Description	Section
Chapter 49-22-08	**PSC Guidelines:** **Energy Conversion and Transmission Facility Siting**	
Section A	**Description**	**1.0**
1.	Type: Describe the type of transmission facility proposed.	1.1.1
2.	Product: Describe the product or products to be transmitted.	
3.	Size and Design: Provide a general description of the proposed size and design, and any alternate size or design, which was considered. Provide one (1) copy of the design data report, separate from the application, for the proposed facility and any associated facilities.	1.1.1.3 &Table 2.5-1
4.	Time Schedule: Provide the anticipated time schedule for the accomplishment of major events including, at a minimum, the following:	1.6
a.	Route Permit;	
b.	Right-of-way acquisition complete;	
c.	Construction start date;	
d.	Construction complete;	
e.	Test operations; and	
f.	In-service date.	
Section B	**Studies**	
	Provide a copy of any evaluative studies or assessments of the environmental impact of the proposed facility submitted to any federal, regional, state, or local agency.	Appendix A
Section C	**Need for Facility**	
1.	An analysis of the need for the proposed facility based on present and projected demand for the product to be transmitted by the facility, including the most recent system studies supporting the analysis of the need.	1.2
2.	A description of any feasible alternative methods of serving the need.	1.2.1
3.	A statement justifying any deviations from the most recent Ten-Year Plan which the proposed facility may present.	1.2.2
Section D	**Location**	
1.	Discuss the utility's policies and commitments to limit the environmental impact of its facilities, including copies of board resolutions and management directives.	4.0
2.	Discuss the factors listed in Section 49-22-09, NDCC to aid the PSC's evaluation of the proposed route.	7.0

State Authority	Description	Section
3.	Identify and map the criteria that led to the proposed route location within the designated corridor.	Figures 4.1, 4.3, & 2.0
4.	Discuss in detail the relative value of each criteria and how the location, construction, and operation of the facility will affect each criteria.	2.0
5.	The criteria to be evaluated shall include at a minimum all of the following which are within the designated corridor:	
a.	Exclusion areas;	2.1
b.	Avoidance areas;	2.2
c.	Selection criteria;	2.3
d.	Policy criteria;	2.4
e.	Design and construction limitations; and	2.5 & Exhibit 2.5-1 through Exhibit 2.5-3
f.	Economic considerations.	2.6
6.	Discuss the mitigative measures that will be taken to minimize adverse impacts which result from the location, construction, and operation of the proposed facility.	4.2.3, 4.3.3, 4.4.3, 4.5.3, 4.6.3, 4.7.3, 4.8.3, 4.9.3, 4.10.3, 4.11.3, 4.12.3, 4.13.3, 4.14.3, 4.15.3, 4.16.3, 4.17.3, & Table 4.18-1.
7.	List the qualifications of the people in the various disciplines that contributed to the facility route location study.	9.0
8.	Maps	Figures
a.	Map the criteria within the designated corridor showing the proposed route and location of any new associated facilities. Several different criteria may be shown on each map, depending on the map scale and the density and nature of the criteria. Minimum map scale shall be ½ inch = 1 mile. All maps shall be at the same scale unless otherwise specified.	
b.	Furnish one (1) set of Mylar maps, separate from the application, of the same scale as the criteria maps and showing the same basic features as the criteria maps, including the designated corridor, but not the proposed route or location of any new associated facilities.	
c.	Furnish one (1) set of uncontrolled 9x9 inch stereo-pair aerial photographs, separate from the application, with acceptable resolution showing the designated corridor, proposed route and location of any new associated faculties, and Section, Township and Range numbers, at a scale of 1 inch = 2,000 feet, together with a flight map at a scale of ½ inch = 1 mile showing each flight line and the beginning and ending photo number of each flight line. Photo mosaic strip maps will also be acceptable. If the applicant can demonstrate that because of the limited size and scope of the project, aerial photographs would not be practical, this requirement may be waived.	
Chapter 49-22-09	**Factors to be considered in evaluating applications and designation of sites, corridors, and routes.**	**7.0**

State Authority	Description	Section
1.	Available research and investigations relating to the effects of the location, construction, and operation of the proposed facility on public health and welfare, natural resources, and the environment.	4.0, 7.1, & Appendix A
2.	The effects of new energy conversion and transmission technologies and systems designed to minimize adverse environmental effects.	7.2
3.	The potential for beneficial uses of waste energy from a proposed energy conversion facility	7.3
4.	Adverse direct and indirect environmental effects which cannot be avoided should the proposed site or route be designated.	7.4
5.	Alternatives to the proposed site, corridor, or route which are developed during the hearing process and which minimize adverse effects.	7.5
6.	Irreversible and irretrievable commitments of natural resources should the proposed site, corridor, or route be designated.	7.6
7.	The direct and indirect economic impacts of the proposed facility	7.7
8.	Existing plans of the state, local government, and private entities for other developments at or in the vicinity of the proposed site, corridor, or route.	7.8
9.	The effect of the proposed site or route on existing scenic areas, historic sites and structures, and paleontological or archaeological sites.	7.9
10.	The effect of the proposed site or route on areas which are unique because of biological wealth or because they are habitats for rare and endangered species	7.10
11.	Problems raised by federal agencies, other state agencies, and local entities	7.10

1.5 Project Summary

Basin Electric is proposing to construct approximately 3.7 miles of 230-kV, 230/115-kV and 345/115-kV transmission line. Segment A of the project will consist of a 345/115 kV double circuit transmission line approximately 1.6 miles in length. This portion of the project would travel south for approximately 1.6 miles from a 345/115 kV transmission line structure located in T154N, R102W Section 15 to the future Judson 345- kV Substation (which is not part of this project). Segment B of the project will consist of a 230/115 kV double circuit transmission line which is approximately 1.9 miles in length and will travel east to a 230/115 kV structure located in Section 24, T15N, R102W. Segment C of the project will separate from the 115 kV line and the 230 kV transmission line will turn north 0.16 miles and then travel approximately 0.04 miles to Western's Williston Substation.

Construction is expected to occur in the summer of 2012 for the placement of the double circuit structures. The stringing of the 230-kV and 345-kV circuits may occur during the construction phase of the 115-kV transmission line. The energization of the 230-kV and 345-kV segments will occur when all permits and approvals are received for the larger 200-mile Antelope Valley Station to Neset 345-kV Transmission line project that Basin Electric is currently developing.

1.5.1 Proposed Corridor/Route

The proposed Corridor/Route is centered on a 150 foot wide right-of-way for the 345/115-kV segment and 80 foot for the 230-kV segment and 100 foot for the 230/115-kV segment. The Corridor is located in Sections 19 of T154N, R101W and 14, 15, and 22-24 of T154N, R102W (Figure 1.2). The Corridor/Route chosen will require a waiver from NDCC 69-06-04-02, which states that the width of the Corridor/Route must be 10 percent of the length of the line, not less than 1 mile, and not more than 6 miles in width. The smaller corridor is proposed due to the short overall length of the project and nearly 100% of the land easements have been acquired prior to the application submittal and 100% is expected to be acquired prior to the administrative Public Hearing.

Several factors were taken into consideration to select the Corridor/Route. Section 2.0, Transmission Facility Corridor/Route Criteria, describes the selection criteria in further detail. The Corridor/Route was selected on the following basis:

- The Route is relatively direct minimizing costs of the transmission line facility and minimizing potential impacts to landowners and the environment.
- The Route utilizes the properties of landowners willing to provide options to purchase easements.
- Double-circuiting the transmission line with MWEC's 115-kV Transmission line will minimize environmental and social impacts in the project area.
- The potential for wetlands and other environmental impacts are minimized to the extent practicable.
- The Route will provide for potential future development of additional energy resources and not prohibit surrounding land utilization.
- The average span length of the new transmission line would be approximately 800 feet with a maximum of 1,020 feet. The criteria identified in Section 2.0 are the primary criteria in the decision-making for the location of the proposed Corridor/Route. In particular, landowner requests dictated the location of the line. Additionally, structure locations will be fine-tuned to more specifically avoid residences and commercial businesses to the extent practicable, as described within this document.

1.5.2 Product

The transmission line will provide increased load service capacity and system reliability in northwest North Dakota. The line is intended to carry 345-kV and 230-kV voltages.

1.6 Project Schedule

The in-service date is dependent upon permitting approvals and construction:

- Project construction is expected to begin in the spring of 2012 subject to road restrictions and weather. Total construction of the 230/345-kV portion of the project will take approximately 3 months.
- MWEC will perform system testing of the 115-kV segment in the fall of 2012. The expected in-service date of MWEC's 115-kV is anticipated to be fall of 2012.
- The 230-kV and 345-kV portion of the project is anticipated to be interconnected and energized with Western's Williston Substation in late 2015 or early 2016.

Construction on the Williston Tie Project may be undertaken in two phases with the first phase beginning as soon as all necessary approvals are obtained (May 2012). The first construction phase consists of MWEC's 115-kV transmission line and Basin Electric's 230- and 345-kV systems. However, the 230- and 345 kV line will not be energized until Basin Electric acquires all the permits and approvals for the approximately 200-mile long Antelope Valley Station to Neset 345-kV Transmission Line Project. It is anticipated that the first phase will be completed in the fall of 2012. The second phase of construction will likely start in 2014.

2 Transmission Facility Corridor/Route Criteria

The Project Corridor/Route selection included an inventory and suitability analysis of criteria listed in NDAC Section 69-06-08-02, including exclusion and avoidance area criteria; selection criteria that relate to minimizing potential land use and environmental impacts; policy criteria that relate to maximizing public benefits; and design and construction limitations. Basin Electric has also included economic considerations as part of the analysis.

None of the exclusion and avoidance criteria encompass greater than 50 percent of the Corridor/Route width. There are no exclusion areas within the Corridor/Route. The Corridor/Route is not expected to cause adverse effects to avoidance or selection criteria. The project will incorporate many of the benefits outlined in the policy criteria.

2.1 Exclusion Areas

Per NDAC Section 69-06-08-02, the following geographical areas (Table 2.1-1) shall not encompass more than fifty percent of the Corridor width unless there is no reasonable alternative. NDAC Section 69-06-08-02-1 states that exclusion areas shall be excluded in the consideration of a route for a transmission facility. A buffer zone of a reasonable width to protect the integrity of the area shall be included. Natural screening may be considered in determine the width of the buffer zone.

Table 2.1-1.
Exclusion Areas

Exclusion Area	Present within Corridor or Route?	Segments A, B, and C	Section Addressed
a. Designated or registered national: parks; memorial parks; historic sites and landmarks; natural landmarks; monuments; wilderness areas.	Not present within Corridor or Route.	No impacts are anticipated and no buffer is proposed.	4.8 & 4.9
b Designated or registered state: parks; historic sites; monuments; historical markers; archaeological sites; and nature preserves.	Not present within Corridor or Route.	No impacts are anticipated and no buffer is proposed.	
c. County parks and recreational areas; municipal parks; and parks owned or administered by other governmental subdivisions.	Not present within Corridor or Route.	No impacts are anticipated and no buffer is proposed.	
d. Areas critical to the life stages of threatened or endangered animal or plant species	Not present within Corridor or Route.	No impacts are anticipated and no buffer is proposed.	4.17
e. Areas where animal or plant species that are unique or rare to this state would be irreversibly damaged	Not present within Corridor or Route.	No impacts are anticipated and no buffer is proposed.	

2.2 Avoidance Areas

Per NDAC Section 69-06-08-02-2, the following geographical areas (Table 2.2-1) shall not be considered in the routing of a transmission facility unless the applicant shows that under the circumstances there is no reasonable alternative. In determining whether an avoidance area should be designated for a facility, the PSC may consider, among other things, proposed management of adverse impacts; orderly siting of facilities; system reliability and integrity; efficient use of resources; and alternative routes. Economic considerations alone shall not justify approval of these areas. A buffer zone of a reasonable width to protect the integrity of the area shall be included unless a distance is specified in the criteria. Natural screening may be considered in determining the width of the buffer zone.

Table 2.2-1.
Avoidance Areas

Avoidance Areas	Present within Corridor /Route?	Proposed Buffer			Section Addressed
		Segment A	Segment B	Segment C	
Designated or registered national; historic districts; wildlife areas; wild, scenic, or recreational rivers; wildlife refuges; and grasslands.	Not present	No impacts are anticipated and no buffer is proposed.	No impacts are anticipated and no buffer is proposed.	No impacts are anticipated and no buffer is proposed.	4.8 & 4.9
b. Designated or registered state: wild, scenic, or recreational rivers; game refuges; game management areas; management areas; forests; forest management lands; and grasslands.	Not present	No impacts are anticipated and no buffer is proposed.	No impacts are anticipated and no buffer is proposed.	No impacts are anticipated and no buffer is proposed.	4.9
c. Historical resources which are not designated as exclusion or avoidance areas	During the Class III Intensive Archeological Resource Inventory, two pre-contact archaeological stone resource sites were identified in the Segment A ROW.	Basin Electric does not anticipate adverse impacts to previously identified archaeological resources as a result of the Project. Basin Electric will avoid known archaeological resources that were identified during the Class III Intensive Archaeological Resource Inventory. A	Basin Electric does not anticipate adverse impacts to previously identified archaeological resources as a result of the Project. Basin Electric will avoid known archaeological resources that were identified during the Class III Intensive Archaeological Resource Inventory.	Basin Electric does not anticipate adverse impacts to previously identified archaeological resources as a result of the Project. Basin Electric will avoid known archaeological resources that were identified during the Class III Intensive Archaeological Resource Inventory.	4.8

Avoidance Areas	Present within Corridor /Route?	Proposed Buffer			Section Addressed
		Segment A	Segment B	Segment C	
		fifty foot buffer will be established around the two pre-contact archaeological stone resource sites in the ROW.			
d. Area which are geologically unstable	Not present.	No impacts are anticipated and no buffer is proposed.	No impacts are anticipated and no buffer is proposed.	No impacts are anticipated and no buffer is proposed.	4.12
e. Within five hundred feet [152.4 meters] of a residence, school, or place of business. This criterion shall not apply to a water pipeline facility.	Yes	There is a designated Recreation Vehicle (RV) Park within 500 feet. A waiver will be obtained from the property owner.	There is one residence located approximately 285 feet from the centerline. Waiver will be obtained from the property owner. There are 3 businesses within 500 feet	There are no residences within 500 feet. There are 4 businesses within 500 feet.	4.2, 4.3, & 4.4
f. Reservoirs and municipal water supplies.	Not present	No impacts are anticipated and no buffer is proposed.	No impacts are anticipated and no buffer is proposed.	No impacts are anticipated and no buffer is proposed.	
g. Water sources for organized rural water districts.	The eastern portion of the Corridor/route is served by the Williams Rural Water District.	No impacts are anticipated and no buffer is proposed.	No impacts are anticipated and no buffer is proposed.	No impacts are anticipated and no buffer is proposed.	
h. Irrigated land. This criterion shall not apply to an underground transmission facility.	Not present	No impacts are anticipated and no buffer is proposed.	No impacts are anticipated and no buffer is proposed.	No impacts are anticipated and no buffer is proposed.	
i. Areas of recreational significance which are not designated as exclusion areas	Not present	No impacts are anticipated and no buffer is proposed.	No impacts are anticipated and no buffer is proposed.	No impacts are anticipated and no buffer is proposed.	4.9

As noted in the Table 2.2-1 above, there is a residence located within 500 feet of Segment B. An analysis of reasonable alternatives to siting the transmission line within 500 feet of the residence in Segment B was completed. The results of this analysis showed that placing the line along the Highway 2 corridor was not a reasonable alternative due to the lack of space and landowner preference to adequately site the line. The area

surrounding the existing Williston Substation, of which the project terminates into, was originally constructed in what was then a very rural setting 40+ years ago. The area surrounding the Williston Substation has seen slight development over the years. The current activity associated with the Bakken oil development, has rapidly changed the immediately land use from mainly agricultural to industrial uses. The majority of the property surrounding this area is under single ownership. The property owner was contacted to finalize the preferred route. The proposed route reflects the property owner's recommendations.

2.3 Selection Criteria

Per NDAC Section 69-06-08-02-3, a corridor or route shall be designated (Table 2.3-1) only when it is demonstrated to the PSC by the applicant that any significant adverse effects resulting from the location, construction and maintenance of the facility, as they relate to the following, will be at an acceptable minimum or that those effects will be managed and maintained at an acceptable minimum. Figures 4.1 through 4.5 identify the selection criteria for the Project as well as other related resources.

Table 2.3-1.
Selection Criteria

Selection Criteria	Potential Adverse Effects			Section Addressed
	Segment A	Segment B	Segment C	
a. The impact upon agriculture:				
(1) Agricultural production.	Approximately 95 percent of the corridor/route is in an agricultural land use Temporary construction impacts such as soil compaction and crop damage may occur within the right-of-way. Basin Electric will work with landowners to minimize impacts to their land.	Approximately 85 percent of the corridor/route is in an agricultural land use. Temporary construction impacts such as soil compaction and crop damage may occur within the right-of-way. Basin Electric will work with landowners to minimize impacts to their land.	Approximately 0 percent of the corridor/ route is in an agricultural land use. Temporary construction impacts such as soil compaction and crop damage may occur within the right-of-way. Basin Electric will work with landowners to minimize impacts to their land.	4.3 & 4.11
(2) Family farms and ranches.	No family farms will be displaced due to construction in the corridor/route. Basin Electric will work with landowners to minimize impacts to their land. Land area lost to the construction of the project will have a minimal adverse effect to family farms.	No family farms will be displaced due to construction of the corridor/ route. Basin Electric will work with landowners to minimize impacts to their land. Land area lost to the construction of the project will have a minimal adverse effect to family farms.	No family farms will be displaced due to construction of the corridor/ route. Basin Electric will work with landowners to minimize impacts to their land. Land area lost to the construction of the project will have a minimal adverse effect to family farms.	4.3 & 4.10

Selection Criteria	Potential Adverse Effects			Section Addressed
	Segment A	Segment B	Segment C	
(3) Land which the owner demonstrates has soil, topography, drainage, and an available water supply that cause the land to be economically suitable for irrigation.	No irrigated land occurs within or adjacent to the corridor/route. No owner has expressed concerns related to economically suitable irrigation on their land.	No irrigated land occurs within or adjacent to the corridor/route No owner has expressed concerns related to economically suitable irrigation on their land.	No irrigated land occurs within or adjacent to the corridor/route No owner has expressed concerns related to economically suitable irrigation on their land.	4.11
(4) Surface drainage patterns and ground water flow patterns.	No impacts to surface drainage patterns or groundwater flow patterns are anticipated.	No impacts to surface drainage patterns or groundwater flow patterns are anticipated.	No impacts to surface drainage patterns or groundwater flow patterns are anticipated.	4.12 & 4.13
b. The impact upon:				
(1) Noise-sensitive land uses.	This transmission segment resides in a primarily rural location with some nearby traffic noise sources. The nearest sensitive receptor to the proposed route is located in this segment and is approximately 75 feet from the transmission line. At this distance away noise levels are predicted to be below rural background levels. No mitigation measures are necessary since there will be no noise impacts from the Project.	This transmission segment resides in a primarily rural location with some nearby traffic noise sources. The nearest sensitive receptor (business) to the proposed route is located in this segment and is approximately 235 feet from the transmission line. No mitigation measures are necessary since there will be no noise impacts from the Project.	This transmission segment resides in a primarily industrial location with nearby traffic noise sources. The nearest sensitive receptor to the proposed route is located in this segment and is approximately 40 feet from the transmission line. No mitigation measures are necessary since there will be no noise impacts from the Project.	4.6
(2) The visual effect on the adjacent area.	The majority of the proposed transmission line will be crossing agricultural land and will result in minimal visual impacts to residences. Visual impacts will be most evident to landowners and residents in close proximity. .	The majority of the proposed transmission line will be crossing agricultural land and will result in minimal visual impacts to residences. Visual impacts will be most evident to landowners and residents in close proximity.	The majority of the proposed transmission line will be industrial areas and will result in minimal visual impacts to residences. Visual impacts will be most evident to business owners in close proximity.	4.7
(3) Extractive and storage resources.	No impacts are anticipated to extractive and storage resources	No impacts are anticipated to extractive and storage resources	No impacts are anticipated to extractive and storage resources	4.10

Selection Criteria	Potential Adverse Effects			Section Addressed
	Segment A	Segment B	Segment C	
(4) Wetlands, woodlands, and wooded areas.	No impacts are anticipated to wetlands or woodlands within the corridor/route.	No impacts are anticipated to wetlands or woodlands within the corridor/route.	No impacts are anticipated to wetlands or woodlands within the corridor/route.	4.3, 4.10, & 4.14
(5) Radio and television reception, and other communication or electronic control facilities.	No impacts to radio and television reception, and other communication or electronic control facilities are expected.	No impacts to radio and television reception, and other communication or electronic control facilities are expected.	No impacts to radio and television reception, and other communication or electronic control facilities are expected.	4.4
(6) Human health and safety.	No impacts to human health and safety are anticipated.	No impacts to human health and safety are anticipated.	No impacts to human health and safety are anticipated.	4.5
(7) Animal health and safety.	No impacts to livestock are anticipated. Impacts to wildlife populations are expected to be minimal. Potential avian collisions may occur, but are anticipated to be relatively small. Basin Electric has committed to marking the shield wires in select areas and designing the line and structures per APLIC guidelines.	No impacts to livestock are anticipated. Impacts to wildlife populations are expected to be minimal. Potential avian collisions may occur, but are anticipated to be relatively small. Basin Electric has committed to marking the shield wires in select areas and designing the line and structures per APLIC guidelines.	No impacts to livestock are anticipated. Impacts to wildlife populations are expected to be minimal. Potential avian collisions may occur, but are anticipated to be relatively small. Basin Electric has committed to marking the shield wires in select areas and designing the line and structures per APLIC guidelines.	4.10, 4.16, & 4.17
(8) Plant life.	The land is primarily agricultural in nature with occasional areas of pastured native prairie. Areas of temporary construction impacts will be restored.	The land is primarily agricultural in nature with occasional areas of pastured native prairie. Areas of temporary construction impacts will be restored.	The land is primarily industrial l in nature. Areas of temporary construction impacts will be restored.	4.15

2.4 Policy Criteria

Per NDAC Section 69-06-08-02-4, the PSC may give preference to an applicant that will maximize benefits that result from the adoption of the following policies and practices, and in a proper case may require the adoption of such policies and practices (Table 2.4-1). The PSC may also give preference to an applicant that will maximize interstate benefits.

Table 2.4-1.
Policy Criteria

Policy Criteria	Suitable Policy or Practice of Applicant	Section Addressed
a. Location and design.	Basin Electric's policy is to locate and design to minimize environmental impacts and utilize existing corridors.	1.1.1 & 4.18
b. Training and utilization of available labor in this state for the general and specialized skills required.	Basin Electric and MWEC will use local labor to the extent practicable.	4.2.2
c. Economies of construction and operation.	This project creates economies of construction and operation by double-circuiting a MWEC 115 kV transmission line.	
d. Use of citizen coordinating committees.	The use of citizen coordinating committees is not expected for this project.	N/A
e. A commitment of a portion of the transmitted product for use in this state.	Basin Electric has identified the need for additional electric transmission capacity in northwestern North Dakota as a result of increased demand and to meet reliability and system stability requirements for the region.	1.1.1
f. Labor relations.	No labor relations will be negatively affected by the project.	4.2.2
g. The coordination of facilities.	Basin Electric has coordinated with MWEC to double-circuit the transmission line with a 115-kV transmission line	1.0
h. Monitoring of impacts.	Basin Electric, MWEC and the construction contractor will employ Best Management Practices (BMPs) during construction to monitor ground disturbance impacts. Surface water impacts will be monitored according to the SWPPP.	4.4.3 & 4.12.2
i. Utilization of existing and proposed rights of way and corridors.	Basin Electric has coordinated with MWEC to double-circuit the transmission line with a 115-kV transmission line. The project follows half- and quarter-section lines to the extent practicable.	4.3.2
j. Other existing or proposed transmission facilities.	Basin Electric has coordinated with MWEC to double-circuit the transmission line with a 115-kV transmission line	1.1.1

2.5 Design and Construction Limitations

The proposed Corridor/Route is the most direct route while minimizing impacts to the criteria identified in NDAC Section 69-06-08-02. Basin Electric intends to span all wetlands and intends to mitigate unavoidable impacts as required by the USACE and NDDH.

The configuration of the existing substation equipment and high voltage overhead transmission lines restrict where the new transmission line may enter the Western's Williston substation. Between the Williston Substation and proposed Basin Electric Judson 345-kV Substation (Section 19, T154N, R101W and Sections 23 and 24, Township 154N, Range 102 W) and north of the Basin Electric 345-kV Judson Substation through Section 15, Township 154N, Range 102W, Basin Electric is proposing to use single-pole steel structures that would accommodate a double circuit transmission line build out. Following geotechnical exploration it may become necessary to utilize special structures or materials to avoid sensitive environmental features or to accommodate poor soil conditions or other design limitations.

The structure types that would be necessary to address the various voltages, terrain and connector scenarios included as part of this project are shown in Exhibit 2.5-1 through Exhibit 2.5-3. A summary of structure characteristics is provided in Table 2.5-1.

Project construction and design would meet the requirements of the National Electrical Safety Code (NESC) for the Heavy Loading District, Basin Electric and USDA-RUS design criteria, and other applicable local or national building codes. The Heavy Loading District refers to those areas (including North Dakota) that are subject to severe ice and wind loading. Minimum conductor clearance is measured at the point where conductor sag is closest proximity to the ground. The proposed transmission line would be constructed with clearances that exceed standards set by NESC. Minimum conductor height would be 30 feet over agricultural land, rural roads, and paved highways for the 345/115-kV segment and 26 feet for the 230-kV and 230/115-kV segments. Clearance will be based on a conductor temperature of 100 degrees Celsius.

Table 2.5-1.
Transmission Line Design Components

Description of Design Component	Segment A 345/115-kV (Exhibit 2.5-2)	Segment B 230/115-kV (Exhibit 2.5-1)	Segment C 230-kV (Exhibit 2.5-3)
Conductor Size (inches)	1.8/1.108	1.345/1.108	1.345
Right-of-way Width (feet)	150	100	80
Typical minimum and maximum Span Distance between Structures (feet) *	650/850	700/1,020	650/950
Average Span (feet)	800	800	800
Minimum and Maximum Structure Height (feet)	115/145	97/127	70/110
Average Height of Structures (feet)	130	112	95
Transmission Line Length(miles)	17	13	0.20
Average Number of Structures per Mile	6.5	6.5	6.5
Number of structures	17	13	2
Permanent disturbance per Structure (acre) **	0.0009	0.0006	0.0005
Temporary disturbance per Structure (acre) **	.29	.29	.23
Minimum Conductor-to-Ground Clearance to agricultural lands, rural roads and paved highways @100 deg C (feet)	30	26	26
Minimum Conductor-to-Ground Clearance to Railroads @100 deg C (feet)	As required by specific railroad		
Circuit Configuration	Exhibit 2.5-2	Exhibit 2.5-1	Exhibit 2.5-3

** Actual span distance will vary depending on topography.*

*** Single pole, angle and dead-end structures (for longitudinal stability) would be constructed with concrete foundations*

Exhibit 2.5-1. 230/115-kV Double Circuit Structure

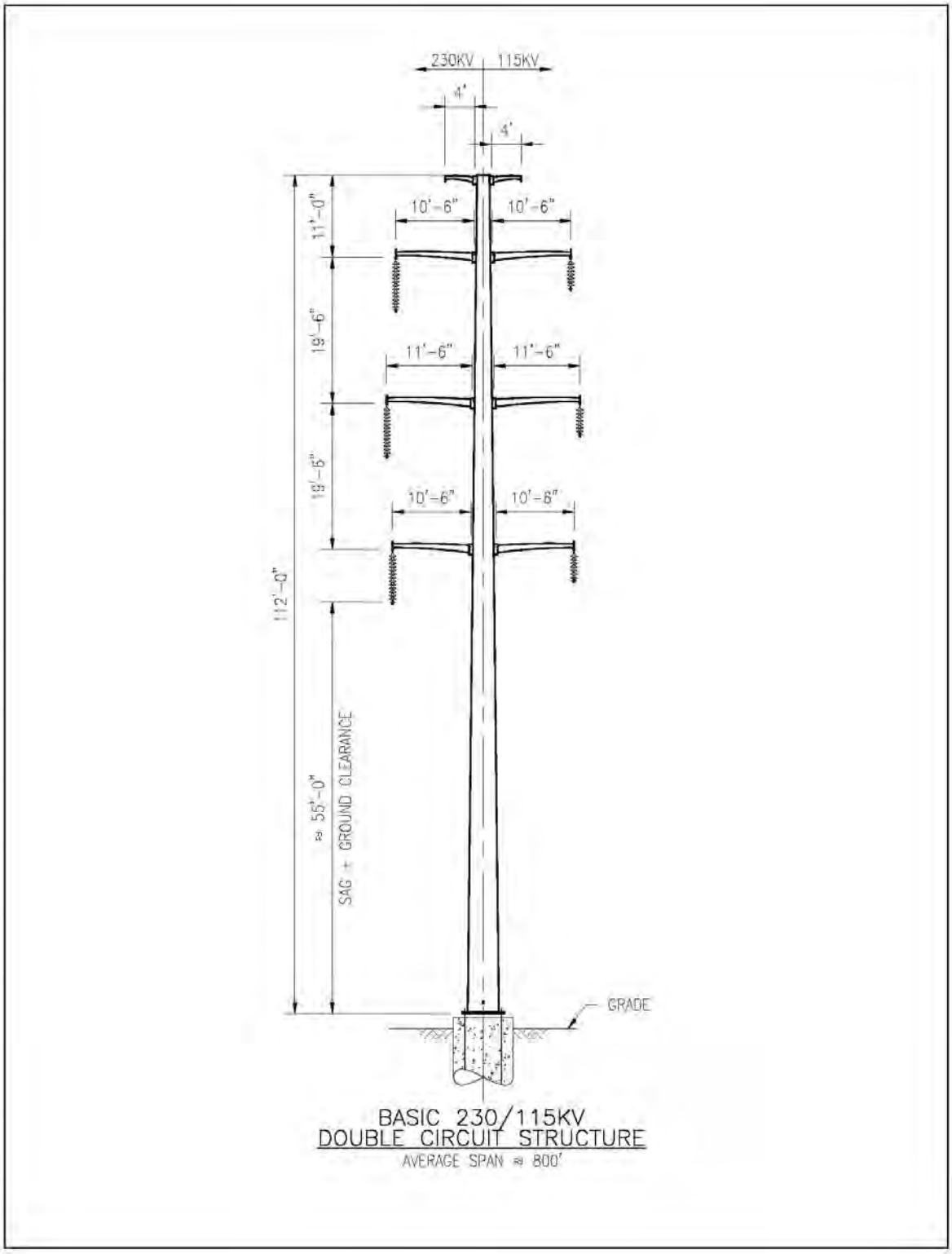


Exhibit 2.5-2. 345/115-kV Double Circuit Structure

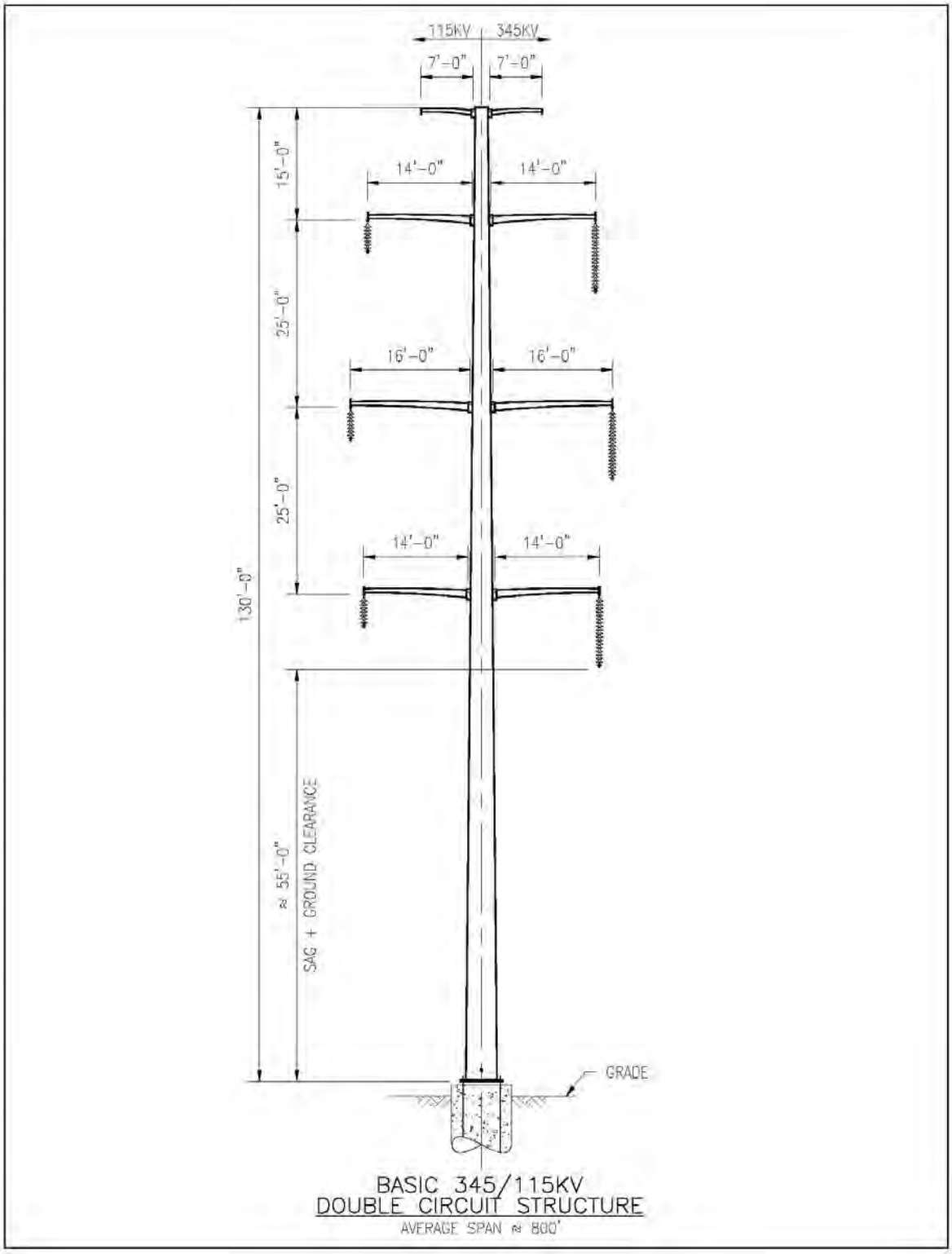
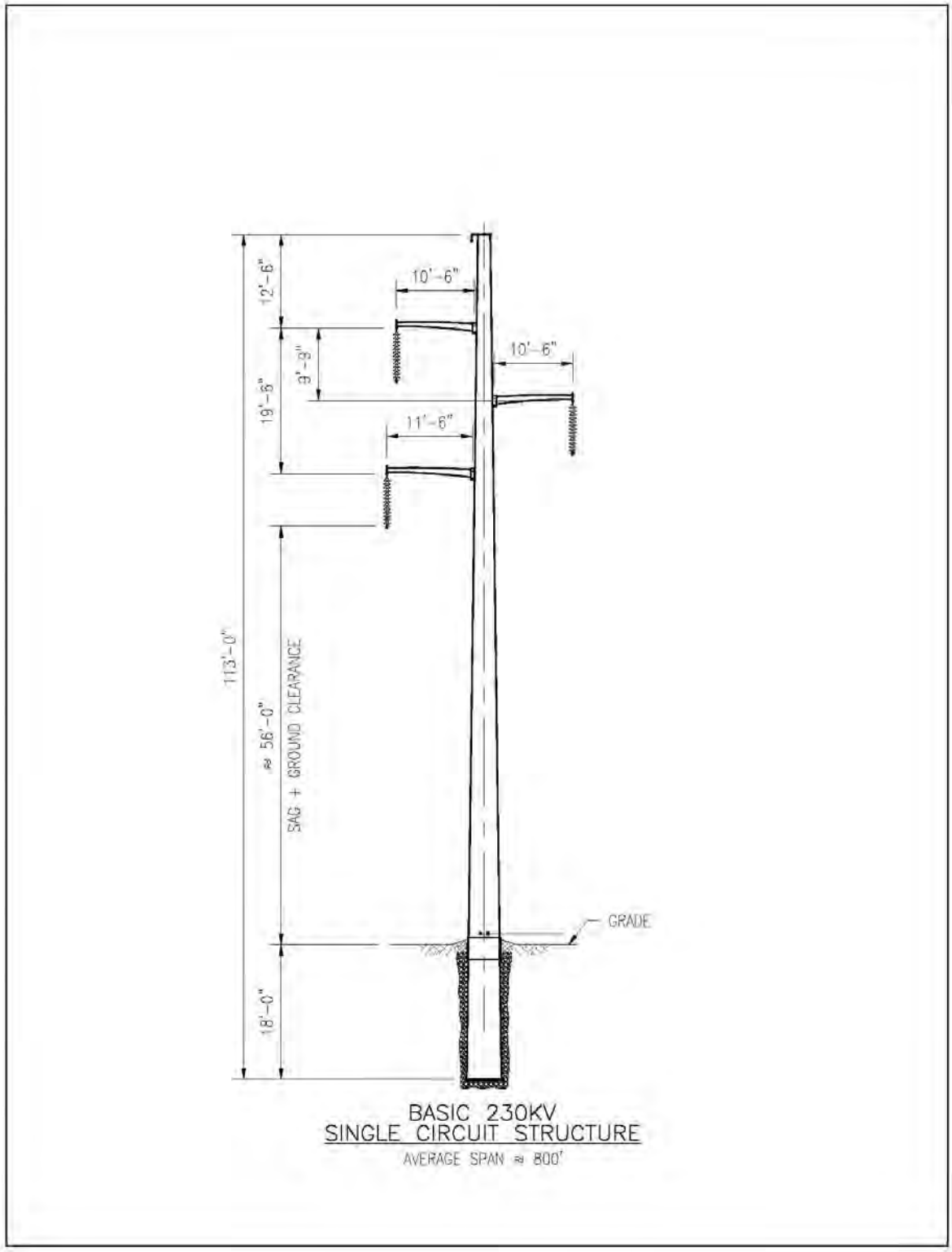


Exhibit 2.5-3. 230-kV Single Circuit Structure



2.6 Economic Considerations

There are many economic considerations in the design and routing of a transmission line. The initial cost of a transmission line increases as the voltage of the line increases. This higher initial cost is offset by a reduction in energy losses for higher voltage lines when compared with lower voltage lines. Basin Electric identified the need for additional electric transmission capacity in northwestern North Dakota as a result of increased demand to meet system reliability requirements for the region. Investigations and analysis conducted for the overall power delivery system found that without improvements, the flow along the existing lines may result in local line overloads, especially in the vicinity of the Williston, North Dakota. This 3.7 mile route is part of a larger approximately 200-mile long Antelope Valley Station to Neset 345-kV Transmission line Project that Basin Electric is currently developing to meet the electrical demands in the area.

In general, minimizing the length of the route and minimizing the number of angle structures decreases the cost of the transmission line by minimizing the material, construction and right-of-way costs. The Corridor/Route effectively balances the economic considerations of overall length of the line and the number of angle structures required with impacts on the environment, agricultural lands, and landowners.

The selection of materials and structure types also affects the cost of a transmission line. Basin Electric proposes to use steel single-pole structures.

3 Engineering and Operational Design

3.1 Preferred Route Description

Segment A of the project will consist of a 345/115 kV double circuit transmission line approximately 1.6 miles in length. This portion of the project would travel south for approximately 1.6 miles from a 345/115 kV transmission line structure located near the northern edge of Section 15, T154N, R102W to the future Judson 345- kV Substation (which is not part of this project). Segment B of the project will consist of a 230/115 kV double circuit transmission line which is approximately 1.9 miles in length and will travel east to a 230/115 kV structure located in T154W, R102W Section 24. Segment C of the project will separate from the 115 kV line and the 230 kV transmission line will turn north for 0.16 miles and turning east for 0.04 miles to Western's Williston Substation.

3.2 Description of Proposed Facility

The purpose of the proposed facility is to increase load service capacity and system reliability in northwest North Dakota. The Williston Tie Project will be designed, constructed, and operated mainly as a double circuit configuration. The 115-kV portions of the Project will be owned by MWEC, and the 345-kV and 230-kV portions of the Project will be owned by Basin Electric. Co-locating transmission structures where appropriate is prudent as it minimizes impacts to the environment, the public, and land owners.

3.2.1 Transmission Structures and Right-of-Way Design

3.2.1.1 Transmission Structures

The proposed transmission line's three segments will be designed to carry 345-kV and 230-kV, alternating current respectively. Basin Electric is proposing to use single pole steel structures that would accommodate a double circuit transmission line build out. The structures would be placed approximately 800 feet apart (with a maximum span of 1,020 feet). The height of the new structures would vary from 70 to 145 feet above ground, depending on terrain and structure type. The transmission line structures would be, at a minimum, constructed with the davit arms for the 345-kV and 230-kV and 115-kV circuits. MWEC's 115-kV circuit will be strung and energized starting in the spring of 2012. The 345-kV and 230-kV circuits may be strung during the same construction phase as MWEC 115-kV due to economics, minimization of environmental impact and the most importantly to ensure the safety of the workforce by eliminating the stringing activity of the 230-kV and 345-kV lines while the 115-kV lines is in service. Should the 345-kV and 230-kV segments be strung in 2012 they will not be energized until all permits and approvals are obtained and all infrastructure is installed for the larger 200-mile Antelope Valley Station to Neset 345-kV Project.

The proposed transmission line will be designed, constructed, operated, and maintained to meet or surpass all relevant state codes, National Electric Safety Code (NESC), Avian Power Line Interaction Committee (APLIC) raptor-safe design standards, and Basin Electric company standards. Appropriate safety standards will be met for construction, operation, and maintenance of the facility.

3.2.1.2 Right-of-Way Design

The 345/115-kV transmission line segment will be constructed within a 150-foot-wide right-of-way (ROW). The 230-kV will be constructed within an 80 foot ROW. The 230/115-kV transmission line segment will be constructed within a 100-foot-wide ROW. Basin Electric representatives have worked with the landowners

along the selected route. Landowners would retain ownership of the land with limitations on building new structures within the right-of-way. Agricultural activities would be permitted to continue within the right-of-way. During construction, each 230/115-kV or 345/115-kV pole and anchor facility would typically involve up to 12,500 square feet, or 0.29 acres, of ground disturbance. The 230-kV structures will impact 10,000 square feet, or 0.23 acres, of ground disturbance. The permanent impact would be approximately 49 square feet (7-foot diameter), or 0.0009 acres for the 345/115-kV structures, approximately 36 square feet (6-foot diameter), or 0.0006 acres for the 230/115-kV structures and approximately 25 square feet (5-foot diameter), or 0.0005 acres for the 230-kV structures.

3.2.2 Right-of-Way Preparation, Construction, Restoration and Maintenance

3.2.2.1 Right-of-Way Preparation

Because the proposed 345/115-kV and 230/115-kV transmission line segments would be constructed in cultivated agricultural fields and pastures (one pasture area includes mixed grass prairie species), minimal vegetation clearing would be required. The 230-kV transmission line segment is located in industrialized area, so minimal ROW preparation will be required. The right-of-way will be surveyed and identified by the placement of stakes identifying the right-of-way and appropriate ROW access points. The proposed transmission line would be constructed at-grade for the majority of the ROW. In some isolated cases, grading could be required at structure locations if there is sloping or uneven ground. Grading may be necessary in that situation to provide a level working area. Equipment used for this grading would likely consist of a front end loader or a small bulldozer. A summary of disturbances is included in Table 4.1-1. The avoidance areas (wetlands and cultural significant areas) will be identified by placement of T-posts at the appropriate interval across the ROW to ensure that no incidental disturbance occurs from construction activity.

3.2.2.2 Transmission Construction Procedures

Construction of the transmission line will begin once all approvals are obtained and easement acquisition is complete. A detailed construction schedule will be developed based upon availability of materials, equipment, and construction labor. The schedule will consider anticipated weather conditions.

Construction of the transmission line will require minimal preparation of the ROW and minimal grading or leveling. Transmission structures will be placed at existing grade elevations. Limited grading may be required to provide level and stable access paths and working surfaces for construction crews at selected structure and wire stringing locations. Once construction is completed, the graded areas will be restored and blended with the original contours to the extent practicable.

During construction of each 230/115-kV or 345/115-kV pole would typically involve up to 125-foot by 100-foot area (12,500 square feet, or 0.29 acres), of ground disturbance. Each 230-kV structure would typically involve up to 125 foot by 80 foot area (10,000 square feet, or 0.23 acres), of ground disturbance.

Insulators and other hardware would be attached to each structure while on the ground. Each single circuit steel pole structure would require excavating or auguring a hole approximately 15 to 40 feet deep and approximately 5 to 7 feet in diameter. Excavation dimensions would depend upon soil conditions, whether the structures would support an angle, and guying room available.

Conductors would be installed by establishing stringing setup areas within the proposed Judson Substation location which would store the spools of conductor cable. Temporary guard or clearance poles would be installed as needed over existing distribution or communication lines, streets, roads, highways, or other

obstructions after any necessary notifications are made and permits obtained. This ensures that conductors would not obstruct traffic or contact existing energized conductors or other cables. Once the structures have been erected, crews would drive along the ROW, securing the conductor line through the insulators on the poles and installing shield wire clamps once final sag is established. The structures would be accessed by a hydraulic bucket system vehicle or "cherry picker."

3.2.2.3 Restoration Procedures

During construction, crews would attempt to limit ground disturbance wherever possible. Temporary disturbance areas would be restored to their original condition to the extent practicable, as negotiated with the landowner. Reclamation activities would include removing and disposing debris, dismantling all temporary facilities (including staging and temporary material storage areas), leveling or filling tire ruts, and erosion control. Reseeding areas disturbed by construction activities would be done with a seed mix, free of noxious weeds, containing vegetation similar to that which was removed. Natural Resources Conservation Service (NRCS) recommended seed mixes would be used.

Erosion control measures will be implemented to minimize runoff during construction. Specific measures will be determined once final design of the Route is complete, and a field review is made to determine any areas of concern. Erosion control measures such as silt fence, rock checks, flow diverters, mulching, seeding, or mesh fabric overlay would be installed when and where appropriate. Access routes to structure locations will be reviewed prior to the mobilization of equipment so erosion concerns can be avoided or minimized. Construction crews exercise caution when equipment is within 50 feet of wetland areas and will not drive equipment through the wetland area that the transmission line crosses.

3.2.2.4 Maintenance Procedures

The ROW defines the area where the proposed transmission line can be operated safely and reliably. Maintenance crews would perform inspections, maintain equipment, and make repairs over the life of the transmission line. Inspections would occur by vehicle along the ROW or on foot. Routine maintenance would be performed approximately every five years or more frequently, if necessary, to remove vegetation that may interfere with the safe and reliable operation of the proposed transmission line. Basin Electric will notify property owners prior to conducting routine maintenance.

3.2.3 Easement/Right-of-Way Acquisition

Basin Electric and MWEC will individually and/or jointly, secure the easements required from all private landowners of the 3.7 mile route. The project will require eleven separate easement acquisitions. At the time of this application four easements have been acquired. During the acquisition phase, individual property owners are advised of construction schedules, needed access to the site, and vegetation clearing required for the transmission line. The right-of-way will be cleared of the amount of vegetation necessary to construct, operate, and maintain the proposed transmission line.

Basin Electric/MWEC has notified the landowners prior to conducting the necessary engineering surveys and soil investigations. The future Judson Substation (Basin Electric's 345-kV and MWEC 115-kV) location will be acquired thru fee purchase. This area has acquired Conditional Use Zoning approval from Williams County. MWEC will be developing an access road and will develop their substation area in 2012. This area will be utilized as the major staging area for the project. If additional staging and lay down areas are required they will be located within the ROW and limited to previously disturbed or developed areas. Should

additional property be temporarily required for construction, temporary easements may be obtained from landowners for the duration of construction. These temporary easements will be limited to special construction access needs or additional staging or lay down areas required outside of the proposed ROW.

4 Environmental Analysis

4.1 Overview

This section provides a description of the environmental conditions that exist in the Corridor/Route for Segments A, B and C. Conservative impact estimates associated with the proposed Corridor/Route assumed that Segment A will be approximately 1.62 miles long, Segment B will be 1.9 miles and Segment C is approximately 0.20 miles in length. The average span length between structures for both segments will be approximately 800 feet. There will be approximately 17 structures located in Segment A, 13 structures in Segment B and 2 structures located in Segment C. Basin Electric is proposing to use single-pole steel structures that would accommodate a double circuit transmission line build out for Segments A and B. Segment C will utilize single circuit, single pole structures. The permanent impacts of the 345/115-kV single pole structures would be 49 square feet (0.0009 acres) each. The permanent impacts of the 230/115-kV single pole structure would be 36 square feet (0.0006 acres) each. The permanent impacts of the 230-kV single pole structure will be 25 square feet (0.0005 acres) each. During construction of the single-pole structures, each pole and anchor facility would typically involve up to 12,500 square feet (100 feet x 125 feet), or 0.29 acres, of temporary impacts (Table 4.1-1).

Table 4.1-1.
Summary of Impacts

	Segment A 345/115-kV	Segment B 230/115-kV	Segment C 230-kV	Project Total
Length (miles)	1.62	1.9	.20	3.7
Corridor/Routes Area (ROW)	150 ft	100 ft	80 ft	-
# of Structures	17	13	2	32
Temporary Impact (acres)*	29.5	23.0	1.9	54.4
Permanent Impacts/structure (acres)	0.0009	0.0006	0.0005	-
Total Permanent Impacts (acres)	0.0153	0.0078	0.001	0.0241

** Temporary impacts are considered conservative estimations based on construction occupying the entire ROW width. It is not anticipated that use of the entire ROW will be necessary.*

General information on land use and vegetation within each Segment's Corridor/Route were estimated using the National Land Cover Dataset. Percentages of land use within each Corridor/Route were estimated using the Corridor/Route proposed right-of-way.

The Project has been designed to limit the environmental impact of the proposed facility.

4.2 Demographics & Socioeconomics

4.2.1 Description of Resources

The Project is located within a lightly populated rural area in northwestern North Dakota. Population data for this section was taken from the 2010 U.S. Census; Per Capita Income and Poverty Level percentage was taken from the 2005-2009 American Community Survey 5-Year Estimates via the U.S. Census Bureau.

The population of Williams County is 22,398. The county seat of Williams County is the city of Williston, which is the closest town to the Corridor and has a population of 14,716. The project is located west of Williston in the Judson Township (T154N, R102W) and Williston Township (T154N, R101W). Table 4.2-1 summarizes the population and economic characteristics. The projected population of Williams County is expected to increase due to the burgeoning oil industry.

According to the 2000 U.S. Census, the largest industry employing residents of Williams County was agriculture, and oil and gas development, while the second largest industry was construction.

Table 4.2-1. Population and Economic Characteristics

Location	Population	Per Capita Income* (2009 dollars)	Percentage of Population Below Poverty Level*
Williams County	22,398	27,293	10.2
Judson Township (T145N, R102W)	130	11,490	7.1

**Denotes 2005-2009 American Community Survey 5-Year Estimates Data via U.S. Census Bureau. Williston Township information was not available.*

4.2.2 Impacts

Short-term impacts to socioeconomic resources will be relatively minor. Permanent agricultural land conversion associated with the transmission line structure placement will constitute a small impact to those landowners with structures on their land. Total permanent impacts are show in Table 4.1-1 above. There is no indication that any minority or low-income population is concentrated in any one area of the Corridor/Routes, or that the transmission line will be placed in an area occupied primarily by any minority group.

The construction of the transmission line and associated substation improvements will provide temporary increases to the total personal income of the landowners along the route and businesses in the project area. Additional personal income will be generated by circulation and recirculation of dollars paid out by Basin Electric as business expenditures and state and local taxes. Expenditures made for equipment, energy, fuel, operating supplies, and other products and services benefit businesses in the counties and the state. The transmission line will not cause additional impacts to leading industries along the Corridor/Routes and will support the continued reliability of the electrical system supporting the oil and gas development in the region. Basin Electric and MWEC will use local labor to the extent practicable and no labor relations will be negatively affected by the Project.

Double circuiting the transmission line with the proposed MWEC transmission line will minimize the impacts to agricultural land. Landowner compensation will be established by individual easement agreements.

4.2.2.1 Segment A Corridor/Route

Approximately 29.5 acres of land will be temporarily removed from its original use during transmission line construction. Permanent land conversion associated with the transmission line structures will be approximately 0.0153 acres for the Segment A Corridor/Route.

4.2.2.2 Segment B Corridor/Route

Approximately 23.0 acres of land will be temporarily removed from its original use during transmission line construction. Permanent and conversion associated with the transmission line structures will be approximately 0.0078 acres for the Segment B Corridor/Route.

4.2.2.3 Segment C Corridor/Route

Approximately 1.94 acres of land will be temporarily removed from its original use production during transmission line construction. Permanent and conversion associated with the transmission line structures will be approximately 0.001 acres for the Segment C Corridor/Route.

4.2.3 Mitigation

4.2.3.1 Segment A, B & C Corridor/Routes

Socioeconomic impacts associated with the transmission line will be primarily positive, with an influx of wages and expenditures made at local businesses during the Project construction and an increase in the county's tax base from the construction of the transmission line. As a result, no mitigation is proposed.

4.3 Land Use

4.3.1 Description of Resources

The proposed transmission line would be located in south central Williams County, originating approximately 4 miles west of the city of Williston. The current land use within both Corridor/Routes is mainly rural agricultural land used for crops and grazing cattle with areas of industrial growth developing in the rapidly changing oil industry being experienced by the region. Oil and gas wells and oil infrastructure have become common, and are located throughout the area. Current zoning in both Corridor/Routes is a mix of agricultural, industrial, residential, and commercial (Williams County 1987). The proposed Corridor/Routes are not within Williston city limits or within an area of military installation. The development of the proposed transmission line will not displace any residences or existing or planned industrial facilities.

Based on a review of aerial photographs, land use database information, and visits to the Corridor/Routes, it was determined that the majority of the land area at the site is agricultural (Figure 4.1). Table 4.3-1 identifies current land cover in the Corridor/Routes.

Table 4.3-1. Corridor/Route Land Cover

Major Habitats and Their Relative Abundance	Segment A		Segment B		Segment C	
	Acreage	Percent of Corridor/Route	Acreage	Percent of Corridor/Route	Acreage	Percent of Corridor/Route
Riparian	0.7	2.5	0	0	0	0
Developed	0	0	3.3	13.9	1.9	78.3
Roads	0.7	2.3	0.3	1.2	0.5	21.7
Grassland	27.6	92.5	2.8	11.9	0	0
Cropland	0.8	2.6	17.5	73.0	0	0
Wetland *	0.04	0.1	0	0	0	0
Total	**29.84**	**100**	**23.9**	**100**	**2.4**	**100**

** Wetland acreage for this section was calculated based on available general land cover data, and may vary from acreage calculated from specific wetland data presented in Section 4.14.*

4.3.1.1 Segment A Corridor/Route

Approximately 95 percent of the Corridor/Route is used for agricultural purposes. Agricultural land use includes approximately 3 percent cropland and 92 percent grasslands. Less than 3 percent of the Corridor/Route is wetland or riparian area.

4.3.1.2 Segment B Corridor/Route

Approximately 85 percent of the Corridor/Route is used for agricultural purposes. Agricultural land use includes approximately 73 percent cropland and 12 percent grasslands. There are no riparian areas or wetlands within the Corridor/Route.

4.3.1.3 Segment C Corridor/Route

Approximately 78 percent of the Corridor/Route is developed and 22 percent is roadway.

4.3.2 Impacts

Land use in all three Segments is not expected to change as a result of construction of the proposed transmission line. Land used for crops is abundant in both Segments. Ranching activity is also not expected to be impacted by the proposed transmission line located within the Corridor/Routes studied. The majority of the area under or adjacent to the transmission line can still be used for agricultural practices following construction of the line.

The total impact would be minimal. The proposed Corridor/Route Segments minimize impacts to farmland by paralleling existing road section lines, quarter section lines, and property lines wherever possible. The locations for the transmission line were selected based on landowner preference to minimize loss of farmland and help ensure access to the land near the poles.

4.3.2.1 Segment A Corridor/Route

Permanent impacts to cropland would be localized to pole placement. The total permanent impacts from the 17 structures in Segment A will be 0.0153 acres. Cropland represents 2.6 percent of the land use in Segment A. The impacts to cropland will be minimal.

4.3.2.2 Segment B Corridor/Route

Permanent impacts to cropland would be localized to pole placement. The total permanent impacts from the 13 structures in Segment B will be 0.0078 acres. Cropland represents 73 percent of the land use in Segment B. The impacts to cropland will be minimal.

4.3.2.3 Segment C Corridor/Route

There is no cropland in Segment C.

4.3.3 Mitigation

4.3.3.1 Segment A, B & C Corridor/Routes

Basin Electric will work closely with landowners and agencies in finalizing transmission structure locations and access to the site to minimize land use disruptions and impacts to environmentally sensitive areas to the extent possible. These areas will be graded to original contours and if necessary reseeded with vegetation recommended by the NRCS. Construction of the transmission line will not change the land use in the Corridor/Routes. Basin Electric would compensate landowners for damages that may occur as a result of the

Project. This compensation may be by either providing financial compensation to landowners, or by using contractors to restore the disturbed area.

4.4 Public Services

4.4.1 Description of Resources

4.4.1.1 Local Services

The Route is located in a lightly populated, rural area in northwestern North Dakota. There is an established transportation and utility network that provides access and necessary services to the light industry, small cities, homesteads, and farms existing in and near the Corridor/Routes. Williams County provides emergency and social services and manages several county parks. The closest town to both Segments is Williston, located approximately 4 miles east of the southeastern terminus of the transmission Corridor/Route in Segment A. The city provides recreation and parks, a community center, a golf course, community pool, and a community library. Additionally, the city's local services include emergency services, a fire department, ambulance service, and a police department. There are also local retail service facilities and institutions.

4.4.1.2 Electrical Service

There are currently no other transmission lines present within Segment A or B's Corridor/Routes, but the alignment will be double circuited with MWEC's 115 kV line. Segment C's Corridor/Route will be interconnect with Western's Williston Substation. Currently there are five transmission lines of entering and exiting this major Substation facility. Williams County is located within the MWEC and Montana-Dakota Utilities Co. service area. MWEC is a not-for-profit, member-owned electric distribution cooperative, and Montana-Dakota Utilities Company is a division of MDU Resources Group, Inc. Both provide electrical services to residential and commercial customers in the Project area. Basin Electric and Western thru the operation of the Integrated System (IS) transmission system also deliver electrical supply to the area.

4.4.1.3 Roads

County and township (section line) roads characterize the existing roadway infrastructure in and around the Corridor/Routes. The entire project Corridor/Route is located north of Hwy 2, and lies mainly between 143rd Ave NW and 141st Ave NW where Western's Williston Substation is located.

Segment A begins ¼ mile west of the intersection of 52nd St NW and 143rd Ave NW. Segment A goes south for one mile and then east for ¼ mile to a location just west of the intersection of 143rd Ave NW and 51st St NW. From there, segment A goes southeast for 4/10 of a mile to the Judson substation location. Segment B begins at the Judson Substation location about 0.55 miles north of US Hwy 2. It heads east from the Judson Substation for 1.2 miles, then southeast for 0.45 miles, then east for 0.25 miles to 141st Ave NW. Segment C begins about 1/10th of a mile north of the intersection of US Hwy 2 and 141st Ave NW. It follows the west side of 141st Ave NW for 1/8th of a mile and then crosses 141st Ave NW to the Williston Substation.

4.4.1.4 Traffic

The existing traffic volumes on the area's county highways are documented in Table 4.4-1. Determining the specific capacity of any highway is a complex process; however, general estimates are used for planning purposes. For purposes of comparison, the functional capacity of a two-lane paved rural highway is approximately 5,000 vehicles per day, or Average Daily Traffic (ADT). In general, the state highways in and

near the Corridor/Routes carry higher levels of traffic than what is average for rural North Dakota, but represent only a fraction of the capacity of the roadway.

Table 4.4-1.
Existing Daily Traffic Levels

Roadway Segment	2010 Average Annual Daily Traffic (AADT)	2010 Commercial Truck Traffic
State Highway 2 east at State Highway 85	4450	735
State Highway 2 east of Williston	1700	235

Source: 2010 Traffic Volumes from NDDOT, Bismarck

Additional county and township roads run through the Corridor/Routes, but have no count data available. In general, the North Dakota Department of Transportation (NDDOT) provides traffic counts for designated U.S. and State Highways (NDDOT 2011). As per NDDOT, the routes with no counts are likely lower than those with count data.

4.4.1.5 Water Supply

Judson Township and western Williston Township have limited public infrastructure services, which is typical of most rural townships. Homes typically utilize septic systems and water wells for their household needs. The eastern portion of the project Corridor/Route (Segment A) is served by the Williams Rural Water District, which is similar to a city water system in that it pipes water underground directly to the user's residence.

4.4.1.6 Telephone, Fiber Optic, Television and Radio Communications

No radio or television signal interference directly from the transmission of electricity is anticipated because of the differences in frequency of the signals. It is possible that localized interference could occur as a result of electric discharges across small gaps in the transmission system hardware or from the development of partial electric discharges from the line itself (generally referred to as "corona"). While it is unlikely that either of these situations would occur, in the event that radio and television signals are impacted, the use of corona-free hardware and routine transmission line maintenance would eliminate the problem.

4.4.2 Impacts

4.4.2.1 Segment A, B & C Corridor/Routes

Local Services

No negative impacts to local services are anticipated.

Electrical Service

No impact is anticipated to the transmission system; the new transmission line will increase overall service reliability.

Roads

Constructing the transmission line will require temporary access roads along the Corridor/Routes, which are approximately 3.7 miles in total length (Segment A is 1.6 miles, Segment B is 1.9 miles, and Segment C is 0.20 miles). The access path will be approximately 10-12 feet wide with no major grading or filling is anticipated.

Traffic

The maximum transmission line construction workforce is expected to generate an approximate average of 20-30 additional vehicle trips per day. Using any combination of state and county highways and other township roads throughout the Project area, the traffic impacts are considered negligible. The traffic volume in and around Williston has increased significantly with the oil and gas development occurring in the area. Additional vehicles in the area as a result of the transmission line would be temporary in nature. The capacity of any route and Level-of-Service to the traveling public would not be impacted.

Truck access to the Corridor/Routes is served by State Highway 85 and State Highway 2. From Williston, Highway 2 to 143rd Avenue NW will serve as the primary truck access into the Corridor/Routes. Specific additional truck routes will be dictated by the location required for delivery. Additional operating permits will be issued by the state, county, and/or township for over-sized truck movements.

Water Supply

Construction and operation of the transmission line will not significantly impact the water supply. During excavation of foundations for the steel monopole structures in unstable soil conditions, it may be necessary to pump water in the excavation to stabilize the soils. Potable water would be utilized for this purpose.

Telephone, Fiber Optic, Television and Radio Communications

No impacts to these communication resources are anticipated.

4.4.3 Mitigation

4.4.3.1 Segment A, B & C Corridor/Routes

Construction and operation of the Project will be in accordance with all associated Federal, state and local permits and laws, as well as industry construction and operation standards. Due to the minor impacts expected on the existing infrastructure during project construction and operation, no mitigation is proposed.

Local Services

Construction, operation, and maintenance of the transmission line will not impact local services, and no mitigation proposed.

Electrical Service

The construction of the transmission line will not negatively impact existing electrical service so no mitigation is proposed.

Roads

Impacts from transmission line construction are expected to primarily consist of compaction of agricultural soils. Where necessary, the soil will be disked following construction.

Traffic

No impacts are anticipated, and no mitigation is proposed.

Water Supply

If temporary dewatering of groundwater is required during construction activities, dewatering water discharge will be conducted under the requirements of a National Pollutant Discharge Elimination System (NPDES) permit and Storm Water Pollution Prevention Plan (SWPPP).

Telephone, Fiber Optic, Television and Radio Communications

North Dakota One Call will be contacted prior to construction to locate and avoid underground facilities. To the extent project facilities cross or otherwise affect existing telephone or fiber optic lines or equipment, Basin Electric/MWEC will comply with all regulations required to avoid interference with these existing facilities.

Since no impacts to microwave or land based telecom systems are anticipated, no mitigation is proposed.

4.5 Human Health and Safety

Human health and safety concerns include potential issues such as electric and magnetic fields (EMF) (collectively referred to as electromagnetic fields), stray voltage, and air quality. The majority of the information in this section was obtained from federal and state agencies and national and international organizations, including the National Institute of Environmental Health Sciences (NIEHS), U.S. Environmental Protection Agency (EPA), and World Health Organization (WHO). See Appendix A for EMF literature.

4.5.1 Description of Resources

4.5.1.1 Human Health

EMF, as it relates to transmission lines, references two separate fields: electric fields and magnetic fields. Electric fields are produced by the line voltage, and magnetic fields are produced by the electric current in the lines. An electric field results from the voltage on an electrical wire as caused by electric charges, and electric fields can exert forces on other nearby charges. The intensity of the electric field is related to the voltage of the line and proximity to the conductor. Electric fields are measured in volts per meter (V/m) or kilovolts per meter (kV/m) where 1 kV = 1,000 V.

A magnetic field is created when charges move along a wire. The moving charges produce an electric current. The intensity of the magnetic field is proportional to the current flow through the conductors and proximity to the conductor. Magnetic fields are measured in milligauss (mG) or microTeslas (uT). Peak magnetic field levels can vary considerably depending upon the amount of current carried by the line.

Electric fields and magnetic fields are produced both by the natural world around us and the electricity we use on a daily basis. The earth's steady electric field is approximately 100 V/m and the earth's steady magnetic field is approximately 550 mG. However, thunderstorms can temporarily increase the electric field in a given location to several thousand V/m. The EMF produced by electrical equipment varies in time at a frequency of 60 cycles per second or "60 Hz." According to the Electric Power Research Institute (EPRI), the average household background 60-Hz magnetic field is between 0.5 and 4 mG with an average of 1 mG, and the average 60-Hz electric field is 1-20 V/m.

The table below displays typical 60-Hz magnetic field levels from common household appliances. The EMF produced by electrical appliances and transmission lines are considered to be extremely-low-frequency (ELF) fields. Both the electric and magnetic fields that constitute EMF are strongest close to the sources of voltage and current, and decrease rapidly with distance.

Table 4.5-1.
Typical 60 Hz Magnetic Field Levels from Common Household Appliance

Appliance	Median Magnetic Field 6 Inches from Appliance (Mg)	Median Magnetic Field 2 Feet Away (Mg)
Refrigerator	2	1
Vacuum cleaner	300	10
Electric oven	9	-
Dishwasher	20	4
Microwave oven	200	10
Hair dryer	300	-
Computers	14	2
Fluorescent lights	40	2

Source: NIEHS 2002

The frequency of transmission line EMF in the United States is 60 Hertz (Hz) (60 cycles per second). High frequency EMF is associated with radio, TV, radar, and cell phone signals. There are no standards established for safe levels of exposure to 60-Hz EMF. Although some states have established standards or guidelines with regard to transmission line electric and magnetic fields, there are no North Dakota published guidelines for EMF. The standards and guidelines established by other states are displayed in Table 4.5-2.

Table 4.5-2.
State EMF Standards and Guidelines for Transmission Lines

State/Line Voltage		Electric Field (kV/m)		Magnetic Field (mG)	
		On ROW	Edge ROW	On ROW	Edge ROW
Florida[c]	69-230 kV	8.0	2.0[f]	--	150
	230-500 kV	10.0	2.0[f]	--	200
	>500 kV	15.0	5.5[f]	--	250[e]
Massachusetts		--	1.8	--	85
Minnesota		8.0	--	--	--
Montana		7.0[a]	1.0[b]	--	--
New Jersey		--	3.0	--	--
New York		11.8	1.6	--	200
		11.0[d]			
		7.0[a]			
Oregon		9.0	--	--	--

[a] *Maximum for highway crossings*
[b] *May be waived by the landowner*
[c] *Magnetic fields for winter-normal, maximum line current-carrying capability*
[d] *Maximum for private road crossings*
[e] *Includes 500 kV double-circuit lines built on existing ROWs*
[f] *Includes the property boundary of a substation*

Some organizations have set EMF advisory limits that serve as guidelines for permissible EMF exposure levels. For example, the International Commission on Non-Ionizing Radiation Protection (ICNIRP) recently established a continuous magnetic field exposure limit of 2,000 mG and a continuous electric field exposure limit of 4,200 V/m (4.2 kV/m) for members of the general public. The American Council of Governmental Industrial Hygienists (ACGIH) has set a Threshold Limit Value for occupational exposure to 60 Hz magnetic fields of 10,000 mG and electric fields of 25,000 V/m (25 kV/m). Table 4.5-3 displays EMF guidelines established by health and safety organizations.

Table 4.5-3.
Electric and Magnetic Field Exposure Guidelines for Power-Line Fields

Organization	Electric Field (kV/m)		Magnetic Field (mG)	
	General Public	Occupational	General Public	Occupational
ICNIRP (2010)	4.2	8.3	2,000	4,200
IEEE (2002)	5	20	9,040	27,100
ACGIH (2009)	--	25	_	10,000

ICNIRP – International Commission on Non-Ionizing Radiation Protection
IEEE – Institute of Electrical and Electronic Engineers
ACGIH – American Conference of Governmental Industrial Hygienists

Burns & McDonnell analyzed EMF on a 345/115-kV line configuration due to the understanding that the 345/115-kV segment represented the greatest potential for EMF. The analysis was based on methods developed by the Bonneville Power Administration. Electric fields 75 feet from the center line to the edge of the ROW exhibited the maximum predicted value of 0.214 kV/m, which, based on the International Commission on Non-Ionizing Radiation protection (2010), is far less than 4.2 kV/m protection standard for the general public. The study also analyzed magnetic fields at a distance of 75 feet from the center line and the maximum predicted value is 94 mG, again, far less than the 2,000 mG protection standard for the general public (Burns & McDonnell 2011). The complete memorandum is included in Appendix A.

The National Institute of Environmental Health Sciences and the National Institutes of Health prepared a Questions and Answers paper on Electric and Magnetic Fields Associated with the Use of Electric Power in 2002 (included in Appendix A). The document indicates that the typical EMF level for a 230kV transmission line at 50 feet from the centerline is 1.5 kV/m and 19.5mG. Both values are far less than the International Commission on Non-Ionizing Radiation protection (2010) levels. The ROW for Segment C is 80 feet (40 feet on either side of the centerline). A commercial building is immediately adjacent to the ROW and, based on the data described above, the EMF levels at the edge of Segment C ROW will be far less than the recommended levels.

4.5.1.2 Electric and Magnetic Field Research

Concerns about potential health effects of EMF from transmission lines were first raised in the late 1970s, triggered by a weak statistical correlation between living in proximity to utility distribution systems and childhood leukemia cases. There has been much public debate and research regarding ELF-EMF for over 35 years. Considerable research has been undertaken to understand how electric and magnetic fields interact with the physical nature of matter. Because electric fields are blocked by ordinary substances that conduct electricity, such as skin, foliage, and house structures, magnetic fields have been the focus of most of the

research regarding possible health effects to both humans and livestock. While there are numerous internet sites devoted to EMF (whether from transmission lines, cell phones, or radio frequency signals), the vast majority of public-health agencies believe that EMF from transmission lines do not cause health problems. In part, these scientific consensus groups note the physical impossibility of any health effect (or adverse biological effect) being caused by exposure to low-frequency, low-intensity magnetic fields. Exhaustive reviews of the health effects from power-frequency fields conclude that the evidence of health risk is weak and there is little laboratory evidence correlating extra low frequency EMF exposure with health risk, as demonstrated in the following discussion.

EMF and Leukemia

After reviewing more than two decades of research, NIEHS scientists concluded that the overall pattern of results suggests a weak association between increasing exposure to EMF and an increased risk of childhood leukemia (NIEHS 1999). ICNIRP reviewed the scientific evidence relating to extremely low magnetic fields and increased risk of childhood leukemia and concluded that the evidence "is too weak to form the basis for exposure guidelines" (ICNIRP, 1998, 2010). Several scientific organizations including the American Medical Association (AMA 1994), American Cancer Society (ACS 2010), American Physical Society (APS 2005), and National Academy of Sciences (NAS 1997) have stated that the body of evidence in regard to ELF-EMF, particularly magnetic fields, indicates that exposure to these fields do not present a human health hazard.

A large number of credible, scientific organizations have come to similar conclusions about ELF-EMF and public health:

- The epidemiology studies on EMF are not based on actual EMF exposures and show weak and generally inconsistent correlations between estimates of EMF exposure and health statistics.
- Laboratory research has not been able to establish either cause and effect relationship between exposure to magnetic fields and any human disease, or a plausible biophysical or biological mechanism by which exposure to EMF could cause cellular changes that would lead to disease.
- The magnetic fields produced by power lines do not have the energy necessary to break chemical bonds and cause DNA mutations, and hence cannot interfere with basic biological function at the molecular level.

Many public health agencies (e.g. American Cancer Society, Environmental Protection Agency, Food and Drug Administration, Centers for Disease Control) have not established numerical guidelines for power line EMF, because they have not found scientific studies sufficiently supportive of the need to set either an EMF exposure guideline or a "safe distance" criterion. No legitimate public health agency has proposed that an "unsafe" region exists in the proximity of overhead transmission lines.

EMF and Livestock

The vast amount of laboratory animal research focused on EMF effects on living organisms has not demonstrated that power line magnetic fields affect reproductive function. In addition, a considerable amount of research on EMF and livestock (particularly cows) has been conducted in Quebec, Canada and has been funded by Hydro-Quebec. A recent joint study conducted by McGill University, Ministere de l'Agriculture, des Pecheries et de l'Alimentation du Quebec (MAPAQ) and the Quebec Dairy Committee exposed cows to high levels of EMF. This study did not show any changes in the hormonal profile and dairy production of Holstein cows. This, in addition to several other studies conducted since the 1970s; provide reassurance that

no biological disorder can be attributed to the exposure of livestock to EMFs generated by high-voltage transmission lines. In addition, no harmful effect on the health, productivity, fertility, reproduction, or behavior of livestock exposed to EMFs has been observed, and typical EMF exposures are not anticipated to be harmful to farm animals.

Basin Electric, and other utilities in agricultural regions of the country, has operated 345-kV systems for many years. Through the years, no statements concerning the potential adverse effects of the 345-kV power systems on cattle were received.

EMF and Implantable Medical Devices

Implantable medical devices, for example cardiac pacemakers, defibrillators, neurostimulators, and insulin pumps may experience interference from strong EMF. The 2004 EPRI report indicated that implantable medical devices may be more susceptible to interference from electric fields than to magnetic fields. Electric fields will be strongest directly under the transmission line and decrease with increasing distance from the transmission line towards the ROW edge. Although no actual real-world events have been reported in people near high-voltage transmission lines, laboratory research has shown the following potential effects can occur to pacemakers exposed to electric fields:

- Rate increasing.
- Erratic pacing.
- Switching to asynchronous pacing or fixed-rate pacing.
- Single beat inhibition (i.e., a single beat is missed by the pacemaker).
- Total inhibition.

Research completed by Toivonen et al. (1991) indicated that the lowest field intensity suggestive of possible interference was in electric fields ranging from 1.2 to 1.7 kV/m (near a 110 kV power line), but some pacemakers maintained normal function in electric fields up to 8 kV/m (near a 400 kV power line). The 15 patients in this study collectively had 12 different models of pacemakers from four manufacturers. Scholten et al. (2005) concludes that the risk of interference inhibition of unipolar cardiac pacemakers from high voltage power lines in everyday life is small. In the unlikely event a pacemaker experiences interference, the pacemaker goes into a default pacing mode and then returns to its normal operation when the person moves away from the source of the interference. Modern bipolar devices are much less susceptible to interactions with electric fields. Dyrda et al.'s (2009) review of Trigano et al. (2005) concluded "risks with bipolar sensing [in pacemakers] appeared negligible." In addition, major manufacturers (Medtronic and Guidant) of pacemakers and implantable medical devices have indicated that electric fields below 6 kV/m are unlikely to cause interactions affecting operation of most of their devices (Tower Project 2005). Scholten (2004) indicated that moving 20 meters away from the point directly underneath the line (two 380 kV circuits) resulted in the most precipitous drop in electric fields.

4.5.1.3 Human Safety

Proper safeguards will be implemented during construction and operation of the facility. The transmission line and associated facilities will be designed to meet local, state, NESC, and Basin Electric safety standards. Construction crews will comply with local, state, NESC, and Basin Electric standards regarding the installation of facilities.

The proposed transmission line will be equipped with protective devices such as breakers and relays at the substation to safeguard the public from the transmission line if an accident occurs or if a structure or conductor falls to the ground.

4.5.2 Impacts

4.5.2.1 Segment A, B & C Corridor/Routes

Human Health

EMF will be strongest directly under the transmission line and decrease with increasing distance from the transmission line towards the ROW edge. As load changes on the transmission line, electric current flow changes, thus changing the magnetic field.

At the maximum-load operating condition under the transmission line, the electric field is 3.7 kV/m and the magnetic field is 277 mG. This would be considered the worst-case scenario for the Project. The results of Burns & McDonnell's analysis show that calculated EMF levels for the 345/115 kV project under maximum operating conditions and normal operating conditions are below the published guidelines from organizations (such as ICNIRP and ACGIH [Table 4.5-1]) and the states (Table 4.5-2) that have published safe-exposure guidelines.

The effects that may occur to a person with an implantable medical device are usually temporary and the medical device generally resumes normal function once the person is removed from the source of electric fields. At levels associated with high-voltage transmission lines, a transmission line within the Project Corridor will not have regular, temporary interference with implantable medical devices. No other EMF-related impacts to humans or animals are anticipated.

The nearest sensitive receptor (RV Park) from the centerline of Segment A is 75 feet, where EMF from the transmission line is predicted to be significantly within the protection standards for protection of the general public.

The nearest sensitive receptor (business) from the centerline of Segment B is approximately 235 feet, where EMF from the transmission line is predicted to be significantly within the protection standards for protection of the general public.

The nearest sensitive receptor (business) from the centerline of Segment C is approximately 40 feet, where EMF from the transmission line is predicted to be significantly within the protection standards for the general public.

Human Safety

No impacts are anticipated.

4.5.3 Mitigation

4.5.3.1 Segment A Corridor/Route

Human Health

The transmission corridor resides in a primarily rural location. There is one sensitive business receptor within 500 feet from the centerline of Segment A. The nearest sensitive business receptor to the proposed route will be no closer than approximately 75 feet. The land area in the NE ¼ of Section 22, T154, R102W is zoned as

a RV Park. At present, the RV Park is not operational. In selecting a route that avoids impacts to residences and other occupied structures, Basin Electric has limited human exposure to EMF to the extent practicable. At the edge of the 150 ROW, EMF from the transmission line is predicted to be significantly within the protection standards for protection of the general public. No additional mitigation should be needed.

A waiver from the RV Park owner will be acquired.

Human Safety

If the proper safeguards and protective measures are implemented as described above, no additional mitigation is required.

4.5.3.2 Segment B Corridor/Route

Human Health

Transmission Segment B corridor/route resides in a primarily rural location. The nearest sensitive residential receptor to the proposed centerline is approximately 285 feet, where EMF from the transmission line is predicted to be below rural background levels. A waiver will be acquired from the residence owner. There are three sensitive business receptors within 500 feet of Segment B. The closest is approximately 235 feet from Segment B's centerline. In selecting a route that avoids impacts to residences and other occupied structures, Basin Electric has limited human exposure to EMF to the extent practicable. EMF from the transmission line is predicted to be significantly within the protection standards for protection of the general public. No additional mitigation should be needed.

Human Safety

If the proper safeguards and protective measures are implemented as described above, no additional mitigation is required.

4.5.3.3 Segment C Corridor/Route

Human Health

The transmission corridor resides in a primarily industrial area. There are four sensitive business receptors within 500 feet of Segment C. The nearest sensitive business receptor to the proposed route is approximately 40 feet. In selecting a route that avoids impacts to residences and other occupied structures, Basin Electric has limited human exposure to EMF to the extent practicable. EMF from the transmission line is predicted to be significantly within the protection standards for protection of the general public. No additional mitigation should be needed.

Human Safety

If the proper safeguards and protective measures are implemented as described above, no additional mitigation is required.

4.6 Noise

Noise is composed of a variety of sounds of different intensities, across the entire frequency spectrum. Humans perceive sound when sound pressure waves encounter the auditory components in the ear. These components convert these pressure waves into perceivable sound.

Noise is measured in units of decibels (dB) on a logarithmic scale. Because human hearing is not equally sensitive to all frequencies of sound, certain frequencies are given more "weight." The A-weighted (dBA) scale corresponds to the sensitivity range for human hearing. A noise level change of 3-dBA is imperceptible to human hearing. A 5-dBA change in noise level, however, is clearly noticeable. A 10-dBA change in noise levels is perceived as a doubling of noise loudness.

As the decibel is logarithmic, direct addition of two noise sources is not proper. Rather, two similar noise sources added together only equate to a 3 dB in over-all noise. That is, if one noise source is measured at 40 dB in an environment, and an additional noise source of 40 dB is introduced into the same environment, the resultant noise level is not 80 dB, it is 43 dB. As the differences in noise levels between two noise sources deviate, the less the resultant noise level will be. If a 35 dB noise source is added to a 40 dB noise source, the resultant noise level would be approximately 42.5 dB. It is generally accepted that a difference of 10 dB between two added noise sources will not result in a measureable difference higher than the loudest noise source. Or, if a 9 dB noise source is introduced into a 40 dB environment, the resultant level will remain 40 dB and the lower noise source will typically be masked by the louder one.

Table 4.6-1 shows noise levels associated with common, everyday sources, and places the magnitude of noise levels discussed here in context. Low to mid-30 dBA are relatively low background levels and are generally representative of the Corridor. The project is in a rural area. Ambient noise in rural areas is commonly made up of wind and rustling vegetation, intermittent farm equipment operation, and infrequent vehicle pass-bys.

Table 4.6-1.
Common Noise Sources and Levels

Sound Pressure Level (dB)	Typical Sources
120	Jet aircraft takeoff at 100 feet
110	Same aircraft at 400 feet
90	Motorcycle at 25 feet
80	Garbage disposal
70	City street corner
60	Conversational Speech
50	Typical office
40	Living room (without TV)
30	Quiet bedroom at night

Source: Environmental Impact Analysis Handbook, ed. By Rau and Wooten, 1980

Transmission conductors and transformers at substations produce noise under certain conditions. The level of noise or its loudness depends on conductor conditions, voltage level, and weather conditions. Noise emissions from a transmission line are greatest during heavy rain and wet conductor conditions. In foggy, damp, or rainy weather conditions, power lines can create a subtle crackling sound due to the small amount of the electricity ionizing the moist air near the wires. During heavy rain the general background noise level is usually greater than the noise from a transmission line. In addition, very few people are out near the transmission line. For these reasons audible noise is not noticeable during heavy rain. During light rain, dense fog, snow, and other times when there is moisture in the air, the proposed transmission lines will produce

audible noise higher than rural background levels but similar to household background levels. During dry weather, audible noise from transmission lines is a slight, sporadic crackling sound.

4.6.1 Description of Resources

4.6.2 Impacts

Transmission line conductor noise levels were estimated using the Bonneville Power Administration Corona and Fields Interactive 1989 Experimental (CFI8X) model to evaluate audible noise from high voltage transmission lines. Where possible, the CFIX8 model was executed in a worst-case manner, to ensure that audible noise was not under-predicted. This involved adjusting the orientation of phase angles used in the CFIX8 model and assuming a wet environment.

4.6.2.1 Segment A, B and C Corridor/Routes

Audible noise was modeled from all proposed structures. These included the 345/115kV structure on Segment A, the 230/115kV structure on Segment B, and the 230kV structure on Segment C. Table 4.6-2 presents modeling results for the proposed line in dBA on an L_{50} basis. These levels are predicted to occur at a point five feet above the ground and positioned between the center-most pair of conductors wet conditions. The attenuation rate is approximately -3 dB per distance doubled. This rate is typical of noise sources that are characterized as line sources with the propagation path over agricultural lands.

Table 4.6-2.
Predicted Audible Noise from all lines for Route

	Distance from Center of Transmission Line Corridor (feet)										
	-300	-200	-100	-60	-40	0	40	60	100	200	300
Predicted Noise, L_{50} (dBA) from Proposed 345/115 kV line (Segment A)	50	52	55	56	57	57	56	55	54	51	49
Predicted Noise, L_{50} (dBA) from Proposed 230/115 kV line (Segment B)	30	32	35	37	37	38	37	36	34	32	30
Predicted Noise, L_{50} (dBA) from Proposed 115 kV line (Segment C)	12	14	16	18	19	20	19	18	16	14	12

As demonstrated in Table 4.6-2, the noise levels produced by the transmission line are as high as 57 dBA immediately below the structures (Segment A) and as low as 12 dBA 300 feet away from the structures (Segment C). It is anticipated that no noise from the transmission line will be encountered at distances further than 300 feet away as it will be masked by other noise sources such as traffic from nearby roadways, wind and other human activity.

Because North Dakota does not have definitive noise regulations and exceedance metrics listed within state or city guidelines, a noise "exceedance" or "impact" is difficult to define. However, a noise analysis performed by the firm Burns and McDonnell for this project introduced HUD noise guidelines as a measure for noise impact and exceedance. HUD recommends that noise levels do not exceed certain decibel levels gauged by an L_{dn} metric. The L_{dn} metric is a 24-hour noise metric (Level-*day*/*night*) which applies a 10 dB

penalty for nighttime hours between 10PM and 7AM. This is of course because most resting and sleeping activities are occurring during these hours. The Ldn HUD noise guidance is provided in Table 4.6-3 below.

Table 4.6-3. HUD Site Acceptability Standards

Noise Level, L_{dn} (dBA)	Acceptability
Not exceeding 65	Acceptable
65 to 75	Normally not acceptable
Exceeding 75	Unacceptable

Burns and McDonnell continue further that because HUD applies a 10 dB penalty to noise levels occurring during the evening, that 10 dB penalty should be applied to the standards for this analysis and that the final acceptability standard for noise along the proposed route should 55 dBA L_{eq} during the nighttime and 65 dBA L_{eq} during the day.

Therefore, because transmission lines emit noise throughout a 24-hour cycle, the 55 dBA metric is used here as a definition for a noise impact as it is the most conservative.

Construction Noise

The same firm, Burns and McDonnell examined construction noise and determined that the project has the potential to elevate local noise levels due to traffic, construction of transmission lines and ancillary electrical generation stations. However, these noise levels are deemed to be relatively short and temporary in their nature over the life of the project and cannot therefore be considered a noise impact.

4.6.2.2 Segment A Corridor/Route

The transmission corridor resides in a primarily rural location with some nearby traffic noise sources. There is one sensitive residential receptor within 500 feet from the centerline of Segment A. The nearest sensitive residential receptor to the proposed route will be no closer than approximately 75 feet. The land area in the NE ¼ of Section 22, T154, R102W is zoned as a RV Park. At present, the RV Park is not operational. At the edge of the 150 foot ROW, noise from the transmission line is predicted to be <55 dBA. It is somewhat likely that noise from the transmission line could be audible during late evening hours and at times when the ambient noise environment is the lowest however it is not classified as an impact as it will not exceed 55 dBA. A waiver from the RV Park owner will be acquired.

4.6.2.3 Segment B Corridor/Route

The transmission corridor resides in a primarily rural location with some nearby traffic noise sources. The nearest sensitive residential receptor to the proposed route is approximately 285 feet, where noise from the transmission line is predicted to be below rural background levels. A waiver will be acquired from the residence owner. There are three sensitive business receptors within 500 feet of Segment B. The closest is approximately 235 feet from Segment B's centerline. No mitigation measures are necessary since there will be no noise levels above 55 dBA at these receptors and therefore there area no noise impacts from the Project.

4.6.2.4 Segment C Corridor/Route

The transmission corridor resides in a primarily rural location with some nearby traffic noise sources. There are four sensitive business receptors within 500 feet of Segment C. The nearest sensitive business receptor to the proposed route is approximately 40 feet, where noise from the transmission line is predicted to be below

rural background levels. No mitigation measures are necessary since there will be no noise levels above 55 dBA at these receptors and therefore there area no minimal noise impacts from the Project.

4.7 Visual Impacts

4.7.1 Description of Resources

The topography in the Project area is mostly flat with some rolling hills. Elevations range between 2,031 and 2,264 feet above sea level. A topographic map of the Project area is shown in Figure 4.3. The landscape is characterized by short grass prairie containing a mixture of native grasses interspersed with crop fields. Large portions of the Project area are used for grazing livestock and hay production.

Existing electric infrastructure, such as transmission lines, distribution lines and substations, as well as oil and gas facilities are also scattered throughout the landscape. The settlements in the area are residences and farm buildings (inhabited and uninhabited) scattered along the county roads. These structures are focal points in the dominant open space character of the vicinity. Typically, the farmsteads and residences are located at lower elevations and/or are surrounded by wind-breaks to avoid winds common to the area. Roads generally follow along sections line following the topography.

4.7.2 Impacts

4.7.2.1 Segment A, B & C Corridor/Routes

The proposed transmission line will be visible to landowners and community residents who live near the proposed line within the Corridor/Routes. Double-circuiting the 230-kV and the 345-kV lines with the 115-kV will reduce visual impacts and over all land use impacts than if the lines were single-circuit. The majority of the proposed transmission line will be crossing agricultural land and will result in minimal visual impacts to residences. The impact to aesthetics will be minimal, due to the existing transmission lines. Segments A, B and C will be located outside the city of Williston; therefore, it will have minimal visual impacts to the city.

The predominant structure design will be double circuit steel single-pole structures which minimize visual impacts. The structures will be erected and will be directly imbedded into the ground. The structures will be up to 145 feet in height with an average span between each structure of 800 feet. Exhibit 2.5-1 through and Exhibit 2.5-3 show diagrams of the proposed structures.

4.7.3 Mitigation

4.7.3.1 Segment A, B & C Corridor/Routes

Although the transmission line will contrast with the surrounding land uses, these areas have already been impacted visually by the existing 41.6-kV, 115-kV, 230-kV, and 250-kV transmission infrastructure and more recently the industrialization of the project's eastern area due to the recent increase in oil activity in northwest North Dakota. The proposed Route will minimize the number of residences impacted by the line. Care will also be taken to avoid structure placement, as much as possible, in biologically sensitive areas such as wetlands and high quality native prairies.

4.8 Cultural Resources

4.8.1 Description of Resources

Basin Electric reviewed records at the North Dakota State Historic Preservation Office (SHPO) in June 2011 to understand any potential impacts of the proposed facilities on known or suspected cultural resources. Basin Electric reviewed the cultural resources records within the data gathering area (which includes Segments A, B and C as one continuous Corridor/Route). The data gathering area is defined as the route, plus one mile buffer area surrounding the route. Basin Electric has prepared a Class III Intensive Archaeological Resource Inventory (available upon request at SHPO) based on the information gathered for the data gathering area. Within this report Basin Electric summarized the Class I Literature Search data. A review of previous cultural resources studies and cultural resource recordation forms at the SHPO identified one previously recorded archaeological resource and one archaeological site lead within the Project area (Table 4.8-1).

In compliance with the North Dakota Century Code (Chapter 49-12, Energy Conversion and Transmission Line Siting Act), archaeological sites should be considered as a part of the process for the designation of transmission line sites, corridors, and routes. In an effort to meet guidance under this act Basin Electric completed a background records search at SHPO, completed a review of Government Land Office (GLO) maps, and completed a Class III Intensive Archaeological Resource Inventory of the project corridor. The project corridor was established by Basin Electric to be 150-foot-wide centered on the transmission line centerline. The surveys were conducted in September and October 2011.

Eighteen previously recorded surveys or investigations fall within the data gathering area. The SHPO files indicate that there are two previously recorded archaeological resources within the data gathering area (Table 4.8-1). The archaeological resources are composed of one archaeological site and one archaeological site lead. The Class I literature record search revealed that the archaeological site is represented by a historic transmission line and the site lead is represented by a prehistoric lithic scatter. At this time the NRHP eligibility status for both of these sites are unresolved. Review of the GLO maps did not produce any resources or features within the Project area.

Table 4.8-1.
Previously Identified Archaeological Sites and Leads within the Project Area

County	Site Number	Site Type	Location			NRHP Status
			T	R	S	
Williams	32WI482	Historic Transmission Line	Confidential			Not evaluated
Williams	32WIX103	Lithic scatter				Not evaluated

During the Class III Intensive Archeological Resource Inventory, two precontact archaeological stone resource sites were identified within the Corridor/Routes of Segment A. The two sites contained multiple stone features, totaling nine cairns, three stone circles, and two stone arcs. The NRHP statuses for these resources remain unresolved.

Basin Electric has provided the results of the Class III Intensive Archaeological Resource Inventory to SHPO for their review. These investigations were conducted by a professional archeologist permitted by the state of North Dakota per NDCC 55-03-01.

4.8.2 Impacts

4.8.2.1 Segment A, B & C Corridor/Routes

Basin Electric does not anticipate adverse impacts to previously identified archaeological resources as a result of the Project. Basin Electric will avoid known archaeological resources and any resources identified during the Class III Intensive Archaeological Resource Inventory.

4.8.3 Mitigation

4.8.3.1 Segment A, B & C Corridor/Routes

Basin Electric will avoid impacts to identified archaeological resources. In the event that an impact on unidentified resources would occur, Basin Electric would determine the nature of the impact and consult with SHPO on whether or not the resource was eligible for listing in the NRHP. If needed Basin Electric and SHPO would define a treatment plan for any NRHP eligible resources on case by case bases. Mitigation for resource related impacts may include an effort to minimize construction impacts on the resource and/or additional documentation through data recovery.

The two precontact archaeological stone resource sites will be identified by the placement of T-posts across the ROW incorporating a 50 foot buffer. No construction activity will occur within the restricted area.

4.9 Recreational Resources

4.9.1 Description of Resources

Recreational opportunities in Williams County include camping, hiking, biking, swimming, golfing, hunting, fishing and nature observation. Review of state and federal databases indicates that no registered national wildlife refuges, state wildlife management areas, state game refuges, game management areas, nature preserves, or county parks are present within either Segment's Corridor/Route. A ND State Land Department managed parcel is located 2.3 miles northeast of the northern end of Segment A. ND State Land Department land is open to walk-in hunting unless otherwise posted.

The Missouri River, located approximately 2.5 miles from the Western Williston Substation, provides opportunities for a variety of recreational activities in the region. Much of the land surrounding the Missouri River is managed by state and federal agencies which allow hunting in compliance with state regulations. The Trenton Wildlife Management Area, managed by the ND Game and Fish, is located approximately 12 miles southwest of Williston near Trenton, along the Missouri River and Lake Sakakawea (NDGFD 2006). The southern bank of the Missouri River, South of Williston, is managed by the US Fish and Wildlife as part of the Little Missouri National Grassland.

4.9.2 Impacts

4.9.2.1 Segment A, B & C Corridor/Routes

In general, recreational impacts will be visual in nature and limited to individuals using public or private property in the area for hiking, hunting, fishing, or nature observation. See Section 4.7 for detailed discussion

of anticipated visual impacts and proposed mitigative measures. No other significant impacts to recreational resources are anticipated.

4.9.3 Mitigation

4.9.3.1 Segment A, B & C Corridor/Routes

Recreational resources will not be impacted by the Project so no mitigation is proposed.

4.10 Effects on Land Based Economies

4.10.1 Description of Resources

4.10.1.1 Agriculture/Farming

The majority of both Segments' Corridor/Routes is cultivated farmland, pasture, and grasslands as shown on Figure 4.1. Cultivated land comprises approximately 28 acres of Segment A, 20 acres of Segment B and 0 acres of Segment C. There may be areas of cultivated land currently enrolled in the Conservation Reserve Program (CRP). Approximately 95 % of the land in Segment A, 85 percent of the land in the Segment B and 0 percent of the land in Segment C is utilized for agricultural purposes.

Williams County contains 857 farms of which the primary commodity is crops, primarily wheat. Cattle are the primary livestock in the counties. According to the 2007 Census of Agriculture, the amount of land in farms decreased 3 percent from 2002. The market value of production in 2007 was approximately $127,333,000. Crop sales account for approximately 91 percent of the total value.

Crops are a large percentage of the value and the land type, such as prime farmland, is important in production. Prime farmland is the land that has the best combination of physical and chemical characteristics for producing food, feed, forage, fiber, and oilseed crops. The National Resource Conservation Service (NRCS) has two classifications for prime farmland. The first is where all areas of the soil series are classified prime farmland. The second is where only the drained areas of the soil series are prime farmland. The NRCS also identifies farmland of statewide and local importance, which is land that is important for the production of food, feed, fiber, forage, and oilseed crops. Generally, additional farmlands of statewide or local importance include those that are nearly prime and that produce high yields of crops in an economic manner when treated and managed according to acceptable farming methods. Some may produce as high a yield as prime farmland soils if conditions are favorable.

Table 4.10-1 and Table 4.10-2 list the soils considered prime farmland and soils of statewide or local importance within Segments A and B. Figure 4.4 shows the prime farmland soil distribution in the Corridor/Routes. Figure 4.4 identifies the soils in Segment C as prime farmland of statewide importance, however, the entire area is currently being used as commercial and industrial land uses.

The North Dakota State Water Commission's database reveals two irrigation permits were issued within the vicinity of the Route and may or may not be located within the Corridor/Routes. Basin Electric will avoid these parcels of land once final locations are determined. It is unlikely the Route will adversely impact any irrigation permits since it is primarily located adjacent to roads or property boundaries and will therefore not affect mechanical irrigation.

There is a zoned recreational vehicle (RV) park within 500 feet of Corridor/Route Segment A. In Segment B there is one residence (approximately 285 feet) and three industrial businesses within 500 feet (Figure 4.2).

There are no permanent residences within Segment A or C's Corridor/Routes. The RV Park currently is zoned but is not presently operational. There are four industrial businesses within 500 feet of Segment C (Figure 4.6).

Table 4.10-1.
Prime Farmlands, Segment A

Corridor Soil Units	All Areas Are Prime Farmland	Soil of Statewide/ Local Importance	Prime Farmland Only When Drained	Prime Farmland if Irrigated
Arnegard-Shambo loams, 2 to 6 percent slopes		X		
Williams-Bowbells loams, 0 to 3 percent slopes		X		
Williams-Bowbells loams, 3 to 6 percent slopes		X		
Williams-Zahl loams, 6 to 9 percent slopes				
Zahl-Williams loams, 15 to 60 percent slopes				
Zahl-Williams loams, 9 to 15 percent slopes				

Table 4.10-2.
Prime Farmlands, Segment B

Corridor Soil Units	All Areas Are Prime Farmland	Soil of Statewide/ Local Importance	Prime Farmland Only When Drained	Prime Farmland if Irrigated
Arnegard loam, 0 to 2 percent slopes	X			
Parnell silty clay loam, 0 to 1 percent slopes				
Williams-Bowbells loams, 0 to 3 percent slopes		X		
Williams-Bowbells loams, 3 to 6 percent slopes		X		
Williams-Zahl loams, 6 to 9 percent slopes				
Zahl-Williams loams, 9 to 15 percent slopes				

4.10.1.2 Woodlands

Economically important forestry resources are not found in any of the Segments.

4.10.2 Impacts

4.10.2.1 Agriculture/Farming

Impacts to agriculture will be nominal. No impacts are anticipated to animal health and safety due to the construction or operation of the transmission line. Except for the physical locations of the transmission line structures, all the land surrounding the transmission line will be available for grazing. Permanent impacts will be the areas surrounding the transmission line structures. All areas underneath and surrounding the proposed

transmission line will be available for agricultural use following construction. Temporary impacts typically include soil disturbance, possible compaction around each pole and crop damage, if construction is during the growing season.

The effect of heavy equipment on agricultural soils was considered. Compaction of soil is a concern where construction equipment is used intensively, even during a relatively short duration such as the construction season needed for transmission line installation.

4.10.2.2 Woodlands

No woodlots are located within the Corridor/Routes so no impacts are anticipated.

4.10.2.3 Segment A Corridor/Route

Agriculture/Farming

Temporary impacts for each pole would typically involve up to 0.29 acres of ground disturbance. Temporary impacts from transmission line construction were developed assuming the entire 150 foot ROW could potentially be used during construction in the Segment A ROW. The total temporary impacts from construction were estimated to be approximately 29.5 acres. This is considered a conservative estimation because using the entire ROW during construction is not anticipated.

Permanent impacts would be approximately 0.0009 acres per pole. Segment A is likely to have 17 poles constructed in the ROW and the estimated total impacts will be approximately 0.0153 acres. These impacts were not calculated according to land use types because the final structure locations were not known at the time of application submittal.

Woodlands

No woodlots are located within the Corridor/Routes so no impacts are anticipated and no mitigation is proposed.

4.10.2.4 Segment B Corridor/Route

Agriculture/Farming

Temporary impacts for each pole would typically involve up to 0.29 acres of ground disturbance. Temporary impacts from transmission line construction were developed assuming the entire 100 foot ROW could potentially be used during construction in the Segment B ROW. The total temporary impacts from construction were estimated to be approximately 23.0 acres. This is considered a conservative estimation because using the entire ROW is not anticipated.

Permanent impacts would be approximately 0.0006 acres per pole. Segment B is likely to have 13 poles constructed in the ROW and the estimated total impacts will be approximately 0.0078 acres. These impacts were not calculated according to land use types because the final structure locations were not known at the time of application submittal.

Woodlands

No woodlots are located within the Corridor/Routes so no impacts are anticipated and no mitigation is proposed.

4.10.2.5 Segment C Corridor/Route

Agriculture/Farming

Temporary impacts for each pole would typically involve up to 0.29 acres of ground disturbance. Temporary impacts from transmission line construction were developed assuming the entire 100 foot ROW could potentially be used during construction in the Segment C ROW. The total temporary impacts from construction were estimated to be approximately 2.4 acres. This is considered a conservative estimation because using the entire ROW is not anticipated.

Permanent impacts would be approximately 0.0005 acres per pole. Segment C is likely to have 2 poles constructed in the ROW and the estimated total impacts will be approximately 0.001 acres. These impacts were not calculated according to land use types because the final structure locations were not known at the time application submittal.

Woodlands

No woodlots are located within the Corridor/Routes so no impacts are anticipated and no mitigation is proposed.

4.10.3 Mitigation

4.10.3.1 Segment A, B & C Corridor/Routes

Agriculture/Farming

Only land used for structures will be unavailable for crop production. Basin Electric will work with landowners to minimize impacts to their land. Once the transmission line is constructed, all land surrounding the structures can still be farmed or grazed. Construction staging areas and temporary transmission line access roads will be disked as necessary to relieve excessive compaction caused by construction. Landowners will be compensated for any damage that occurs to crops due to the construction of the transmission line.

Woodlands

No woodlots are located within the Corridor/Routes so no impacts are anticipated and no mitigation is proposed.

4.11 Soils

A soil association is made up of two or more geographically associated soils or miscellaneous areas that are shown as one unit on a map (Soil Survey Staff & NRCS 2011).

4.11.1 Description of Resources

4.11.1.1 Segment A Corridor/Route

The soils in Segment A are composed of one soil association the Williams-Bowbells loam. A description of these soil associations is found below.

4.11.1.2 Segment B Corridor/Route

The soils in the Segment B are largely composed of two soils associations; Williams-Bowbells loam, and the Arnegard loam. A description of these soil associations is found below.

4.11.1.3 Segment C Corridor/Route

The soils in the Segment C are largely composed of two soils associations; Williams-Bowbells loam, and the Arnegard loam.

Williams-Bowbells loam soils are very deep, well drained, commonly found on level to steep glacial till plains and moraines. Major uses included cultivation, hay, or pasture. Arnegard loam and it is characterized as being very deep, well drained soils that forms in calcareous loamy alluvium on upland swales, terraces, fans, and foot slopes. Most land uses include spring wheat, oats, and barley and hay crops. Williams-Zahl (and Zahl-Williams) loams are similar to Williams-Bowbells loams in that they are very deep, well drained soils commonly found on glacial till plains, moraines and valley side slopes. They are typically found in range and pasture lands (NRCS 1998a, 1998b, 1998c).

4.11.2 Impacts

The permanent impact to soils in the area will be limited to areas removed from agricultural production at transmission line structure locations. Temporary impacts to soils are anticipated during construction in the areas immediately surrounding the transmission line structures.

The potential for wind and water erosion exists in the soil types found within the Corridor/Routes. Construction practices will minimize soil erosion during and after transmission line construction and impacts are not expected to be significant.

4.11.2.1 Segment A Corridor/Route

The permanent impact to soils in the area will be limited to areas removed from agricultural production at transmission line structure locations. These impacts will be relatively minor, totaling approximately 0.0009 acres per structure. During transmission line construction, approximately 29.5 acres may be impacted temporarily. This impact calculation is considered conservation because using the entire ROW is not anticipated. In isolated cases, grading may be required for access roadway construction. Generally, soil removed in these cases will be on steep slopes and not agriculturally productive.

4.11.2.2 Segment B Corridor/Route

The permanent impact to soils in the area will be limited to areas removed from agricultural production at transmission line structure locations. These impacts will be relatively minor, totaling approximately 0.0006 acres per structure. During transmission line construction, approximately 23.0 acres may be impacted temporarily. This impact calculation is considered conservation because using the entire ROW is not anticipated. In isolated cases, grading may be required for access roadway construction. Generally, soil removed in these cases will be on steep slopes and not agriculturally productive.

4.11.2.3 Segment C Corridor/Route

The permanent impact to soils in the area will be limited to areas removed from industrial areas at transmission line structure locations. These impacts will be relatively minor, totaling approximately 0.0006 acres per structure. During transmission line construction, approximately 2.4 acres may be impacted temporarily. This impact calculation is considered conservation because using the entire ROW is not anticipated. In isolated cases, grading may be required for access roadway construction. Generally, soil removed in these cases will be on steep slopes and not agriculturally productive.

4.11.3 Mitigation

4.11.3.1 Segment A, B & C Corridor/Routes

Wind and water erosion are potential hazards for the soils found within the Corridor/Route. To minimize erosion during and after construction, BMPs for erosion and sediment control (SN 19389 9/99) will be utilized. Only non-structural practices should be required. These practices include: temporary seeding, permanent seeding, mulching, filter strips, erosion blankets, grassed waterways, and sod stabilization. Top soil will be segregated if cuts are made during construction and reapplied after final contours have been graded.

4.12 Geologic and Groundwater Resources

4.12.1 Description of Resources

The bedrock geology in the Project area consists of the Paleocene Epoch aged (65.5 to 56 million years ago) Sentinel Butte Formation. The Sentinel Butte Formation consists of alternating beds of grayish brown to gray sandstone, siltstone, mudstone, claystone, and lignite (USGS 2008a). It contains many river, lake, and swamp sediment and can range up to 200 meters (600 feet) in thickness.

The surficial geology in the Project area is Pleistocene Epoch aged (2.6 million years to 11,700 years) Coleharbor Formation. The Coleharbor Formation is a moderately well sorted cross-bedded sand and plane-bedded gravel deposit of glacial till. The formation also includes sediment of melt-water and other river deposits and can reach a thickness of up to 30 - 200 meters (100 - 600 feet).

Oil and gas development is ongoing in the Project area. According to the North Dakota Department of Mineral Resources, more than 1.8 million barrels of oil have been produced in Williams County. Currently, there are 43 rigs actively drilling in Williams County (NDDMR 2011). Information about the exact locations and scope of future developments was not available as this information is generally confidential and proprietary. As a result, the exact well locations, the number of new wells, and associated impacts are not known at this time.

The Paleontology Portal and the U.S. Geological Survey (USGS) website did not identify any known paleontological resources near the Project area (USGS 2008b). The closet identified paleontological sites are in the Theodore Roosevelt National Park and Historic Medora areas, which are located more than 100 miles to the southwest of the Proposed Action.

According to the North Dakota Geological Survey (NDGS), North Dakota is located in an area of very low earthquake probability. There are no known active tectonic features in south-central North Dakota and the deep basement formations underlying North Dakota are expected to be geologically stable (Bluemle 1991). This information is supported by USGS seismic hazard maps, which show that the Project area would be located in an area with very low seismic risk (USGS 2008a). Related hazards, such as soil liquefaction, are therefore also unlikely.

Groundwater resources in the Project area are included in the Fort Union and Fox Hills Formations, Tertiary period aquifers. Tertiary aquifers consist mostly of semi-consolidated to consolidated sandstone beds of Oligocene to Paleocene age (USGS 1996). These water-yielding sandstones are an important water source in the region. According to the North Dakota State Water Commission (NDSWC), water observation wells access groundwater resources as shallow as 6 feet below the ground surface (NDSWC 2011).

Review of the North Dakota State Water Commission (Commission) database indicates that depths of wells within the Corridor range from approximately 110 to 1,880 feet. The State Water Commission database identifies various different wells. Within half mile of the Corridor there were a total of 33 domestic wells, 2 stock wells and one test hole boring that have been identified by the Commission. No municipal water supplies or reservoirs have been identified in the Corridor/Routes. Given the presence of residences in the Corridor/Routes, it appears that the some of the existing wells are not recorded in the State Water Commission database. This indicates that more domestic wells are in the area than have been documented; it is assumed that each residence has at least one water supply well. Domestic groundwater supply appears to be fairly accessible in the Corridor/Routes, and is dependent on the occurrences of sand and gravel aquifers at any given area.

4.12.2 Impacts

4.12.2.1 Segment A, B & C Corridor/Routes

Impacts to geologic and groundwater resources are not anticipated. Construction and maintenance personnel traveling on gravel roads and across ROWs, would impact surficial soils. Due to the temporary and intermittent nature of these activities a measurable loss in soil productivity and a contribution to air or water degradation would not occur as a result of the day to day operation, and permanent installation of the Project.

The Project is anticipated to result in minor impacts to geology during excavations for transmission line structures, given the following:

- Appropriate design that incorporates results of subsurface characterization
- Implementation of BMPs, including appropriate strategies for selection of final locations of Project facilities, utilization of foundation types best suited to the site subsurface conditions, inclusion of drainage control features, and proper construction techniques
- A SWPPP will be produced that includes procedures for proper storage and disposal of all hazardous and non-hazardous wastes generated during the construction process.

4.12.3 Mitigation

4.12.3.1 Segment A, B & C Corridor/Routes

Geologic resources may be impacted since there is the possibility with any construction activity of spilling fuel, hydraulic fluid, or other regulated materials. The specified contractor would minimize the likelihood of such an event by ensuring that refueling takes place at secure areas. Spill kits would be maintained at these sites to contain and clean up any spills that may occur. Construction crew members would be trained in spill prevention and clean up.

If the dewatering of groundwater is found to be necessary during construction (i.e., during pole embedding), the effects on water tables would be localized and short-term. Dewatered groundwater would be properly discharged to minimize erosion and facilitate infiltration back into the ground. The Project would have no impact on either municipal or private water uses in the Project area. No water storage, reprocessing, or cooling is required for either the construction or operation of the transmission line. Therefore the Project would not result in violations of groundwater quality.

4.13 Surface Water and Floodplain Resources

4.13.1 Description of Resources

Surface water and floodplain resources for both Segments were identified by reviewing U.S. Geological Survey National Water Information System Maps, North Dakota State Water Commission Map Services, and USFWS National Wetlands Inventory (NWI) data. Flood Insurance Rate Maps (FIRM) produced by the Federal Emergency Management Agency (FEMA) are not available for this section of Williams County. Surface waters located within the Corridor include several intermittent streams, multiple wetlands (discussed in detail in Section 4.14), and a few freshwater ponds. These water resources are shown in Figure 4.5.

The Project area lies within the City of Williston and Painted Woods Creek watersheds and is within an area of possible but undetermined flood hazards, as no flood hazard analysis has been conducted for the area.

4.13.2 Impacts

4.13.2.1 Segment A, B & C Corridor/Routes

Construction of the transmission line will disturb land along the Corridor/Routes. In general, the transmission line structures will be built on uplands; this will avoid intermittent streams and wetlands located in the lower positions in the landscape. The transmission line construction access road will be built to avoid temporary impacts to surface waters.

Impacts to the intermittent streams along the Route are not anticipated. Impacts to wetlands are addressed below in Section 4.14.

4.13.3 Mitigation

4.13.3.1 Segment A, B & C Corridor/Routes

Both Segments minimize impacts to waters of the U.S. to the extent practicable. It is not anticipated that a permits through the USACE will be required due to the minimal presence of wetlands in the Corridor/Routes. Basin Electric anticipates spanning any wetlands within the Corridor/Routes so no poles will be placed within a wetland.

Construction access roads adjacent to wetlands or intermittent streams and drainageways will be designed in a manner so runoff from the upper portions of the watershed can flow unrestricted to the lower portion of the watershed. A NPDES permit application and Storm Water Pollution Prevention Plan (SWPPP), will be prepared by Basin Electric and submitted to the NDDH prior to the initiation of transmission line construction.

No impacts to intermittent streams and drainageways are anticipated, therefore no mitigation is necessary. Mitigation for surface water impacts will meet or exceed regulatory requirements.

4.14 Wetlands

4.14.1 Description of Resources

Wetlands within the Corridor/Routes were initially identified by reviewing NWI Maps (Figure 4.5). The USFWS uses aerial photographs as a basis for NWI maps. The NWI map provides guidance in determining areas to be evaluated for wetland characteristics, but should not be used as the sole basis for wetland determinations.

A formal wetland delineation of both Corridor/Routes was completed in August and November 2011. Wetlands within the Corridor/Routes are all isolated and relatively small, ranging in size from approximately 100 square feet to 2 acres. All of the wetlands in the Corridor/Routes have been mapped as either freshwater emergent or freshwater ponds. The NWI wetland types and their acreages within the Corridor/Routes are presented in Table 4.14-1.

No riverine wetlands were identified along the Route. Basin Electric completed a wetland delineation to verify the presence and type of wetlands along the Corridor/Routes. Some wetlands in farmed areas may have been drained for agriculture.

Table 4.14-1.
NWI Wetland Types and Acreages in Segments A, B & C

Cowardin Classification	Acres within Segment A	Acres within Segment B	Acres within Segment C
Freshwater Emergent Wetland (PEMC)	0.18	0	0

4.14.2 Impacts

4.14.2.1 Segment A, B & C Corridor/Routes

There are minimal wetlands within the Corridor/Routes. No impacts to wetlands are anticipated.

During construction there is the possibility of sediment reaching surface waters as the ground is disturbed by excavation, grading, and construction traffic. Once the Project is completed, it will have no impact on surface water quality.

Basin Electric conducted a wetland delineation to assure impacts to wetlands are avoided to the extent practicable. Basin Electric intends to span all wetlands. Should wetland delineations determine impacts are unavoidable, Basin Electric/MWEC will mitigate those impacts as required by the USACE.

4.14.3 Mitigation

4.14.3.1 Segment A, B & C Corridor/Routes

Wetlands will be avoided to the extent practicable during the construction phase of the Project. If USACE jurisdictional wetland impacts are unavoidable, then a Section 404 and 401 permit application will be submitted to the USACE and state of North Dakota, respectively. Permanent impacts to wetlands and waters will be mitigated according to regulatory requirements.

Basin Electric will use BMPs during construction and operation of the transmission line to protect topsoil, adjacent wetland resources and minimize soil erosion. Practices may include containing excavated material, protecting exposed soil, stabilizing restored material and revegetating disturbed areas with native species.

4.15 Vegetation

4.15.1 Description of Resources

The Project area is located in the Northern Great Plains Spring Wheat Land Resource Region Major Land Resource Area (MLRA 2011) and the Glaciated Dark Brown Prairie Ecoregion. Native grasslands are largely replaced by spring wheat, alfalfa, and rangeland areas. This area supports natural prairie vegetation

characterized by western wheatgrass (*Pascopyrum smithii*), needle-and-thread (*Hesperostipa comata*), green needlegrass (*Stipa viridula*), and blue grama (*Bouteloua gracilis*). Little bluestem (*Schizachyrium scoparium*) is present on shallow soils and some sage (*Salvia spp.*) can be found on droughty soils. There are numerous temporary and seasonal wetlands with vegetation that includes cattails, cordgrass, rushes, and sedges. Historically, vegetation in the western region of North Dakota consisted of mixed-grass prairie. The present vegetative cover in the area is primarily row crops, pastured mixed-grass prairie, and non-native grassland. Trees and shrubs are scarce, consisting of planted trees and shrubs associated with farmstead windbreaks and tree rows

Based on a review of aerial photographs, land use database information, USFWS database information, and a visit to the Corridor and Route, it was determined that the majority of the land area is agricultural land use. Table 4.3-1 identifies current land use. Eighty-two percent of the land use within the Corridor is cropland or grassland. Approximately 2 percent of the Corridor is wetland or riparian area.

Eighty-six percent of the land use within the Route is cropland and grassland. Approximately 1 percent of the Route is wetland or riparian area. Wetland acreage for this section was calculated based on available general land cover data, and may vary from acreage calculated from specific wetland data presented in Section 5.14.

The principal crop in Williams County is wheat. Other crops include barley, lentils, and hay (USDA 2011 - Cropscape). Grasslands are used for range and pasture of cattle. Heavily grazed range typically contains Kentucky bluegrass, quack grass, and brome grasses. Lightly grazed or undisturbed range contains native prairie species. Additional information on agriculture and farming can be found in Section 4.10.

4.15.2 Impacts

Permanent impacts to vegetation will occur at each structure location. Temporary impacts will occur around each pole and along the easement as the transmission line is constructed.

4.15.2.1 Segment A, B & C Corridor/Routes

It is anticipated that approximately 32 structures will be required for the Project, which is dependent on the length of approximately 3.7 miles and average spans of 800 feet. Approximately 1045 ft^2 (0.024 acres) of permanent impacts are anticipated due to structure placement. Temporary impacts will occur during construction and will include ground disturbance by construction equipment around each structure and along the right-of-way as the line is constructed. These impacts are anticipated to be approximately 56 acres.

Temporarily disturbed areas will be reseeded per NRCS recommendations to blend in with existing vegetation.

4.15.3 Mitigation

4.15.3.1 Segment A, B & C Corridor/Routes

Basin Electric will use BMPs during construction and operation of the transmission line to protect topsoil and adjacent resources and to minimize soil erosion. Practices may include containing excavated material, protecting exposed soil, stabilizing restored material and revegetating rangelands with native species.

4.16 Wildlife

4.16.1 Description of Resources

Wildlife in the Project area consists of birds, mammals, fish, reptiles, amphibians, and insects, both resident and migratory, which utilize the Project area habitat for forage, migratory stopover, breeding, and/or shelter.

Species present in the Project area are associated with agricultural fields, pasture grasslands, and wetland areas. Common mammals in the Project area include raccoon, mink, skunk, weasel, white-tailed deer, coyote, red fox, badger, porcupine, and rabbit.

4.16.2 Impacts

4.16.2.1 Segment A, B & C Corridor/Routes

Raptors, waterfowl, and other bird species may be affected by the construction and placement of the transmission lines. Avian collisions are a possibility after the completion of the transmission line. Waterfowl are typically more susceptible to transmission line collision, especially if the line is placed between agricultural fields that serve as feeding areas, or between wetlands and open water, which serve as resting areas. Generally, the most difficult part of the structure for the bird to see is the shield wire.

Additionally, large birds, such as raptors, could potentially be impacted by new transmission lines through electrocution. Electrocution occurs when birds with large wingspans come in contact with either two conductors or a conductor and a grounding device.

4.16.3 Mitigation

4.16.3.1 Segment A, B & C Corridor/Routes

The following measures will be used, to the extent practicable, to help avoid potential impacts to wildlife along the Route during transmission line design and operation:

- Single-pole steel structures will be used as the primary structure design for the transmission line.
- The proposed transmission line will be designed to meet APLIC raptor-safe design standards.
- Basin Electric is working with agencies to identify any areas that may require marking transmission line shield wires and/or to use alternate structures to reduce collisions.
- Basin Electric will avoid or minimize disturbance of individual wetlands or drainage systems during construction and operation of the Project.
- Basin Electric will maintain sound water and soil conservation practices during construction and operation of the Project to protect topsoil and adjacent resources and to minimize soil erosion. To minimize erosion during and after construction, North Dakota BMPs for erosion and sediment control (SN 19389 9/99) will be utilized. These practices include: temporary seeding, permanent seeding, mulching, filter strips, erosion blankets, grassed waterways, and sod stabilization.
- Basin Electric will revegetate non-cropland and pasture areas with seeding mix as recommended by the NRCS.
- Basin Electric will inspect and control noxious weeds in the vicinity of the transmission line and associated facilities immediately after construction and periodically for the life of the project.

Basin Electric is committed to minimizing wildlife impacts within the Project area.

4.17 Rare and Unique Natural Resources

4.17.1 Description of Resources

The Endangered Species Act (ESA) of 1973, as amended, provides for the conservation of ecosystems upon which threatened and endangered species of fish, wildlife, and plants depend. Section 7 of the ESA requires federal agencies to insure that any action authorized, funded, or carried out by them is not likely to jeopardize

the continued existence of listed species, or to modify their critical habitat. The RUS is developing a Biological Assessment (BA) to support their efforts to meet their responsibilities under Section 7(a) of the ESA.

Federally threatened species are those species likely to become endangered within the foreseeable future throughout all or a significant portion of their range. Federally endangered species are those species already in danger of extinction throughout all, or a significant portion of, their range. Table 4.17-1 below summarizes federally-designated species that may occur within the Project area. Of these five, the whooping crane and Sprague's pipit have the highest potential of occurring in the Project area. Habitat for the other species is either completely lacking or is extremely limited in the Project area.

Table 4.17-1.
Federally-Listed Threatened and Endangered Species

Species		Habitat and Range	Status
Common Name	Scientific Name		
Pallid sturgeon	*Scaphirhynchus albus*	Bottom dwelling, Missouri and Yellowstone Rivers	E
Piping plover	*Charadrius melodus*	Missouri River sandbars, alkali beaches	T, CH
Interior least tern	*Sterna antillarum*	Missouri River and Yellowstone sandbars; beaches;	E
Whooping crane	*Grus americana*	Wetlands; migrant western ND	E
Gray wolf	*Canis lupus*	Frequently observed in Turtle Mtns.	E
Sprague's pipit	*Anthus spragueii*	Native medium to intermediate height prairie.	C
Pallid sturgeon	*Scaphirhynchus albus*	Bottom dwelling, Missouri and Yellowstone Rivers	E

Surveys indicated that suitable mixed-grass prairie habitat is present within the area, and that Sprague's pipits likely utilize the habitat. Loss of habitat could occur where transmission line structures. Impacts to mixed-grass prairie would be limited to localized permanent impacts due to structure installation or temporary impacts due to construction activities. Minimization of habitat disturbance and limiting ground clearing to fall and winter (prior to the nesting season) make the Project not likely to adversely affect Sprague's pipit.

Historic whooping crane observations do not indicate that the area is frequently used by whooping cranes for migration, stopover, or foraging (USFWS 2008). Surveys identified two wetlands within one mile of the proposed project that offer suitable whooping crane stopover habitat. Construction and operation of the project could displace whooping cranes from available stopover habitat, both temporarily and in the long-term. Additionally, if whooping cranes should frequent the area, collisions with transmission lines during take-off and landing would be a concern. In order to prevent whooping crane collisions, the lines would be marked with devices within one mile of two separate wetland areas that would alert the birds to the presence of a line in the air. By following these mitigation measures, the Project would not likely adversely affect whooping cranes.

North Dakota Game and Fish (NDGF) indicated that there are several Species of Conservation Priority (SoCP) that have been documented in the Missouri Coteau geographic region. Impacts to many of these species can be avoided or minimized by focusing construction activities on cultivated landscapes. No SoCP or significant ecological communities are known to occur within one mile of the proposed transmission line

according to the records obtained from the North Dakota Natural Heritage biological conservation database Appendix D.

Areas of suitable and potentially suitable habitat for level I SoCP were reviewed during field surveys, and no high quality habitat was observed. Additionally, no SoCP were identified during the surveys. It is possible that these species could be present in or near the Project but no high quality habitat was observed in the Project Area. If the SoCP were present, it is likely that they would avoid the area during construction when crews are present.

4.17.2 Impacts

4.17.2.1 Segment A, B & C Corridor/Routes

Sprague's Pipit

Impacts to mixed-grass prairie would be limited to localized permanent impacts due to structure installation or temporary impacts due to construction activities. Minimization of habitat disturbance and limiting ground clearing to fall and winter (prior to the nesting season) make the Project not likely to adversely affect Sprague's pipit.

Whooping Crane

Surveys identified one wetland within one mile of Segment A that offer suitable whooping crane stopover habitat. Construction and operation of the project could displace whooping cranes from available stopover habitat, both temporarily and in the long-term. Additionally, if whooping cranes should frequent the area, collisions with transmission lines during take-off and landing could be a concern.

4.17.3 Mitigation

4.17.3.1 Segment A, B & C Corridor/Routes

The transmission line(s) will be marked with bird flight diverters within a mile of suitable habitat whooping crane habitat.

4.18 Summary of Route Impacts

Table 4.18-1 summarizes the resources that will be impacted as a result of the construction of the transmission line and the appropriate mitigation.

Table 4.18-1.
Summary of Route Impacts and Mitigation

Resource	Impact	Mitigation
Demographics	Socioeconomic impacts are primarily positive due to increased expenditures during construction and the long-term benefits of an increased tax base of the county due to property taxes. A nominal amount of land will be permanently removed from production due to the construction of the Project.	Impacts are primarily positive, so no mitigation is proposed for socioeconomic impacts. Impacts to landowners will be minimized to the extent practicable.
Land Use	Approximately 0.024 acres of land will be permanently impacted due to the construction of the transmission line. Land use is primarily agriculture and will remain in agriculture land use since the land under or adjacent to the line can still be used by the landowner.	Basin Electric will work with landowners and regulatory agencies to minimize impacts of the Project.
Public Services	No impacts are anticipated.	The transmission system will be designed and constructed according to the configuration identified by NESC to mitigate any potential impacts. Impacts to existing public services will be avoided to the extent practicable.
Human Health and Safety	No impacts are anticipated.	Basin Electric will follow "prudent avoidance" methods to minimize EMF exposure and any potential impacts to human health. If proper safeguards are implemented, no additional mitigation is required.
Noise	The noise sensitive land uses along the Route are the residences near transmission line. The noise level at 300 feet from the existing and proposed lines is between 38 and 40 dBA. Noise impacts are nominal. No impacts to noise sensitive land uses are anticipated.	No mitigative measures are proposed. Basin Electric has acquired a waiver to the avoidance criteria requirement of having a buffer of 500 feet from a residence. This will mitigate any potential impacts due to noise.
Visual	The transmission line will be evident to individuals traveling on County roads in close proximity to the Route.	The Route minimizes the number of residences impacted by the line.
Cultural and Archaeological	No impacts to identified cultural resources are anticipated.	Basin Electric will avoid impacts to cultural resources
Recreational Resources	Impacts to recreational resources are not anticipated but would be primarily visual in nature.	The Route will follow existing transmission line routes and will avoid direct impacts to recreational areas.
Land Based Economies	A total of approximately 0.024 acres of land will be permanently impacted by the transmission line construction. Approximately 6 acres of temporary impacts are anticipated.	Basin Electric will work with landowners to minimize impacts to their land. Prime farmland will be avoided to the extent practicable.

Resource	Impact	Mitigation
Soils	A total of approximately 0.024 acre of land will be permanently impacted by the transmission line construction. Approximately 6 acres of temporary impacts are anticipated.	BMPs for erosion and sediment control will be utilized to minimize wind and water erosion along the Route. Only land needed for the transmission line structures will be permanently impacted. Temporarily disturbed areas will be restored.
Geologic and Groundwater Resources	No impacts to geologic and groundwater resources are anticipated.	No mitigative measures are necessary.
Surface Water and Floodplain Resources	No impacts are anticipated to intermittent streams and drainageways.	To minimize impacts during construction an NPDES permit and SWPPP will be prepared and submitted to the North Dakota of Health.
Wetlands	There are no anticipated impacts to wetlands.	Basin Electric will span wetlands to mitigate impacts.
Vegetation	A total of approximately 0.024 acre of land will be permanently impacted by the transmission line construction. Approximately 6 acres of temporary impacts are anticipated.	Basin Electric will use BMPs during construction and operation to minimize impacts.
Wildlife	Impacts to wildlife populations are expected to be minimal. Potential avian collisions may occur, but are anticipated to be relatively small.	A variety of mitigative measures will be implemented, as discussed in Section 4.16.
Rare and Unique Natural Resources	Impacts to rare and unique natural resources are not anticipated.	No mitigative measures are necessary.

5 Public and Agency Coordination

Keeping the public informed on the status of the Project is a key component to its success. Principal stakeholders in the Project are landowners that have entered into easement agreements with Basin Electric and MWEC. Public agencies have also been consulted as part of Project development.

The Project involves double-circuiting an approximately 3.7 mile section of the proposed MWEC Williston to Stateline 115-kV transmission line project. This double-circuit was studied as part of the Williston to Stateline Project Environmental Assessment (EA) that was developed by Western Area Power Administration and MWEC. Consequently, public coordination for the Project primarily occurred as part of the Williston to Stateline 115-kV transmission line project.

Coordination activities associated with the Project include:

- June 17, 2011 public scoping meeting Notice for the Williston to Stateline EA;
- July 6, 2011 public scoping meeting held at Ernie French Extension Center in Williston, ND;
- Public comment period for the Williston to Stateline EA;

Correspondence with US Army Corps of Engineers, ND Department of Health, ND Game & Fish Department, State Historical Society of North Dakota, ND Parks & Recreation Department, US Fish and Wildlife Department. Agency response letters for the Williston to Stateline EA (which includes the area of the Project) are included in Appendix B.

6 Identification of Required Permits/Approvals

The Federal and state permits or approvals that have been identified as potentially being required for the construction and operation of the Project are shown in Table 4.18-1.

Table 4.18-1. Possible Permits and Approvals

Agency	Type of Approval	Status*	Need
Federal Approvals			
Western Area Power Administration	Findings of no Significant Impact	In Process	Need Findings before construction can begin
US Army Corps of Engineers (USACE)	Section 404 Permit	Final layout will determine whether permit/approval is needed	Permit required for filling in jurisdictional waters of the U.S. Project will avoid or minimize impacts on waters of the U.S. to the extent practicable. Coverage under an existing Nationwide Permit may be necessary for minor unavoidable impacts. MWEC will acquire.
Federal Aviation Administration	FAA Form 7460-1, Notice of Proposed Construction or Alteration	Will apply for determination at least 45 days prior to construction.	The FAA must confirm that construction of the Project does not constitute a hazard to air navigation
	FAA Form 7460-2 - Notice of Actual Construction or Alteration		Notifies FAA of actual constructed or altered structures. MWEC will acquire.
State of North Dakota			
Public Service Commission	Waiver of Procedures and Time Schedules	Subject of this Application	Included herein.
	Certificate of Corridor Compatibility	Subject of this Application	Included herein.
	Route Permit	Subject of this Application	Included herein.
North Dakota Department of Health	401 Water Quality Certification	Final layout will determine whether permit/approval is needed	Required for fill in jurisdictional waters of U.S. Need for this approval is not anticipated at this time. MWEC will acquire.

Agency	Type of Approval	Status*	Need
	NPDES Permit: General Construction Storm Water	Will apply once Certificate is received	Permits required if: • land disturbance (clearing, grading or excavating) is greater than or equal to one acre, or • land disturbance is less than one acre and the site is part of a larger common plan of development or sale with the total land area disturbed in the development being equal to or greater than one acre or, • there is potential for contribution to a violation of a water quality standard or potential for significant contribution of pollutants to waters of the state Permit application requires the preparation of a Storm Water Pollution Prevention Plan (SWPPP).
State Historical Society of North Dakota – State Historic Preservation Office (SHPO)	Section 106 Compliance Approval	Final Layout will determine whether permit/approval is needed	Section 106 Compliance Approval is required if there is federal involvement in the Project (i.e. federal funding or wetland fill). Need for this approval is not anticipated at this time.
North Dakota Highway Patrol	Over-height/Over-weight Permit	Will apply once Certificate is received and prior to construction.	Permit required for hauling construction equipment and materials on state highways. Contractors will obtain as necessary
Local Permits			
Williams County	Conditional Use Permit	Will apply once Certificate is received	Permit will be required for Project construction.

7 Factors Considered

NDCC Section 49-22-09 of the North Dakota Energy Conversion and Transmission Facility Siting Act lists 11 factors to guide the PSC in evaluation of the Sites, Corridors, and Routes. The following sections address these factors where applicable to the Corridor and the Route.

7.1 Public Health and Welfare, Natural Resources, and the Environment

The preceding sections discuss the research and investigations relating the effects of the proposed facility on public health and welfare, natural resources, and the environment. Chapter 4 details the research and investigations that were used to identify expected environmental impacts and mitigation in relation to the Corridor/Routes. Chapter 3 discussed construction and operation techniques. All impacts evaluated in the Corridor/Routes are minor.

7.2 Technologies to Minimize Adverse Environmental Effects

Basin Electric will utilize the most recent transmission technologies and systems that minimize impacts to the environment. Chapter 3 discusses the engineering and operational design of the project, including the proposed structure type and construction techniques. These technologies and techniques are the most appropriate technologies to minimize adverse environmental effects. This is evident in the minimal environmental effects identified by the research and investigations discussed in this application.

7.3 Potential for Beneficial Uses of Waste Energy

This factor is not applicable to this project.

7.4 Unavoidable Adverse Environmental Effects of the Corridor/Routes

Chapter 4 details the research and investigations that were used to identify expected environmental impacts and mitigation in relation to the Corridor/Routes. The environmental effects of the Corridor/Routes are minor.

Unavoidable adverse environmental effects include the visual impacts and physical impacts to the land (primarily agricultural land) associated with the Project. Basin Electric will implement the mitigation and BMPs discussed in this application and as identified by regulatory agencies to minimize these unavoidable adverse environmental effects.

7.5 Alternatives to the Proposed Corridor/ Routes which are Identified During the Hearing Process and Which Minimize Adverse Affects

The Project involves double-circuiting an approximately 3.7 mile section of the Basin Electric's Williston Tie Project. This double-circuit was studied as part of MWEC's Williston to Stateline Project EA that was developed by Western Area Power Administration. This EA included the review of four alternatives: No-Build, Alternative A, Proposed Action, and Alternative B.

The Project Corridor/Routes are centered on an approximately 3.7 mile segment of the Proposed Action for the Williston to Stateline Project.

7.6 Irreversible and Irretrievable Commitment of Natural Resources for the Corridor/Routes

Irreversible and irretrievable resource commitments are related to the use of nonrenewable resources and the effects that the use of these resources have on future generations. Irreversible effects primarily result from use or destruction of a specific resource that cannot be replaced within a reasonable time frame. Irretrievable resource commitments involve the loss in value of an affected resource that cannot be restored as a result of the action. There are few commitments of resources associated with this project that are irreversible and irretrievable, but include those resources primarily related to construction.

Resources that will be used to construct the project include aggregate resources, concrete, steel, and hydrocarbon fuel.

7.7 Direct and Indirect Economic Impacts of the Proposed Facility

Direct economic impacts include the impacts associated with a small amount of agricultural land being removed from production due to the construction of the transmission line. In general, agricultural areas surrounding each structure can still be farmed, and landowners will be compensated for the land occupied by the transmission line.

The remaining direct and indirect economic impacts are primarily positive. To the extent that local contractors are used for portions of the construction, total wages and salaries paid to contractors and workers will contribute to the total personal income of the region. Additional personal income will be generated for residents in the county and the state by circulation and recirculation of dollars paid out by Basin Electric as business expenditures and state and local taxes. Expenditures made for equipment, energy, fuel, operating supplies, and other products and services also benefit businesses in the county and the state.

7.8 Existing Development Plans of the State, Local Government and Private Entities at or in the Vicinity of the Corridor and Route

No conflicts with existing development plans were identified as part of this application. The following summarizes known development plans and reasonably foreseeable development.

Basin Electric's Williston Tie Project would double circuit with MWEC's Williston to Stateline 115-kV transmission line. The proposed Williston to Stateline 115-kV transmission line connects to the Bear Paw Gas Plant located about 9 miles northwest of the Williston Tie Project.

In recent years, oil and gas development has continued to expand in the Williston area. It is reasonably foreseeable that areas within the Corridor and Route will be considered for gas and oil development. This is evidenced by the existing oil wells in the vicinity of the Corridor. The location of the Corridor and Route is not expected to inhibit the potential for future gas and oil development.

The long range planning section in the 2010 Williston Comprehensive Plan identifies a small area in the eastern terminus of the Corridor as a possible future industrial land use. This "future industrial land use" area is on the peripheries of a planning area that is "much larger than the anticipated growth area of Williston over the next 25 years" and thus will not necessarily be developed in the near-future. Double-circuiting with the

proposed Williston to Stateline 115-kV transmission line in will help maximize future development opportunities for the city of Williston.

7.9 Effect of Route on Cultural Resources

Basin Electric has reviewed cultural resources information on file at the SHPO for the data gathering area and prepared a Class III Intensive Archaeological Resource Inventory report (available upon request from SHPO). A review of previous cultural resources studies and cultural resource recordation forms at the SHPO identified one previously recorded archaeological site and one archaeological site lead within a half mile of the proposed transmission line corridor centerline. The result of the cultural resource effort is detailed in the Class III report. In summary, the Class III survey identified two archaeological features in Segment A of the Corridors/Routes. Currently, no impacts are anticipated to known or newly identified cultural resources. Basin Electric is committed to minimizing impacts to these resources and will avoid to the best of their ability these resources and any additional resources identified throughout the life of the Project. If avoidance is not possible, Basin Electric will work with the North Dakota SHPO to develop appropriate treatment plans for the impacted site(s).Effect of Route on Biological Resources.

HDR suggest Basin Electric consider the development of an Unanticipated Discovery Plan before construction in the project area begins. The plan should detail steps to take if previously unknown archaeological resources of human remains are encountered during construction. The plan should outline a communication framework for reporting on such discoveries in an efficient and legally compliant manner. The Unanticipated Discovery Plan may include the following topics: construction contractor training, identification of resources in the field, contact information for Basin Electric designated professionals to address a discovery, procedures for avoidance, and associated tasks event of work stoppage in a construction area. With regard to a discovery of human remains, procedures would be followed to ensure that the appropriate authorities would become involved quickly and in accordance with local and state guidelines.

7.10 Effects of Route on Biological Resources

Chapter 4 discusses potential impacts to biological resources such as wetlands, vegetation, wildlife, and rare and unique species. Basin Electric has implemented measures to avoid and minimize effects to biological resources at the proposed site. The impact of the Project on cultural resources is expected to be minimal. The Project will be designed to minimize impacts to avian species.

7.11 Effect of Route on Sensitive Species and Habitats

Federally-listed species may occur within the Project area; the whooping crane and the Sprague's pipit have the highest potential of occurring in the Project area. Habitat for the other species listed in Table 4.17-1 is either completely lacking or is extremely limited in the Project area.

Impacts to mixed-grass prairie (Sprague's pipit habitat) would be limited to localized permanent impacts due to structure installation or temporary impacts due to construction activities. Minimization of habitat disturbance and limiting ground clearing to fall and winter (prior to the nesting season) make the Project not likely to adversely affect Sprague's pipit.

Whooping crane surveys identified one wetland within one mile of Segment A that offer suitable whooping crane stopover habitat. Construction and operation of the project could displace whooping cranes from

available stopover habitat, both temporarily and in the long-term. Additionally, if whooping cranes should frequent the area, collisions with transmission lines during take-off and landing could be a concern. The transmission line will be marked with bird flight diverters within a mile of suitable habitat whooping crane habitat.

7.12 Concerns Raised by Agencies

The Project involves double-circuiting an approximately 3.7 mile section with the proposed MWEC Williston to Stateline 115-kV transmission line. The area in the vicinity of the Project was reviewed by state and federal agencies as part of the EA of the Williston to Stateline 115-kV transmission line. Agency comments varied according to agency function and jurisdiction, but agency comments generally emphasized a desire to minimize impacts to environmental resources such as wetlands, waterways, prairie, wildlife, and cultural resources. These environmental resources are addressed in Chapter 4 of this application. Agency response letters for the Williston to Stateline EA (which includes the area of the Project) are included in Appendix B.

8 Definitions

Term	Definition
ADT	Average Daily Traffic
APLIC	Avian Power Line Interaction Committee
BMPs	Best Management Practices; prevents soil erosion and sedimentation
Basin Electric	Basin Electric Power Company
Capacity	The capability of a system, circuit, or device for storing electric charge.
Certificate	Certificate of Site Compatibility
Class I Cultural Resources Inventory	Existing data inventory – a large-scale review and compilation of known cultural resource data.
Class III Cultural Resources Inventory	Intensive field inventory – complete surface inventory of a specific area.
CRP	Conservation Reserve Program
Corridor Certificate	Certificate of Corridor Compatibility
dBA	A-weighted decibel
Distribution	Relatively low-voltage lines that deliver electricity to the retail customer's home or business.
DOE	U.S. Department of Energy
Electromechanical	Of, relating to, or being a mechanical process or device actuated or controlled electrically; especially being a transducer for converting electrical energy to mechanical energy.
EMF	Electric and Magnetic Field
FEMA	Federal Emergency Management Agency
FIRM	Flood Insurance Rate Maps
FPPA	Farmland Protection Policy Act
Ft	Foot/Feet
Geotechnical	A science that deals with the application of geology to engineering.
GIS	Geographic Information Services
Interconnection	To be or become mutually connected.
kV	kilovolt

Term	Definition
m	meter
mG	milligaus
NDDOT	North Dakota Department of Transportation
NESC	National Electric Safety Code
NDAC	North Dakota Administrative Code
NDCC	North Dakota Century Code
NDDH	North Dakota Department of Health
NDGFD	North Dakota Game and Fish Department
NDPRD	North Dakota Parks and Recreation Department
NHID	Natural Heritage Inventory Database
NPDES	National Pollutant Discharge Elimination System
NRCS	National Resource Conservation Service
NRHP	National Register of Historic Places
NWI	National Wetlands Inventory
Project, the	Williston Tie Project
PSC	North Dakota Public Service Commission
RECs	Recognized Environmental Conditions
Resistance	The opposition offered by a body or substance to the passage through it of a steady electric current.
RD	Rotor Diameter: Diameter of the rotor from the tip of a single blade to the tip of the opposite blade.
ROW	Right-of-Way
SHPO	North Dakota State Historic Preservation Office
SoCP	Species of Conservation Priority
Substation	A subsidiary station in which electric current is transformed.
SWPPP	Storm Water Pollution Prevention Plan
Transformer	An electrical device by which alternating current of one voltage is changed to another voltage.

Term	Definition
Transmission	An assembly of parts including the speed-changing gears and the propeller shaft by which the power is transmitted from an automobile engine to a live axle; the speed-changing gears in such an assembly.
USACE	U.S. Army Corps of Engineers
USFWS	U.S. Fish and Wildlife Service
WMA	Wildlife Management Areas
WMD	Wetland Management District
WPAs	Waterfowl Protection Areas

9 Qualifications

Table 7.12-1. Basin Electric Power Cooperative Qualifications

Name Project Role	Education And Professional Experience
DUEY MARTHALLER Project Manager	M.S. Civil Engineering B.S. Civil Engineering 31Years Experience Registered Professional Engineer
GARY CHRISTENSON Project Engineer	B.S Civil Engineering 39 Years Experience Registered Professional Engineer
CRIS MILLER Environmental Permitting	B.S. Civil Engineering 29 Years Experience Registered Professional Engineer
MIKE MURRAY Right-of Way	A.A. Business Administration Various Courses through International ROW Association SR/WA (Senior ROW designation) 12 years experience
VALEREE KING Right-of-Way	Interstate Business College – Legal Writing and Descriptions Various Course through International ROW Association 8 Years Experience
JASON BREKKE GIS Analyst	B.S. Geography 8 years Experience
CURT PEARSON Corporate Communications	B.S. Business Administration M.B.A. Certified Cooperative Communicator 34 Years Experience

Table 7.12-2. HDR Engineering, Inc. Qualifications

Name Project Role	Education And Professional Experience
KELLY GARVEY Project Manager	Ms. Garvey currently is a project manager with 23 years of experience focused on environmental review and environmental permitting. She has prepared and managed consultants in the preparation of environmental documents and studies for compliance with NEPA, Section 4(f), and applicable environmental laws and executive orders. She has worked with several federal and state agencies on environmental documents and permitting issues. Associate of Applied Science, Environmental Studies, Arrowhead Comm Co Vermilion, 1981
GINA RAMIREZ Acoustics Engineer	Ms. Ramirez is an acoustic engineer with experience in environmental noise and architectural acoustics. She has experience performing noise and vibration analyses for projects such as wind farms, construction projects, surface transportation systems, and industrial noise. Her primary responsibilities include the monitoring, analysis and modeling of noise producing elements, in for both environmental and architectural projects. B.A., Acoustics, Columbia College, Chicago, IL, 2008
KENT PETERSON Acoustics & Noise Specialist	Mr. Peterson has more than 22 years of experience in the audio and acoustics industry ranging from recording studio management and engineering to industrial intercom systems design and high performance audio system design specification and installation. As a specialist in indoor and outdoor acoustics, noise measurement, and system installation and commissioning, Kent has served clients in over 9 countries. Mr. Peterson is an expert in Enhanced Acoustics Simulator for Engineers (EASE) modeling and brings extensive architectural acoustics experience to his clients.
STEPHEN SABATKE Archaeologist	Mr. Sabatke has ten years of experience working in the cultural resource field. He has worked on a variety of cultural resource projects including: wind power transmission, transmission lines, rail roads, pipeline, recreation use development, prehistoric site preservation, historic building preservation, and historic building rehabilitation. Additionally, he has prepared cultural resource studies for federal and state review. He has reviewed and developed cultural resource plans, cultural resource proposals, conducted meetings with SHPO, led field survey investigations, managed cultural resource contractors, subcontractors, and staff, and has managed cultural resource budgets for projects. M.A., Anthropology, University of Minnesota Twin Cities, 2006 B.A., Anthropology, University of Minnesota Duluth, 2002
MEG DESMOND Senior Technical Editor	Ms. Desmond brings more than 30 years of writing and editing experience to HDR. She is responsible for managing document production and the document production staff for the Environmental Sciences Section of HDR Minneapolis. She provides day-to-day supervision in terms of adjusting priorities and deadlines, determines consistency and style within technical reports, and edits technical reports and documents. She interacts with professional staff members to clarify the meaning, format, and style of their work. She also assists HDR's Minneapolis marketing department with quality control review of proposals and presentations. B.A., English Language & Literature, University of New Hampshire, 1976

Name Project Role	Education And Professional Experience
Sean Tuohey GIS Specialist	Mr. Tuohey's experience in the GIS profession involves working primarily with electrical utility, gas utility, wind, and e911 data. His experience covers several aspects of GIS projects, including field data collection, the creation, maintenance, and quality control of public utility and e911 GIS data, and database design for e911 software implementation and data maintenance. Mr. Tuohey has implemented ArcSDE at GeoComm, assigned privileges to data, and provided database maintenance. Mr. Tuohey also has experience analyzing wind projects for aviation and radar related issues.
SARA TWITCHELL Environmental Scientist	Ms. Twitchell has six years of experience working on environmental documents and supporting regulatory compliance. Ms. Twitchell is trained in biological surveys, stream assessments, and wetland delineation. Ms. Twitchell has provided support on the organization and submittal of a variety of environmental regulatory permits and documents from federal, state and local agencies across the country. Her regulatory experience ranges from energy, water resource, transportation, and municipal projects. M.S., Environmental Science, Portland State University, In Progress B.S., Ecology and Evolutionary Biology, University of California at Santa Cruz, 2005.
CHRISTINA ROLFES Environmental Scientist	Ms. Rolfes has almost four years of experience working on environmental documents and supporting regulatory compliance. Ms. Rolfes is experienced in transmission line siting and routing, Phase I Environmental Site Assessments, wetland delineations, bald eagle helicopter surveys and public involvement. Ms. Rolfes has provided support on the organization and submittal of a variety of environmental regulatory permits and documents from federal, state and local agencies in the Midwest. B.S., Biology, University of Minnesota - Duluth, 2006.

10 References

Avian Power Line Interaction Committee (APLIC). 2006. *Suggested Practices for Raptor Protection on Power Lines: The State of the Art in 2006*. Accessed October, 2011. <http://www.aplic.org/SuggestedPractices2006(LR).pdf>.

Bluemle, John P. 1991. The Face of North Dakota, Revised Edition. North Dakota Geological Survey, Bismarck, North Dakota.

Carlson, Clarence G. 1983. *Geology of Morton County, North Dakota*. North Dakota Geological Survey. Grand Forks, North Dakota. North Dakota State Water Commission. Accessed November, 2011. <http://www.swc.state.nd.us/4dlink9/4dcgi/GetContentRecord/PB-272>.

———. 1973. *Geology of Mercer and Oliver Counties, North Dakota*. North Dakota Geological Survey. Grand Forks, North Dakota. North Dakota State Water Commission. Accessed November, 2011. <http://www.swc.state.nd.us/4dlink9/4dcgi/GetContentRecord/PB-271>.

Major Land Resource Regions Custom Report. USDA Agriculture Handbook 296 (2006). Accessed November, 2011. http://soils.usda.gov/MLRAExplorer

North Dakota Department of Transportation (NDDOT). 2010 State Traffic Counts. Accessed October, 2011. http://www.dot.nd.gov/road-map/traffic/index.htm

North Dakota Game and Fish Department (NDGFD). 2006. Wildlife Management Area Regulations. Accessed October, 2011. < http://gf.nd.gov/hunting/wildlife.html>.

North Dakota State Water Commission (NDSWC). 2011. *Query Water Permits*. Accessed October, 2011. <http://www.swc.state.nd.us/4dlink7/4dcgi/permitsearchform/Map%20and%20Data%20Resources>.

North Dakota State Water Commission. ND State Water Commission MapService. Accessed October, 2011. <http://mapservice.swc.nd.gov/>.

———. Map Service, Drillers Logs. Accessed November 2011. <http://mapservice.swc.nd.gov>.

Natural Resources Conservation Service (NRCS). 1998a. *Williams Series*. Soil Description. Accessed October, 2011. < https://soilseries.sc.egov.usda.gov/OSD_Docs/W/WILLIAMS.html>.

_____1998b. *Bowbells Series*. Soil Description. Accessed October, 2011. <https://soilseries.sc.egov.usda.gov/OSD_Docs/B/BOWBELLS.html>.

_____1998c. *Arnegard Series*. Soil Description. Accessed October, 2011. <https://soilseries.sc.egov.usda.gov/OSD_Docs/A/ARNEGARD.html>.

Soil Survey Staff, Natural Resources Conservation Service (NRCS). 2011. United States Department of Agriculture. U.S. General Soil Map (STATSGO2) for North Dakota. Accessed November, 2011. <http://soildatamart.nrcs.usda.gov>.

U.S. Census Bureau. Profile of General Population and Housing Characteristics 2010: Williams County, ND. Accessed October, 2011. <http://factfinder2.census.gov/faces/tableservices/jsf/pages/productview.xhtml?pid=DEC_10_DP_DPDP1&prodType=table>.

U.S. Department of Agriculture/The Census of Agriculture. 2007 Census Publications. Accessed October 2011. Accessed October, 2011. <http://www.agcensus.usda.gov/Publications/2007/Online_Highlights/County_Profiles/North_Dakota/index.as>.

———. CropScape – Cropland Data Layer. Accessed October, 2011. <http://nassgeodata.gmu.edu/CropScape/>.

U.S. Fish and Wildlife Service (USFWS). 2011. National Wetlands Inventory: Wetlands Mapper. Accessed October, 2011. <http://107.20.228.18/Wetlands/WetlandsMapper.html>.

_____. 2008. Cooperative Whooping Crane Tracking Database. Maintained by the USFWS, Nebraska Ecological Services Field Office. Data received from the USFWS.

U.S. Geological Survey (USGS). 1980. Mineral Resources on-Line Spatial Data, Coleharbor Formation, Geologic Map of North Dakota. Accessed November, 2011. <http://tin.er.usgs.gov/geology/state/sgmc-unit.php?unit=NDQcoh%3B0>.

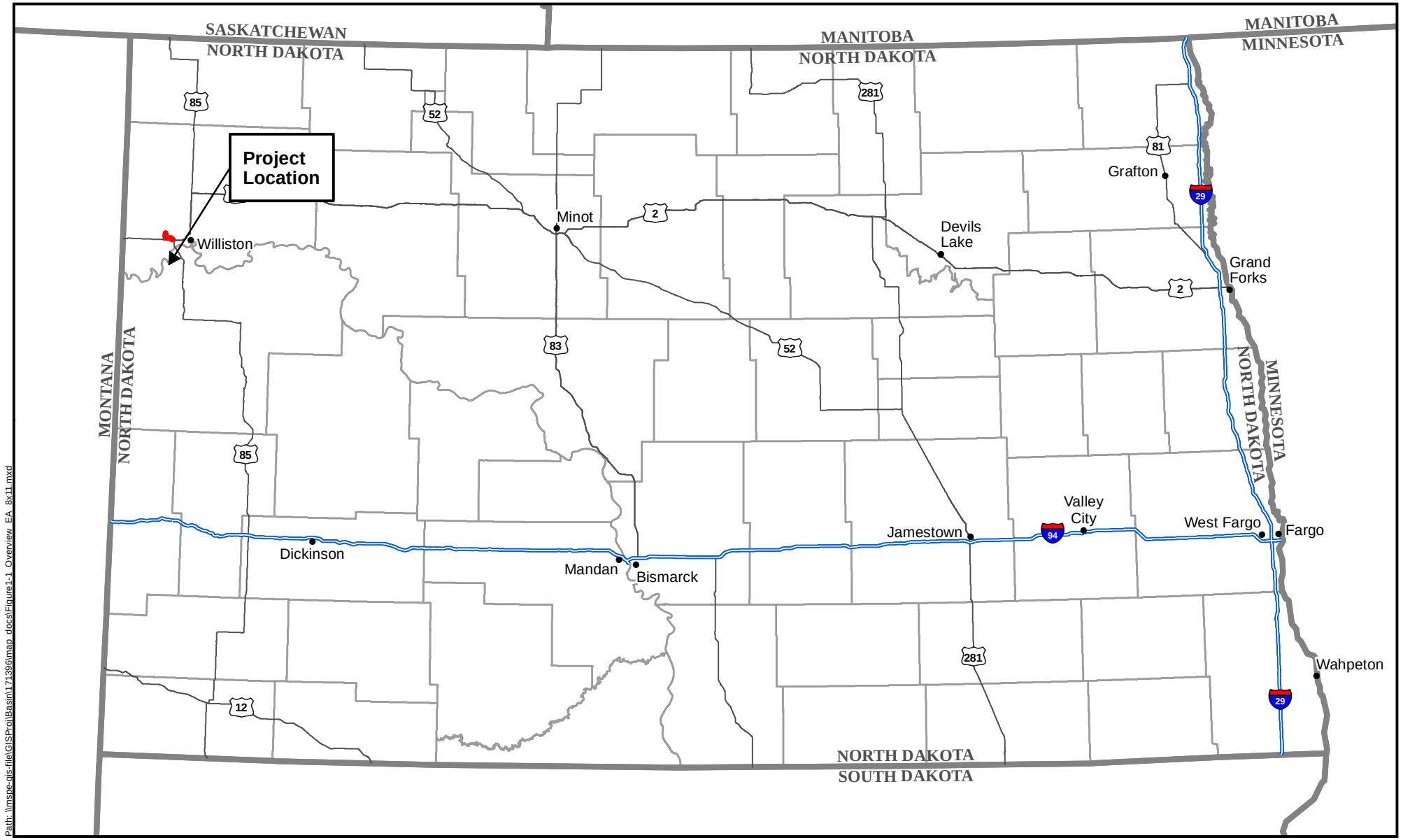
_____. 1996. *Ground Water Atlas of the United States: Montana, North Dakota, South Dakota, and Wyoming*, HA 730-I.

———. 2008a. Earthquake Center. Accessed November, 2011. < http://earthquake.usgs.gov/>.

———. 2008b. Paleontology Portal. Accessed November, 2011. <http://www.paleoportal.org/>.

Williams County Planning and Zoning Administration. 1987. Williams County Zoning District Map. Updated May 27, 1987.

Figures



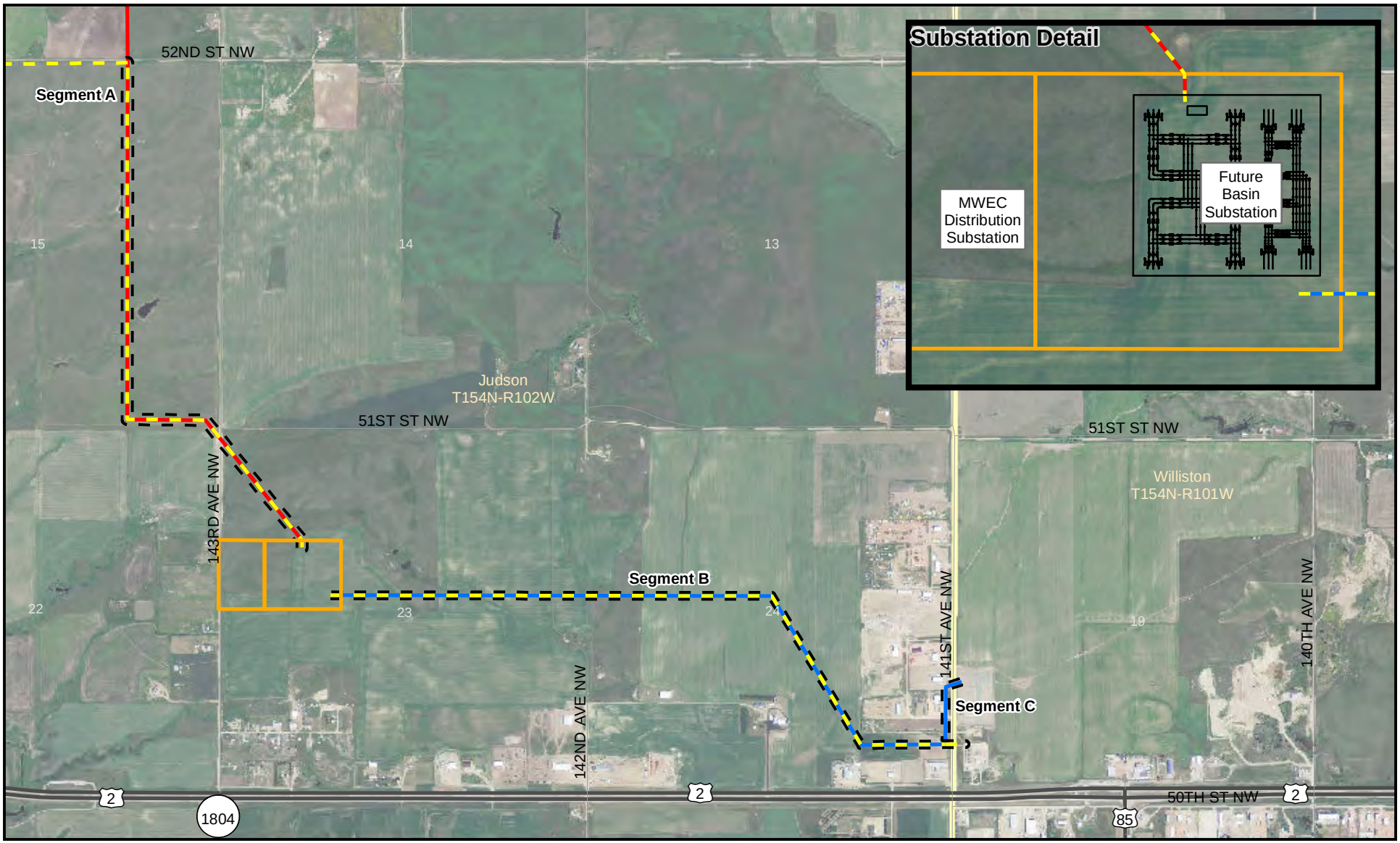
Path: \\mspe-gis-file\GISProj\Basin\171396\map_docs\Figure1-1_Overview_EA_8x11.mxd

0 10 20 40 Miles

Project Location
Interstate Highway
US Highway
County Boundary
City

Figure 1.1
Project Location
Basin Electric Power Cooperative
Williston Tie Project
Route Corridor and Permit Application

BASIN ELECTRIC POWER COOPERATIVE
A Touchstone Energy® Cooperative



N

Feet
0 2,000

VOLTAGE
- MWEC 115 kV
- Basin 230 kV
- Basin 230 kV / MWEC 115 kV
- Basin 345 kV
- Basin 345 kV / MWEC 115 kV

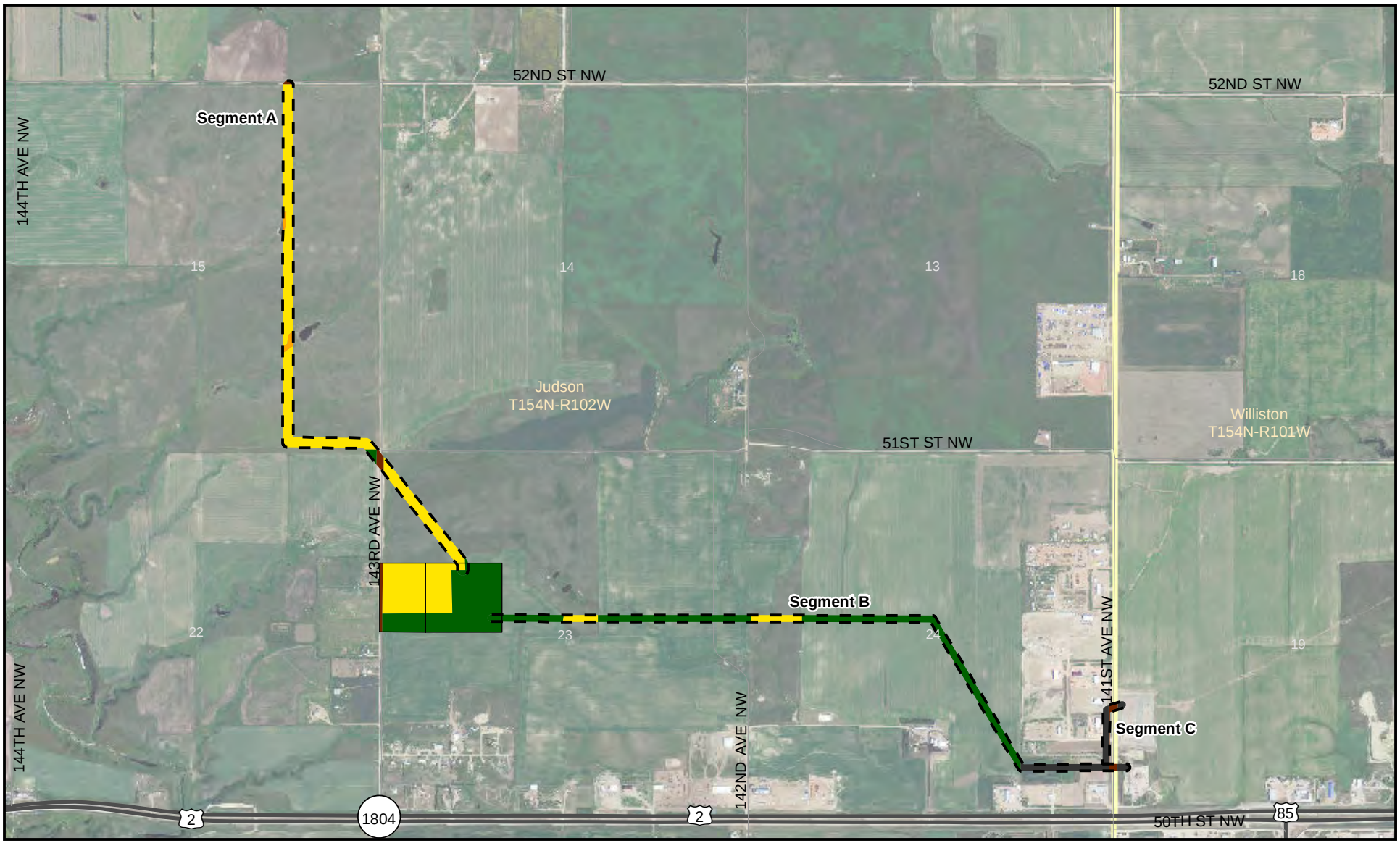
Corridor

Substation Property

Figure 1.2
Substation and Double Circuit Areas
Basin Electric Power Cooperative
Williston Tie Project
Route Corridor and Permit Application

BASIN ELECTRIC POWER COOPERATIVE
A Touchstone Energy Cooperative

Path: \\mspe-gis-file\gisproj\Basin\171396\map_docs\Figure1-2_Substation_EA_8x11.mxd



N

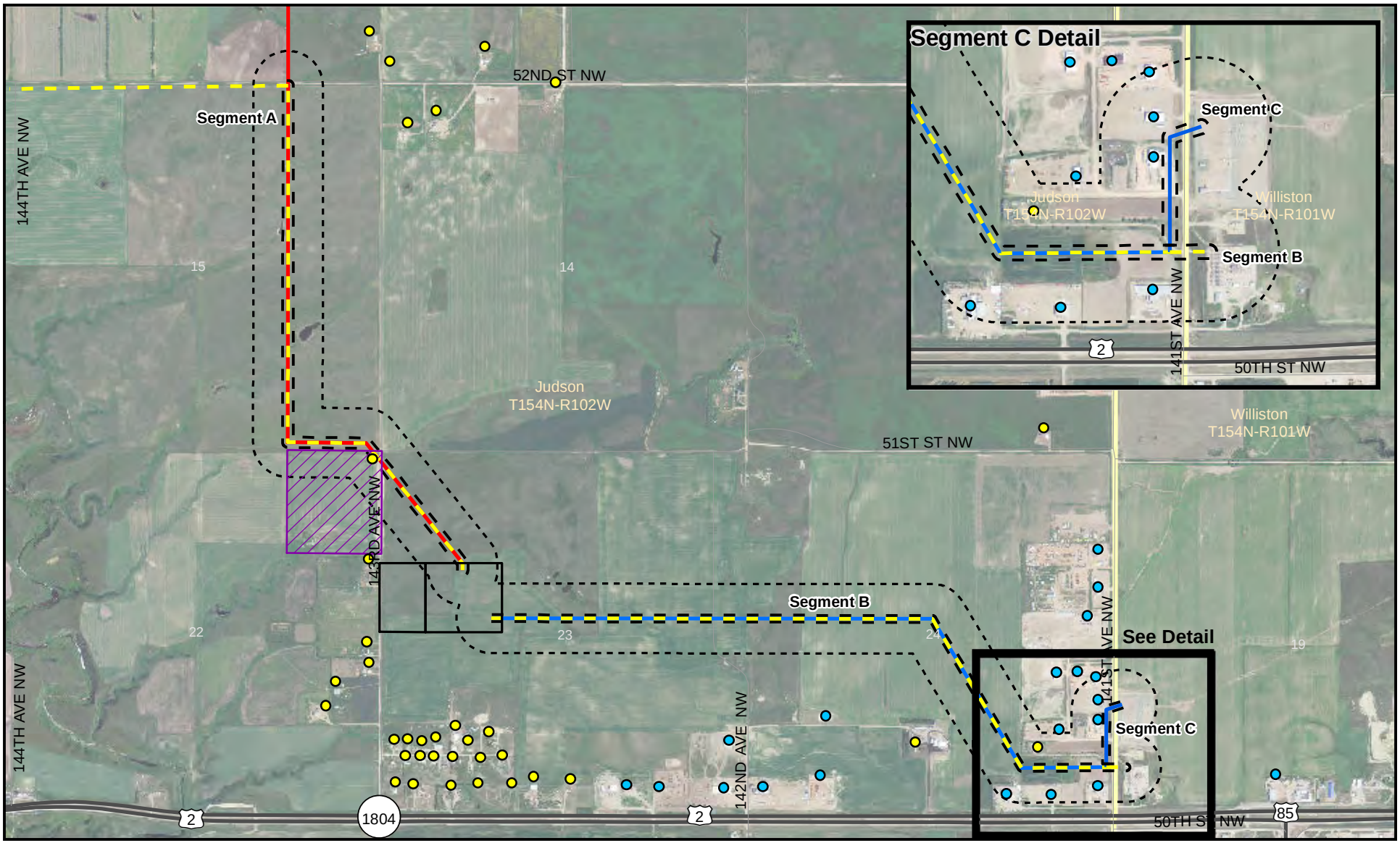
Feet
0 2,000

Cropland
Developed
Grassland
Riparian
Road
Wetland
Corridor
Substation Property

Figure 4.1
Land Cover
Basin Electric Power Cooperative
Williston Tie Project
Route Corridor and Permit Application

BASIN ELECTRIC POWER COOPERATIVE
A Touchstone Energy® Cooperative

Path: \\mspe-gis-file\gisproj\Basin\171396\map_docs\Figure4-1_LandUse_EA_8x11.mxd



N

Feet
0
2,000

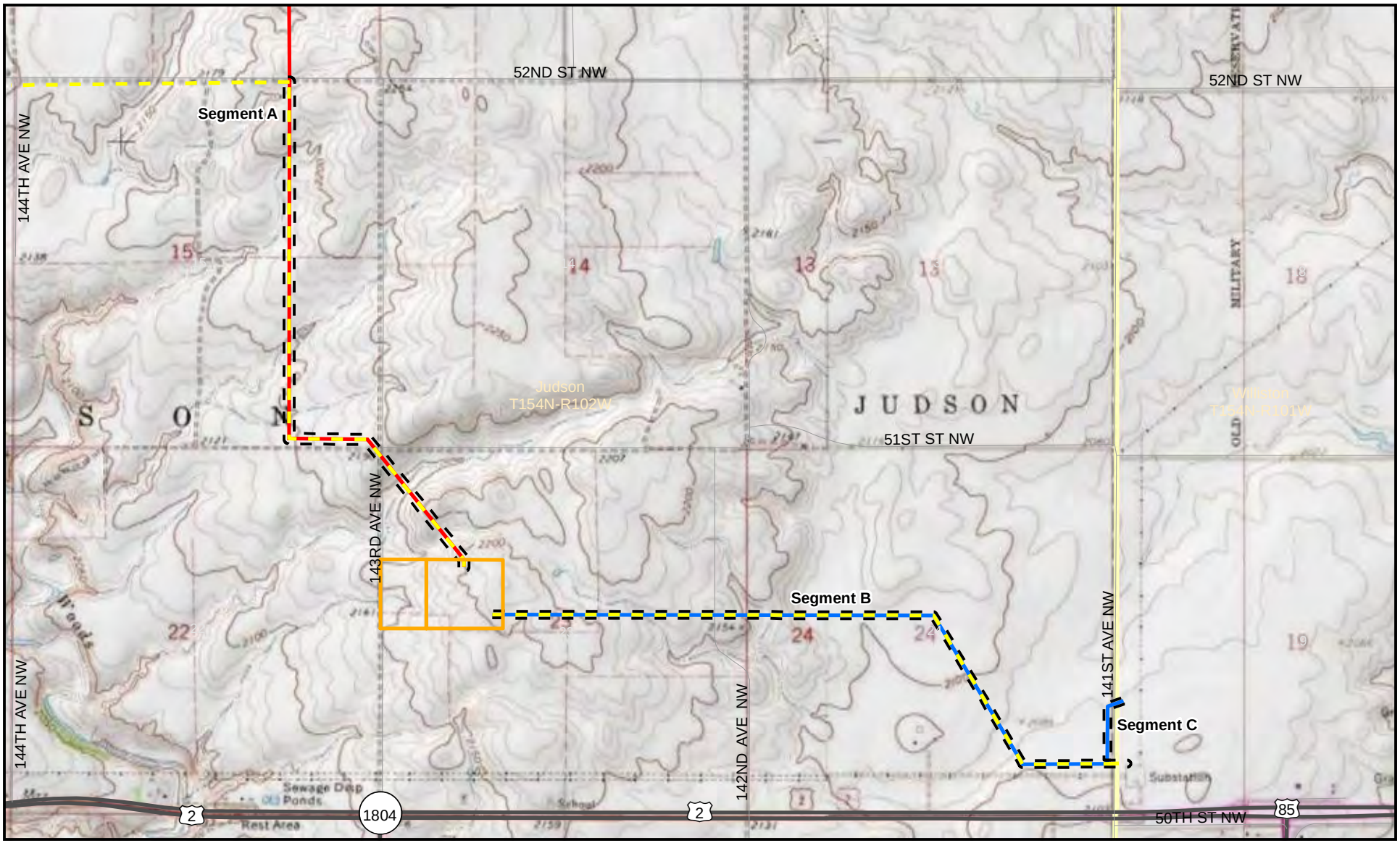
115 kV Single Circuit
230 kV Single Circuit
230/115 kV Double Circuit
345 kV Single Circuit
345/115 kV Double Circuit
500ft Buffer
Corridor
Substation Property
Proposed RV Park

Receptor
Commercial
Residential

Figure 4.2
Sensitive Receptors
Basin Electric Power Cooperative
Williston Tie Project
Route Corridor and Permit Application

BASIN ELECTRIC POWER COOPERATIVE
A Touchstone Energy® Cooperative

Path: \\mspe-gis-file\gisproj\Basin\171396\map_docs\Figure4-2_Receptors_EA_8x11.mxd



N

Feet
0 2,000

VOLTAGE
- MWEC 115 kV
- Basin 230 kV
- Basin 230 kV / MWEC 115 kV
- Basin 345 kV
- Basin 345 kV / MWEC 115 kV

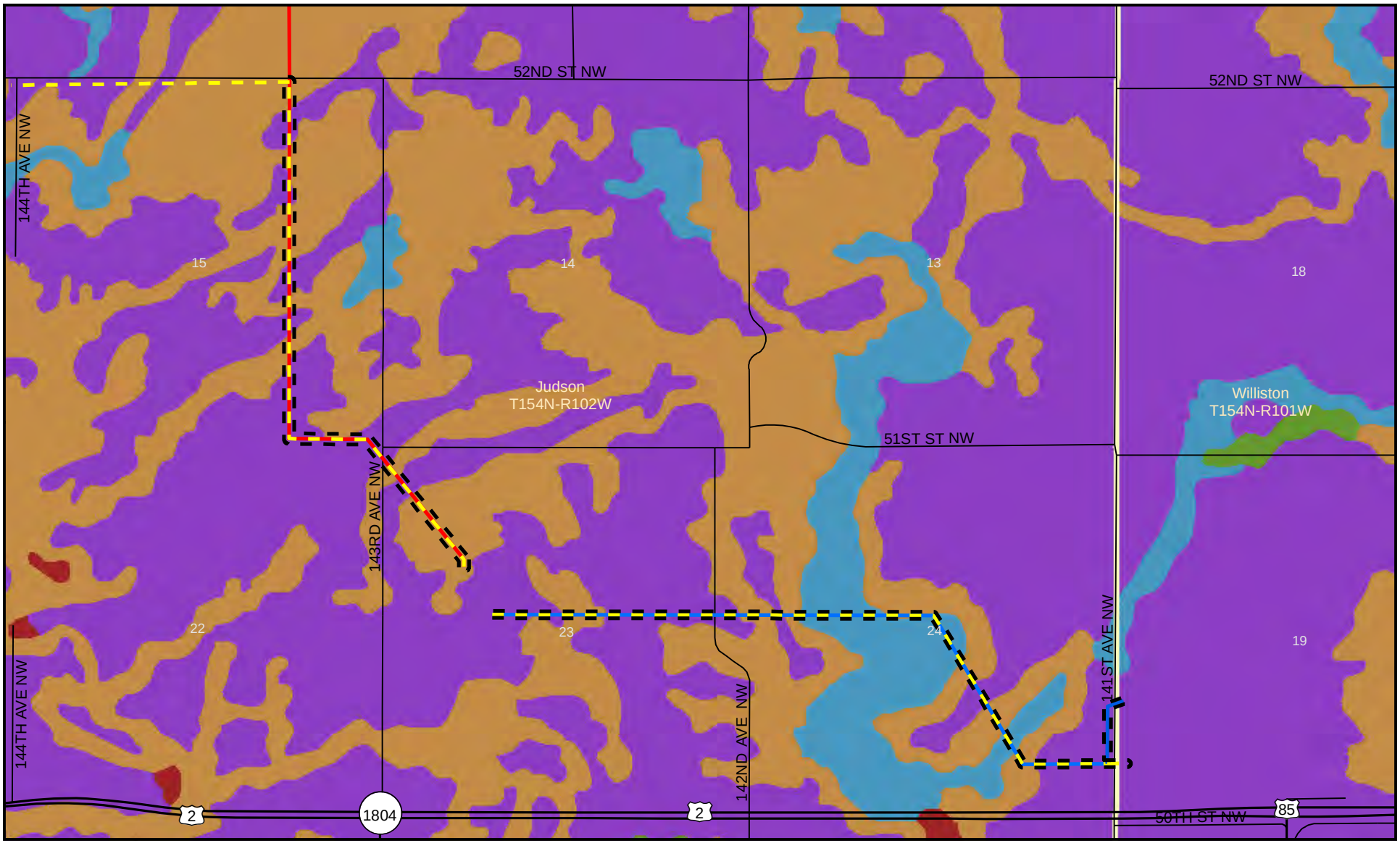
Corridor

Substation Property

Figure 4.3
Topography
Basin Electric Power Cooperative
Williston Tie Project
Route Corridor and Permit Application

BASIN ELECTRIC POWER COOPERATIVE
A Touchstone Energy® Cooperative

Path: \\mspe-gis-file\gisproj\Basin\171396\map_docs\Figure4-3_Topo_8x11.mxd



N

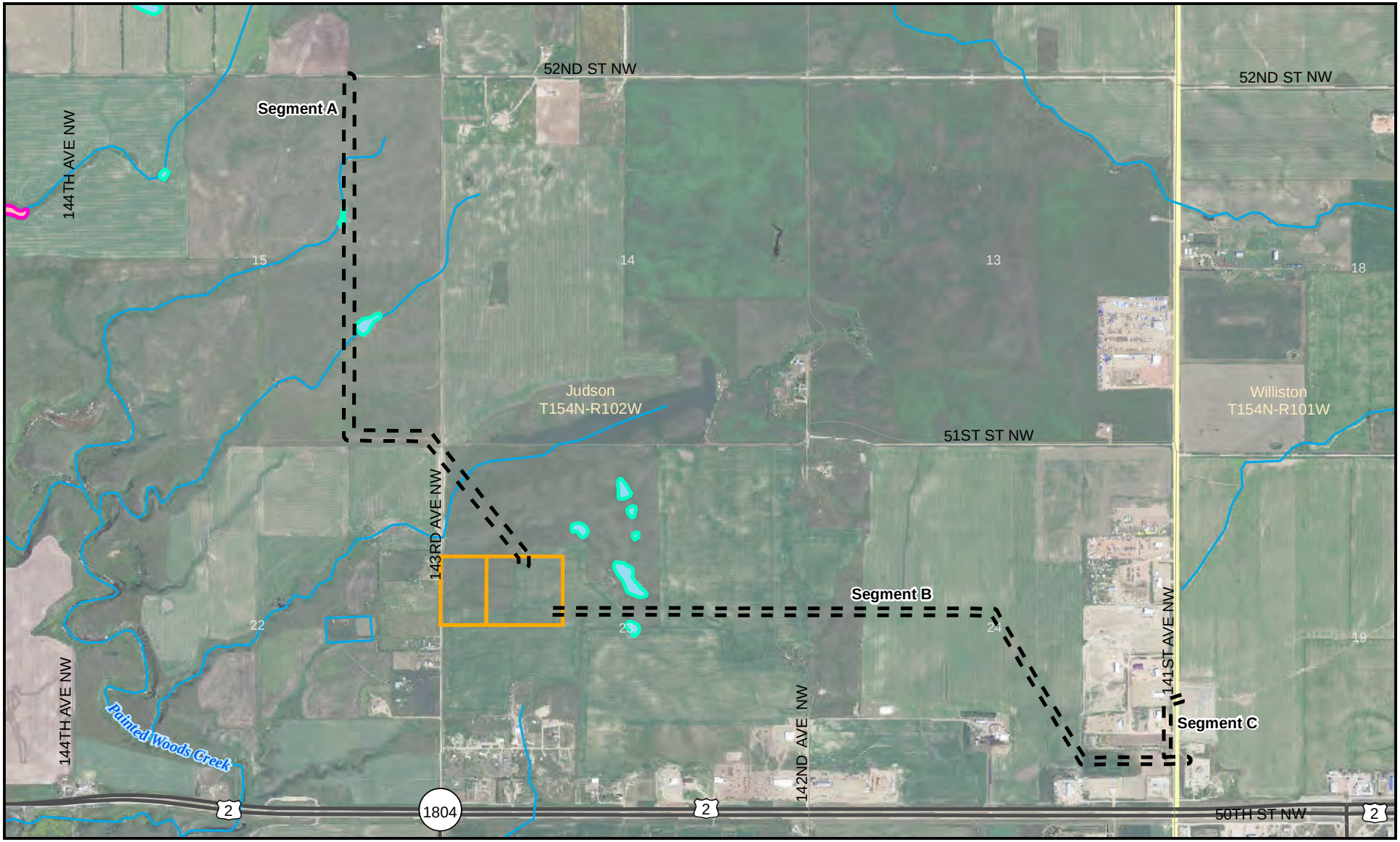
Feet
0
2,000

- 115 kV Single Circuit
- 230 kV Single Circuit
- 230/115 kV Double Circuit
- 345 kV Single Circuit
- 345/115 kV Double Circuit
- All areas are prime farmland
- Farmland of statewide importance
- Not prime farmland
- Prime farmland if drained
- Prime farmland if irrigated

Figure 4.4
Soils
Basin Electric Power Cooperative
Williston Tie Project
Route Corridor and Permit Application

BASIN ELECTRIC POWER COOPERATIVE
A Touchstone Energy® Cooperative

Path: \\mspe-gis-file\gisproj\Basin\171396\map_docs\Figure4-4_Soils_8x11.mxd



N

0 Feet 2,000

Corridor
Evaluated Wetland
Whooping Crane Roosting Habitat
Stream
Substation Property

Figure 4.5
Water Resources
Basin Electric Power Cooperative
Williston Tie Project
Route Corridor and Permit Application

BASIN ELECTRIC POWER COOPERATIVE
A Touchstone Energy® Cooperative

Path: \\mspe-gis-file\gisproj\Basin\171396\map_docs\Figure4-5_Water_8x11.mxd

Appendix A
Studies and Assessments

Burns & McDonnell
EMF Analysis

Memorandum

Date: October 12, 2011

To: Cris Miller, Basin Electric Power Cooperative

Subject: Electric and Magnetic Fields (EMF) Analysis

The purpose of this analysis was to determine the EMF conditions at the edge of the Right of Way for the Basin Electric Power Cooperative (Basin Electric) proposed 345/115-kV electrical transmission line. EMF are generated by electrical charges and their movement. These fields are controlled by conductor (transmission line) geometry, size of conductor and position of conductors on the supporting structure, voltage of the conductors and current on the conductors.

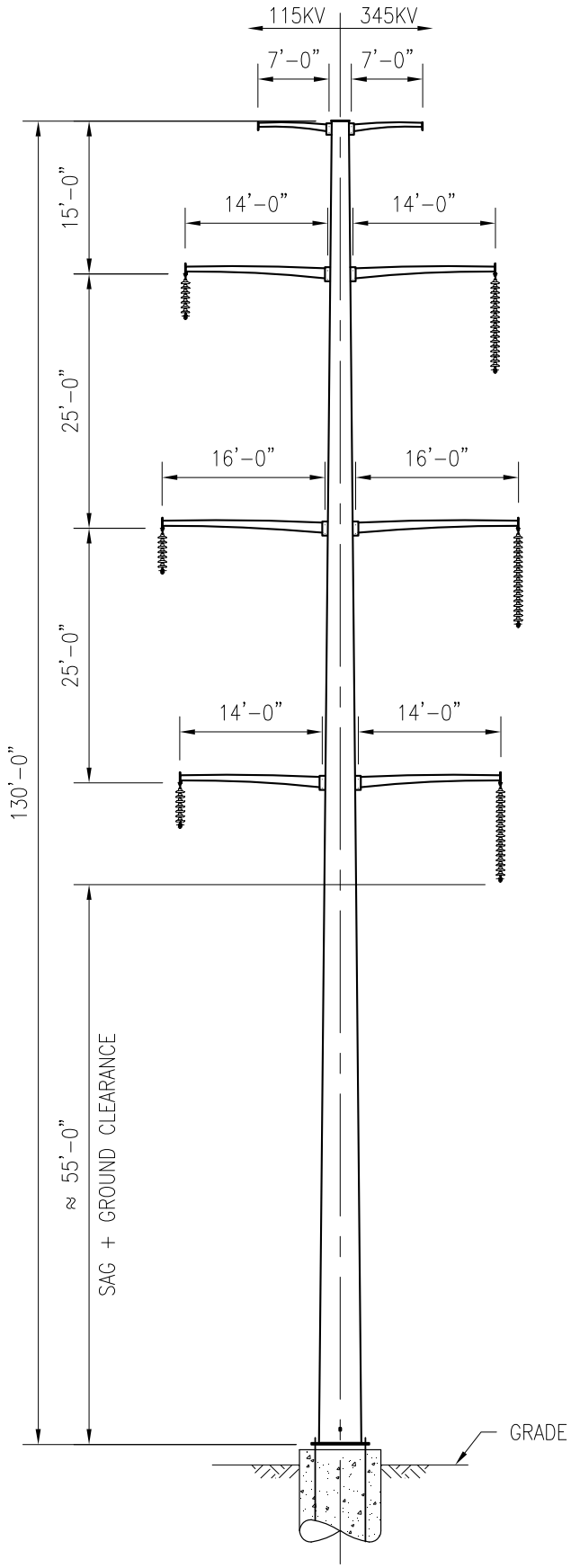
For this project, Burns & McDonnell was provided inputs from Basin Electric for the various parameters for typical conditions of a double circuit 345/115 kV transmission line (Figure 1) and conducted an analysis for predicted EMF conditions. Basin Electric is proposing to construct 345, 345/115, 230/115 and 230 kV transmission line configurations for their anticipated project. The 345/115 kV configuration was selected for the EMF analysis because this configuration would have the potential to generate the highest levels of EMF conditions. Burns & McDonnell used the input variables to calculate the approximate EMF levels using a computer program that is based on the equations and calculation methods developed by the Bonneville Power Administration. The output from these calculations was used to plot the electric and magnetic field profiles across distances from the centerline of the transmission line configuration.

Figure 2 illustrates the electric field values in kilovolts/meter (kV/m) and at a distance of 75 feet from the center line to the edge of the Right of Way the maximum predicted value is 0.214 kV/m, which is far less than 4.2 kV/m protection standard for protection of the general public(ICNIRP, 2010). Figure 3 illustrates the magnetic field values in milligaus (mG) and at a distance of 75 feet from the center line the maximum predicted value is 94 mG, which is far less than the 2,000 mG standard for the protection of the general public (ICNIRP, 2010).

In general, EMF measured outside of substations are attributable to the power lines entering and exiting the substation. Beyond the substation fence the EMF produced by substation equipment is typically indistinguishable from background levels are therefore have not been evaluated for this project. (National Institute of Environmental Health Sciences, 2002)

ICNIRP, 2010 – International Commission on Non-Ionizing Radiation Protection. Guidelines for Limiting Exposure to Time-Varying Electric, Magnetic and Electromagnetic Fields

FIGURE 1: TYPICAL 345/115-KV STRUCTURE



BASIC 345/115KV
DOUBLE CIRCUIT STRUCTURE
AVERAGE SPAN ≈ 800'

FIGURE 2: ELECTRIC FIELD STRENGTH

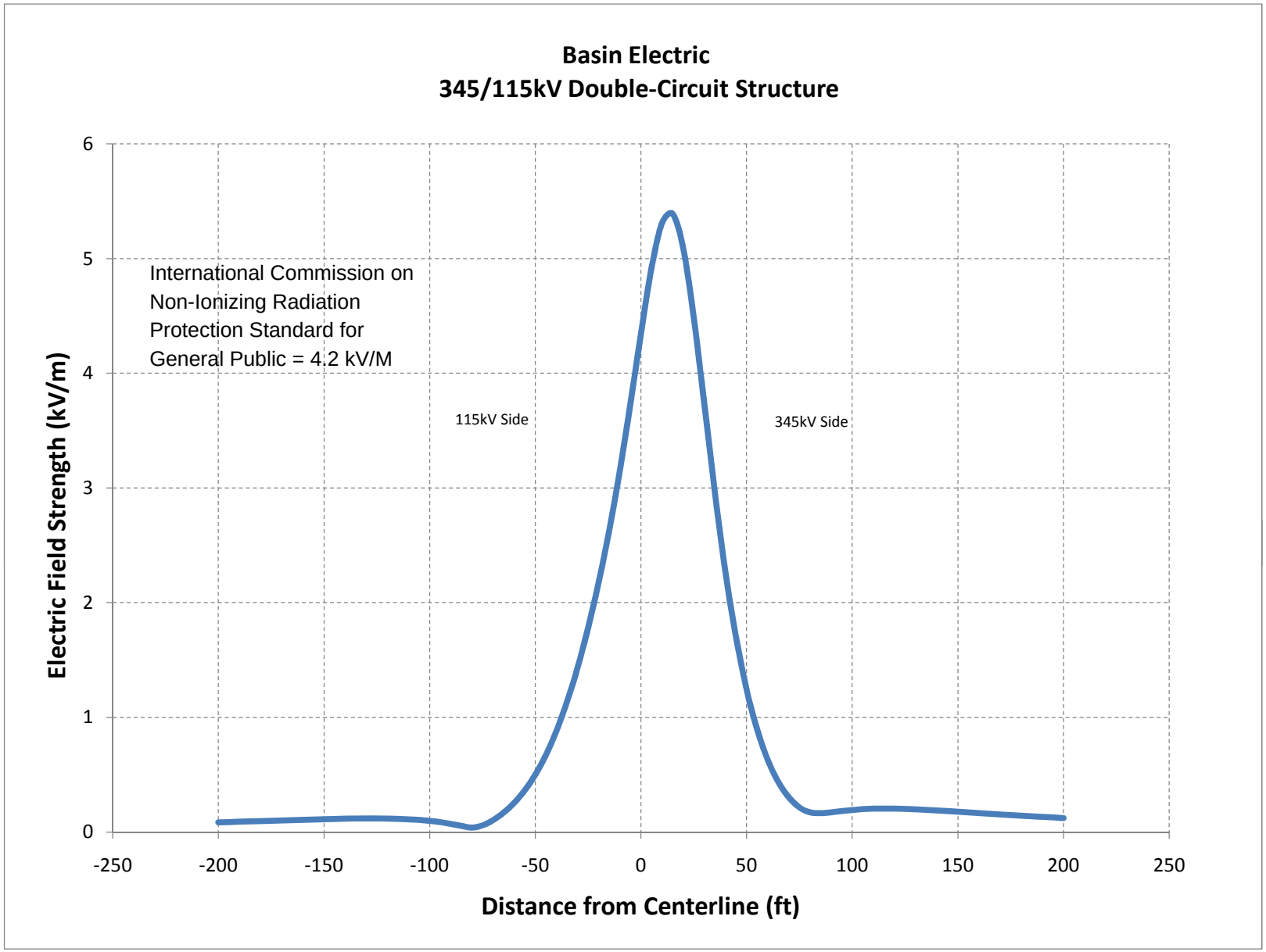
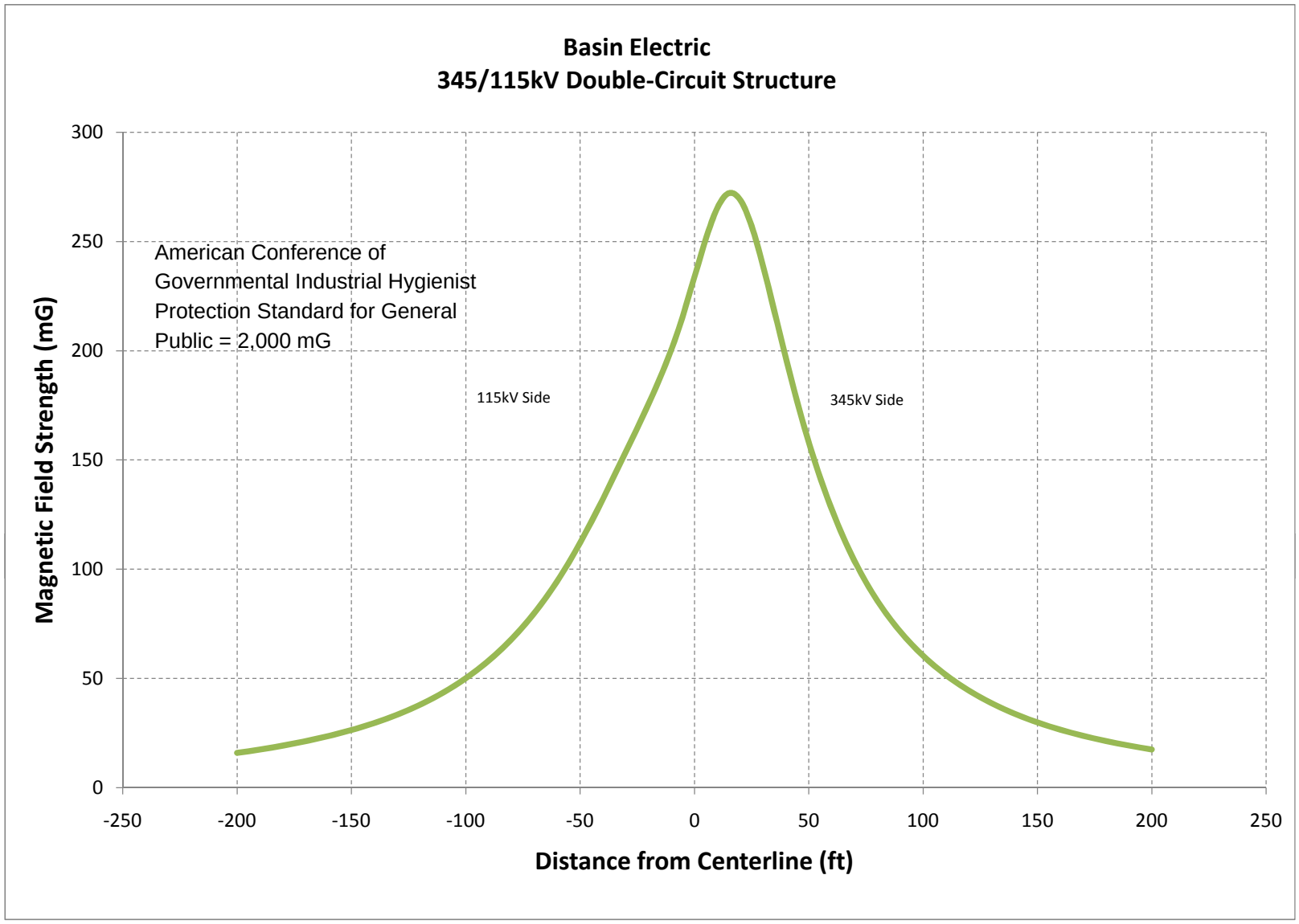


FIGURE 3: MAGNETIC FIELD STRENGTH



```
          ********************************************
          *      C O R O N A   A N D   F I E L D     *
          *       E F F E C T S   P R O G R A M      *
          *   Source: Bonneville Power Administration *
          ********************************************

         +++++++++++++++++++
         + INPUT DATA LIST +

        ++++++++++++++++++++++++++++++++++++++++++++++++++++++++++
       10/ 6/2011           5:46:35 pm
     +********  Basin 345/115kV EMF Calcs  ***************************
     +****  Double-Circuit Vertical -- (1)2306.2kcmil, (1)795kcmil ACSR ****
     +      1       0       6       8   362.0    2.00    1.00     .00

     (ENGLISH UNITS OPTION)

        LINE GRADIENTS COMPUTED BY PROGRAM

     PHYSICAL SYSTEM CONSISTS OF   8 CONDUCTORS, OF WHICH   6 ARE ENERGIZED PHASES

     +COMB  MF  XX  XX  XX  XX  XX  XX
     +   4.921   6.562   9.842    .000   1.000  75.000   3.280   4.000   3.280
     +115-A        A   -15.00   90.00    1   1.063     .00   69.70      .0     .88     .00
     +115-B        A   -17.00   65.00    1   1.063     .00   69.70  -120.0     .88     .00
     +115-C        A   -15.00   40.00    1   1.063     .00   69.70   120.0     .88     .00
     +345-A        A    15.00   80.00    1   1.802     .00  209.00      .0    1.65     .00
     +345-B        A    17.00   55.00    1   1.802     .00  209.00  -120.0    1.65     .00
     +345-C        A    15.00   30.00    1   1.802     .00  209.00   120.0    1.65     .00
     +GND-1        A    -8.00  110.00    1    .500     .00     .00      .0     .00     .00
     +GND-2        A     8.00  110.00    1    .500     .00     .00      .0     .00     .00
     +      81  -200.0     5.0
     +       0      .0      .0
```

COMBINED OUTPUT OF AUDIBLE NOISE, RADIO NOISE, TVI, OZONE CONCENTRATION, GROUND GRADIENT AND MAGNETIC FIELD

******** Basin 345/115kV EMF Calcs ***************************
**** Double-Circuit Vertical -- (1)2306.2kcmil, (1)795kcmil ACSR ****

362.0 KV

	DIST. FROM CENTER OF TOWER (FEET)	HEIGHT (FEET)	MAXIMUM GRADIENT (KV/CM)	SUBCON DIAM. (IN)	NO. OF SUBCON	SUBCON SPACING (IN)	VOLTAGE L-N (KV)	PHASE ANGLE (DEGREES)	CURRENT (KAMPS)	CORONA LOSSES (KW/MI)
115-A	-15.00	90.00	6.39	1.06	1.00	.00	69.70	.00	.875	.009
115-B	-17.00	65.00	7.93	1.06	1.00	.00	69.70	-120.00	.875	.038
115-C	-15.00	40.00	7.55	1.06	1.00	.00	69.70	120.00	.875	.028
345-A	15.00	80.00	14.96	1.80	1.00	.00	209.00	.00	1.650	19.347
345-B	17.00	55.00	15.88	1.80	1.00	.00	209.00	-120.00	1.650	28.506
345-C	15.00	30.00	15.44	1.80	1.00	.00	209.00	120.00	1.650	23.775
GND-1	-8.00	110.00	4.80	.50	1.00	.00	.00	.00	.000	.000
GND-2	8.00	110.00	5.50	.50	1.00	.00	.00	.00	.000	.000

AN MICROPHONE HT.= 4.9 FT, RI ANT. HT.= 6.6 FT, TV ANT. HT.= 9.8 FT, ALTITUDE= .0 FT
RI FREQ= 1.000 MHZ, TV FREQ= 75.000 MHZ, WIND VEL.(OZ) = 2.000 MPH, GROUND CONDUCTIVITY = 4.0 MMHOS /M
E-FIELD TRANSDUCER HT.= 3.3FT, B-FIELD TRANSDUCER HT. = 3.3FT

LATERAL DIST FROM REFERENCE (FEET)	AUDIBLE NOISE (RAIN) L50 DBA	AUDIBLE NOISE (FAIR) L50 DBA	RADIO INTERFERENCE (RAIN) L50 DBUV/M	RADIO INTERFERENCE (FAIR) L50 DBUV/M	TVI TOTAL RAIN DBUV/M	OZONE FOR RAIN RATE OF 1.00 IN/HR AT 0. FT.LEVEL PPB	ELECTRIC FIELD KV/M	MAGNETIC FIELD GAUSS
-200.0	47.6	22.6	49.1	32.1	14.8	.000000	.085	.01588
-195.0	47.7	22.7	49.4	32.4	15.0	.000000	.087	.01662
-190.0	47.8	22.8	49.7	32.7	15.2	.000000	.090	.01741
-185.0	47.9	22.9	49.9	32.9	15.4	.000000	.093	.01826
-180.0	48.0	23.0	50.2	33.2	15.6	.000000	.096	.01917
-175.0	48.2	23.2	50.5	33.5	15.9	.000000	.098	.02015
-170.0	48.3	23.3	50.8	33.8	16.1	.000000	.101	.02121
-165.0	48.4	23.4	51.1	34.1	16.3	.000000	.104	.02234
-160.0	48.5	23.5	51.4	34.4	16.5	.000000	.107	.02356
-155.0	48.7	23.7	51.8	34.8	16.8	.000000	.109	.02488
-150.0	48.8	23.8	52.1	35.1	17.0	.000000	.112	.02631
-145.0	49.0	24.0	52.5	35.5	17.2	.000000	.114	.02786
-140.0	49.1	24.1	52.8	35.8	17.5	.000000	.116	.02955
-135.0	49.2	24.2	53.2	36.2	17.8	.000000	.117	.03138
-130.0	49.4	24.4	53.6	36.6	18.0	.000000	.118	.03337
-125.0	49.5	24.5	54.0	37.0	18.3	.000000	.118	.03555
-120.0	49.7	24.7	54.4	37.4	18.6	.000000	.117	.03793
-115.0	49.9	24.9	54.9	37.9	18.9	.000000	.115	.04054
-110.0	50.0	25.0	55.3	38.3	19.2	.000000	.111	.04341
-105.0	50.2	25.2	55.8	38.8	19.5	.000000	.105	.04656
-100.0	50.4	25.4	56.3	39.3	19.8	.000000	.097	.05002
-95.0	50.6	25.6	56.8	39.8	20.1	.000000	.086	.05385
-90.0	50.8	25.8	57.4	40.4	20.5	.000000	.071	.05807
-85.0	51.0	26.0	58.0	41.0	20.8	.000000	.054	.06274
-80.0	51.2	26.2	58.5	41.5	21.2	.000000	.039	.06790

LATERAL DIST FROM REFERENCE (FEET)	AUDIBLE NOISE (RAIN) L50 DBA	AUDIBLE NOISE (FAIR) L50 DBA	RADIO INTERFERENCE (RAIN) L50 DBUV/M	RADIO INTERFERENCE (FAIR) L50 DBUV/M	TVI TOTAL RAIN DBUV/M	OZONE FOR RAIN RATE OF 1.00 IN/HR AT 0. FT.LEVEL PPB	ELECTRIC FIELD KV/M	MAGNETIC FIELD GAUSS
-75.0	51.4	26.4	59.2	42.2	21.5	.000000	.058	.07361
-70.0	51.6	26.6	59.8	42.8	21.9	.000000	.104	.07993
-65.0	51.8	26.8	60.5	43.5	22.3	.000000	.168	.08690
-60.0	52.1	27.1	61.2	44.2	22.7	.000000	.253	.09456
-55.0	52.3	27.3	61.9	44.9	23.2	.000000	.362	.10295
-50.0	52.6	27.6	62.6	45.6	23.6	.000000	.500	.11206
-45.0	52.8	27.8	63.4	46.4	24.3	.000000	.671	.12184
-40.0	53.1	28.1	64.2	47.2	25.0	.000000	.881	.13216
-35.0	53.4	28.4	65.0	48.0	25.7	.000000	1.133	.14286
-30.0	53.7	28.7	65.8	48.8	26.4	.000000	1.432	.15374
-25.0	54.0	29.0	66.6	49.6	27.3	.000000	1.778	.16468
-20.0	54.3	29.3	67.5	50.5	28.2	.000000	2.176	.17580
-15.0	54.7	29.7	68.6	51.6	29.1	.000000	2.629	.18759
-10.0	55.0	30.0	70.3	53.3	30.2	.000000	3.147	.20086
-5.0	55.3	30.3	72.1	55.1	31.2	.000000	3.727	.21630
.0	55.6	30.6	73.9	56.9	32.3	.000022	4.343	.23370
5.0	55.9	30.9	75.4	58.4	33.3	.000115	4.915	.25125
10.0	56.1	31.1	76.4	59.4	34.0	.000254	5.310	.26541
15.0	56.1	31.1	76.8	59.8	34.2	.000401	5.389	.27219
20.0	56.1	31.1	76.4	59.4	34.0	.000536	5.091	.26924
25.0	55.9	30.9	75.4	58.4	33.3	.008542	4.488	.25721
30.0	55.7	30.7	73.9	56.9	32.3	.078357	3.728	.23901
35.0	55.4	30.4	72.1	55.1	31.2	.170008	2.958	.21798
40.0	55.0	30.0	70.3	53.3	30.2	.241779	2.269	.19666
45.0	54.7	29.7	68.9	51.9	29.1	.297819	1.696	.17651
50.0	54.4	29.4	68.1	51.1	28.2	.344113	1.242	.15819
55.0	54.1	29.1	67.3	50.3	27.3	.382264	.893	.14188
60.0	53.8	28.8	66.5	49.5	26.4	.412707	.630	.12750
65.0	53.5	28.5	65.7	48.7	25.7	.435999	.437	.11489
70.0	53.2	28.2	64.8	47.8	25.0	.452955	.301	.10384
75.0	52.9	27.9	64.0	47.0	24.4	.464513	.214	.09414
80.0	52.7	27.7	63.2	46.2	24.0	.471607	.172	.08562
85.0	52.4	27.4	62.5	45.5	23.5	.475091	.164	.07812
90.0	52.2	27.2	61.7	44.7	23.1	.475709	.172	.07148
95.0	51.9	26.9	61.0	44.0	22.7	.474085	.183	.06560
100.0	51.7	26.7	60.3	43.3	22.3	.470733	.192	.06036
105.0	51.5	26.5	59.7	42.7	21.9	.466068	.199	.05570
110.0	51.2	26.2	59.0	42.0	21.5	.460423	.203	.05152
115.0	51.0	26.0	58.4	41.4	21.1	.454061	.204	.04777
120.0	50.8	25.8	57.8	40.8	20.7	.447193	.203	.04439
125.0	50.6	25.6	57.3	40.3	20.4	.439981	.201	.04135
130.0	50.5	25.5	56.7	39.7	20.1	.432554	.198	.03859
135.0	50.3	25.3	56.2	39.2	19.7	.425012	.193	.03609
140.0	50.1	25.1	55.7	38.7	19.4	.417433	.188	.03381
145.0	49.9	24.9	55.3	38.3	19.1	.409875	.182	.03174
150.0	49.8	24.8	54.8	37.8	18.8	.402385	.177	.02984
155.0	49.6	24.6	54.4	37.4	18.5	.394997	.171	.02810
160.0	49.4	24.4	53.9	36.9	18.2	.387736	.165	.02651
165.0	49.3	24.3	53.5	36.5	18.0	.380620	.159	.02504
170.0	49.1	24.1	53.1	36.1	17.7	.373663	.153	.02369
175.0	49.0	24.0	52.8	35.8	17.4	.366874	.147	.02244
180.0	48.9	23.9	52.4	35.4	17.2	.360259	.142	.02129
185.0	48.7	23.7	52.0	35.0	17.0	.353819	.137	.02022
190.0	48.6	23.6	51.7	34.7	16.7	.347556	.131	.01922
195.0	48.5	23.5	51.4	34.4	16.5	.341469	.127	.01830
200.0	48.3	23.3	51.1	34.1	16.3	.335557	.122	.01744

NIEHS and NIH
EMF Questions & Answers

June 2002

EMF

Electric and Magnetic Fields Associated with the Use of Electric Power

Questions & Answers

prepared by the
National Institute of Environmental Health Sciences
National Institutes of Health

EMF RAPID
Electric and Magnetic Fields Research and Public Information Dissemination Program

sponsored by the
NIEHS/DOE EMF RAPID Program

Contents

Introduction

Since the mid-twentieth century, electricity has been an essential part of our lives. Electricity powers our appliances, office equipment, and countless other devices that we use to make life safer, easier, and more interesting. Use of electric power is something we take for granted. However, some have wondered whether the electric and magnetic fields (EMF) produced through the generation, transmission, and use of electric power [power-frequency EMF, 50 or 60 hertz (Hz)] might adversely affect our health. Numerous research studies and scientific reviews have been conducted to address this question.

Unfortunately, initial studies of the health effects of EMF did not provide straightforward answers. The study of the possible health effects of EMF has been particularly complex and results have been reviewed by expert scientific panels in the United States and other countries. This booklet summarizes the results of these reviews. Although questions remain about the possibility of health effects related to EMF, recent reviews have substantially reduced the level of concern.

The largest evaluation to date was led by two U.S. government institutions, the National Institute of Environmental Health Sciences (NIEHS) of the National Institutes of Health and the Department of Energy (DOE), with input from a wide range of public and private agencies. This evaluation, known as the Electric and Magnetic Fields Research and Public Information Dissemination (EMF RAPID) Program, was a six-year project with the goal of providing scientific evidence to determine whether exposure to power-frequency EMF involves a potential risk to human health.

In 1999, at the conclusion of the EMF RAPID Program, the NIEHS reported to the U.S. Congress that the overall scientific evidence for human health risk from EMF exposure is weak. No consistent pattern of biological effects from exposure to EMF had emerged from laboratory studies with animals or with cells. However, epidemiological studies (studies of disease incidence in human populations) had shown a fairly consistent pattern that associated potential EMF exposure with a small increased risk for leukemia in children and chronic lymphocytic leukemia in adults. Since 1999, several other assessments have been completed that support an association between childhood leukemia and exposure to power-frequency EMF. These more recent reviews, however, do not support a link between EMF exposures and adult leukemias. For both childhood and adult leukemias, interpretation of the epidemiological findings has been difficult due to the absence of supporting laboratory evidence or a scientific explanation linking EMF exposures with leukemia.

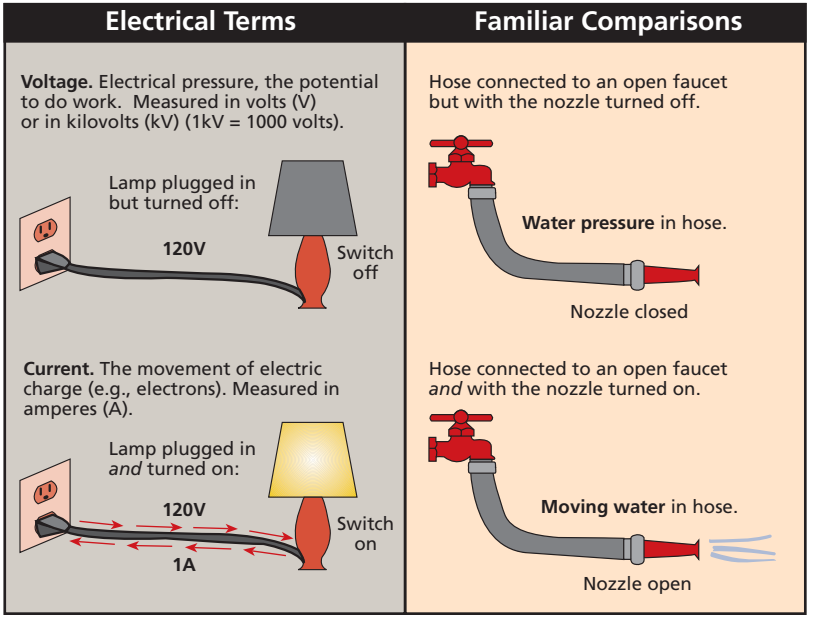
EMF exposures are complex and exist in the home and workplace as a result of all types of electrical equipment and building wiring as well as a result of nearby power lines. This booklet explains the basic principles of electric and magnetic fields, provides an overview of the results of major research studies, and summarizes conclusions of the expert review panels to help you reach your own conclusions about EMF-related health concerns.

1 EMF Basics

This chapter reviews terms you need to know to have a basic understanding of electric and magnetic fields (EMF), compares EMF with other forms of electromagnetic energy, and briefly discusses how such fields may affect us.

Q A What are electric and magnetic fields?

Electric and magnetic fields (EMF) are invisible lines of force that surround any electrical device. Power lines, electrical wiring, and electrical equipment all produce EMF. There are many other sources of EMF as well (see pages 33–35). The focus of this booklet is on power-frequency EMF—that is, EMF associated with the generation, transmission, and use of electric power.



Voltage produces an electric field and current produces a magnetic field.

Electric fields are produced by voltage and increase in strength as the voltage increases. The electric field strength is measured in units of volts per meter (V/m). Magnetic fields result from the flow of current through wires or electrical devices and increase in strength as the current increases. Magnetic fields are measured in units of gauss (G) or tesla (T).

Most electrical equipment has to be turned on, i.e., current must be flowing, for a magnetic field to be produced. Electric fields are often present even when the equipment is switched off, as long as it remains connected to the source of electric power. Brief bursts

of EMF (sometimes called "transients") can also occur when electrical devices are turned on or off.

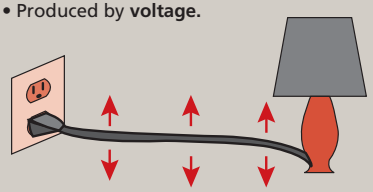
Electric fields are shielded or weakened by materials that conduct electricity—even materials that conduct poorly, including trees, buildings, and human skin. Magnetic fields, however, pass through most materials and are therefore more difficult to shield. Both electric fields and magnetic fields decrease rapidly as the distance from the source increases.

Even though electrical equipment, appliances, and power lines produce both electric and magnetic fields, most recent research has focused on potential health effects of magnetic field exposure. This is because some epidemiological studies have reported an increased cancer risk associated with estimates of magnetic field exposure (see pages 19 and 20 for a summary of these studies). No similar associations have been reported for electric fields; many of the studies examining biological effects of electric fields were essentially negative.

A Comparison of Electric and Magnetic Fields

Electric Fields

- Produced by **voltage.**

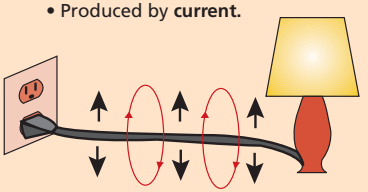


Lamp plugged in but turned off.
Voltage produces an electric field.

- Measured in **volts per meter (V/m)** or in **kilovolts per meter (kV/m).**
- **Easily shielded** (weakened) by conducting objects such as trees and buildings.
- Strength decreases rapidly with increasing distance from the source.

Magnetic Fields

- Produced by **current.**

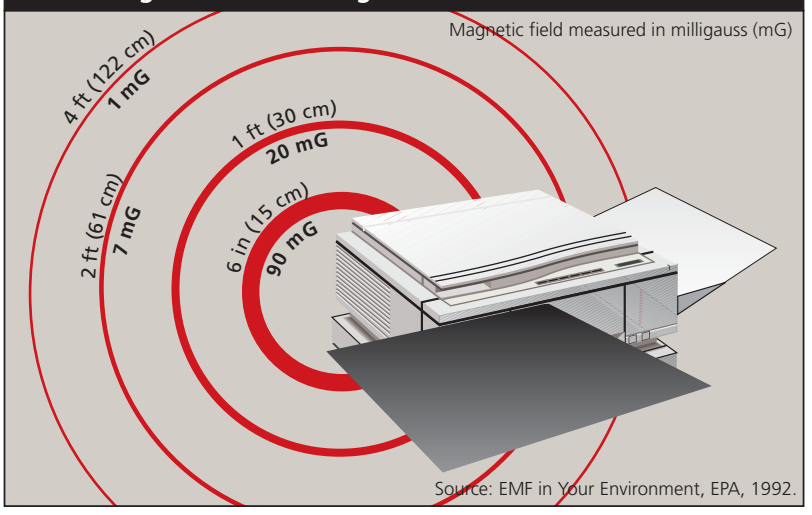


Lamp plugged in and turned on. Current now produces a magnetic field also.

- Measured in **gauss (G)** or **tesla (T).**
- **Not easily shielded** (weakened) by most material.
- Strength decreases rapidly with increasing distance from the source.

An appliance that is plugged in and therefore connected to a source of electricity has an electric field even when the appliance is turned off. To produce a magnetic field, the appliance must be plugged in and turned on so that the current is flowing.

Magnetic Field Strength Decreases with Distance



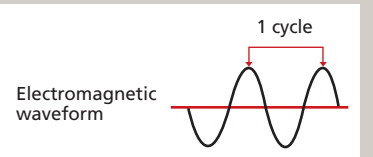
You cannot see a magnetic field, but this illustration represents how the strength of the magnetic field can diminish just 1–2 feet (30–61 centimeters) from the source. This magnetic field is a 60-Hz power-frequency field.

Characteristics of electric and magnetic fields

Electric fields and magnetic fields can be characterized by their wavelength, frequency, and amplitude (strength). The graphic below shows the waveform of an alternating electric or magnetic field. The direction of the field alternates from one polarity to the opposite and back to the first polarity in a period of time called one cycle. Wavelength describes the distance between a peak on the wave and the next peak of the same polarity. The frequency of the field, measured in hertz (Hz), describes the number of cycles that occur in one second. Electricity in North America alternates through 60 cycles per second, or 60 Hz. In many other parts of the world, the frequency of electric power is 50 Hz.

Frequency and Wavelength

Frequency is measured in hertz (Hz).
1 Hz = 1 cycle per second.



Examples:

Source	Frequency	Wavelength
Power line (North America)	60 Hz	3100 miles (5000 km)
Power line (Europe and most other locations)	50 Hz	3750 miles (6000 km)

Q How is the term EMF used in this booklet?

A The term "EMF" usually refers to electric and magnetic fields at extremely low frequencies such as those associated with the use of electric power. The term EMF can be used in a much broader sense as well, encompassing electromagnetic fields with low or high frequencies (see page 8).

Measuring EMF: Common Terms

Electric fields

Electric field strength is measured in volts per meter (V/m) or in kilovolts per meter (kV/m). 1 kV = 1000 V

Magnetic fields

Magnetic fields are measured in units of gauss (G) or tesla (T). Gauss is the unit most commonly used in the United States. Tesla is the internationally accepted scientific term. 1 T = 10,000 G

Since most environmental EMF exposures involve magnetic fields that are only a fraction of a tesla or a gauss, these are commonly measured in units of microtesla (μT) or milligauss (mG). A milligauss is 1/1,000 of a gauss. A microtesla is 1/1,000,000 of a tesla. 1 G = 1,000 mG; 1 T = 1,000,000 μT

To convert a measurement from microtesla (μT) to milligauss (mG), multiply by 10.
1 μT = 10 mG; 0.1 μT = 1 mG

When we use EMF in this booklet, we mean extremely low frequency (ELF) electric and magnetic fields, ranging from 3 to 3,000 Hz (see page 8). This range includes power-frequency (50 or 60 Hz) fields. In the ELF range, electric and magnetic fields are not coupled or interrelated in the same way that they are at higher frequencies. So, it is more useful to refer to them as "electric and magnetic fields" rather than "electromagnetic fields." In the popular press, however, you will see both terms used, abbreviated as EMF.

This booklet focuses on extremely low frequency EMF, primarily power-frequency fields of 50 or 60 Hz, produced by the generation, transmission, and use of electricity.

Q How are power-frequency EMF different from other types of electromagnetic energy?

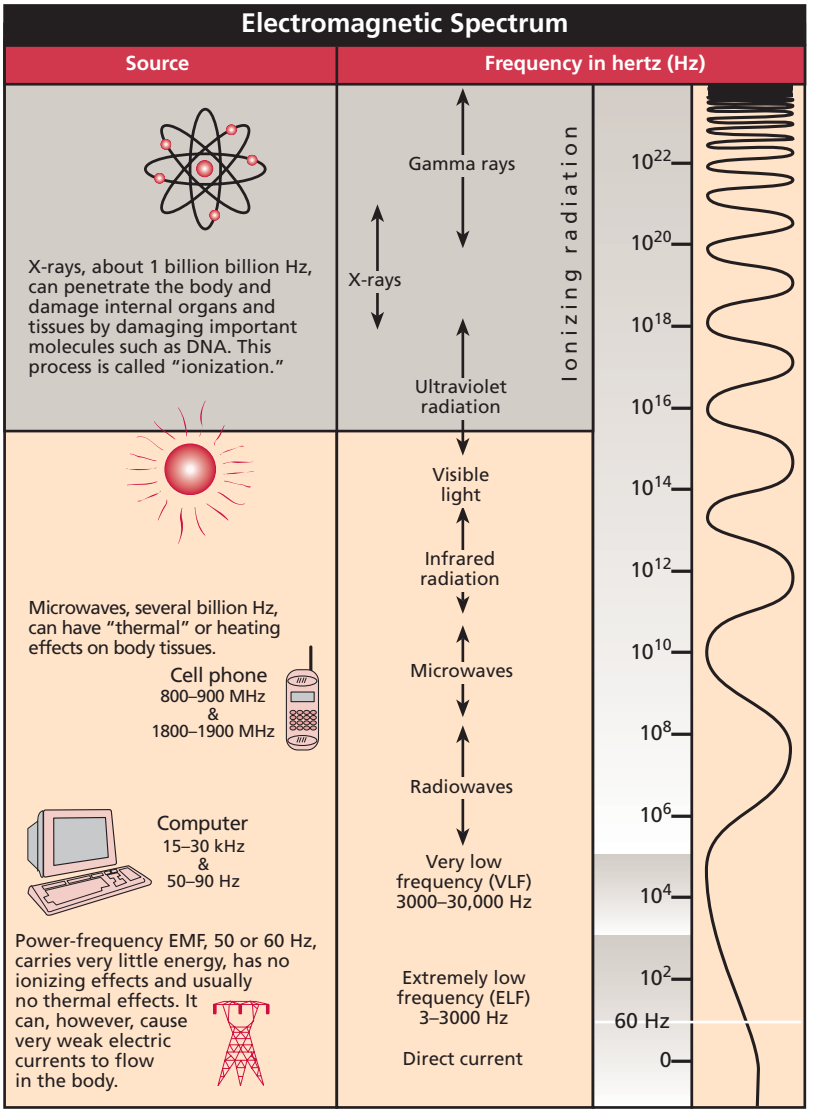
A X-rays, visible light, microwaves, radio waves, and EMF are all forms of electromagnetic energy. One property that distinguishes different forms of electromagnetic energy is the frequency, expressed in hertz (Hz). Power-frequency EMF, 50 or 60 Hz, carries very little energy, has no ionizing effects, and usually has no thermal effects (see page 8). Just as various chemicals affect our bodies in different ways, various forms of electromagnetic energy can have very different biological effects (see "Results of EMF Research" on page 16).

Some types of equipment or operations simultaneously produce electromagnetic energy of different frequencies. Welding operations, for example, can produce electromagnetic energy in the ultraviolet, visible, infrared, and radio-frequency ranges, in addition to power-frequency EMF. Microwave ovens produce 60-Hz fields of several hundred milligauss, but they also create microwave energy inside the oven that is at a much higher frequency (about 2.45 billion Hz). We are shielded from the higher frequency fields inside the oven by its casing, but we are not shielded from the 60-Hz fields.

Cellular telephones communicate by emitting high-frequency electric and magnetic fields similar to those used for radio and television broadcasts. These radio-frequency and microwave fields are quite different from the extremely low frequency EMF produced by power lines and most appliances.

Q How are alternating current sources of EMF different from direct current sources?

A Some equipment can run on either alternating current (AC) or direct current (DC). In most parts of the United States, if the equipment is plugged into a household wall socket, it is using AC electric current that reverses direction in the electrical wiring—or alternates—60 times per second, or at 60 hertz (Hz). If the equipment uses batteries, then electric current flows in one direction only. This



The wavy line at the right illustrates the concept that the higher the frequency, the more rapidly the field varies. The fields do not vary at 0 Hz (direct current) and vary trillions of times per second near the top of the spectrum. Note that 10^4 means 10 x 10 x 10 x 10 or 10,000 Hz. 1 kilohertz (kHz) = 1,000 Hz. 1 megahertz (MHz) = 1,000,000 Hz.

produces a "static" or stationary magnetic field, also called a direct current field. Some battery-operated equipment can produce time-varying magnetic fields as part of its normal operation.

Q What happens when I am exposed to EMF?

A In most practical situations, DC electric power does not induce electric currents in humans. Strong DC magnetic fields are present in some industrial environments, can induce significant currents when a person moves, and may be of concern for other reasons, such as potential effects on implanted medical devices (see page 47 for more information on pacemakers and other medical devices).

AC electric power produces electric and magnetic fields that create weak electric currents in humans. These are called "induced currents." Much of the research on how EMF may affect human health has focused on AC-induced currents.

Electric fields

A person standing directly under a high-voltage transmission line may feel a mild shock when touching something that conducts electricity. These sensations are caused by the strong electric fields from the high-voltage electricity in the lines. They occur only at close range because the electric fields rapidly become weaker as the distance from the line increases. Electric fields may be shielded and further weakened by buildings, trees, and other objects that conduct electricity.

Magnetic fields

Alternating magnetic fields produced by AC electricity can induce the flow of weak electric currents in the body. However, such currents are estimated to be smaller than the measured electric currents produced naturally by the brain, nerves, and heart.

Q Doesn't the earth produce EMF?

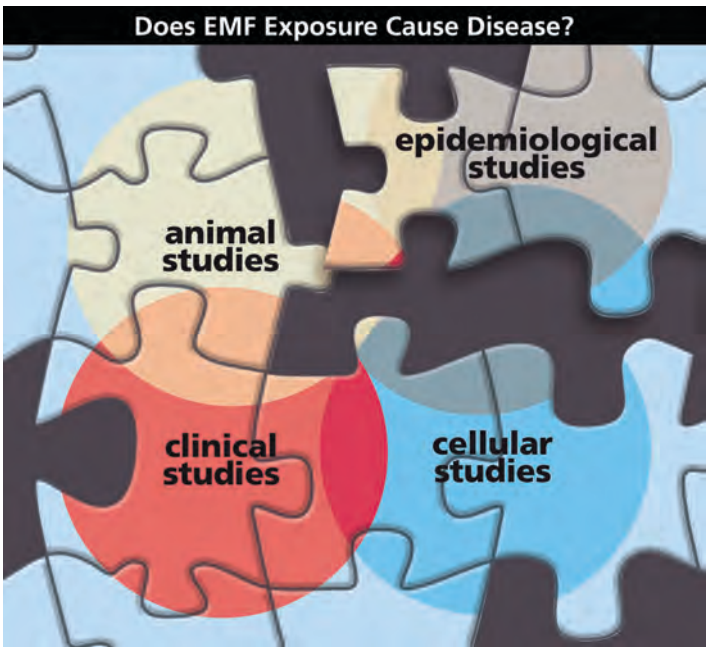
A Yes. The earth produces EMF, mainly in the form of static fields, similar to the fields generated by DC electricity. Electric fields are produced by air turbulence and other atmospheric activity. The earth's magnetic field of about 500 mG is thought to be produced by electric currents flowing deep within the earth's core. Because these fields are static rather than alternating, they do not induce currents in stationary objects as do fields associated with alternating current. Such static fields can induce currents in moving and rotating objects.

2 Evaluating Potential Health Effects

This chapter explains how scientific studies are conducted and evaluated to assess potential health effects.

Q How do we evaluate whether EMF exposures cause health effects?

A Animal experiments, laboratory studies of cells, clinical studies, computer simulations, and human population (epidemiological) studies all provide valuable information. When evaluating evidence that certain exposures cause disease, scientists consider results from studies in various disciplines. No single study or type of study is definitive.



Laboratory studies and human studies provide pieces of the puzzle, but no single study can give us the whole picture.

Laboratory studies

Laboratory studies with cells and animals can provide evidence to help determine if an agent such as EMF causes disease. Cellular studies can increase our understanding of the biological mechanisms by which disease occurs. Experiments with animals provide a means to observe effects of specific agents under carefully controlled conditions. Neither cellular nor animal studies, however, can recreate the complex nature of the whole human organism and its environment. Therefore, we must use caution in applying the results of cellular or animal studies directly to humans or concluding that a lack of an effect in laboratory studies proves that an agent is safe. Even with these limitations, cellular and animal studies have proven very

useful over the years for identifying and understanding the toxicity of numerous chemicals and physical agents.

Very specific laboratory conditions are needed for researchers to be able to detect EMF effects, and experimental exposures are not easily comparable to human exposures. In most cases, it is not clear how EMF actually produces the effects observed in some experiments. Without understanding how the effects occur, it is difficult to evaluate how laboratory results relate to human health effects.

Some laboratory studies have reported that EMF exposure can produce biological effects, including changes in functions of cells and tissues and subtle changes in hormone levels in animals. It is important to distinguish between a biological effect and a health effect. Many biological effects are within the normal range of variation and are not necessarily harmful. For example, bright light has a biological effect on our eyes, causing the pupils to constrict, which is a normal response.

Clinical studies

In clinical studies, researchers use sensitive instruments to monitor human physiology during controlled exposure to environmental agents. In EMF studies, volunteers are exposed to electric or magnetic fields at higher levels than those commonly encountered in everyday life. Researchers measure heart rate, brain activity, hormonal levels, and other factors in exposed and unexposed groups to look for differences resulting from EMF exposure.

Epidemiology

A valuable tool to identify human health risks is to study a human population that has experienced the exposure. This type of research is called epidemiology.

The epidemiologist observes and compares groups of people who have had or have not had certain diseases and exposures to see if the risk of disease is different between the exposed and unexposed groups. The epidemiologist does not control the exposure and cannot experimentally control all the factors that might affect the risk of disease.

Most researchers agree that epidemiology—the study of patterns and possible causes of diseases—is one of the most valuable tools to identify human health risks.

Q How do we evaluate the results of epidemiological studies of EMF?

A Many factors need to be considered when determining whether an agent causes disease. An exposure that an epidemiological study associates with increased risk of a certain disease is not always the actual cause of the disease. To judge whether an agent actually causes a health effect, several issues are considered.

Strength of association

The stronger the association between an exposure and disease, the more confident we can be that the disease is due to the exposure being studied. With cigarette smoking and lung cancer, the association is very strong—20 times the normal risk. In the studies that suggest a relationship between EMF and certain rare cancers, the association is much weaker (see page 19).

Dose-response

Epidemiological data are more convincing if disease rates increase as exposure levels increase. Such dose-response relationships have appeared in only a few EMF studies.

Consistency

Consistency requires that an association found in one study appears in other studies involving different study populations and methods. Associations found consistently are more likely to be causal. With regard to EMF, results from different studies sometimes disagree in important ways, such as what type of cancer is associated with EMF exposure. Because of this inconsistency, scientists cannot be sure whether the increased risks are due to EMF or other factors.

Biological plausibility

When associations are weak in an epidemiological study, results of laboratory studies are even more important to support the association. Many scientists remain skeptical about an association between EMF exposure and cancer because laboratory studies thus far have not shown any consistent evidence of adverse health effects, nor have results of experimental studies revealed a plausible biological explanation for such an association.

Reliability of exposure information

Another important consideration with EMF epidemiological studies is how the exposure information was obtained. Did the researchers simply estimate people's EMF exposures based on their job titles or how their houses were wired, or did they actually conduct EMF measurements? What did they measure (electric fields, magnetic fields, or both)? How often were the EMF measurements made and at

what time? In how many different places were the fields measured? More recent studies have included measurements of magnetic field exposure. Magnetic fields measured at the time a study is conducted can only estimate exposures that occurred in previous years (at the time a disease process may have begun). Lack of comprehensive exposure information makes it more difficult to interpret the results of a study, particularly considering that everyone in the industrialized world has been exposed to EMF.

Confounding

Epidemiological studies show relationships or correlations between disease and other factors such as diet, environmental conditions, and heredity. When a disease is correlated with some factor, it does not necessarily mean that the correlated factor causes the disease. It could mean that the factor occurs together with some other factor, not measured in the study, that actually causes the disease. This is called confounding.

For example, a study might show that alcohol consumption is correlated with lung cancer. This could occur if the study group consists of people who drink and also smoke tobacco, as often happens. In this example, alcohol use is correlated with lung cancer, but cigarette smoking is a confounding factor and the true cause of the disease.

Statistical significance

Researchers use statistical methods to determine the likelihood that the association between exposure and disease is due simply to chance. For a result to be considered "statistically significant," the association must be stronger than would be expected to occur by chance alone.

Meta-analysis

One way researchers try to get more information from epidemiological studies is to conduct a meta-analysis. A meta-analysis combines the summary statistics of many studies to explore their differences and, if appropriate, calculates an overall summary risk estimate. The main challenge faced by researchers performing meta-analyses is that populations, measurements, evaluation techniques, participation rates, and potential confounding factors vary in the original studies. These differences in the studies make it difficult to combine the results in a meaningful way.

Pooled analysis

Pooled analysis combines the original data from several studies and conducts a new analysis on the primary data. It requires access to the original data from individual studies and can only include diseases or factors included in all the studies, but it has the advantage that the same parameters can be applied to all studies. As with meta-analysis, pooled analysis is still subject to the limitations of the experimental

design of the original studies (for example, evaluation techniques, participation rates, etc.). Pooled analysis differs from meta-analysis, which combines the summary statistics from different studies, not their original data.

Q How do we characterize EMF exposure?

A No one knows which aspect of EMF exposure, if any, affects human health. Because of this uncertainty, in addition to the field strength, we must ask how long an exposure lasts, how it varies, and at what time of day or night it occurs. House wiring, for example, is often a significant source of EMF exposure for an individual, but the magnetic fields produced by the wiring depend on the amount of current flowing. As heating, lighting, and appliance use varies during the day, magnetic field exposure will also vary.

For many studies, researchers describe EMF exposures by estimating the average field strength. Some scientists believe that average exposure may not be the best measurement of EMF exposure and that other parameters, such as peak exposure or time of exposure, may be important.

Q What is the average field strength?

A In EMF studies, the information reported most often has been a person's EMF exposure averaged over time (average field strength). With cancer-causing chemicals, a person's average exposure over many years can be a good way to predict his or her chances of getting the disease.

There are different ways to calculate average magnetic field exposures. One method involves having a person wear a small monitor that takes many measurements over a work shift, a day, or longer. Then the average of those measurements is calculated. Another method involves placing a monitor that takes many measurements in a residence over a 24-hour or 48-hour period. Sometimes averages are calculated for people with the same occupation, people working in similar environments, or people using several brands of the same type or similar types of equipment.

Q How is EMF exposure measured in epidemiological studies?

A Epidemiologists study patterns and possible causes of diseases in human populations. These studies are usually observational rather than experimental. This means that the researcher observes and compares groups of people who have had certain diseases and exposures and looks for possible "associations." The epidemiologist must find a way to estimate the exposure that people had at an earlier time.

Association

In epidemiology, a positive association between an exposure (such as EMF) and a disease is not necessarily proof that the exposure *caused* the disease. However, the more often the exposure and disease occur together, the stronger the association, and the stronger is the possibility that the exposure may increase the risk of the disease.

Some exposure estimates for residential studies have been based on designation of households in terms of "wire codes." In other studies, measurements have been made in homes, assuming that EMF levels at the time of the measurement are similar to levels at some time in the past. Some studies involved "spot measurements." Exposure levels change as a person moves around in his or her environment, so spot measurements taken at specific locations only approximate the complex variations in exposure a person experiences. Other studies measured magnetic fields over a 24-hour or 48-hour period. Exposure levels for some occupational studies are measured by having certain employees wear personal monitors. The data taken from these monitors are sometimes used to estimate typical exposure levels for employees with certain job titles. Researchers can then estimate exposures using only an employee's job title and avoid measuring exposures of all employees.

Methods to Estimate EMF Exposure

Wire Codes

A classification of homes based on characteristics of power lines outside the home (thickness of the wires, wire configuration, etc.) and their distance from the home. This information is used to code the homes into groups with higher and lower predicted magnetic field levels.

Spot Measurement

An instantaneous or very short-term (e.g., 30-second) measurement taken at a designated location.

Time-Weighted Average

A weighted average of exposure measurements taken over a period of time that takes into account the time interval between measurements. When the measurements are taken with a monitor at a fixed sampling rate, the time-weighted average equals the arithmetic mean of the measurements.

Personal Monitor

An instrument that can be worn on the body for measuring exposure over time.

Calculated Historical Fields

An estimate based on a theoretical calculation of the magnetic field emitted by power lines using historical electrical loads on those lines.

3 Results of EMF Research

This chapter summarizes the results of EMF research worldwide, including epidemiological studies of children and adults, clinical studies of how humans react to typical EMF exposures, and laboratory research with animals and cells.

Q Is there a link between EMF exposure and childhood leukemia?

A Despite more than two decades of research to determine whether elevated EMF exposure, principally to magnetic fields, is related to an increased risk of childhood leukemia, there is still no definitive answer. Much progress has been made, however, with some lines of research leading to reasonably clear answers and others remaining unresolved. The best available evidence at this time leads to the following answers to specific questions about the link between EMF exposure and childhood leukemia:

Is there an association between power line configurations (wire codes) and childhood leukemia? No.

Is there an association between measured fields and childhood leukemia? Yes, but the association is weak, and it is not clear whether it represents a cause-and-effect relationship.

Q What is the epidemiological evidence for evaluating a link between EMF exposure and childhood leukemia?

A The initial studies, starting with the pioneering research of Dr. Nancy Wertheimer and Ed Leeper in 1979 in Denver, Colorado, focused on power line configurations near homes. Power lines were systematically evaluated and coded for their presumed ability to produce elevated magnetic fields in homes and classified into groups with higher and lower predicted magnetic field levels (see discussion of wire codes on page 15). Although the first study and two that followed in Denver and Los Angeles showed an association between wire codes indicative of elevated magnetic fields and childhood leukemia, larger, more recent studies in the central part of the United States and in several provinces of Canada did not find such an

association. In fact, combining the evidence from all the studies, we can conclude with some confidence that wire codes are not associated with a measurable increase in the risk of childhood leukemia.

The other approach to assessing EMF exposure in homes focused on the measurements of magnetic fields. Unlike wire codes, which are only applicable in North America due to the nature of the electric power distribution system, measured fields have been studied in relation to childhood leukemia in research conducted around the world, including Sweden, England, Germany, New Zealand, and Taiwan. Large, detailed studies have recently been completed in the United States, Canada, and the United Kingdom that provide the most evidence for making an evaluation. These studies have produced variable findings, some reporting small associations, others finding no associations.

National Cancer Institute Study

In 1997, after eight years of work, Dr. Martha Linet and colleagues at the National Cancer Institute (NCI) reported the results of their study of childhood acute lymphoblastic leukemia (ALL). The case-control study involved more than 1,000 children living in 9 eastern and midwestern U.S. states and is the largest epidemiological study of childhood leukemia to date in the United States. To help resolve the question of wire code versus measured magnetic fields, the NCI researchers carried out both types of exposure assessment. Overall, Linet reported little evidence that living in homes with higher measured magnetic-field levels was a disease risk and found no evidence that living in a home with a high wire code configuration increased the risk of ALL in children.

United Kingdom Childhood Cancer Study

In December 1999, Sir Richard Doll and colleagues in the United Kingdom announced that the largest study of childhood cancer ever undertaken—involving nearly 4,000 children with cancer in England, Wales, and Scotland—found no evidence of excess risk of childhood leukemia or other cancers from exposure to power-frequency magnetic fields. It should be noted, however, that because most power lines in the United Kingdom are underground, the EMF exposures of these children were mostly lower than 0.2 microtesla or 2 milligauss.

After reviewing all the data, the U.S. National Institute of Environmental Health Sciences (NIEHS) concluded in 1999 that the evidence was weak, but that it was still sufficient to warrant limited concern. The NIEHS rationale was that no individual epidemiological study provided convincing evidence linking magnetic field exposure with childhood leukemia, but the overall pattern of results for some methods of measuring exposure suggested a weak association between increasing exposure to EMF and increasing risk of childhood leukemia. The small number of cases in these studies made it impossible to firmly demonstrate this association. However, the fact that similar results had been observed in studies of different populations using a variety of study designs supported this observation.

A major challenge has been to determine whether the most highly elevated, but rarely encountered, levels of magnetic fields are associated with an increased risk of leukemia. Early reports focused on the risk associated with exposures above 2 or 3 milligauss, but the more recent studies have been large enough to also provide some information on levels above 3 or 4 milligauss. It is estimated that 4.5% of homes in the United States have magnetic fields above 3 milligauss, and 2.5% of homes have levels above 4 milligauss.

What is Cancer?

Cancer

"Cancer" is a term used to describe at least 200 different diseases, all involving uncontrolled cell growth. The frequency of cancer is measured by the incidence—the number of new cases diagnosed each year. Incidence is usually described as the number of new cases diagnosed per 100,000 people per year.

The incidence of cancer in adults in the United States is 382 per 100,000 per year, and childhood cancers account for about 1% of all cancers. The factors that influence risk differ among the forms of cancer. Known risk factors such as smoking, diet, and alcohol contribute to specific types of cancer. (For example, smoking is a known risk factor for lung cancer, bladder cancer, and oral cancer.) For many other cancers, the causes are unknown.

Leukemia

Leukemia describes a variety of cancers that arise in the bone marrow where blood cells are formed. The leukemias represent less than 4% of all cancer cases in adults but are the most common form of cancer in children. For children age 4 and under, the incidence of childhood leukemia is approximately 6 per 100,000 per year, and it decreases with age to about 2 per 100,000 per year for children 10 and older. In the United States, the incidence of adult leukemia is about 10 cases per 100,000 people per year. Little is known about what causes leukemia, although genetic factors play a role. The only known causes are ionizing radiation, benzene, and other chemicals and drugs that suppress bone marrow function, and a human T-cell leukemia virus.

Brain Cancer

Cancer of the central nervous system (the brain and spinal cord) is uncommon, with incidence in the United States now at about 6 cases in 100,000 people per year. The causes of the disease are largely unknown, although a number of studies have reported an association with certain occupational chemical exposures. Ionizing radiation to the scalp is a known risk factor for brain cancer. Factors associated with an increased risk for other types of cancer—such as smoking, diet, and excessive alcohol use—have not been found to be associated with brain cancer.

To determine what the integrated information from all the studies says about magnetic fields and childhood leukemia, two groups have conducted pooled analyses in which the original data from relevant studies were integrated and analyzed. One report (Greenland et al., 2000) combined 12 relevant studies with magnetic field measurements, and the other considered 9 such studies (Ahlbom et al., 2000). The details of the two pooled analyses are different, but their findings are similar. There is weak evidence for an association (relative risk of approximately 2) at exposures above 3 mG. However, few individuals had high exposures in these studies; therefore, even combining all studies, there is uncertainty about the strength of the association.

The following table summarizes the results for the epidemiological studies of EMF exposure and childhood leukemia analyzed in the pooled analysis by Greenland et al. (2000). The focus of the summary review was the magnetic fields that occurred three months prior to diagnosis. The results were derived from either calculated historical fields or multiple measurements of magnetic fields. The North American

Residential Exposure to Magnetic Fields and Childhood Leukemia

	Magnetic field category (mG)					
	>1 – ≤2 mG		>2 – ≤3 mG		>3 mG	
First author	Estimate	95% CL	Estimate	95% CL	Estimate	95% CL
Coghill	0.54	0.17, 1.74	No controls		No controls	
Dockerty	0.65	0.26, 1.63	2.83	0.29, 27.9	No controls	
Feychting	0.63	0.08, 4.77	0.90	0.12, 7.00	4.44	1.67, 11.7
Linet	1.07	0.82, 1.39	1.01	0.64, 1.59	1.51	0.92, 2.49
London	0.96	0.54, 1.73	0.75	0.22, 2.53	1.53	0.67, 3.50
McBride	0.89	0.62, 1.29	1.27	0.74, 2.20	1.42	0.63, 3.21
Michaelis	1.45	0.78, 2.72	1.06	0.27, 4.16	2.48	0.79, 7.81
Olsen	0.67	0.07, 6.42	No cases		2.00	0.40, 9.93
Savitz	1.61	0.64, 4.11	1.29	0.27, 6.26	3.87	0.87, 17.3
Tomenius	0.57	0.33, 0.99	0.88	0.33, 2.36	1.41	0.38, 5.29
Tynes	1.06	0.25, 4.53	No cases		No cases	
Verkasalo	1.11	0.14, 9.07	No cases		2.00	0.23, 17.7
Study summary	0.95	0.80, 1.12	1.06	0.79, 1.42	1.69*	1.25, 2.29
	1 – <2 mG		2 – <4 mG		≥4 mG	
**United Kingdom	0.84	0.57, 1.24	0.98	0.50, 1.93	1.00	0.30, 3.37

95% CL = 95% confidence limits.

Source: Greenland et al., 2000.

* Mantel-Haenszel analysis (p = 0.01). Maximum-likelihood summaries differed by less than 1% from these summaries; based on 2,656 cases and 7,084 controls. Adjusting for age, sex, and other variables had little effect on summary results.

** These data are from a recent United Kingdom study not included in the Greenland analysis but included in another pooled analysis (Ahlbom et al. 2000). The United Kingdom study included 1,073 cases and 2,224 controls.

For this table, the column headed "estimate" describes the relative risk. Relative risk is the ratio of the risk of childhood leukemia for those in a magnetic field exposure group compared to persons with exposure levels of 1.0 mG or less. For example, Coghill estimated that children with exposures between 1 and 2 mG have 0.54 times the risk of children whose exposures were less than 1 mG. London's study estimates that children whose exposures were greater than 3 mG have 1.53 times the risk of children whose exposures were less than 1 mG. The column headed "95% CL" (confidence limits) describes how much random variation is in the estimate of relative risk. The estimate may be off by some amount due to random variation, and the width of the confidence limits gives some notion of that variation. For example, in Coghill's estimate of 0.54 for the relative risk, values as low as 0.17 or as high as 1.74 would not be statistically significantly different from the value of 0.54. Note there is a wide range of estimates of relative risk across the studies and wide confidence limits for many studies. In light of these findings, the pooling of results can be extremely helpful to calculate an overall estimate, much better than can be obtained from any study taken alone.

studies (Linet, London, McBride, Savitz) were 60 Hz; all other studies were 50 Hz. Results from the recent study from the United Kingdom (see page 17) are also included in the table. This study was included in the analysis by Ahlbom et al. (2000). The relative risk estimates from the individual studies show little or no association of magnetic fields with childhood leukemia. The study summary for the pooled analysis by Greenland et al. (2000) shows a weak association between childhood leukemia and magnetic field exposures greater 3 mG.

Q Is there a link between EMF exposure and childhood brain cancer or other forms of cancer in children?

A Although the earliest studies suggested an association between EMF exposure and all forms of childhood cancer, those initial findings have not been confirmed by other studies. At present, the available series of studies indicates no association between EMF exposure and childhood cancers other than leukemia. Far fewer of these studies have been conducted than studies of childhood leukemia.

Q Is there a link between residential EMF exposure and cancer in adults?

A The few studies that have been conducted to address EMF and adult cancer do not provide strong evidence for an association. Thus, a link has not been established between residential EMF exposure and adult cancers, including leukemia, brain cancer, and breast cancer (see table below).

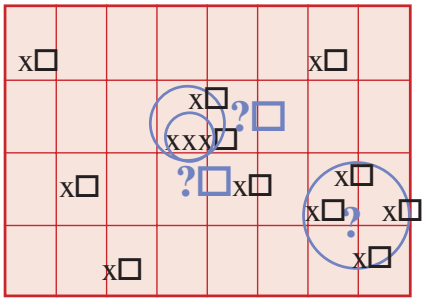
Residential Exposure to Magnetic Fields and Adult Cancer

First author	Location	Type of exposure data	Results (odds ratios)		
			Leukemia	CNS tumors	All cancers
Coleman	United Kingdom	Calculated historical fields	0.92	NA	NA
Feychting and Ahlbom	Sweden	Calculated & spot measurements	1.5*	0.7	NA
Li	Taiwan	Calculated historical fields	1.4*	1.1	NA
Li	Taiwan	Calculated historical fields		1.1 (breast cancer)	
McDowall	United Kingdom	Calculated historical fields	1.43	NA	1.03
Severson	Seattle	Wire codes & spot measurements	0.75	NA	NA
Wrensch	San Francisco	Wire codes & spot measurements	NA	0.9	NA
Youngson	United Kingdom	Calculated historical fields	1.88	NA	NA

CNS = central nervous system.
*The number is statistically significant (greater than expected by chance).
Study results are listed as "odds ratios" (OR). An odds ratio of 1.00 means there was no increase or decrease in risk. In other words, the odds that the people in the study who had the disease (in this case, cancer) and were exposed to a particular agent (in this case, EMF) are the same as for the people in the study who did not have the disease. An odds ratio greater than 1 may occur simply by chance, unless it is statistically significant.

Q Have clusters of cancer or other adverse health effects been linked to EMF exposure?

A An unusually large number of cancers, miscarriages, or other adverse health effects that occur in one area or over one period of time is called a "cluster." Sometimes clusters provide an early warning of a health hazard. But most of the time the reason for the cluster is not known. There have been no proven instances of cancer clusters linked with EMF exposure.



The definition of a "cluster" depends on how large an area is included. Cancer cases (x's in illustration) in a city, neighborhood, or workplace may occur in ways that suggest a cluster due to a common environmental cause. Often these patterns turn out to be due to chance. Delineation of a cluster is subjective—where do you draw the circles?

Q If EMF does cause or promote cancer, shouldn't cancer rates have increased along with the increased use of electricity?

A Not necessarily. Although the use of electricity has increased greatly over the years, EMF exposures may not have increased. Changes in building wiring codes and in the design of electrical appliances have in some cases resulted in lower magnetic field levels. Rates for various types of cancer have shown both increases and decreases through the years, due in part to improved prevention, diagnosis, reporting, and treatment.

Q Is there a link between EMF exposure in electrical occupations and cancer?

A For almost as long as we have been concerned with residential exposure to EMF and childhood cancers, researchers have been studying workplace exposure to EMF and adult cancers, focusing on leukemia and brain cancer. This research began with surveys of job titles and cancer risks, but has progressed to include very large, detailed studies of the health of workers, especially electric utility workers, in the United States, Canada, France, England, and several Northern European countries. Some studies have found evidence that suggests a link between EMF exposure and both leukemia and brain cancer, whereas other studies of similar size and quality have not found such associations.

California

A 1993 study of 36,000 California electric utility workers reported no strong, consistent evidence of an association between magnetic fields and any type of cancer.

Canada/France

A 1994 study of more than 200,000 utility workers in 3 utility companies in Canada and France reported no significant association between all leukemias combined and cumulative exposure to magnetic fields. There was a slight, but not statistically significant, increase in brain cancer. The researchers concluded that the study did not provide clear-cut evidence that magnetic field exposures caused leukemia or brain cancer.

North Carolina

Results of a 1995 study involving more than 138,000 utility workers at 5 electric utilities in the United States did not support an association between occupational magnetic field exposure and leukemia, but suggested a link to brain cancer.

Denmark

In 1997 a study of workers employed in all Danish utility companies reported a small, but statistically significant, excess risk for all cancers combined and for lung cancer. No excess risk was observed for leukemia, brain cancers, or breast cancer.

United Kingdom

A 1997 study among electrical workers in the United Kingdom did not find an excess risk for brain cancer. An extension of this work reported in 2001 also found no increased risk for brain cancer.

Efforts have also been made to pool the findings across several of the above studies to produce more accurate estimates of the association between EMF and cancer (Kheifets et al., 1999). The combined summary statistics across studies provide insufficient evidence for an association between EMF exposure in the workplace and either leukemia or brain cancer.

Q Have studies of workers in other industries suggested a link between EMF exposure and cancer?

A One of the largest studies to report an association between cancer and magnetic field exposure in a broad range of industries was conducted in Sweden (1993). The study included an assessment of EMF exposure in 1,015 different workplaces and involved more than 1,600 people in 169 different occupations. An association was reported between estimated EMF exposure and increased risk for chronic lymphocytic leukemia. An association was also reported between exposure to magnetic fields and brain cancer, but there was no dose-response relationship.

Another Swedish study (1994) found an excess risk of lymphocytic leukemia among railway engine drivers and conductors. However, the total cancer incidence (all tumors included) for this group of workers was lower than in the general Swedish population. A study of Norwegian railway workers found no evidence for an association between EMF exposure and leukemia or brain cancer. Although both positive and negative effects of EMF exposure have been reported, the majority of studies show no effects.

Q Is there a link between EMF exposure and breast cancer?

A Researchers have been interested in the possibility that EMF exposure might cause breast cancer, in part because breast cancer is such a common disease in adult women. Early studies identified a few electrical workers with male breast cancer, a very rare disease. A link between EMF exposure and alterations in the hormone melatonin was considered a possible hypothesis (see page 24). This idea provided motivation to conduct research addressing a possible link between EMF exposure and breast cancer. Overall, the published epidemiological studies have not shown such an association.

Q What have we learned from clinical studies?

A Laboratory studies with human volunteers have attempted to answer questions such as,

Does EMF exposure alter normal brain and heart function?
Does EMF exposure at night affect sleep patterns?
Does EMF exposure affect the immune system?
Does EMF exposure affect hormones?

The following kinds of biological effects have been reported. Keep in mind that a biological effect is simply a measurable change in some biological response. It may or may not have any bearing on health.

Heart rate

An inconsistent effect on heart rate by EMF exposure has been reported. When observed, the biological response is small (on average, a slowing of about three to five beats per minute), and the response does not persist once exposure has ended.

Two laboratories, one in the United States and one in Australia, have reported effects of EMF on heart rate variability. Exposures used in these experiments were relatively high (about 300 mG), and lower exposures failed to produce the effect. Effects have not been observed consistently in repeated experiments.

Sleep electrophysiology

A laboratory report suggested that overnight exposure to 60-Hz magnetic fields may disrupt brain electrical activity (EEG) during night sleep. In this study subjects were exposed to either continuous or intermittent magnetic fields of 283 mG. Individuals exposed to the intermittent magnetic fields showed alterations in traditional EEG sleep parameters indicative of a pattern of poor and disrupted sleep. Several studies have reported no effect with continuous exposure.

Hormones, immune system, and blood chemistry

Several clinical studies with human volunteers have evaluated the effects of power-frequency EMF exposure on hormones, the immune system, and blood chemistry. These studies provide little evidence for any consistent effect.

Melatonin

The hormone melatonin is secreted mainly at night and primarily by the pineal gland, a small gland attached to the brain. Some laboratory experiments with cells and animals have shown that melatonin can slow the growth of cancer cells, including breast cancer cells. Suppressed nocturnal melatonin levels have been observed in some studies of laboratory animals exposed to both electric and magnetic fields. These observations led to the hypothesis that EMF exposure might reduce melatonin and thereby weaken one of the body's defenses against cancer.

Many clinical studies with human volunteers have now examined whether various levels and types of magnetic field exposure affect blood levels of melatonin. Exposure of human volunteers at night to power-frequency EMF under controlled laboratory conditions has no apparent effect on melatonin. Some studies of people exposed to EMF at work or at home do report evidence for a small suppression of melatonin. It is not clear whether the decreases in melatonin reported under environmental conditions are related to the presence of EMF exposure or to other factors.

Q What effects of EMF have been reported in laboratory studies of cells?

A Over the years, scientists have conducted more than 1,000 laboratory studies to investigate potential biological effects of EMF exposure. Most have been *in vitro* studies; that is, studies carried out on cells isolated from animals and plants, or on cell components such as cell membranes. Other studies involved animals, mainly rats and mice. In general, these studies do not demonstrate a consistent effect of EMF exposure.

Most *in vitro* studies have used magnetic fields of 1,000 mG (100 μT) or higher, exposures that far exceed daily human exposures. In most incidences, when one laboratory has reported effects of EMF exposure on cells, other laboratories have not been able to reproduce the findings. For such research results to be widely accepted by scientists as valid, they must be replicated—that is, scientists in other laboratories should be able to repeat the experiment and get similar results. Cellular studies have investigated potential EMF effects on cell proliferation and differentiation, gene expression, enzyme activity, melatonin, and DNA. Scientists reviewing the EMF research literature find overall that the cellular studies provide little convincing evidence of EMF effects at environmental levels.

Q Have effects of EMF been reported in laboratory studies in animals?

A Researchers have published more than 30 detailed reports on both long-term and short-term studies of EMF exposures in laboratory animals (bioassays). Long-term animal bioassays constitute an important group of studies in EMF research. Such studies have a proven record for predicting the carcinogenicity of chemicals, physical agents, and other suspected cancer-causing agents. In the EMF studies, large groups of mice or rats were continuously exposed to EMF for two years or longer and were then evaluated for cancer. The U.S. National Toxicology Program (http://ntp-server.niehs.nih.gov/) has an extensive historical database for hundreds of different chemical and physical agents evaluated using this model. EMF long-term bioassays examined leukemia, brain cancer, and breast cancer—the diseases some epidemiological studies have associated with EMF exposure (see pages 16–23).

Several different approaches have been used to evaluate effects of EMF exposure in animal bioassays. To investigate whether EMF could promote cancer after genetic damage had occurred, some long-term studies used cancer initiators such as ultraviolet light, radiation, or certain chemicals that are known to cause genetic damage. Researchers compared groups of animals treated with cancer initiators to groups treated with cancer initiators and then exposed to EMF, to see if EMF exposure promoted the cancer growth (initiation-promotion model). Other studies tested the cancer promotion potential of EMF using mice that were predisposed to cancer because they had defects in the genes that control cancer.

Animal Leukemia Studies: Long-Term, Continuous Exposure Studies, Two or More Years in Length

First author	Sex/species	Exposure/animal numbers	Results
Babbitt (U.S.)	Female mice	14,000 mG, 190 or 380 mice per group. Some groups treated with ionizing radiation.	No effect
Boorman (U.S.)	Male and female rats	20 to 10,000 mG, 100 per group	No effect
McCormick (U.S.)	Male and female mice	20 to 10,000 mG, 100 per group	No effect
Mandeville (Canada)	Female rats	20 to 20,000 mG, 50 per group *In utero* exposure	No effect
Yasui (Japan)	Male and female rats	5,000 to 50,000 mG, 50 per group	No effect

10 milligauss (mG) = 1 microtesla (μT) = 0.001 millitesla (mT)

Leukemia

Fifteen animal leukemia studies have been completed and reported. Most tested for effects of exposure to power-frequency (60-Hz) magnetic fields using rodents. Results of these studies were largely negative. The Babbitt study evaluated the subtypes of leukemia. The data provide no support for the reported epidemiology findings of leukemia from EMF exposure. Many scientists feel that the lack of effects seen in these laboratory leukemia studies significantly weakens the case for EMF as a cause of leukemia.

Breast cancer

Researchers in the Ukraine, Germany, Sweden, and the United States have used initiation-promotion models to investigate whether EMF exposure promotes breast cancer in rats.

The results of these studies are mixed; while the German studies showed some effects, the Swedish and U.S. studies showed none. Studies in Germany reported effects on the numbers of tumors and tumor volume. A National Toxicology Program long-term bioassay performed without the use of other cancer-initiating substances showed no effects of EMF exposure on the development of mammary tumors in rats and mice.

The explanation for the observed difference among these studies is not readily apparent. Within the limits of the experimental rodent model of mammary carcinogenesis, no conclusions are possible regarding a promoting effect of EMF on chemically induced mammary cancer.

Other cancers

Tests of EMF effects on skin cancer, liver cancer, and brain cancer have been conducted using both initiation-promotion models and non-initiated long-term bioassays. All are negative.

Three positive studies were reported for a co-promotion model of skin cancer in mice. The mice were exposed to EMF plus cancer-causing chemicals after cancers

had already been initiated. The same research team as well as an independent laboratory were unable to reproduce these results in subsequent experiments.

Non-cancer effects

Many animal studies have investigated whether EMF can cause health problems other than cancer. Researchers have examined many endpoints, including birth defects, immune system function, reproduction, behavior, and learning. Overall, animal studies do not support EMF effects on non-cancer endpoints.

Q A Can EMF exposure damage DNA?

Studies have attempted to determine whether EMF has genotoxic potential; that is, whether EMF exposure can alter the genetic material of living organisms. This question is important because genotoxic agents often also cause cancer or birth defects. Studies of genotoxicity have included tests on bacteria, fruit flies, and some tests on rats and mice. Nearly 100 studies on EMF genotoxicity have been reported. Most evidence suggests that EMF exposure is not genotoxic. Based on experiments with cells, some researchers have suggested that EMF exposure may inhibit the cell's ability to repair normal DNA damage, but this idea remains speculative because of the lack of genotoxicity observed in EMF animal studies.

4 Your EMF Environment

This chapter discusses typical magnetic field exposures in home and work environments and identifies common EMF sources and field intensities associated with these sources.

Q How do we define EMF exposure?

A Scientists are still uncertain about the best way to define "exposure" because experiments have yet to show which aspect of the field, if any, may be relevant to reported biological effects. Important aspects of exposure could be the highest intensity, the average intensity, or the amount of time spent above a certain baseline level. The most widely used measure of EMF exposure has been the time-weighted average magnetic field level (see discussion on page 15).

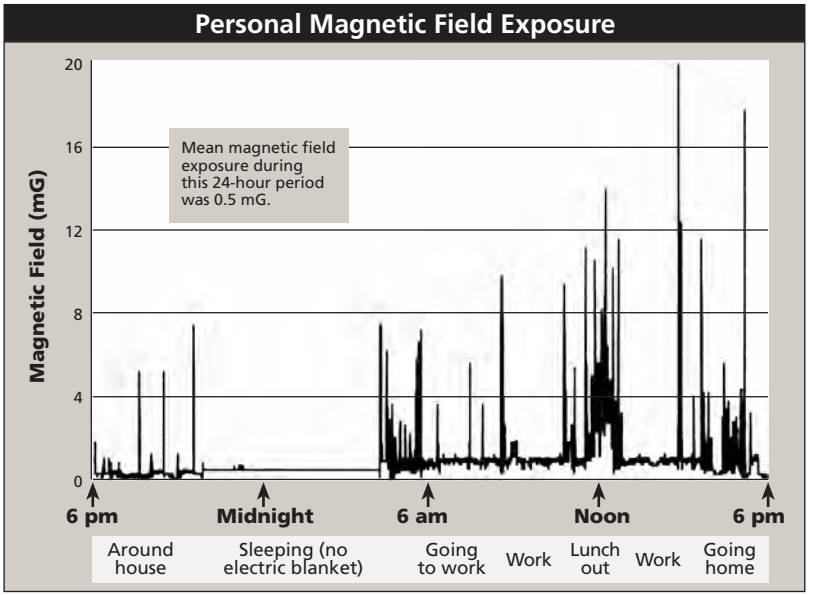
Q How is EMF exposure measured?

A Several kinds of personal exposure meters are now available. These automatically record the magnetic field as it varies over time. To determine a person's EMF exposure, the personal exposure meter is usually worn at the waist or is placed as close as possible to the person during the course of a work shift or day.

EMF can also be measured using survey meters, sometimes called "gaussmeters." These measure the EMF levels in a given location at a given time. Such measurements do not necessarily reflect personal EMF exposure because they are not always taken at the distance from the EMF source that the person would typically be from the source. Measurements are not always made in a location for the same amount of time that a person spends there. Such "spot measurements" also fail to capture variations of the field over time, which can be significant.

Q What are some typical EMF exposures?

A The figure below is an example of data collected with a personal exposure meter.



In the above example, the magnetic field was measured every 1.5 seconds over a period of 24 hours. For this person, exposure at home was very low. The occasional spikes (short exposure to high fields) occurred when the person drove or walked under power lines or over underground power lines or was close to appliances in the home or office.

Several studies have used personal exposure meters to measure field exposure in different environments. These studies tend to show that appliances and building wiring contribute to the magnetic field exposure that most people receive while at home. People living close to high voltage power lines that carry a lot of current tend to have higher overall field exposures. As shown on page 32, there is considerable variation among houses.

Q What are typical EMF exposures for people living in the United States?

A Most people in the United States are exposed to magnetic fields that average less than 2 milligauss (mG), although individual exposures vary.

The following table shows the estimated average magnetic field exposure of the U.S. population, according to a study commissioned by the U.S. government as part

of the EMF Research and Public Information Dissemination (EMF RAPID) Program (see page 50). This study measured magnetic field exposure of about 1,000 people of all ages randomly selected among the U.S. population. Participants wore or carried with them a small personal exposure meter and kept a diary of their activities both at home and away from home. Magnetic field values were automatically recorded twice a second for 24 hours. The study reported that exposure to magnetic fields is similar in different regions of the country and similar for both men and women.

Estimated Average Magnetic Field Exposure of the U.S. Population

Average 24-hour field (mG)	Population exposed (%)	95% confidence interval (%)	People exposed* (millions)
> 0.5	76.3	73.8–78.9	197–211
> 1	43.6	40.9–46.5	109–124
> 2	14.3	11.8–17.3	31.5–46.2
> 3	6.3	4.7–8.5	12.5–22.7
> 4	3.6	2.5–5.2	6.7–13.9
> 5	2.42	1.65–3.55	4.4–9.5
> 7.5	0.58	0.29–1.16	0.77–3.1
> 10	0.46	0.20–1.05	0.53–2.8
> 15	0.17	0.035–0.83	0.09–2.2

*Based on a population of 267 million. This table summarizes some of the results of a study that sampled about 1,000 people in the United States. In the first row, for example, we find that 76.3% of the sample population had a 24-hour average exposure of greater than 0.5 mG. Assuming that the sample was random, we can use statistics to say that we are 95% confident that the percentage of the overall U.S. population exposed to greater than 0.5 mG is between 73.8% and 78.9%. Source: Zaffanella, 1993.

The following table shows average magnetic fields experienced during different types of activities. In general, magnetic fields are greater at work than at home.

Estimated Average Magnetic Field Exposure of the U.S. Population for Various Activities

Average field (mG)	Population exposed (%)				
	Home	Bed	Work	School	Travel
> 0.5	69	48	81	63	87
> 1	38	30	49	25	48
> 2	14	14	20	3.5	13
> 3	7.8	7.2	13	1.6	4.1
> 4	4.7	4.7	8.0	< 1	1.5
> 5	3.5	3.7	4.6		1.0
> 7.5	1.2	1.6	2.5		0.5
> 10	0.9	0.8	1.3		< 0.2
> 15	0.1	0.1	0.9		

Source: Zaffanella, 1993.

Q A What levels of EMF are found in common environments?

Magnetic field exposures can vary greatly from site to site for any type of environment. The data shown in the following table are median measurements taken at four different sites for each environment category.

EMF Exposures in Common Environments
Magnetic fields measured in milligauss (mG)

Environment	Median* exposure	Top 5th percentile
OFFICE BUILDING		
Support staff	0.6	3.7
Professional	0.5	2.6
Maintenance	0.6	3.8
Visitor	0.6	2.1
SCHOOL		
Teacher	0.6	3.3
Student	0.5	2.9
Custodian	1.0	4.9
Administrative staff	1.3	6.9
HOSPITAL		
Patient	0.6	3.6
Medical staff	0.8	5.6
Visitor	0.6	2.4
Maintenance	0.6	5.9
MACHINE SHOP		
Machinist	0.4	6.0
Welder	1.1	24.6
Engineer	1.0	5.1
Assembler	0.5	6.4
Office staff	0.7	4.7
GROCERY STORE		
Cashier	2.7	11.9
Butcher	2.4	12.8
Office staff	2.1	7.1
Customer	1.1	7.7

*The median of four measurements. For this table, the median is the average of the two middle measurements.
Source: National Institute for Occupational Safety and Health.

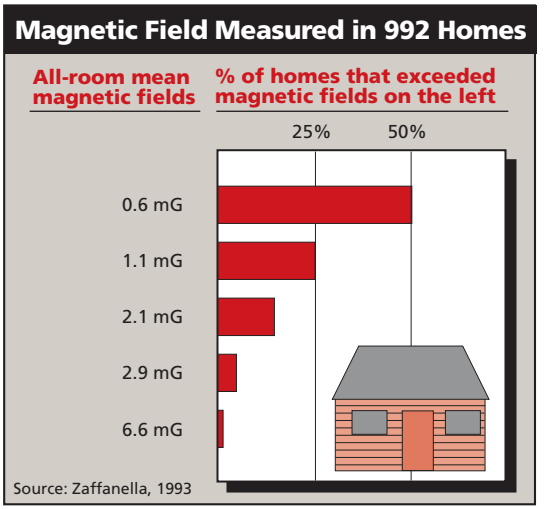
Q A What EMF field levels are encountered in the home?

Electric fields

Electric fields in the home, on average, range from 0 to 10 volts per meter. They can be hundreds, thousands, or even millions of times weaker than those encountered outdoors near power lines. Electric fields directly beneath power lines may vary from a few volts per meter for some overhead distribution lines to several thousands of volts per meter for extra high voltage power lines. Electric fields from power lines rapidly become weaker with distance and can be greatly reduced by walls and roofs of buildings.

Magnetic fields

Magnetic fields are not blocked by most materials. Magnetic fields encountered in homes vary greatly. Magnetic fields rapidly become weaker with distance from the source.



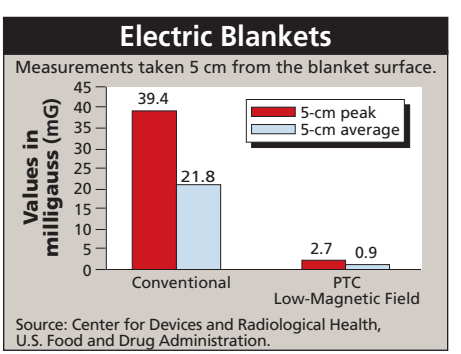
The chart on the left summarizes data from a study by the Electric Power Research Institute (EPRI) in which spot measurements of magnetic fields were made in the center of rooms in 992 homes throughout the United States. Half of the houses studied had magnetic field measurements of 0.6 mG or less, when the average of measurements from all the rooms in the house was calculated (the all-room mean magnetic field). The all-room mean magnetic field for all houses studied was 0.9 mG. The measurements were made away from electrical appliances and reflect primarily the fields from household wiring and outside power lines.

If you are comparing the information in this chart with measurements in your own home, keep in mind that this chart shows averages of measurements taken throughout the homes, not the single highest measurement found in the home.

Q A What are EMF levels close to electrical appliances?

Magnetic fields close to electrical appliances are often much stronger than those from other sources, including magnetic fields directly under power lines. Appliance fields decrease in strength with distance more quickly than do power line fields.

The following table, based on data gathered in 1992, lists the EMF levels generated by common electrical appliances. Magnetic field strength (magnitude) does not depend on how large, complex, powerful, or noisy the appliance is. Magnetic fields near large appliances are often weaker than those near small devices. Appliances in your home may have been redesigned since the data in the table were collected, and the EMF they produce may differ considerably from the levels shown here.



The graph shows magnetic fields produced by electric blankets, including conventional 110-V electric blankets as well as the PTC (positive temperature coefficient) low-magnetic-field blankets. The fields were measured at a distance of about 2 inches from the blanket's surface, roughly the distance from the blanket to the user's internal organs. Because of the wiring, magnetic field strengths vary from point to point on the blanket. The graph reflects this and gives both the peak and the average measurement.

Sources of Magnetic Fields (mG)*

Office Sources

	Distance from source 6″	1′	2′	4′
AIR CLEANERS				
Lowest	110	20	3	–
Median	180	35	5	1
Highest	250	50	8	2
COPY MACHINES				
Lowest	4	2	1	–
Median	90	20	7	1
Highest	200	40	13	4
FAX MACHINES				
Lowest	4	–	–	–
Median	6	–	–	–
Highest	9	2	–	–
FLUORESCENT LIGHTS				
Lowest	20	–	–	–
Median	40	6	2	–
Highest	100	30	8	4
ELECTRIC PENCIL SHARPENERS				
Lowest	20	8	5	–
Median	200	70	20	2
Highest	300	90	30	30
VIDEO DISPLAY TERMINALS (see page 48) (PCs with color monitors)**				
Lowest	7	2	1	–
Median	14	5	2	–
Highest	20	6	3	–

Bathroom Sources

	Distance from source 6″	1′	2′	4′
HAIR DRYERS				
Lowest	1	–	–	–
Median	300	1	–	–
Highest	700	70	10	1
ELECTRIC SHAVERS				
Lowest	4	–	–	–
Median	100	20	–	–
Highest	600	100	10	1

Workshop Sources

	Distance from source 6″	1′	2′	4′
BATTERY CHARGERS				
Lowest	3	2	–	–
Median	30	3	–	–
Highest	50	4	–	–
DRILLS				
Lowest	100	20	3	–
Median	150	30	4	–
Highest	200	40	6	–
POWER SAWS				
Lowest	50	9	1	–
Median	200	40	5	–
Highest	1000	300	40	4
ELECTRIC SCREWDRIVERS (while charging)				
Lowest	–	–	–	–
Median	–	–	–	–
Highest	–	–	–	–

Living/Family Room Sources

	Distance from source 1′	2′	4′
CEILING FANS			
Lowest	–	–	–
Median	3	–	–
Highest	50	6	1
WINDOW AIR CONDITIONERS			
Lowest	–	–	–
Median	3	1	–
Highest	20	6	4
COLOR TELEVISIONS**			
Lowest	–	–	–
Median	7	2	–
Highest	20	8	4

Continued

Sources of Magnetic Fields (mG)*

	Distance from source			
	6″	1′	2′	4′
Kitchen Sources				
BLENDERS				
Lowest	30	5	–	–
Median	70	10	2	–
Highest	100	20	3	–
CAN OPENERS				
Lowest	500	40	3	–
Median	600	150	20	2
Highest	1500	300	30	4
COFFEE MAKERS				
Lowest	4	–	–	–
Median	7	–	–	–
Highest	10	1	–	–
DISHWASHERS				
Lowest	10	6	2	–
Median	20	10	4	–
Highest	100	30	7	1
FOOD PROCESSORS				
Lowest	20	5	–	–
Median	30	6	2	–
Highest	130	20	3	–
GARBAGE DISPOSALS				
Lowest	60	8	1	–
Median	80	10	2	–
Highest	100	20	3	–
MICROWAVE OVENS***				
Lowest	100	1	1	–
Median	200	4	10	2
Highest	300	200	30	20
MIXERS				
Lowest	30	5	–	–
Median	100	10	1	–
Highest	600	100	10	–

	Distance from source			
	6″	1′	2′	4′
Kitchen Sources				
ELECTRIC OVENS				
Lowest	4	1	–	–
Median	9	4	–	–
Highest	20	5	1	–
ELECTRIC RANGES				
Lowest	20	–	–	–
Median	30	8	2	–
Highest	200	30	9	6
REFRIGERATORS				
Lowest	–	–	–	–
Median	2	2	1	–
Highest	40	20	10	10
TOASTERS				
Lowest	5	–	–	–
Median	10	3	–	–
Highest	20	7	–	–
Bedroom Sources				
DIGITAL CLOCK****				
Lowest		–	–	–
Median		1	–	–
High		8	2	1
ANALOG CLOCKS (conventional clockface)****				
Lowest		1	–	–
Median		15	2	–
Highest		30	5	3
BABY MONITOR (unit nearest child)				
Lowest	4	–	–	–
Median	6	1	–	–
Highest	15	2	–	–

Continued

Sources of Magnetic Fields (mG)*

	Distance from source 6″	1′	2′	4′
Laundry/Utility Sources				
ELECTRIC CLOTHES DRYERS				
Lowest	2	–	–	–
Median	3	2	–	–
Highest	10	3	–	–
WASHING MACHINES				
Lowest	4	1	–	–
Median	20	7	1	–
Highest	100	30	6	–
IRONS				
Lowest	6	1	–	–
Median	8	1	–	–
Highest	20	3	–	–

	Distance from source 6″	1′	2′	4′
Laundry/Utility Sources				
PORTABLE HEATERS				
Lowest	5	1	–	–
Median	100	20	4	–
Highest	150	40	8	1
VACUUM CLEANERS				
Lowest	100	20	4	–
Median	300	60	10	1
Highest	700	200	50	10
SEWING MACHINES				
Home sewing machines can produce magnetic fields of 12 mG at chest level and 5 mG at head level. Magnetic fields as high as 35 mG at chest level and 215 mG at knee level have been measured from industrial sewing machine models (Sobel, 1994).				

Source: EMF In Your Environment, U.S. Environmental Protection Agency, 1992.

* Dash (–) means that the magnetic field at this distance from the operating appliance could not be distinguished from background measurements taken before the appliance had been turned on.

** Some appliances produce both 60-Hz and higher frequency fields. For example, televisions and computer screens produce fields at 10,000-30,000 Hz (10-30 kHz) as well as 60-Hz fields.

*** Microwave ovens produce 60-Hz fields of several hundred milligauss, but they also create microwave energy inside the appliance that is at a much higher frequency (about 2.45 billion hertz). We are shielded from the higher frequency fields but not from the 60-Hz fields.

**** Most digital clocks have low magnetic fields. In some analog clocks, however, higher magnetic fields are produced by the motor that drives the hands. In the above table, the clocks are electrically powered using alternating current, as are all the appliances described in these tables.

Q A What EMF levels are found near power lines?

Power transmission lines bring power from a generating station to an electrical substation. Power distribution lines bring power from the substation to your home. Transmission and distribution lines can be either overhead or underground. Overhead lines produce both electric fields and magnetic fields. Underground lines do not produce electric fields above ground but may produce magnetic fields above ground.

Power transmission lines

Typical EMF levels for transmission lines are shown in the chart on page 37. At a distance of 300 feet and at times of average electricity demand, the magnetic fields from many lines can be similar to typical background levels found in most homes. The distance at which the magnetic field from the line becomes indistinguishable from typical background levels differs for different types of lines.

Power distribution lines

Typical voltage for power distribution lines in North America ranges from 4 to 24 kilovolts (kV). Electric field levels directly beneath overhead distribution lines may vary from a few volts per meter to 100 or 200 volts per meter. Magnetic fields directly beneath overhead distribution lines typically range from 10 to 20 mG for main feeders and less than 10 mG for laterals. Such levels are also typical directly above underground lines. Peak EMF levels, however, can vary considerably depending on the amount of current carried by the line. Peak magnetic field levels as high as 70 mG have been measured directly below overhead distribution lines and as high as 40 mG above underground lines.

Q How strong is the EMF from electric power substations?

A In general, the strongest EMF around the outside of a substation comes from the power lines entering and leaving the substation. The strength of the EMF from equipment within the substations, such as transformers, reactors, and capacitor banks, decreases rapidly with increasing distance. Beyond the substation fence or wall, the EMF produced by the substation equipment is typically indistinguishable from background levels.

Q Do electrical workers have higher EMF exposure than other workers?

A Most of the information we have about occupational EMF exposure comes from studies of electric utility workers. It is therefore difficult to compare electrical workers' EMF exposures with those of other workers because there is less information about EMF exposures in work environments other than electric utilities. Early studies did not include actual measurements of EMF exposure on the job but used job titles as an estimate of EMF exposure among electrical workers. Recent studies, however, have included extensive EMF exposure assessments.

A report published in 1994 provides some information about estimated EMF exposures of workers in Los Angeles in a number of electrical jobs in electric utilities and other industries. Electrical workers had higher average EMF exposures (9.6 mG) than did workers in other jobs (1.7 mG). For this study, the category "electrical workers" included electrical engineering technicians, electrical engineers, electricians, power line workers, power station operators, telephone line workers, TV repairers, and welders.

Typical EMF Levels for Power Transmission Lines*

115 kV

	Approx. Edge of Right-of-Way	15 m (50 ft)	30 m (100 ft)	61 m (200 ft)	91 m (300 ft)
Electric Field (kV/m)	1.0	0.5	0.07	0.01	0.003
Mean Magnetic Field (mG)	29.7	6.5	1.7	0.4	0.2

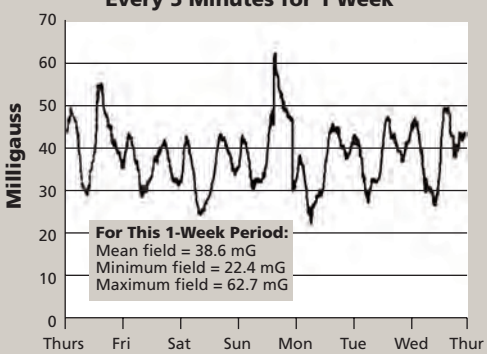
230 kV

	Approx. Edge of Right-of-Way	15 m (50 ft)	30 m (100 ft)	61 m (200 ft)	91 m (300 ft)
Electric Field (kV/m)	2.0	1.5	0.3	0.05	0.01
Mean Magnetic Field (mG)	57.5	19.5	7.1	1.8	0.8

500 kV

	Approx. Edge of Right-of-Way	20 m (65 ft)	30 m (100 ft)	61 m (200 ft)	91 m (300 ft)
Electric Field (kV/m)	7.0	3.0	1.0	0.3	0.1
Mean Magnetic Field (mG)	86.7	29.4	12.6	3.2	1.4

Magnetic Field from a 500-kV Transmission Line Measured on the Right-of-Way Every 5 Minutes for 1 Week



Electric fields from power lines are relatively stable because line voltage doesn't change very much. Magnetic fields on most lines fluctuate greatly as current changes in response to changing loads. Magnetic fields must be described statistically in terms of averages, maximums, etc. The magnetic fields above are means calculated for 321 power lines for 1990 annual mean loads. During peak loads (about 1% of the time), magnetic fields are about twice as strong as the mean levels above. The graph on the left is an example of how the magnetic field varied during one week for one 500-kV transmission line.

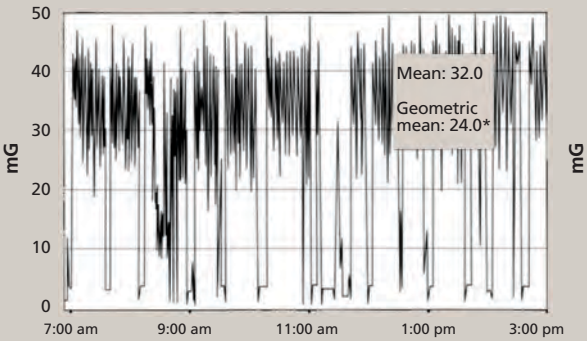
*These are typical EMFs at 1 m (3.3 ft) above ground for various distances from power lines in the Pacific Northwest. They are for general information. For information about a specific line, contact the utility that operates the line.
Source: Bonneville Power Administration, 1994.

Q What are possible EMF exposures in the workplace?

A The figures below are examples of magnetic field exposures determined with exposure meters worn by four workers in different occupations. These measurements demonstrate how EMF exposures vary among individual workers. They do not necessarily represent typical EMF exposures for workers in these occupations.

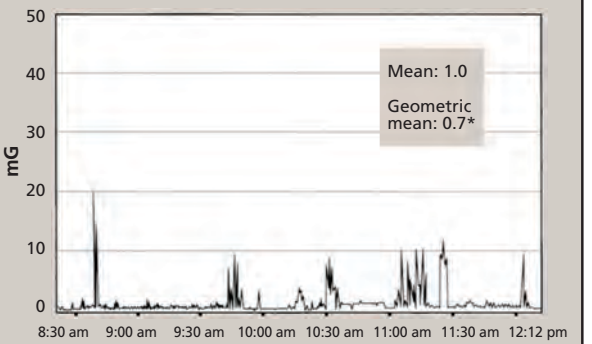
Magnetic Field Exposures of Workers (mG)

Sewing machine operator in garment factory



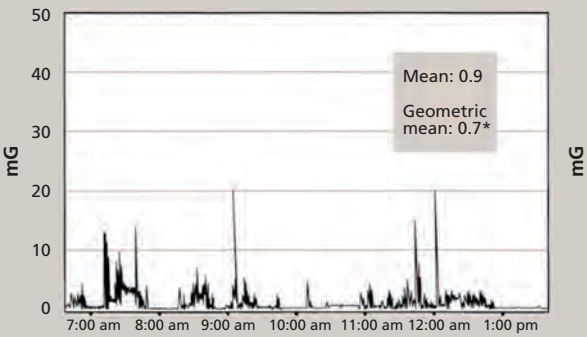
The sewing machine operator worked all day, took a 1-hour lunch break at 11:15 am, and took 10-minute breaks at 8:55 am and 2:55 pm.

Maintenance mechanic



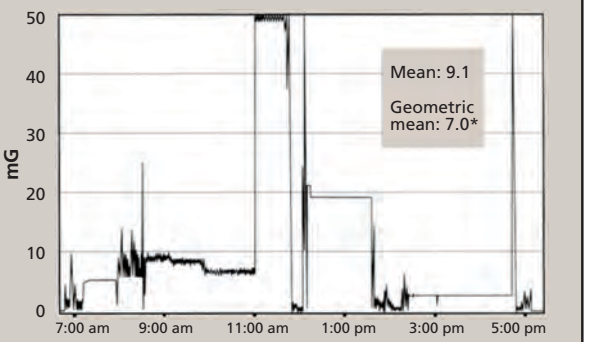
The mechanic repaired a compressor at 9:45 am and 11:10 am.

Electrician



The electrician repaired a large air-conditioning motor at 9:10 am and at 11:45 am.

Government office worker



The government worker was at the copy machine at 8:00 am, at the computer from 11:00 am to 1:00 pm and also from 2:30 pm to 4:30 pm.

*The geometric mean is calculated by squaring the values, adding the squares, and then taking the square root of the sum.
Source: National Institute for Occupational Safety and Health and U.S. Department of Energy.

The tables below and on page 41 can give you a general idea about magnetic field levels for different jobs and around various kinds of electrical equipment. It is important to remember that EMF levels depend on the actual equipment used in

EMF Measurements During a Workday

Industry and occupation	ELF magnetic fields measured in mG: Median for occupation*	ELF magnetic fields measured in mG: Range for 90% of workers**
ELECTRICAL WORKERS IN VARIOUS INDUSTRIES		
Electrical engineers	1.7	0.5–12.0
Construction electricians	3.1	1.6–12.1
TV repairers	4.3	0.6–8.6
Welders	9.5	1.4–66.1
ELECTRIC UTILITIES		
Clerical workers without computers	0.5	0.2–2.0
Clerical workers with computers	1.2	0.5–4.5
Line workers	2.5	0.5–34.8
Electricians	5.4	0.8–34.0
Distribution substation operators	7.2	1.1–36.2
Workers off the job (home, travel, etc.)	0.9	0.3–3.7
TELECOMMUNICATIONS		
Install, maintenance, & repair technicians	1.5	0.7–3.2
Central office technicians	2.1	0.5–8.2
Cable splicers	3.2	0.7–15.0
AUTO TRANSMISSION MANUFACTURE		
Assemblers	0.7	0.2–4.9
Machinists	1.9	0.6–27.6
HOSPITALS		
Nurses	1.1	0.5–2.1
X-ray technicians	1.5	1.0–2.2
SELECTED OCCUPATIONS FROM ALL ECONOMIC SECTORS		
Construction machine operators	0.5	0.1–1.2
Motor vehicle drivers	1.1	0.4–2.7
School teachers	1.3	0.6–3.2
Auto mechanics	2.3	0.6–8.7
Retail sales	2.3	1.0–5.5
Sheet metal workers	3.9	0.3–48.4
Sewing machine operators	6.8	0.9–32.0
Forestry and logging jobs	7.6	0.6–95.5***

Source: National Institute for Occupational Safety and Health.
ELF (extremely low frequency)—frequencies 3–3,000 Hz.
* The median is the middle measurement in a sample arranged by size. These personal exposure measurements reflect the median magnitude of the magnetic field produced by the various EMF sources and the amount of time the worker spent in the fields.
** This range is between the 5th and 95th percentiles of the workday averages for an occupation.
*** Chain saw engines produce strong magnetic fields that are not pure 60-Hz fields.

the workplace. Different brands or models of the same type of equipment can have different magnetic field strengths. It is also important to keep in mind that the strength of a magnetic field decreases quickly with distance.

If you have questions or want more information about your EMF exposure at work, your plant safety officer, industrial hygienist, or other local safety official can be a good source of information. The National Institute for Occupational Safety and Health (NIOSH) is asked occasionally to conduct health hazard evaluations in workplaces where EMF is a suspected cause for concern. For further technical assistance contact NIOSH at 800-356-4674.

Q A What are some typical sources of EMF in the workplace?

Exposure assessment studies so far have shown that most people's EMF exposure at work comes from electrical appliances and tools and from the building's power supply. People who work near transformers, electrical closets, circuit boxes, or other high-current electrical equipment may have 60-Hz magnetic field exposures of hundreds of milligauss or more. In offices, magnetic field levels are often similar to those found at home, typically 0.5 to 4.0 mG. However, these levels can increase dramatically near certain types of equipment.

EMF Spot Measurements

Industry and sources	ELF magnetic fields (mG)	Other frequencies	Comments
ELECTRICAL EQUIPMENT USED IN MACHINE MANUFACTURING			
Electric resistance heater	6,000–14,000	VLF	
Induction heater	10–460	High VLF	
Hand-held grinder	3,000	–	Tool exposures measured at operator's chest.
Grinder	110	–	Tool exposures measured at operator's chest.
Lathe, drill press, etc.	1–4	–	Tool exposures measured at operator's chest.
ALUMINUM REFINING			
Aluminum pot rooms	3.4–30	Very high static field	Highly-rectified DC current (with an ELF ripple) refines aluminum.
Rectification room	300–3,300	High static field	
STEEL FOUNDRY			
Ladle refinery			
Furnace active	170–1,300	High ULF from the ladle's big magnetic stirrer	Highest ELF field was at the chair of control room operator.
Furnace inactive	0.6–3.7	High ULF from the ladle's big magnetic stirrer	Highest ELF field was at the chair of control room operator.
Electrogalvanizing unit	2–1,100	High VLF	
TELEVISION BROADCASTING			
Video cameras (studio and minicams)	7.2–24.0	VLF	
Video tape degaussers	160–3,300	–	Measured 1 ft away.
Light control centers	10–300	–	Walk-through survey.
Studio and newsrooms	2–5	–	Walk-through survey.
HOSPITALS			
Intensive care unit	0.1–220	VLF	Measured at nurse's chest.
Post-anesthesia care unit	0.1–24	VLF	
Magnetic resonance imaging (MRI)	0.5–280	Very high static field, VLF and RF	Measured at technician's work locations.
TRANSPORTATION			
Cars, minivans, and trucks	0.1–125	Most frequencies less than 60 Hz	Steel-belted tires are the principal ELF source for gas/diesel vehicles.
Bus (diesel powered)	0.5–146	Most frequencies less than 60 Hz	
Electric cars	0.1–81	Some elevated static fields	
Chargers for electric cars	4–63	–	Measured 2 ft from charger.
Electric buses	0.1–88	–	Measured at waist. Fields at ankles 2-5 times higher.
Electric train passenger cars	0.1–330	25 & 60 Hz power on U.S. trains	Measured at waist. Fields at ankles 2-5 times higher.
Airliner	0.8–24.2	400 Hz power on airliners	Measured at waist.
GOVERNMENT OFFICES			
Desk work locations	0.1–7	–	Peaks due to laser printers.
Desks near power center	18–50	–	
Power cables in floor	15–170	–	
Building power supplies	25–1,800	–	
Can opener	3,000	–	Appliance fields measured 6 in. away.
Desktop cooling fan	1,000	–	Appliance fields measured 6 in. away.
Other office appliances	10–200	–	

Source: National Institute for Occupational Safety and Health, 2001.
ULF (ultra low frequency)—frequencies above 0, below 3 Hz.
ELF (extremely low frequency)—frequencies 3–3,000 Hz.
VLF (very low frequency)—frequencies 3,000–30,000 Hz (3–30 kilohertz).

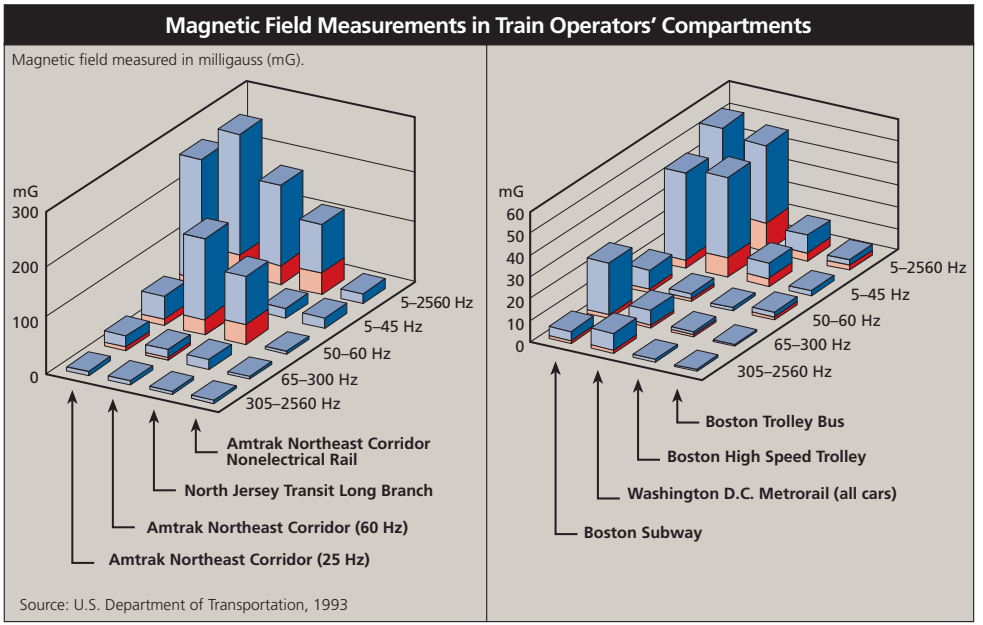
Q A What EMF exposure occurs during travel?

Inside a car or bus, the main sources of magnetic field exposure are those you pass by (or under) as you drive, such as power lines. Car batteries involve direct current (DC) rather than alternating current (AC). Alternators can create EMF, but at frequencies other than 60 Hz. The rotation of steel-belted tires is also a source of EMF.

Most trains in the United States are diesel powered. Some electrically powered trains operate on AC, such as the passenger trains between Washington, D.C. and New Haven, Connecticut. Measurements taken on these trains using personal exposure monitors have suggested that average 60-Hz magnetic field exposures for passengers and conductors may exceed 50 mG. A U.S. government-sponsored exposure assessment study of electric rail systems found average 60-Hz magnetic field levels in train operator compartments that ranged from 0.4 mG (Boston high speed trolley) to 31.1 mG (North Jersey transit). The graph on the next page shows average and maximum magnetic field measurements in operator compartments of several electric rail systems. It illustrates that 60 Hz is one of several electromagnetic frequencies to which train operators are exposed.

Workers who maintain the tracks on electric rail lines, primarily in the northeastern United States, also have elevated magnetic field exposures at both 25 Hz and 60 Hz. Measurements taken by the National Institute for Occupational Safety and Health show that typical average daily exposures range from 3 to 18 mG, depending on how often trains pass the work site.

Rapid transit and light rail systems in the United States, such as the Washington D.C. Metro and the San Francisco Bay Area Rapid Transit, run on DC electricity. These DC-powered trains contain equipment that produces AC fields. For example, areas of strong AC magnetic fields have been measured on the Washington Metro close to the floor, during braking and acceleration, presumably near equipment located underneath the subway cars.



These graphs illustrate that 60 Hz is one of several electromagnetic frequencies to which train operators are exposed. The maximum exposure is the top of the blue (upper) portion of the bar; the average exposure is the top of the red (lower) portion.

Q How can I find out how strong the EMF is where I live and work?

A The tables throughout this chapter can give you a general idea about magnetic field levels at home, for different jobs, and around various kinds of electrical equipment. For specific information about EMF from a particular power line, contact the utility that operates the line. Some will perform home EMF measurements.

You can take your own EMF measurements with a magnetic field meter. For a spot measurement to provide a useful estimate of your EMF exposure, it should be taken at a time of day and location when and where you are typically near the equipment. Keep in mind that the strength of a magnetic field drops off quickly with distance.

Independent technicians will conduct EMF measurements for a fee. Search the Internet under "EMF meters" or "EMF measurement." You should investigate the experience and qualifications of commercial firms, since governments do not standardize EMF measurements or certify measurement contractors.

At work, your plant safety officer, industrial hygienist, or other local safety official can be a good source of information. The National Institute for Occupational Safety and Health (NIOSH) sometimes conducts health hazard evaluations in workplaces where EMF is a suspected cause for concern. For further technical assistance, contact NIOSH at 800-356-4674.

Q How much do computers contribute to my EMF exposure?

A Personal computers themselves produce very little EMF. However, the video display terminal (VDT) or monitor provides some magnetic field exposure unless it is of the new flat-panel design. Conventional VDTs containing cathode ray tubes use magnetic fields to produce the image on the screen, and some emission of those magnetic fields is unavoidable. Unlike most other appliances which produce predominantly 60-Hz magnetic fields, VDTs emit magnetic fields in both the extremely low frequency (ELF) and very low frequency (VLF) frequency ranges (see page 8). Many newer VDTs have been designed to minimize magnetic field emissions, and those identified as "TCO'99 compliant" meet a standard for low emissions (see page 48).

Q What can be done to limit EMF exposure?

A Personal exposure to EMF depends on three things: the strength of the magnetic field sources in your environment, your distance from those sources, and the time you spend in the field.

If you are concerned about EMF exposure, your first step should be to find out where the major EMF sources are and move away from them or limit the time you spend near them. Magnetic fields from appliances decrease dramatically about an arm's length away from the source. In many cases, rearranging a bed, a chair, or a work area to increase your distance from an electrical panel or some other EMF source can reduce your EMF exposure.

Another way to reduce EMF exposure is to use equipment designed to have relatively low EMF emissions. Sometimes electrical wiring in a house or a building can be the source of strong magnetic field exposure. Incorrect wiring is a common source of higher-than-usual magnetic fields. Wiring problems are also worth correcting for safety reasons.

In its 1999 report to Congress, the National Institute of Environmental Health Sciences suggested that the power industry continue its current practice of siting power lines to reduce EMF exposures.

There are more costly actions, such as burying power lines, moving out of a home, or restricting the use of office space that may reduce exposures. Because scientists are still debating whether EMF is a hazard to health, it is not clear that the costs of such measures are warranted. Some EMF reduction measures may create other problems. For instance, compacting power lines reduces EMF but increases the danger of accidental electrocution for line workers.

We are not sure which aspects of the magnetic field exposure, if any, to reduce. Future research may reveal that EMF reduction measures based on today's limited understanding are inadequate or irrelevant. No action should be taken to reduce EMF exposure if it increases the risk of a known safety hazard.

5 EMF Exposure Standards

This chapter describes standards and guidelines established by state, national, and international safety organizations for some EMF sources and exposures.

Q Are there exposure standards for 60-Hz EMF?

A In the United States, there are no federal standards limiting occupational or residential exposure to 60-Hz EMF.

At least six states have set standards for transmission line electric fields; two of these also have standards for magnetic fields (see table below). In most cases, the maximum fields permitted by each state are the maximum fields that existing lines produce at maximum load-carrying conditions. Some states further limit electric field strength at road crossings to ensure that electric current induced into large metal objects such as trucks and buses does not represent an electric shock hazard.

State Transmission Line Standards and Guidelines

	Electric Field		Magnetic Field	
State	On R.O.W.*	Edge R.O.W.	On R.O.W.	Edge R.O.W.
Florida	8 kV/m[a] 10 kV/m[b]	2 kV/m	—	150 mG[a] (max. load) 200 mG[b] (max. load) 250 mG[c] (max. load)
Minnesota	8 kV/m	—	—	—
Montana	7 kV/m[d]	1 kV/m[e]		
New Jersey	—	3 kV/m		
New York	11.8 kV/m 11.0 kV/m[f] 7.0 kV/m[d]	1.6 kV/m	—	200 mG (max. load)
Oregon	9 kV/m	—	—	—

*R.O.W. = right-of-way (or in the Florida standard, certain additional areas adjoining the right-of-way). kV/m = kilovolt per meter. One kilovolt = 1,000 volts. [a]For lines of 69-230 kV. [b]For 500 kV lines. [c]For 500 kV lines on certain existing R.O.W. [d]Maximum for highway crossings. [e]May be waived by the landowner. [f]Maximum for private road crossings.

Two organizations have developed voluntary occupational exposure guidelines for EMF exposure. These guidelines are intended to prevent effects, such as induced currents in cells or nerve stimulation, which are known to occur at high magnitudes, much higher (more than 1,000 times higher) than EMF levels found typically in

occupational and residential environments. These guidelines are summarized in the tables on the right.

The International Commission on Non-Ionizing Radiation Protection (ICNIRP) concluded that available data regarding potential long-term effects, such as increased risk of cancer, are insufficient to provide a basis for setting exposure restrictions.

The American Conference of Governmental Industrial Hygienists (ACGIH) publishes "Threshold Limit Values" (TLVs) for various physical agents. The TLVs for 60-Hz EMF shown in the table are identified as guides to control exposure; they are not intended to demarcate safe and dangerous levels.

ICNIRP Guidelines for EMF Exposure

Exposure (60 Hz)	Electric field	Magnetic field
Occupational	8.3 kV/m	4.2 G (4,200 mG)
General Public	4.2 kV/m	0.833 G (833 mG)

International Commission on Non-Ionizing Radiation Protection (ICNIRP) is an organization of 15,000 scientists from 40 nations who specialize in radiation protection.
Source: ICNIRP, 1998.

ACGIH Occupational Threshold Limit Values for 60-Hz EMF

	Electric field	Magnetic field
Occupational exposure should not exceed	25 kV/m	10 G (10,000 mG)
Prudence dictates the use of protective clothing above	15 kV/m	–
Exposure of workers with cardiac pacemakers should not exceed	1 kV/m	1 G (1,000 mG)

American Conference of Governmental Industrial Hygienists (ACGIH) is a professional organization that facilitates the exchange of technical information about worker health protection. It is not a government regulatory agency.
Source: ACGIH, 2001.

Q Does EMF affect people with pacemakers or other medical devices?

A According to the U.S. Food and Drug Administration (FDA), interference from EMF can affect various medical devices including cardiac pacemakers and implantable defibrillators. Most current research in this area focuses on higher frequency sources such as cellular phones, citizens band radios, wireless computer links, microwave signals, radio and television transmitters, and paging transmitters.

Sources such as welding equipment, power lines at electric generating plants, and rail transportation equipment can produce lower frequency EMF strong enough to interfere with some models of pacemakers and defibrillators. The occupational exposure guidelines developed by ACGIH state that workers with cardiac pacemakers should not be exposed to a 60-Hz magnetic field greater than 1 gauss (1,000 mG) or a 60-Hz electric field greater than 1 kilovolt per meter (1,000 V/m) (see ACGIH guidelines above). Workers who are concerned about EMF exposure effects on pacemakers, implantable defibrillators, or other implanted electronic medical devices should consult their doctors or industrial hygienists.

Nonelectronic metallic medical implants (such as artificial joints, pins, nails, screws, and plates) can be affected by high magnetic fields such as those from magnetic resonance imaging (MRI) devices and aluminum refining equipment, but are generally unaffected by the lower fields from most other sources.

The FDA MedWatch program is collecting information about medical device problems thought to be associated with exposure to or interference from EMF. Anyone experiencing a problem that might be due to such interference is encouraged to call and report it (800-332-1088).

Q What about products advertised as producing low or reduced magnetic fields?

A Virtually all electrical appliances and devices emit electric and magnetic fields. The strengths of the fields vary appreciably both between types of devices and among manufacturers and models of the same type of device. Some appliance manufacturers are designing new models that, in general, have lower EMF than older models. As a result, the words "low field" or "reduced field" may be relative to older models and not necessarily relative to other manufacturers or devices. At this time, there are no domestic or international standards or guidelines limiting the EMF emissions of appliances.

The U.S. government has set no standards for magnetic fields from computer monitors or video display terminals (VDTs). The Swedish Confederation of Professional Employees (TCO) established in 1992 a standard recommending strict limits on the EMF emissions of computer monitors. The VDTs should produce magnetic fields of no more than 2 mG at a distance of 30 cm (about 1 ft) from the front surface of the monitor and 50 cm (about 1 ft 8 in) from the sides and back of the monitor. The TCO'92 standard has become a *de facto* standard in the VDT industry worldwide. A 1999 standard, promulgated by the Swedish TCO (known as the TCO'99 standard), provides for international and environmental labeling of personal computers. Many computer monitors marketed in the U.S. are certified as compliant with TCO'99 and are thereby assured to produce low magnetic fields.

Beware of advertisements claiming that the federal government has certified that the advertised equipment produces little or no EMF. The federal government has no such general certification program for the emissions of low-frequency EMF. The U.S. Food and Drug Administration's Center for Devices and Radiological Health (CDRH) does certify medical equipment and equipment producing high levels of ionizing radiation or microwave radiation. Information about certain devices as well as general information about EMF is available from the CDRH at 888-463-6332.

Q Are cellular telephones and towers sources of EMF exposure?

A Cellular telephones and towers involve radio-frequency and microwave-frequency electromagnetic fields (see page 8). These are in a much higher frequency range than are the power-frequency electric and magnetic fields associated with the transmission and use of electricity.

The U.S. Federal Communications Commission (FCC) licenses communications systems that use radio-frequency and microwave electromagnetic fields and ensures that licensed facilities comply with exposure standards. Public information on this topic is published on two FCC Internet sites: http://www.fcc.gov/oet/info/documents/bulletins/#56 and http://www.fcc.gov/oet/rfsafety/

The U.S. Food and Drug Administration also provides information about cellular telephones on its web site (http://www.fda.gov/cdrh/ocd/mobilphone.html).

6 National and International EMF Reviews

This chapter presents the findings and recommendations of major EMF research reviews, including the U.S. government's EMF RAPID Program.

Q What have national and international agencies concluded about the impact of EMF exposure on human health?

A Since 1995, two major U.S. reports have concluded that limited evidence exists for an association between EMF exposure and increased leukemia risk, but that when all the scientific evidence is considered, the link between EMF exposure and cancer is weak. The World Health Organization in 1997 reached a similar conclusion.

The two reports were the U.S. National Academy of Sciences report in 1996 and, in 1999, the National Institute of Environmental Health Sciences report to the U.S. Congress at the end of the U.S. EMF Research and Public Information Dissemination (RAPID) Program.

The U.S. EMF RAPID Program

Initiated by the U.S. Congress and established by law in 1992, the U.S. EMF Research and Public Information Dissemination (EMF RAPID) Program set out to study whether exposure to electric and magnetic fields produced by the generation, transmission, or use of electric power posed a risk to human health. For more information about the EMF RAPID Program, visit the web site (http://www.niehs.nih.gov/emfrapid).

The U.S. Department of Energy (DOE) administered the overall EMF RAPID Program, but health effects research and risk assessment were supervised by the National Institute of Environmental Health Sciences (NIEHS), a branch of the U.S. National Institutes of Health (NIH). Together, DOE and NIEHS oversaw more than 100 cellular and animal studies, as well as engineering and exposure assessment studies. Although the EMF RAPID Program did not fund any additional epidemiological studies, an analysis of the many studies already conducted was an important part of its final report.

The electric power industry contributed about half, or $22.5 million, of the $45 million eventually spent on EMF research over the course of the EMF RAPID Program. The NIEHS received $30.1 million from this program for research, public outreach, administration, and the health assessment evaluation of extremely low frequency (ELF) EMF. The DOE received approximately $15 million from this program for engineering and EMF mitigation research. The NIEHS contributed an additional $14.5 million for support of extramural and intramural research including long-term toxicity and carcinogenicity studies conducted by the National Toxicology Program.

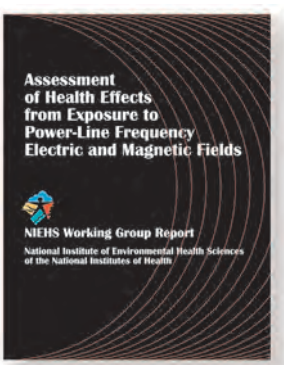
EMF RAPID Program Interagency Committee

- National Institute of Environmental Health Sciences
- Department of Energy
- Department of Defense
- Department of Transportation
- Environmental Protection Agency
- Federal Energy Regulatory Commission
- National Institute of Standards and Technology
- Occupational Safety and Health Administration
- Rural Electrification Administration

An interagency committee was established by the President of the United States to provide oversight and program management support for the EMF RAPID Program. The interagency committee included representatives from NIEHS, DOE, and seven other federal agencies with EMF-related responsibilities.

The EMF RAPID Program also received advice from a National EMF Advisory Committee (NEMFAC), which included representatives from citizen groups, labor, utilities, the National Academy of Sciences, and other groups. They met regularly with DOE and NIEHS staff to express their views. NEMFAC meetings were open to the public. The EMF RAPID Program sponsored citizen participation in some scientific meetings as well. A broad group of citizens reviewed all major public information materials produced for the program.

NIEHS Working Group Report 1998



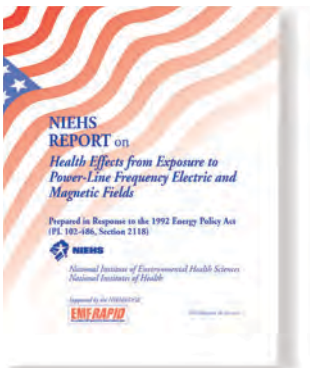
In preparation for the EMF RAPID Program's goal of reporting to the U.S. Congress on possible health effects from exposure to EMF from power lines, the NIEHS convened an expert working group in June 1998. Over 9 days, about 30 scientists conducted a complete review of EMF studies, including those sponsored by the EMF RAPID Program and others. Their conclusions offered guidance to the NIEHS as it prepared its report to Congress.

Using criteria developed by the International Agency for Research on Cancer, a majority of the members of the working group concluded that exposure to power-frequency EMF is a possible human carcinogen.

The majority called their opinion "a conservative public health decision based on limited evidence for an increased occurrence of childhood leukemias and an increased occurrence of chronic lymphocytic leukemia (CLL) in occupational settings." For these

diseases, the working group reported that animal and cellular studies neither confirm nor deny the epidemiological studies' suggestion of a disease risk. This report is available on the NIEHS EMF RAPID web site (http://www.niehs.nih.gov/emfrapid).

NIEHS Report to Congress at Conclusion of EMF RAPID Program



In June 1999, the NIEHS reported to the U.S. Congress that scientific evidence for an EMF-cancer link is weak.

The following are excerpts from the 1999 NIEHS report:

> The NIEHS believes that the probability that ELF-EMF exposure is truly a health hazard is currently small. The weak epidemiological associations and lack of any laboratory support for these associations provide only marginal, scientific support that exposure to this agent is causing any degree of harm.
>
> The scientific evidence suggesting that extremely low frequency EMF exposures pose any health risk is weak. The strongest evidence for health effects comes from associations observed in human populations with two forms of cancer: childhood leukemia and chronic lymphocytic leukemia in occupationally exposed adults. While the support from individual studies is weak, the epidemiological studies demonstrate, for some methods of measuring exposure, a fairly consistent pattern of a small, increased risk with increasing exposure that is somewhat weaker for chronic lymphocytic leukemia than for childhood leukemia. In contrast, the mechanistic studies and the animal toxicology literature fail to demonstrate any consistent pattern across studies, although sporadic findings of biological effects (including increased cancers in animals) have been reported. No indication of increased leukemias in experimental animals has been observed.

The full report is available on the NIEHS EMF RAPID web site (http://www.niehs.nih.gov/emfrapid).

No regulatory action was recommended or taken based on the NIEHS report. The NIEHS director, Dr. Kenneth Olden, told the Congress that, in his opinion, the conclusion of the NIEHS report was not sufficient to warrant aggressive regulatory action.

The NIEHS did not recommend adopting EMF standards for electric appliances or burying electric power lines. Instead, it recommended providing public information about practical ways to reduce EMF exposure. The NIEHS also suggested that power companies and utilities "continue siting power lines to reduce exposures and . . . explore ways to reduce the creation of magnetic fields around transmission and distribution lines without creating new hazards." The NIEHS encouraged manufacturers to reduce magnetic fields at a minimal cost, but noted that the risks do not warrant expensive redesign of electrical appliances.

The NIEHS also encouraged individuals who are concerned about EMF in their homes to check to see if their homes are properly wired and grounded, since incorrect wiring or other code violations are a common source of higher-than-usual magnetic fields.

National Academy of Sciences Report

In October 1996, a National Research Council committee of the National Academy of Sciences (NAS) released its evaluation of research on potential associations between EMF exposure and cancer, reproduction, development, learning, and behavior. The report concluded:

> Based on a comprehensive evaluation of published studies relating to the effects of power-frequency electric and magnetic fields on cells, tissues, and organisms (including humans), the conclusion of the committee is that the current body of evidence does not show that exposure to these fields presents a human-health hazard. Specifically, no conclusive and consistent evidence shows that exposures to residential electric and magnetic fields produce cancer, adverse neurobehavioral effects, or reproductive and developmental effects.

The NAS report focused primarily on the association of childhood leukemia with the proximity of the child's home to power lines. The NAS panel found that although a link between EMF exposure and increased risk for childhood leukemia was observed in studies that had estimated EMF exposure using the wire code method (distance of home from power line), such a link was not found in studies that had included actual measurements of magnetic fields at the time of the study. The panel called for more research to pinpoint the unexplained factors causing small increases in childhood leukemia in houses close to power lines.

World Health Organization International EMF Project

The World Health Organization (WHO) International EMF Project, with headquarters in Geneva, Switzerland, was launched at a 1996 meeting with representatives of 23 countries attending. It was intended to respond to growing concerns in many member states over possible EMF health effects and to address the conflict between such concerns and technological and economic progress. In its advisory role, the WHO International EMF Project is now reviewing laboratory and epidemiological evidence, identifying gaps in scientific knowledge, developing an agenda for future research, and developing risk communication booklets and other public information. The WHO International EMF Project is funded with contributions from governments and institutions and is expected to provide an overall EMF health risk assessment. Additional information about this program can be found on the WHO EMF web site (http://www.who.int/peh-emf).

As part of this project, in 1997 a working group of 45 scientists from around the world surveyed the evidence for adverse

EMF health effects. They reported that, "taken together, the findings of all published studies are suggestive of an association between childhood leukemia and estimates of ELF (extremely low frequency or power-frequency) magnetic fields."

Much like the 1996 U.S. NAS report, the WHO report noted that living in homes near power lines was associated with an approximate 1.5-fold excess risk of childhood leukemia. But unlike the NAS panel, WHO scientists had seen the results of the 1997 U.S. National Cancer Institute study of EMF and childhood leukemia (see page 17). This work showed even more strongly the inconsistency between results of studies that used a wire code to estimate EMF exposure and studies that actually measured magnetic fields.

Regarding health effects other than cancer, the WHO scientists reported that the epidemiological studies "do not provide sufficient evidence to support an association between extremely-low-frequency magnetic-field exposure and adult cancers, pregnancy outcome, or neurobehavioural disorders."

World Health Organization International Agency for Research on Cancer

The WHO International Agency for Research on Cancer (IARC) produces a monograph series that reviews the scientific evidence regarding potential carcinogenicity associated with exposure to environmental agents. An international scientific panel of 21 experts from 10 countries met in June 2001 to review the scientific evidence regarding the potential carcinogenicity of static and ELF (extremely low frequency or power-frequency) EMF. The panel categorized its conclusions for carcinogenicity based on the IARC classification system—a system that evaluates the strength of evidence from epidemiological, laboratory (human and cellular), and mechanistic studies. The panel classified power-frequency EMF as "possibly carcinogenic to humans" based on a fairly consistent statistical association between a doubling of risk of childhood leukemia and magnetic field exposure above 0.4 microtesla (0.4 μT, 4 milligauss or 4 mG).

In contrast, they found no consistent evidence that childhood EMF exposures are associated with other types of cancer or that adult EMF exposures are associated with increased risk for any kind of cancer. The IARC panel reported that no consistent carcinogenic effects of EMF exposure have been observed in experimental animals and that there is currently no scientific explanation for the observed association between childhood leukemia and EMF exposure. Further information can be obtained at the IARC web sites (http://www.iarc.fr and http://monographs.iarc.fr).

International Commission on Non-Ionizing Radiation Protection

The International Commission on Non-Ionizing Radiation Protection (ICNIRP) issued exposure guidelines to guard against known adverse effects such as stimulation of nerves and muscles at very high EMF levels, as well as shocks and burns caused by touching objects that conduct electricity (see page 47). In April 1998, ICNIRP revised its exposure guidelines and characterized as "unconvincing" the evidence for an association between everyday power-frequency EMF and cancer.

European Union

In 1996, a European Union (EU) advisory panel provided an overview of the state of science and standards among EU countries. With respect to power-frequency EMF, the panel members said that there is no clear evidence that exposure to EMF results in an increased risk of cancer.

Australia—Radiation Advisory Committee Report to Parliament

In 1997, Australia's Radiation Advisory Committee briefly reviewed the EMF scientific literature and advised the Australian Parliament that, overall, there is insufficient evidence to come to a firm conclusion regarding possible health effects from exposure to power-frequency magnetic fields.

The committee also reported that "the weight of opinion as expressed in the U.S. National Academy of Sciences report, and the negative results from the National Cancer Institute study (Linet et al., 1997) would seem to shift the balance of probability more towards there being no identifiable health effects" (see pages 17 and 53).

Canada—Health Canada Report

In December 1998, a working group of public health officers at Health Canada, the federal agency that manages Canada's health care system, issued a review of the scientific literature regarding power-frequency EMF health effects. They found the evidence to be insufficient to conclude that EMF causes a risk of cancer.

The report concluded that while EMF effects may be observed in biological systems in a laboratory, no adverse health effects have been demonstrated at the levels to which humans and animals are typically exposed.

As for epidemiology, 25 years of study results are inconsistent and inconclusive, the panel said, and a plausible EMF-cancer mechanism is missing. Health Canada pledged to continue monitoring EMF research and to reassess this position as new information becomes available.

Germany—Ordinance 26

On January 1, 1997, Germany became the first nation to adopt a national rule on EMF exposure for the general public. Ordinance 26 applies only to facilities such as overhead and underground transmission and distribution lines, transformers, switchgear and overhead lines for electric-powered trains. Both electric (5 kV/m) and magnetic field exposure limits (1 Gauss) are high enough that they are unlikely to be encountered in ordinary daily life. The ordinance also requires that precautionary measures be taken on a case-by-case basis when electric facilities are sited or upgraded near homes, hospital, schools, day care centers, and playgrounds.

Great Britain—National Radiological Protection Board Report

The National Radiological Protection Board (NRPB) in Great Britain advises the government of the United Kingdom regarding standards of protection for exposure to non-ionizing radiation. The NRPB's advisory group on non-ionizing radiation periodically reviews new developments in EMF research and reports its findings. Results of the advisory group's latest review were published in 2001. The report reviewed residential and occupational epidemiological studies, as well as cellular, animal, and human volunteer studies that had been published.

The advisory group noted that there is "some epidemiological evidence that prolonged exposure to higher levels of power frequency magnetic fields is associated with a small risk of leukaemia in children." Specifically, the NRPB advisory group's analysis suggests "that relatively heavy average exposures of 0.4 μT [4 mG] or more are associated with a doubling of the risk of leukaemia in children under 15 years of age." The group pointed out, however, that laboratory experiments have provided "no good evidence that extremely low frequency electromagnetic fields are capable of producing cancer."

Scandinavia—EMF Developments

In October 1995, a group of Swedish researchers and government officials published a report about EMF exposure in the workplace. This "Criteria Group" reviewed EMF scientific literature and, using the IARC classification system, ranked occupational EMF exposure as "possibly carcinogenic to humans." They also endorsed the Swedish government's 1994 policy statement that public exposure limits to EMFs were not needed, but that people might simply want to use caution with EMFs.

In 1996, five Swedish government agencies further explained their precautionary advice about EMF. EMF exposure should be reduced, they said, but only when practical, without great inconvenience or cost.

Health experts in Norway, Denmark, and Finland generally agreed in reviews published in the 1990s that if an EMF health risk exists, it is small. They acknowledged that a link between residential magnetic fields and childhood leukemia cannot be confirmed or denied. In 1994, several Norwegian government ministries also recommended increasing the distance between residences and electrical facilities, if it could be done at low cost and with little inconvenience.

Q What other U.S. organizations have reported on EMF?

A American Medical Association

In 1995, the American Medical Association advised physicians that no scientifically documented health risk had been associated with "usually occurring" EMF, based on a review of EMF epidemiological, laboratory studies, and major literature reviews.

American Cancer Society

In 1996, the American Cancer Society released a review of 20 years of EMF epidemiological research including occupational studies and residential studies of

adult and childhood cancer. The society noted that some data support a possible relationship of magnetic field exposure with leukemia and brain cancer, but further research may not be justified if studies continue to find uncertain results. Of particular interest is the summary of results from eight studies of risk from use of household appliances with relatively high magnetic fields, such as electric blankets and electric razors. The summary suggested that there is no persuasive evidence for increased risk with more frequent or longer use of these appliances.

American Physical Society

The American Physical Society (APS) represents thousands of U.S. physicists. Responding to the NIEHS Working Group's conclusion that EMF is a possible human carcinogen, the APS executive board voted in 1998 to reaffirm its 1995 opinion that there is "no consistent, significant link between cancer and power line fields."

California's Department of Health Services

In 1996, California's Department of Health Services (DHS) began an ambitious five-year effort to assess possible EMF public health risk and offer guidance to school administrators and other decision-makers. The California Electric and Magnetic Fields (EMF) Program is a research, education, and technical assistance program concerned with the possible health effects of EMF from power lines, appliances, and other uses of electricity. The program's goal is to find a rational and fair approach to dealing with the potential risks, if any, of exposure to EMF. This is done through research, policy analysis, and education. The web site has educational materials on EMF and related health issues for individuals, schools, government agencies, and professional organizations (http://www.dhs.ca.gov/ps/deodc/ehib/emf).

Q A What can we conclude about EMF at this time?

Electricity is a beneficial part of our daily lives, but whenever electricity is generated, transmitted, or used, electric and magnetic fields are created. Over the past 25 years, research has addressed the question of whether exposure to power-frequency EMF might adversely affect human health. For most health outcomes, there is no evidence that EMF exposures have adverse effects. There is some evidence from epidemiology studies that exposure to power-frequency EMF is associated with an increased risk for childhood leukemia. This association is difficult to interpret in the absence of reproducible laboratory evidence or a scientific explanation that links magnetic fields with childhood leukemia.

EMF exposures are complex and come from multiple sources in the home and workplace in addition to power lines. Although scientists are still debating whether EMF is a hazard to health, the NIEHS recommends continued education on ways of reducing exposures. This booklet has identified some EMF sources and some simple steps you can take to limit your exposure. For your own safety, it is important that any steps you take to reduce your exposures do not increase other obvious hazards such as those from electrocution or fire. At the current time in the United States, there are no federal standards for occupational or residential exposure to 60-Hz EMF.

7 References

Selected references on EMF topics.

Basic Science

Kovetz A. Electromagnetic Theory. New York: Oxford University Press (2000).

Vanderlinde J. Classical Electromagnetic Theory. New York: Wiley (1993).

EMF Levels and Exposures

Dietrich FM & Jacobs WL. Survey and Assessment of Electric and Magnetic (EMF) Public Exposure in the Transportation Environment. Report of the U. S. Department of Transportation. NTIS Document PB99-130908. Arlington, VA: National Technical Information Service (1999).

Kaune WT. Assessing human exposure to power-frequency electric and magnetic fields. Environmental Health Perspectives 101:121-133 (1993).

Kaune WT & Zaffanella L. Assessing historical exposure of children to power frequency magnetic fields. Journal of Exposure Analysis Environmental Epidemiology 4:149-170 (1994).

Tarone RE, Kaune WT, Linet MS, Hatch EE, Kleinerman RA, Robison LL, Boice JD & Wacholder S. Residential wire codes: Reproducibility and relation with measured magnetic fields. Occupational and Environmental Medicine 55:333-339 (1998).

U.S. Environmental Protection Agency. EMF in your environment: magnetic field measurements of everyday electrical devices. Washington, DC: Office of Radiation and Indoor Air, Radiation Studies Division, U.S. Environmental Protection Agency, Report No. 402-R-92-008 (1992).

Zaffanella L. Survey of residential magnetic field sources. Volume 1: Goals, Results and Conclusions. EPRI Report No. TR-102759. Palo Alto, CA:Electric Power Research Institute (EPRI), 1993;1-224.

EMF Standards and Regulations

Documentation of the Threshold Limit Values and Biological Exposure Indices, 7th Ed. Publication No. 0100. Cincinnati, OH: American Conference of Governmental Industrial Hygienists (2001).

ICNIRP International Commission on Non-Ionizing Radiation Protection. Guidelines for Limiting Exposure to Time-Varying Electric, Magnetic, and Electromagnetic Fields (up to 300 GHz). Health Physics 74:494-522 (1998).

Swedish National Board of Occupational Safety and Health. Low-Frequency Electrical and Magnetic Fields (SNBOSH): The Precautionary Principle for National Authorities. Guidance for Decision-Makers. Solna (1996).

U.S. Department of Transportation, F.R.A. Safety of High Speed Guided Ground Transportation Systems, Magnetic and Electric Field Testing of the Amtrak Northeast Corridor and New Jersey Coast Line Rail Systems, Volume I: Analysis. Washington, DC: Office of Research and Development (1993).

Residential Childhood Cancer Studies

Ahlbom A, Day N, Feychting M, Roman E, Skinner J, Dockerty J, Linet M, McBride M, Michaelis J, Olsen JH, Tynes T & Verkasalo PK. A pooled analysis of magnetic fields and childhood leukemia. British Journal of Cancer 83:692-698 (2000).

Coghill RW, Steward J & Philips A. Extra low frequency electric and magnetic fields in the bedplace of children diagnosed with leukemia: A case-control study. European Journal of Cancer Prevention 5:153-158 (1996).

Dockerty JD, Elwood JM, Skegg DC, & Herbison GP. Electromagnetic field exposures and childhood cancers in New Zealand. Cancer Causes and Control 9:299-309 (1998).

Feychting M & Ahlbom A. Magnetic fields and cancer in children residing near Swedish high-voltage power lines. American Journal of Epidemiology 138:467-481 (1993).

Greenland S, Sheppard AR, Kaune WT, Poole C & Kelsh MA. A pooled analysis of magnetic fields, wire codes and childhood leukemia. EMF Study Group. Epidemiology 11:624-634 (2000).

Linet MS, Hatch EE, Kleinerman RA, Robison LL, Kaune WT, Friedman DR, Severson RK, Haines CM, Hartsock CT, Niwa S, Wacholder S & Tarone RE. Residential exposure to magnetic fields and acute lymphoblastic leukemia in children. New England Journal of Medicine 337:1-7 (1997).

London SJ, Thomas DC, Bowman JD, Sobel E, Cheng TC & Peters JM. Exposure to residential electric and magnetic fields and risk of childhood leukemia. American Journal of Epidemiology 134:923-937 (1991).

McBride ML, Gallagher RP, Thériault G, Armstrong BG, Tamaro S, Spinelli JJ, Deadman JE, Fincham B, Robson D & Choi W. Power-frequency electric and magnetic fields and risk of childhood leukemia in Canada. American Journal of Epidemiology 149:831-842 (1999).

Michaelis J, Schuz J, Meinert R, Zemann E, Grigat JP, Kaatsch P, Kaletsch U, Miesner A, Brinkmann K, Kalkner W, & Karner H. Combined risk estimates for two German population-based case-control studies on residential magnetic fields and childhood leukemia. Epidemiology 9:92-94 (1998).

Olsen JH, Nielsen A & Schulgen G. Residence near high voltage facilities and risk of cancer in children. British Medical Journal 307:891-895 (1993).

Savitz DA, Wachtel H, Barnes FA, John EM & Tvrdik JG. Case-control study of childhood cancer and exposure to 60-Hz magnetic fields. American Journal of Epidemiology 128:21-38 (1988).

Tomenius L. 50-Hz electromagnetic environment and the incidence of childhood tumors in Stockholm county. Bioelectromagnetics 7:191-207 (1986).

Tynes T & Haldorsen T. Electromagnetic fields and cancer in children residing near Norwegian high-voltage power lines. American Journal of Epidemiology 145:219-226 (1997).

UK Childhood Cancer Study Investigators. Exposure to power frequency magnetic fields and the risk of childhood cancer: a case/control study. Lancet 354:1925-1931 (1999).

Verkasalo PK, Pukkala E, Hongisto MY, Valjus JE, Jarvinen PJ, Heikkila KV & Koskenvuo M. Risk of cancer in Finnish children living close to power lines. British Medical Journal 307:895-899 (1993).

Residential Adult Cancer Studies

Coleman MP, Bell CM, Taylor HL & Primie-Zakelj M. Leukemia and residence near electricity transmission equipment: a case-control study. British Journal of Cancer 60:793-798 (1989).

Feychting M & Ahlbom A. Magnetic fields, leukemia, and central nervous system tumors in Swedish adults residing near high-voltage power lines. Epidemiology 5:501-509 (1994).

Li CY, Theriault G & Lin RS. Residential exposure to 60-hertz magnetic fields and adult cancers in Taiwan. Epidemiology 8:25-30 (1997).

McDowall ME. Mortality of persons resident in the vicinity of electricity transmission facilities. British Journal of Cancer 53:271-279 (1986).

Severson RK, Stevens RG, Kaune WT, Thomas DB, Heuser L, Davis S & Sever LE. Acute nonlymphocytic leukemia and residential exposure to power frequency magnetic fields. American Journal of Epidemiology 128:10-20 (1988).

Wrensch M, Yost M, Miike R, Lee G & Touchstone J. Adult glioma in relation to residential power-frequency electromagnetic field exposures in the San Francisco Bay area. Epidemiology 10:523-527 (1999).

Youngson JH, Clayden AD, Myers A & Cartwright RA. A case/control study of adult haematological malignancies in relation to overhead powerlines. British Journal of Cancer 63:977-985 (1991).

Occupational EMF Cancer Studies

Coogan PF, Clapp RW, Newcomb PA, Wenzl TB, Bogdan G, Mittendorf R, Baron JA & Longnecker MP. Occupational exposure to 60-Hertz magnetic fields and risk of breast cancer in women. Epidemiology 7:459-464 (1996).

Floderus B, Persson T, Stenlund C, Wennberg A, Ost A, & Knave B. Occupational exposure to electromagnetic fields in relation to leukemia and brain tumors: a case-control study in Sweden. Cancer Causes Control 4:465-476 (1993).

Floderus B, Tornqvist S, & Stenlund C. Incidence of selected cancers in Swedish railway workers, 1961-79. Cancer Causes Control 5:189-194 (1994).

Sorahan T, Nichols L, van Tongeren M, & Harrington JM. Occupational exposure to magnetic fields relative to mortality from brain tumours: updated and revised findings from a study of United Kingdom electricity generation and transmission workers, 1973–97. Occupational and Environmental Medicine 58(10):626-630 (2001).

Johansen C, & Olsen JH Risk of cancer among Danish utility workers - A nationwide cohort study. American Journal of Epidemiology, 147:548-555 (1998).

Kheifets LI, Gilbert ES, Sussman SS, Guenel P, Sahl JD, Savitz DA, & Theriault G. Comparative analyses of the studies of magnetic fields and cancer in electric utility workers: studies from France, Canada, and the United States. Occupational and Environmental Medicine 56(8):567-574 (1999).

London SJ, Bowman JD, Sobel E, Thomas DC, Garabrant DH, Pearce N, Bernstein L & Peters JM . Exposure to magnetic fields among electrical workers in relation to leukemia risk in Los Angeles County. American Journal of Industrial Medicine 26:47-60 (1994).

Matanoski GM, Breysse PN & Elliott EA. Electromagnetic field exposure and male breast cancer. Lancet 337:737 (1991).

Sahl JD, Kelsh MA, & Greenland S. Cohort and nested case-control studies of hematopoietic cancers and brain cancer among utility worker. Epidemiology 4:21-32 (1994).

Savitz DA & Loomis DP. Magnetic field exposure in relation to leukemia and brain cancer mortality among electric utility workers. American Journal of Epidemiology 141:123-134 (1995).

Sorahan T, Nichols L, van Tongeren M, & Harrington JM. Occupational exposure to magnetic fields relative to mortality from brain tumours: updated and revised findings from a study of United Kingdom electricity generation and transmission workers, 1973–97. Occupational and Environmental Medicine 58:626-630 (2001).

Thériault G, Goldberg M, Miller AB, Armstrong B, Guénel P, Deadman J, Imbernon E, To T, Chevalier A, Cyr D, & Wall C. Cancer risks associated with occupational exposure to magnetic fields among electric utility workers in Ontario and Quebec, Canada and France: 1970–1989. American Journal of Epidemiology 139:550-572 (1994).

Tynes T, Jynge H, & Vistnes AI. Leukemia and brain tumors in Norwegian railway workers, a nested case-control study. American Journal of Epidemiology 139:645-653 (1994).

Laboratory Animal EMF Studies

Anderson LE, Boorman GA, Morris JE, Sasser LB, Mann PC, Grumbein SL, Hailey JR, McNally A, Sills RC & Haseman JK. Effect of 13-week magnetic field exposures on DMBA-initiated mammary gland carcinomas in female Sprague-Dawley rats. Carcinogenesis 20:1615-1620 (1999).

Baum A, Mevissen M, Kamino K, Mohr U & Löscher W. A histopathological study on alterations in DMBA-induced mammary carcinogenesis in rats with 50 Hz, 100 mT magnetic field exposure. Carcinogenesis 16:119-125 (1995).

Babbitt JT, Kharazi AI, Taylor JMG, Rafferty CN, Kovatch R, Bonds CB, Mirell SG, Frumkin E, Dietrich F, Zhuang D & Hahn TJM. Leukemia/lymphoma in mice exposed to 60-Hz magnetic fields: Results of the chronic exposure study TR-110338. Los Angeles: Electric Power Research Institute (EPRI) (1998).

Babbitt JT, Kharazi AI, Taylor JMG, Rafferty CN, Kovatch R, Bonds CB, Mirell SG, Frumkin E, Dietrich F, Zhuang D & Hahn TJM. Leukemia/lymphoma in mice exposed to 60-Hz magnetic fields: Results of the chronic exposure study, Second Edition. Electric Power Research Institute (EPRI) and B. C. Hydro, Palo Alto, California and Burnaby, British Columbia, Canada (1999).

Boorman GA, Anderson LE, Morris JE, Sasser LB, Mann PC, Grumbein SL, Hailey JR, McNally A, Sills RC & Haseman JK. Effect of 26-week magnetic field exposures in a DMBA initiation-promotion mammary gland model in Sprague-Dawley rats. Carcinogenesis 20:899-904 (1999).

Boorman GA, McCormick DL, Findlay JC, Hailey JR, Gauger JR, Johnson TR, Kovatch RM, Sills RC & Haseman JK. Chronic toxicity/oncogenicity of 60 Hz (power frequency) magnetic fields in F344/N rats. Toxicological Pathology 27:267-278 (1999).

Boorman GA, McCormick DL, Ward JM, Haseman JK & Sills RC. Magnetic fields and mammary cancer in rodents: A critical review and evaluation of published literature. Radiation Research 153:617-626 (2000).

Boorman GA, Rafferty CN, Ward JM & Sills RC. Leukemia and lymphoma incidence in rodents exposed to low-frequency magnetic fields. Radiation Research 153:627-636 (2000).

Ekström T, Mild KH & Holmberg B. Mammary tumours in Sprague-Dawley rats after initiation with DMBA followed by exposure to 50 Hz electromagnetic fields in a promotional scheme. Cancer Letters 123:107-111 (1998).

Mandeville R, Franco E, Sidrac-Ghali S, Paris-Nadon L, Rocheleau N, Mercier G, Desy M & Gaboury L. Evaluation of the potential carcinogenicity of 60 Hz linear sinusoidal continuous-wave magnetic fields in Fisher F344 rats. Federation of the American Society of Experimental Biology Journal 11:1127-1136 (1997).

McCormick DL, Boorman GA, Findlay JC, Hailey JR, Johnson TR, Gauger JR, Pletcher JM, Sills RC & Haseman JK. Chronic toxicity/oncogenicity of 60 Hz (power frequency) magnetic fields in B6C3F1 mice. Toxicological Pathology 27:279-285 (1999).

Mevissen M, Lerchl A, Szamel M & Löscher W. Exposure of DMBA-treated female rats in a 50-Hz, 50 microTesla magnetic field: Effects on mammary tumor growth, melatonin levels and T-lymphocyte activation. Carcinogenesis 17:903-910 (1996).

Yasui M, Kikuchi T, Ogawa M, Otaka Y, Tsuchitani M & Iwata H. Carcinogenicity test of 50 Hz sinusoidal magnetic fields in rats. Bioelectromagnetics 18:531-540 (1997).

Laboratory Cellular EMF Studies

Balcer-Kubiczek EK, Harrison GH, Zhang XF, Shi ZM, Abraham JM, McCready WA, Ampey LL, III, Meltzer SJ, Jacobs MC, & Davis CC. Rodent cell transformation and immediate early gene expression following 60-Hz magnetic field exposure. Environmental Health Perspectives 104:1188-1198 (1996).

Boorman GA, Owen RD, Lotz WG & Galvin MJ, Jr. Evaluation of *in vitro* effects of 50 and 60 Hz magnetic fields in regional EMF exposure facilities. Radiation Research 153:648-657 (2000).

Lacy-Hulbert A, Metcalfe JC, & Hesketh R. Biological responses to electromagnetic fields. Federation of the American Society of Experimental Biology (FASEB) Journal 12:395-420 (1998).

Morehouse CA & Owen RD. Exposure of Daudi cells to low-frequency magnetic fields does not elevate MYC steady-state mRNA levels. Radiation Research 153:663-669 (2000).

Snawder JE, Edwards RM, Conover DL & Lotz WG. Effect of magnetic field exposure on anchorage-independent growth of a promoter-sensitive mouse epidermal cell line (JB6). Environmental Health Perspectives 107:195-198 (1999).

Wey HE, Conover DL, Mathias P, Toraason MA & Lotz WG. 50-Hz magnetic field and calcium transients in Jurkat cells: Results of a research and public information dissemination (RAPID) program study. Environmental Health Perspectives 108:135-140 (2000).

National Reviews of EMF Research

American Medical Association. Council on Scientific Affairs. Effects of Electric and Magnetic Fields. Chicago: American Medical Association (December 1994).

National Institute for Occupational Safety and Health, National Institute of Environmental Health Sciences, U.S. Department of Energy. Questions and Answers: EMF in the Workplace. Electric and Magnetic Fields Associated with the Use of Electric Power. Report No. DOE/GO-10095-218 (September 1996).

National Radiological Protection Board. ELF Electromagnetic Fields and the Risk of Cancer. Volume 12:1, Chilton, Didcot, Oxon, UK OX11 ORQ (2001).

National Research Council, Committee on the Possible Effects of Electromagnetic Fields on Biologic Systems. Possible Health Effects of Exposure to Residential Electric and Magnetic Fields. Washington: National Academy Press (1997).

National Institute of Environmental Health Sciences Report on Health Effects from Exposure to Power-Line Frequency Electric and Magnetic Fields. NIH Publication No. 99-4493. Research Triangle Park, National Institute of Environmental Health Sciences (1999).

Portier CJ & Wolfe MS, Eds. Assessment of Health Effects from Exposure to Power-Line Frequency Electric and Magnetic Fields—NIEHS Working Group Report NIH Publication No. 98-3981. Research Triangle Park, National Institute of Environmental Health Sciences (1998).

HDR Engineering, Inc.
Wetland Report

Wetland Report

Basin Electric Power Cooperative Williston Tie Project

November 2011

Prepared for:

Basin Electric Power Cooperative

Prepared by:

HDR Engineering, Inc.

Table of Contents

List of Tables

List of Figures

List of Appendices

1.0 INTRODUCTION

The Williston Tie Project (Project) is an approximately 4 mile portion of the larger approximately 200 mile Antelope Valley Station to Neset 345 kV Transmission Project that Basin Electric is currently developing. The project proposes to string and energize approximately two miles of 230 kV and approximately two miles of 345 kV overhead electrical transmission line. The 230 kV and 345 kV transmission line will double circuit with a Mountrail Williams Electric Cooperative (MWEC) 115 kV transmission line (Figure 1).

This wetland report reviews the proposed 150-foot-wide right-of-way (ROW) for the approximately 4 mile double circuit described above.

On August 2-3, 2011 HDR conducted wetlands delineations within the ROW. On November 3, 2011 Burns & McDonnell conducted wetland delineations in Section 15, T154N, R102W in response to a minor routing revision that occurred after the August wetland delineations.

2.0 PURPOSE

Wetland delineations are required in order to determine potential Project impacts and to acquire necessary state and federal permits or approvals. Additionally, wetland delineations provide information valuable in identifying avoidance and minimization strategies for the Project.

Dredging and filling of jurisdictional waters of the U.S. are regulated according to the Section 404 of the Clean Water Act (CWA). These rules are administered by the U.S Army Corps of Engineers (USACE) and the Environmental Protection Agency (EPA), although the USACE typically takes the lead role in reviewing actions that may result in dredging and/or filling waters of the U.S. Waters that are not jurisdictional (i.e., waters that are "isolated" from waters of the U.S), do not typically fall within the purview of the Section 404.

3.0 METHODS

The wetland delineation was conducted using the methods outlined in the *1987 Corps of Engineers Wetlands Delineation Manual* (USACE 1987) and the *Great Plains Regional Supplement* (USACE, 2010) for all wetlands. US Army Corps of Engineers (USACE) defines areas as wetlands based on the following:

> "Those areas that are inundated or saturated by surface or ground water at a frequency and duration sufficient to support, and that under normal circumstances do support, a prevalence of vegetation typically adapted for life in saturated soil conditions. Wetlands generally include swamps, marshes, bogs and similar areas" [33 CFR 328 3.b].

Wetland delineations are based on the presence of the following three parameters:

- The area must exhibit indicators of wetland hydrology
- The area must have a predominance of hydrophytic vegetation
- Hydric soils must be present

"Atypical" or "problem areas" may be missing one or more of the three parameters.

An initial off-offsite evaluation of the ROW, using available off-site information including, Farm Service Agency (FSA) aerial photographs, National Wetland Inventory (NWI) data, and USGS topographic maps, was completed to evaluate the area for wetlands (Figure 1 and Figure 2).

On-site delineations were conducted on August 2-3, 2011 (August Surveys) and—in response to a minor route revision—on November 2011 (November Surveys). No wetlands were identified within the ROW during August Surveys. During the November Survey two wetlands and two ponds were delineated.

USACE wetlands determination datasheets were not collected during November Surveys, but wetlands were identified according to the USACE methods described below. A detailed map of wetlands located within the ROW is attached as Figure 3.

Data sheets and wetland boundaries were collected for these wetlands according to the *1987 Manual* and *Great Plains Regional Supplement* as described below. Anticipated wetland jurisdiction was identified in accordance to guidance set forth with the *U.S. Army Corps of Engineers Jurisdictional Determination Form Instructional Guidebook*.

Upland and wetland plots were conducted at wetland locations. At each plot location, a soil pit was dug for observation of soil and hydrology characteristics. The vegetation was analyzed for plant species dominance in a 5-foot radius from the sample pit for the herbaceous layer, in a 15-foot radius for shrub layer, and in a 30-foot radius for overstory trees. The wetland indicator status of plants was identified using the USFWS *1988 National List of Plant Species that Occur in Wetlands (Region 4)*.

Wetland boundaries were mapped using a GPS unit with sub-meter accuracy. Using GIS, an accurate delineation map (Figures 3) was created from the GPS data and field drawings, providing a record of the on-site delineation wetland boundaries for the proposed Project.

4.0 SITE DESCRIPTION

4.1 General Characteristics of the Project Area

The Project is located in southwest Williams County, just to the northwest of the city of Williston The U.S. Geological Survey characterizes this area as the Glaciated Dark Brown Prairie (Ecoregion 42i), which marks a transition to drier conditions. Ecoregion 42i consists of a well defined drainage system and fewer wetlands than the Missouri Coteau Slope (Ecoregion 42c) to the east. Mean annual rainfall is 14-16 inches and natural vegetation includes mixed-grass prairie species such as green needlegrass (*Stipa viridula*), needleandthread (*Stipa comata*), western wheatgrass (*Agropyron smithii*), and blue grama (*Bouteloua gracilis*) (USGS, 2006). Scattered small wetlands (less than one 1 acre in size) occur throughout the landscape. Some of these wetlands are associated with the relatively numerous intermittent drainages that direct water to the Missouri River to the south of the Project; some of the wetlands are isolated prairie pothole wetlands. According to USGS stream mapping there are no perennial streams that are crossed by the Project.

Land use near the ROW consists of cropland, hayland, and pasture. Most of the pasture areas still maintain native vegetation associated with mixed-grass prairie communities.

The Project is located within a geologic resource known as the Bakken Formation, which contains large qualities of recoverable oil. There are several oil wells in the general vicinity of the Project. Oil production in the Bakken Formation has continued to increase (Polson, 2010), and it is possible that additional oil wells will be sited near the Project.

Table 1 lists the townships and sections crossed by the ROW. The full alignment is shown in Figure 1 and Figure 2.

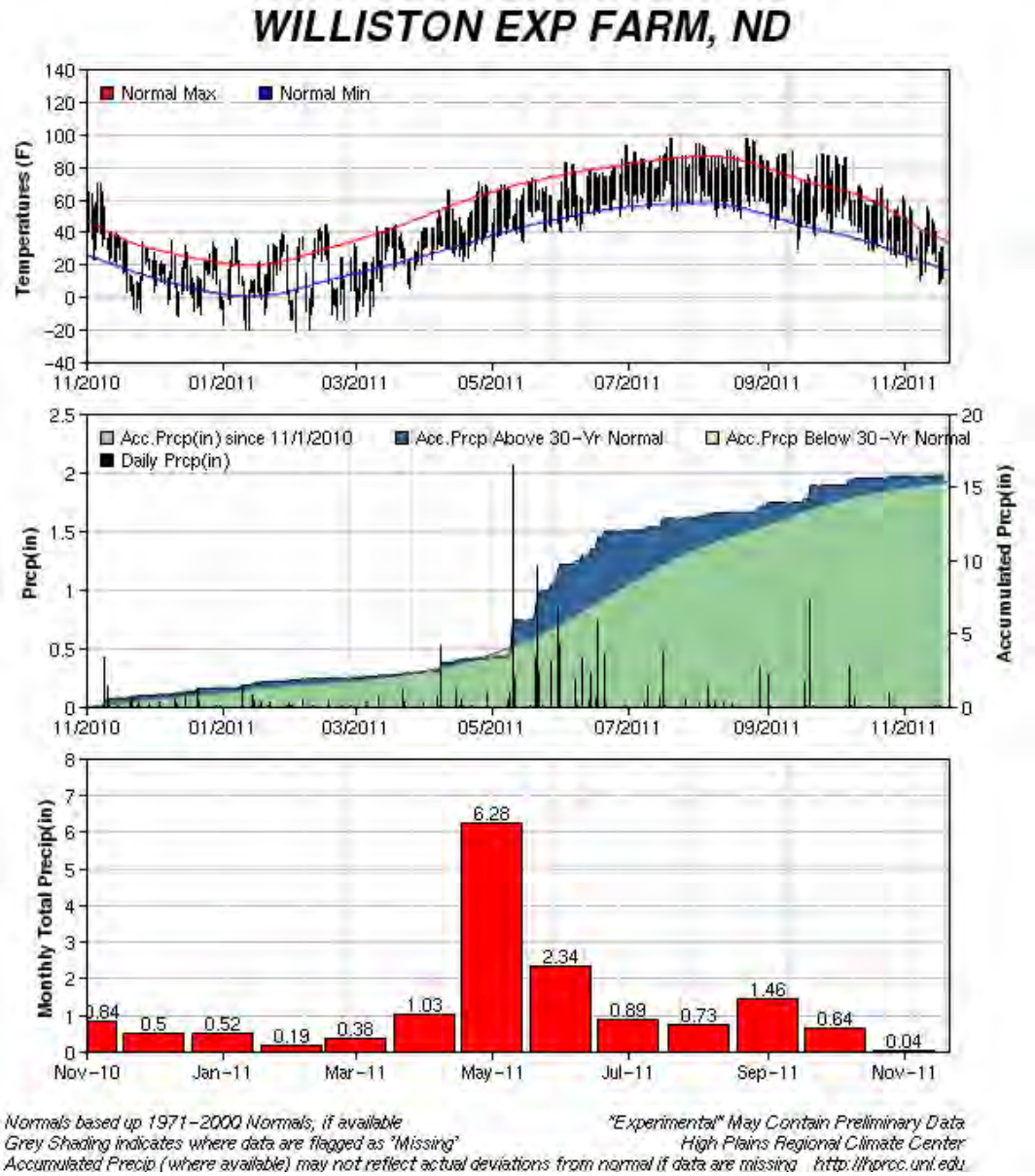
Table 1. Townships and Sections within the proposed ROW

Township Name	Township	Range	Sections
Judson	154N	102W	15,22-24

4.2 Precipitation History

The Williston Exp Farm weather station, which is located about one mile south of the southeast Project, recorded about 18 inches of precipitation from August 2010 to August 2011. This is about 3 inches above normal for this time period (Table 2). An additional 2 inches of rainfall occurred between the August Surveys and November Surveys. Accumulated precipitation was near the 30-year normal during November Surveys.

Table 2. Precipitation Data: Williston Exp Farm, (Station #329430) August 1, 2010 – November 21, 2011



(HPRCC, 2011)

Prairie pothole type wetlands in North Dakota have wetland boundaries that may vary in response to precipitation patterns. Wetland boundaries mapped during August Surveys represent the above normal precipitation levels for 2010 and 2011 (Table 2 and Table 3). This is particularly evident when compared to NWI data which was produced based on 1979 data (USFWS, 2002), a year with below-normal precipitation levels (WRCC, 2011). While precipitation was near normal during November Surveys the wetlands signatures still reflect the above normal precipitation patterns for 2010 and 2011.

Table 3. Annual Precipitation Data: Williston Exp Farm, (Station #329430) Years 1979 to 2010

(WRCC, 2011)

5.0 RESULTS

Two wetlands and two ponds were identified within the ROW, during August and November Surveys. Wetland AA-1 is characterized as PEMB and Wetland AA-2 is PEMA. These Cowardin wetland types are described below.

- **PEMA - Temporarily Flooded.** Surface water is present for brief periods during the growing season, but the water table usually lies well below the soil surface for most of the season. Plants that grow both in uplands and wetlands are characteristic of the temporarily flooded regime.
- **PEMB - Saturated.** The substrate is saturated to the surface for extended periods during the growing season, but surface water is seldom present.

Pond A is formed by a man-made berm located across an intermittent drainage. Pond B is formed by a shallow excavated cattle pond. Project wetlands are shown in Figures 3 and are summarized in Table 3. Representative photos of these wetlands are included as Appendix A.

The maximum transmission line span for the Project is expected to be around 850 feet; all of these wetlands and ponds are well within the span range of the proposed transmission line.

Table 4. Wetland Delineation Summary

Wetland ID[1]	Section Township Range	Wetland Impacts Expected	Minor Watershed[2]	Cowardian Class	Expected Jurisdiction	Brief Wetland Description
Wetland AA-1	Sec 9, T154N, R102W	No	Middle Painted Woods Creek	PEMB	USACE	Shallow wetland within a swale.
Pond A	Sec 9, T154N, R102W	No	Middle Painted Woods Creek	PABFh	USACE	Deep Pond with man-made berm and culvert
Pond B	Sec 9, T154N, R102W	No	Middle Painted Woods Creek	PEMBx	USACE	Small, shallow excavated cattle pond
Wetland AA-2	Sec 9, T154N, R102W	No	Middle Painted Woods Creek	PEMA	Isolated	Damp swale

1 Wetlands are numbered chronologically from south to north.

2 Watersheds are based on HUC12 data provided by the United States Geological Survey

6.0 REFERENCES

High Plains Regional Climate Center. 2011. *Williston Exp Farm, ND Observation Station.* http://www.hprcc.unl.edu/stations/index.php?action=metadata&network_station_id=329430. Accessed August 11, 2011.

Polson, Jim. 2010. *North Dakota Raises Oil Forecast on Advances by Shale Explorers*. Bloomberg. http://www.bloomberg.com/apps/news?pid=newsarchive&sid=a4rgLha.Q0zc . Accessed August 11, 2011.

Reed, P.B., Jr. 1988. *National List of Plant Species That Occur in Wetlands: National Summary. U.S. Fish and Wildlife Service Biological Report 88(24).* 244 pp.

U.S. Army Corps of Engineers. 1987. *Corps of Engineers Wetlands Delineation Manual. Technical Report Y-87-1*, U.S. Army Corps of Engineers Waterways Experiment Station, Vicksburg, MS, 100 pp. and appendices.

U.S. Army Corps of Engineers and Environmental Protection Agency. 2007. *U.S. Army Corps of Engineers Jurisdictional Determination Form Instructional Guidebook*. http://www.usace.army.mil/CECW/Documents/cecwo/reg/cwa_guide/jd_guidebook_051207final.pdf. Accessed August 31, 2011.

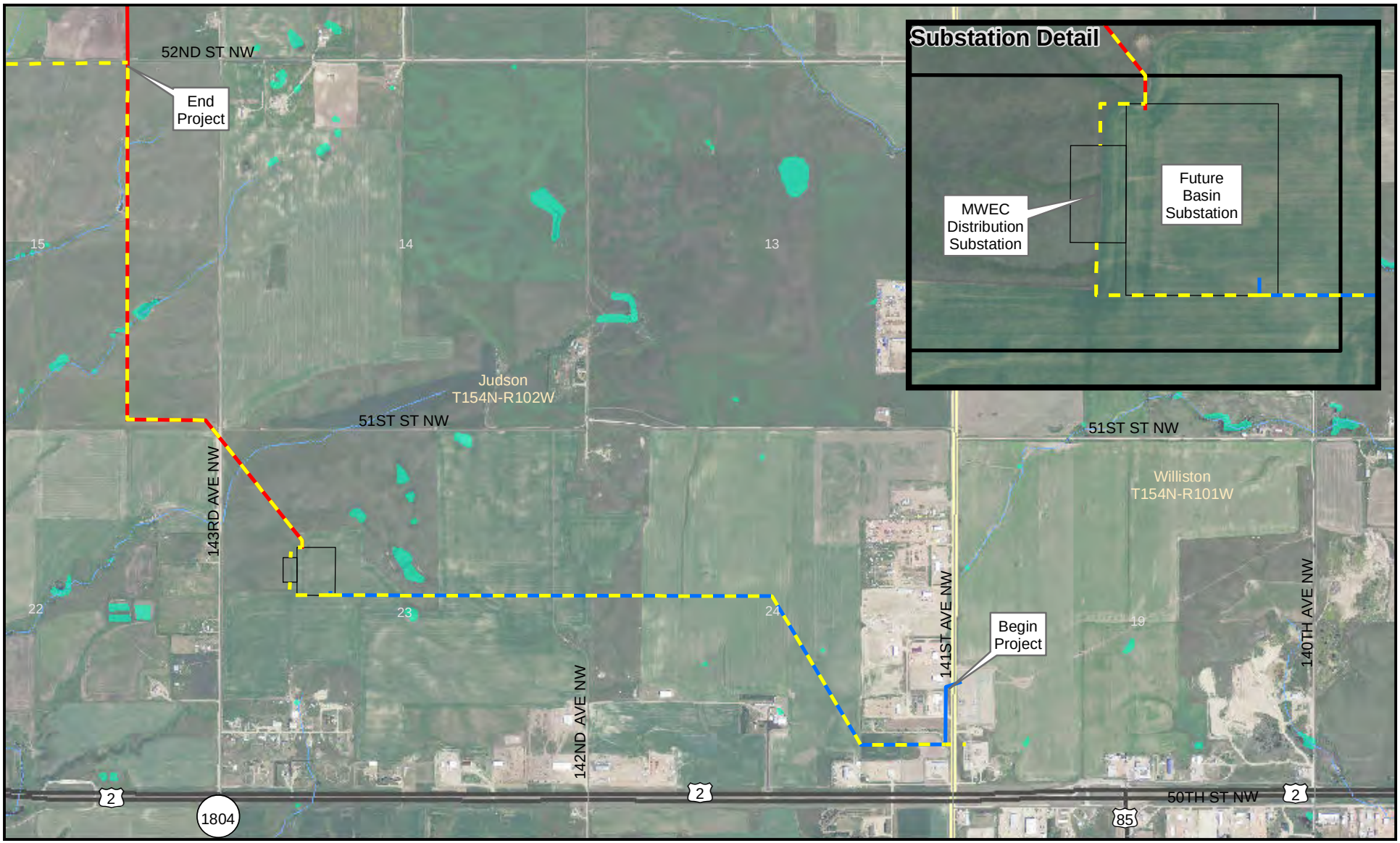
U. S. Army Corps of Engineers. 2010. *Regional Supplement to the Corps of Engineers Wetland Delineation Manual: Great Plains Region (Version 2.0),* ed. J. S. Wakeley, R. W. Lichvar, and C. V. Noble. ERDC/EL TR-10-1. Vicksburg, MS: U.S. Army Engineer Research and Development Center.

U.S. Fish and Wildlife Service. 2002. *National Wetland Inventory*: *A Strategy for the 21st Century*. http://library.fws.gov/Wetlands/21stcentury.pdf. Accessed August 31, 2011.

U.S. Geological Survey. 2006. *Ecoregions of North Dakota and South Dakota: 42i. Glaciated Dark Brown Prairie.* http://www.npwrc.usgs.gov/resource/habitat/ndsdeco/42i.htm. Accessed August 12, 2011.

Western Regional Climate Center. 2011. *Williston Exp Farm, North Dakota: Total Monthly Precipitation – 1956 to 2011*. http://www.wrcc.dri.edu/cgi-bin/cliMONtpre.pl?nd9430. Accessed November 21, 2011.

Figures



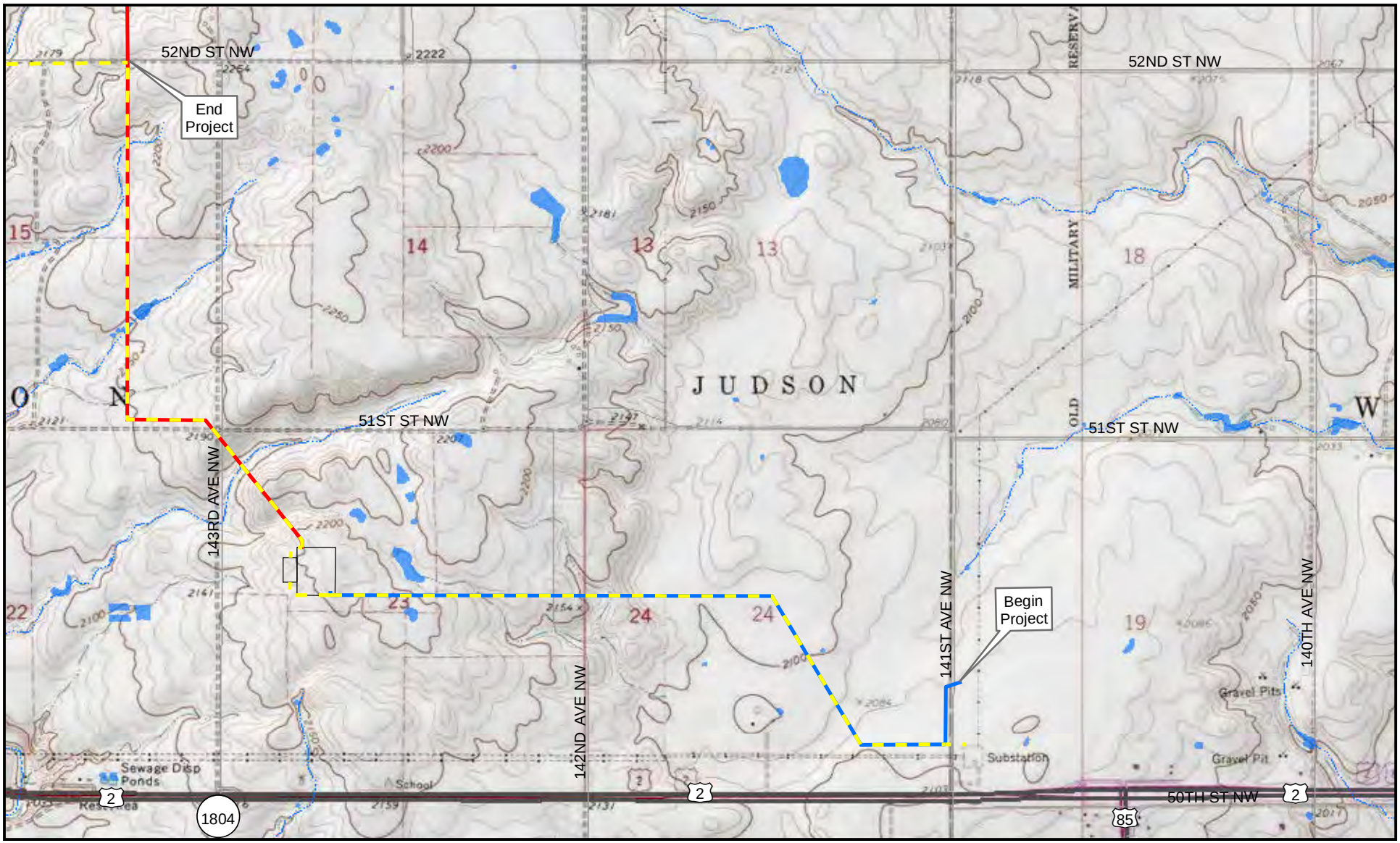
Feet
0 2,000

VOLTAGE
- MWEC 115 kV
- Basin 230 kV
- Basin 230 kV / MWEC 115 kV
- Basin 345 kV
- Basin 345 kV / MWEC 115 kV
- Substation

- NWI Wetland
- Intermittent Stream

Figure 1
Project Overview
Basin Electric Power Cooperative
Williston Tie Project

Path: Y:\MWEC\163629\map_docs\BiologicalSurveys\Wetland_Review\Figures\Basin_Figures\Figure1_Overview_Basin_WetlandReport_8.5x11L.mxd



Feet
0 2,000

VOLTAGE
- MWEC 115 kV
- Basin 230 kV
- Basin 230 kV / MWEC 115 kV
- Basin 345 kV
- Basin 345 kV / MWEC 115 kV
- Substation

- NWI Wetland
- Intermittent Stream

Figure 2
USGS Topo
Basin Electric Power Cooperative
Williston Tie Project

Path: Y:\MWEC\163629\map_docs\BiologicalSurveys\Wetland_Review\Figures\Basin_Figures\Figure2_Topo_Basin_WetlandReport_8.5x11L.mxd

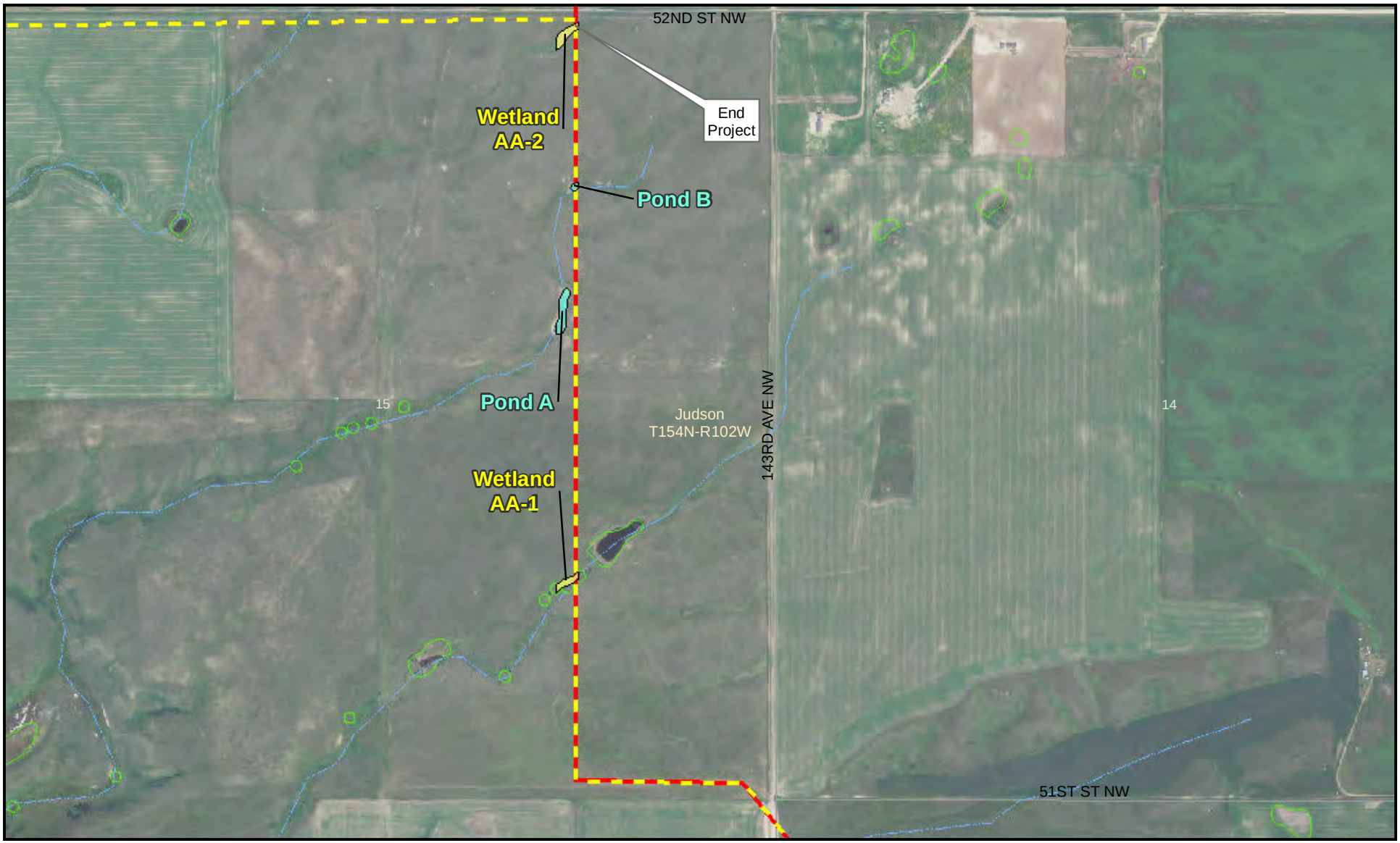


Figure 3
Detailed Wetlands
Basin Electric Power Cooperative
Williston Tie Project

Path: Y:\MWEC\163629\map_docs\BiologicalSurveys\Wetland_Review\Figures\Basin_Figures\Figure3_Detail_Basin_WetlandReport_8.5x11L.mxd

Appendix A
Representative Wetland Photos

Pond 1: looking north

Pond 2: looking east

Wetland AA-1: type PEMB, looking east

Wetland AA-2: type PEMA, looking north

Appendix B
Agency Letters

Agency response letters for the Williston to Stateline EA (which includes the area of the Project) are included below.

On June 17, 2011, Western Area Power Administration sent out a notification for a public scoping meeting on the Mountrail Williams Electric Cooperative 115 kV transmission line near Williston, North Dakota. The scoping meeting was held on July 6 at the Ernie French Extension Center in Williston. Unfortunately, the notification that was sent to you came back return to sender on Tuesday July 12, 2011. We are resending this notification and requesting that you contact us with comments and concerns you may have by August 5, 2011. There will also be another opportunity to comment once the draft Environmental Assessment is published. If we do not hear back from you we will assume you do not have comments on the project. We apologize for any inconvenience this may have caused. You can send, email, or phone in your comments to Western at the contact information listed on page two of this notification.

Western Requests Your Help to Consider Environmental Impacts

Mountrail Williams Electric Cooperative (MWEC) is proposing to construct a new 115-kilovolt (kV) transmission line in Williams County, North Dakota. The new transmission line would connect to the existing Western Area Power Administration (Western) Williston substation. The transmission line would be located north of U.S. Highway 2 and would extend approximately 16 miles to the Bear Paw Gas Plant. The intent of this notice is to inform the public about this proposed project and request public input.

Western will be preparing an Environmental Assessment (EA) in compliance with the National Environmental Policy Act (NEPA), and is seeking comments regarding the project. Part of the NEPA process is to solicit comments from interested parties regarding environmental impacts that may be associated with a project. The EA will evaluate potential impacts on environmental resources to determine their level of significance. Your comments on the proposed project will be considered before the EA is completed. Should significant environmental impacts be identified during the EA process that cannot be mitigated to a less-than-significant level, Western would initiate the preparation of an Environmental Impact Statement (EIS).

The transmission line is being proposed in order to serve growth associated with oil and gas developments in this area, particularly the load associated with the gas plant. MWEC has evaluated multiple transmission line routes and determined the proposed route discussed below best serves the increased demand. The new transmission line would help ensure that the area has adequate infrastructure to accommodate growth and provide system reliability.

The route proposed by MWEC for the new transmission line begins at the existing Williston substation. The route would exit the Western Williston substation and proceed diagonally northwest for approximately 2 miles. At 146th Avenue NW the route would turn north for 1 mile to 52nd Street NW, where it would then turns west for 1 mile to 147th Avenue NW, and then continue north for 2 miles where it would intersect 54th Street NW. The line would proceed west along 54th Street NW (and the existing distribution line) for approximately 6 miles to 153rd Avenue NW. (The existing distribution lines in this segment would be underbuilt on the same structure as the proposed transmission line.) The route would continue north for approximately 2 miles and parallel 153rd Avenue NW to 56th Street NW where would turn west for 1 mile. The transmission line would cross mostly agricultural land and would terminate at the Bear Paw Gas Plant, which is currently being constructed at the intersection of 56th Street NW and 154th Avenue NW.

The proposed transmission line would consist of single wood-pole structures placed between 300 and 400 feet apart, depending on underbuild of the existing distribution lines. Near the substation, single steel-pole structures may be used to allow more space between structures and accommodate potential growth. The standard right-of-way width for a single-pole, 115-kV transmission line would be 100 feet. The height of the new structures would vary from 75 to 100 feet above ground, depending on terrain and structure type.

MWEC plans to build the new transmission line upon receiving approval from Western, the lead federal agency responsible for NEPA review of project. Before Western can approve the project, potential environmental impacts must be considered in compliance with NEPA. Part of the NEPA process is to solicit comments from interested parties regarding alternative line routes and environmental impacts that may be associated with the project. Western will use comments received to help define the scope of the EA. Any questions or concerns you have about the NEPA process and your participation in it, and any comments you wish to provide on the project, may be directed to:

Mr. Gregory Liebelt
Environmental Protection Specialist
Western Area Power Administration
P.O. Box 145
Fort Peck Montana 59223
e-mail: liebelt@wapa.gov
fax: (406) 526-8501
telephone: (406)526-8515.

Any questions you have for MWEC about the proposed project may be directed to:

Mr. Dale Haugen
MWEC
P.O. Box 1346
218 58th Street West
Williston, North Dakota
e-mail: dhaugen@mwec.com
telephone:(800) 279-2667 telephone .

Proposed Project Schedule

November 30, 2011 - Draft EA Available for Public Review
January 6, 2012 - Draft EA Public Comment Period Ends
March 5, 2012 - Environmental Review Completed/Construction Starts (subject to approvals)

Williston Substation to Bear Paw Gas Plant 115 kV Transmission Line

Western Area Power Administration

Bear Paw Gas Plant

Heron T155N R103W

Mont T155N R102W

Missouri Ridge T155N R101W

Round Prairie T154N R103W

Judson T154N R102W

Williston T154N R101W

Williston

Map Location — Williams County — North Dakota

Proposed Route and Alteratives

- Preferred route
- Alternative A
- Alternative B

- Gasplant
- Substation

- Wetland
- ND Land Dept
- Gas pipeline
- Communication tower

- Business
- Church and/or cemetery
- Farm unit
- Gravel pit

- Home
- Mine
- Other structure
- School

1 in = 2,500 feet

0 2,500 5,000 Feet

July 2011

Data source: aerial photo-NAIP 2010 or USGS 7.5' quad, MWEC, North Dakota

DEPARTMENT OF THE ARMY
CORPS OF ENGINEERS, OMAHA DISTRICT
NORTH DAKOTA REGULATORY OFFICE
1513 SOUTH 12TH STREET
BISMARCK ND 58504-6640

REPLY TO
ATTENTION OF

June 20, 2011

North Dakota Regulatory Office

Western Area Power Administration
Attn: Mr. Gregory Liebelt
Environmental Protection Specialist
PO Box 145
Fort Peck, Montana 59223

Dear Mr. Liebelt:

This is in response to your letter on behalf of Mountrail Williams Electric Cooperative, received June 20, 2011, requesting Department of the Army (DA), US Army Corps of Engineers (Corps) comments regarding constructing new transmission line that would connect to the existing Western Area Power Administration (Western) Williston substation in Williams County, North Dakota.

Corps regulatory offices administer Section 10 of the Rivers and Harbors Act and Section 404 of the Clean Water Act. Section 10 of the Rivers and Harbors Act regulates work in, over or under navigable waters. The Missouri River (Lake Sakakawea) is considered navigable waters. Section 404 of the Clean Water Act regulates the discharge of dredge or fill material (temporarily or permanently) in waters of the United States. Waters of the United States may include, but are not limited to, rivers, streams, ditches, coulees, lakes, ponds, and their adjacent wetlands. Fill material include, but is not limited to, rock, sand, soil, clay, plastics, construction debris, wood chips, overburden from mines or other excavation activities and materials used to create any structure or infrastructure in the waters of the United States.

Nationwide Permit 12 authorizes activities for the construction of utility lines. A copy of this nationwide permit and conditions is enclosed. **The nationwide permit and conditions are submitted only for informational purposes and in no way is it, or this letter, to confirm that your activity complies with the nationwide permit and conditions.** As explained within Nationwide Permit 12, the permittee is required to submit a pre-construction notification to the Corps of Engineers prior to construction if any of seven criteria are met.

Your proposal will require review by the Corps in accordance with Section 10 of the Rivers and Harbors Act and possibly Section 404 of the Clean Water Act. Please complete and submit the enclosed Corps of Engineers permit application to the U. S. Army Corps of Engineers, North Dakota Regulatory Office, 1513 South 12th Street, Bismarck, North Dakota 58504.

If we can be of further assistance or should you have any questions regarding our program, please do not hesitate to contact this office by letter or phone at (701) 255-0015.

Sincerely,

Daniel E. Cimarosti
Regulatory Program Manager
North Dakota

Enclosures
ENG Form 4345
Fact Sheet NWP 12

Instructions for Preparing a
Department of the Army Permit Application

Blocks 1 through 4. To be completed by Corps of Engineers.

Block 5. Applicant's Name. Enter the name and the E-mail address of the responsible party or parties. If the responsible party is an agency, company, corporation, or other organization, indicate the name of the organization and responsible officer and title. If more than one party is associated with the application, please attach a sheet with the necessary information marked Block 5.

Block 6. Address of Applicant. Please provide the full address of the party or parties responsible for the application. If more space is needed, attach an extra sheet of paper marked Block 6.

Block 7. Applicant Telephone Number(s). Please provide the number where you can usually be reached during normal business hours.

Blocks 8 through 11. To be completed, if you choose to have an agent.

Block 8. Authorized Agent's Name and Title. Indicate name of individual or agency, designated by you, to represent you in this process. An agent can be an attorney, builder, contractor, engineer, or any other person or organization. Note: An agent is not required.

Blocks 9 and 10. Agent's Address and Telephone Number. Please provide the complete mailing address of the agent, along with the telephone number where he / she can be reached during normal business hours.

Block 11. Statement of Authorization. To be completed by applicant, if an agent is to be employed.

Block 12. Proposed Project Name or Title. Please provide name identifying the proposed project, e.g., Landmark Plaza, Burned Hills Subdivision, or Edsall Commercial Center.

Block 13. Name of Waterbody. Please provide the name of any stream, lake, marsh, or other waterway to be directly impacted by the activity. If it is a minor (no name) stream, identify the waterbody the minor stream enters.

Block 14. Proposed Project Street Address. If the proposed project is located at a site having a street address (not a box number), please enter it here.

Block 15. Location of Proposed Project. Enter the latitude and longitude of where the proposed project is located. If more space is required, please attach a sheet with the necessary information marked Block 15.

Block 16. Other Location Descriptions. If available, provide the Tax Parcel Identification number of the site, Section, Township, and Range of the site (if known), and / or local Municipality that the site is located in.

Block 17. Directions to the Site. Provide directions to the site from a known location or landmark. Include highway and street numbers as well as names. Also provide distances from known locations and any other information that would assist in locating the site. You may also provide description of the proposed project location, such as lot numbers, tract numbers, or you may choose to locate the proposed project site from a known point (such as the right descending bank of Smith Creek, one mile downstream from the Highway 14 bridge). If a large river or stream, include the river mile of the proposed project site if known

Block 18. Nature of Activity. Describe the overall activity or project. Give appropriate dimensions of structures such as wing walls, dikes (identify the materials to be used in construction, as well as the methods by which the work is to be done), or excavations (length, width, and height). Indicate whether discharge of dredged or fill material is involved. Also, identify any structure to be constructed on a fill, piles, or float-supported platforms.

The written descriptions and illustrations are an important part of the application. Please describe, in detail, what you wish to do. If more space is needed, attach an extra sheet of paper marked Block 18.

Block 19. Proposed Project Purpose. Describe the purpose and need for the proposed project. What will it be used for and why? Also include a brief description of any related activities to be developed as the result of the proposed project. Give the approximate dates you plan to both begin and complete all work.

Block 20. Reasons for Discharge. If the activity involves the discharge of dredged and/or fill material into a wetland or other waterbody, including the temporary placement of material, explain the specific purpose of the placement of the material (such as erosion control).

Block 21. Types of Material Being Discharged and the Amount of Each Type in Cubic Yards. Describe the material to be discharged and amount of each material to be discharged within Corps jurisdiction. Please be sure this description will agree with your illustrations. Discharge material includes: rock, sand, clay, concrete, etc.

Block 22. Surface Areas of Wetlands or Other Waters Filled. Describe the area to be filled at each location. Specifically identify the surface areas, or part thereof, to be filled. Also include the means by which the discharge is to be done (backhoe, dragline, etc.). If dredged material is to be discharged on an upland site, identify the site and the steps to be taken (if necessary) to prevent runoff from the dredged material back into a waterbody. If more space is needed, attach an extra sheet of paper marked Block 22.

Block 23. Description of Avoidance, Minimization, and Compensation. Provide a brief explanation describing how impacts to waters of the United States are being avoided and minimized on the project site. Also provide a brief description of how impacts to waters of the United States will be compensated for, or a brief statement explaining why compensatory mitigation should not be required for those impacts.

Block 24. Is Any Portion of the Work Already Complete? Provide any background on any part of the proposed project already completed. Describe the area already developed, structures completed, any dredged or fill material already discharged, the type of material, volume in cubic yards, acres filled, if a wetland or other waterbody (in acres or square feet). If the work was done under an existing Corps permit, identity the authorization, if possible.

Block 25. Names and Addresses of Adjoining Property Owners, Lessees, etc., Whose Property Adjoins the Project Site. List complete names and full mailing addresses of the adjacent property owners (public and private) lessees, etc., whose property adjoins the waterbody or aquatic site where the work is being proposed so that they may be notified of the proposed activity (usually by public notice). If more space is needed, attach an extra sheet of paper marked Block 24.

Information regarding adjacent landowners is usually available through the office of the tax assessor in the county or counties where the project is to be developed.

Block 26. Information about Approvals or Denials by Other Agencies. You may need the approval of other federal, state, or local agencies for your project. Identify any applications you have submitted and the status, if any (approved or denied) of each application. You need not have obtained all other permits before applying for a Corps permit.

Block 27. Signature of Applicant or Agent. The application must be signed by the owner or other authorized party (agent). This signature shall be an affirmation that the party applying for the permit possesses the requisite property rights to undertake the activity applied for (including compliance with special conditions, mitigation, etc.).

DRAWINGS AND ILLUSTRATIONS

General Information.

Three types of illustrations are needed to properly depict the work to be undertaken. These illustrations or drawings are identified as a Vicinity Map, a Plan View or a Typical Cross-Section Map. Identify each illustration with a figure or attachment number.

Please submit one original, or good quality copy, of all drawings on 8½ x11 inch plain white paper (electronic media may be substituted). Use the fewest number of sheets necessary for your drawings or illustrations.

Each illustration should identify the project, the applicant, and the type of illustration (vicinity map, plan view, or cross-section). **While illustrations need not be professional (many small, private project illustrations are prepared by hand), they should be clear, accurate, and contain all necessary information.**

APPLICATION FOR DEPARTMENT OF THE ARMY PERMIT *(33 CFR 325)*	OMB APPROVAL NO. 0710-0003 EXPIRES: 31 August 2012

Public reporting burden for this collection of information is estimated to average 11 hours per response, including the time for reviewing instructions, searching existing data sources, gathering and maintaining the data needed, and completing and reviewing the collection of information. Send comments regarding this burden estimate or any other aspect of this collection of information, including suggestions for reducing this burden, to Department of Defense, Washington Headquarters, Executive Services and Communications Directorate, Information Management Division and to the Office of Management and Budget, Paperwork Reduction Project (0710-0003). Respondents should be aware that notwithstanding any other provision of law, no person shall be subject to any penalty for failing to comply with a collection of information if it does not display a currently valid OMB control number. Please DO NOT RETURN your form to either of those addresses. Completed applications must be submitted to the District Engineer having jurisdiction over the location of the proposed activity.

PRIVACY ACT STATEMENT

Authorities: Rivers and Harbors Act, Section 10, 33 USC 403; Clean Water Act, Section 404, 33 USC 1344; Marine Protection, Research, and Sanctuaries Act, Section 103, 33 USC 1413; Regulatory Programs of the Corps of Engineers; Final Rule 33 CFR 320-332. Principal Purpose: Information provided on this form will be used in evaluating the application for a permit. Routine Uses: This Information may be shared with the Department of Justice and other federal, state, and local government agencies, and the public and may be made available as part of a public notice as required by Federal law. Submission of requested information is voluntary, however, if information is not provided the permit application cannot be evaluated nor can a permit be issued. One set of original drawings or good reproducible copies which show the location and character of the proposed activity must be attached to this application (see sample drawings and instructions) and be submitted to the District Engineer having jurisdiction over the location of the proposed activity. An application that is not completed in full will be returned.

(ITEMS 1 THRU 4 TO BE FILLED BY THE CORPS)

1. APPLICATION NO.	2. FIELD OFFICE CODE	3. DATE RECEIVED	4. DATE APPLICATION COMPLETE

(ITEMS BELOW TO BE FILLED BY APPLICANT)

5. APPLICANT'S NAME: First - Middle - Last – Company – E-mail Address –	8. AUTHORIZED AGENT'S NAME AND TITLE (an agent is not required) First - Middle - Last – Company – E-mail Address –
6. APPLICANT'S ADDRESS. Address - City – State – Zip – Country –	9. AGENT'S ADDRESS Address - City – State – Zip – Country –
7. APPLICANT'S PHONE NOs. W/AREA CODE. a. Residence b. Business c. Fax	10. AGENT'S PHONE NOs. W/AREA CODE a. Residence b. Business c. Fax

STATEMENT OF AUTHORIZATION

11. I hereby authorize, _____ to act in my behalf as my agent in the processing of this application and to furnish, upon request, supplemental information in support of this permit application.

_____
APPLICANT'S SIGNATURE DATE

NAME, LOCATION, AND DESCRIPTION OF PROJECT OR ACTIVITY

12. PROJECT NAME OR TITLE (see instructions)

13. NAME OF WATERBODY, IF KNOWN (if applicable)	14. PROJECT STREET ADDRESS (if applicable) Address
15. LOCATION OF PROJECT Latitude: °N Longitude: °W	City - State – Zip -

16. OTHER LOCATION DESCRIPTIONS, IF KNOWN (see instructions)
State Tax Parcel ID Municipality
Section – Township – Range –

17. DIRECTIONS TO THE SITE

18. Nature of Activity (Description of project, include all features)

19. Project Purpose (Describe the reason or purpose of the project, see instructions)

USE BLOCKS 20-23 IF DREDGED AND/OR FILL MATERIAL IS TO BE DISCHARGED

20. Reason(s) for Discharge

21. Type(s) of Material Being Discharged and the Amount of Each Type in Cubic Yards:

Type Amount in Cubic Yards	Type Amount in Cubic Yards	Type Amount in Cubic Yards

22. Surface Area in Acres of Wetlands or Other Waters Filled (see instructions)

Acres

Or

Liner Feet

23. Description of Avoidance, Minimization, and Compensation (see instructions)

24. Is Any Portion of the Work Already Complete? Yes ☐ No ☐ IF YES, DESCRIBE THE COMPLETED WORK

25. Addresses of Adjoining Property Owners, Lessees, Etc., Whose Property Adjoins the Waterbody (If more than can be entered here, please attach a supplemental list).

Address –

City – State – Zip –

26. List of Other Certifications or Approvals/Denials Received from other Federal, State, or Local Agencies for Work Described in This Application.

AGENCY	TYPE APPROVAL*	IDENTIFICATION NUMBER	DATE APPLIED	DATE APPROVED	DATE DENIED

* Would include but is not restricted to zoning, building, and flood plain permits

27. Application is hereby made for a permit or permits to authorize the work described in this application. I certify that the information in this application is complete and accurate. I further certify that I possess the authority to undertake the work described herein or am acting as the duly authorized agent of the applicant.

SIGNATURE OF APPLICANT _____ DATE _____ SIGNATURE OF AGENT _____ DATE _____

The application must be signed by the person who desires to undertake the proposed activity (applicant) or it may be signed by a duly authorized agent if the statement in block 11 has been filled out and signed.

18 U.S.C. Section 1001 provides that: Whoever, in any manner within the jurisdiction of any department or agency of the United States knowingly and willfully falsifies, conceals, or covers up any trick, scheme, or disguises a material fact or makes any false, fictitious or fraudulent statements or representations or makes or uses any false writing or document knowing same to contain any false, fictitious or fraudulent statements or entry, shall be fined not more than $10,000 or imprisoned not more than five years or both.

NORTH DAKOTA
DEPARTMENT of HEALTH

ENVIRONMENTAL HEALTH SECTION
Gold Seal Center, 918 E. Divide Ave.
Bismarck, ND 58501-1947
701.328.5200 (fax)
www.ndhealth.gov

Construction and Environmental Disturbance Requirements

These represent the minimum requirements of the North Dakota Department of Health. They ensure that minimal environmental degradation occurs as a result of construction or related work which has the potential to affect the waters of the State of North Dakota. All projects will be designed and implemented to restrict the losses or disturbances of soil, vegetative cover, and pollutants (chemical or biological) from a site.

Soils

Prevent the erosion of exposed soil surfaces and trapping sediments being transported. Examples include, but are not restricted to, sediment dams or berms, diversion dikes, hay bales as erosion checks, riprap, mesh or burlap blankets to hold soil during construction, and immediately establishing vegetative cover on disturbed areas after construction is completed. Fragile and sensitive areas such as wetlands, riparian zones, delicate flora, or land resources will be protected against compaction, vegetation loss, and unnecessary damage.

Surface Waters

All construction which directly or indirectly impacts aquatic systems will be managed to minimize impacts. All attempts will be made to prevent the contamination of water at construction sites from fuel spillage, lubricants, and chemicals, by following safe storage and handling procedures. Stream bank and stream bed disturbances will be controlled to minimize and/or prevent silt movement, nutrient upsurges, plant dislocation, and any physical, chemical, or biological disruption. The use of pesticides or herbicides in or near these systems is forbidden without approval from this Department.

Fill Material

Any fill material placed below the high water mark must be free of top soils, decomposable materials, and persistent synthetic organic compounds (in toxic concentrations). This includes, but is not limited to, asphalt, tires, treated lumber, and construction debris. The Department may require testing of fill materials. All temporary fills must be removed. Debris and solid wastes will be removed from the site and the impacted areas restored as nearly as possible to the original condition.

NORTH DAKOTA
DEPARTMENT of HEALTH

ENVIRONMENTAL HEALTH SECTION
Gold Seal Center, 918 E. Divide Ave.
Bismarck, ND 58501-1947
701.328.5200 (fax)
www.ndhealth.gov

June 22, 2011

Mr. Gregory Liebelt
Environmental Protection Specialist
Western Area Power Administration
P.O. Box 145
Fort Peck. MT 59223

Re: MWEC Williston to Bear Paw Gas Plant 115 kV Transmission Line Project
Williams County, North Dakota

Dear Mr. Liebelt:

This department has reviewed the information concerning the above-referenced project submitted under date of June 17, 2011, with respect to possible environmental impacts.

This department believes that environmental impacts from the proposed construction will be minor and can be controlled by proper construction methods. With respect to construction, we have the following comments:

1. All necessary measures must be taken to minimize fugitive dust emissions created during construction activities. Any complaints that may arise are to be dealt with in an efficient and effective manner.

2. Care is to be taken during construction activity near any water of the state to minimize adverse effects on a water body. This includes minimal disturbance of stream beds and banks to prevent excess siltation, and the replacement and revegetation of any disturbed area as soon as possible after work has been completed. Caution must also be taken to prevent spills of oil and grease that may reach the receiving water from equipment maintenance, and/or the handling of fuels on the site. Guidelines for minimizing degradation to waterways during construction are attached.

3. Noise from construction activities may have adverse effects on persons who live near the construction area. Noise levels can be minimized by ensuring that construction equipment is equipped with a recommended muffler in good working order. Noise effects can also be minimized by ensuring that construction activities are not conducted during early morning or late evening hours.

The department owns no land in or adjacent to the proposed improvements, nor does it have any projects scheduled in the area. In addition, we believe the proposed activities are consistent with the State Implementation Plan for the Control of Air Pollution for the State of North Dakota.

These comments are based on the information provided about the project in the above-referenced submittal. The U.S. Army Corps of Engineers may require a water quality certification from this department for the project if the project is subject to their Section 404 permitting process. Any additional information which may be required by the U.S. Army Corps of Engineers under the process will be considered by this department in our determination regarding the issuance of such a certification.

If you have any questions regarding our comments, please feel free to contact this office.

Sincerely,

L. David Glatt, P.E., Chief
Environmental Health Section

LDG:cc
Attach.

NORTH DAKOTA
DEPARTMENT of HEALTH

ENVIRONMENTAL HEALTH SECTION
Gold Seal Center, 918 E. Divide Ave.
Bismarck, ND 58501-1947
701.328.5200 (fax)
www.ndhealth.gov

Construction and Environmental Disturbance Requirements

These represent the minimum requirements of the North Dakota Department of Health. They ensure that minimal environmental degradation occurs as a result of construction or related work which has the potential to affect the waters of the State of North Dakota. All projects will be designed and implemented to restrict the losses or disturbances of soil, vegetative cover, and pollutants (chemical or biological) from a site.

Soils

Prevent the erosion of exposed soil surfaces and trapping sediments being transported. Examples include, but are not restricted to, sediment dams or berms, diversion dikes, hay bales as erosion checks, riprap, mesh or burlap blankets to hold soil during construction, and immediately establishing vegetative cover on disturbed areas after construction is completed. Fragile and sensitive areas such as wetlands, riparian zones, delicate flora, or land resources will be protected against compaction, vegetation loss, and unnecessary damage.

Surface Waters

All construction which directly or indirectly impacts aquatic systems will be managed to minimize impacts. All attempts will be made to prevent the contamination of water at construction sites from fuel spillage, lubricants, and chemicals, by following safe storage and handling procedures. Stream bank and stream bed disturbances will be controlled to minimize and/or prevent silt movement, nutrient upsurges, plant dislocation, and any physical, chemical, or biological disruption. The use of pesticides or herbicides in or near these systems is forbidden without approval from this Department.

Fill Material

Any fill material placed below the high water mark must be free of top soils, decomposable materials, and persistent synthetic organic compounds (in toxic concentrations). This includes, but is not limited to, asphalt, tires, treated lumber, and construction debris. The Department may require testing of fill materials. All temporary fills must be removed. Debris and solid wastes will be removed from the site and the impacted areas restored as nearly as possible to the original condition.

"VARIETY IN HUNTING AND FISHING"

NORTH DAKOTA GAME AND FISH DEPARTMENT

100 NORTH BISMARCK EXPRESSWAY BISMARCK, NORTH DAKOTA 58501-5095 PHONE 701-328-6300 FAX 701-328-6352

June 30, 2011

Gregory Liebelt
Environmental Protection Specialist
Western Area Power Administration
P.O. Box 145
Fort Peck, MT 59223

Dear Mr. Liebelt:

RE: Mountrail Williams Electric Cooperative - 115-kV Transmission Line
Williston Substation to Bear Paw Gas Plant
Williams County, North Dakota

The North Dakota Game and Fish Department has reviewed this project for wildlife concerns.

Our primary concern is the possible disturbance of native prairie and wetland areas during construction of the transmission line. We ask that work within these areas be avoided to the extent possible, above-ground appurtenances not be placed in wetland areas, and disturbed areas be reclaimed to pre-project conditions.

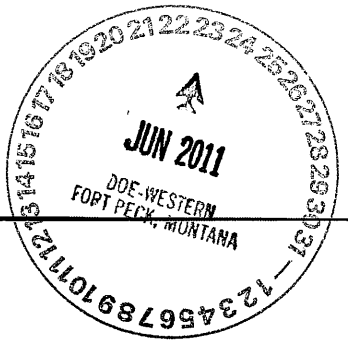
We would appreciate a copy of the Draft Environmental Assessment when it becomes available.

Sincerely,

(for) Paul Schadewald
Chief
Conservation & Communication Division

js

STATE HISTORICAL SOCIETY OF NORTH DAKOTA



June 21, 2011

Mr. Gregory Leibelt
Environmental Protection Specialist
WAPA
PO Box 145
Fort Peck MT 59223

ND SHPO Ref.: 11-1758 WAPA/Mountrail Williams Electric Cooperative new 115kV Transmission line from WAPA Williston substation to the Bear Paw Gas Plant in portions of Williams County, North Dakota

Dear Mr. Leibelt,

We received your Public Notice letter dated June 17, 2011 and recommend a Cultural Resources Inventory at the Class I (file search), Class II (reconnaissance or driving) and Class III (pedestrian) levels of the APE (Area of Potential Effect).

Thank you for the opportunity to review this project to date. We look forward to review of the Cultural Resources Inventory before any ground disturbance takes effect. Please include the ND SHPO reference number listed above in further correspondence for this specific project. If you have any questions, please contact Susan Quinnell at 701-328-3576, or squinnell@nd.gov

Sincerely,

Merlan E. Paaverud, Jr.
State Historic Preservation Officer (North Dakota)

STATE HISTORICAL SOCIETY OF NORTH DAKOTA

September 2, 2011

Mr. David W. Kluth
Regional Preservation Officer
WAPA
South Dakota Maintenance Office
200 4th Street SW
Huron SD 57350-2474

ND SHPO Ref.: 11-1758 WAPA/Mountrail Williams Electric Cooperative new 115kV Transmission line from WAPA Williston substation to the Bear Paw Gas Plant in portions of Williams County, North Dakota

Dear Mr. Kluth,

We received your letter dated August 26, 2011, 2011 and recommend a Cultural Resources Inventory at the Class I (file search), Class II (reconnaissance or driving) and Class III (pedestrian) levels of the APE (Area of Potential Effect).

Thank you for the opportunity to review this project to date. We look forward to review of the Cultural Resources Inventory before any ground disturbance takes effect. Please include the ND SHPO reference number listed above in further correspondence for this specific project. If you have any questions, please contact Susan Quinnell at 701-328-3576, or squinnell@nd.gov

Sincerely,

Merlan E. Paaverud, Jr.
State Historic Preservation Officer (North Dakota)

North Dakota Heritage Center • 612 East Boulevard Avenue, Bismarck, ND 58505-0830 • Phone: 701-328-2666 • Fax: 701-328-3710
Email: histsoc@nd.gov • Web site: http://history.nd.gov • TTY: 1-800-366-6888

United States Department of the Interior

FISH AND WILDLIFE SERVICE
Ecological Services
3425 Miriam Avenue
Bismarck, North Dakota 58501

AUG - 3 2011

Mr. Gregory Liebelt
Environmental Protection Specialist
Western Area Power Administration
P.O. Box 145
Fort Peck, Montana 59223

Re: Mountrail Williams Electric Cooperative 115 kV Transmission Line near Williston, North Dakota

Dear Mr. Liebelt:

The U.S. Fish and Wildlife Service (Service) has reviewed Mountrail Williams Electric Cooperative's (MWEC) proposed new overhead 115-kilovolt (kV) transmission line, described in a letter we received July 15, 2011. The proposed project would occur in Williams County. The new transmission line would connect the Bear Paw Gas Plant to an existing Western Area Power Administration (Western) Williston substation, a distance of approximately 16 miles. We offer the following comments under the authority of and in accordance with Endangered Species Act (16 U.S.C. 1531 et seq.) (ESA), the Migratory Bird Treaty Act (16 U.S.C. 703 et seq.) (MBTA), the Bald and Golden Eagle Protection Act (16 U.S.C. 668-668d, 54 Stat. 250) (BGEPA), the the National Environmental Policy Act (42 U.S.C. 4321 et seq.) (NEPA), and in accordance with Executive Order 11990 "Protection of Wetlands" (E.O. 11990) and Executive Order 13186 "Responsibilities of Federal Agencies to Protect Migratory Birds" (E.O. 13186).]

Threatened, Endangered and Candidate Species

If a Federal agency authorizes, funds, or carries out a proposed action, the responsible Federal agency, or its designated agent, is required to evaluate whether the action "may affect" listed species and critical habitat. If the Federal agency determines the action "may affect, is likely to adversely affect" listed species and/or critical habitat, then the responsible Federal agency shall request formal section 7 consultation with this office, or work with this office to remove the likely adverse effects before proceeding. If the evaluation shows a "no effect" determination on listed species or critical habitat, further consultation is not necessary. If a non-Federal entity receives Federal funding for an activity, or if a Federal permit or license is required, the Federal funding, licensing, or permitting agency may designate in writing the fund recipient or permittee as its agent for purposes of informal section 7 consultation. The Federal action agency is

responsible to ensure that its actions comply with the ESA, including obtaining concurrence from the Service for any action that may affect a threatened or endangered species or designated critical habitat prior to carrying out the activity, funding, permitting or licensing the activity.

A list of federally listed endangered and threatened species that may be present within the proposed project's area of influence is enclosed. This list fulfills requirements of the Service under Section 7 of the Endangered Species Act. This list remains valid for 90 days.

The Aransas Wood Buffalo Population (AWBP) of the whooping crane is the only self-sustaining migratory population of whooping cranes remaining in the wild. These birds breed in the wetlands of Wood Buffalo National Park in Alberta and the Northwest Territories of northern Canada, and overwinter on the Texas Gulf Coast. Whooping cranes in the AWBP annually migrate through North Dakota during their spring and fall migrations. Currently, collisions with power lines are the greatest known source of mortality for fledged whooping cranes, and have accounted for the death or serious injury of at least 46 whooping cranes since 1956.

Whooping cranes normally migrate from 1,000 to 6,000 feet above the ground (Kuyt 1992) and well above the height of power lines, but stop every night to roost in shallow wetlands (Howe 1989). Potentially suitable migratory stopover roosting habitat for whooping cranes includes wetlands with areas of shallow water (approximately 18 inches or less) without visual obstructions (i.e., high or dense vegetation) (Austin and Richert 2001; Johns et al. 1997; Lingle et al. 1991; Howe 1987) and submerged sandbars in wide, unobstructed river channels that are isolated from human disturbance (Armbruster 1990). Roosting wetlands are often located within 1 mile of grain fields.

The proposed project area is located within the whooping crane migration corridor that includes 95% of all confirmed whooping crane sightings in North Dakota (enclosure). Conservation measures to avoid or reduce potential impacts to whooping cranes include, but are not limited to: burying all new electrical transmission lines; if new transmission lines cannot be buried, mark all new overhead transmission lines within 1 mile of suitable whooping crane stopover habitat with visual marking devices such as aviation marker balls, swinging plates, spiral vibration dampeners, or swan flight diverters to make the lines more visible, reducing the potential for avian collision. However, marking devices only reduce the risk of a whooping crane strike by between 50 and 80 percent (Morkill and Anderson 1990). To further reduce the increased risk of a strike from proposed new overhead lines, additional existing lines will need to be marked. The Service suggests that in addition to marking the new line, an equal amount of existing line be marked within 1 mile of suitable wetlands in the 95 percent migration corridor.

In addition to marking line, the Service requests that if a whooping crane is seen within 1 mile of a portion of the project under construction, construction be halted on that portion of the project and the Service be notified immediately. In consultation with the Service, work may resume once birds have left the area.

Sprague's pipit was added to the candidate species list in 2010. Migratory bird species such as the Sprague's pipit that are candidates are not protected under the ESA, but are still protected under the MBTA. Sprague's pipits require large patches of grassland habitat for breeding, with preferred grass height between 4 and 12 inches. The species prefers to breed in well-drained, open grasslands and avoids grasslands with excessive shrubs. They can be found in lightly-to-heavily grazed areas. They avoid intrusive human features on the landscape, so the impact of a development can be much larger than the actual footprint of the feature. If Sprague's pipit habitat is present within your proposed project area, the Service requests that you document any steps taken to avoid and minimize disturbance of this habitat, and that you share this information with our office.

For candidate species such as the Sprague's pipit, Federal agencies and non-Federal applicants have the option of requesting a conference with the Service to ensure that their actions minimize and mitigate effects to candidate species. Western has previously indicated that they wish to provide protection for the Sprague's pipit as if the species has been proposed for Federal listing.

Migratory Birds

The MBTA prohibits the taking, killing, possession, and transportation (among other actions) of migratory birds, their eggs, parts, and nests, except when specifically permitted by regulations. While the MBTA has no provision for allowing unauthorized take, the Service realizes that some birds may be killed during project construction and operation even if all known reasonable and effective measures to protect birds are used. The Service Office of Law Enforcement carries out its mission to protect migratory birds through investigations and enforcement, as well as by fostering relationships with individuals, companies, and industries that have taken effective steps to avoid take of migratory birds, and by encouraging others to implement measures to avoid take of migratory birds. It is not possible to absolve individuals, companies, or agencies from liability even if they implement bird mortality avoidance or other similar protective measures. However, the Office of Law Enforcement focuses its resources on investigating and prosecuting individuals and companies that take migratory birds without identifying and implementing all reasonable, prudent, and effective measures to avoid that take. Companies are encouraged to work closely with Service biologists to identify available protective measures when developing project plans and/or avian protection plans, and to implement those measures prior to/during construction or similar activities.

To the extent practicable, schedule construction for late summer or fall/early winter so as not to disrupt migratory birds during the breeding season (February 1 to July). If work is proposed to take place during the breeding season or at any other time which may result in the take of migratory birds, their eggs, or active nests, the Service recommends that the project proponent implement all practicable measures to avoid all take, such as suspending construction where necessary, and/or maintaining adequate buffers to protect the birds until the young have fledged. The Service further recommends that if you choose to conduct field surveys for nesting birds with the intent of avoiding take, that you maintain any documentation of the presence of

migratory birds, eggs, and active nests, along with information regarding the qualifications of the biologist(s) performing the survey(s), and any avoidance measures implemented at the project site. Should surveys or other available information indicate a potential for take of migratory birds, their eggs, or active nests, the Service requests that you contact this office for further coordination on the extent of the impact and the long-term implications of the intended use of the project on migratory bird populations. Marking lines to prevent whooping crane strikes would also protect other migratory and resident birds against line strikes.

Bald and Golden Eagles

The BGEPA prohibits anyone without a permit issued by the Secretary of the Interior from taking bald eagles, including their parts, nests, or eggs. The Act provides criminal and civil penalties for persons who take, possess, sell, purchase, barter, offer to sell, purchase or barter, transport, export or import, at any time or any manner, any bald or golden eagle, alive or dead, or any part, nest, or egg thereof. The Act defines take as pursue, shoot, shoot at, poison, wound, kill, capture, trap, collect, molest or disturb. "Disturb means to agitate or bother a bald or golden eagle to a degree that causes, or is likely to cause, based on the best scientific information available, 1) injury to an eagle, 2) a decrease in its productivity, by substantially interfering with normal breeding, feeding, or sheltering behavior, or 3) nest abandonment, by substantially interfering with normal breeding, feeding, or sheltering behavior." In addition to immediate impacts, this definition also covers impacts that result from human-induced alterations initiated around a previously used nest site during a time when eagles are not present, if, upon the eagles return, such alterations agitate or bother an eagle to a degree that injures an eagle or substantially interferes with normal breeding, feeding, or sheltering habits and causes, or is likely to cause, a loss of productivity or nest abandonment.

The Service recommends surveying ½ mile out from the proposed project areas to determine the presence of any eagle nests. If an eagle nest is observed within ½ mile of the proposed project areas, the Service requests that the location be documented and the Service be contacted for further coordination.

Executive Order 11990

Our review of the National Wetland Inventory (NWI) maps and photographs indicate the proposed planning area includes several wetland basins. You may access the NWI data directly through their website (wetlands.fws.gov). Wetland impacts can be avoided by spanning them so that poles are placed in the upland habitat.

High Value Habitat Avoidance

- Avoid construction in native prairie, if possible, and reseed disturbed native prairie with a comparable native grass/forb seed mixture. The Service recommends planting a diverse mixture of native cool and warm season grasses and forbs. Recent research has

suggested that a more diverse mix, including numerous forb species, is not only ecologically beneficial but is also more weed resistant, allowing for less intensive management and chemical use. In essence, the more species included in a mixture, the higher the probability of providing competition to resist invasion by non-native plants. The seed source should be as local as possible, preferably collected from the nearby native prairie. Obtain seed stock from nurseries within 250 miles of the project area to ensure the particular cultivars are well adapted to the local climate. The Natural Resources Conservation Service (NRCS) compiles a list of vendors in North Dakota that supply conservation seed and plants (http://www.plant-materials.nrcs.usda.gov/pubs/ndpmcmt8152.pdf). Additional information on native grasses and forbs may be found at the NRCS Bismarck Plant Materials Center (http://www.plant-materials.nrcs.usda.gov/ndpmc/).

- Make no changes in drainage patterns.

- Install and maintain appropriate erosion control measures to reduce sediment transport to adjacent wetlands and stream channels.

Thank you for the opportunity to comment on this project. If additional information is required, please have your staff contact Carol Aron of my staff, or contact me directly at (701) 250-4481 or at the letterhead address.

Sincerely,

Jeffrey K. Towner

Jeffrey K. Towner
Field Supervisor
North Dakota Field Office

Enclosures

FEDERAL THREATENED, ENDANGERED, AND CANDIDATE SPECIES AND DESIGNATED CRITICAL HABITAT FOUND IN WILLIAMS COUNTY, NORTH DAKOTA

ENDANGERED SPECIES

Birds

Interior least tern (Sterna antillarum): Nests along midstream sandbars of the Missouri and Yellowstone Rivers.

Whooping crane (Grus Americana): Aransas-Wood Buffalo Population (264 birds) occurs in North Dakota counties during spring and fall migration between breeding and wintering areas. Whooping cranes prefer to roost overnight in shallow open water wetland habitat with good visibility during migration stopovers.

Fish

Pallid sturgeon (Scaphirhynchus albus): Known only from the Missouri and Yellowstone Rivers. No reproduction has been documented in 15 years.

Mammals

Gray wolf (Canis lupus): Occasional visitor in North Dakota. Most frequently observed in the Turtle Mountains area.

THREATENED SPECIES

Birds

Piping plover (Charadrius melodus): Nests on midstream sandbars of the Missouri and Yellowstone Rivers and along shorelines of saline wetlands. More nest in North Dakota than any other state.

CANDIDATE SPECIES

Birds

Sprague's Pipit (Anthus spragueii): Nests in native and planted grassland. Prefers patches of grassland at least 72 acres (29 hectares).

DESIGNATED CRITICAL HABITAT

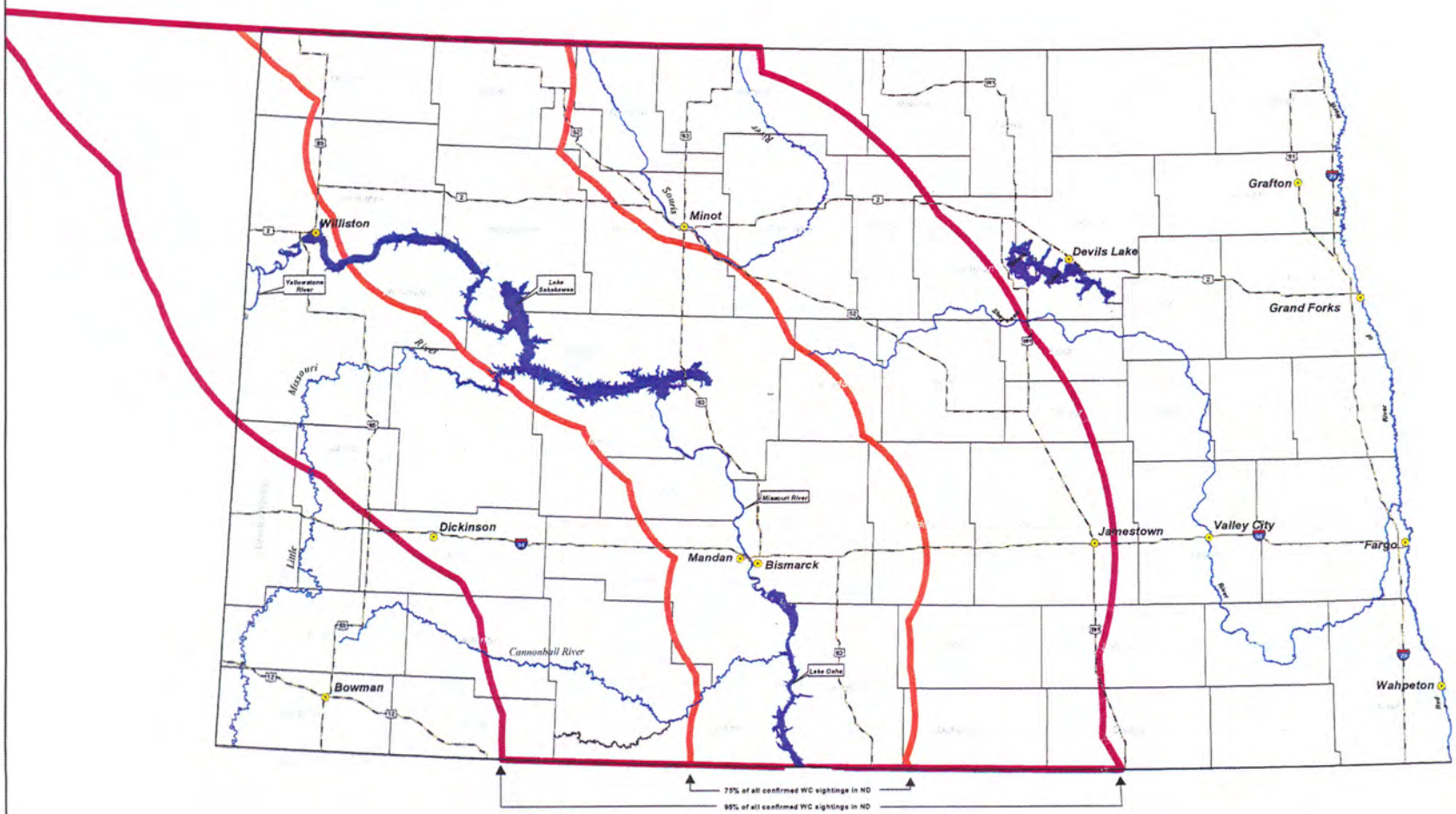
Birds

Piping Plover - Alkali Lakes and Wetlands - Critical habitat includes: (1) shallow, seasonally to permanently flooded, mixosaline to hypersaline wetlands with sandy to gravelly, sparsely vegetated beaches, salt-encrusted mud flats, and/or gravelly salt flats; (2) springs and fens along edges of alkali lakes and wetlands; and (3) adjacent uplands 200 feet (61 meters) above the high water mark of the alkali lake or wetland.

Piping Plover - Missouri River - Critical habitat includes sparsely vegetated channel sandbars, sand and gravel beaches on islands, temporary pools on sandbars and islands, and the interface with the river.

Piping Plover - Lake Sakakawea and Oahe - Critical habitat includes sparsely vegetated shoreline beaches, peninsulas, islands composed of sand, gravel, or shale, and their interface with the water bodies.

North Dakota
Whooping Crane Migration Corridor



75% Whooping Crane Migration Corridor

95% Whooping Crane Migration Corridor

0 12.5 25 50 75 100 Miles

DISCLAIMER:

The USFWS makes no claim as to the accuracy or completeness of the displayed information. Species occurrence and habitat information is provided for illustrative purposes only. Federal action agencies and project proponents should contact the USFWS North Dakota Field Office for more detailed species information and technical assistance in evaluating potential project impacts to fish and wildlife resources.

Map produced 04/21/2010 by USFWS Ecological Services, Bismarck, ND.

Schneider, Karen

To: Lutz-Zimmerman, Laura R.
Subject: RE: Williston to Stateline Natural Heritage Database Search

AMServiceURLStr: https://Slingshot.hdrinc.com/CFSS/control?view=services/FTService

---

From: Chris Brostuen [mailto:brostuen@mwec.com]
Sent: Monday, July 18, 2011 12:45 PM
To: kgduttenhefner@nd.gov
Cc: Lutz-Zimmerman, Laura R.
Subject: FW: Williston to Stateline Natural Heritage Database Search

Ms. Duttenhefner:

Mountrail Williams Electric Cooperative (MWEC) is preparing an environmental assessment for an approximate 16-mile transmission line near Williston ND. The transmission line would start at the Williston substation and connect to the Bear Paw Gas plant that is currently under construction. I would like to request a natural heritage inventory database search of the transmission line project area. I have attached a shapefile of the proposed transmission line right-of-way for your use in completing the search. The coordinate system for the shapefile is North Dakota State Plane, zone 3301. I understand that I can receive the data in an electronic format. Please provide me the necessary data agreement form to receive the data in an electronic format.

If you have any questions, please contact me using the contact information below or contact Laura Lutz-Zimmerman of HDR Engineering, our consultant hired to complete the EA. Her contact information is 303-318-6344 or laura.lutz-zimmerman@hdrinc.com

Thank you.
Chris J. Brostuen
Assistant General Manager
Mountrail-Williams Electric Cooperative
PO Box 1346
Williston, ND 58802-1346
701.577.3765 (Office)
701.770.0773 (Cell)
701.577.3777 (Fax)
Email: brostuen@mwec.com

Jack Dalrymple, Governor
Mark A. Zimmerman, Director

1600 East Century Avenue, Suite 3
Bismarck, ND 58503-0649
Phone 701-328-5357
Fax 701-328-5363
E-mail parkrec@nd.gov
www.parkrec.nd.gov

August 17, 2011

Laura R. Lutz-Zimmerman
HDR Engineering, Inc.
303 E. 17th Ave., Suite 700
Denver, CO 80203

Re: Williston to State Line Transmission Line

Dear Ms. Lutz-Zimmerman:

Thank you for your interest in the Department's Natural Heritage Inventory biological conservation database. The Department did not conduct an environmental review for this particular project site but only conducted a search in our database which includes data only for species of concern and significant ecological communities. Other lands and projects that are owned or managed by the ND Parks & Recreation Department were not included in this search such as: state parks, state nature preserves, Land and Water Conservation Fund projects, Recreational Trails Program projects, and Scenic Byways and Backways.

The North Dakota Natural Heritage biological conservation database has been reviewed to determine if any current or historical plant or animal species of concern or other significant ecological communities are known to occur within an approximate one-mile radius of the project area. Based on this review, there are no known occurrences within or adjacent to the project area.

Because this information is not based on a comprehensive inventory, there may be species of concern or otherwise significant ecological communities in the area that are not represented in the database. The lack of data for any project area cannot be construed to mean that no significant features are present. The absence of data may indicate that the project area has not been surveyed, rather than confirm that the area lacks natural heritage resources. We recommend also contacting the North Dakota Game and Fish Department and the United States Fish and Wildlife Service regarding animal species.

The ND Parks & Recreation Department would appreciate being consulted during the public scoping and/or environmental assessment phase of the project.

Thank you for the opportunity to provide preliminary data for the project site. Please contact me if additional information is needed.

Sincerely,

Kathy Duttenhefner
Coordinator/Biologist
Natural Resource Program
Natural Areas Registry/Natural Heritage Inventory
701-328-5370 (office)
701-220-3377 (cell)
kgduttenhefner@nd.gov

R.USNDNHI*R11-10

B0401.BL

AUG 1 6 2011

Mr. Morris Belgard
Cultural Resource Liason
Fort Belknap Indian Community
R.R. 1 Box 66
Harlem, MT 59526

Dear Mr. Belgard:

Western Area Power Administration (Western), a power-marketing agency with the Department of Energy, has received a request from Mountrail-Williams Electric Cooperative (MWEC) to interconnect a newly proposed 115-kilovolt (kV) transmission line in Williams County, North Dakota, into Western's transmission system (Project). The new transmission line would connect to Western's existing Williston Substation and extend approximately 16 miles to the Bear Paw Gas Plant. The new transmission line would be located north of U.S. Highway 2.

The purpose of this letter is to inform you of this proposed Project, provide notice that Western will prepare an Environmental Assessment (EA) for the proposed Project unless the need for an Environmental Impact Study (EIS) develops, initiate government-to-government consultation, and invite your participation in the environmental review and National Historic Preservation Act Section 106 consultation process. The information presented in this letter includes a brief Project description and map. Additional information will continue to be provided to you and designated tribal departments or staff as it becomes available.

The transmission line is being proposed in order to serve growth associated with oil and gas developments in this area, particularly the load associated with the gas plant. MWEC has evaluated multiple transmission line routes. The new transmission line would ensure that the area has adequate infrastructure to accommodate growth and provide system reliability.

The proposed Project would consist of single wood pole structures placed about 300 to 400 feet apart, depending on underbuild of the existing distribution lines. Near the substation, single steel pole structures may be used to allow farther spacing between structures and accommodate potential future growth. The standard right-of-way width for a single pole 115-kV transmission line would be 100 feet. The height of the new structures would vary from 75 feet above ground to 100 feet above ground, depending on terrain and structure type.

An interconnection with Western is considered a "major Federal action" under the regulations of the National Environmental Policy Act. It is our understanding that there may be important cultural and natural resources, and/or places with traditional cultural significance for your Tribe within the area that may be impacted by the proposed Project. At this time, we would appreciate receiving any information you would be willing to share with us on any unique, special, ethnographic, or archaeological resources or areas in or near the proposed Project.

For questions related to the Project, please contact Western's staff Steve Tromly toll-free at (800) 366-7549, or Greg Liebelt at (406) 526-8515. Steve Tromly's e-mail is tromly@wapa.gov and Greg Liebelt's e-mail is liebelt@wapa.gov.

I am looking forward to working with you as this process moves forward.

Sincerely,

/S/ Matt Marsh

for Nicholas J. Stas
Environmental Manager

Enclosure

bcc:
S. Tromly, A7400, Lakewood, CO
D. Kluth, B0411.HU, Huron, SD
G. Liebelt, B0430.FP, Fort Peck, MT
B0401.BL

B0401.BL:mm:db:8/16/11:R:\Groups\Environmental\Letters to Customers\Final Williston to Stateline Tribal Consult.docx

Tribal Consultation

FT BELKNAP INDIAN COMMUNITY

Morris Belgard
Cultural Resource Liaison
R.R. 1 Box 66
Fort Belknap Agency
Harlem, MT 59526
406-353-8433
mbelgarde@yahoo.com

NORTHERN CHEYENNE TRIBE:

Mr. Eugene Littlecoyote, President (Send original here, certified mail)
Northern Cheyenne Tribal Council
P.O. Box 128
Lame Deer, MT 59043
(406) 477-6284

cc:

Mr. Conrad Fisher
Tribal Historic Preservation Officer
P.O. Box 128
Lame Dear, MT 59043
(406) 477-6035

Mr. Steven Brady
Traditional Spokesperson
P.O. Box 542
Lame Deer, MT 59043
(406) 477-8344

OGLALA LAKOTA NATION:

Ms. Cecelia Firethunder, President (Send original here, certified mail)
Oglala Sioux Tribal Council
P.O. Box H
Pine Ridge, SD 57770
(605) 867-5821
Fax (605) 867-5659

ROSEBUD SIOUX TRIBE:

Mr. Rodney Bordeaux President (Send original here, certified mail)
Rosebud Sioux Tribal Council
P.O. Box 430
Rosebud, SD 57570
(605) 747-2381
Fax (605) 747-2243

cc:

Mr. Terry Gray (Primary cultural contact)
Cultural Resource Coordinator

Rosebud Sioux Tribe
Sinte Gleska College
P.O. Box 675
Mission, SD 57555
(605) 856-4901

CHEYENNE RIVER SIOUX TRIBE:

Mr. Herold Frazier, Chairman (Send original here, certified mail)
Cheyenne River Sioux Tribal Council
P.O. Box 590
Eagle Butte, SD 57625
(605) 964-4155
Fax (605) 964-4155

cc:

James Ticotte (Primary cultural contact)
Tribal Historic Preservation Officer
Cheyenne River Sioux Tribe
P.O. Box 590
Eagle Butte, SD 57625
(605) 964-7554

STANDING ROCK SIOUX:

Mr. Ron His-Horse-is-Thunder, Chairman
Standing Rock Sioux Tribal Council
P.O. Box D
Fort Yates, ND 58538
(701)-854-7448

cc:

Mr. Tim Mentz
Tribal Historic Preservation Officer
P.O. Box D
Fort Yates, ND 58538
(701) 854-2120

CROW TRIBE:

Mr. Carl Venne, Chairman (Send original here, certified mail)
Crow Tribal Council
P.O. Box 159
Crow Agency, MT 59022
(406) 638-3708
Fax (406) 638-7283

cc:

Mr. Dale Old Horn (Primary cultural contact)
Tribal Historic Preservation Officer
Crow Tribal Administration
P.O. Box 159
Crow Agency, MT 59022
(406) 638-3793

FT PECK TRIBES:

Mr. A.T. "Rusty" Stafne, Chairman
Ft. Peck Tribes
P.O. Box 836
Poplar, MT 59255

Mr. Curley Youpee, THPO
Ft. Peck Tribes
P.O. Box 836
Poplar, MT 59255

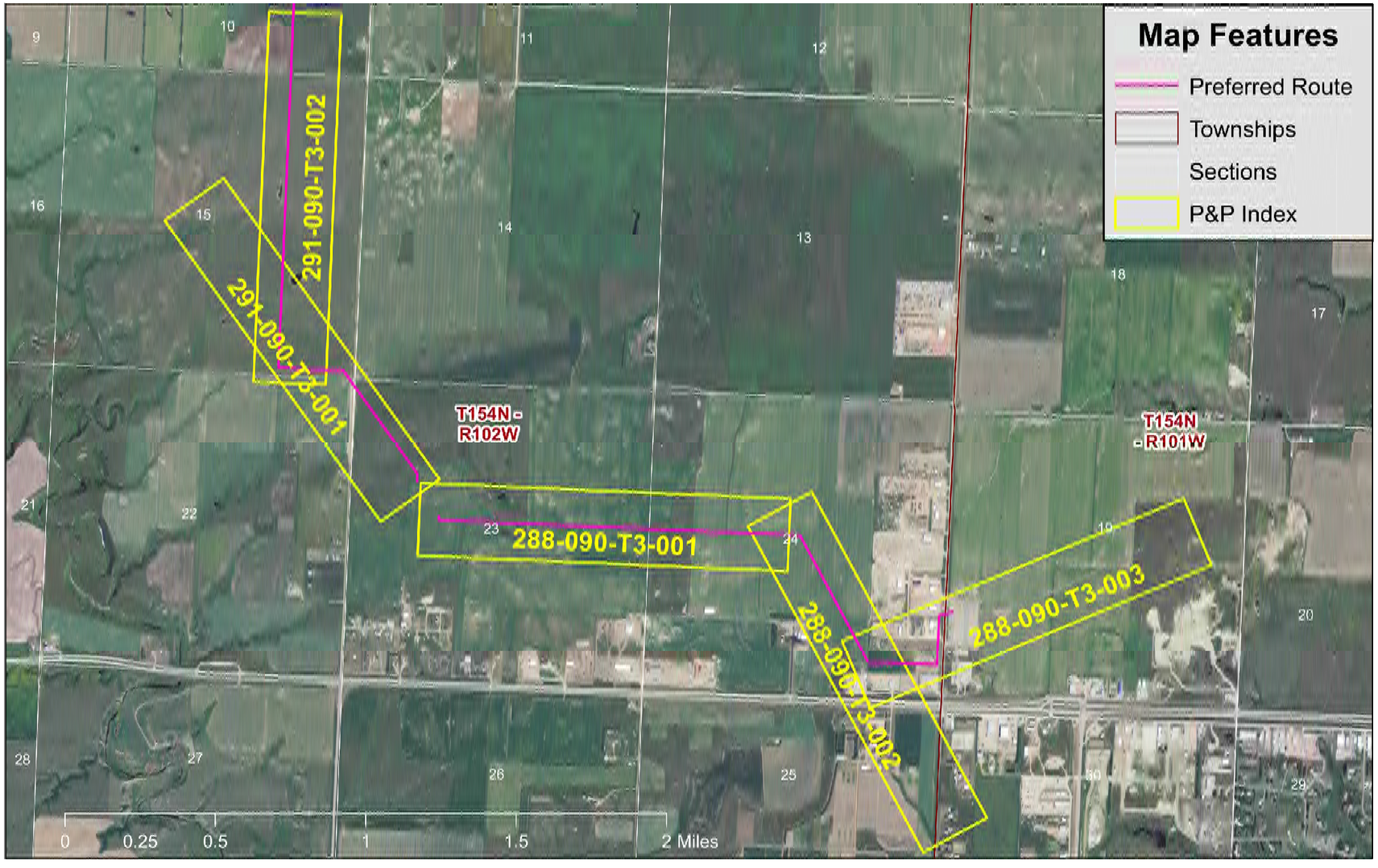
THREE AFFILIATED TRIBES:

Tex Hall, Chairman
Three Affiliated Tribes Business Council
404 Frontage Road
New Town, ND 58763

Mr. Elgin Crows Breast
Cultural Preservation Officer
Three Affiliated Tribes
404 Frontage Road
New Town, ND 58763

Appendix C
Plan & Profile

WILLISTON TIE PROJECT

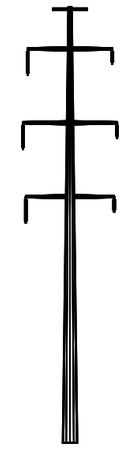


LINE FEATURES:

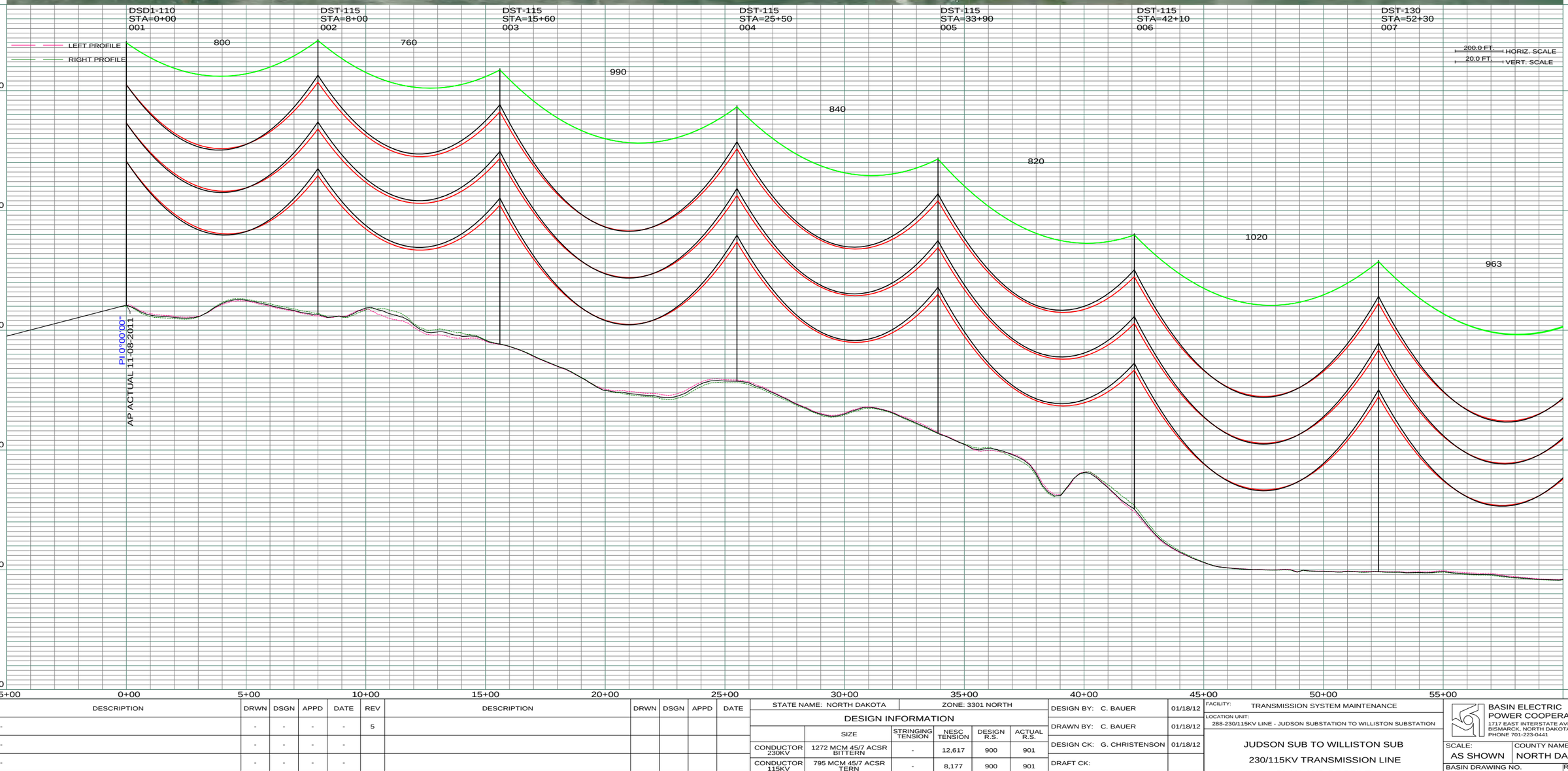
LINE LENGTH---------- 3.7 MILES

RIGHT OF WAY WIDTH---------- 150, 125, & 80 FEET

STRUCTURE TYPE---------- STEEL SINGLE POLE



TYPICAL TANGENT STRUCTURE



REV	DESCRIPTION	DRWN	DSGN	APPD	DATE	REV	DESCRIPTION	DRWN	DSGN	APPD	DATE
1	-	-	-	-	-	5					
2	-	-	-	-	-						
3	-	-	-	-	-						
4											

STATE NAME: NORTH DAKOTA — ZONE: 3301 NORTH

DESIGN INFORMATION

	SIZE	STRINGING TENSION	NESC TENSION	DESIGN R.S.	ACTUAL R.S.
CONDUCTOR 230KV	1272 MCM 45/7 ACSR BITTERN	-	12,617	900	901
CONDUCTOR 115KV	795 MCM 45/7 ACSR TERN	-	8,177	900	901
OPGW	AC 71/571	-	6,936	900	901

DESIGN BY:	C. BAUER	01/18/12
DRAWN BY:	C. BAUER	01/18/12
DESIGN CK:	G. CHRISTENSON	01/18/12
DRAFT CK:		
APPROVED:		

FACILITY: TRANSMISSION SYSTEM MAINTENANCE

LOCATION UNIT: 288-230/115KV LINE - JUDSON SUBSTATION TO WILLISTON SUBSTATION

JUDSON SUB TO WILLISTON SUB
230/115KV TRANSMISSION LINE
PLAN AND PROFILE

BASIN ELECTRIC POWER COOPERATIVE
1717 EAST INTERSTATE AVENUE
BISMARCK, NORTH DAKOTA
PHONE 701-223-0441

SCALE:	COUNTY NAME:
AS SHOWN	NORTH DAKOTA

BASIN DRAWING NO. 288-090-T3-001 — REV. 0

DSD65R-115
STA=61+93
008

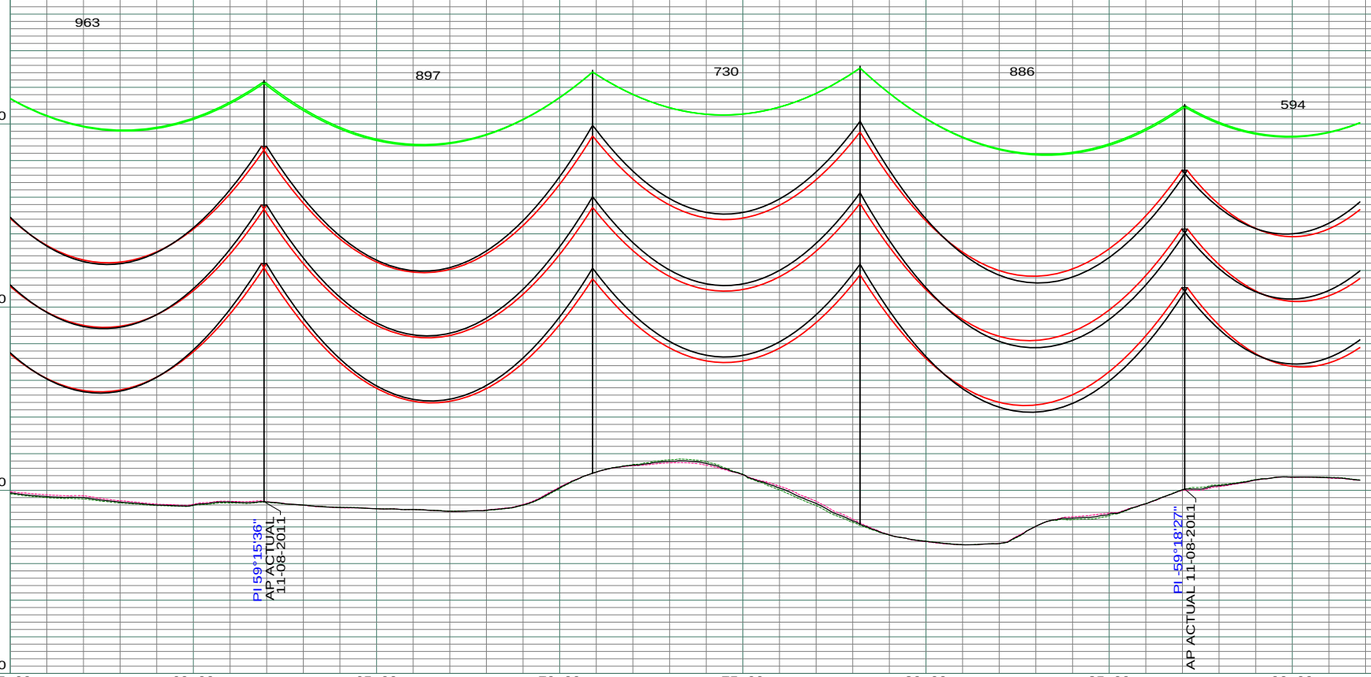
DST-110
STA=70+90
009

DST-125
STA=78+20
010

DSD65L-105
STA=87+06
011

LEFT PROFILE
RIGHT PROFILE

200.0 FT. HORIZ. SCALE
20.0 FT. VERT. SCALE



REV	DESCRIPTION	DRWN	DSGN	APPD	DATE	REV	DESCRIPTION	DRWN	DSGN	APPD	DATE
1	-	-	-	-		5					
2	-	-	-	-							
3	-	-	-	-							
4											

STATE NAME: NORTH DAKOTA ZONE: 3301 NORTH

DESIGN INFORMATION

	SIZE	STRINGING TENSION	NESC TENSION	DESIGN R.S.	ACTUAL R.S.
CONDUCTOR 230KV	1272 MCM 45/7 ACSR BITTERN	-	12,617	800	848
CONDUCTOR 115KV	795 MCM 45/7 ACSR TERN	-	8,177	800	848
OPGW	AC 71/571	-	6,936	800	848

DESIGN BY:	C. BAUER	01/18/12
DRAWN BY:	C. BAUER	01/18/12
DESIGN CK:	G. CHRISTENSON	01/18/12
DRAFT CK:		
APPROVED:		

FACILITY: TRANSMISSION SYSTEM MAINTENANCE

LOCATION UNIT: 288-230/115KV LINE - JUDSON SUBSTATION TO WILLISTON SUBSTATION

JUDSON SUB TO WILLISTON SUB
230/115KV TRANSMISSION LINE
PLAN AND PROFILE

BASIN ELECTRIC POWER COOPERATIVE
1717 EAST INTERSTATE AVENUE
BISMARCK, NORTH DAKOTA
PHONE 701-223-0441

SCALE: AS SHOWN
COUNTY NAME: NORTH DAKOTA
BASIN DRAWING NO.: 288-090-T3-002
REV.: 0

DSD65L-105
STA=87+06
011

DST-105
STA=93+00
012

DSD1-110
STA=99+23
013

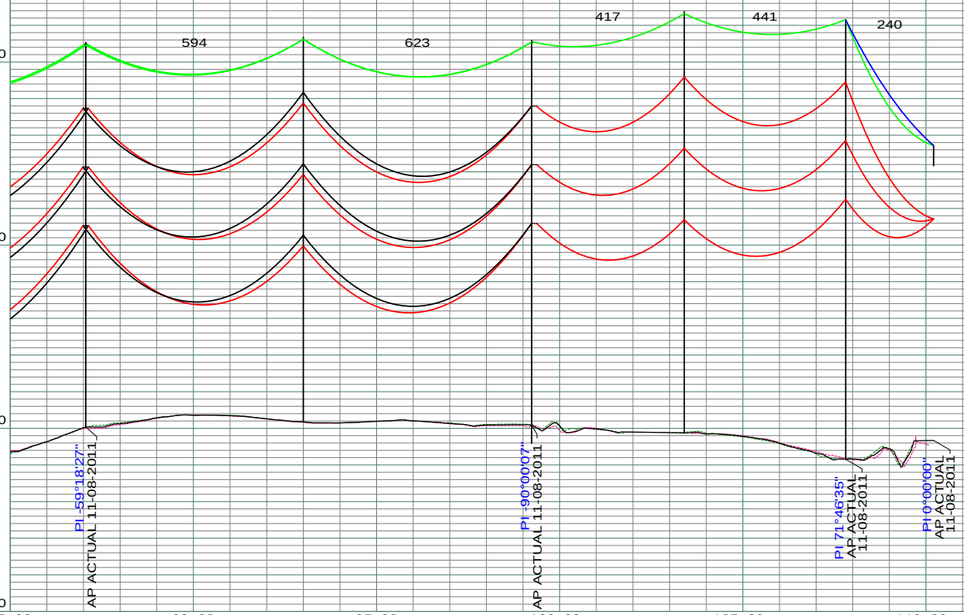
DST-115
STA=103+40
014

SD90-120
STA=107+81
015

A-FRAME
STA=110+21
T.O.S.

LEFT PROFILE
RIGHT PROFILE

200.0 FT. HORIZ. SCALE
20.0 FT. VERT. SCALE



REV	DESCRIPTION	DRWN	DSGN	APPD	DATE	REV	DESCRIPTION	DRWN	DSGN	APPD	DATE
1	-	-	-	-		5					
2	-	-	-	-							
3	-	-	-	-							
4											

STATE NAME: NORTH DAKOTA ZONE: 3301 NORTH

DESIGN INFORMATION

	SIZE	STRINGING TENSION	NESC TENSION	DESIGN R.S.	ACTUAL R.S.
CONDUCTOR 230KV	1272 MCM 45/7 ACSR BITTERN	-	12,617	600	605.7
CONDUCTOR 115KV	795 MCM 45/7 ACSR TERN	-	8,177	600	612.5
OPGW	AC 71/571	-	6,936	600	607.4

DESIGN BY:	C. BAUER	01/18/12
DRAWN BY:	C. BAUER	01/18/12
DESIGN CK:	G. CHRISTENSON	01/18/12
DRAFT CK:		
APPROVED:		

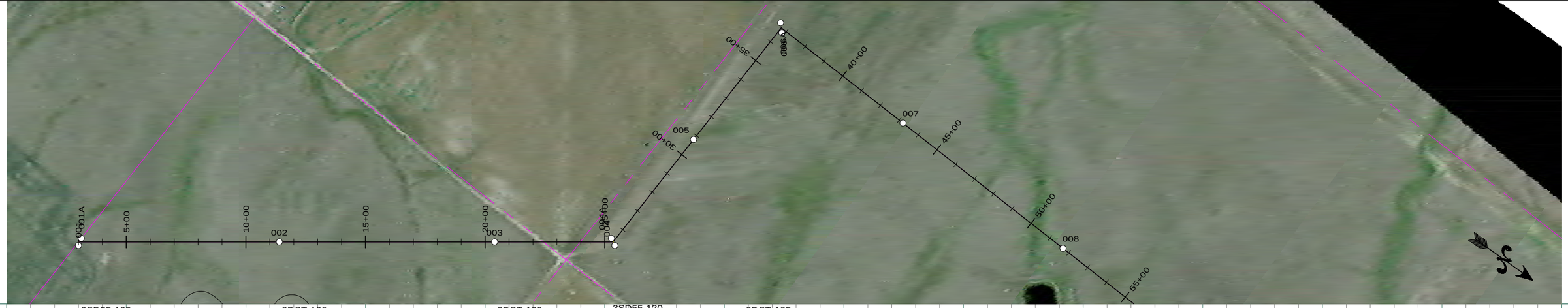
FACILITY: TRANSMISSION SYSTEM MAINTENANCE

LOCATION UNIT: 288-230/115KV LINE - JUDSON SUBSTATION TO WILLISTON SUBSTATION

JUDSON SUB TO WILLISTON SUB
230/115KV TRANSMISSION LINE
PLAN AND PROFILE

BASIN ELECTRIC POWER COOPERATIVE
1717 EAST INTERSTATE AVENUE
BISMARCK, NORTH DAKOTA
PHONE 701-223-0441

SCALE: AS SHOWN
COUNTY NAME: NORTH DAKOTA
BASIN DRAWING NO.: 288-090-T3-003
REV.: 0



3SD55-125
STA=3+00
HT ADJUST=1.50
001

3DST-130
STA=11+40
002

3DST-130
STA=20+40
003

3SD55-120
STA=25+35
HT ADJUST=1.50
004

1SD55-75
STA=25+28
HT ADJUST=1.50
004A

3DST-125
STA=30+80
005

LEFT PROFILE
RIGHT PROFILE

1SD55-75
STA=3+12
HT ADJUST=1.50
001A

200.0 FT. HORIZ. SCALE
20.0 FT. VERT. SCALE

2350
2300
2250
2200
2150
2100

900
503, 488
552
538
609, 579

PI 0°00'00"
PI -51°52'31"
AP ACTUAL 11-08-2011

0+00 5+00 10+00 15+00 20+00 25+00 30+00 35+00

REV	DESCRIPTION	DRWN	DSGN	APPD	DATE	REV	DESCRIPTION	DRWN	DSGN	APPD	DATE
1	-	-	-	-	-	5					
2	-	-	-	-	-						
3	-	-	-	-	-						
4											

STATE NAME: NORTH DAKOTA | ZONE: 3301 NORTH

DESIGN INFORMATION

	SIZE	STRINGING TENSION	NESC TENSION	DESIGN R.S.	ACTUAL R.S.
CONDUCTOR 345KV	2306.2 MCM 45/7 ACSR	TBD	21,283	800	803.7
CONDUCTOR 115KV	795 MCM 45/7 ACSR TERN	TBD	8,177	800	798.2
OPGW	AC 71/571	TBD	6,936	800	803.7

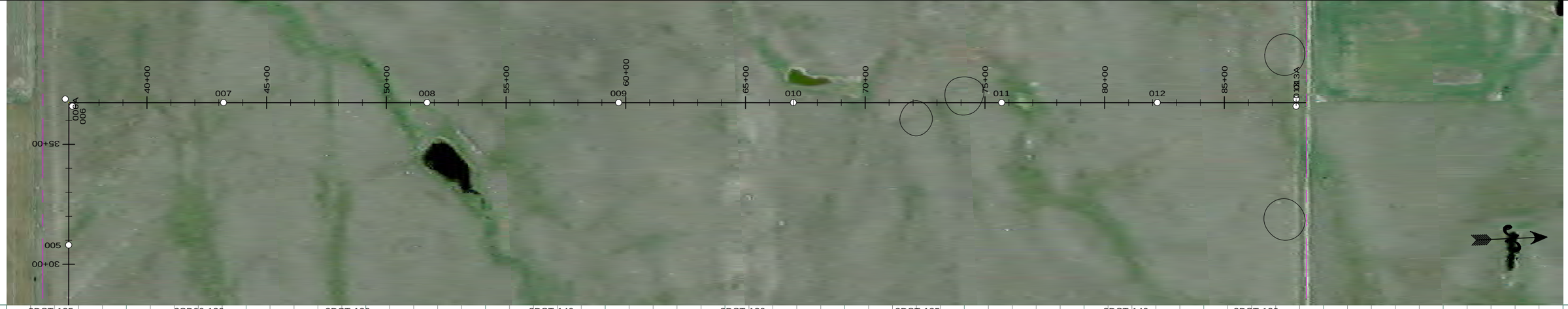
DESIGN BY:	C. BAUER	01/18/12
DRAWN BY:	C. BAUER	01/18/12
DESIGN CK:	G. CHRISTENSON	01/18/12
DRAFT CK:		
APPROVED:		

FACILITY: TRANSMISSION SYSTEM MAINTENANCE
LOCATION UNIT: 291-345/115KV LINE - JUDSON SUBSTATION TO NESET SUBSTATION

JUDSON SUBSTATION TO NESET SUBSTATION
345/115KV TRANSMISSION LINE
PLAN AND PROFILE

BASIN ELECTRIC POWER COOPERATIVE
1717 EAST INTERSTATE AVENUE
BISMARCK, NORTH DAKOTA
PHONE 701-223-0441

SCALE: AS SHOWN
COUNTY NAME: NORTH DAKOTA
BASIN DRAWING NO.: 291-090-T3-001
REV.: 0



3DST-125
STA=30+80
005

3SD90-130
STA=36+89
HT ADJUST=1.50
006

1SD90-85
STA=36+74
HT ADJUST=1.50
006A

3DST-130
STA=43+20
007

3DST-140
STA=51+70
008

3DST-130
STA=59+70
009

3DST-135
STA=67+00
010

3DST-140
STA=75+70
011

3DST-120
STA=82+20
012

3SDT-120
STA=88+00
HT ADJUST=1.50
013

1SD90-65
STA=88+01
013A

LEFT PROFILE
RIGHT PROFILE

200.0 FT. HORIZ. SCALE
20.0 FT. VERT. SCALE

2350
2300
2250
2200
2150
2100

609, 579
631
650
581, 580
800
730
850
870
PI 89°56'33"
AP ACTUAL
11-08-2011
PI 0°00'00"
AP ACTUAL 11-08-2011

30+00 35+00 40+00 45+00 50+00 55+00 60+00 65+00 70+00 75+00 80+00 85+00

REV	DESCRIPTION	DRWN	DSGN	APPD	DATE
1	-	-	-	-	
2	-	-	-	-	
3	-	-	-	-	
4					
5					

REV	DESCRIPTION	DRWN	DSGN	APPD	DATE

STATE NAME: NORTH DAKOTA ZONE: 3301 NORTH

DESIGN INFORMATION

	SIZE	STRINGING TENSION	NESC TENSION	DESIGN R.S.	ACTUAL R.S.
CONDUCTOR 345KV	2306.2 MCM 45/7 ACSR	TBD	21,283	750	752.5
CONDUCTOR 115KV	795 MCM 45/7 ACSR TERN	TBD	8,177	750	755.1
OPGW	AC 71/571	TBD	6,936	750	752.5

DESIGN BY:	C. BAUER	01/18/12
DRAWN BY:	C. BAUER	01/18/12
DESIGN CK:	G. CHRISTENSON	01/18/12
DRAFT CK:		
APPROVED:		

FACILITY: TRANSMISSION SYSTEM MAINTENANCE
LOCATION UNIT: 291-345/115KV LINE - JUDSON SUBSTATION TO NESET SUBSTATION

JUDSON SUBSTATION TO NESET SUBSTATION
345/115KV TRANSMISSION LINE
PLAN AND PROFILE

BASIN ELECTRIC POWER COOPERATIVE
1717 EAST INTERSTATE AVENUE
BISMARCK, NORTH DAKOTA
PHONE 701-223-0441

SCALE: AS SHOWN
COUNTY NAME: NORTH DAKOTA
BASIN DRAWING NO.: 291-090-T3-002
REV.: 0

Appendix D
SHPO Consultation

The Class III Archeological Inventory for the Basin Electric Power Cooperative Williston Tie Project was submitted to the North Dakota State Historic Preservation Office on Tuesday January 10, 2011 for their review.