Exhibit DD
Specific Standards for Transmission Lines

Boardman to Hemingway Transmission Line Project

1221 West Idaho Street
Boise, Idaho 83702

Mark Stokes, Project Leader
(208) 388-2843
mstokes@idahopower.com

Zach Funkhouser, Permitting
(208) 388-5375
zfunkhouser@idahopower.com

Application for Site Certificate

September 2018

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ACRONYMS AND ABBREVIATIONS

AC	alternating current
BPA	Bonneville Power Administration
CAFE	Corona and Field Effects
EFSC or Council	Energy Facility Siting Council
EPRI	Electric Power Research Institute
IPC	Idaho Power Company
kV	kilovolt
kV/m	kilovolt per meter
m	meter
mA	milliampere
NESC	National Electrical Safety Code
OAR	Oregon Administrative Rules
Project	Boardman to Hemingway Transmission Line Project
ROW	right-of-way
Second Amended Project Order	Second Amended Project Order, Regarding Statutes, Administrative Rules, and Other Requirements Applicable to the Proposed BOARDMAN TO HEMINGWAY TRANSMISSION LINE (July 26, 2018)

Exhibit DD
Specific Standards for Transmission Lines

1.0 INTRODUCTION

Exhibit DD demonstrates that the transmission lines associated with the Boardman to Hemingway Transmission Line Project (Project) will be designed, constructed, and operated to ensure alternating current (AC) electric fields do not exceed 9 kilovolts (kV) per meter (m) at one meter above the ground surface in areas accessible to the public. Exhibit DD also shows that the induced currents resulting from the Project transmission lines and related or supporting facilities will be as low as reasonably achievable.

2.0 APPLICABLE RULES AND SECOND AMENDED PROJECT ORDER PROVISIONS

2.1 Specific Standards for Transmission Lines

The Specific Standards for Transmission Lines under Oregon Administrative Rule (OAR) 345-024-0090 provide Idaho Power Company (IPC) must demonstrate it:

> *(1) Can design, construct and operate the proposed transmission line so that alternating current electric fields do not exceed 9 kV per meter at one meter above the ground surface in areas accessible to the public;*
>
> *(2) Can design, construct and operate the proposed transmission line so that induced currents resulting from the transmission line and related or supporting facilities will be as low as reasonably achievable.*

2.2 Site Certificate Application Requirements

OAR 345-021-0010(1)(dd) provides Exhibit DD must include information showing IPC can demonstrate compliance with the Specific Standards for Transmission Lines:

> *If the proposed facility is a facility for which the Council has adopted specific standards, information about the facility providing evidence to support findings by the Council as required by the following rules: . . . (C) For any transmission line under Council jurisdiction, OAR 345-024-0090.*

2.3 Second Amended Project Order Provisions

The Second Amended Project Order states IPC must demonstrate compliance with the Specific Standards for Transmission Lines:

> *The Council applies specific standards for transmission lines under its jurisdiction in OAR 345-024-0090. The applicant should provide analysis regarding compliance with OAR 345-024-0090.*

(Second Amended Project Order, Section III(dd)).

3.0 ANALYSIS

3.1 Analysis Area

The analysis area for Exhibit DD is the Site Boundary (see Second Amended Project Order, Section IV). The Site Boundary is defined as "the perimeter of the site of a proposed energy facility, its related or supporting facilities, all temporary laydown and staging areas, and all corridors and micrositing corridors proposed by the applicant" (OAR 345-001-0010(55)). The Site Boundary encompasses the following facilities in Oregon:

- The Proposed Route, consisting of 270.8 miles of new 500-kilovolt (kV) electric transmission line, removal of 12 miles of existing 69-kV transmission line, rebuilding of 0.9 mile of a 230-kV transmission line, and rebuilding of 1.1 miles of an existing 138-kV transmission line;
- Four alternatives that each could replace a portion of the Proposed Route, including the West of Bombing Range Road Alternative 1 (3.7 miles), West of Bombing Range Road Alternative 2 (3.7 miles), Morgan Lake Alternative (18.5 miles), and Double Mountain Alternative (7.4 miles);
- One proposed 20-acre station (Longhorn Station);
- Ten communication station sites of less than ¼ acre each and two alternative communication station sites;
- Permanent access roads for the Proposed Route, including 206.3 miles of new roads and 223.2 miles of existing roads requiring substantial modification, and for the Alternative Routes including 30.2 miles of new roads and 22.7 miles of existing roads requiring substantial modification; and
- Thirty temporary multi-use areas and 299 pulling and tensioning sites of which four will have light-duty fly yards within the pulling and tensioning sites.

The Project features are fully described in Exhibit B, and the location of the Project features and the Site Boundary is described in Exhibit C and Table C-24.

3.2 Methods

The methods IPC used to model expected electric fields and induced current for the Project are the same as described in Exhibit AA, Section 2.1, and are summarized here.

The electric field, magnetic field, and audible noise that may be produced by the proposed transmission line was predicted using EMFWorkstation: ENVIRO (Version 3.52), a Windows-based model developed by the Electric Power Research Institute (EPRI) (EPRI 1997). The ENVIRO program uses the algorithms developed by the Bonneville Power Administration (BPA), which were originally described in the Corona and Field Effects (CAFE) program from BPA (BPA n.d.). The inputs to the ENVIRO model are line voltage, load flow (current), and the physical dimensions of the line (number of phases, conductor diameter, spacing, height, and subconductor configuration).

3.3 Alternating Current Electric Fields

OAR 345-024-0090: To issue a site certificate for a facility that includes any transmission line under Council jurisdiction, the Council must find that the applicant: (1) Can design, construct and operate the proposed transmission line so that alternating current electric fields do not exceed 9 kV per meter at one meter above the ground surface in areas accessible to the public; . . . .

The modeling results (see Attachment AA-1 in Exhibit AA) show that the Project's transmission lines will produce AC electric fields that will be less than 9 kV per meter (kV/m) at 1 meter above the ground throughout the ROW for the Proposed Route and each alternative route, and therefore, the Project will comply with the AC electric field standard. Table DD-1 summarizes the electric field strengths at the peak and edge of the ROW for the different transmission line configurations proposed for the Project. The electric field profiles in Exhibit AA show how the strength of the electric field will vary across the ROW for each transmission line configuration (see Exhibit AA).

Table DD-1. Electric Field Strength for Each Considered Structural Configuration

Structure Type	ROW Width (feet)	South/West ROW Edge (kV/m)	Maximum within ROW (kV/m)	North/East ROW Edge (kV/m)
500-kV lattice	250	0.8	8.9	0.8
500-kV tubular steel H-frame and Y-frame monopole	250	0.9	8.8	0.9
230-kV wood H-frame	125	0.8	5.0	0.8
138-kV wood H-frame	100	0.5	2.3	0.5

Electric field strength calculated at standard height of one meter above ground surface.
kV/m = kilovolt per meter; ROW = right-of-way

The modeling results are based on certain minimum ground clearances. To ensure compliance with the AC electric field provisions of the Specific Standards for Transmission Lines, IPC proposes that the Energy Facility Siting Council (EFSC or Council) include the following conditions in the site certificate providing that IPC comply with the minimum ground clearances used in the modeling and that the Project otherwise meet the 9 kV/m standard:

> ***Siting Standard Condition 1****: During construction, the certificate holder shall take the following steps to reduce or manage human exposure to electromagnetic fields:*
> *a. Constructing all aboveground transmission lines at least 200 feet from any residence or other occupied structure, measured from the centerline of the transmission line;*
> *b. Constructing all aboveground 500-kV transmission lines with a minimum clearance of 34.5 feet from the ground at normal operating conditions;*
> *c. Constructing all aboveground 230-kV transmission lines with a minimum clearance of 20 feet from the ground at normal operating conditions;*
> *d. Constructing all aboveground 138-kV transmission lines with a minimum clearance of 20 feet from the ground at normal operating conditions;*
> *e. In areas where aboveground transmission line will cross an existing transmission line, constructing the transmission line at a height and separation ensuring that alternating current electric fields do not exceed 9-kV per meter at one meter above the ground surface; and*
> *. . . .*

3.4 Induced Currents

> OAR 345-024-0090: To issue a site certificate for a facility that includes any transmission line under Council jurisdiction, the Council must find that the applicant: . . . (2) Can design, construct and operate the proposed transmission line so that induced currents resulting from

> the transmission line and related or supporting facilities will be as low as reasonably achievable.

3.4.1 Overview of Induced Current, Induced Voltage, and Nuisance Shock

The flow of electricity in a transmission line can induce a small electric charge, or voltage, in nearby conductive objects. An induced electric charge can flow, or become electric current, when a path to ground is presented. Induced current can be observed as a continuous flow of electricity or, under some circumstances, as a sudden discharge, commonly known as a "nuisance shock." The most common example of a nuisance shock is when a vehicle, which is insulated from grounding by its tires, is parked under a transmission line for sufficient time to build up a charge. A person touching such a charged vehicle could become a conducting path for the current and can feel a momentary shock if the available electrical charge is sufficient, generally above 1 milliampere (mA) (Dalziel and Mansfield 1950).

The amount of current flow, or the magnitude of the nuisance shock, is determined by the level of charge that can be induced and the nature (conductivity or impedance) of the path to ground. Metallic roofs, vehicles, equipment, or wire fences are examples of metallic objects in the vicinity of the Project in which a small electric charge could be induced. Factors to consider when assessing the potential hazards and mitigation measures for induced voltage include the characteristics of nearby objects, and the degree and nature of grounding of those objects. More conductive materials accumulate greater charge than less conductive materials while large objects, such as a tractor-trailer, will accumulate a greater charge than smaller objects such as a pick-up truck (EPRI 2005). A linear object that is parallel to the transmission line would be more greatly affected than one that is perpendicular to the line. An object passing quickly under the transmission line would be minimally affected compared to a stationary object. A grounded or partially grounded object will accumulate charge that could be discharged as a nuisance shock, while continuous current would occur in a grounded object. The total amount of charge that can be induced in a perfectly nongrounded object is limited by the strength of the magnetic field and the nature of the object; after a time, the field and the induced charge in the object will reach equilibrium (steady-state), and the induced charge would stop building.

Continuous induced current may occur if a metallic object is partially grounded or grounded some distance from the transmission line. Continuous induced current may occur in linear objects that are parallel to the transmission line, such as some fences, railroads, pipelines, irrigation piping, or other transmission or power distribution lines.

3.4.2 National Electrical Safety Code Provisions Relevant to Induced Current

The National Electrical Safety Code (NESC) sets the ground rules for practical safeguarding of persons during the installation, operation, or maintenance of electric supply and communication lines and associated equipment. NESC Rule 234G.3 (NESC 2012) addresses induced current and sets forth a certain standard to ensure the safety and health implications of the same are properly addressed:

> *[f]or voltages exceeding 98 kV ac to ground, either the clearances shall be increased or the electric field, or the effects thereof, shall be reduced by other means, as required, to limit the steady-state current due to electrostatic effects to 5 mA, rms, if an ungrounded metal fence, building, sign, billboard, chimney, radio or television antenna, tank or other installation, or any ungrounded metal attachments thereto, were short-circuited to ground.*

The 5-mA figure embedded in the NESC rule is a scientifically derived health and safety limitation, intended to eliminate the potential for harmful electric shock. The threshold of perception for current flowing through the human body is approximately 1 mA (Dalziel and Mansfield 1950). If the current is increased sufficiently beyond a person's perception threshold, it can become bothersome and possibly startling. Larger currents can cause the muscles of the arm and hand to involuntarily contract so that a person cannot let go of an electrified object. The value at which 99.5 percent of men, women, and children can still let go of an object is approximately 9, 6, and 5 mA, respectively. To address this safety concern, NESC Rule 234G.3 limits the steady-state current due to electrostatic effects to 5 mA; it is a performance standard aimed at limiting the potential charge that could be developed so that a potential nuisance shock would not be harmful to children.

The NESC is updated every 5 years. IPC will design, construct, and operate the Project in accordance with the version of the NESC that is most current at the time final engineering of the Project is completed.

3.4.3 Predicted Induced Current

Empirical evidence has yielded a known relationship between short-circuit current and electric field strength for various types and sizes of objects (EPRI, 2005). Based on these known relationships, Table DD-2 indicates the maximum current that could be induced in several types of vehicles and agricultural-related pieces of equipment potentially present in the transmission line ROW.

Table DD-2. Induced Current Factors

Object	I_{sc}/E (mA/kV/m)	Maximum Induced Current (mA)[1]
Car—L 4.6 m x W 1.78 m x 1.37 m	0.088	0.78
Pickup Truck—L 5.2 m x W 2.0 m x H 1.7m	0.10	0.89
Large Tractor-Trailer—Total Length 15.75 m Trailer: 12.2 m x W 2.4 m x H 3.7 m	0.64	5.70
Combine—L 9.15 m x W 2.3 m x H 3.5 m	0.38	3.38

Source: Table 7-8.2, EPRI AC Transmission Line Reference Book: 200 kV and Above (EPRI 2005).
[1] Maximum induced current calculated for strongest predicted electric field of 8.9 kV/m, associated with the proposed lattice segment.
I_{sc} = short-circuit current
E = AC electric field
m = meter

Multiplying the factors listed in Table DD-2 by the transmission line electric field strength yields the short-circuit current expected under conditions expected to produce the greatest magnitude short-circuit currents. The strongest electric field calculated for any of the proposed or alternative line configurations is 8.9 kV/m for the 500-kV lattice structure. The vehicles and equipment listed in Table DD-2 will have short-circuit currents less than the 5-mA current required by the NESC, except for the tractor-semitrailer for which the induced current would be 5.7 mA if the entire length of the tractor-semitrailer were in a 8.9 kV/m electric field (e.g., parallel to and directly under the line). Tractor-semitrailers generally will not be anticipated directly under the line where the 8.9 kV/m electric field occurs, except at road crossings where the tractor-semitrailers will not be parallel to the line and will be present only for a short duration while crossing under the line—that being so, the inducible charge under those circumstances likely would be less than 5 mA. At locations where large vehicles are anticipated to occur directly under the transmission line in parallel with the line and for a meaningful period (e.g., parking lots or gas stations), the line design would be altered if necessary, for example by an increase in the height of the line at that location, so that the line complies with the NESC 5-mA safety requirement.

The NESC provides industry standards for transmission line design and operation, including standards for ensuring induced currents are as low as reasonably achievable. Accordingly, to ensure compliance with the induced current provisions of the Specific Standards for Transmission Lines, IPC proposes that the Council include the following conditions in the site certificate providing that the Project will be designed consistent with the version of the NESC—including the induced current provisions—most recent as of the time of final Project design:

> ***Siting Standard Condition 1****: During construction, the certificate holder shall take the following steps to reduce or manage human exposure to electromagnetic fields:*
> *. . .*
> *f. Constructing all aboveground transmission lines in accordance with the requirements of the 2017 edition of the National Electrical Safety Code.*

In addition to the transmission line, the Project includes the following components and related or supporting facilities: Longhorn Station, communication stations, new access roads, substantially modified existing access roads, temporary multiuse areas, and pulling and tensioning sites. The Longhorn Station and communication stations will be constructed in a manner to minimize induced currents in surrounding facilities, while the access roads, multiuse areas, and pulling and tensioning sites will not include components that will contribute to induced currents or voltages.

3.4.4 Stray Voltage

Stray voltage is not an issue for this Project. Stray voltage is an issue that may occur with lower voltage distribution systems that have unequally loaded phases and an improperly grounded neutral wire. Stray voltage can also be an issue that occurs with the customer's electrical system beyond the local utility company's meter. The issue of stray voltage related to the Project is eliminated by the balanced three-phase configuration of the proposed transmission lines.

Though stray voltage is an unrelated issue to this Project, more information on this topic is available from the following sources:

- http://www.idahopower.com/AboutUs/Safety/default.cfm
- http://www.idahopower.com/pdfs/Safety/StrayVoltageBooklet.pdf
- http://www.idahopower.com/pdfs/Safety/Stray_Voltage_Brochure.pdf
- http://www.idahopower.com/pdfs/AboutUs/PlanningForFuture/ProjectNews/AgriOps.pdf

3.4.5 Landowner Education Regarding Overhead Transmission Lines

IPC has a robust program intended to educate landowners on the risks associated with the transmission lines on their property. The education process begins with the ROW acquisition process. As easements are acquired, each landowner is provided with an information packet containing several IPC pamphlets regarding hazards around transmission lines and power quality issues that might be experienced. IPC also maintains a Power Quality Group that is available free of charge to assist the public with any issues associated with electric fields, magnetic fields, audible noise, radio noise, stray voltage, and equipment interference. Information is available on these topics at:

- http://www.idahopower.com/pdfs/Safety/safetyBrochure.pdf
- http://www.idahopower.com/pdfs/Safety/EMFbrochure.pdf

To ensure affected landowners are provided IPC's educational information, IPC proposes that the Council include the following condition in the site certificate:

> ***Siting Standard Condition 2**: During operation, the certificate holder shall take the following steps to reduce or manage human exposure to electromagnetic fields:*
> *a. Providing to landowners a map of overhead transmission lines on their property and advising landowners of possible health and safety risks from induced currents caused by electric and magnetic fields;*
> . . . .

3.4.6 Program to Prevent Induced Current and Nuisance Shock

Nuisance shocks and induced currents can be reduced or eliminated by proper grounding of metallic objects near the transmission line, shielding them from the electric field, or positioning the transmission line farther from the objects. Grounding an object will reduce the induced potential to essentially zero and eliminate the object as a source of shocks or currents.

During final engineering and construction of the Project, IPC will identify all wire fences, pipelines, irrigation lines, metal roofs, and other objects nearby the ROW in which a current could be induced. All such objects will be properly grounded within or as close as practicable to the ROW in order to prevent induced current and nuisance shocks. IPC proposes that the Council include the following conditions in the site certificate providing for the same:

> ***Siting Standard Condition 2**: During operation, the certificate holder shall take the following steps to reduce or manage human exposure to electromagnetic fields:*
> *. . .*
> *b. Developing and implementing a program that provides reasonable assurance that all fences, gates, cattle guards, trailers, irrigation systems, or other objects or structures of a permanent nature that could become inadvertently charged with electricity are grounded or bonded throughout the life of the line; and*
> *c. Implementing a safety protocol to ensure adherence to NESC grounding requirements.*

4.0 IDAHO POWER'S PROPOSED SITE CERTIFICATE CONDITIONS

IPC proposes the following site certificate conditions to ensure compliance with the relevant EFSC standards:

<u>During Construction</u>

> ***Siting Standard Condition 1**: During construction, the certificate holder shall take the following steps to reduce or manage human exposure to electromagnetic fields:*
> *a. Constructing all aboveground transmission lines at least 200 feet from any residence or other occupied structure, measured from the centerline of the transmission line;*
> *b. Constructing all aboveground 500-kV transmission lines with a minimum clearance of 34.5 feet from the ground at normal operating conditions;*
> *c. Constructing all aboveground 230-kV transmission lines with a minimum clearance of 20 feet from the ground at normal operating conditions;*
> *d. Constructing all aboveground 138-kV transmission lines with a minimum clearance of 20 feet from the ground at normal operating conditions;*

e. In areas where aboveground transmission line will cross an existing transmission line, constructing the transmission line at a height and separation ensuring that alternating current electric fields do not exceed 9-kV per meter at one meter above the ground surface; and
f. Constructing all aboveground transmission lines in accordance with the requirements of the 2017 edition of the National Electrical Safety Code.

During Operation

***Siting Standard Condition 2**: During operation, the certificate holder shall take the following steps to reduce or manage human exposure to electromagnetic fields:*
a. Providing to landowners a map of overhead transmission lines on their property and advising landowners of possible health and safety risks from induced currents caused by electric and magnetic fields;
b. Implementing a program that provides reasonable assurance that all fences, gates, cattle guards, trailers, irrigation systems, or other objects or structures of a permanent nature that could become inadvertently charged with electricity are grounded or bonded throughout the life of the line; and
c. Implementing a safety protocol to ensure adherence to NESC grounding requirements.

5.0 CONCLUSION

Exhibit DD, together with the data provided in Exhibit AA, demonstrates that the Project's AC electric fields will not exceed 9 kV/m at 1 meter above the ground surface in areas accessible to the public; and that induced currents resulting from the transmission line and related or supporting facilities will be as low as reasonably achievable.

6.0 COMPLIANCE CROSS-REFERENCES

Table DD-3 identifies the location within this application for site certificate of the information responsive to the application submittal requirements of OAR 345-021-0010(1)(dd), the Specific Standards for Transmission Lines at OAR 345-024-0090, and the relevant Second Amended Project Order provisions.

Table DD-3. Compliance Requirements and Relevant Cross-References

Requirement	Location
OAR 345-021-0010(1)(dd)	
Exhibit DD. If the proposed facility is a facility for which the Council has adopted specific standards, information about the facility providing evidence to support findings by the Council as required by the following rules: . . .	
(C) For any transmission line under Council jurisdiction, OAR 345-024-0090.	Exhibit DD, Section 3.3 and Section 3.4
OAR 345-024-0090	
To issue a site certificate for a facility that includes any transmission line under Council jurisdiction, the Council must find that the applicant:	

Requirement	Location
(1) Can design, construct and operate the proposed transmission line so that alternating current electric fields do not exceed 9 kV per meter at one meter above the ground surface in areas accessible to the public;	Exhibit AA, Section 3.5; Exhibit DD, Section 3.3
(2) Can design, construct and operate the proposed transmission line so that induced currents resulting from the transmission line and related or supporting facilities will be as low as reasonably achievable.	Exhibit AA, Section 3.5; Exhibit DD, Section 3.4
Second Amended Project Order	
The Council applies specific standards for transmission lines under its jurisdiction in OAR 345-024-0090. The applicant should provide analysis regarding compliance with OAR 345-024-0090.	Exhibit AA, Section 3.5; Exhibit DD, Section 3.3 and Section 3.4

7.0 RESPONSE TO NOTICE OF INTENT AND SCOPING MEETING COMMENTS

ODOE received over 450 comments based on the Notice of Intent and the related scoping meetings. ODOE summarized those comments in the First Amended Project Order (December 2014) and then removed the summaries from the Second Amended Project Order “to reduce the risk of misinterpreting the intention of the individual comment.”[1] Although ODOE eliminated the requirement that IPC address the comment summaries, IPC nonetheless voluntarily addresses those summaries here in Table DD-4, identifying the location within the Application for Site Certificate of the information responsive to the comments summarized in the First Amended Project Order.

[1] Second Amended Project Order, Section VI(a).

Table DD-4. Comment Summaries

Comment Summaries	Location
Numerous commenters expressed concern about potential human health impacts of a high voltage transmission line from electromagnetic fields, corona effects, and induced currents. Exhibit AA shall include evidence that the proposed facility can meet the Council standards specific to transmission lines, and include mitigation measures proposed by the applicant to reduce or eliminate threats to human health and safety during construction and operation of the transmission line.	Exhibit AA, Section 3.10; Exhibit DD, Section 3.5

8.0 REFERENCES

BPA (Bonneville Power Administration). Undated. “Corona and Field Effects” Computer Program – Public Domain Software. Bonneville Power Administration, Vancouver, WA.

Dalziel, C.F., and T H. Mansfield. 1950. Effects of Frequency on Perception Currents. *AIEE Transactions* 69:1162–1168.

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NESC (National Electric Safety Code). 2012. National Electrical Safety Code. 2012 ed. Institute of Electrical and Electronics Engineers, Inc., New York, NY. 287 pages.