J16 115kV Transmission Line Reconductoring Project

Woonsocket and Cumberland, Rhode Island

PREPARED FOR

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Glossary

AAAC	All Aluminum Alloy Conductor.
AAL:	Annual Average Load.
AAPL	Average Annual Peak Load.
AC:	Alternating Current. An electric current which reverses its direction of flow periodically. (In the United States this occurs 60 times a second -60 cycles or 60 Hertz). This is the type of current supplied to homes and businesses.
ACSR:	Aluminum Conductor Steel Reinforced wire.
ACSS:	Aluminum Conductor Steel Supported wire.
Ampere (Amp):	A unit of measure for the flow of electric current. A typical home service capability (i.e., size) is 100 amps. 200 amps or more is required for homes with electric heat.
ANSI:	American National Standards Institute.
APL:	Annual Peak Load.
BMPs:	Best Management Practices.
Bundle:	Two or more wires joined together to operate as a single phase.
Cable:	A fully insulated conductor usually installed underground but in some circumstances can be installed overhead.
Circuit:	A system of conductors (three conductors or three bundles of conductors) through which an electric current is intended to flow and which may be supported above ground by transmission structures or placed underground.
Conductor:	A metallic wire or cable which serves as a path for electric current to flow.
Conduit:	Pipes, usually PVC plastic, typically encased in concrete to house and protect underground power cables or other subsurface utilities.
Davit Arm Structure:	A single-shaft steel pole with an alternating arm configuration each of which supports a phase conductor.

Demand:	The total amount of electric power required at any given time by an electric supplier's customers.
Distribution Line or System:	Power lines that operate between 4 kV and 35 kV that transport electricity to the customer.
Double-Circuit:	Two circuits on one structure.
Duct Bank:	A group of ducts or conduit usually encased in concrete in a trench.
Duct:	Pipe for underground power cables (see also Conduit).
EFI	Environmental Field Issue Guidance Document.
EFSB:	Rhode Island Energy Facility Siting Board.
Electric Field (EF):	A field produced as a result of voltages applied to electrical conductors and equipment; usually measured in units kilovolts per meter.
Electric Transmission:	The facilities (≥69 kV) that transmit electrical energy from generating plants to substations.
EMF:	Electric and magnetic fields.
Environmental Monitor:	Inspects environmental conditions within the construction site, reviews the contractors' compliance with environmental permit conditions during the construction phase of a project, and makes recommendations for corrective actions to protect sensitive environmental resources proximate to a construction site.
Fault:	A failure or interruption in an electrical circuit (a.k.a. short circuit).
FEMA:	Federal Emergency Management Agency.
Gauss (G):	A unit of measure for magnetic fields. 1G equals 1,000 milligauss (mG).
Gigawatt (GW):	One gigawatt equals 1,000 megawatts.
Glacial till:	Type of surficial geologic deposit that consists of boulders, gravel, sand silt, and clay mixed in various proportions. These deposits are predominantly nonsorted, nonstratified sediment and are deposited directly by glaciers.
H-frame Structure:	A wood or steel transmission line structure constructed of two upright poles with a horizontal cross-arm and diagonal bracings.
Hel:	Highly erodible land.
ISO-NE:	ISO New England, Inc. The independent system operator of New England.

kcmil:	1,000 circular mils, approximately 0.0008 square inches. A measure of conductor cross-sectional area.
kV:	Kilovolt. 1 kV equals 1,000 volts.
kV/m:	Kilovolts per meter. A measurement of electric field strength.
Load:	Amount of power delivered upon demand at any point or points in the electric system. Load is created by the power demands of customers' equipment (residential, commercial, and industrial).
LTE:	Long-Term Emergency rating.
MCM	Thousands of circular mils.
mG:	milliGauss. Equals 1/1000 Gauss.
Msl:	Mean sea level.
NEPOOL	New England Power Pool.
NERC:	North American Electric Reliability Corporation.
NESC:	National Electrical Safety Code.
NPCC:	Northeast Power Coordinating Council.
OPGW:	Optical Ground Wire
PAL:	Public Archaeological Laboratory, Inc.
Phase:	Transmission and distribution AC circuits are comprised of three conductors that have voltage and angle differences between them. Each of these conductors is referred to as a phase.
Phel:	Potentially highly erodible land.
Power Transformer:	A device used to transform voltage levels to facilitate the efficient transfer of power from the generating plant to the customer. A step-up transformer increases the voltage while a step-down transformer decreases it. Power transformers have a high voltage and a low voltage winding for each phase.
PVC:	PolyVinyl Chloride.
Reconductor:	Replacement of existing conductors with new conductors, and any necessary structure reinforcements or replacements.
Reinforcement:	Any of a number of approaches to improve the capacity of the transmission system, including rebuilding, reconductoring, uprating, conversion and conductor bundling methods.

RIDEM:	Rhode Island Department of Environmental Management.
RIDOT:	Rhode Island Department of Transportation.
RIGIS:	Rhode Island Geographic Information System.
RIHPHC:	Rhode Island Historical Preservation & Heritage Commission.
RINHP:	Rhode Island Natural Heritage Program.
Rip Rap:	A permanent erosion-resistant ground cover of large, loose, angular stone with filter fabric or granular underlining used to protect soil from the erosive forces of concentrated runoff.
RIPDES:	Rhode Island Pollutant Discharge Elimination System.
ROW:	Right of way. Corridor of land within which a utility company holds legal rights necessary to build, operate and maintain power lines.
Shieldwire:	Wire strung at the top of transmission lines intended to prevent lightning from striking transmission circuit conductors. Sometimes referred to as static wire or aerial ground wire. May contain glass fibers to serve dual function of overhead ground wire and a telecommunications path. See also "OPGW".
Steel Pole Structure:	Transmission line structure consisting of tubular steel pole(s) with arms or other components to support insulators and conductors.
Step-down Transformer:	See Power Transformer.
Step-up Transformer:	See Power Transformer.
Substation:	A fenced-in yard containing switches, power transformers, line terminal structures, and other equipment enclosures and structures. Voltage change, adjustments of voltage, monitoring of circuits and other service functions take place in this installation.
Switching Station:	Same as Substation except with no power transformers. Switching of circuits and other service functions take place in this installation.
Terminal Points:	The substation or switching stations at which a transmission line terminates.
Terminal Structure:	Structure typically within a substation that ends a section of transmission line.
Terminator:	An insulated fitting used to connect underground cables to overhead lines.

TMDL:	Total Maximum Daily Load, Maximum allowed pollutant load to a water body without exceeding water quality standards.
Transmission Line:	An electric power line operating at 69,000 volts or more.
USDA:	United States Department of Agriculture.
USEPA	United States Environmental Protection Agency.
USGS:	United States Geological Survey.
V/m:	Volts per meter. A measure of electric field strength.
Voltage Collapse:	A condition where voltage drops to unacceptable levels and cascading interruptions of transmission system elements occur resulting in widespread blackouts.
Voltage:	A measure of the electrical pressure which transmits electricity. Usually given as the line-to-line root-mean square magnitude for three-phase systems.
Watercourse:	Rivers, streams, brooks, waterways, lakes, ponds, marshes, swamps, bogs, and all other bodies of water, natural or artificial, public or private.
Wetland:	Land, including submerged land, which consists of any of the soil types designated as poorly drained, very poorly drained, alluvial or Floodplain by the U.S. Department of Agriculture, Natural Resources Conservation Service. Wetlands include federally jurisdictional wetlands of the U.S. and navigable waters, freshwater wetlands or coastal resources regulated by a state or local regulatory authority. Jurisdictional wetlands are classified based on a combination of soil type, wetland plants, and hydrologic regime, or state-defined wetland types.
Wire:	See Conductor.

1.0 Executive Summary

1.1 Introduction

This Environmental Report (the "ER" or "Report") has been prepared in accordance with Rule 1.6 (f) of the *EFSB Rules of Practice and Procedure* to support a Notice of Intent ("NOI") for the reconductoring of the existing J16 115-kilovolt ("kV") overhead electrical transmission line (J16 Line), owned by The Narragansett Electric Company d/b/a National Grid ("TNEC" or the "Company")[1] and located in Woonsocket and Cumberland, Rhode Island (the "Project"). This report discusses the purpose of and need for the Project, the details of the work activities associated with the Project, Project alternatives, the existing natural and social environments that may be affected by the Project, an impact analysis, and proposed mitigation measures.

1.2 Proposed Action

TNEC is proposing to reconductor a portion of the J16 Line which is situated within an approximately 125-foot wide right-of-way ("ROW") in the City of Woonsocket and Town of Cumberland. Reconductoring involves replacing the conductors (wires) of a transmission line with new larger conductors which are capable of carrying more power. In many cases, a reconductoring project requires existing structures to be replaced or reinforced. For this Project four of the 23 existing steel supporting lattice tower structures will be replaced, one new steel structure will be installed, and 19 existing steel lattice tower structures will be reinforced by replacing specific members and bolts. This Project will also include the replacement of the existing 465.4 thousands of circular mils ("MCM") All Aluminum Alloy Conductor ("AAAC") conductors with larger 477 MCM Aluminum Conductor Steel Supported ("ACSS") conductors. This work will occur within the existing ROW located between the Riverside Substation off Florence Drive in Woonsocket and the Highland Park Substation off Highland Corporate Drive in the Town of Cumberland, a distance of approximately 2.2 miles[2] (see Figure 1-1).

1 TNEC, a subsidiary of National Grid USA, is an electricity distribution and transmission company serving approximately 465,000 customers in 38 Rhode Island communities. National Grid USA is a public utility holding company. National Grid USA Service Company, Inc. ("National Grid") is another subsidiary of National Grid USA and provides services such as engineering, facilities construction and accounting.

2 The 2.2 mile Project occurs within the City of Woonsocket with one exception, the last structure associated with the Project occurs within the Town of Cumberland.

1.3 Need for Project

The "Highland Drive Transmission Solution Study Report" (November 2012) ("2012 Highland Drive Report") identified thermal overloads on this section of the J16 Line under contingency conditions. Overload on the J16 Line above applicable emergency ratings under contingency conditions does not meet the performance requirements set by North American Electric Reliability Corporation ("NERC"), ISO-New England ("ISO-NE") and Northeast Power Coordinating Council Inc. ("NPCC") planning standards and National Grid transmission guidelines. Reconductoring is needed to maintain firm and reliable electric supply to TNEC customers.

1.4 Summary of Environmental Effects and Mitigation

The Project will occur within the existing ROW and will use existing access roads, thereby minimizing adverse environmental impacts. No long-term impacts to soil, bedrock, vegetation, surface water, groundwater, wetland resources or air quality will occur. Any potential sedimentation impacts and other short-term construction impacts to wetlands and surface waters will be mitigated by the use of soil erosion and sediment control best management practices (BMPs) and equipment access mats (swamp mats) to protect wetland soils, vegetation root stock, and streams. Minor, temporary disturbances of wildlife may result from equipment travel and construction crews working in the Project corridor. Any wildlife displacement will be negligible and temporary, since no permanent alteration of the existing habitat is proposed. An environmental monitor will be part of the Project team to confirm compliance with all regulatory programs and permit conditions, and to oversee the proper installation and maintenance of the soil erosion and sediment control BMPs.

1.5 Summary of Social Effects and Mitigation

The Project involves an existing transmission line within an existing ROW. No long-term impacts to residential, commercial or industrial land uses will occur as a result of the Project. Any construction noise impacts are expected to be brief and localized. No visual impacts will result from the reconductoring. The Project will improve the reliability of the electric supply and as such will have a positive effect. Traffic control plans will be employed as necessary at the ROW access points off local and state roads. The Project will not adversely impact the social and economic conditions in the Project area.

1.6 Conclusion

The reconductoring of the J16 Line in its existing ROW is proposed to maintain a firm and reliable supply of electricity to TNEC's customers in a cost effective manner. No significant environmental or social impacts will result from the Project.

2.0 Purpose and Need

2.1 Introduction

TNEC strives to provide its customers with high quality and reliable electric service at the lowest possible cost, while minimizing adverse environmental and social impacts. Reliability is measured in terms of the frequency and duration of power outages lasting one minute or more. The quality of electric service refers to voltage levels, variations in voltage frequency, harmonics, and outages lasting less than one minute.

To reduce the chance of a long-term outage affecting large numbers of customers in one geographic area, TNEC, like other U.S. electric utilities, has developed design criteria, policies, and standards used both to assess the adequacy of the existing and future transmission system for all reasonably anticipated conditions and also to provide guidance in the design of future modifications or upgrades to the transmission system. These design criteria and standards are contained in the latest version of the National Grid Transmission Group Procedure 28 – Transmission Planning Guide ("Transmission Planning Guide").

Transmission planning studies are routinely completed to determine what facilities are needed to supply reliable electric power to specific geographic areas. The need for the transmission upgrades from Riverside Substation to Highland Park Substation was identified by the 2012 Highland Drive Report. The study was performed to evaluate and identify the impact of the addition of Highland Park Substation[3] on the transmission system.

The purpose of the Project is to maintain firm and reliable electric supply to the loads of the northern Rhode Island area by avoiding overload of the transmission line conductors during certain contingency operating conditions. Overloading conductors can lead to annealing, loss of tensile strength, excessive conductor sag, possible loss of adequate clearances, and ultimately, failure. To avoid an overload, the system operator would be forced to drop electric service to customers to avoid damage to the conductors.

3 The Highland Park Substation was formerly designated as the Highland Drive Substation in the 2012 Highland Drive Report.

2.2 Purpose of Studies

The interconnected electric power system is a complex network of generation, transmission and distribution facilities which must reliably deliver electrical power to utility customers. To be reliable, the system must provide acceptable performance when components are out of service for maintenance or due to unexpected failures of equipment. Performance is typically measured in terms of transmission equipment thermal loading, nominal voltage and voltage variation, power transfers (transfers), generator stability response, and available short-circuit current.

National Grid routinely undertakes transmission planning studies to determine whether new or upgraded transmission facilities are needed within a specified timeframe (typically ten years) to maintain reliable electric power within a specific geographic area. These studies are conducted using a "what-if" approach that tests the loading of each piece of equipment under a range of reasonably stressed system conditions. National Grid's Transmission Planning Guide which is based on ISO-NE, New England Power Pool (NEPOOL), NPCC and NERC standards, identify the range of conditions which need to be considered in a particular transmission planning study. The capability of the system under these conditions is studied using computer simulations which model the electrical parameters of the system. The transmission system is analyzed under "normal" conditions, and also under contingencies involving the loss of one or more transmission system facilities. The contingency analysis is carried out for various system generation dispatches and system transfer levels in order to ensure that the area of interest is tested under conditions that reasonably maximize the electrical stress to the area.

It is therefore necessary to determine specific conditions that need to be studied which address the adequacy of the system. The identification of conditions which need to be considered is accomplished with design criteria and guidelines which generically define "deterministic conditions" that reasonably stress the system. Deterministic conditions recognize the state (i.e., in-service, out-of-service) of the equipment, but not the probability of the state. The capability of the system under these conditions is studied using computer simulations which model the electrical parameters of the system.

All National Grid transmission facilities in New England are designed in accordance with the reliability criteria contained in the Transmission Planning Guide, ISO-NE and NEPOOL standards, the NPCC criteria, and the NERC Reliability Standards (collectively, the "Planning Documents").

In summary, the purpose of performing computer simulated studies is part of an effort to maintain firm and reliable operation of the electric power system as the system continues to evolve and grow.

2.3 Process for Determining Need and Selecting a Solution

The 2012 Highland Drive Report evaluated the impact of the installation of the new Highland Park Substation in order to facilitate customer interconnection. The system impact study identified several projected thermal issues in the surrounding area prior to the new project interconnection; however, per agreement with ISO-NE, this study was responsible for upgrades in the surrounding area where the project is projected to cause significant incremental impact over N-1 pre-existing overloads. The study considered several alternatives for connecting the Highland Park Substation to the nearby 115 kV line(s). The options included the following:

1. Tapping onto the J16 and R9 Lines to feed each transformer radially.
2. Loop in and out on the J16 Line through a 115 kV in-line breaker.
3. Loop in and out on the R9 Line through a 115 kV in-line breaker.

Ultimately, TNEC chose option #2, connecting the new Highland Park Substation using a loop of the J16 Line in and out through a 115 kV in-line breaker, as this option resulted with the least incremental N-1 impact on transmission system. However, one of the identified significant incremental N-1 impacts caused by choosing this option is to the J16 Line between Riverside No. 108 Substation and Highland Park Substation, and such impact is addressed by the Project, and specifically, the following upgrades:

- Reconductoring of the J16 Line overhead conductor (approximately 2.24 miles) between Riverside and Highland Park Substations to 477 ACSS.
- Upgrade the 115 kV bus work for the J16 Line at Riverside Substation.

The identified incremental N-1 impact for a stressed SEMA/RI transmission system (2014 summer peak, 90/10 forecast with two units out scenario and the West-East interface stressed at 1000 MW) needs to be mitigated in order to serve the projected design capacity of approximately 39 MVA at Highland Park Substation.

2.4 ISO-NE Approval of Project

TNEC filed the J16 Reconductor Project – Proposed Plan Application NEP-12-T15 on December 5, 2012 and ISO-NE approved the application on January 18, 2013. The ISO-NE approval is included in Appendix B.

2.5 Need for the Proposed Reconductoring

The transmission system is designed to avoid loading equipment above the Long-Term Emergency (LTE) rating. A recent review of the need for transmission upgrades, as documented in the 2012 Highland Drive Report, indicates that the section of the J16 Line between Highland Park Substation and the Riverside Substation requires upgrade to avoid thermal overloads. As further detailed in the 2012 Highland Drive Report, the option to reconductor J16 Line has been recommended as the preferred alternative to address the potential thermal condition, to comply with performance standards, and to maintain reliability of the transmission system.

2.6 Consequences of Not Reconductoring the J16 Line

If the J16 Line is not reconductored, the line may be overloaded during certain N-1 contingencies. As a result, it would be necessary to shed load under certain contingency conditions. Shedding load reduces reliability of service and is not an acceptable practice as it may result in the temporary loss of service to some customers. Furthermore, if the J16 Line is not reconductored then it will not meet the standards contained in the Planning Documents.

3.0 Project Description and Proposed Action

3.1 Introduction

In this section of the Report, the scope of the Project is identified, the proposed facilities and National Grid's construction practices are described, estimated Project costs are identified, and the anticipated Project schedule is discussed.

3.2 Description of the Existing J16 Line

The existing J16 Line originates at TNEC's Riverside Substation located on Florence Drive Extension in Woonsocket, and extends a distance of approximately 3.8 miles to the Staples Substation, located off Staples Road in Cumberland. The J16 Line is located in an existing approximately 125-foot wide ROW that was established in the 1920s. Also located within the ROW are the R9 115kV Transmission Line and, in sections, the H-17 115kV Transmission Line and an unenergized sub-transmission line. TNEC's rights to the ROW are by fee ownership or easement. The 2.2 mile portion of the J16 Line which is proposed to be reconductored begins at the Riverside Substation in Woonsocket and extends south to the Project's southern terminus at the Highland Park Substation located at 500 Highland Corporate Drive in Cumberland (see Figure 1-1). Figure 3-1, Sheets 1 through 12, is a detailed ROW site plan which shows the entire Project route and all existing facilities.

The portion of the J16 Line which is proposed to be reconductored contains approximately 1.6 miles of double-circuit steel lattice tower structures which support both the J16 Line and the adjacent R9 Transmission Line from the northern limit of the Woonsocket Wastewater Treatment Plant to the Project southern terminus at the Highland Park Substation, with two exceptions. Structure 144 is a double circuit steel H-frame structure and Structure 153 is a single circuit steel lattice tower structure. The remaining 0.6 miles is comprised of steel canal structures (Structures 159-163 and 165) (refer to Figure 3-2) and a special steel bridge structure (Structure 164) from the Riverside Substation to Hamlet Avenue. The canal and bridge structures support the J16 Line and the adjacent R9 and H-17 Transmission Lines as well as an unenergized sub-transmission line. Single circuit structures are designed to support a single electrical circuit and double-circuit structures are designed to support two electrical circuits.

The section of the J16 Line between Riverside Substation and Highland Park Substation consists of 465.4 MCM AAAC "Ragout" conductors. This portion of the line has been identified as requiring reconductoring to meet current load growth and to avoid thermal overload of the conductors under certain contingency conditions.

3.3 Scope of the Project

TNEC proposes to reconductor its existing J16 Line between the Riverside Substation located on Florence Drive Extension in Woonsocket and the Highland Park Substation located on Highland Corporate Park in Cumberland, a distance of approximately 2.2 miles. An overview of the Project area is provided in Figure 1-1 and a more detailed overview is provided in Figure 3-1 (Sheets 1-12). The scope of the Project involves replacing the existing 465.4 MCM AAAC "Ragout" conductors with new 477 MCM 26/7 ACSS "Hawk" conductors. Existing insulator assemblies on all structures will be reused. Additionally, the existing 3#5 Copperweld shieldwire will be replaced with Optical Ground Wire (OPGW).

To support the proposed reconductoring, it has been determined that four double-circuit steel lattice deadend towers will need to be replaced with double-circuit steel single pole deadend structures to provide the necessary strength and ground clearances required for the new larger conductors (see Figure 3-3). Each of the four double-circuit structures being replaced will require a new concrete caisson foundation. Additionally, one new direct embedded intermediate double-circuit steel two-pole davit arm suspension structure is needed to provide adequate clearance for the reconductored line (see Figure 3-4). The remaining 19 existing steel lattice structures were found to be sufficient to support the proposed new conductors, with some reinforcements at specific structures and will therefore remain in place.

Vegetation mowing and minor tree trimming will be performed along the existing ROW in conjunction with the Project. The proposed modifications will not significantly change the appearance of the existing ROW or the J16 Line.

In summary, the full scope of the Project consists of replacing a total of four structures with galvanized steel structures, installing one new structure, replacing the existing conductors of the transmission line with new conductors and associated hardware, and replacing the existing shieldwire of the transmission line with new OPGW.

3.4 Construction Practices

The reconductoring of the J16 Line will be accomplished using conventional overhead electric power line construction techniques. Typical construction works hours for the Project will be 7:00 a.m. to 7:00 p.m. Monday through Friday when daylight permits and 7:00 a.m. to 5:00 p.m. on Saturdays. Some exceptions to these standard hours are described in Section 7.10 of this Report. The proposed reconductoring will be carried out in a sequence of activities that will normally proceed as follows:

- ROW vegetation maintenance/mowing.
- Installation of BMPs.
- Access road maintenance.
- Pole replacement and installation of foundations.
- Conductor and shieldwire removal and replacement.
- Structure maintenance and foundation repair.
- Restoration of the ROW.

Each of these transmission line construction activities is described in the following sections.

TNEC will retain the services of an environmental monitor throughout the entire construction phase of the Project. The purpose of the environmental monitor will be to perform site inspections, confirm compliance with applicable federal, state, and local permit conditions, maintain strict adherence to National Grid policies, and monitor effectiveness of and, if required, propose modifications to BMPs.

3.4.1 ROW Vegetation Maintenance/Mowing

To facilitate construction equipment access along the majority of the ROW and at structure sites, vegetation mowing and selective tree trimming will be required in certain areas. This will be done to provide access to structure locations to facilitate safe equipment passage, to provide safe work sites for personnel within the ROW, and to maintain safe and reliable clearances between vegetation and transmission line conductors.

3.4.2 Installation of BMPs

Following the ROW mowing and vegetation maintenance activities, appropriate sedimentation control devices, such as compost or wood chip mulch filter tubes, will be installed following the procedures identified in the Rhode Island Soil Erosion and Sediment Control Handbook, and in accordance with approved plans and permit requirements. The installation of these erosion control devices will be supervised by the environmental monitor. The devices will function to mitigate construction-related soil erosion and sedimentation, and will also serve as a physical boundary to separate construction activities from resource areas.

The temporary placement of swamp mats will be used for both access across wetland areas and workpads at structures within wetlands, where upland access and work areas are not available. Swamp mats consist of timbers which are bolted together and temporarily placed over wetland areas to distribute equipment loads and minimize disturbance to the wetland and soil substrates. Swamp mats will be installed in a manner so as to not impede water flow. Such temporary swamp mat access roads and work pads will be removed following completion of construction, and if any soils are exposed they will be seeded and mulched to promote vegetative growth and soil stabilization. Vegetation will not be permanently affected by the installation of these mats.

All work will be in conformance with National Grid environmental guidance document EG-303NE, ROW Access, Maintenance and Construction Best Management Practices (EP No. 3 – Natural Resource Protection (Chapter 6), dated August 29, 2014).

3.4.3 Access Road Maintenance

Access roads are utilized along the ROW to construct, inspect, and maintain the transmission facilities. For the Project, existing access roads are suitable in a majority of the work areas. In some cases, existing access roads will require maintenance to support the proposed construction activities.

Access across wetland areas will be accomplished by the temporary placement of swamp mats and/or swamp mat bridges where upland access is not available, as described in Section 3.4.2.

Any access road maintenance will be carried out in compliance with the conditions and approvals of the appropriate federal and state regulatory agencies. Exposed soils on access roads will be wetted and stabilized as necessary to suppress dust generation. Crushed stone aprons (stabilized construction exits) will be used at all access road entrances at public roadways to minimize the amount of soil tracked onto paved roads by construction equipment. If necessary, public roads will be swept to remove any accumulation of Project related soil.

Equipment typically used during the maintenance of access roads will include dump trucks used to transport fill materials to work sites, and bulldozers, excavators, backhoes and graders which will be used to place fill materials or make cuts to achieve the proper access road profile. Cranes or log trucks will be used to place swamp mats in locations where temporary access across wetland areas is proposed.

Throughout the Project, pick-up trucks will be used to transport crews and hand held equipment to work sites. Low-bed trailers will be used to transport tracked equipment which cannot be operated on public roadways to the work site.

3.4.4 Pole Replacement and Installation of Foundations

As noted in the Project Description (Section 3.3), only 4 of the 23 transmission structures will be replaced and one new structure will be installed. Structures will be replaced within 35 feet of their existing locations. The process for installing the new direct embedded structure and constructing new foundations required for four double-circuit structures are discussed in this section.

Excavation will be required to install the new structure and the foundations associated with the four replacement structures. Minor grading may be required at some structure locations to provide a level work surface for construction equipment and crews, however, no grading will occur within the Blackstone Canal.

If rock is encountered during excavation, rock removal will be accomplished by means of rock drilling or hammering.

The new 2-pole direct embedment structure will require excavations approximately 15 feet in depth and ranging from three to six feet in diameter. Excavated material will be temporarily stockpiled next to the excavation but will not be placed directly into resource areas. If a stockpile is located in close proximity to wetlands, it will be enclosed by an erosion and sediment control device. Steel casings may be used to support the sides of deeper excavations. Once the structure has been properly positioned and plumbed within the hole, the excavation will be backfilled with the native soil or clean gravel, and tamped to provide structural integrity. Following the backfilling operation, any remaining excavated material will be spread over adjacent upland areas and stabilized or removed from the site.

As previously discussed, the four double-circuit transmission line structures to be replaced will require new reinforced concrete caisson foundations. These foundations will measure approximately 20-50 feet in depth, and 6-10 feet in diameter. Installation of foundations will include foundation excavation, steel caisson installation, rebar work and concrete placement. Steel casings may be used to support the sides of foundation excavations. Following the completion of foundation construction, excavated soil, clean gravel or concrete will be used to backfill around the foundation. The transmission structures are then erected upon the completed foundations. Any remaining excavated materials are then spread over upland areas or removed from the site. Old structures will be removed from the Project site and disposed of appropriately. The old concrete lattice tower footings will be cut off 18 inches below grade and the resulting void will be backfilled with topsoil.

Dewatering may be necessary during excavations for structures. The dewatering pumpate will be discharged into a straw bale and geotextile fabric settling basin or dewatering filter bag which will be located in an upland area. The pump intake will not be allowed to rest on the bottom of the excavation throughout dewatering. The basin and all accumulated sediment will be removed following dewatering operations and the area will be seeded and mulched.

Equipment typically used during the installation of foundations and pole structures will include excavating equipment such as backhoes and clam shell diggers, drill rigs, rock drills and concrete trucks. Cranes will be used to erect structures. Hand held equipment including shovels and vibratory tampers will be used during the backfilling of foundations and pole structures. Dump trucks will be used to remove excavated materials from the work site if necessary. Tracked equipment which cannot be operated on public roadways will be transported to the work site by means of a low-bed trailer.

3.4.5 Conductor and Shieldwire Removal and Replacement

The existing conductors and shieldwire and/or a pulling rope will be used to pull in the new conductors and OPGW. The new conductors will be installed using stringing blocks and tensioning equipment. The tensioning equipment is used to pull the conductors through the stringing blocks and to achieve the desired sag and tension condition. During the stringing operation, temporary guard structures or boom trucks will be placed at road and highway crossings and at crossings of existing utility lines to ensure the public safety and the continued operation of other utility equipment. To minimize any additional disturbance to soils and vegetation, existing access roads will be used to the fullest extent possible in the placement of pulling and tensioning equipment.

The equipment that will typically be used during the conductor installation operation includes puller-tensioners and conductor reel stands that will be located at the stringing sites. Bucket trucks and platform cranes will be used at non-wetland locations to mount stringing blocks on the structures. To avoid setting temporary poles as guard structures in environmentally sensitive areas, the booms of small cranes and bucket trucks will be used as guard structures in such areas during the stringing operation to prevent the conductors from falling across roads or other utility lines. Pickup trucks will be used to transport work crews and small materials to work sites. TNEC will coordinate work across state highways with the Rhode Island Department of Transportation (RIDOT).

3.4.6 Structure Maintenance and Foundation Repair

To ensure that the existing structures can withstand the new loading from the reconductored line, reinforcements are required at certain tower locations. The reinforcements would involve replacing any damaged steel members or plates. Each of the existing structures as well as the new and replacement structures will also be grounded per the current standards. Additional maintenance work would occur on certain existing structures and include concrete footing repairs and the painting of steel members.

3.4.7 Restoration of the ROW

Restoration efforts, including final grading and installation of permanent erosion control devices, will be completed following the reconductoring operation. All construction debris will be removed from the Project site and properly disposed. All disturbed areas around structures and other graded locations will be seeded with an appropriate conservation seed mixture and/or mulched to stabilize the soils in accordance with applicable regulations. Temporary erosion control devices will be removed following the stabilization of disturbed areas. Pre-existing drainage patterns, ditches, roads, walls, and fences will generally be restored to their former condition.

3.4.8 Environmental Compliance and Monitoring

Throughout the entire construction process, the services of an environmental monitor will be retained. The primary responsibility of the monitor will be to confirm compliance with federal, state, and local permit requirements and National Grid company policies. The environmental monitor will be a trained environmental scientist responsible for supervising construction activities relative to environmental issues. The environmental monitor will be experienced in the erosion control techniques described in this report and will have an understanding of wetland resources to be protected.

At regular intervals and during periods of prolonged precipitation, the monitor will inspect all locations to determine that the environmental controls are functioning properly and to make recommendations for correction or maintenance, as necessary. In addition to retaining the services of an environmental monitor, the construction contractor will be required to designate an individual to be responsible for the daily inspection and upkeep of environmental controls. This person will also be responsible for providing direction to the other members of the construction crew regarding matters such as wetland access and appropriate work methods. Installation and repair of BMPs and other compliance issues are tracked on an inspection form or action log that is updated and distributed weekly to appropriate personnel. Additionally, all construction personnel will be briefed on Project environmental issues and obligations prior to the start of construction. Regular construction progress meetings will reinforce the contractor's awareness of these issues.

3.4.9 Construction Traffic

Construction-related traffic will occur over the term of the construction period. Access to the ROW for construction equipment will typically be gained from public roadways crossed by the ROW in various locations along the route. Because each of the construction tasks will occur at different times and locations over the course of the Project, traffic will be intermittent at these entry roadways. Traffic will consist of various vehicle types ranging from pick-up trucks to heavy construction equipment. Traffic impacts are expected to be negligible.

TNEC will coordinate closely with the RIDOT to develop acceptable traffic management plans for work within state highways. TNEC will coordinate with local authorities for work on local streets and roads. At locations where construction equipment must be staged in a public way, the contractor will follow a pre-approved work zone traffic control plan.

3.5 Right-of-Way Maintenance

As is the present case, vegetation along the ROW will continue to be managed in order to provide clearance between vegetation and electrical conductors and supporting structures so that safe, reliable delivery of power to consumers is assured, and provide access for necessary inspection, repair, and maintenance of the facility.

All vegetation maintenance is carried out in strict accordance with TNEC's "ROW Vegetation Management Policies and Procedures," the requirements of the Rhode Island Department of Environmental Management (RIDEM) Division of Agriculture, and federal regulations as administered by the Environmental Protection Agency.

National Grid manages vegetation on its ROWs through integrated procedures combining removal of danger trees, hand cutting, targeted herbicide use, mowing, selective trimming and side trimming. Three methods of targeted herbicide treatments are utilized: basal application, cut stump treatment, and foliar application.

The appropriate method of National Grid vegetation management is chosen by a National Grid forester or arborist in accordance with TNEC's vegetation management policy. The long-term vegetation maintenance of the ROW will continue to be accomplished by hand and mechanical cutting and the selective application of herbicides where necessary. Herbicides will continue to be applied by licensed applicators to select target species. Herbicides are never applied in areas of standing water or within proximity to residences, within designated protective buffer areas associated with wells, surface waters, and agricultural areas.

3.6 Safety and Public Health Considerations

The reconductored J16 Line will be designed, built, and maintained so that the health and safety of the public are protected. This will be accomplished through adherence to all applicable regulations, and industry standards and guidelines established for the protection of the public. Specifically, the Project will be designed, built and maintained in accordance with the National Electrical Safety Code[4] (NESC). The facilities will be designed in accordance with sound engineering practices using established design codes and guides published by, among others, the Institute of Electrical and Electronic Engineers (IEEE), the American Society of Civil Engineers (ASCE), the American Concrete Institute (ACI), and the ANSI. Practices which will be used to protect the public during construction will include, but not be limited to, establishing traffic control plans for construction traffic on busy streets to maintain safe driving conditions, restricting public access to potentially hazardous work areas, and use of temporary guard structures at road and electric line crossings to prevent accidental contact with conductors during installation.

Following construction of the facilities, all transmission structures will be clearly marked with warning signs to alert the public of potential hazards if climbed or entered.

A discussion of the current status of the health research relevant to exposure to electric and magnetic fields (EMF) is attached as Appendix A. This report was prepared by Exponent.

3.7 Project Costs

National Grid prepared a planning grade estimate of the costs associated with the Project. Planning estimates are prepared prior to detailed engineering and are prepared in accordance with National Grid's estimating guidelines. Planning grade estimates are prepared using historical cost data, data from similar Projects, and other stated assumptions of the Project engineers. The accuracy of planning estimates is expected to be ± 25 percent. Estimated costs include costs of materials, labor and

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4 The NESC is an American National Standards Institute (ANSI) standard which covers basic provisions for the safeguarding of persons from hazards arising from the installation, operation, or maintenance of (1) conductors and equipment in electrical supply stations, and (2) overhead and underground electric supply and communication lines. It also includes work rules for the construction, maintenance, and operation of electric supply and communication lines and equipment.

equipment, and escalation. The estimated capital cost of the Project is $4.08 million. This estimate includes all materials, labor and equipment for the Project.

Annual operation and maintenance activities for transmission lines include periodic ROW vegetation management, helicopter patrol, and miscellaneous route inspections. Since the J16 Line is an existing line and the ROW has other existing transmission lines within it, any increase in operation and maintenance costs will be minimal.

3.8 Project Schedule

It is necessary to take a transmission line out of service while it is being reconductored. TNEC anticipates starting the Project in October of 2015 with completion by the summer of 2016. This schedule is based on estimates of the duration of Project permitting, detailed engineering, materials acquisition, scheduling of outages and construction.

3.9 Project Outreach

Community outreach efforts for the Project include individual abutter contacts and briefings for municipal officials, as described below.

3.9.1 Abutter Contacts

TNEC has conducted a detailed ROW audit to identify residences within 200 feet of the ROW. Prior to construction, abutters within 200 feet of the ROW will be sent fact sheets describing the Project need, location and anticipated construction schedule. The fact sheet will also include the direct contact number for the TNEC Stakeholder Specialist assigned to the Project. Additional meetings will be arranged with abutters who contact the Stakeholder Specialist with specific questions and/or concerns.

3.9.2 Municipal Briefings

TNEC met with municipal officials from the City of Woonsocket and Town of Cumberland to brief them on the Project. These meetings were held in December, 2014 and February, 2015.

4.0 Alternatives to the Proposed Action

4.1 Introduction

Foremost in the development of the Project was TNEC's desire to ensure that the plan selected to meet the electrical system need is most appropriate in terms of cost and reliability, and that environmental and social impacts are minimized to the fullest extent possible. Alternatives to the Project have been evaluated to ensure that these objectives are met.

In this section of the Report, alternatives to the proposed action are discussed and analyzed, including the "Do Nothing" alternative, the non-transmission alternative, and the preferred "reconductoring of the existing J16 Line".

4.2 "Do Nothing" Alternative

The "Do Nothing" option would be to continue operating the existing electrical transmission system without reconductoring the J16 Line. Doing nothing will not address the incremental thermal issues as a result of loading Highland Park Substation to the projected design capacity. If the incremental thermal issues are not resolved, then the needed load relief at Riverside and Staples Substations will not occur since ISO-NE will not allow Highland Park Substation to be loaded to a level that triggers the incremental impact.

If the "Do Nothing" option were to be pursued and there was such a contingency condition, the system operator would be forced to drop electric service to customers to avoid overloading conductors. Overloading conductors can lead to annealing, loss of tensile strength, excessive conductor sag, and possible loss of adequate clearances beneath the transmission line.

Because of the potential for a thermal overload, the alternative of continuing to operate the existing system without reconductoring the J16 Line is not an acceptable alternative for maintaining a firm and reliable electric supply to TNEC's customers. If the capacity of this line is not increased, operational flexibility will continue to be limited.

4.3 Non-Transmission Wire Alternatives

Where a transmission need has been identified, a non-transmission wire alternative ("NWA") such as energy efficiency, demand response, distributed generation, or any combination of the same may also be considered as an option to defer the transmission wire solution for a period of time. However, considering NWAs to every wires solution is not practical given the low cost of a large number of potential wires solutions, the magnitude of load relief required in certain situations, the time to acquire NWAs and verify their availability or instances where the issue is poor operating condition of the asset.

TNEC evaluated the potential for a NWA to defer or eliminate the need for the Project. TNEC assessed the feasibility of this approach consistent with the criterion set forth in its Guidelines for Consideration of Non-Wires Alternatives in Transmission and Distribution Planning ("Non-Wires Guidelines"). The Non-Wires Guidelines identify the following criteria to guide transmission planners when determining whether an NWA may be evaluated as an alternative to a wires solution:

1. The need is not based on asset condition;
2. The wires solution, based on engineering judgment, will likely cost more than one million dollars;
3. If load reductions are necessary, then they are expected to be less than 20 percent of the relevant peak load in the area of the defined need; and
4. Start of wires alternative construction is at least 36 months in the future.

TNEC concluded there is no feasible NWA for the Project because TNEC would be unable to acquire NWAs and verify their availability by the start of Project construction, which is scheduled to begin in October 2015.

4.4 Other Alternatives

TNEC examined other alternatives to address the incremental thermal issues. These alternatives included the construction of a new overhead electric transmission line parallel to the existing line on the existing ROW or in a new ROW, or the construction of a new underground transmission line in the ROW or along the public roadway network. These alternatives presented time, cost, and permitting challenges as each alternative required the construction of new transmission infrastructure. For these reasons, it was concluded that a new overhead or underground transmission line was not a viable alternative to the proposed action.

4.5 Reconductor the J16 Line (Preferred)

The preferred alternative of reconductoring the J16 Line between Riverside and Highland Park Substations mitigates the identified N-1 incremental thermal issues in order to be able to load the new Highland Park Substation to its projected loading and allow the needed load relief at Riverside and Staples Substations.

The Do Nothing alternative is not an acceptable means of maintaining a firm and reliable electric supply to TNEC customers. Furthermore, the NWA is not acceptable because TNEC would be unable to acquire NWAs and verify their availability by the start of Project construction.

For these reasons the preferred option involves reconductoring the J16 Line from Riverside Substation to Highland Park Substation.

5.0 Description of the Affected Natural Environment

5.1 Introduction

This section of the Report describes the existing natural environment that may be affected by the Project, both within and surrounding the existing transmission line ROW. As required by the Rules and Regulations of the EFSB, a detailed description of the environmental characteristics within and immediately surrounding the Project has been prepared. The following section describes the specific natural features which have been assessed for the evaluation of impacts and the preparation of mitigation measures. Information pertaining to existing site conditions was obtained through available published resource information, the Rhode Island Geographic Information System (RIGIS) database, various state and local agencies, and field investigations of the ROW.

This chapter describes the existing environmental conditions in the Project corridor. The following sections describe the soils, surface waters, groundwater, plant communities, wetlands, and wildlife characterizing the Project area. These environmental features and how each will be potentially affected by the Project will be further discussed in the impact and mitigation sections of this Report. As permitted by EFSB Rule 1.6(f), several environmental factors (e.g., geology, air quality, climate and weather) have not been addressed by this document, since the Project will have no potential to impact them.

5.2 Project Study Area

A Project study area was established to accurately assess the existing environment within and immediately surrounding the ROW. This study area consists of a 2,000 foot wide corridor centered on the existing ROW (see Figure 5-1) (the "Study Area"). The boundaries of this corridor were determined to allow for a detailed inventory of existing conditions within and adjacent to the ROW.

The 2.2-mile long Project corridor is characterized by gently sloping terrain that closely follows the banks of the Blackstone River along the western portion of the Project to steeper and hillier terrain in the eastern portion of the Project. In the western portion of the Project corridor, elevations of 150-200 feet mean sea level (msl) are present, as indicated by the United States Geological Survey (USGS) mapping[5] for this area. The highest lands (approximate elevation of 370 feet msl) in the Project corridor are in the vicinity of Mendon Road and Park East Drive west of the Woonsocket/Cumberland municipal boundary. The lowest elevations in the Project corridor (100 feet msl) are found in the areas proximate to the Blackstone River.

Land use along the ROW includes a mix of residential, institutional, transportation, industrial, commercial and open space land uses. The western portion of the Project corridor occurs adjacent the Blackstone River and then crosses Hamlet Avenue (Route 122), parallels the Blackstone River and Woonsocket Wastewater Treatment Plant and then crosses Cumberland Hill Road (Route 122), Mendon Road, Park Drive, Dudley Street and Park East Drive and terminates at the Woonsocket/Cumberland municipal boundary northwest of the Highland Park Substation in Cumberland, Rhode Island.

5.3 Soils

Detailed information concerning the physical properties, classification, agricultural suitability, and erodibility of soils in the vicinity of the ROW are presented in this section. Descriptions of soil types identified within the ROW and Study Area were obtained from the Natural Resources Conservation Service (NRCS) Web Soil Survey[6], the Soil Survey of Rhode Island (Rector, 1981), and from on-site investigations conducted by VHB. The Survey delineates map units that may consist of one or more soil series and/or miscellaneous non-soil areas that are closely and continuously associated on the landscape. In addition to the named series, map units include specific phase information that describes the texture and stoniness of the soil surface and the slope class. A total of 10 named soil series have been mapped within the Study Area. Table 5-1 lists the characteristics of the 16 soil phases (lower taxonomic units than series) found within the Study Area. Figure 5-2 depicts soil classes grouped by erodibility hazard as well as hydric soils.

Table 5-1 Characteristics of Soil Phases within the Study Area

Soil Map Unit Symbol	Soil Phase	Drainage Class	Percent Slope
CeC	Canton and Charlton fine sandy loams, very rocky	wd	3 to 15
CaD	Canton-Charlton-Rock outcrop complex	wd	15 to 35
CB	Canton-Urban land complex	wd	0 to 15
CC	Canton-Urban land complex, very rocky	wd	0 to 15

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5 http://store.usgs.gov/b2c_usgs/usgs/maplocator/(ctype=areaDetails&xcm=r3standardpitrex_prd&carea=%24ROOT&layout=6_1_61_48&uiarea=2)/.do

6 Soil Survey Staff, Natural Resources Conservation Service, United States Department of Agriculture. Web Soil Survey. Available online at http://websoilsurvey.nrcs.usda.gov/. Accessed [July 25, 2013].

Soil Map Unit Symbol	Soil Phase	Drainage Class	Percent Slope
ChB	Canton and Charlton very fine sandy loam	wd	3 to 8
ChC	Canton and Charlton very stony fine sandy loam	wd	8 to 15
ChD	Canton and Charlton very stony fine sandy loams	wd	15 to 25
Du	Dumps	-	-
HkC	Hinckley gravelly sandy loam, rolling	ed	3 to 15
HkD	Hinckley gravelly sandy loam, hilly	ed	15 to 35
MU	Merrimac-Urban land complex	mwd	0 to15
Rf	Ridgebury, Whitman & Leicester ex. stony fine sandy loam	pd-vpd	0 to 3
SwA	Swansea mucky peat	vpd	0 to 2
Ur	Urban land	mwd-sed-wd	0 to 10
UD	Udorthents-Urban land complex	mwd -wd	0 to 15
Wa	Walpole sandy loam	pd	0 to 3

Source: NRCS Web Soil Survey.
Notes: ed = excessively drained
swed = somewhat excessively drained
wd = well drained
mwd = moderately well drained
pd = poorly drained (hydric)
vpd = very poorly drained (hydric)
8-15 percent slope = highly erodible

5.3.1 Prime Farmland Soils

Prime farmland, as defined by the United States Department of Agriculture (USDA), is the land that is best suited to producing food, feed, forage, fiber, and oilseed crops. It has the soil quality, growing season, and moisture supply needed to economically produce a sustained high yield of crops when it is treated and managed using acceptable farming methods.

Rhode Island recognizes 34 prime farmland soils[7]. Prime farmland soils could be utilized as cropland, pastureland, rangeland, forestland, or other land. Urbanized land and water are exempt from consideration as prime farmland. There are no prime farmland soils occurring within the Study Area.

5.3.2 Farmland of Statewide Importance

Farmland of statewide importance is land that is designated by the Rhode Island Department of Administration Division of Planning to be of statewide importance for the production of food, feed, fiber, forage, and oilseed crops. Generally, farmlands of

7 USDA Natural Resources Conservation Service. 2012. Prime and Other Important Farmlands, State of Rhode Island:

statewide importance include those lands that do not meet the requirements to be considered prime farmland, yet they economically produce high crop yields when treated and managed with modern farming methods. Some may produce as high a yield as prime farmland if conditions are favorable.

In order to extend the additional protection of state regulation to prime farmland, the State of Rhode Island has expanded its definition of farmland of statewide importance to include all prime farmland areas. Therefore, in Rhode Island, all USDA-designated prime farmland soils are also farmland of statewide importance.

Table 5-2 lists soil units designated as farmland soils of statewide importance that occur within small portions of the Study Area.

Table 5-2 Farmland Soils of Statewide Importance within the Study Area

Soil Map Unit Symbol	Name	Percent Slope
HkC	Hinckley gravelly sandy loam	3 to 15
Wa	Walpole sandy loam	0 to 3

Source: USA Natural Resource Conservation Service, 2012. Prime and Other Important Farmlands of Rhode Island.

5.3.3 Potentially Erosive Soils

The erodibility of a soil is dependent upon the slope of the land occupied by the soil and the texture of the soil. NRCS has characterized soil map units, as "highly erodible", "potentially highly erodible" or “not highly erodible” due to sheet and rill erosion. This determination is done by using the Universal Soil Loss Equation (USLE). The USLE relates the effects of rainfall, soil characteristics, and the length and steepness of slope to the soil's tolerable sheet and rill erosion rate (see Figure 5-2).

Soils are applied an erodibility factor (K), which is a measure of the susceptibility of the soil to erosion by water. Soils having the highest K values are the most erodible. K values in Rhode Island range from 0.10 to 0.64 and vary throughout the depth of the soil profile with changes in soil texture. Very poorly drained soils and certain Floodplain soils usually occupy areas with little or no slope. Therefore, these soils are not subject to erosion under normal conditions and are not given an erodibility factor. Soil map units described as strongly sloping or rolling may include areas with slopes greater than eight percent and soil map units with moderate erosion hazard are listed in Table 5-3.

Table 5-3 Soil Mapping Units with Potential Steep Slopes within the Study Area

Soil Map Unit Symbol	Soil Phase	Percent Slope	Erodibility Hazard	Surface K Values
CaD	Canton-Charlton-Rock Outcrop Complex	15 to 35	Hel	0.17-0.24
CeC	Canton and Charlton fine sandy loams, very rocky	3 to 14	Phel	0.17-0.24
ChB	Canton and Charlton-very stony fine sandy loams	3 to 8	Phel	0.17-0.24
ChC	Canton and Charlton very stony fine sandy loams	8 to 15	Hel	0.20-0.24
ChD	Canton and Charlton very stony fine sandy loams	15 to 25	Hel	0.20-0.24
HkC	Hinckley gravelly sandy loam, rolling	3 to 15	Phel	0.17
HkD	Hinckley gravelly sandy loam, hilly	15 to 35	Hel	0.17

Source: Soil Survey of Rhode Island (Rector, 1981) and United States Department of Agriculture, Natural Resources Conservation Service, Highly Erodible Soil Map Units of Rhode Island, Revised January 1993.

Notes: hel = highly erodible land
phel = potentially highly erodible land

5.4 Surface Water

The Project lies within the Blackstone River drainage basin of Rhode Island. A drainage basin is the area of land that drains water, sediment, and dissolved materials to a common outlet at some point along a stream channel[8] and is synonymous with watershed. Within the Blackstone River drainage basin are numerous subordinate watersheds associated with river systems. The Blackstone River Basin is located in south-central Massachusetts and northern Rhode Island and has a length of about 48 miles and an average width of about 12 miles[9]. The Blackstone River flows south from Worcester, MA to the Main Street Dam in Pawtucket, RI where it becomes the headwater for the Seekonk River. The Blackstone River is the second largest source of freshwater to Narragansett Bay and the total drainage area is 454 square miles. Primary tributaries to the Blackstone River in Rhode Island are the Branch River, Mill River, Peters River, and Abbot Run Brook.

The waters of the State of Rhode Island (meaning all surface water and groundwater of the State) are assigned a Use Class which is defined by the most sensitive, and therefore governing, uses which it is intended to protect. Waters are classified according to specific physical, chemical and biological criteria which establish

8 Dunne, T. and L.B. Leopold. 1978. Water in Environmental Planning. W.H. Freeman and Company, New York.
9 Rhode Island Department of Environmental Management, Office of Water Resources. February 2013. Total Maximum Daily Load Analysis for Blackstone River Watershed: Pathogen and Trace Metal Impairments, Final Report.

parameters of minimum water quality necessary to support the water Use Classification. The water quality classification of the major surface waters within the Study Area are identified in the descriptions of the water courses that follow. Classification and use of all water courses within the Study Area are presented in Table 5-4.

The ROW is located adjacent to the Blackstone River in the western portion of the Project corridor and the eastern portion is drained by waterways that flow west and southwest into the Blackstone River. Figure 5-3 depicts surface waters within the Study Area.

Pursuant to the requirements of Section 305(b) of the Federal Clean Water Act, water bodies which do not support their designated uses in whole or in part are considered impaired, and placed on the Clean Water Act, Section 303(d) List of Impaired Waters or have a total maximum daily load (TMDL) assessment where they are prioritized and scheduled for restoration. The causes of impairment are those pollutants or other stressors that contribute to the actual or threatened impairment of designated uses in a water body. Causes include chemical contaminants, physical parameters, and biological parameters. Sources of impairment are not determined until a TMDL assessment is conducted on a water body. Three impaired waters are located within the Study Area: Blackstone River, Mill River, and Peters River (Table 5-5). TMDLs have been approved for the pathogens and trace metal impairments for the Blackstone River and Peters River, and the Mill River has an approved TMDL for pathogens.

Table 5-4 Surface Water Resources within the Study Area

Water Body Name	City	Approximate Location	Use Classification
Blackstone River	Woonsocket	100 feet north of Truman Drive	B1
Mill River (Tributary to the Blackstone River)	Woonsocket	550 feet west of Cumberland Street	B
Peters River (Tributary to the Blackstone River)	Woonsocket	750 feet northwest of Cumberland Street	B

Classification	Use
A	Public drinking water supply, no treatment.
B	Public drinking water supply with appropriate treatment; agricultural uses; bathing, other primary contact recreational activities; fish and wildlife habitat
B1	Class B1 waters have the same designated uses as class B waters. However, the primary contact recreation may be impacted by pathogens from approved wastewater facilities (i.e. Woonsocket WWTP)
Source:	R.I. Department of Environmental Management. Water Quality Regulations (December 2010). R.I. Department of Environmental Management. State of Rhode Island 2012 303(d) List of Impaired Waters Final (August 2012)

Table 5-5 Impaired Surface Water Resources within the Study Area

Water Body Name	Impairment	Category
Blackstone River	Pathogens, Cadmium, Lead	TMDL
Blackstone River	Benthic Macroinvertebrate Bioassessments, Dissolved Oxygen, Total Phosphorous, Mercury in Fish Tissue, PCB in Fish Tissue	5
Mill River	Pathogens	TMDL
Peters River	Pathogens, Copper	TMDL

Category	Explanation
TMDL	TMDL developed for pathogens/bacteria impairments and approved by United States Environmental Protection Agency (EPA).
5	Impaired or threatened for one or more designated uses by a pollutant(s), and requires a TMDL. This Category constitutes the 303(d) List of waters impaired or threatened by a pollutant(s) for which one or more TMDL(s) are needed.
Source:	R.I. Department of Environmental Management. State of Rhode Island 2012 303(d) List of Impaired Waters, Final August 2012.

5.4.1 Blackstone River Watershed

The Blackstone River Basin drains an area of approximately 454 square miles and is located in south-central Massachusetts and northern Rhode Island. The Blackstone River falls within the Study Area and is the second largest source of freshwater to Narragansett Bay. The Blackstone River originates in Worcester, MA and flows south to Main Street Dam in Pawtucket, RI. At this point, the Blackstone River becomes the headwater for the Seekonk River, which is a tidal estuary that flows for approximately seven miles before combining with the Providence River. Elevations within the Blackstone River Watershed range from sea level at the drainage outlet in Upper Narragansett Bay to 1,300 feet above sea level where it originates on the slopes of

Asnebumskit Hill in Massachusetts[10]. The Woonsocket Wastewater Treatment Plant, which serves the city of Woonsocket as well as the towns of North Smithfield, RI and Blackstone, MA is situated between the banks of the Blackstone River and Cumberland Hill Road (Route 122). The Blackstone River is a RIDEM Use Class B1 waterway. Class B1 waters meet the same designation as Class B waters, which state that these waters are designated for fish and wildlife habitat and primary and secondary contact recreational activities. Class B1 waters shall be suitable for compatible industrial processes and cooling, hydropower, aquacultural uses, navigation, and irrigation and other agricultural uses. These waters shall have good aesthetic value. The conditions of a B1 classification caution that primary recreational activities may be impacted due to pathogens from approved wastewater discharges. Two of the river's primary tributaries, Peters and Mill Rivers, also fall within the Study Area. The following is a brief description of the characteristics of each tributary.

5.4.1.1 Mill River

The Mill River watershed consists of approximately 35 square miles and extends from its headwaters in Mill Pond in Hopkinton, MA to northern Woonsocket.[11] The river itself spans 11 miles. The drainage area is characterized by open land and low-density residential development, with limited areas of high-density urban development. The watershed is an area which has experienced a large amount of growth over the past decades as a result of convenient access to Routes 90 and 495. The Mill River is culverted for approximately 900 feet before it empties into the Blackstone River south of the intersection of Clinton Street and John E. Cummings Way in the Social Flatlands area of the City of Woonsocket. A small area of deciduous wetlands and shrub swamp is associated with the Mill River south of Privilege Street in Woonsocket. Mill River is classified by the RIDEM as a Class B water.

5.4.1.2 Peters River

The Peters River originates in the northern section of the Town of Bellingham, MA, and outlets into a 1,200 foot long culvert at Elm Street in Woonsocket, where it empties into the Blackstone River. The Peters River watershed is approximately 12 square miles, of which less than 10 percent is in Rhode Island. The Wood Estate is a 23-acre conservation area comprised mainly of deciduous wetlands, and emergent marsh/wet meadow which abuts the Peters River south of Diamond Hill Road in Woonsocket, RI.

10 Rhode Island Rivers Council. Blackstone River Watershed. Available online at: http://www.ririvers.org/wsp/Watersheds/BlackstoneRiverWatershed.htm. Accessed [October 6, 2014].
11 City of Woonsocket, Rhode Island 2012 Comprehensive Plan.

5.4.2 Floodplain

The 100-year Floodplain represents the extent of flooding that would result during a storm event having a one percent chance of occurring per year. Based on available Federal Emergency Management Agency (FEMA) mapping for Woonsocket, portions of the ROW that are adjacent to the Blackstone River occurs within an area designated 100-year (Zone A) frequency Floodplain. The nearby Woonsocket Middle School and the Woonsocket Wastewater Treatment Plant are mapped within the 500-year Floodplain. The unnamed watercourse within the ROW between Structure nos. 144 and 145 may also contain 100 year Floodplain though not mapped by FEMA.

5.5 Groundwater

The presence and availability of groundwater resources is a direct function of the geologic deposits in the area. Within the portion of the Study Area overlying deep stratified drift deposits outside of the urban city center, groundwater resources have the highest potential yield and quality, and thus are given the highest classification (Class GAA). These groundwater resources are presumed suitable for public drinking water use without prior treatment. None of the ROW and less than five percent of the Study Area are located within areas classified as GAA by the RIDEM, Groundwater Division.

The portion of the Study Area east of Cumberland Hill Road is located within areas classified as GA. Groundwater classified GA is also presumed suitable for public or private drinking water use without prior treatment, however, the potential yield of this resource is less than that of Class GAA due to the nature of the surrounding geologic deposits (glacial till and bedrock). Both GAA and GA classes are subject to the same groundwater quality standards and preventative action limits for organic and inorganic chemicals, microbiological substances and radionuclides. Groundwater resources within the Study Area are depicted in Figure 5-3.

Groundwater classified GB are those groundwater resources which may not be suitable for public or private drinking water use without treatment due to known or presumed degradation resulting from overlying land uses. Class GC groundwater is known to be unsuitable for drinking water use due to waste disposal practices such as landfills. Class GB and GC areas are served by a public water supply. The portion of the Study Area west of Cumberland Hill Road is within the more densely developed portion of the City and the groundwater in these areas is classified as GB. No GC classified areas are within the Study Area.

5.5.1 Sole Source Aquifers

The EPA defines a sole source aquifer as an aquifer that supplies at least 50 percent of the drinking water consumed in the area overlying the aquifer.[12] The sole source aquifer designation is a tool used to protect drinking water supplies in areas where there are few or no alternatives sources to the groundwater resource.[12] There are no Sole Source Aquifers identified within the Study Area.

5.6 Vegetation

The Study Area contains a variety of vegetative cover types typical of southern New England. These types include oak/pine forest (greater than 80 percent hardwood), old field and managed lawn. This section of the report focuses on upland communities. Wetland communities are discussed in Section 5.7 of this report.

5.6.1 Oak/Pine Forest Community

The forested habitats located within the Study Area are dominated by an oak/pine/hemlock canopy, a habitat commonly associated with Northeastern coastal and interior pine-oak forests.[13] This system occurs over broad areas and most of it is in early to mid-successional stages and heavily fragmented. This type of forested habitat may be more widespread today as a result of human occupation and changes in the New England landscape. Although these woodlands appear similar throughout, differences in the tree and shrub communities occur between sites. Precipitation and aspect are important factors in determining what vegetation a particular site will support. Hilltops and south facing slopes are often deficient in the amount of soil moisture available to the plant community. In summer, when the moisture requirements of plants are highest, hilltops become substantially drier than sites farther down slope. The trees growing on hilltops, therefore, are more tolerant of dry conditions, smaller, more widely spaced and are a different species composition than those on more favorable sites. Red oak (*Quercus rubra*) (with mixtures of other oaks) and white pine (*Pinus strobus*) generally occur on outwash soils and sandy till hills in the Study Area. Oak/pine forest also occurs on shallow-to-bedrock nutrient poor soils in the vicinity of the ROW. Hemlock tends is often more abundant in moister settings.

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12 Environmental Protection Agency. Sole Source Aquifer Protection Program. Available online at: http://water.epa.gov/infrastructure/drinkingwater/sourcewater/protection/solesourceaquifer.cfm Accessed [October 7, 2014].

13 Anderson, M.G., M. Clark, C.E. Ferree, A. Jospe, O. Sheldon, and K.J. Weaver. 2013. Northeast Habitat Guides: A companion to the terrestrial and aquatic habitat maps. The Nature Conservancy, Eastern Conservation Science, Eastern Regional Office. Boston, MA. http://nature.ly/HabitatGuide

Common associates of the hilltop oak/pine forests in the vicinity of the transmission line ROW include black (*Q. velutina*) scarlet (*Q. coccinea*), and white (*Q. alba*) oaks as well as aspen (*Populus sp*.), and gray birch (*Betula populifolia*). The shrub/sapling understory includes such species as black cherry (*Prunus serotina*), lowbush blueberry (*Vaccinium angustifolium*) and greenbrier (*Smilax rotundifolia*). Sheep laurel (*Kalmia angustifolia*) and sweet fern (*Comptonia peregrina*) occasionally occur under oak stands with canopy openings on rocky slopes. Herbaceous species include bracken fern (*Pteridium aquilinum*), tree clubmoss (*Lycopodium obscurum*) and hay-scented fern (*Dennstaedtia punctilobula*). These hilltop communities occur where excessively drained soils predominate, and on hilltops throughout the Study Area.

There is an increase in the diversity within plant communities on midslopes compared with dry hilltops. The increase in soil moisture produces this greater diversity in trees, shrubs and herbs. Midslope tree species in addition to oaks include black birch (*Betula lenta*), white ash (*Fraxinus americana*), American beech (*Fagus grandifolia*) and several species of hickory (*Carya* sp.). Shrubs include witch hazel (*Hamamelis virginiana*), sassafras (*Sassafras albidum*) and ironwood (*Carpinus caroliniana*). Greenbrier and poison ivy (*Toxicodendron radicans*) are also common in this community. Common groundcover species include tree clubmoss and wintergreen (*Gaultheria procumbens*). Midslope oak/pine communities occur on cool north facing slopes and adjacent to forested wetlands on the uncleared portion of the ROW.

5.6.2 Old Field Community

Vegetation within the cleared portions of the ROW is typically representative of an old field successional community. Old field communities are established through the process of natural succession from cleared land to mature forest. Within the cleared ROW, periodic vegetation management has favored the establishment and persistence of grasses and herbs. Over time, pioneer woody plant species including gray birch, black cherry, sumac (*Rhus* sp.) and eastern red cedar (*Juniperus virginiana*) have become established.

Within the cleared portions of the ROW, vegetation varies considerably. On dry hilltops, little bluestem (*Schizachyrium scoparium*), round-head bushclover (*Lespedeza capitata*), staghorn sumac (*Rhus typhina*) and eastern red cedar are common. On the mid-slope, greenbrier and blackberry (*Rubus* sp.) form dense, impenetrable thickets. Numerous herbs including goldenrod (*Solidago* sp.), aster (*Aster* sp.), pokeweed (*Phytolacca americana*), and mullein (*Verbascum thapsus*) are also common.

5.6.3 Managed Lawn

Portions of the cleared ROW are managed residential lawn. Typically these areas consist of a continuous grass cover which may include Kentucky bluegrass, red fescue, clover, and plantains. Ornamental shrubs may also occur within these areas.

5.6.4 Agricultural Areas

Based on the existing land use mapping obtained from the RIGIS, the J16 Line does not cross any areas of agricultural use and no agricultural areas occur within the Study Area.

5.7 Wetlands

Wetlands are resources which potentially provide ecological functions and societal values. Wetlands are characterized by three criteria including the (i) presence of undrained hydric soils, (ii) a prevalence (>50 percent) of hydrophytic vegetation, and (iii) wetland hydrology, soils that are saturated near the surface or flooded by shallow water during at least a portion of the growing season.

5.7.1 Study Area Wetlands

State-regulated freshwater wetlands and/or streams were delineated within the ROW and are shown on Figure 5-4. Those wetlands outside of the ROW and within the Study Area are based on available RIGIS data and are also shown on Figure 5-4. Field methodology for the delineation of State-regulated resource areas within the ROW was based upon vegetative composition, presence of hydric soils and evidence of wetland hydrology. The Project ROW contains shrub swamp, shrub wetland, and emergent wetland plant communities as further described below.

Based on the provisions of the Rhode Island Fresh Water Wetlands Act and Rules and Regulations Governing the Administration and Enforcement of the Freshwater Wetlands Act (RIDEM 2014) (the "Rules"), state-regulated fresh water wetlands include swamps, marshes, bogs, forested or shrub wetlands, emergent plant communities and other areas dominated by wetland vegetation and showing wetland hydrology. Swamps are defined as areas at least three acres in size, dominated by woody vegetation, where groundwater is at or near the ground surface for a significant part of the growing season. Marshes are wetlands at least one acre in size where water is generally above the surface of the substrate and where the vegetation is dominated by emergent herbaceous species. No bogs are known to occur within the Study Area. Emergent plant communities are areas similar to marshes in vegetation composition; however, there is no size criteria. Forested and shrub wetlands are similar to swamps, but do not meet the three acre size criteria.

The upland area within 50 feet of the edge of a swamp, marsh or bog is regulated as the 50-foot Perimeter Wetland under the Rules. Emergent plant communities, forested wetlands and shrub wetlands do not merit a 50-foot Perimeter Wetland.

In addition to these vegetated wetland communities, Rhode Island also regulates activities in and around streams and open waterbodies which include Rivers, Streams, Ponds, Areas Subject to Storm Flowage (ASSF), Areas Subject to Flooding (ASF) and Floodplain. A river is any perennial stream indicated as a blue line on a USGS topographic map. If the river is less than 10 feet wide, the area within 100 feet of each bank is regulated as 100 foot Riverbank Wetland. If the river is greater than 10 feet wide, the area within 200 feet of each bank is regulated as 200 foot Riverbank Wetland.

A pond is an area of open standing or slow moving water present for six or more months during the year and at least one quarter acre in size. Ponds have a 50 foot Perimeter Wetland associated with the boundary. An ASSF is defined as any body of flowing water as identified by a scoured channel or change in vegetative composition or density that conveys storm runoff into or out of a wetland.

The following wetland types are located in the Study Area with more descriptions as provided in the subsections below: Swamp, Marsh, Shrub/Forested Wetland, Emergent Plant Community, Special Aquatic Site, Pond, River, Stream/intermittent stream, Area Subject to Storm Flowage, and Floodplain.

5.7.1.1 Pond

No ponds are located within the ROW. Sylvestre Pond within Cass Park is located approximately 450 feet north of the ROW in the vicinity of the Hamlet Avenue Bridge in Woonsocket and occurs within the Study Area.

5.7.1.2 Swamp

Shrub Swamps are areas dominated by broad-leaved deciduous shrubs and have an emergent herbaceous layer. Dominant species include sweet pepperbush (*Clethra alnifolia*), highbush blueberry (*Vaccinium corymbosum*), winterberry (*Ilex verticillata*), and swamp azalea (*Rhododendron viscosum*). Other species occurring in these swamps include arrowwood (*Viburnum dentatum*), and silky dogwood (*Cornus amomum*). Drier portions of shrub swamps are often densely overgrown with wild grape (*Vitus labrusca*) and greenbrier. Common species in the herbaceous layer include cinnamon fern, sensitive fern (*Onoclea sensibilis*), poison ivy (*Toxicodendron radicans*), and dewberry (*Rubus hispidus*). The Shrub Swamp primarily occurs in the eastern portion of the ROW.

Forested Swamps mainly occur on the edges of the maintained ROW where the Shrub Swamps are present. Vegetation in a Forested Swamp is comprised of red maple, willow (*Salix* sp.), black gum (*Nyssa sylvatica*), alder (*Alnus* sp.), silky dogwood, sweet pepperbush, winterberry, swamp azalea, cinnamon fern (*Osmunda cinnamomea*), common reed (*Phragmites australis*), and peat moss (*Sphagnum* sp.).

5.7.1.3 Marsh

Marsh vegetation is typically dominated by broad-leaved cattail (*Typha latifolia*) and tussock sedge (*Carex stricta*), with lesser amounts of common reed, sensitive fern, marsh fern (*Thelypteris palustris*), soft rush (*Juncus effusus*), and woolgrass (*Scirpus cyperinus*). Marsh is the dominant cover type in the large wetland system associated with a backwater area of the Blackstone River south of and outside the ROW, and within the Study Area.

5.7.1.4 River

A River is a body of water designated as a perennial stream by the US Geologic Survey (a blue line stream on a USGS topographic map). Rivers located within the Study Area are the Blackstone River, Peters River and Mill River.

5.7.1.5 Stream/Intermittent Stream

A stream is any flowing body of water or watercourse other than a river which flows during sufficient periods of the year to develop and maintain defined channels. Such watercourses carry groundwater discharge and/or surface runoff. Such watercourses may not have flowing water during extended dry periods but may contain isolated pools or standing water. Streams and intermittent streams within the Study Area include unnamed tributaries to the Blackstone River. The ROW crosses one intermittent stream in the easern portion of the ROW near the Highland Park Substation.

5.7.1.6 Emergent Plant Community

Emergent plant communities within the ROW are characterized by cattail, bulrush (*Scirpus pungens*), blue joint (*Calamagrostis canadensis*), woolgrass (*Scirpus cyperinus*), meadowsweet, Joe-Pye weed (*Eupatorium dubium*), sensitive fern (*Onoclea sensibilis*), soft rush, and reed canary grass (*Phalaris arundinacea*). EPCs are primarily located in the Blackstone Canal portions of the ROW.

5.7.1.7 Shrub/Forested Wetland

Shrub wetlands in the transmission line ROW are dominated by highbush blueberry, sweet pepper bush, arrowwood, spicebush, winterberry, greenbrier and cinnamon fern with minor amounts of skunk cabbage and poison ivy. The wetlands within the ROW west of Mendon Road classify as shrub wetland.

Forested wetlands occur at the edge of the maintained ROW where most shrub wetlands are present. Vegetation includes red maple, yellow birch (*Betula alleghaniensis*) and ash with an understory generally consisting of vegetation mentioned previously in the shrub wetland.

5.7.1.8 Floodplain

A Floodplain is the land area adjacent to a river or stream or other body of flowing water which is, on the average, likely to be covered with flood waters resulting from a 100-year frequency storm event as mapped by FEMA. Based on available Federal Emergency Management Agency (FEMA) mapping for Woonsocket, portions of the ROW that are adjacent to the Blackstone River occurs within an area designated 100-year (Zone A) frequency Floodplain. The Floodplain areas within the ROW are also described in Section 5.4.2.

5.7.1.9 Area Subject to Storm Flowage

ASSFs are channel areas and water courses which carry storm, surface, groundwater discharge or drainage waters out of, into, and/or connect freshwater wetlands or coastal wetlands. ASSFs are recognized by evidence of scouring and/or a marked change in vegetative density and/or composition. Two ASSFs were identified in the ROW, one is located east of Cumberland Hill Road and the other is west of the wastewater treatment plant.

5.7.1.10 Special Aquatic Site

A Special Aquatic Site (vernal pool) is a contained basin that lacks a permanent above ground outlet. It fills with water with the rising water table of fall and winter or with the meltwater and runoff of winter and spring snow and rain. Special aquatic sites contain water for a few months in the spring and early summer. No Special Aquatic Sites were observed in the ROW.

5.8 Wildlife

As previously described, the ROW passes through a variety of aquatic and terrestrial habitats. The wildlife assemblages present within the Study Area vary according to habitat characteristics. An overall list of wildlife species expected to occur within the transmission line ROW was compiled. This list encompasses the major habitats encountered within the ROW. It should be noted that individual species may not occur in one particular area as opposed to another, but may be found in the general area of the transmission line. A list of amphibian, reptiles, birds and mammals expected to occur within a given habitat are provided in Table 5-7. This information is based on geographical distribution and habitat preferences as described in New England Wildlife: Habitat, Natural History and Distribution (DeGraaf and Yamasaki, 2001).

Table 5-7 Expected and Observed Wildlife Species

	Terrestrial Habitats		Aquatic Habitats					
	Oak/Pine Forest	Old Field	Bog	Shallow Marsh	Shrub Swamp	Forested Wetland	River	Stream
AMPHIBIANS AND REPTILES								
Spotted Salamander	X				X	X		
Red Spotted Newt	X				X			
Northern Dusky Salamander	X							
Redback Salamander	X		X			X		
Northern Two-Lined Salamander	X		X			X	X	X
Eastern American Toad	X	X		X	X	X		
Fowler's Toad	X					X		
Northern Spring Peeper				X	X	X		
Gray Tree Frog	X		X		X	X		
Bullfrog				X	X	X		
Green Frog				X	X	X	X	X
Wood Frog	X		X	X	X	X		X
Pickerel Frog	X		X			X		X
Common Snapping Turtle	X	X	X	X		X	X	X
Stinkpot		X						
Spotted Turtle		X	X	X	X			
Eastern Box Turtle	X	X				X		
Eastern Painted Turtle						X		
Northern Water Snake			X		X	X	X	
Northern Brown Snake	X				X	X		

Legend:
X = expected to occur; O = observed by VHB. Fall 2014
Source: New England Wildlife: Habitat, Natural History and Distribution (DeGraaf and Yamasaki, 2001

	Terrestrial Habitats		Aquatic Habitats					
	Oak/Pine Forest	Old Field	Bog	Shallow Marsh	Shrub Swamp	Forested Wetland	River	Stream
Eastern Garter Snake	X	X	X		X	X		
Northern Ringneck Snake	X					X		
Northern Black Racer	X	X			X	X		
Eastern Smooth Green Snake		X			X			
Eastern Milk Snake	X		X			X		
BIRDS								
Green Heron				X		X	X	X
Wood Duck				X		X	X	
American Black Duck			X	X		X		
Mallard			X	X	X	X	O	X
Canada Goose		X	X	X	X	X	O	X
Sharp-shinned Hawk	X	X				X		
Red-shouldered Hawk	X				X			
Red-tailed Hawk	O	X				X		
Rough-legged Hawk		X	X					
American Kestrel		X						
Ring-necked Pheasant		X						
Ruffed Grouse	X	X				X		
American Woodcock	X	X			X			
Morning Dove	X	O						
Eastern Screech-Owl	X			X		X		
Great Horned Owl	X	X				X		
Barred Owl	X					X	X	X
Whip-poor-will	X	X				X		
Ruby-throated Hummingbird		X				X		
Downy Woodpecker	O					X		
Hairy Woodpecker	X					X		
Northern Flicker	X					X		
Eastern Wood-Pewee	X					X		
Alder Flycatcher				X				
Willow Flycatcher		X						
Least Flycatcher	X					X		
Eastern Phoebe	X					X		
Great Crested Flycatcher	X							
Eastern Kingbird		X				X		
Tree Swallow		X		X				
Blue Jay	X	O				X		

Legend:
X = expected to occur; O = observed by VHB. Fall 2014
Source: New England Wildlife: Habitat, Natural History and Distribution (DeGraaf and Yamasaki, 2001

	Terrestrial Habitats		Aquatic Habitats					
	Oak/Pine Forest	Old Field	Bog	Shallow Marsh	Shrub Swamp	Forested Wetland	River	Stream
American Crow	X	X						
Black-capped Chickadee	O	X						
Tufted Titmouse	O					X		
Red-breasted Nuthatch	X		X			X		
White-breasted Nuthatch	X					X		
Brown Creeper	X		X			X		
Carolina Wren	X	O						
House Wren	X	X				X		
Blue-gray Gnatcatcher	X	X			X	X		
Eastern Bluebird	X	X						
Veery	X					X		
Hermit Thrush	X	X	X		X	X		
Wood Thrush	X					X		
American Robin	X	O	X		X	X		
Gray Catbird		O	X		X			
Northern Mockingbird		O						
Brown Thrasher	X	X						
Cedar Waxwing	X	X			X			
Northern Shrike		X						
European Starling		O						
Yellow-throated Vireo	X					X		
Warbling Vireo	X					X		
Red-eyed Vireo	X					X		
Blue-winged Warbler		X			X			
Nashville Warbler	X		X		X			
Yellow Warbler	X	X			X			
Chestnut-sided Warbler		X			X			
Yellow-rumped Warbler	X	X			X	X		
Black-throated Green Warbler	X					X		
Pine Warbler	X							
Prairie Warbler		X						
Black & White Warbler	X		X			X		
American Redstart	X					X		
Ovenbird	X					X		
Northern Waterthrush	X		X		X	X	X	X
Common Yellowthroat	X	X	X	X	X	X		
Canada Warbler	X		X		X	X		
Scarlet Tanager	X					X		
Northern Cardinal		X			X		X	X

Legend:
X = expected to occur; O = observed by VHB. Fall 2014
Source: New England Wildlife: Habitat, Natural History and Distribution (DeGraaf and Yamasaki, 2001

	Terrestrial Habitats		Aquatic Habitats					
	Oak/Pine Forest	Old Field	Bog	Shallow Marsh	Shrub Swamp	Forested Wetland	River	Stream
Rose-breasted Grosbeak	X	X				X		
Indigo Bunting	X	X						
Rufous-sided Towhee	X	X						
Chipping Sparrow	X							
Fox Sparrow	X	X			X			
Song Sparrow	X	X			X			
Tree Sparrow		X			X			
Swamp Sparrow			X	X	X			
Field Sparrow		X						
Red-winged Blackbird			X	X	X			
Common Grackle	O		X	X	X			
Brown-headed Cowbird	X					X		
Northern Oriole	X					X		
Purple Finch	X							
House Finch	X							
American Goldfinch			X	X	X	X		
House Sparrow		X						
MAMMALS								
Virginia Opossum	X	X		X	X	X		
Masked Shrew	X	X	X	X	X	X		
Northern Short-tailed Shrew	X	X	X	X	X	X		
Hairy-tailed Mole	X	X				X		
Eastern Mole		X				X		
Star-nosed Mole			X	X	X		X	X
Little Brown Myotis	X	X	X	X	X	X	X	X
Keen's Myotis	X	X	X	X	X	X	X	X
Silver-haired Bat		X	X	X	X		X	X
Eastern Pipistrelle	X	X	X	X	X	X	X	X
Big Brown Bat	X	X	X	X	X	X	X	X
Eastern Cottontail		X		X				
Snowshoe Hare	X		X			X		
Eastern Chipmunk	X	O				X		
Woodchuck	X	O						
Gray Squirrel	X	O				X		
Red Squirrel						X		
Southern Flying Squirrel	X							
White-footed Mouse	X	X	X		X	X		
Southern Red-backed Vole	X	X	X		X	X		

Legend:
X = expected to occur; O = observed by VHB. Fall 2014
Source: New England Wildlife: Habitat, Natural History and Distribution (DeGraaf and Yamasaki, 2001

	Terrestrial Habitats		Aquatic Habitats					
	Oak/Pine Forest	Old Field	Bog	Shallow Marsh	Shrub Swamp	Forested Wetland	River	Stream
Meadow Vole		X	X	X	X			
Woodland Vole	X	X				X		
Muskrat			X	X	X		X	X
House Mouse		X						
Meadow Jumping Mouse		X	X	X				
Red Fox	X	X			X	X		
Gray Fox	X	X			X	X		
Raccoon	X	X	X	X	X	X		
Ermine	X	X			X	X		
Mink	X	X	X	X	X	X	X	X
Striped Skunk	X	X			X	X		
White-tailed Deer	X	O			X	X		

Legend:
X = expected to occur; O = observed by VHB. Fall 2014
Source: New England Wildlife: Habitat, Natural History and Distribution (DeGraaf and Yamasaki, 2001

5.8.1 Rare and Endangered Species

The Rhode Island Natural Heritage Program (RINHP) database hosted on the RIDEM Environmental Resource Mapping website[14] as the "Regulatory Overlays: Natural Heritage Areas" does not identify any rare species habitat polygons within the ROW, therefore, the project is not expected to have any adverse effect on state or federally-designated species.

14 http://www.dem.ri.gov/maps/index.htm

6.0 Description of Affected Social Environment

6.1 Introduction

As part of this application, TNEC is providing information on the land uses within and proximate to the ROW, visual resources in vicinity of the Project, and the public roadway systems in the area. Based on the nature of the Project (reconductoring of existing facilities) and the limited scope of the proposed work, information is not being provided on regional population trends, or employment conditions as permitted by EFSB Rule 1.6(f).

6.2 Land Use

This section describes existing and future land use within the Study Area. The scope of this discussion will address those features which might be affected by the Project.

Land use along the ROW includes a mix of residential, institutional, transportation, industrial, commercial and open space land uses as shown in Figure 6-1. The natural open-water areas in the Study Area are the Blackstone River and its tributaries, the Peters and Mill Rivers. Sylvestre Pond also occurs within the Study Area.

6.2.1 Land Use Along the Transmission Line Corridor

The northwestern terminus of the Project is located at the Riverside Substation in the City of Woonsocket. From the Riverside Substation, the ROW runs along the southwest bank of the Blackstone River, which is local conservation land owned by the City, and passes the Woonsocket Middle School before it crosses the river near Hamlet Avenue (Route 122). From Hamlet Avenue the ROW parallels the east bank of the Blackstone River along the western side of the Woonsocket Wastewater Treatment Plant for approximately 2,000 feet. From this point the ROW continues east crossing Cumberland Hill Road (Route 122) adjacent to a commercial strip mall and residential homes. Proceeding easterly the ROW at Park Drive passes the Oakland Grove Health Care Center and residential homes at Mendon Road and Dudley Street. The ROW then continues southeasterly within the Highland Industrial Business Park to its terminus at structure no. 144 located along the Woonsocket/Cumberland municipal boundary. While within the business park the ROW crosses Park East Drive and abuts portions of the Iron Rock Brook Conservation Area.

6.2.2 Open Space and Recreation

Some areas of open space, including conservation areas, are present within the Study Area. These include the conservation land along the western banks of the Blackstone River, Cass Park and the Iron Rock Brook Conservation Easement Area near the Cumberland town boundary. The Iron Rock Brook Conservation Area will preclude any future development there and thus ensures the protection of quality open space in Woonsocket.

The Blackstone River Greenway is a bikeway that is in development that will connect Worcester, MA to Providence, RI and portions of it will be constructed within the Study Area along the banks of the Blackstone River. In Woonsocket, the bikeway will begin at the River's Edge Recreation Complex at Davison Avenue and follow the crest of a flood control berm on the west side of the Blackstone River north for 600 feet. The bikeway will then turn west, descend from the berm, then parallel Davison Avenue to the intersection with Hamlet Avenue. After crossing Hamlet Avenue, the Bikeway will gain the crest of another flood control berm and parallel Florence Drive and the Riverside Substation driveway until it crosses the Blackstone River between Structure nos. 163 and 164 on a proposed bridge. On the northeastern side of the River the bikeway would gain the crest of a flood control berm, continue west and terminates at Truman Avenue. When completed, the bike path project will result in a mostly off-road alternative transportation facility passing through the historic John H. Chafee Blackstone River Valley National Heritage Corridor. The Blackstone River Bikeway will serve as an alternate mode of transportation for commuters as well as an important multi-use recreational facility.

The Blackstone River Valley National Historical Park was established in December of 2014.

6.2.3 Future Land Use

In order to assess future land use, an analysis of current zoning was undertaken. Typically, towns and cities manage future growth through zoning regulations which provide a degree of control over a community. The Study Area is zoned institutional, residential, industrial, open space, and water and sewage treatment.

The Study Area falls within the Blackstone Valley National Heritage Corridor and the City of Woonsocket may develop a combined master plan for parks and tourism development along the Blackstone River. Such a plan would likely include development of land adjacent to the planned Blackstone River Bikeway.

The City of Woonsocket Comprehensive Plan was adopted by the City Council on April 4, 2012, but does not specifically address transmission lines.

There is no mention of electric transmission facilities in the Comprehensive Plan adopted by Cumberland Town Council on July 20, 2003.

6.3 Visual Resources

Although there are no designated scenic areas in Woonsocket based on the Rhode Island Department of Environmental Management's Rhode Island Landscape Inventory[15], the City has listed noteworthy areas within Woonsocket. Within the Study Area, the Iron Rock Brook Conservation Area that lies just west of the Cumberland town line has been designated a scenic area by the City. It was created in 1993 and has been expanded since then to encompass approximately 40 acres. This conservation area abuts the northern and southern limits of the Project ROW. There are tentative plans to create interpretive signage and nature trails within the property. Additionally, signage designed and provided by the Heritage Corridor Commission has been produced and placed throughout the city marking various mill villages as well as on the scenic Blackstone River Bikeway.

Facilities and institutions that have a viewscape of the existing transmission lines within the ROW includes the Woonsocket Middle School, the Woonsocket Senior Services Center, Oakland Grove Health Care Center, and the Landmark Medical Center.

6.4 Historic and Cultural Resources

The Public Archaeology Laboratory, Inc. (PAL) completed a cultural resources due diligence review to identify historic archaeological properties and archaeological sites within the vicinity of the Project area. The ROW is adjacent to a portion of the Blackstone Canal Historic District in Woonsocket which is listed in the National Register. The ROW crosses canal Section No. 12 which consists of an approximately 700-foot long by 50-70-foot wide broad trench that follows a river curve from the Villanova Street Footbridge to the Hamlet Dam in Woonsocket. There is one pre-contact archaeological site within the ROW (RI-1847: Indian Rock) and one post-

15 Rhode Island Department of Environmental Management, Division of Planning and Development. January 1990. The Rhode Island Landscape Inventory: A Survey of the State's Scenic Areas.

contact archeological site (RI-0898 – RI0912: granite quarries) with unknown locations possibly in the ROW. TNEC met with the Rhode Island Historic Preservation and Heritage Commission (RIHPHC) on December 3, 2014 to review the project and receive feedback on the identified historic and cultural resources within the ROW.

Based on the meeting, PAL, at TNEC's request, proceeded with a Phase 1 Survey for the Indian Rock location and concluded that there is no evidence to support that a site exists in the vicinity of the proposed new structure located in the vicinity of Indian Rock. A report was submitted to the RIHPHC for a final determination in January 2015. RIHPHC concurred in their February 13, 2015 letter that the Indian Rock site is not eligible for listing on the National Register of Historic Places (Appendix B) and that no further archaeological survey is warranted for the project. RIHPHC concurred in their March 9, 2015 letter that the foundation repair work at Structures 158, 159, and 161-164 which occur within the Blackstone Canal Historic District will have no adverse effects on historic resources (Appendix B). TNEC also received the Army Corps of Engineers Permit for the project on January 29, 2015 which concluded the federal review for properties potentially eligible or listed in the National Register under Section 106 of the National Historic Preservation Act.

6.5 Transportation

The transportation needs of the Project are served by a network of state and local roads and highways. The ROW crosses four City roads and three state roads (Table 6-1) which will be utilized to access the J16 Line.

Table 6-1 Right-of-Way Road Crossings

Road Name	Type
Hamlet Avenue (Route 122)	State
Cumberland Hill Road (Route 122)	State
Hartford Avenue	City
Park Drive	City
Mendon Road	State
Dudley Street	City
Park East Drive	City

6.6 Electric and Magnetic Fields

Electric and magnetic fields are present whenever electricity is used. The voltage causes an electric field which is usually measured in kilovolts per meter (kV/m). The current causes a magnetic field which is usually measured in milligauss (mG). Electric and magnetic fields were modeled and calculated to determine the edge of ROW field strengths with the existing conductors. These calculations were made based upon pre-Project Projected Summer 2016 annual average load (AAL) and annual peak load (APL). For the purpose of EMF modeling the Project is divided into three separate cross sections where the transmission lines change configuration. The limits of each cross section are described in tables 6-2 through 6-4, the pole numbers for each cross section are shown in Figure 3-1, and the structure and line configuration for each cross section are shown in Figures 3-2, 3-3, and 3-4. The electric fields for the three cross sections are listed in Table 6-2 and the magnetic fields for the cross sections listed in Tables 6-3 and 6-4.

Table 6-2 Calculated Electric Fields for Cross Sections 1 through 3

Cross Section	Description	Configuration	Location[1] Electric field (kV/m) −ROW edge	+ROW edge
1	Highland Park to Str. No.153	Pre-Project (2016)	0.05	0.34
2	Str. No.153 to Str. No. 157	Pre-Project (2016)	0.25	0.38
3	Str. No. 158 to Str. No. 165	Pre-Project (2016)	0.13	1.13

[1] "- ROW edge" is the northern side of the ROW.
"+ ROW edge" is the southern side of the ROW.

Table 6-3 Calculated Magnetic Fields at AAL for Cross Sections 1 through 3

Cross section	Description	Configuration	Location[1] Magnetic Field (mG) −ROW edge	+ROW edge
1	Highland Park to Str. No.153	Pre-Project (2016)	4.4	19.6
2	Str. No.153 to Str. No. 157	Pre-Project (2016)	24.2	61.0
3	Str. No. 158 to Str. No. 165	Pre-Project (2016)	23.0	94.9

[1] "- ROW edge" is the northern side of the ROW.
"+ ROW edge" is the southern side of the ROW.

Table 6-4 Calculated Magnetic Fields at APL for Cross Sections 1 through 3

Cross section	Description	Configuration	Location[1] Magnetic Field (mG) −ROW edge	+ROW edge
1	Highland Park to Str. No.153	Pre-Project (2016)	5.6	21.7
2	Str. No.153 to Str. No. 157	Pre-Project (2016)	30.4	77.1
3	Str. No. 158 to Str. No. 165	Pre-Project (2016)	28.7	119.0

[1] "- ROW edge" is the northern side of the ROW.
"+ ROW edge" is the southern side of the ROW.

7.0 Impact Analysis

7.1 Introduction

The Project will include reconductoring 2.2 miles of the J16 Line extending from Riverside Substation in Woonsocket southeast to the Highland Park Substation in Cumberland, and will include the replacement of 4 of 23 structures and installation of one new structure. Impacts to environmental resources and the social environment will be negligible, and any anticipated minor impacts are addressed in the following sections. No impacts to bedrock, groundwater, farmland soils, or air quality are expected.

7.2 Soils

Construction activities which disturb soil have the potential to increase the rates of erosion and sedimentation. Vehicle travel within the ROW may result in soil compaction and decreased infiltration rates. To minimize these potential impacts, standard construction techniques and BMPs, in accordance with the Rhode Island Soil Erosion and Sediment Control Handbook, will be installed and routinely maintained throughout the construction period. BMPs including the installation of sedimentation control barriers and swamp mats; the re-establishment of vegetation; and dust control measures will be employed to minimize any short or long term effects due to construction activity. These devices will be inspected by the environmental monitor frequently during construction and supplemented, repaired or replaced when needed. TNEC will develop and implement an Environmental Field Issue (EFI) document which will detail the BMPs and inspection protocols to guide the construction contractor and its personnel.

Excess soil from excavation at pole structures in uplands outside of RIDEM jurisdiction will be spread around the poles and stabilized to prevent migration to wetland areas or removed from the ROW. Topsoil from excavation for pole structures near wetlands will be segregated and preserved for use during site restoration. Excess material excavated from pole structure locations near wetlands will be disposed of at upland sites or removed from the ROW. Topsoil will be spread over any excess excavated subsoil material which will then be seeded and mulched to promote rapid revegetation.

Highly erodible and potentially highly erodible soils are present within the ROW. Generally these areas include sloping till dominated uplands in the eastern portion of the Project and the steeply sloping outwash terrace faces associated with the Blackstone River. Any soils disturbed by construction activity within these areas will be stabilized with straw mulch or an erosion control blanket to minimize the off-site migration of sediments.

The ROW does not cross any mapped areas of prime farmland soils. The Project will not displace any prime farmland soils.

Once work activities are completed, disturbed soils will be stabilized with seed and mulch to promote establishment of vegetative cover.

7.3 Surface Waters

Any impact of the Project upon surface watercourses will be minor and temporary. Construction activities temporarily increase risks for erosion and sedimentation that may temporarily degrade existing water quality; however, appropriate BMPs will be implemented, maintained, and inspected to effectively control sediment. In addition, construction equipment will not cross rivers and streams along the construction corridor without the use of temporary mat bridges or other crossing structures. Swamp mats will be installed so as to not impede water flow. Emphasis has been placed on utilizing existing gravel roadways within the ROW and seeking access points that avoid crossing wetlands and surface waters.

The major surface water features within the transmission line ROW include the Blackstone River. Swamp mats will be used to access structure locations adjacent to the Blackstone River as conditions warrant. Access to most structure locations adjacent to the Blackstone River will be provided without impacting the channel either by using swamp matting, alternate upland access on the ROW, or by utilizing handheld equipment during construction. Sedimentation and erosion within these watercourses will be minimized through the implementation of BMPs prior to construction activities.

Potential impacts to surface waters if sediment transport is not controlled include increased sedimentation (locally and downstream) and subsequent alterations of benthic substrates, decreases in primary production and dissolved oxygen concentrations, releases of toxic substances and/or nutrients from sediments, and destruction of benthic invertebrates. Erosion and sedimentation controls will effectively minimize the potential for this situation to occur. The implementation and maintenance of erosion and sedimentation control BMPs will limit the levels of Project related sedimentation and will minimize adverse impacts to surface waters.

7.3.1 Floodplain

Based on available FEMA mapping, 100-year Floodplain is crossed by the ROW at the Blackstone River in Woonsocket. The 100-year Floodplain represents the extent of flooding that would result during a storm event having a one percent chance of occurring per year. It is recognized that by definitions provided in the Rules, all Rivers, streams and intermittent streams have 100-year Floodplain though they may not be mapped by FEMA.

Permanent impacts to Floodplain will occur at replacement Structures 154 and 155, and totals approximately 157 square feet of permanent disturbance.

7.4 Groundwater

Potential impacts to groundwater resources within the transmission line ROW as a result of construction activity will be negligible. In accordance with National Grid policies and procedures, equipment used for the construction of the transmission line will be properly maintained and operated to reduce the chances of spills of petroleum products and antifreeze. Refueling of equipment will be conducted in upland areas. Within groundwater recharge areas, special safeguards will be implemented to assure the protection of groundwater resources. Refueling equipment will be required to carry spill containment and prevention devices (i.e., absorbent pads, clean up rags, five gallon containers, absorbent material, etc.) at all times. In addition, maintenance equipment and replacement parts for construction equipment will be on hand to repair failures and stop a spill in the event of equipment malfunction. In some scenarios, refueling in place will be allowed for equipment that cannot be moved from a fixed location. Appropriate precautions will be utilized and TNEC Environmental representatives will be consulted prior to initiating the refueling.

Following construction, the normal operation and maintenance of the transmission line facility will pose no threat to groundwater resources.

7.5 Vegetation

The Project will occur within an existing ROW that has been managed to maintain vegetation at a height that does not interfere with the existing power lines. The Project will require mowing of vegetation in and along the ROW access roads and near structures that are to be replaced or accessed. Selective tree trimming will be required for the Project. Management of the ROW vegetation will continue after the Project is completed to ensure continued access to the transmission line structures.

ROW vegetation management will be completed in accordance with the National Grid Five Year Vegetation Management Plan 2014-2018 and the Rules.

7.6 Wetlands

The Project will result in some minor temporary wetland impacts at wetlands northeast of Florence Drive to access Structure Nos. 159-161, west of Mendon Road to access Structure No. 150, and east of Park East Drive to access Structure No. 145. Access road locations have been chosen to avoid wetlands completely where possible. Where unavoidable, wetland crossings were chosen to cross at previously impacted locations or at narrow points of the wetland. Swamp mats will be used at all unavoidable wetland crossings. The remaining structures are located in upland and have upland access resulting in no wetland impact. Where structures are located in or near wetland areas, erosion control measures in addition to swamp mats, will be employed as needed to reduce sedimentation impacts on the wetland. No long-term impacts to wetlands in the Project corridor will result from the proposed reconductoring. The Army Corps of Engineers issued the Section 404 Wetlands permit No. NAE 2014-2643 on January 29, 2015 under the Rhode Island Programmatic General Permit.

7.7 Wildlife

Minor, temporary disturbances of wildlife may result from equipment travel and construction crews working in the Project corridor. During construction, displacement of wildlife may occur due to disturbances associated with ROW mowing and the operation of construction equipment. Wildlife currently utilizing the forested edge of the cleared ROW may be affected by the construction of the Project. Larger, more mobile species, such as eastern white tailed deer or red fox, will leave the construction area. Individuals of some bird species will also be temporarily displaced. Depending on the time of year of these operations, this displacement could impact breeding and nesting activities.

Small animals within the work areas may be affected during vegetation mowing and the transmission line construction. The species impacted during the reconductoring of the transmission line are expected to be limited in number. Effects will be localized to the immediate area of construction around structure locations and along existing access roads. However, this is anticipated to be a temporary effect as it is expected that existing wildlife utilization patterns will resume and population sizes will recover once work activities are completed. Any wildlife displacement will be negligible and temporary, since no permanent alteration of the existing habitat is proposed. No long-term impacts to wildlife are expected to result from the Project.

7.8 Land Use and Recreation

Since the Project involves the reconductoring of existing facilities within an existing cleared ROW, there will be no permanent, long-term impacts to the existing residential, commercial, institutional, or recreational land uses in the ROW as outlined in the following sections.

7.8.1 Residential

A number of residential areas are located in proximity to the ROW. In most locations, existing vegetation will continue to provide visual screening of the facilities from residences. Because the Project occurs within an area dedicated to use for electrical facilities, the Project will not displace any existing residential uses, nor will it adversely affect any future development proposals.

7.8.2 Commercial

The Project crosses a business area at Cumberland Hill Road and ends within the Highland Industrial Business Park. These businesses include commercial and retail uses. Normal operations will not be adversely affected by the Project. No displacement of business will result from the Project.

7.8.3 Institutions

The Woonsocket Middle School is the only public institutional facility located along the Project route. The Woonsocket Middle School is located at 60 Florence Drive. The Oakland Grove Health Care Center is a private nursing home located at 560 Cumberland Hill Road The existing transmission lines are visible from both the middle school and the nursing home. The proposed reconductoring work in these locations will have no impact on existing land uses in the vicinity of the middle school and nursing home.

7.8.4 Recreation

The Project route passes through the future Blackstone River Greenway bikeway from Hamlet Avenue along the flood control berm and parallel to Florence Drive to Structure 164. The Blackstone River Bikeway will serve as an alternate mode of transportation for commuters. Since the Project is expected to be constructed prior to the construction of the bikeway, recreational uses will not be displaced by the Project.

Impacts to the nearby existing parks and recreational areas from the Project will be minimal and short-term. Since the Project is located within an existing electric transmission line ROW, potential long-term impacts will be avoided.

7.8.5 Consistency with Local Planning

The City of Woonsocket and Town of Cumberland have Comprehensive Plans which describe the local direction regarding future development and growth in each community. Each municipality's Comprehensive Plan was evaluated with regard to expressed town-wide goals. The Project was then evaluated for consistency with the local planning initiatives in each community.

Because the Project will use existing ROW, it will not alter existing land use patterns and will not adversely impact future planned development. The Project will provide an adequate supply of electricity for the growth and development envisioned by the Comprehensive Plans of the host communities.

7.9 Visual Resources

Reconductoring consists of replacing existing conductors with new conductors. The Project will also require replacement of four structures and construction of one new structure. Structures will be replaced along the same alignment and in roughly the same locations. The four structures to be replaced are existing double circuit steel lattice tower structures that will be replaced with steel davit arm structures. Due to clearance requirements associated with the reconductored J16 Line, the replacement structures will range from 10.5 to 19.5 feet taller than the existing lattice towers. The one additional new structure will be a double-circuit steel two-pole davit arm suspension structure. The additional new structure will only be two feet taller than the adjacent existing structures. No significant impacts to visual resources are anticipated as a result of the Project.

7.10 Noise

Temporary, minor construction noise may be generated by the reconductoring work that will occur during normal daytime working hours. Proper mufflers will be required to control noise levels generated by construction equipment. Noise impacts are expected to be negligible. Typical construction works hours for the Project will be 7:00 a.m. to 7:00 p.m. Monday through Friday when daylight permits and 7:00 a.m. to 5:00 p.m. on Saturdays. However, some work tasks, such as concrete pours and transmission line stringing, once started, must be continued through to completion and may go beyond normal work hours. In addition, the nature of transmission line construction requires line outages for certain procedures such as transmission line connections, equipment cutovers, or stringing under or over other transmission lines. These outages are dictated by the system operator, ISO-NE, and can be very limited based on regional system load and weather conditions. Work requiring scheduled outages and crossings of certain transportation and utility corridors may need to be performed on a limited basis outside of normal work hours, including Sundays and holidays.

7.11 Transportation

The construction related traffic increase will be small relative to total traffic volume on public roads in the area. In addition, it will be intermittent and temporary, and construction related traffic will cease once the Project is completed. The addition of this traffic for the limited periods of time is not expected to result in any additional congestion or change in operating conditions along any of the roadways along the ROW.

TNEC will coordinate closely with RIDOT to develop acceptable traffic management plans for work within state highway ROWs. At all locations where access to the ROW intersects a public way, the contractor will coordinate with municipalities such that appropriate traffic safety measures will be utilized. Although traffic entering and exiting the ROW at these locations is expected to be small, vehicles entering and exiting the site will do so safely and with minimal disruption to traffic along the public way. Following construction, traffic activity will be minimal and will occur only when the ROW or transmission lines have to be maintained. As a result, the construction and operation of the transmission line will have minimal impact on the traffic of the surrounding area roadways. No long-term impacts to traffic flow or roadways are expected.

7.12 Historic and Cultural Resources

As described in Section 6.4, TNEC completed a cultural resource assessment in coordination with RIHPHC to investigate potential impacts to properties potentially eligible, eligible or listed in the National Register. RIHPHC concurred in their February 13, 2015 letter that the Indian Rock site is not eligible for listing on the National Register of Historic Places (Appendix B). RIHPHC concurred in their March 9, 2015 letter that the foundation repair work at Structures 158, 159, and 161-164 which occur within th Blackstone Canal Historic District will have no adverse effects on historic resources (Appendix B).

7.13 Safety and Public Health

Because the proposed electrical facilities will be designed, built and maintained in accordance with the standards and codes as discussed in Section 3.6, public health and safety will be protected.

7.14 Electric and Magnetic Fields

Electric field levels are a function of the voltage of transmission lines and other factors such as the phasing and configuration of the lines. Since the voltage will not change with the reconductoring, the electric field levels will not change from those shown in Table 6-2. Magnetic field levels are a function of the current (load) on transmission lines and other factors such as the phasing and configuration of the lines. The Project will not change the phasing or configurations of the lines.

The magnetic field levels at the edges of the ROW associated with the Project have been modeled and calculated. These calculations were based upon Projected Summer 2016 and 2021 AAL and APL loads. The calculated magnetic field levels for the three cross-sections at AAL and APL are shown on Tables 7-1 and 7-2, respectively. A comparison of Pre-project (2016) and Post-project (2016) magnetic field levels on Tables 7-1 and 7-2 shows small differences between existing and proposed conditions which are attributable to the change in projected loading of the parallel H-17 115kV Transmission Line. The magnitude of the field levels on the southern side of the ROW in cross-section 3 (Str. No. 158 to Str. No. 165) is a result of the configuration of the canal structures as shown on Figure 3-2 which are designed for four (4) transmission lines. Because of the configuration of the lines and the structures, there is little cancellation of magnetic fields among the lines.

A discussion of the current status of the health research relevant to exposure to electric and magnetic fields (EMF) is attached as Appendix A.

Table 7-1 Calculated Magnetic Field at AAL for Cross Sections 1 through 3

Cross Section	Description	Configuration	Location[1] Magnetic Field (mG) −ROW edge	+ROW edge
1	Highland Park to Str. No. 153	Pre-Project (2016)	4.4	19.6
		Post- Project (2016)	4.3	19.3
		Post- Project (2021)	4.9	23.3
2	Str. No. 153 to Str. No. 157	Pre-Project (2016)	24.2	61.0
		Post- Project (2016)	26.1	61.6
		Post- Project (2021)	30.1	70.7
3	Str. No. 158 to Str. No. 165	Pre-Project (2016)	23.0	94.9
		Post- Project (2016)	23.0	95.0
		Post- Project (2021)	26.5	109.5

[1] "- ROW edge" is the northern side of the ROW.
"+ ROW edge" is the southern side of the ROW.

Table 7-2 Calculated Magnetic Field at APL for Cross Sections 1 through 3

Cross Section	Description	Configuration	Location[1] Magnetic Field (mG) −ROW edge	+ROW edge
1	Highland Park to Str. No. 153	Pre-Project (2016)	5.6	21.7
		Post- Project (2016)	5.4	21.3
		Post- Project (2021)	5.6	24.2
2	Str. No. 153 to Str. No. 157	Pre-Project (2016)	30.4	77.1
		Post- Project (2016)	32.8	77.9
		Post- Project (2021)	34.6	82.6
3	Str. No. 158 to Str. No. 165	Pre-Project (2016)	28.7	119.0
		Post- Project (2016)	28.8	118.9
		Post- Project (2021)	30.3	127.4

[1] "- ROW edge" is the northern side of the ROW.
"+ ROW edge" is the southern side of the ROW.

8.0 Mitigation Measures

8.1 Introduction

Mitigation measures for this Project will be used to reduce the impacts of the work on the natural and social environment. The Project consists of the reconductoring of an existing transmission line in an existing ROW. As described in Chapter 7, there are no long-term impacts to mitigate as a result of this Project. Therefore, mitigation efforts are focused on the construction phase.

8.2 Construction Phase

The construction phase of the Project will include the replacement of four structures, construction of one new structure, and replacement of conductors and shieldwire of the J16 Line. This work will require only minor disturbances to the surrounding natural environment. The use of existing access roads and erosion and sedimentation controls will mitigate possible disturbances to soils, wetlands, and other water resources. Compost or wood chip mulch filter tubes will be placed around existing structures as needed where the structures are to be replaced near wetland or surface water resources. Stabilization of soil will occur when areas are disturbed.

TNEC will implement several measures during construction which will minimize impacts to the environment. These include the use of existing access roads and structure work pads where possible, installation of erosion and sedimentation controls, supervision and inspection of construction activities within resource areas by an environmental monitor and minimization of disturbed areas. An Environmental Field Issue (EFI) guidance document will be utilized as a basic field reference for field construction personnel and environmental inspectors. The EFI provides a basic summary of the permits and approvals secured to facilitate completion of the project, as well as a summary of conditions that must be met to confirm environmental permit compliance for the duration of the project. The following section details various mitigation measures which will be implemented to minimize construction related impacts.

8.2.1 Mitigation of Natural Resource Impacts

When the existing transmission lines were constructed, access roads were established within most portions of the ROW. During construction of the Project, vehicles will utilize these existing access roads where practical to minimize disturbance within the ROW.

Access through wetlands to the existing structure locations will be provided by utilizing swamp mats from the existing maintained portion of the ROW. Construction access will be limited to the existing structure locations and proposed access routes, and will be lined with erosion and sedimentation control BMPs where needed. Following erection of the structures, each area will be restored.

Vegetation management operations will be confined to the ROW. Vegetation mowing adjacent to wetland areas is of particular concern due to the potential for erosion, and therefore, specific mitigation measures will be implemented to minimize this potential where needed. These measures will include the installation of compost or wood chip mulch filter tube diversion berms across the slope to intercept storm water runoff which will be directed through compost or wood chip mulch filter tubes to remove suspended sediment. These structures will be maintained until vegetative cover is re-established. In addition, compost or wood chip mulch filter tubes and/or erosion control blankets will be installed across disturbed slopes adjacent to wetland areas in accordance with an erosion and sediment control plan. Excavated soils will be stockpiled and spread in approved soil areas well outside all biological wetland areas in such a manner that general drainage patterns will not be affected.

Where possible, existing vegetation will be retained at all road crossings and areas subject to public view to maintain a visual buffer to the ROW.

8.2.1.1 Erosion and Sedimentation Control

Erosion and sediment control devices will be installed between the proposed work areas and the identified wetland areas, including the Blackstone River, prior to the onset of soil disturbance activities to ensure that soil stockpiles and other disturbed soil areas are confined and do not result in downslope sedimentation of sensitive areas. Low growing tree species, shrubs and grasses will only be mowed along access roads and at pole locations. Construction crews will be responsible for conducting daily inspections and identifying erosion controls that must be maintained or replaced as necessary.

Dewatering may be necessary during excavations for pole structures adjacent to wetland areas. Water will be pumped into hay bale or silt fence settling basins or dewatering filter bags which will be located in approved areas outside wetland resource areas. The pump intake hose will not be allowed to set on the bottom of the excavation throughout dewatering. The basins or bags and all accumulated sediment will be removed following dewatering operations and the areas will be seeded and mulched.

8.2.1.2 Supervision and Monitoring

Throughout the entire construction process, the services of an environmental monitor will be retained. The primary responsibility of the monitor will be to oversee construction activities including the installation and maintenance of erosion and sedimentation controls, on a regular basis to confirm compliance with federal and state permit requirements, and ensure construction activities are in compliance with National Grid company policies and other commitments. The environmental monitor will be a trained environmental scientist responsible for supervising construction activities relative to environmental issues. The environmental monitor will be experienced in the erosion control techniques described in this report and will have an understanding of wetland resources to be protected.

During periods of prolonged precipitation, the monitor will inspect all locations to confirm that the environmental controls are functioning properly. In addition to retaining the services of an environmental monitor, the contractors will be required to designate an individual to be responsible for the daily inspection and upkeep of environmental controls. This person will also be responsible for providing direction to the other members of the construction crew regarding matters of wetland access and appropriate work methods. Installation and repair of BMPs and other compliance issues are tracked on an inspection form or action log that is updated and distributed weekly to appropriate personnel. Additionally, all construction personnel will be briefed on Project environmental compliance issues and obligations prior to the start of construction. Regular construction progress meetings will provide the opportunity to reinforce the contractor's awareness of these issues.

8.2.2 Mitigation of Social Resource Impacts

TNEC will minimize social resource impacts during construction by incorporating several standard mitigation measures. By use of an established transmission line ROW rather than creating a new ROW, the potential for disruption due to construction activities will be limited to an area already dedicated to transmission line uses. Construction noise will be limited by the use of mufflers on all construction equipment. Dust will be controlled by wetting and stabilizing access road surfaces, as necessary, and by maintaining crushed stone aprons at the intersections of access roads with paved roads. TNEC will minimize the potential for disturbance from the construction by notifying abutters of planned construction activities before and during construction of the line.

Some short term impacts are unavoidable, even though they have been minimized. By carrying out the reconductoring of the line in a timely fashion, TNEC will keep these impacts to a minimum.

TNEC will coordinate closely with RIDOT to develop acceptable traffic management plans for work within state highway ROWs. At all locations where access to the ROW intersects a public way, the contractor will coordinate with municipalities such that appropriate traffic safety measures will be utilized.

8.3 Post-Construction Phase

Following the completion of construction, TNEC uses standard measures on all transmission line construction projects to minimize the impacts of projects on the natural and social environment. These measures include revegetation and stabilization of disturbed soils, ROW vegetation management practices and vegetation screening maintenance at road crossings and in sensitive areas. Other measures are used on a site specific basis. TNEC will implement the following standard and site specific mitigation measures for the Project.

8.3.1 Mitigation of Natural Resource Impacts

Restoration efforts, including final grading and installation of permanent erosion control devices, and seeding of disturbed areas, will be completed following construction. Construction debris will be removed from the Project site and disposed of at an appropriate landfill. Pre-existing drainage patterns, ditches, roads, fences, and stone walls will be restored to their former condition, where appropriate. Permanent slope breakers and erosion control devices will be installed in areas where the disturbed soil has the potential to impact wetland resource areas.

Vegetation maintenance of the ROW will be accomplished with methods identical to those currently used in maintaining the existing ROW. TNEC's ROW vegetation maintenance practices encourage the growth of low-growing shrubs and other vegetation which provides a degree of natural vegetation control. In addition to reducing the need to remove tall growing tree species from the ROW, the vegetation maintained on the ROW inhibits erosion.

8.3.2 Mitigation of Social Resource Impacts

Upon completion of the Project, magnetic field levels at the edges of the ROW will increase slightly from the existing condition.

9.0 Conclusions

This document presents a comprehensive overview of the J16 115 kV Transmission Line Reconductoring Project in Cumberland and Woonsocket, Rhode Island, including Project need, existing conditions for environmental and social environment parameters, potential impacts to these parameters, and the measures that will be implemented to avoid, minimize or mitigate these impacts. The Project is proposed to allow TNEC to continue to provide a reliable supply of electricity to customers in a cost effective manner.

Based on the analysis presented herein, there are no significant long-term impacts associated with the Project. The implementation of appropriate BMPs and mitigation measures during construction will avoid or minimize the construction-phase impacts to environmental resources and the social environment. Thus the short-term impacts will be temporary and negligible.

Appendix A: Current Status of Research on Extremely Low Frequency Electric and Magnetic Fields and Health: Rhode Island Transmission Projects – The Narragansett Electric Company (March 9, 2015)

Health Sciences Practice

Exponent®

Current Status of Research on Extremely Low Frequency Electric and Magnetic Fields and Health:

Rhode Island Transmission Projects – The Narragansett Electric Company d/b/a/ National Grid

Current Status of Research on Extremely Low Frequency Electric and Magnetic Fields and Health:

Rhode Island Transmission Projects – The Narragansett Electric Company d/b/a National Grid

Prepared for:

Rhode Island
Energy Facility Siting Board
and
The Narragansett Electric Company d/b/a
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March 9, 2015

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Acronyms and Abbreviations

AC	Alternating current
ALL	Acute lymphoblastic leukemia
ALS	Amyotrophic lateral sclerosis
AMI	Acute myocardial infarction
CI	Confidence interval
DMBA	7,12-dimethylbenz[a]anthracene
ELF	Extremely low frequency
EMF	Electric and magnetic fields (or electromagnetic fields)
G	Gauss
HCN	Health Council of the Netherlands
Hz	Hertz
IARC	International Agency for Research on Cancer
ICES	International Commission on Electromagnetic Safety
ICNIRP	International Committee on Non-Ionizing Radiation Protection
JEM	Job exposure matrix
kV	Kilovolt
kV/m	Kilovolts per meter
mG	Milligauss
OR	Odds ratio
RR	Relative risk
SCENIHR	Scientific Committee on Emerging and Newly Identified Health Risks
TWA	Time weighted average
V/m	Volts per meter
WHO	World Health Organization

Limitations

At the request of Narragansett Electric Company d/b/a National Grid, Exponent prepared this summary report on the status of research related to extremely low-frequency electric- and magnetic-field exposure and health. The findings presented herein are made to a reasonable degree of scientific certainty. Exponent reserves the right to supplement this report and to expand or modify opinions based on review of additional material as it becomes available, through any additional work, or review of additional work performed by others.

The scope of services performed during this investigation may not adequately address the needs of other users of this report, and any re-use of this report or its findings, conclusions, or recommendations presented herein are at the sole risk of the user. The opinions and comments formulated during this assessment are based on observations and information available at the time of the investigation. No guarantee or warranty as to future life or performance of any reviewed condition is expressed or implied.

1 Executive Summary

This report was prepared to address the topic of health and extremely low frequency (ELF) electric and magnetic fields (EMF) for the Rhode Island Energy Facility Siting Board at the request of The Narragansett Electric Company d/b/a National Grid as part of its Applications for the 2015 Rhode Island Transmission Projects.

ELF EMF are invisible fields surrounding all objects that generate, use, or transmit electricity. There are also natural sources of ELF EMF, including the electric fields associated with the normal functioning of our circulatory and nervous systems. People living in developed countries are constantly exposed to ELF EMF in their environments, since electricity is fundamental part of technologically-advanced societies. Sources of man-made ELF EMF include appliances, wiring, and motors, as well as distribution and transmission lines. Section 3 of this report provides information on the nature and sources of ELF EMF, as well as typical exposure levels.

Research on ELF EMF and health began with the goal of finding therapeutic application and understanding biological electricity, i.e., the role of electrical potentials across cell membranes and current flows between cells in our bodies. Over the past 35 years, researchers have examined whether ELF EMF from man-made sources can cause short- or long-term health effects in humans using a variety of study designs and techniques. Research on ELF EMF and long-term human health effects was prompted by an epidemiology study conducted in 1979 of children in Denver, Colorado, which studied the relationship of their cancers with the potential for ELF EMF exposure from nearby distribution and transmission lines. The results of that study prompted further research on childhood leukemia and other cancers. Childhood leukemia has remained the focus of EMF and health research, although many other diseases have been studied, including other cancers in children and adults, neurodegenerative diseases, reproductive effects, and cardiovascular disease, among others.

Guidance on the possible health risks of all types of exposures comes from health risk assessments, or systematic weight-of-evidence evaluations of the cumulative literature, on a particular topic conducted by expert panels organized by scientific organizations. The public and policy makers should look to the conclusions of these reviews, since the reviews are conducted using set scientific standards by scientists representing the various disciplines required to understand the topic at hand. In a health risk assessment of any exposure, it is essential to consider the type and strength of research studies available for evaluation. Human health studies vary in methodological rigor and, therefore, in their capacity to extrapolate findings to the population at large. Furthermore, relevant studies in three areas of research (epidemiologic, *in vivo,* and *in vitro* research) must be evaluated to understand possible health risks. Section 4 of this report provides a summary of the methods used to conduct a health risk assessment.

The World Health Organization (WHO) published a health risk assessment of ELF EMF in 2007 that critically reviewed the cumulative epidemiologic and laboratory research to date, taking into account the strength and quality of the individual research studies. Section 5 provides a summary of the WHO's conclusions with regard to the major outcomes they evaluate. The WHO report provided the following overall conclusions:

> New human, animal, and in vitro studies published since the 2002 IARC Monograph, 2002 [*sic*] do not change the overall classification of ELF as a possible human carcinogen (WHO, 2007, p. 347).
>
> Acute biological effects [i.e., short-term, transient health effects such as a small shock] have been established for exposure to ELF electric and magnetic fields in the frequency range up to 100 kHz that may have adverse consequences on health. Therefore, exposure limits are needed. International guidelines exist that have addressed this issue. Compliance with these guidelines provides adequate protection. Consistent epidemiological evidence suggests that chronic low-intensity ELF magnetic field exposure is associated with an increased risk of childhood leukaemia. However, the evidence for a causal relationship is limited, therefore exposure limits based upon epidemiological evidence are not recommended, but some precautionary measures are warranted (WHO, 2007, p. 355).

This report provides a systematic literature review and a critical evaluation of relevant epidemiology and *in vivo* studies published from July 2013 to November 2014, and it updates the report submitted as part of the Application for the G-185S 115-kilovolt Transmission Line Project.[1] These recent studies did not provide sufficient evidence to alter the basic conclusion of the WHO: the research does not suggest that electric fields or magnetic fields are a cause of cancer or any other disease at the levels we encounter in our everyday environment.

There are no national recommendations, guidelines, or standards in the United States to regulate ELF EMF or to reduce public exposures, although the WHO recommends adherence to the International Commission on Non-Ionizing Radiation Protection's or the International Committee for Electromagnetic Safety's exposure limits for the prevention of acute health effects at high exposure levels and low-cost measures to minimize exposures. In light of the epidemiologic data on childhood leukemia, scientific organizations are still in agreement that only low-cost interventions to reduce ELF EMF exposure are appropriate. This approach is mirrored by the Rhode Island Energy Facility Siting Board that has approved transmission projects that have proposed effective no-cost and low-cost technologies to reduce magnetic-field exposure to the public. While the large body of existing research does not indicate any harm associated with ELF EMF, research on this topic will continue to reduce remaining uncertainty.

[1] Exponent, Inc. *Current Status of Research on Extremely Low Frequency Electric and Magnetic Fields and Health: G-185S 115-kV Transmission Line*. Prepared for the Rhode Island Energy Facility Siting Board. October 31, 2013.

Note that this Executive Summary provides only an outline of the material discussed in this report. Exponent's technical evaluations, analyses, conclusions, and recommendations are included in the main body of this report, which at all times the controlling document.

2 Introduction

Questions about electric and magnetic fields (EMF) and health are commonly raised during the permitting of transmission lines. Numerous national and international scientific and health agencies have reviewed the research and evaluated potential health risks of exposure to extremely low frequency (ELF) EMF. The most comprehensive of these reviews of ELF EMF research was published by the World Health Organization (WHO) in 2007. The WHO's Task Group critically reviewed the cumulative epidemiologic and laboratory research through 2005, taking into account the strength and quality of the individual research studies.

The Narragansett Electric Company d/b/a National Grid requested that Exponent provide an easily-referenced document that supplements a report previously prepared for the Rhode Island Energy Facility Siting Board to bring the WHO report's conclusions up to date.[2] The G-185S 115-kilovolt (kV) Transmission Line Project report systematically evaluated peer-reviewed research and reviews by scientific panels published up to July 2013. This current report systematically evaluates peer-reviewed research and reviews by scientific panels published between July 2013 and November 2014 and also describes if and how these recent results affect conclusions reached by the WHO in 2007.

[2] Exponent, Inc. *Current Status of Research on Extremely Low Frequency Electric and Magnetic Fields and Health: G-185S 115-kV Transmission Line*. Prepared for the Rhode Island Energy Facility Siting Board. October 31, 2013.

3 Extremely Low Frequency Electric and Magnetic Fields: Nature, Sources, Exposure, and Known Effects

Nature of ELF EMF

Electricity is transmitted as current from generating sources to high-voltage transmission lines, substations, distribution lines, and then finally to our homes and workplaces for consumption. The vast majority of electricity in North America is transmitted as alternating current (AC), which changes direction 60 times per second (i.e., a frequency of 60 Hertz [Hz]).

Everything that is connected to our electrical system (i.e., power lines, wiring, appliances, and electronics) produces ELF EMF (Figure 1). Both electric fields and magnetic fields are properties of the space near these electrical sources. Forces are experienced by objects capable of interacting with these fields; electric charges are subject to a force in an electric field, and moving charges experience a force in a magnetic field.

- **Electric fields** are the result of voltages applied to electrical conductors and equipment. The electric field is expressed in measurement units of volts per meter (V/m) or kilovolts per meter (kV/m); one kV/m is equal to 1,000 V/m. Conducting objects including fences, buildings, and our own skin and muscle easily block electric fields. Therefore, certain appliances within homes and workplaces are the major source of electric fields indoors, while transmission and distribution lines are the major source of electric fields outdoors.

- **Magnetic fields** are produced by the flow of electric currents; however, unlike electric fields, most materials do not readily block magnetic fields. The strength of a magnetic field is expressed as magnetic flux density in units called gauss (G), or in milligauss (mG), where 1 G = 1,000 mG.[3] The strength of the magnetic field at any point depends on characteristics of the source; in the case of power lines, strength is dependent on the arrangement of conductors, the amount of current flow, and distance from the conductors.

[3] Scientists also refer to magnetic flux density at these levels in units of microtesla. Magnetic flux density in units of mG can be converted to microtesla by dividing by 10, i.e., 1 mG = 0.1 microtesla.

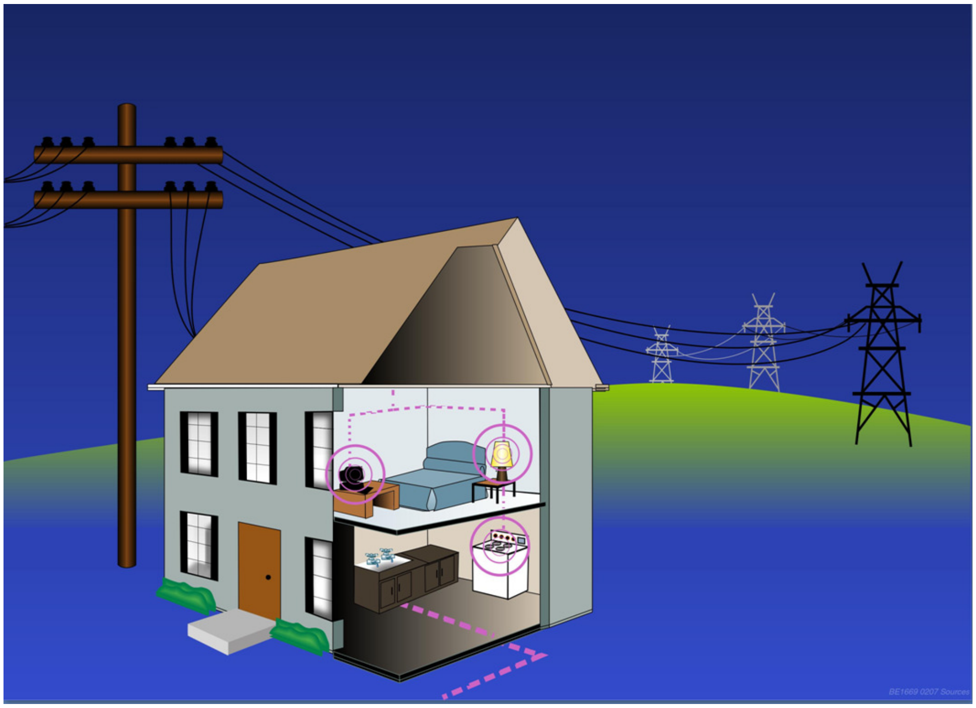

Figure 1. Numerous sources of ELF EMF in our homes (appliances, wiring, currents running on water pipes, and nearby distribution and transmission lines).

Sources and exposure

The intensity of both electric fields and magnetic fields diminishes with increasing distance from the source. Electric and magnetic fields from transmission lines generally decrease with distance from the conductors in proportion to the square of the distance, described as creating a bell-shaped curve of field strength around the lines.

Since electricity is such an integral part of our infrastructure (e.g., transportation systems, homes, and businesses), people living in modern communities literally are surrounded by these fields. Figure 2 describes typical EMF levels measured in residential and occupational environments, compared to levels measured on or at the edge of transmission-line rights-of-way. While EMF levels decrease with distance from the source, any home, school, or office tends to have a "background" EMF level as a result of the combined effect of the numerous EMF sources. In general, the background magnetic-field level in a house away from appliances is typically less than 20 mG, while levels can be hundreds of mG in close proximity to appliances. Background levels of electric fields range from 10-20 V/m, while appliances produce levels up to several tens of V/m (WHO, 2007).

Experiments have yet to show which aspect of ELF EMF exposure, if any, may be relevant to biological systems. The current standard of EMF exposure for health research is long-term, average personal exposure, which is the average of all exposures to the varied electrical sources encountered in the many places we live, work, eat, and shop. As expected, this exposure is difficult to approximate, and exposure assessment is a major source of uncertainty in studies of ELF EMF and health (WHO, 2007).

Little research has been done to characterize the general public's exposure to magnetic fields, although some basic conclusions are available from the literature:

- *Personal magnetic-field exposure:*
    - The vast majority of persons in the United States have a *time-weighted average* (TWA) exposure to magnetic fields less than 2 mG (Zaffanella and Kalton, 1998).[4]
    - In general, personal magnetic-field exposure is greatest at work and during travel (Zaffanella and Kalton, 1998).
- *Residential magnetic-field exposure:*
    - The highest magnetic-field levels are typically found directly next to appliances (Zaffanella, 1993). For example, Gauger (1985) reported the maximum AC magnetic field at 3 centimeters from a sampling of appliances as 3,000 mG (can opener), 2,000 mG (hair dryer), 5 mG (oven), and 0.7 mG (refrigerator).
    - The following parameters affect the distribution of personal magnetic-field exposures at home: residence type, residence size, type of water line, and proximity to overhead power lines. Persons living in small homes, apartments, homes with metallic piping, and homes close to three-phase electric power distribution and transmission lines tended to have higher at-home magnetic-field levels (Zaffanella and Kalton, 1998).
    - Residential magnetic-field levels are caused by currents from nearby transmission and distribution systems, pipes or other conductive paths, and electrical appliances (Zaffanella, 1993).
- *Workplace magnetic-field exposure*
    - Some occupations (e.g., electric utility workers, sewing machine operators, telecommunication workers) have higher exposures due to work near equipment with high magnetic-field levels.[5]

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[4] TWA is the average exposure over a given specified time period (i.e., an 8-hour workday or a 24-hour day) of a person's exposure to a chemical or physical agent. The average is determined by sampling the exposure of interest throughout the time period.

[5] http://www.niehs.nih.gov/health/assets/docs_p_z/emf-02.pdf

- *Power line magnetic-field exposure*
    - The magnetic-field levels associated with transmission and distribution lines vary substantially depending on their configuration, amount of current flow (load), and distance from conductors, among other parameters. At distances of approximately 300 feet from overhead transmission lines and during average electricity demand, the magnetic-field levels from many transmission lines are often similar to the background levels found in most homes (Figure 2).

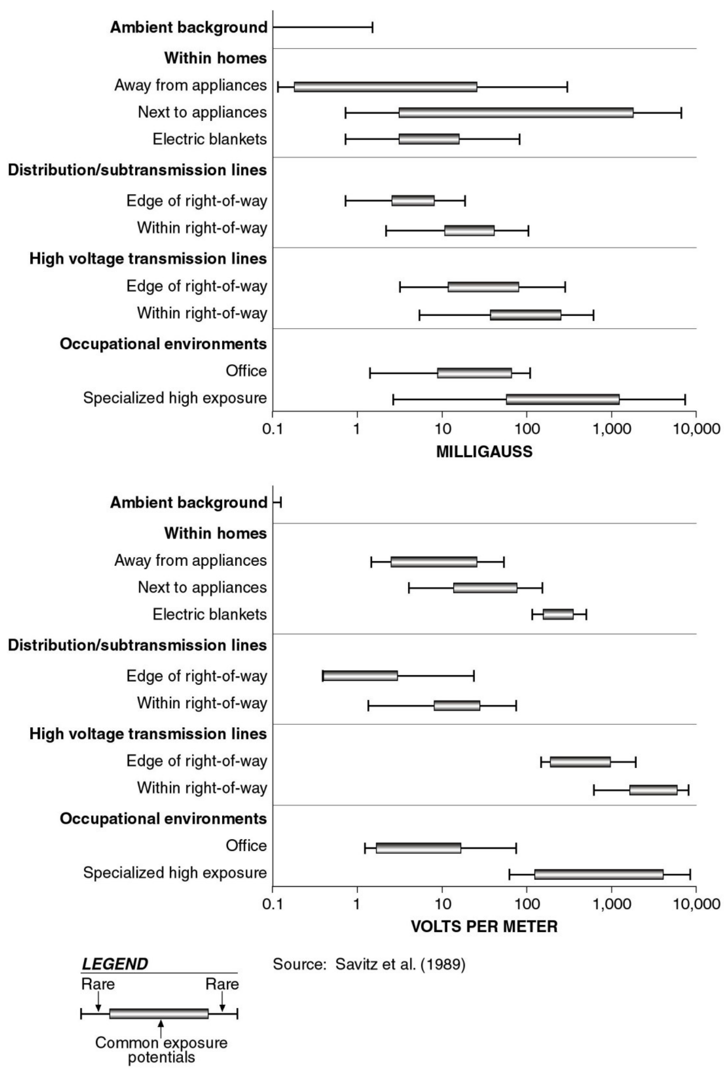


Figure 2. Electric- and magnetic-field strengths in the environment.

Known effects

Similar to virtually any exposure, adverse effects can be expected from exposure to very high levels of ELF EMF. If the current density or electric field induced by an extremely strong magnetic field exceeds a certain threshold, excitation of muscles and nerves is possible. Also, strong electric fields can induce charges on the surface of the body that can lead to small shocks, i.e., micro shocks. These are acute and shock-like effects that cause no long-term damage or health consequences. Limits for the general public and workplace have been set to prevent these effects, but real-life situations where these levels would be exceeded are rare. Standards and guidelines are discussed in more detail in Section 8.

4 Methods for Evaluating Scientific Research

Science is more than a collection of facts. It is a method of obtaining information and of reasoning to ensure that the information and conclusions are accurate and correctly describe physical and biological phenomena. Many misconceptions in human reasoning occur when people casually interpret their observations and experience. Therefore, scientists use systematic methods to conduct and evaluate scientific research and assess the potential impact of a specific agent on human health. This process is designed to ensure that more weight is given to those studies of better quality and studies with a given result are not selected out from all of the studies available to advocate or suppress a preconceived idea of an adverse effect. Scientists and scientific agencies and organizations use these standard methods to draw conclusions about the many exposures in our environment.

Weight-of-evidence reviews

The scientific process entails looking at *all* the evidence on a particular issue in a systematic and thorough manner to evaluate if the overall data presents a logically coherent and consistent picture. This is often referred to as a weight-of-evidence review, in which all studies are considered together, giving more weight to studies of higher quality and using an established analytic framework to arrive at a conclusion about a possible causal relationship. Weight-of-evidence reviews are typically conducted within the larger framework of health risk assessments or evaluations of particular exposures or exposure circumstances that qualitatively and quantitatively define health risks. Weight-of-evidence and health risk assessment methods have been described by several agencies, including the International Agency for Research on Cancer (IARC), which routinely evaluates substances such as drugs, chemicals, and physical agents for their ability to cause cancer; the WHO International Programme for Chemical Safety; and the US Environmental Protection Agency, which set guidance for public exposures (WHO, 1994; USEPA, 1993; USEPA, 1996). Two steps precede a weight-of-evidence evaluation: a systematic review to identify the relevant literature and an evaluation of each relevant study to determine its strengths and weaknesses.

The following sections discuss important considerations in the evaluation of human health studies of EMF in a weight-of-evidence review, including exposure considerations, study design, methods for estimating risk, bias, and the process of causal inference. The purpose of discussing these considerations here is to provide context for the later weight-of-evidence evaluations.

Exposure considerations

Exposure methods range widely in studies of ELF EMF, including: the classification of residences based on the relative capacity of nearby power lines to produce magnetic fields (i.e., wire code categories); occupational titles; calculated magnetic-field levels based on job histories (i.e., a job-exposure matrix [JEM]); residential distance from nearby power lines; spot measurements of magnetic-field levels inside or outside residences; 24-hour and 48-hour measurements of magnetic fields in a particular location in the house (e.g., a child's bedroom); calculated magnetic-field levels based on the characteristics of nearby power installations; and, finally, personal 24-hour and 48-hour magnetic-field measurements.

Each of these methods has strengths and limitations (Kheifets and Oksuzyan, 2008). Since magnetic-field exposures are ubiquitous and vary over a lifetime as the places we frequent and the sources of ELF EMF in those places change, making valid estimates of personal magnetic-field exposure challenging. Furthermore, without a biological basis to define a relevant exposure metric (average exposure or peak exposure) and a defined critical period for exposure (e.g., *in utero*, shortly before diagnosis), relevant and valid assessments of exposure are problematic. Exposure misclassification is one of the most significant concerns in studies of ELF EMF.

In general, long-term personal measurements are the metrics selected by epidemiologists. Other methods are generally weaker because they may not be strong predictors of long-term exposure and do not take into account all magnetic-field sources. ELF EMF can be estimated indirectly by assigning an estimated amount of exposure to an individual based on calculations considering nearby power installations or a person's job title. For instance, a relative estimate of exposure could be assigned to all machine operators based on historical information on the magnitude of the magnetic field produced by the machine. Indirect measurements are not as accurate as direct measurements because they do not contain information specific to that person or the exposure situation. In the example of machine operators, the indirect measurement may not account for how much time any one individual spends working at that machine or any potential variability in magnetic fields produced by the machines over time. In addition, such occupational measurements do not take into account the worker's residential magnetic-field exposures.

While JEMs are an advancement over earlier methods, they still have some important limitations, as highlighted in a review by Kheifets et al. (2009) summarizing an expert panel's findings.[6] A person's occupation provides some relative indication of the overall magnitude of their occupational magnetic-field exposure, but it does not take into account the possible variation in exposure due to different job tasks within occupational titles, the frequency and intensity of contact to relevant exposure sources, or variation by calendar time. This was highlighted by a recent study of 48-hour magnetic-field measurements of 543 workers in Italy in a variety of occupational settings, including: ceramics, mechanical engineering, textiles, graphics, retail, food, wood, and biomedical industries (Gobba et al., 2011). In this study, there was significant variation in measured TWA magnetic-field levels for workers in many of the International Standard Classification of Occupations' job categories, which the authors attributed to variations within these task-defined categories in some of the industries.

Types of health research studies

Research studies can be broadly classified into two groups: 1) epidemiologic observations of people and 2) experimental studies on animals, humans, cells, and tissues conducted in laboratory settings. Epidemiology studies investigate how disease is distributed in populations

[6] Kheifets et al. (2009) reports on the conclusions of an independent panel organized by the Energy Networks Association in the United Kingdom in 2006 to review the current status of the science on occupational EMF exposure and identify the highest priority research needs.

and what factors influence or determine this disease distribution (Gordis, 2000). Epidemiology studies attempt to identify potential causes for human disease while observing people as they go about their normal, daily lives. Such studies are designed to quantify and evaluate the associations between disease and reported exposures to environmental factors.

The most common types of epidemiology studies in the ELF EMF literature are case-control and cohort studies. In case-control studies, people with and without the disease of interest are identified and the exposures of interest are evaluated. Often, people are interviewed or their personal records (e.g., medical records or employment records) are reviewed in order to establish the exposure history for each individual. The exposure histories are then compared between the diseased and non-diseased populations to determine whether any statistically significant differences in exposure histories exist. In cohort studies, on the other hand, individuals within a defined cohort of people (e.g., all persons working at a utility company) are classified as exposed or non-exposed and followed over time for the incidence of disease. Researchers then compare disease incidence in the exposed and non-exposed groups.

Experimental studies are designed to test specific hypotheses under controlled conditions and are vital to assessing cause-and-effect relationships. An example of a human experimental study relevant to this area of research would be studies that measure the impact of magnetic-field exposure on acute biological responses in humans, such as hormone levels. These studies are conducted in laboratories under controlled conditions. *In vivo* and *in vitro* experimental studies are also conducted under controlled conditions in laboratories. *In vivo* studies expose laboratory animals to very high levels of a chemical or physical agent to determine whether exposed animals develop cancer or other effects at higher rates than unexposed animals, while attempting to control other factors that could possibly affect disease rates (e.g., diet, genetics). *In vitro* studies of isolated cells and tissues are important because they can help scientists understand biological mechanisms as they relate to the same exposure in intact humans and animals. In the case of *in vitro* studies, the responses of cells and tissues outside the body may not reflect the response of those same cells if maintained in a living system, so their relevance cannot be assumed. Therefore, it is both necessary and desirable that agents that could present a potential health threat be explored by both epidemiology and experimental studies.

Both of these approaches—epidemiology and experimental laboratory studies—have been used to evaluate whether exposure to ELF EMF has any adverse effects on human health. Epidemiology studies are valuable because they are conducted in human populations, but they are limited by their non-experimental design and typical retrospective nature. In epidemiology studies of magnetic fields, for example, researchers cannot control the amount of individual exposure, how exposure occurs over time, the contribution of different field sources, or individual behaviors other than exposure that may affect disease risk, such as diet. In valid risk assessments of ELF EMF, epidemiology studies are considered alongside experimental studies of laboratory animals, while studies of isolated tissues and cells are generally considered supplementary.

Estimating risk

Epidemiologists measure the statistical association between exposures and disease in order to estimate risk. This brief summary of risk is included to provide a foundation for understanding and interpreting statistical associations in epidemiology studies as risk estimates.

Two common types of risk estimates are absolute risk and relative risk (RR). Absolute risk, also known as incidence, is the amount of new disease that occurs in a given period of time. For example, the absolute risk of invasive childhood cancer in children ages 0 to 19 years for 2004 was 14.8 per 100,000 children (Reis et al., 2007). RRs are calculated to evaluate whether a particular exposure or inherent quality (e.g., EMF, diet, genetics, race) is associated with a disease outcome. This is calculated by looking at the absolute risk in one group relative to a comparison group. For example, white children in the 0 to 19 year age range had an estimated absolute risk of childhood cancer of 15.4 per 100,000 in 2004, and African American children had an estimated absolute risk of 13.3 per 100,000 in the same year. By dividing the absolute risk of white children by the absolute risk of African American children, we obtain a RR of 1.16. This RR estimate can be interpreted to mean that white children have a risk of childhood cancer that is 16% greater than the risk of African American children. Additional statistical analysis is needed to evaluate whether this association is statistically significant, as defined in the following sub-section.

It is important to understand that risk is estimated differently in cohort and case-control studies because of the way the studies are designed. Traditional cohort studies provide a direct estimate of RR, while case-control studies only provide indirect estimates of RR, called odds ratios (OR). For this reason, among others, cohort studies usually provide more reliable estimates of the risk associated with a particular exposure. Case-control studies are more common than cohort studies, however, because they are less costly and more time efficient.

Thus, the association between a particular disease and exposure is measured quantitatively in an epidemiology study as either the RR (cohort studies) or OR (case-control studies) estimate. The general interpretation of a risk estimate equal to 1.0 is that the exposure is not associated with an increased incidence of the disease. If the risk estimate is greater than 1.0, the inference is that the exposure is associated with an increased incidence of the disease. On the other hand, if the risk estimate is less than 1.0, the inference is that the exposure is associated with a reduced incidence of the disease. The magnitude of the risk estimate is often referred to as its strength (i.e., strong vs. weak). Stronger associations are given more weight because they are less susceptible to the effects of bias.

Statistical significance

Statistical significance testing provides an idea of whether or not a statistical association is a chance occurrence or whether the association is likely to be observed upon repeated testing. The terms "statistically significant" or "statistically significant association" are used in epidemiology studies to describe the tendency of the level of exposure and the occurrence of disease to be linked, with chance as an unlikely explanation. Statistically significant associations, however, are not necessarily an indication of cause-and-effect, because the interpretation of statistically significant associations depends on many other factors associated with the design and conduct of the study, including how the data were collected and the number of study participants.

Confidence intervals (CI) reported along with RR and OR values, indicate a range of values for an estimate of effect that has a specified probability (e.g., 95%) that the sample of data examined includes the "true" estimate of effect; CIs evaluate statistical significance, but do not address the role of bias, as described further below. A 95% CI indicates that, if the study were conducted a very large number of times, 95% of the measured estimates would be within the upper and lower confidence limits based on sampling of a normal statistical distribution.

The range of the CI is also important for interpreting estimated associations, including the precision and statistical significance of the association. A very wide CI indicates great uncertainty in the value of the "true" risk estimate. This is usually due to a small number of observations. A narrow CI provides more certainty about where the "true" RR estimate lies. If the 95% CI does not include 1.0, the probability of an association being due to chance alone is 5% or lower and the result is considered statistically significant, as discussed above.

While a 95% CI is commonly applied, it provides marginal protection against falsely rejecting a hypothesis of no effect, so acceptance of a 99% CI level is recommended (e.g., Goodman, 1999).

Meta-analysis and pooled analysis

In scientific research, the results of smaller studies may be difficult to distinguish from normal, random variation. This is also the case for sub-group analyses where few cases are estimated to have high exposure levels, e.g., in case-control studies of childhood leukemia and TWA magnetic-field exposure greater than 3-4 mG. Meta-analysis is an analytic technique that combines the published results from a group of studies into one summary result. A pooled analysis, on the other hand, combines the raw, individual-level data from the original studies and analyzes the data from the studies altogether. These methods are valuable because they increase the number of individuals in the analysis, which allows for a more robust and stable estimate of association. Meta- and pooled analyses are an important tool for qualitatively synthesizing the results of a large group of studies.

The disadvantage of meta- and pooled analyses is that they can convey a false sense of consistency across studies if *only* the combined estimate of effect is considered (Rothman and Greenland, 1998). These analyses typically combine data from studies with different study populations, methods for measuring and defining exposure, and disease definitions. This is particularly true for analyses that combine data from case-control studies, which often use very different methods for the selection of cases and controls and exposure assessment. Therefore, in addition to the synthesis or combining of data, meta- and pooled analyses should be used to understand what factors cause the results of the studies to vary (i.e., publication date, study design, possibility of selection bias), and how these factors affect the associations calculated from the data of all the studies combined (Rothman and Greenland, 1998).

Meta- and pooled analyses are a valuable technique in epidemiology; however, in addition to calculating a summary RR, they should follow standard techniques (Stroup et al., 2001) and analyze the factors that contribute to any heterogeneity between the studies.

Bias in epidemiology studies

One key reason that the results of epidemiology studies cannot directly provide evidence for cause-and-effect is the presence of bias. Bias is defined as "any systematic error in the design, conduct or analysis of a study that results in a mistaken estimate of an exposure's effect on the risk of disease" (Gordis, 2000, p. 204). In other words, sources of bias are factors or research situations that can mask a true association or cause an association that does not truly exist. As a result, the extent of bias, as well as its types and sources, is one of the most important considerations in the interpretation of epidemiology studies. Since it is not possible to fully control human populations, perfectly measure their exposures, or control for the effects of all other risk factors, bias will exist in some form in all epidemiology studies of human health. Laboratory studies, on the other hand, more effectively manage bias because of the tight control the researchers have over most study variables.

One important source of bias occurs in epidemiology studies when a third variable confuses the relationship between the exposure and disease of interest because of its relationship to both. Consider an example of a researcher whose study finds that people who exercise have a lower risk of diabetes compared to people who do not exercise. It is known that people who exercise more tend to also consume healthier diets and healthier diets may lower the risk of diabetes. If the researcher does not control for the impact of diet, it is not possible to say with certainty that the lower risk of diabetes is due to exercise and not to a healthier diet. In this example, diet is the confounding variable.

Cause vs. association and evaluating evidence regarding causal associations

Epidemiology studies can help suggest factors that may contribute to the risk of disease, but they are not used as the sole basis for drawing inferences about cause-and-effect relationships. Since epidemiologists do not have control over the many other factors to which people in are exposed in their studies, and diseases can be caused by a complex interaction of many factors, the results of epidemiology studies must be interpreted with caution. A single epidemiology study is rarely unequivocally supportive or non-supportive of causation; rather, a weight is assigned to the study based on the validity of its methods and all relevant studies (epidemiology, *in vivo*, and *in vitro*) must be considered together in a weight-of-evidence review to arrive at a conclusion about possible causality between an exposure and disease.

In 1964, the Surgeon General of the United States published a landmark report on smoking-related diseases (HEW, 1964). As part of this report, nine criteria for evaluating epidemiology studies (along with experimental data) for causality were outlined. In a more recent version of this report, these criteria have been reorganized into seven criteria. In the earlier version, which was based on the commonly referenced Hill criteria (Hill, 1965), coherence, plausibility, and analogy were considered as distinct items, but are now summarized together because they have been treated in practice as essentially reflecting one concept (HHS, 2004). Table 1 provides a listing and brief description of each criterion.

Table 1. Criteria for evaluating whether an association is causal

Criteria	Description
Consistency	Repeated observation of an association between exposure and disease in multiple studies of adequate statistical power, in different populations, and at different times.
Strength of the association	The larger (stronger) the magnitude and statistical strength of an association is between exposure and disease, the less likely such an effect is the result of chance or unmeasured confounding.
Specificity	The exposure is the single (or one of a few) cause of disease.
Temporality	The exposure occurs prior to the onset of disease.
Coherence, plausibility, and analogy	The association cannot violate known scientific principles and the association must be consistent with experimentally demonstrated biologic mechanisms.
Biologic gradient	This is also known as a dose-response relationship, i.e., the observation that the stronger or greater the exposure is, the stronger or greater the effect.
Experiment	Observations that result from situations in which natural conditions imitate experimental conditions. Also stated as a change in disease outcome in response to a non-experimental change in exposure patterns in population.

Source: Department of Health and Human Services, 2004

The criteria were meant to be applied to statistically significant associations that have been observed in the cumulative epidemiologic literature (i.e., if no statistically significant association has been observed for an exposure then the criteria are not relevant). It is important to note that these criteria were not intended to serve as a checklist but as guide to evaluate associations for causal inference. Theoretically, it is possible for an exposure to meet all seven criteria, but still not be deemed a causal factor. Also, no one criterion can provide indisputable evidence for causation, nor can any single criterion, aside from temporality, rule out causation.

In summary, the judicious consideration of these criteria is useful in evaluating epidemiology studies, but they cannot be used as the sole basis for drawing inferences about cause-and-effect relationships. In line with the criteria of "coherence, plausibility, and analogy," epidemiology studies are considered along with *in vivo* and *in vitro* studies in a comprehensive weight-of-evidence review. Epidemiologic support for causality is usually based on high-quality studies reporting consistent results across many different populations and study designs that are supported by the experimental data collected from *in vivo* and *in vitro* studies.

Biological response vs. disease in human health

When interpreting research studies, it is important to distinguish between a reported biological response and an indicator of disease. This is relevant because exposure to ELF EMF may elicit a biological response that is simply a normal response to environmental conditions. This response, however, may not be a disease, cause a disease, or be otherwise harmful. There are many exposures or factors encountered in day-to-day life that elicit a biological response, but the response is neither harmful nor a cause of disease. For example, when an individual walks from a dark room indoors to a sunny day outdoors, the pupils of the eye naturally constrict to limit the amount of light passing into the eye. This constriction of the pupil is considered a biological response to the change in light conditions. Pupil constriction, however, is neither a disease itself, nor is it known to cause disease.

5 The WHO 2007 Report: Methods and Conclusions

The WHO is a scientific organization within the United Nations system whose mandate includes providing leadership on global health matters, shaping health research agendas, and setting norms and standards. The WHO established the International EMF Project in 1996, in response to public concern about exposure to ELF EMF and possible adverse health outcomes. The project's membership includes 8 international organizations, 8 collaborating institutions, and over 54 national authorities. The overall purpose of the Project is to assess health and environmental effects of exposure to static and time varying fields in the frequency range of 0 Hz to 300 gigahertz. A key objective of the Project is to evaluate the scientific literature and make periodic status reports on health effects to be used as the basis for a coherent international response, including the identification of important research gaps and the development of internationally acceptable standards for ELF EMF exposure.

In 2007, the WHO published their Environmental Health Criteria (EHC) 238 on EMF summarizing health research in the ELF range. The EHC used standard scientific procedures, as outlined in its Preamble and described above in Section 4, to conduct the review. The Task Group responsible for the report's overall conclusions consisted of 21 scientists from around the world with expertise in a wide range of scientific disciplines. They relied on the conclusions of previous weight-of-evidence reviews,[7] where possible, and mainly focused on evaluating studies published after an IARC review of ELF EMF and cancer in 2002.

The WHO Task Group and IARC use specific terms to describe the strength of the evidence in support of causality between specific agents and cancer. These categories are described here because, while they are meaningful to scientists who are familiar with the IARC process, they can create an undue level of concern with the general public. *Sufficient evidence of carcinogenicity* is assigned to a body of epidemiologic research if a positive association has been observed in studies in which chance, bias, and confounding can be ruled out with reasonable confidence. *Limited evidence of carcinogenicity* describes a body of epidemiologic research where the findings are inconsistent or there are outstanding questions about study design or other methodological issues that preclude making a conclusion. *Inadequate evidence of carcinogenicity* describes a body of epidemiologic research where it is unclear whether the data is supportive or unsupportive of causation because there is a lack of data or there are major quantitative or qualitative issues. A similar classification system is used for evaluating *in vivo* studies and mechanistic data for carcinogenicity.

Summary categories are assigned by considering the conclusions of each body of evidence (epidemiologic, *in vivo,* and *in vitro*) together (see Figure 3). *In vitro* research is not described in Figure 3 because it provides ancillary information and, therefore, is used to a lesser degree in evaluating carcinogenicity and is classified simply as strong, moderate, or weak. Categories

[7] The term "weight-of-evidence review" is used in this report to denote a systematic review process by a multidisciplinary, scientific panel involving experimental and epidemiologic research to arrive at conclusions about possible health risks. The WHO EHC on EMF does not specifically describe their report as a weight-of-evidence review. Rather, they describe conducting a health risk assessment. A health risk assessment differs from a weight-of-evidence review in that it also incorporates an exposure and exposure-response assessment.

include (from highest to lowest risk): carcinogenic to humans, probably carcinogenic to humans, possibly carcinogenic to humans, unclassifiable, and probably not carcinogenic to humans. These categories are intentionally meant to err on the side of caution, giving more weight to the possibility that the exposure is truly carcinogenic and less weight to the possibility that the exposure is not carcinogenic. The category “possibly carcinogenic to humans” denotes exposures for which there is limited evidence of carcinogenicity in epidemiology studies and less than sufficient evidence of carcinogenicity in studies of experimental animals.

	Epidemiology Studies				Animal Studies			
	Sufficient evidence	Limited evidence	Inadequate evidence	Evidence suggesting lack of carcinogenicity	Sufficient evidence	Limited evidence	Inadequate evidence	Evidence suggesting lack of carcinogenicity
Known Carcinogen	✓							
Probable Carcinogen		✓			✓			
Possible Carcinogen		✓				✓	✓	
Not Classifiable			✓			✓	✓	
Probably not a Carcinogen				✓				✓

Sufficient evidence in epidemiology studies—A positive association is observed between the exposure and cancer in studies, in which chance, bias and confounding were ruled out with “reasonable confidence.”

Limited evidence in epidemiology studies—A positive association has been observed between the exposure and cancer for which a causal interpretation is considered to be credible, but chance, bias or confounding could not be ruled out with “reasonable confidence.”

Inadequate evidence in epidemiology studies—The available studies are of insufficient quality, consistency or statistical power to permit a conclusion regarding the presence or absence of a causal association between exposure and cancer, or no data on cancer in humans are available.

Evidence suggesting a lack of carcinogenicity in epidemiology studies—There are several adequate studies covering the full range of levels of exposure that humans are known to encounter, which are mutually consistent in not showing a positive association between exposure to the agent and any studied cancer at any observed level of exposure. The results from these studies alone or combined should have narrow confidence intervals with an upper limit close to the null value (e.g. a relative risk of 1.0). Bias and confounding should be ruled out with reasonable confidence, and the studies should have an adequate length of follow-up.

Sufficient evidence in animal studies—An increased incidence of malignant neoplasms is observed in (a) two or more species of animals or (b) two or more independent studies in one species carried out at different times or indifferent laboratories or under different protocols. An increased incidence of tumors in both sexes of a single species in a well-conducted study, ideally conducted under Good Laboratory Practices, can also provide sufficient evidence.

Limited evidence in animal studies—The data suggest a carcinogenic effect but are limited for making a definitive evaluation, e.g. (a) the evidence of carcinogenicity is restricted to a single experiment; (b) there are unresolved questions regarding the adequacy of the design, conduct or interpretation of the studies; etc.

Inadequate evidence in animal studies—The studies cannot be interpreted as showing either the presence or absence of a carcinogenic effect because of major qualitative or quantitative limitations, or no data on cancer in experimental animals are available

Evidence suggesting a lack of carcinogenicity in animal studies—Adequate studies involving at least two species are available which show that, within the limits of the tests used, the agent is not carcinogenic.

Figure 3. Basic IARC method for classifying exposures based on potential carcinogenicity.

The IARC has reviewed close to 1,000 substances and exposure circumstances to evaluate their potential carcinogenicity. Over 80% of exposures fall in the categories possible carcinogen

(29%) or non-classifiable (52%). This occurs because, as described above, it is nearly impossible to prove that something is completely safe, and few exposures show a clear-cut or probable risk, so most agents will end up in either of these two categories. Throughout the history of the IARC, only one agent has been classified as probably not a carcinogen, which illustrates the conservatism of the evaluations and the difficulty in proving the absence of an effect beyond all doubt.

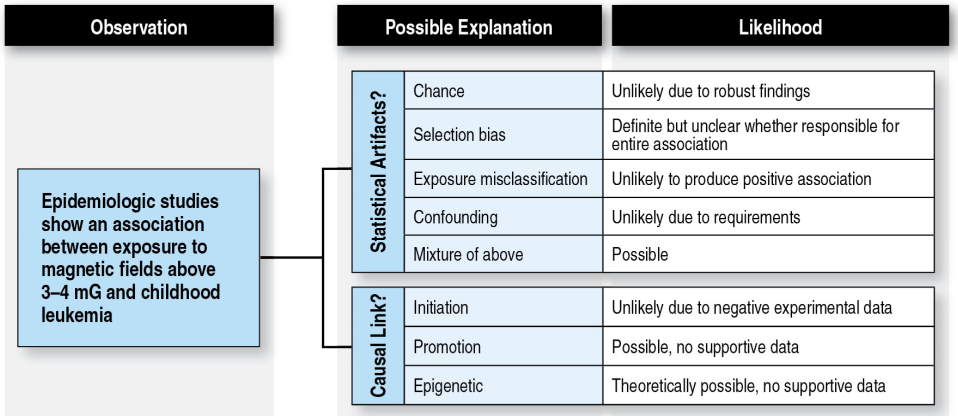
The WHO report provided the following overall conclusions with regard to ELF EMF:

> New human, animal, and in vitro studies published since the 2002 IARC Monograph, 2002 [*sic*] do not change the overall classification of ELF as a possible human carcinogen (p. 347).
>
> Acute biological effects [i.e., short-term, transient health effects such as a small shock] have been established for exposure to ELF electric and magnetic fields in the frequency range up to 100 kHz that may have adverse consequences on health. Therefore, exposure limits are needed. International guidelines exist that have addressed this issue. Compliance with these guidelines provides adequate protection. Consistent epidemiological evidence suggests that chronic low-intensity ELF magnetic field exposure is associated with an increased risk of childhood leukaemia. However, the evidence for a causal relationship is limited, therefore exposure limits based upon epidemiological evidence are not recommended, but some precautionary measures are warranted (p. 355, WHO, 2007).

With regard to specific diseases, the WHO concluded the following:

Childhood cancers. The WHO report paid particular attention to childhood leukemia because the most consistent epidemiologic association in the area of ELF EMF and health research has been reported between this disease and TWA exposure to high, magnetic-field levels. Two pooled analyses reported an association between childhood leukemia and TWA magnetic-field exposure >3-4 mG (Ahlbom et al., 2000; Greenland et al., 2000); it is these data, categorized as limited epidemiologic evidence, that resulted in the classification of magnetic fields as possibly carcinogenic by the IARC in 2002.

The WHO report systematically evaluated several factors that might be partially, or fully, responsible for the consistent association, including: chance, misclassification of magnetic-field exposure, confounding from hypothesized or unknown risk factors, and selection bias. The authors concluded that chance is an unlikely explanation since the pooled analyses had a larger sample size and decreased variability; control selection bias probably occurs to some extent in these studies and would result in an overestimate of the true association, but would not explain the entire observed association; it is less likely that confounding occurs, although the possibility that some yet-to-be identified confounder is responsible for the association cannot be fully excluded; and, finally, exposure misclassification would likely result in an underestimate of the true association, although it is not entirely clear (see Figure 4 below). The WHO concluded that reconciling the epidemiologic data on childhood leukemia and the negative (i.e., no hazard or risk observed) experimental findings through innovative research is currently the highest priority in the field of ELF EMF research. Given that few children are expected to have long-term *average* magnetic-field exposures greater than 3-4 mG, however, the WHO stated that the public health impact of magnetic fields on childhood leukemia would likely be minimal, if the association was determined to be causal.



Source: Adapted from Schüz and Ahlbom (2008)

Figure 4. Possible explanations for the observed association between magnetic fields and childhood leukemia.

Fewer studies have been published on magnetic fields and childhood brain cancer compared to studies of childhood leukemia. The WHO Task Group described the results of these studies as inconsistent and limited by small sample sizes and recommended a meta-analysis to clarify the research findings.

Breast cancer. The WHO concluded that the more recent studies they reviewed on breast cancer and ELF EMF exposure were higher in quality compared with earlier studies, and for that reason, they provide strong support to previous consensus statements that magnetic-field exposure does not influence the risk of breast cancer. In summary, the WHO stated "[w]ith these [more recent] studies, the evidence for an association between ELF magnetic-field exposure and the risk of female breast cancer is weakened considerably and does not support an association of this kind" (WHO, 2007, p. 9). The WHO recommended no further research with respect to breast cancer and magnetic-field exposure.

Adult leukemia and brain cancer. The WHO concluded, "In the case of adult brain cancer and leukaemia, the new studies published after the IARC monograph do not change the conclusion that the overall evidence for an association between ELF [EMF] and the risk of these disease remains inadequate" (WHO, 2007, p. 307). The WHO panel recommended updating the existing European cohorts of occupationally-exposed individuals and pooling the epidemiologic data on brain cancer and adult leukemia to confirm the absence of an association.

In vivo research on carcinogenesis. The WHO concluded the following with respect to *in vivo* research, "[t]here is no evidence that ELF [EMF] exposure alone causes tumours. The evidence that ELF field exposure can enhance tumour development in combination with carcinogens is inadequate" (WHO, 2007, p. 10). Recommendations for future research included the development of a rodent model for childhood acute lymphoblastic leukemia (ALL) and the continued investigation of whether magnetic fields can act as a co-carcinogen.

Reproductive and developmental effects. The WHO concluded that, overall, the body of research does not suggest that maternal or paternal exposures to ELF EMF cause adverse reproductive or developmental outcomes. The evidence from epidemiology studies on miscarriage was described as inadequate and further research on this possible association was recommended, although low priority was given to this recommendation.

Neurodegenerative diseases. The WHO reported that the majority of epidemiology studies have reported associations between occupational magnetic-field exposure and mortality from Alzheimer's disease and amyotrophic lateral sclerosis (ALS), although the design and methods of these studies were relatively weak (e.g., disease status was based on death certificate data, exposure was based on incomplete occupational information from census data, and there was no control for confounding factors). The WHO concluded that there is inadequate data in support of an association between magnetic-field exposure and Alzheimer's disease or ALS. The panel highly recommended that further studies be conducted in this area, particularly studies where the association between magnetic fields and ALS is estimated while controlling for the possible confounding effect of electric shocks.

Cardiovascular disease. It has been hypothesized that magnetic-field exposure reduces heart rate variability, which in turn increases the risk for acute myocardial infarction (AMI). With one exception (Savitz et al., 1999), however, none of the studies of cardiovascular disease morbidity and mortality that were reviewed show an association with exposure. Whether a specific association exists between exposure and altered autonomic control of the heart remains speculative and overall the evidence does not support an association. Experimental studies of both short- and long-term exposure indicate that, while electric shock is an obvious health hazard, other hazardous cardiovascular effects associated with ELF EMF are unlikely to occur at exposure levels commonly encountered environmentally or occupationally.

6 Current Scientific Consensus

The following sections identify and describe epidemiology and *in vivo* studies related to ELF EMF and health published between July 2013 and November 2014. The purpose of this section is to evaluate whether the findings of these recent studies alter the conclusions published by the WHO in their 2007 report, as described in Section 5. The previous Exponent report that summarized the literature up to July 2013[8] concluded that recent results did not provide sufficient evidence to alter the basic conclusion of the WHO EHC published in 2007.

A structured literature search was conducted using PubMed, a search engine provided by the National Library of Medicine and the National Institutes of Health that includes over 15 million up-to-date citations from MEDLINE and other life science journals for biomedical articles (http://www.pubmed.gov). A well-defined search strategy was used to identify literature indexed between July 2013 and November 2014.[9] All fields (e.g., title, abstract, keywords) were searched with various search strings that referenced the exposure and disease of interest.[10] A researcher with experience in this area reviewed the titles and abstracts of these publications for inclusion in this evaluation. Only peer-reviewed, epidemiology studies, meta-analyses, and human experimental studies of 50/60-Hz AC ELF EMF and recognized disease entities, along with whole animal *in vivo* studies of carcinogenesis, were included. The following specific inclusion criteria were applied:

1. **Outcome**. Included studies evaluated one of the following diseases: cancer; reproductive effects; neurodegenerative diseases; or cardiovascular disease. Research on other outcomes was not included (e.g., psychological effects, behavioral effects, hypersensitivity). Few studies are available in these research areas and, as such, research evolves more slowly.

2. **Exposure**. The study must have evaluated 50/60-Hz AC ELF EMF.

3. **Exposure assessment methods**. Exposure must have been evaluated beyond self-report of an activity or occupation. Included studies estimated exposure through various methods including calculated EMF levels using distance from power lines; time-weighted average EMF exposures; and average exposure estimated from JEMs.

4. **Study design**. Epidemiology studies, meta-analyses, human experimental studies, and *in*

8 Exponent, Inc. *Current Status of Research on Extremely Low Frequency Electric and Magnetic Fields and Health: G-185S 115-kV Transmission Line*. Prepared for the Rhode Island Energy Facility Siting Board. October 31, 2013.

9 Since there is sometimes a delay between the publication date of a study and the date it is indexed in PubMed, it is possible that some studies not yet indexed, but published prior to November 2014, are not included in this update.

10 EMF OR magnetic fields OR electric fields OR electromagnetic OR power frequency OR transmission line AND cancer (cancer OR leukemia OR lymphoma OR carcinogenesis) OR neurodegenerative disease (neurodegenerative disease OR Alzheimer's disease OR amyotrophic lateral sclerosis OR Lou Gehrig's disease) OR cardiovascular effects (cardiovascular OR heart rate) OR reproductive outcomes (miscarriage OR reproduction OR developmental effects).

vivo studies were included. Only *in vivo* studies of carcinogenicity were evaluated in this review; the review relies on the conclusions of the WHO with regard to *in vivo* studies in the areas of reproduction, development, neurology, and cardiology. Further, this report relies on the conclusions of the WHO report (as described in Section 5) with regard to mechanistic data from *in vitro* studies since this field of study is less informative to the risk assessment process (IARC, 2002).

5. **Peer-review**. The study must have been peer-reviewed and published. Therefore, no conference proceedings, abstracts, or on-line material were included.

Epidemiology studies are evaluated below first by outcome (childhood cancer; adult cancer; reproductive or developmental effects; neurodegenerative disease; and cardiovascular effects), followed by an evaluation of *in vivo* research on carcinogenesis. Tables 3 through 9 list the relevant studies that were published between July 2013 and November 2014 in these areas.

Childhood health outcomes

Childhood leukemia

In 2002, the IARC assembled and reviewed research related to ELF EMF to evaluate the strength of the evidence in support of carcinogenicity. The IARC expert panel noted that, when studies with the relevant information were combined in a pooled analysis, a statistically significant two-fold association was observed between childhood leukemia and estimated exposure to high, average levels of magnetic fields (i.e., greater than 3-4 mG of average 24- and 48-hour exposure). This evidence was classified as “limited evidence” in support of carcinogenicity, falling short of “sufficient evidence” because chance, bias, and confounding could not be ruled out with “reasonable confidence.” Largely as a result of the findings related to childhood leukemia, the IARC classified magnetic fields as “possibly carcinogenic,” a category that describes exposures with limited epidemiologic evidence and inadequate evidence from *in vivo* studies. The classification of “possibly carcinogenic” was confirmed by the WHO in June 2007.

Recent studies (July 2013 to November 2014)

Childhood leukemia remains one of the most studied health outcomes in ELF EMF epidemiologic research. Three large case-control studies from France, Denmark, and the United Kingdom have assessed the risk of childhood leukemia in relation to residential proximity to high-voltage power lines (Sermage-Faure et al., 2013; Bunch et al., 2014; Pedersen et al., 2014). The French study, which was discussed in the previous update, included 2,779 cases of childhood leukemia diagnosed between 2002 and 2007 and 30,000 control children (Sermage-Faure et al., 2013). The authors used geocoded information on residential address at the time of diagnosis for cases and at time of selection for controls. They reported no statistically significant increase in leukemia risk with distance to power lines. The authors, however, noted a statistically non-significant risk increase in a sub-analysis within 50 meters of 225-400 kV lines, but this was based on a small number of cases (n=9). The ensuing scientific correspondence following the publication of the study focused on the magnitude of inaccuracies in distance assessment with geocoding as a main limitation of the study, and its implication on the inference that can be drawn from the study. The correspondence also addressed the statistical uncertainties of the results that are based on small numbers (Bonnet-Belfais et al. 2013; Magana Torres and Garcia, 2013).

A similar study from Denmark identified 1,698 cases of childhood leukemia from the Danish Cancer Registry and 3,396 individually matched healthy control children from the Danish Central Population Registry (Pedersen et al., 2014). The investigators used geographical information systems to determine the distance between birth addresses and the 132-400 kV overhead transmission lines of the seven Danish transmission companies. The authors reported no risk increases for childhood leukemia with residential distance to power lines; the reported ORs were 0.76 (95 % CI 0.40–1.45) and 0.92 (95% CI 0.67–1.25) for children who lived 0–199 meters and for those who lived 200–599 meters from the nearest power line compared to children who lived more than 600 meters away.

The third study by Bunch et al. (2014) provided an update and extension of the 2005 study conducted by Draper et al. (2005) in the United Kingdom. The update included 13 additional years of data, included Scotland in addition to England and Wales, and included 132-kV lines in addition to 275-kV and 400-kV transmission lines. Bunch et al. included over 53,000 childhood cancer cases, diagnosed between 1962 and 2008, and over 66,000 healthy children as controls, representing the largest study to date in this field of study. The authors reported no overall association with residential proximity to power lines with any of the voltage categories. The statistical association that was reported in the earlier study (Draper et al., 2005) was no longer apparent in the updated and extended study. An analysis by calendar time revealed that the association was apparent only in the earlier decades (1960s and 1970s) but not in the later decades starting from the 1980s (Bunch et al., 2014). This observation does not support the hypothesis that the associations observed earlier were due to the effects of magnetic-fields.

These three studies had a large sample size and they were population-based studies requiring no subject participation, which minimizes the potential for selection bias. The main limitation of all of these studies was the reliance on distance to power lines as the main exposure metric. Estimated distance to power lines is known to be a poor predictor of actual residential magnetic field exposure. Chang et al. (2014) recently provided a detailed discussion on exposure assessment methods based on geographical information systems and their potential to result in severe bias. Using data from the UK study, Swanson et al. (2014a) also showed that geocoding data may not be sufficiently reliable to accurately predict actual magnetic-field exposures due to inaccuracies in distance assessment, especially when the exact address is not available.

The meta-analysis conducted by Zhao et al. (2014a) included nine case-control studies of EMF exposure and childhood leukemia published between 1997 and 2013. Zhao et al. reported a statistically significant association between average exposure above 4 mG and all types of childhood leukemia (OR 1.57; 95% CI 1.03-2.4). The meta-analysis relied on published results from some of the same studies included in previous pooled analyses, and thus, provided little new insight.

Swanson et al. (2014b) investigated the potential role of corona ions from power lines in childhood cancer development in the largest-to-date epidemiologic study of childhood cancer conducted in the United Kingdom. The authors used an improved model to predict exposure to corona ions using meteorological data on wind conditions, power line characteristics and proximity to residential address. Swanson et al. concluded that their results provided no empirical support for the corona ion hypothesis

Methodological studies have also examined the potential role of alternative, non-causal explanations for the reported epidemiologic associations. Swanson (2013) examined differences in residential mobility among residents who lived at varying distances from power lines. Swanson attempted to assess if these differences in mobility may explain the statistical association of leukemia with residential proximity to power lines. Although some variations in residential mobility were observed, these were "only small ones, and not such as to support the hypothesis." Scientists in California evaluated whether selection bias may influence the association in an epidemiologic study of childhood leukemia and residential magnetic-field exposure (Slusky et al., 2014). Wire code categories were used to assess exposure among participant and nonparticipant subjects in the Northern California Childhood Leukemia Study. The authors reported systematic differences between participant and nonparticipant subjects in both wire code categories and socioeconomic status and concluded that these differences did not appear to explain the lack of an association between childhood leukemia and exposure estimates in this study. The main limitation of the study is the use of wire code categories for exposure assessment; wire code categories are known to be poor predictors for actual magnetic-field exposure.

In a recent review, Grellier et al. (2014) estimated that, if the association was causal, ~1.5% to 2% of leukemia cases might be attributable to ELF EMF in Europe. They conclude that "this contribution is small and is characterized by considerable uncertainty."

Assessment

While some of the recently published large and methodologically advanced studies showed no association (e.g., Bunch et al., 2014; Pedersen et al., 2014), and one showed weak associations in selected subgroups (Sermage-Faure et al., 2013), the previously observed association between childhood leukemia and magnetic fields reported in some studies (e.g., Ahlbom et al., 2000; Greenland et al., 2000; Kheifets et al., 2010) remains unexplained. Overall, the results of recent studies do not change the classification of the epidemiologic data as limited, which is consistent with the most recent assessment conducted by the Scientific Committee on Newly-Identified Health Risks (SCENIHR) in 2015.

One of the major limitations of recent work remains the limited validity of the exposure assessment methods. Magnetic-field estimates have largely been based on calculated levels from nearby power lines, distance from nearby power lines, and measured, short-term residential levels. Recent analyses (e.g., Swanson et al., 2014a) have further demonstrated the limitations of distance assessment in childhood cancer epidemiologic studies basing the exposure assessment on distance from power lines. Scientists have continued to examine the role of selection bias in the childhood leukemia association, but no conclusive evidence has emerged that could attribute the entire observed association to bias (e.g., Swanson, 2013; Slusky et al., 2014). Some scientists have opined that epidemiology has reached its limits in this area and any future research must demonstrate a significant methodological advancement (e.g., an improved exposure metric or a large sample size in high exposure categories) to be justified (Savitz, 2010; Schmiedel and Blettner, 2010).

The findings from the recent literature do not alter previous conclusions of the WHO and other reviews, including ours, that the epidemiologic evidence on magnetic fields and childhood leukemia is "limited" from the perspective of the IARC classification. Chance, confounding, and several sources of bias still cannot be ruled out. Conclusions from several published reviews (Kheifets and Oksuzyan, 2008; Pelissari et al., 2009; Schüz and Ahlbom, 2008; Calvente et al., 2010; Eden, 2010; Schüz, 2011) and scientific organizations (SSI, 2007; SSI, 2008; HCN, 2009a; SCENIHR, 2015; EFHRAN, 2012; SSM, 2013) support this conclusion.

Researchers will continue to investigate the association between exposure to magnetic fields and childhood leukemia. In recent assessments of the epidemiologic evidence of magnetic-field exposure and childhood leukemia, it has been concluded that only 1% to 3% of all childhood leukemia cases in Europe and North America could be due to magnetic-field exposure, should a causal relationship exist (Schüz, 2011; Grellier et al., 2014).

It is important to note that magnetic fields are just one area of study in the extensive body of research on the possible causes of childhood leukemia. There are several other hypotheses under investigation that point to possible genetic, environmental, and infectious explanations for childhood leukemia (e.g., McNally and Parker, 2006; Belson et al., 2007; Rossig and Juergens, 2008; Urayama et al., 2010; Bartley et al., 2010 [diagnostic x-rays]; Amigou et al., 2011 [road traffic]; Swanson, 2013).

Table 2. Relevant studies of childhood leukemia

Author	Year	Study Title
Bunch et al.	2014	Residential distance at birth from overhead high-voltage powerlines: childhood cancer risk in Britain 1962-2008.
Grellier et al.	2014	Potential health impacts of residential exposures to extremely low frequency magnetic fields in Europe
Pedersen et al.	2014	Distance from residence to power line and risk of childhood leukemia: a population-based case-control study in Denmark
Sermage-Faure et al.*	2013	Childhood leukaemia close to high-voltage power lines – the Geocap study, 2002–2007
Slusky et al.	2014	Potential role of selection bias in the association between childhood leukemia and residential magnetic fields exposure: a population-based assessment
Swanson	2013	Residential mobility of populations near UK power lines and implications for childhood leukaemia
Swanson et al.	2014a	Relative accuracy of grid references derived from postcode and address in UK epidemiological studies of overhead power lines

Author	Year	Study Title
Swanson et al.	2014b	Childhood cancer and exposure to corona ions from power lines: an epidemiological test
Zhao et al.	2014a	Magnetic fields exposure and childhood leukemia risk: a meta-analysis based on 11,699 cases and 13,194 controls
*Comments and Replies on Sermage-Faure et al.:		
Bonnet-Belfais et al.	2013	Comment: childhood leukaemia and power lines--the Geocap study: is proximity an appropriate MF exposure surrogate?
Magana Torres and Garcia	2013	Comment on 'Childhood leukaemia close to high-voltage power lines--the Geocap study, 2002-2007'--odds ratio and confidence interval.
Clavel and Hemon	2013	Reply: Comment on 'Childhood leukaemia close to high-voltage power lines--the Geocap study, 2002-2007'--odds ratio and confidence interval
Clavel et al.	2013	Reply: Comment on 'Childhood leukaemia close to high-voltage power lines--the Geocap study, 2002-2007'--is proximity an appropriate MF exposure surrogate?

Childhood brain cancer

Compared to the research on magnetic fields and childhood leukemia, there have been fewer studies of childhood brain cancer. The data are less consistent and limited by even smaller numbers of exposed cases compared with studies of childhood leukemia. The WHO review recommended the following:

> As with childhood leukaemia, a pooled analysis of childhood brain cancer studies should be very informative and is therefore recommended. A pooled analysis of this kind can inexpensively provide a greater and improved insight into the existing data, including the possibility of selection bias and, if the studies are sufficiently homogeneous, can offer the best estimate of risk (WHO 2007, p. 18).

Recent studies (July 2013 to November 2014)

There has been one new publication that specifically examined the potential relationship between residential proximity to transmission lines and childhood brain cancer among other childhood cancers. The Bunch et al. (2014) study, described above, also included cases of brain cancer (n=11,968) and other solid tumors (n=21,985) among children in the United Kingdom between 1962 and 2008. No association was reported by the authors for either brain cancer or for other cancers.

The results of the methodological study that investigated the accuracy of distance assessment in childhood cancer studies (Swanson et al., 2014a) are also relevant for childhood brain cancer. The study that investigated the role of corona ions in childhood cancer development, similarly to childhood leukemia, reported no consistent associations for childhood brain cancer (Swanson et al., 2014b).

Assessment

Overall, the weight-of-evidence does not support an association between magnetic-field exposures and the development of childhood brain cancer. The results of recent studies do not alter the classification of the epidemiologic data in this field as "inadequate."

Table 3. Relevant studies of childhood brain cancer

Authors	Year	Study
Bunch et al.	2014	Residential distance at birth from overhead high-voltage powerlines: childhood cancer risk in Britain 1962-2008.
Swanson et al.	2014a	Relative accuracy of grid references derived from postcode and address in UK epidemiological studies of overhead power lines
Swanson et al.	2014b	Childhood cancer and exposure to corona ions from power lines: an epidemiological test

Adult health outcomes

Breast cancer

The WHO reviewed studies of breast cancer and residential magnetic-field exposure, electric blanket usage, and occupational magnetic-field exposure. These studies did not report consistent associations between magnetic-field exposure and breast cancer. The WHO concluded that the recent body of research on this topic was less susceptible to bias compared with previous studies, and, as a result, it provided strong support to previous consensus statements that magnetic-field exposure does not influence the risk of breast cancer. Specifically, the WHO stated:

> Subsequent to the IARC monograph a number of reports have been published concerning the risk of female breast cancer in adults associated with ELF magnetic field exposure. These studies are larger than the previous ones and less susceptible to bias, and overall are negative. With these studies, the evidence for an association between ELF exposure and the risk of breast cancer is weakened considerably and does not support an association of this kind (WHO 2007, p. 307).

The WHO recommended no specific research with respect to breast cancer and magnetic-field exposure.

Recent studies (July 2013 to November 2014)

A Dutch study, that included a cohort of about 120,000 men and women in the Netherlands Cohort, investigated occupational exposure to ELF magnetic fields and cancer development (Koeman et al., 2014). The study was a case-cohort analysis of 2,077 breast cancer cases among women (no breast cancer was identified among men in the cohort). Job titles were used to assign estimates of ELF magnetic field exposures using a JEM. No association was reported for breast cancer with the level of estimated ELF magnetic-field exposure, the length of employment, or cumulative exposure in the exposed jobs.

A nested case-cohort analysis of breast cancer incidence was conducted in a large cohort of more than 267,000 female textile workers in Shanghai (Li et al., 2013). A total of 1,687 incident breast cancer cases were identified in the cohort between 1989 and 2000; their estimated exposure was compared with the estimated exposure of 4,702 non-cases. Exposure was assigned based on complete work history and a JEM specifically developed for the cohort. No association was reported between cumulative exposure and risk of breast cancer regardless of age, histological type, and whether a lag period was used or not. An accompanying editorial opined that this well-designed study further adds to the already large pool of data not supporting an association between ELF EMF and breast cancer (Feychting, 2013). The editorial suggests that further studies in breast cancer "have little new knowledge to add," following the considerable improvement in study quality over time in breast cancer epidemiologic studies, and with the evidence being "consistently negative."

Zhao et al. (2014b) reported the results of their meta-analysis of 16 case-control epidemiologic studies of ELF EMF and breast cancer published between 2000 and 2007. They reported a weak but statistically significant association, which appeared to be stronger among non-menopausal women. The conclusion of the authors that ELF magnetic fields might be related to breast cancer is contrary to the conclusion of the WHO and other risk assessment panels. This may be due to the inclusion of earlier and methodologically less advanced studies in the meta-analysis.

Assessment

The two large recently published studies (Li et al., 2013; Koeman et al., 2014) support the growing body of scientific evidence against a causal role for magnetic fields in breast cancer. The meta-analyses by Zhao et al. (2014b) include numerous limitations and therefore should be interpreted with great caution due to flaws within the individual studies and the crude pooling of data with a vast range of exposure definitions and cut-points. Several review papers (Feychting and Forssén 2006; Hulka and Moorman, 2008) and expert groups (SCENIHR, 2009) support the previous WHO (2007) conclusion that magnetic-field exposure does not influence the risk of breast cancer.

Table 4. Relevant studies of breast cancer

Authors	Year	Study
Koeman et al.	2014	Occupational extremely low-frequency magnetic field exposure and selected cancer outcomes in a prospective Dutch cohort
Feytching	2013	Invited commentary: extremely low-frequency magnetic fields and breast cancer--now it is enough!
Li et al	2013	Occupational exposure to magnetic fields and breast cancer among women textile workers in Shanghai, China
Zhao et al.	2014b	Relationship between exposure to extremely low-frequency electromagnetic fields and breast cancer risk: a meta-analysis.

Adult brain cancer

Brain cancer was studied along with leukemia in many of the occupational studies of ELF EMF. The findings were inconsistent, and there was no pattern of stronger findings in studies with more advanced methods, although a small association could not be ruled out. The WHO classified the epidemiologic data on adult brain cancer as inadequate and recommended (1) updating the existing cohorts of occupationally-exposed individuals in Europe and (2) pooling the epidemiologic data on brain cancer and adult leukemia to confirm the absence of an association.

The WHO stated the following:

> In the case of adult brain cancer and leukaemia, the new studies published after the IARC monograph do not change the conclusion that the overall evidence for an association between ELF [EMF] and the risk of these disease remains inadequate (WHO 2007, p. 307).

Recent studies (July 2013 to November 2014)

Epidemiology studies published since our last review on adult brain cancer and ELF EMF exposure are listed in Table 5 and include two cohort studies and one case-control study.

The large cohort study of occupational ELF EMF exposure in the Netherlands (Koeman et al., 2014) also investigated adult brain cancer development. The authors reported no association with adult brain cancer for any of the exposure metrics investigated for EMF exposure for either men or women.

Sorahan (2014a) reported the analysis of brain cancer incidence between 1973 and 2010 among more than 70,000 British electricity supply workers in a cohort analysis. The study reported no consistent association between brain cancer risk (glioma and meningioma) and estimated cumulative, recent and distant occupational exposure to ELF EMF.

Turner et al. (2014) investigated the association between occupational exposure to ELF EMF and brain cancer in a large international case-control epidemiologic study. While the authors reported both an increase (with exposure 1-4 years prior to diagnosis) and a decrease (with the highest maximum exposure) in associations with brain cancer in some of the sub-analyses, overall there was no association with lifetime cumulative or average exposure for either main type of brain cancer (glioma or meningioma).

Assessment

Findings from the recent literature predominantly support no association between exposure to ELF EMF and brain cancer in adults, but remain limited due to the exposure assessment methods and insufficient data available on specific brain cancer subtypes. Currently, the literature provides very weak evidence of an association in some studies, if any, between magnetic fields and brain cancer.[11] The overall evidence for brain cancer has not materially changed and remains inadequate as classified by the WHO in 2007.

Table 5. Relevant studies of adult brain cancer

Authors	Year	Study
Koeman et al.	2014	Occupational extremely low-frequency magnetic field exposure and selected cancer outcomes in a prospective Dutch cohort
Sorahan	2014a	Magnetic fields and brain tumour risks in UK electricity supply workers.
Turner et al	2014	Occupational exposure to extremely low frequency magnetic fields and brain tumour risks in the INTEROCC study

Adult leukemia

There is a vast amount of literature on adult leukemia and ELF EMF, most of which is related to occupational exposure. Overall, the findings of these studies are inconsistent—with some studies reporting a positive association between measures of ELF EMF and leukemia and other studies showing no association. No pattern has been identified whereby studies of higher quality or design are more likely to produce positive or negative associations. The WHO subsequently classified the epidemiologic evidence for adult leukemia as "inadequate." They recommended updating the existing European occupation cohorts and updating a meta-analysis on occupational magnetic-field exposure.

Recent studies (July 2013 to November 2014)

The Dutch cohort study previously discussed (Koeman et al., 2014) identified 761 and 467 malignancies of the hematopoietic system among men and women, respectively. Overall, no increases in risk or trends were observed in association with cumulative exposure to ELF magnetic fields or duration of exposure among either men or women. In some sub-analyses by subtype, however, statistically significant associations were noted for acute myeloid leukemia and follicular lymphoma among men.

Sorahan also completed detailed analyses for leukemia incidence in the cohort of over 70,000 British electricity supply employees (Sorahan, 2014b). For all leukemias overall, there was no indication for risk increases with cumulative, recent or distant occupational exposure to magnetic fields. In some sub-analyses, however, the authors reported a statistically significant association for adult ALL.

Assessment

Recent studies of adult leukemia have not provided new evidence to support an association of magnetic field exposure with adult leukemia overall or with any leukemia sub-type. Thus, there

[11] A consensus statement by the National Cancer Institute's Brain Tumor Epidemiology Consortium confirms this statement. They classified residential power frequency EMF in the category "probably not risk factors" and described the epidemiologic data as "unresolved" (Bondy et al., 2008, p. 1958).

is no new evidence to alter the overall conclusion and the evidence remains inadequate for adult leukemia.

Table 6. Relevant studies of adult leukemia

Authors	Year	Study
Koeman et al.	2014	Occupational extremely low-frequency magnetic field exposure and selected cancer outcomes in a prospective Dutch cohort
Sorahan	2014b	Magnetic fields and leukaemia risks in UK electricity supply workers.

Reproductive and developmental effects

Two studies in the past have received considerable attention because of a reported association between peak magnetic-field exposure greater than approximately 16 mG and miscarriage—a prospective cohort study of women in early pregnancy (Li et al., 2002) and a nested case-control study of women who miscarried compared to their late-pregnancy counterparts (Lee et al., 2002).

These two studies improved on the existing body of literature because average exposure was assessed using 24-hour personal magnetic-field measurements (early studies on miscarriage were limited because they used surrogate measures of exposure, including visual display terminal use, electric blanket use, or wire code data). Following the publication of these two studies, however, a hypothesis was put forth that the observed association may be the result of behavioral differences between women with "healthy" pregnancies that went to term (less physically active) and women who miscarried (more physically active) (Savitz, 2002). It was proposed that physical activity is associated with an increased opportunity for peak magnetic-field exposures, and the nausea experienced in early, healthy pregnancies and the cumbersomeness of late, healthy pregnancies would reduce physical activity levels, thereby decreasing the opportunity for exposure to peak magnetic fields. Furthermore, nearly half of women who had miscarriages reported in the cohort by Li et al. (2002) had magnetic-field measurements taken after miscarriage occurred, when changes in physical activity may have already occurred, and all measurements in Lee et al. (2002) occurred post-miscarriage.

The scientific panels that have considered these two studies concluded that the possibility of this bias precludes making any conclusions about the effect of magnetic fields on miscarriage (NRPB, 2004; FPTRPC, 2005; WHO, 2007). The WHO concluded, "There is some evidence for increased risk of miscarriage associated with measured maternal magnetic-field exposure, but this evidence is inadequate" (WHO 2007, p. 254). The WHO stated that, given the potentially high public health impact of such an association, further epidemiologic research is recommended.

Recent studies (July 2013 to November 2014)

Two epidemiologic studies investigated the potential association between ELF EMF exposure and miscarriage or stillbirth. A hospital-based case-control study from Iran included 58 women with spontaneous abortion and 58 pregnant women (Shamsi Mahmoudabadi et al., 2013). The authors reported that measured magnetic-field levels were statistically significantly higher among the cases than among controls. The study was small and provided little information on subject recruitment, exposure assessment, type of metric used to summarize exposure, and potential confounders; thus, it contributes little weight to an overall assessment.

A Chinese study identified 413 pregnant women at 8 weeks of gestation between 2010 and 2012 (Wang et al., 2013). Magnetic-field levels were measured at the front door and the alley in front of the participants' homes. No statistically significant association was seen with average exposure at the front door, but the authors reported an association with maximum magnetic-field values measured in the alleys in front of the homes. The study provides a fairly limited contribution to our current knowledge as magnetic-field levels measured at the front door or outside the home are very poor predictors of in-home and personal exposures.

Two studies examined various birth outcomes in relation to ELF EMF exposure. A study from the United Kingdom investigated birth outcomes in relation to residential proximity to power lines during pregnancy between 2004 and 2008 in Northwest England (de Vocht et al., 2014). The researchers examined hospital records of over 140,000 births, and distance to the nearest power lines were determined using geographical information systems. The authors reported moderately lower birth weight within 50 meters of power lines, but observed no statistically significant increase in risk of any adverse clinical birth outcomes (such as preterm birth, small for gestational age, or low birth weight). The limitations of the study include its reliance on distance for exposure assessment and the potential for confounding by socioeconomic status, as also discussed by the authors. A study from Iran reported no association between ELF EMF and pregnancy and developmental outcomes, such as duration of pregnancy, birth weight and length, head circumference, and congenital malformations (Mahram and Ghazavi, 2013). The study, however, provided little information on subject selection and recruitment; thus, it is difficult to assess its quality.

Su et al. (2014) conducted a cross-sectional study in Shanghai to examine correlations between magnetic-field exposure and embryonic development. The authors identified 149 pregnant women who were seeking induced termination of pregnancy during the first trimester. Personal 24-hour measurements were conducted for women within four weeks of the termination. Ultrasound was used to determine embryonic bud and embryonic sac length prior to the termination. The authors reported an association with maternal daily magnetic-field exposure and embryonic bud length. The study has a number of severe limitations, including the cross-sectional design, which cannot distinguish if exposure measured after termination describes that experienced during the first trimester; thus, it is impossible to assess causality. Additionally, the lack of careful consideration for gestational age, which is a major determinant of embryonic bud length, is an issue. Overall, the study provides little, if any, weight in a weight-of-evidence assessment.

Lewis et al. (2014) analyzed magnetic field exposure data over 7 consecutive days among 100 pregnant women from an earlier study. They reported that measures of central tendency (e.g., mean, median) were relatively well correlated day-to-day, and a measurement on one day could be used reasonably well to predict exposure on another day. Peak exposure measures (e.g., maximum value) showed poorer performance. The study did not examine the outcomes of the pregnancies, but these results have implications for earlier studies that reported association for spontaneous abortions with peak measures but not with measures of central tendency.

Assessment

The recent epidemiologic studies have not provided sufficient evidence to alter the conclusion that the evidence for reproductive or developmental effects is inadequate.

Table 7. Relevant studies of reproductive and developmental effects

Authors	Year	Study
de Vocht et al.	2014	Maternal residential proximity to sources of extremely low frequency electromagnetic fields and adverse birth outcomes in a UK cohort
Lewis et al.	2014	Temporal variability of daily personal magnetic field exposure metrics in pregnant women.
Mortazavi et al.	2013	The study of the effects of ionizing and non-ionizing radiations on birth weight of newborns to exposed mothers
Shamsi Mahmoudabadi et al.	2013	Exposure to Extremely Low Frequency Electromagnetic Fields during Pregnancy and the Risk of Spontaneous Abortion: A Case-Control Study
Su et al.	2014	Correlation between exposure to magnetic fields and embryonic development in the first trimester
Wang et al.	2013	Residential exposure to 50 Hz magnetic fields and the association with miscarriage risk: a 2-year prospective cohort study

Neurodegenerative diseases

Research into the possible effect of magnetic fields on the development of neurodegenerative diseases began in 1995, and the majority of research since then has focused on Alzheimer's disease and a specific type of motor neuron disease called amyotrophic lateral sclerosis (ALS), which is also known as Lou Gehrig's disease. Early studies on ALS, which had no obvious biases and were well conducted, reported an association between ALS mortality and estimated occupational magnetic-field exposure. The review panels, however, were hesitant to conclude that the associations provided strong support for a causal relationship. Rather, they felt that an alternative explanation (i.e., electric shocks received at work) may be the source of the observed association.

The majority of the more recent studies discussed by the WHO reported statistically significant associations between occupational magnetic-field exposure and mortality from Alzheimer's disease and ALS, although the design and methods of these studies were relatively weak (e.g., disease status was based on death certificate data, exposure was based on incomplete occupational information from census data, and there was no control for confounding factors). Furthermore, there were no biological data to support an association between magnetic fields and neurodegenerative diseases. The WHO panel concluded that there is "inadequate" data in support of an association between magnetic fields and Alzheimer's disease or ALS. The panel recommended more research in this area using better methods; in particular, studies that enrolled incident Alzheimer's disease cases (rather than ascertaining cases from death certificates) and studies that estimated electrical shock history in ALS cases were recommended. Specifically, the WHO concluded, "When evaluated across all the studies, there is only very limited evidence of an association between estimated ELF exposure and [Alzheimer's] disease risk" (WHO 2007, p. 194).

Recent studies (July 2013 to November 2014)

Davanipour et al. (2014) have reported on a study of severe cognitive dysfunction and occupational ELF magnetic-field exposure, in which "[t]he study population consisted of 3,050 Mexican Americans, aged 65+, enrolled in Phase I of the Hispanic Established Population for the Epidemiologic Study of the Elderly (H-EPESE) study." Occupational history, along with data on other socio-demographic information, was obtained via in-home personal interviews. Occupational exposure to magnetic fields was classified as low, medium, and high. Cognitive function was evaluated with the use of a mini-mental state exam and cognitive dysfunction was defined as an exam score below 10. While the authors describe their study as a population-based case-control study, based on the provided description in the paper, the study appears to be a cross-sectional study. Based on their analyses, the authors reported a statistically significant association between estimated occupational magnetic-field exposure and severe cognitive dysfunction. This study had a number of limitations, including the cross-sectional study design, the lack of clear clinical diagnosis for case-definition, and the crude assessment of occupational exposure.

Seelen et al. (2014) conducted a large population-based case-control study of ALS and residential proximity to high-voltage power lines in the Netherlands. The authors included 1,139 ALS cases diagnosed between 2006 and 2013 and 2,864 frequency-matched controls selected from general practitioners' rosters. Lifetime residential history was determined for all cases and controls using data from the Municipal Personal Records Database. Addresses were geocoded and the shortest distance to a high-voltage power was determined for each address. High-voltage power lines with voltages between 50 kV and 150 kV (high voltage) and between 220 kV and 380 kV were analyzed. No statistically significant association was reported for ALS with residential proximity to power lines with any of the voltages included. The authors also conducted a meta-analysis including their own results along with those of two previously published studies (Marcilio et al., 2011; Frei et al., 2013) and reported an overall OR of 0.9 (95% CI 0.7-1.1) for living within 200 meters of a high voltage power line. Similar to the previous power-line studies, the main limitation of the current study is the use of distance to power lines as a surrogate for magnetic-field exposure. The authors, however, reconstructed lifetime residential history, which represents a methodological improvement.

The role of electric shocks in development of neurodegenerative diseases has been examined in three recent studies. Electric shocks have been hypothesized to be a potential etiologic agent, primarily for ALS, based on the observation that linked "electric occupations," but not estimates of magnetic-field exposure to ALS (Vergara et al., 2013). Researchers in the Netherlands conducted a hospital-based case-control study of Parkinson's disease and occupational exposure to electric shocks and ELF magnetic fields (van der Mark et al., 2014). The study included 444 cases of Parkinson's disease and 876 matched controls. Occupational history was determined based on telephone interviews. JEMs were used to categorize jobs for exposure to both electric shocks and magnetic fields. The authors reported no risk increases with any of the two investigated exposures and concluded that their results suggest no association with Parkinson's disease.

A mortality case-control study using death certificates between 1991 and 1999 was conducted in the United States (Vergara et al., 2014). The study analyzed 5,886 ALS deaths and 10-times as many matched control deaths. Exposure to electric shocks and ELF magnetic fields was classified based on job titles reported on the death certificates and using corresponding JEMs. While a statistically significant association was reported for "electrical occupations," no consistent associations were observed for either magnetic field or electric shock exposures. The main limitation of the study is its reliance on death certificates that may result in disease and exposure misclassifications.

Huss et al. (2014) reported results of their analysis of ALS mortality in the Swiss National Cohort between 2000 and 2008. The cohort included about 2.2 million workers with high, medium, or low exposure to ELF magnetic fields and electric shocks. For exposure classification, JEMs for magnetic-field exposure and electric shocks were applied to occupations reported by the subjects at the 1990 and 2000 censuses. The authors reported a statistically significant association of ALS mortality with estimated medium or high occupational magnetic-field exposure based at both censuses, but not with estimates of electric shock exposure. The main limitations of the study include the reliance on mortality data, which may result in disease misclassification, and the use of census data for exposure assessment, which may result in exposure misclassification.

Assessment

Overall, the recent literature does not alter the conclusion that there are "inadequate" data for a causal link between exposure to ELF magnetic fields and neurodegenerative diseases. Most of the recent studies provided no support for a potential association. Several recent studies have investigated the potential role of electric shocks in neurodegenerative disease development. None of these studies reported results that would support the hypothesis that electric shocks play an etiologic role.

With respect to Alzheimer's disease, the main limitations of the available literature remains: the difficulty in diagnosing Alzheimer's disease; the difficulty of identifying a relevant exposure window given the long and nebulous course of this disease; the difficulty of estimating magnetic-field exposure prior to the appearance of the disease; the under-reporting of Alzheimer's disease on death certificates; crude exposure evaluations that are often based on the recollection of occupational histories by friends and family given the cognitive impairment of the study participants; and the lack of consideration of both residential and occupational exposures or confounding variables.

Although the most-recently published studies on this topic in Table 8 below were not available for inclusion in the SCENIHR opinion (their cut-off date was June 2014), the authors concluded that "[a]lthough the new studies in some cases have methodological weaknesses, they do not provide support for the previous conclusion that ELF MF exposure increases the risk for Alzheimer´s disease" (SCENIHR, 2015, p. 166).

Table 8. Relevant studies of neurodegenerative disease

Authors	Year	Study
Davanipour et al.	2014	Severe cognitive dysfunction and occupational extremely low frequency magnetic field exposure among elderly Mexican Americans.
Huss et al.	2014	Occupational exposure to magnetic fields and electric shocks and risk of ALS: The Swiss National Cohort.
Seelen et al.	2014	Residential exposure to extremely low frequency electromagnetic fields and the risk of ALS
Van der Mark et al.	2014	Extremely low-frequency magnetic field exposure, electrical shocks and risk of Parkinson's disease
Vergara et al.	2014	Case-control study of occupational exposure to electric shocks and magnetic fields and mortality from amyotrophic lateral sclerosis in the US, 1991–1999

Cardiovascular disease

It has been hypothesized that magnetic-field exposure reduces heart rate variability, which in turn increases the risk for AMI. In a large cohort of utility workers, Savitz et al. (1999) reported an association with arrhythmia-related deaths and deaths due to AMI among workers with higher magnetic field exposure. Previous and subsequent studies did not report a statistically significant increase in cardiovascular disease mortality or incidence related to occupational magnetic-field exposure (WHO, 2007).

The WHO concluded:

> Experimental studies of both short- and long-term exposure indicate that, while electric shock is an obvious health hazard, other hazardous cardiovascular effects associated with ELF fields are unlikely to occur at exposure levels commonly encountered environmentally or occupationally. Although various cardiovascular changes have been reported in the literature, the majority of effects are small and the results have not been consistent within and between studies. With one exception [Savitz et al., 1999], none of the studies of cardiovascular disease morbidity and mortality has shown an association with exposure. Whether a specific association exists between exposure and altered autonomic control of the heart remains speculative. Overall, the evidence does not support an association between ELF exposure and cardiovascular disease." (WHO, 2007, p. 220)

Recent studies (July 2013 to November 2014)

Since our last review in July 2013, no newly published studies of ELF EMF and cardiovascular diseases have been identified by our literature search.

Assessment

The conclusion that there is no association between magnetic fields and cardiovascular diseases has not changed.

In vivo studies related to carcinogenesis

In the field of ELF EMF research, a number of research laboratories have exposed rodents, including those with a particular genetic susceptibility to cancer, to high levels of magnetic fields over the course of the animals' lifetime and performed tissue evaluations to assess the incidence of cancer in many organs. In these studies, magnetic-field exposure has been administered alone (to test for the ability of magnetic fields to act as a complete carcinogen), in combination with a known carcinogen (to test for a promotional or co-carcinogenetic effect), or in combination with a known carcinogen and a known promoter (to test for a co-promotional effect).

The WHO review described four large-scale, long-term studies of rodents exposed to magnetic fields over the course of their lifetime that did not report increases in any type of cancer (Mandeville et al., 1997; Yasui et al., 1997; Boorman et al., 1999a, 1999b; McCormick et al., 1999). No directly relevant animal model for childhood ALL existed at the time of the WHO report. Some animals, however, develop a type of lymphoma similar to childhood ALL and studies exposing predisposed transgenic mice to ELF magnetic fields did not report an increased incidence of this lymphoma type (Harris et al., 1998; McCormick et al., 1998; Sommer and Lerchel, 2004).

Studies investigating whether exposure to magnetic fields can promote cancer or act as a co-carcinogen used known cancer-causing agents, such as ionizing radiation, ultraviolet radiation, or other chemicals. No effects were observed for studies on chemically-induced preneoplastic liver lesions, leukemia or lymphoma, skin tumors, or brain tumors; however, the incidence of 7,12-dimethylbenz[a]anthracene (DMBA)-induced mammary tumors was increased with magnetic-field exposure in a series of experiments in Germany (Löscher et al., 1993, 1994, 1997; Mevissen et al., 1993a,1993b, 1996a, 1996b, 1998; Baum et al., 1995; Löscher and Mevissen, 1995), suggesting that magnetic-field exposure increased the proliferation of mammary tumor cells. These results were not replicated in a subsequent series of experiments in a laboratory in the United States (Anderson et al., 1999; Boorman et al.1999a, 1999b), possibly due to differences in experimental protocol and the species strain. In Fedrowitz et al. (2004), exposure enhanced mammary tumor development in one sub-strain (Fischer 344 rats), but not in another sub-strain that was obtained from the same breeder, which argues against a promotional effect of magnetic fields.[12]

Some studies have reported an increase in genotoxic effects among exposed animals (e.g., DNA strand breaks in the brains of mice [Lai and Singh, 2004]), although the results have not been replicated.

[12] The WHO concluded with respect to the German studies of mammary carcinogenesis, "Inconsistent results were obtained that may be due in whole or in part to differences in experimental protocols, such as the use of specific substrains" (WHO 2007, p. 321).

In summary, the WHO concluded the following with respect to *in vivo* research: "There is no evidence that ELF [EMF] exposure alone causes tumours. The evidence that ELF field exposure can enhance tumour development in combination with carcinogens is inadequate" (WHO, 2007, p. 322). Recommendations for future research included the development of a rodent model for childhood ALL and the continued investigation of whether magnetic fields can act as a promoter or co-carcinogen.

Recent studies (July 2013 to November 2014)

No new animal bioassays of tumor development due to magnetic-field exposure alone or in combination with known cancer initiators have been conducted since the study by Bernard et al. (2008) that was the first study to use an animal model of ALL, the most common leukemia type in children, reviewed in the previous update. Instead, various *in vivo* studies examining potential mechanisms that could precipitate cancer development have been conducted. These studies are listed in Table 9.

Two recent animal studies examined the ability of magnetic-field exposure to cause DNA damage. Saha et al. (2014) exposed pregnant mice to one of three different magnetic field (50-Hz) exposure conditions: 1,000 mG for 2 hours on day 13.5 of gestation, 3,000 mG (continuous) for 15 hours on day 12.5 of gestation, or 3,000 mG (intermittent: 5 minutes on, 10 minutes off) for 15 hours on day 12.5 of gestation. Controls were either untreated or sham-exposed under these same conditions, but with the exposure equipment turned off. Additional animals were exposed to either 10 or 25 Gray of X-irradiation on day 13.5 of gestation; however, the amount of time for which these treatments were given is not known. Although X-irradiation was associated with increased DNA double strand breaks and cell apoptosis in the embryonic brain cells of the ventricular and subventricular zones, none of the magnetic field conditions had a significant effect on these parameters. These analyses were not conducted in a blinded manner; however, the potential influence of the animal litter was taken into account in the statistical analysis.

In a related study, Korr et al. (2014) continuously exposed mice for 8 weeks to either 1,000 mG or 10,000 mG, 50-Hz magnetic fields. Controls were not sham-exposed, but maintained in the same room as the magnetic-field-exposed animals. At the end of the exposure period, the animals were injected with radiolabeled thymidine to look for DNA single-strand breaks and unscheduled DNA synthesis in the liver, kidneys, and brain using an autoradiographic method. A slight reduction in mitochondrial DNA synthesis was observed in the epithelial cells of the kidney collecting ducts at 1,000 mG, but no increase in DNA single-strand breaks was observed. At 10,000 mG, a slight reduction in unscheduled DNA synthesis (likely related to reduced mitochondrial DNA synthesis) was observed in the epithelial cells of the choroid plexus of the brain's fourth ventricle and the kidney collecting duct, but again, there was no difference in the degree of DNA single-strand breaks observed between treated and control animals. These investigations were conducted in a blinded manner.

Oxidative stress is a condition in which oxygen free radical levels in the body are elevated and is one mechanism by which DNA damage, as well as other forms of cellular damage, may occur. Numerous recent *in vivo* studies have evaluated whether magnetic-field exposure may be associated with oxidative stress, with mixed results. Seifirad et al. (2014) examined the expression of various markers, including the lipid peroxidation markers malondialdehyde, conjugated dienes, and total antioxidant capacity, in the blood following exposure of rats to a 5,000 mG, 60-Hz magnetic fields for either 4 hours (acute) or 14 days (chronic). The acute exposure was associated with increased total antioxidant capacity, while the chronic exposure was associated with increased malondialdehyde levels and a reduced total antioxidant capacity. Although the controls were reportedly sham-exposed, it is not known if this was for the acute or chronic exposure condition, making interpretation difficult. Blinded analyses and control of environmental conditions also were not reported.

In another study, Glinka et al. (2013) examined the expression of various antioxidant markers in the blood and liver of male rats following 30 minutes of exposure to 100,000 mG, 40-Hz magnetic fields, for 6, 10, or 14 days. The purpose of this analysis was to examine the potential role of magnetic fields in the treatment of wounds; thus, the rats were first wounded surgically prior to exposure. Controls were sham exposed, but blinded analyses were not reported. Further, no details on the preparation of liver homogenates or the methods used to analyze the various samples were reported. Differences from control in the expression of the antioxidant markers superoxide dismutase, glutathione peroxidase, and malondialdehyde were reported in either the blood or the liver on various days, but no clear pattern of expression was apparent. No differences in the expression of glutathione S-transferase was observed. It should be noted, however, that control values varied considerably across the different study days, which may be related to a confounding effect associated with the wound healing process.

Hassan and Abdelkawi (2014) exposed male rats to 100,000 mG, 50-Hz magnetic fields for 1 hour per day for 30 days. Other groups of rats were treated with cadmium chloride or both cadmium chloride and magnetic-field exposure. Although it was reported that the controls were sham-exposed, based on the methods description, this does not appear to be the case; also, analyses were not conducted in a blinded manner. Both magnetic-field exposure and cadmium treatment were reported to increase the total oxidant status and protein carbonyls present in the blood; both exposures combined results in an increased response over either single condition alone. Deng et al. (2013) conducted a similar study in which mice were exposed to 20,000 mG, 50-Hz magnetic fields for 4 hours per day, 6 days per week for 8 weeks. In this case, other treatment groups were exposed to aluminum or both magnetic fields and aluminum. Control mice were not reported to have been sham-exposed and analyses were not reported to have been conducted in a blinded manner. Both brain and serum levels of superoxide dismutase were reported to be lower in all exposure conditions compared to controls. In contrast, malondialdehyde levels were increased in all exposure groups. Other analyses looking at behavior and brain pathology were also conducted in this study, but are not reported here.

Manikonda et al. (2014) looked at the effects in rats of continuous, 90-day exposure to much lower magnetic field strengths (500 mG and 1,000 mG, 50-Hz). Controls were sham exposed in a similar exposure apparatus, but with the equipment turned off. Analyses were not reported to have been conducted in a blinded manner. Reactive oxygen species, thiobarbituric acid reactive substances (a marker of lipid peroxidation), and glutathione peroxidase were significantly increased compared to control levels in the hippocampus and cerebellum with both exposure conditions; they were also increased in the cortex, but at 1,000 mG only. Superoxide dismutase levels were also increased in all three tissues at 1,000 mG, while the thiol status (GSH/GSSG) was reduced with exposure in these tissues. Generally, the cortex was less responsive than the other brain tissues examined. It should be noted, however, that the exposed rats showed significantly higher levels of physical activity than the controls, which may have confounded the study results. Finally, Akdag et al. (2013) examined the effects of more long-term magnetic-field exposure. Rats were continuously exposed to a 1,000 or 5,000 mG, 50-Hz magnetic field for 2 hours per day for 10 months. Control rats were sham exposed (with the exposure system turned off) and analyses were reported to have been conducted in a blinded manner. Neither exposure condition affected the expression of various oxidant/anti-oxidant markers in the testes, although expression of an apoptosis marker seemed to be increased in an exposure-related manner.

Overall, it is hard to draw any conclusions from these studies of oxidative stress markers because the numbers of animals per group were generally low, the exposure parameters and oxidative stress markers examined varied across the studies, reported effects were contradictory across studies in some cases, and none of the analyses (with the exception of that by Akdag et al., 2013) were reported to have been conducted in a blinded manner. The equivocal nature of these data is similar to that of earlier studies investigating the influence of magnetic-field exposure on the expression of oxidative stress markers. Independent replications of findings in studies with greater sample sizes and blinded analyses are needed as well as a better understanding of how such markers may be related to health and disease processes.

Assessment

As previously noted, no new animal bioassays of long-term magnetic-field exposure as a possible carcinogen or co-carcinogen have been conducted since the last update. Rather, more recent animal studies have investigated two potential mechanisms related to carcinogenesis: genotoxicity and oxidative stress. The studies of oxidative stress generally suffer from various methodological deficiencies, including small samples sizes, the absence of sham-exposure treatment groups, and analyses that were not conducted in a blinded manner. Further, the results are generally inconsistent across the body of studies, with some studies reporting effects and other studies showing no change. Even in the studies showing alterations, these changes are not necessarily consistent from one study to the next. While these dissimilarities could be a function of the differences in exposure conditions employed across the body of studies, the equivocal nature of the findings on oxidative stress is consistent with that of earlier studies.

One particularly well-conducted study on genotoxicity found no effect of magnetic-field exposure on DNA double strand breaks. This study employed positive control X-irradiation, sham exposure of negative controls, and blinded analyses. Further, the results are generally consistent with those of another recent investigation that found no influence of magnetic-field exposure on the induction of DNA single strand breaks in the brain, liver, or kidneys of exposed mice.

Overall, the *in vivo* studies published since the last update do not alter the previous conclusion of the WHO that there is inadequate evidence of carcinogenicity due to ELF EMF exposure. Further, the limited recent investigations suggest that DNA single and double strand breaks do not occur as a result of magnetic-field exposure.

Table 9. Relevant *in vivo* studies related to carcinogenesis

Authors	Year	Study
Akdag et al.	2013	Can safe and long-term exposure to extremely low frequency (50 Hz) magnetic fields affect apoptosis, reproduction, and oxidative stress?
Deng et al.	2013	Effects of aluminum and extremely low frequency electromagnetic radiation on oxidative stress and memory in brain of mice
Glinka et al.	2013	Influence of extremely low-frequency magnetic field on the activity of antioxidant enzymes during skin wound healing in rats
Hassan and Abdelkawi	2014	Assessing of plasma protein denaturation induced by exposure to cadmium, electromagnetic fields and their combined actions on rat
Korr et al.	2014	No evidence of persisting unrepaired nuclear DNA single strand breaks in distinct types of cells in the brain, kidney, and liver of adult mice after continuous eight-week 50 Hz magnetic field exposure with flux density of 0.1 mT or 1.0 mT
Manikonda et al.	2014	Extremely low frequency magnetic fields induce oxidative stress in rat brain
Saha et al.	2014	Increased apoptosis and DNA double-strand breaks in the embryonic mouse brain in response to very low-dose X-rays but not 50 Hz magnetic fields
Seifirad et al.	2014	Effects of extremely low frequency electromagnetic fields on paraoxonase serum activity and lipid peroxidation metabolites in rat

7 Reviews Published by Scientific Organizations

A number of national and international scientific organizations have published reports or scientific statements with regard to the possible health effects of ELF EMF since January 2006. Although none of these documents represents a cumulative weight-of-evidence review of the caliber of the WHO review published in June 2007, their conclusions are of relevance. In general, the conclusions of these reviews are consistent with the scientific consensus articulated in Section 6.

The following list indicates the scientific organization and a link to the online reports or statements.

- **The European Health Risk Assessment Network on Electromagnetic Fields Exposure**
  - http://efhran.polimi.it/docs/D2_Finalversion_oct2012.pdf (EFHRAN, 2012 [human exposure])
  - http://efhran.polimi.it/docs/IMS-EFHRAN_09072010.pdf (EFHRAN, 2010 [*in vitro* and *in vivo* studies])
- **The Health Council of Netherlands**
  - http://www.gezondheidsraad.nl/sites/default/files/200902.pdf (HCN, 2009a)
  - http://www.gezondheidsraad.nl/en/publications/advisory-letter-power-lines-and-alzheimer-s-disease (HCN, 2009b)
  - http://www.gezondheidsraad.nl/en/publications/bioinitiative-report-0 (HCN, 2008a)
  - http://www.gezondheidsraad.nl/en/publications/high-voltage-power-lines-0 (HCN, 2008b)
- **The Health Protection Agency (United Kingdom)**
  - http://www.hpa.org.uk/Publications/Radiation/DocumentsOfTheHPA/RCE01PowerFrequencyElectromagneticFieldsRCE1/ (HPA, 2006)
- **The International Commission on Non-Ionizing Radiation Protection**
  - http://www.icnirp.de/documents/LFgdl.pdf (ICNIRP, 2010)

- **The Scientific Committee on Emerging and Newly Identified Health Risks (European Union)**
    - http://ec.europa.eu/health/ph_risk/committees/04_scenihr/docs/scenihr_o_007.pdf (SCENIHR, 2007)
    - http://ec.europa.eu/health/ph_risk/committees/04_scenihr/docs/scenihr_o_022.pdf (SCENIHR, 2009)
    - http://ec.europa.eu/health/scientific_committees/emerging/docs/scenihr_o_041.pdf (SCENIHR, 2015)

  The Swedish Radiation Protection Authority
    - http://www.who.int/peh-emf/publications/reports/SWEDENssi_rapp_2006.pdf (SSI, 2007)
    - http://www.who.int/peh-emf/publications/reports/SWEDENssi_rapp_2007.pdf (SSI, 2008)

- **The Swedish Radiation Safety Authority**
    - http://www.stralsakerhetsmyndigheten.se/Global/Publikationer/Rapport/Stralskydd/2009/SSM-Rapport-2009-36.pdf (SSM, 2009)
    - http://www.stralsakerhetsmyndigheten.se/Global/Publikationer/Rapport/Stralskydd/2010/SSM-Rapport-2010-44.pdf (SSM, 2010)
    - http://www.stralsakerhetsmyndigheten.se/Publikationer/Rapport/Stralskydd/2013/201319/ (SSM, 2013)

8 Standards and Guidelines

Following a thorough review of the research, scientific agencies develop exposure standards to protect against known health effects. The major purpose of a weight-of-evidence review is to identify the lowest exposure level below which no health hazards have been found (i.e., a threshold). Exposure limits are then set well below the threshold level to account for any individual variability or sensitivities that may exist.

Several scientific organizations have published guidelines for exposure to ELF EMF based on acute health effects that can occur at very high field levels.[13] The ICNIRP reviewed the epidemiologic and experimental evidence and concluded that there was insufficient evidence to warrant the development of standards or guidelines on the basis of hypothesized long-term adverse health effects such as cancer; rather, the guidelines put forth in their 2010 document set limits to protect against acute health effects (i.e., the stimulation of nerves and muscles) that occur at much higher field levels. The ICNIRP recommends a residential screening value of 2,000 mG and an occupational exposure screening value of 10,000 mG (ICNIRP, 2010). If exposure exceeds these screening values, then additional dosimetry evaluations are needed to determine whether basic restrictions on induced current densities are exceeded. For reference, in a national survey conducted by Zaffanella and Kalton (1998) for the National Institute for Environmental Health and Safety's EMF Research and Public Information Dissemination program, only about 1.6% of the general public in the United States experienced exposure to magnetic fields of at least 1,000 mG during a 24-hour period.

The ICES also recommends limiting magnetic field exposures at high levels because of the risk of acute effects, although their guidelines are higher than ICNIRP's guidelines; the ICES recommends a residential exposure limit of 9,040 mG and an occupational exposure limit of 27,100 mG (ICES, 2002). Both guidelines incorporate large safety factors.

The ICNIRP and ICES guidelines provide guidance to national agencies and only become legally binding if a country adopts them into legislation. The WHO strongly recommends that countries adopt the ICNIRP guidelines, or use a scientifically sound framework for formulating any new guidelines (WHO, 2006).

There are no national or state standards in the United States limiting exposures to ELF EMF based on health effects. Two states, Florida and New York, have enacted standards to limit magnetic fields at the edge of the right-of-way from transmission lines (NYPSC, 1978; FDER, 1989; NYPSC, 1990; FDEP, 1996), however, the basis for these limits was to maintain the "status quo" so that fields from new transmission lines would be no higher than those produced by existing transmission lines.

[13] Valberg et al. (2011) provides a listing of guidelines provided by health and safety organizations.

Neither Rhode Island nor Massachusetts has EMF standards for transmission lines but the Energy Facility Siting Boards have encouraged the use of practical and cost-effective designs to minimize magnetic field levels along the edges of transmission rights-of-way. This approach is consistent with recommendations of the WHO (2007) for addressing ELF EMF.

Table 10. Screening guidelines for EMF exposure

Organization	Exposure (60 Hz)	Magnetic field
ICNIRP	Occupational	10,000 mG
	General Public	2,000 mG
ICES	Occupational	27,100 mG
	General Public	9,040 mG

Sources: ICNIRP, 2010; ICES, 2002

9 Summary

A significant number of epidemiology and *in vivo* studies have been published on ELF EMF and health since the WHO 2007 report was released in June 2007. The weak statistical association between high, average magnetic fields and childhood leukemia has not been appreciably strengthened or substantially diminished by subsequent research, although the most recent studies tended to show no overall associations. The previously reported association remains unexplained and unsupported by the experimental data. The recent *in vivo* studies confirm the lack of experimental data supporting a leukemogenic risk associated with magnetic-field exposure. Recent publications on other cancer and non-cancer outcomes provided no substantial new information to alter the previous conclusion that the evidence is inadequate to link outcomes to ELF EMF exposure.

In conclusion, recent studies when considered in the context of previous research do not provide evidence to alter the conclusion that ELF EMF exposure is not a cause of cancer or any other disease process at the levels we encounter in our everyday environment.

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Appendix B: Agency Coordination Documentation

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40 Sylvan Road
Waltham, MA 02451

Subject: Highland Drive Substation Project Proposed Plan Applications (PPAs) NEP-12-T15 and NEP-12-T16

Dear Mr. Perez-Perez:

This letter is to inform you that pursuant to review under Section I.3.9 of the ISO Tariff, no significant adverse effect has been identified with regard to the following PPAs:

NEP-12-T15 – Transmission Notification from New England Power Company (NEP) for the construction of a new Highland Drive 115/13.8 kV substation with a single breaker and two 115/13.8 kV, 33/44/55 MVA transformers in Cumberland, RI. Loop the new substation into the J16 line by constructing two new 115 kV taps, each 0.045 miles in length. Reconductor approximately 2.24 miles of the J16 overhead line between Riverside and the new Highland Drive substation. Upgrade the relaying for the J16 at Riverside substation and J16 at Staples substation.

NEP-12-T16 – Transmission Notification from NEP for the upgrade of the 344 and 333 oil circuit breakers to SF6 insulated breakers, aluminum bus conductor and all associated equipment for the V-148S circuit at Robinson Avenue. Reconductor the V-148S overhead conductor (approximately 0.02 miles) between the bus and the V-148 tap.

The in-service date of the project is June 1, 2014. The Reliability Committee (RC) reviewed the materials presented in support of the proposed project and did not identify a significant adverse effect on the reliability or operating characteristics of the transmission facilities of NEP, the transmission facilities of another Transmission Owner or the system of any other Market Participant.

Having given due consideration to the RC review, ISO New England has determined that implementation of the plan will not have a significant adverse effect upon the reliability or operating characteristics of the Transmission Owner's transmission facilities, the transmission facilities of another Transmission Owner, or the system of a Market Participant.

A determination under Section I.3.9 of the ISO Tariff is limited to a review of the reliability impacts of a proposed project as submitted by Participants and does not constitute an approval of a proposed project under any other provisions of the ISO Tariff.

Sincerely,

Stephen J. Rourke
Vice President, System Planning

cc: Proposed Plan Applications

ISO New England Inc.
One Sullivan Road, Holyoke, MA 01040-2841
www.iso-ne.com T 413 535-4306 F 413 540-4203

DEPARTMENT OF THE ARMY
NEW ENGLAND DISTRICT, CORPS OF ENGINEERS
696 VIRGINIA ROAD
CONCORD, MASSACHUSETTS 01742-2751

REPLY TO
ATTENTION OF

January 29, 2015

Regulatory Division
CENAE-R-PEB
Permit Number: NAE-2014-2643

Narragansett Electric Company dba National Grid
ATTN: Michael Ryan
280 Melrose Street
Providence, Rhode Island 02907

Dear Mr. Ryan:

We have reviewed the application by the Narragansett Electric Company dba National Grid to place swamp mats for construction access on the right-of-way of the existing J16 115kV Transmission Line in Woonsocket and Cumberland, Rhode Island. Your company will reconductor the J16 line. Work includes replacing the conductors (wires), replacing 4 of 23 existing steel structures and installing 1 new steel pole structure. The swamp mats will result in a total cumulative temporary wetland impact of approximately 15,232 square feet (0.35 acres). The project is shown on the enclosed plans titled "J16 115 KV TRANSMISSION LINE RECONDUCTORING PROJECT NORTH WOONSOCKET AND CUMBERLAND RHODE ISLAND" dated "DECEMBER 17, 2014."

The project is exempt from state permitting requirements by RIDEM but requires federal permitting. Based on the information you have provided, we have determined that the proposed activity will have only minimal individual or cumulative impacts on waters of the United States, including wetlands. Therefore, this work is authorized as a Category 2 activity under the attached Federal permit known as the Rhode Island General Permit (GP). The work must be performed in accordance with the terms and conditions of the GP and in compliance with the following special conditions:

1.) All mats will be removed following completion of work.

2.) Any disturbed soils will be seeded, mulched and restored to preconstruction condition.

3.) All mats must be cleaned after use before being moved off-site to prevent the spread of Phragmites and other invasive vegetation.

You are responsible for complying with all of the GP's requirements. Please review the attached GP carefully, in particular the GP conditions beginning on Page 4, to familiarize yourself with its contents. You should ensure that whoever does the work fully understands the requirements and that a copy of the permit document and this authorization letter are at the project site throughout the time the work is underway.

This authorization expires on February 22, 2017, unless the GP is modified, suspended or revoked. You must complete the work authorized herein by February 22, 2017. If you do not, you must contact this office to determine the need for further authorization before continuing the activity. We recommend you contact us before this permit expires to discuss a time extension or permit reissuance.

If you change the plans or construction methods for work within our jurisdiction, please contact us immediately to discuss modification of this authorization. This office must approve any changes before you undertake them.

This authorization requires you to complete and return the enclosed Work Start Notification Form to this office at least two weeks before the anticipated starting date. You must also complete and return the enclosed Compliance Certification Form within one month following the completion of the authorized work and any required mitigation.

This permit does not obviate the need to obtain other Federal, state, or local authorizations required by law, as listed on Page 2 of the GP. Performing work not specifically authorized by this determination or failing to comply with any special condition(s) provided above or all the terms and conditions of the GP may subject you to the enforcement provisions of our regulations.

Please contact Michael Elliott of my staff at (978) 318-8131 if you have any questions.

Sincerely,

Barbara Newman

Barbara Newman
Acting Chief, Permits & Enforcement Branch
Regulatory Division

Enclosures

Copies Furnished:

Adam E. Rosenblatt – VHB - arosenblatt@vhb.com

Laura Ernst – National Grid - laura.ernst@nationalgrid.com

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Plan Set

Issued for: Army Corp. of Engineers
Category 2 Application
Date Issued: December 17, 2014
Latest Issue: December 17, 2014

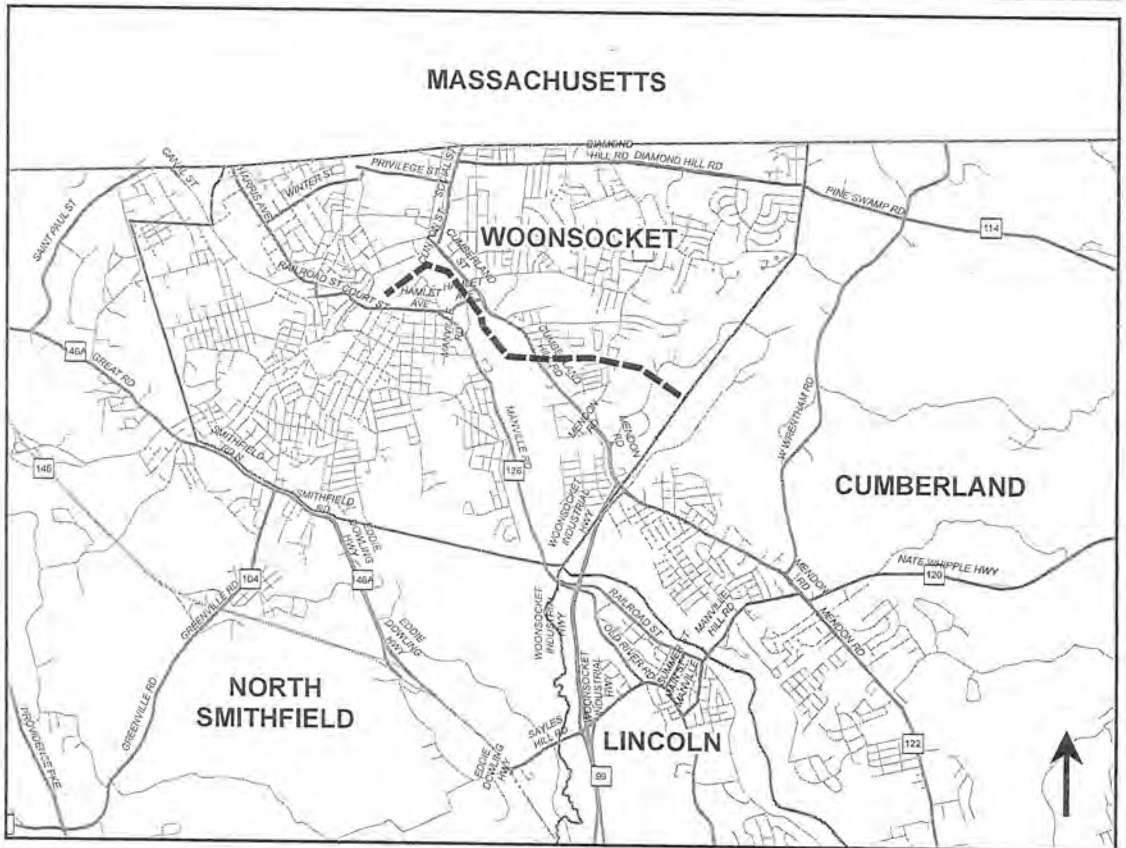
Sheet Index

Number	Drawing Title	Latest Issue
1	General Notes	12/17/2014
2	Details	12/17/2014
3 to 14	Plans	12/17/2014

nationalgrid vhb

J16 115kV Transmission Line Reconductoring Project

Woonsocket and Cumberland, Rhode Island



Site Location Map

1 inch = 0.75 miles

0 0.375 0.75 Miles

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EXISTING CONDITIONS INFORMATION:
REFERENCES:
1. TRANSMISSION LINE RIGHT-OF-WAY (ROW) LIMITS AND EASEMENT BOUNDARIES BASED ON THE FOLLOWING T-SHEETS PROVIDED BY THE NARRAGANSETT ELECTRIC COMPANY. ROW AND EASEMENT LINES ARE APPROXIMATE AND INTENDED TO BE A GRAPHICAL REPRESENTATION. THIS SHALL NOT BE CONSTRUED TO REPRESENT AN ACTUAL BOUNDARY SURVEY AND IS SUBJECT TO SUCH CHANGES AS AN ACCURATE BOUNDARY SURVEY MAY DISCLOSE.
T-SHEET NO.: 5636-1, DATED: NOV. 1922, LAST REVISED: 11/13/02
T-SHEET NO.: 5635-1, DATED: NOV. 1922, LAST REVISED: 06/16/04

2. EXCEPT AS INDICATED ON SPECIFIC PLAN SHEETS, WETLAND BOUNDARY DELINEATION WAS PERFORMED BY VANASSE HANGEN BRUSTLIN, INC. (VHB), PROVIDENCE, RI. FLAG LOCATIONS WERE LOCATED BY A GLOBAL POSITIONING SYSTEM (GPS) FIELD SURVEY CONDUCTED BY VHB IN SEPTEMBER/OCTOBER 2014. THIS SURVEY CONFORMS TO A CLASS IV STANDARD AS DEFINED IN THE PROCEDURAL AND TECHNICAL STANDARDS FOR PERFORMING LAND SURVEYING IN THE STATE OF RHODE ISLAND AND PROVIDENCE PLANTATIONS.

3. NO SIGNIFICANT GRADE CHANGES ARE PROPOSED.

EROSION AND SEDIMENT CONTROL NOTES:
1. PRIOR TO STARTING ANY SITE WORK, THE CONTRACTOR SHALL NOTIFY APPROPRIATE AGENCIES AND SHALL INSTALL EROSION CONTROL MEASURES AS SHOWN ON THE PLANS AND AS IDENTIFIED IN FEDERAL, STATE AND LOCAL APPROVAL DOCUMENTS PERTAINING TO THIS PROJECT.

2. A SOIL EROSION AND SEDIMENTATION CONTROL PLAN HAS BEEN DESIGNED TO PROTECT ON-SITE WETLANDS AND WATERCOURSES AND OFF-SITE AREAS DURING AND AFTER CONSTRUCTION.

3. IN AREAS WHERE HIGH RUNOFF VELOCITIES OR HIGH SEDIMENT LOADS ARE EXPECTED SEDIMENT CONTROL BARRIERS WILL BE BACKED WITH SILT FANCING.

4. EXCAVATION ASSOCIATED WITH FOUNDATION REPAIRS WILL BE APPROPRIATELY CONTAINED WITH AN EROSION CONTROL BARRIER.

5. TYPICAL CRUSHED-STONE CONSTRUCTION ENTRANCE/EXITS WILL BE CONSTRUCTED AT EACH STREET ACCESS POINT THROUGHOUT THE PROJECT AREA.

6. ONCE WORK IS COMPLETE, FINAL SURFACE TREATMENT CONSISTING OF STRAW OR CELLULOSE MULCH WILL BE APPLIED TO STABILIZE THE DISTURBED AREAS.ANY SOIL DISTURBANCE ASSOCIATED WITH EQUIPMENT ACCESS TO STRUCTURES OR STRUCTURE EXCAVATIONS SHOULD BE MULCHED WITH HAY ON ALL DISTURBED AREAS AS SOON AS POSSIBLE BUT NOT MORE THAN 14 DAYS AFTER THE CONSTRUCTION ACTIVITY IN THAT AREA HAS TEMPORARILY OR PERMANENTLY CEASED.

7. IN ACCORDANCE WITH THE RIPDES GENERAL PERMIT, ALL STORMWATER CONTROL MEASURES, DISTURBED AREAS, AREAS USED FOR THE STORAGE OF MATERIALS THAT ARE EXPOSED TO PRECIPITATION (INCLUDING UNSTABILIZED SOIL STOCKPILES), DISCHARGE LOCATIONS AND LOCATIONS WHERE VEHICLES ENTER OR EXIT THE SITE, AS OUTLINED IN PART IV OF THIS PERMIT, MUST BE INSPECTED BY OR UNDER THE SUPERVISION OF THE APPLICANT AT LEAST ONCE EVERY SEVEN (7) CALENDAR DAYS AND WITHIN TWENTY-FOUR (24) HOURS AFTER ANY STORM EVENT WHICH GENERATES AT LEAST 0.25 INCHES OF RAINFALL PER TWENTY-FOUR (24) HOUR PERIOD AND/OR AFTER A SIGNIFICANT AMOUNT OF RUNOFF. SUCH AREAS SHALL BE INSPECTED FOR EVIDENCE OF, OR THE POTENTIAL FOR, POLLUTANTS ENTERING THE WATERS OF THE STATE OR A SEPARATE STORM SEWER SYSTEM. ALL BMPS SHALL BE MAINTAINED TO PREVENT UNCONTROLLED RELEASES OF MEASURABLE AMOUNTS OF SEDIMENT OR SEDIMENT LADEN WATER FROM TRAVELING BEYOND THE LIMITS OF DISTURBANCE.

8. SEDIMENT SHALL BE REMOVED FROM BEHIND BARRIERS IF GREATER THAN 6 INCHES DEEP OR AS NEEDED.

9. DAMAGED OR DETERIORATED EROSION/SEDIMENTATION CONTROL ITEMS WILL BE REPAIRED IMMEDIATELY AFTER IDENTIFICATION.

10. EROSION CONTROL MEASURES SHALL REMAIN IN PLACE UNTIL ALL DISTURBED EARTH HAS BEEN SECURELY STABILIZED. ONCE THE SITE IS STABILIZED, COMPOST OR WOOD CHIP MULCH FILTER SOCK CAN BE LEFT IN PLACE IF A BIODEGRADABLE FABRIC ENCLOSURE IS UTILIZED. IF A NONBIODEGRADABLE ENCLOSURE IS UTILIZED THE ENCLOSURE SHALL BE REMOVED AND PROPERLY DISPOSED BY THE CONTRACTOR. ALL OTHER CONTROLS SHALL BE REMOVED AND PROPERLY DISPOSED OF BY THE CONTRACTOR.

11. IN THE EVENT OF A FUEL SPILL OR EQUIPMENT MALFUNCTION RESULTING IN A RELEASE OF HAZARDOUS MATERIAL, ALL WORK WILL BE STOPPED IN THIS AREA UNTIL THE RELEASE/SPILL IS CLEANED UP.

12. EQUIPMENT USED FOR CONSTRUCTION WILL BE PROPERLY MAINTAINED AND OPERATED TO REDUCE THE CHANCES OF SPILL OCCURRENCES OF PETROLEUM PRODUCTS. REFUELING OF EQUIPMENT WILL BE REQUIRED TO CARRY SPILL CONTAINMENT AND PREVENTION DEVICES (I.E., ABSORBENT PADS, CLEAN UP RAGS, FIVE GALLON CONTAINERS, ABSORBENT MATERIAL, ETC.) AT ALL TIMES. IN ADDITION, MAINTENANCE EQUIPMENT AND REPLACEMENT PARTS FOR CONSTRUCTION EQUIPMENT WILL BE ON HAND TO REPAIR FAILURES AND STOP A SPILL IN THE EVENT OF EQUIPMENT MALFUNCTION.

13. ANY HAZARDOUS WASTE SPILLS SHALL BE CLEANED UP IMMEDIATELY, AND IF THE SPILL AMOUNT IS EQUAL TO OR EXCEEDS THE EPA REPORTABLE QUANTITY (RQ) FOR THAT SUBSTANCE IN ACCORDANCE WITH 40 CFR PARTS 1010, 117, OR 302, THE CONTRACTOR SHALL IMMEDIATELY CONTACT THE NATIONAL RESPONSE CENTER AT 1-800-424-8802. THE CONTRACTOR WILL ALSO BE RESPONSIBLE FOR SUBMITTING IN WRITING A DESCRIPTION OF THE RELEASE TO THE EPA REGIONAL OFFICE AND RIDEM PROVIDING THE DATE AND CIRCUMSTANCES OF THE RELEASE AND THE STEPS TO BE TAKEN TO PREVENT ANOTHER RELEASE. DIRECTIONS FOR CLEANING UP SPILLS SHALL BE CLEARLY POSTED AT A DESIGNATED ON-SITE LOCATION, AND CONSTRUCTION PERSONNEL SHALL BE MADE AWARE OF THE PROCEDURES AND LOCATION OF CLEANUP SUPPLIES. PERSONNEL SHALL WEAR APPROPRIATE PROTECTIVE GEAR AND HAVE PROPER TRAINING TO PREVENT INJURY FROM CONTACT WITH ANY HAZARDOUS SUBSTANCES.

Scale

J16 115KV TRANSMISSION LINE RECONDUCTORING PROJECT
WOONSCOKET AND CUMBERLAND, RHODE ISLAND

General Notes
Sheet 1 of 14

Source:
Vanasse Hangen Brustlin, Inc.

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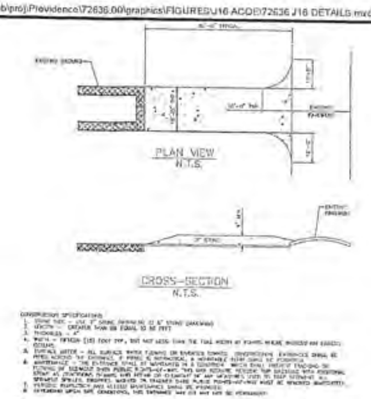
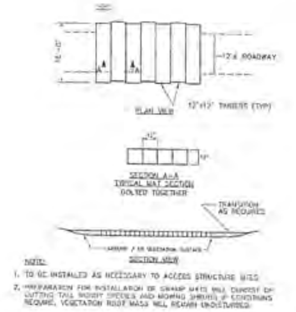
Path: \\vhb\proj\Providence\72636.00\graphics\FIGURES\J16 ACOE\72636 J16 DETAILS.mxd



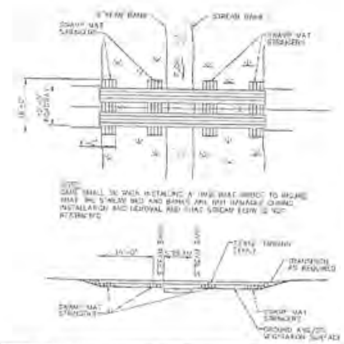
Stabilized Construction Exit
N.T.S.



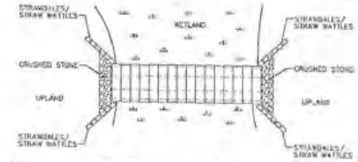
NOTE:

1. TO BE INSTALLED AS NECESSARY TO ACCESS STRUCTURE SITES
2. PREPARATION FOR INSTALLATION OF SWAMP MATS WILL CONSIST OF CUTTING TALL WOODY SPECIES AND MOWING SHRUBS IF CONDITIONS REQUIRE. VEGETATION ROOT MASS WILL REMAIN UNDISTURBED.

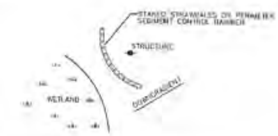
Swamp Mat Detail
N.T.S.



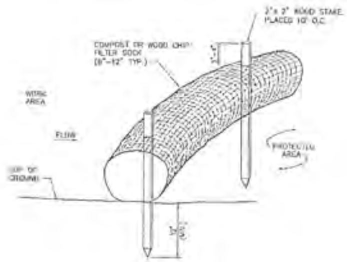
Timber Mat Bridge Over Stream
N.T.S.



Typical Swamp Mat Approach
N.T.S.



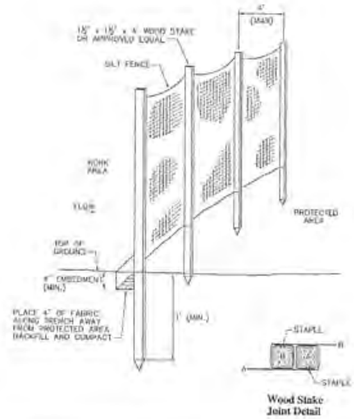
Typical Erosion Control Detail
N.T.S.



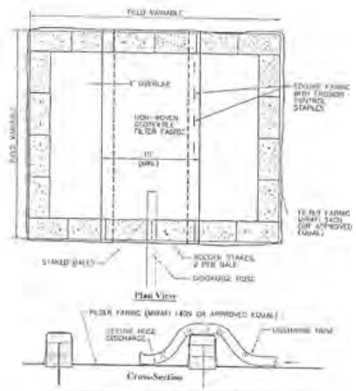
Notes:

1. COMPOST OR WOOD CHIP FILTER SOCK SHALL BE AS MANUFACTURED BY EARTHSAVER OR APPROVED EQUAL.
2. COMPOST OR WOOD CHIP FILTER SOCK SHALL OVERLAP A MINIMUM OF 12 INCHES.
3. COMPOST OR WOOD CHIP FILTER SOCK SHALL BE INSPECTED PERIODICALLY AND AFTER ALL STORM EVENTS, AND REPAIR OR REPLACEMENT SHALL BE PERFORMED PROMPTLY AS NEEDED.
4. TEMPORARY COMPOST OR WOOD CHIP FILTER SOCK TO BE REMOVED BY CONTRACTOR. ALL OTHERS TO REMAIN IN PLACE UNLESS DIRECTED OTHERWISE BY ENGINEER.
5. IF NON BIODEGRADABLE NETTING IS USED THE NETTING SHALL BE COLLECTED AND DISPOSED OF OFFSITE.

Compost or Wood Chip Filter Sock-Sediment Control Barrier
N.T.S.



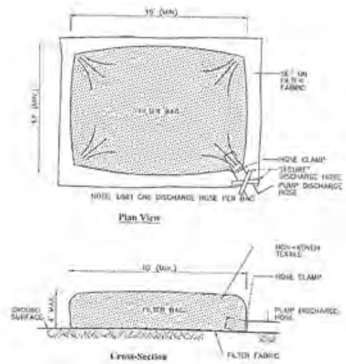
Silt Fence Barrier
N.T.S.



Notes:

1. NUMBER OF BALES MAY VARY DEPENDING ON SITE CONDITIONS.
2. THE BASIN TO BE SIZED TO PREVENT DISCHARGE WATER FROM OVERTOPPING BASIN.

Dewatering Straw Bale Basin
N.T.S.



Note:
BAG TO BE USED IN ACCORDANCE WITH MANUFACTURERS RECOMMENDATIONS.

Dewatering Filter Bag
N.T.S.

Scale

J16 115KV TRANSMISSION LINE RECONDUCTORING PROJECT
WOONSCOKET AND CUMBERLAND, RHODE ISLAND

Details
Sheet 2 of 14

Source:
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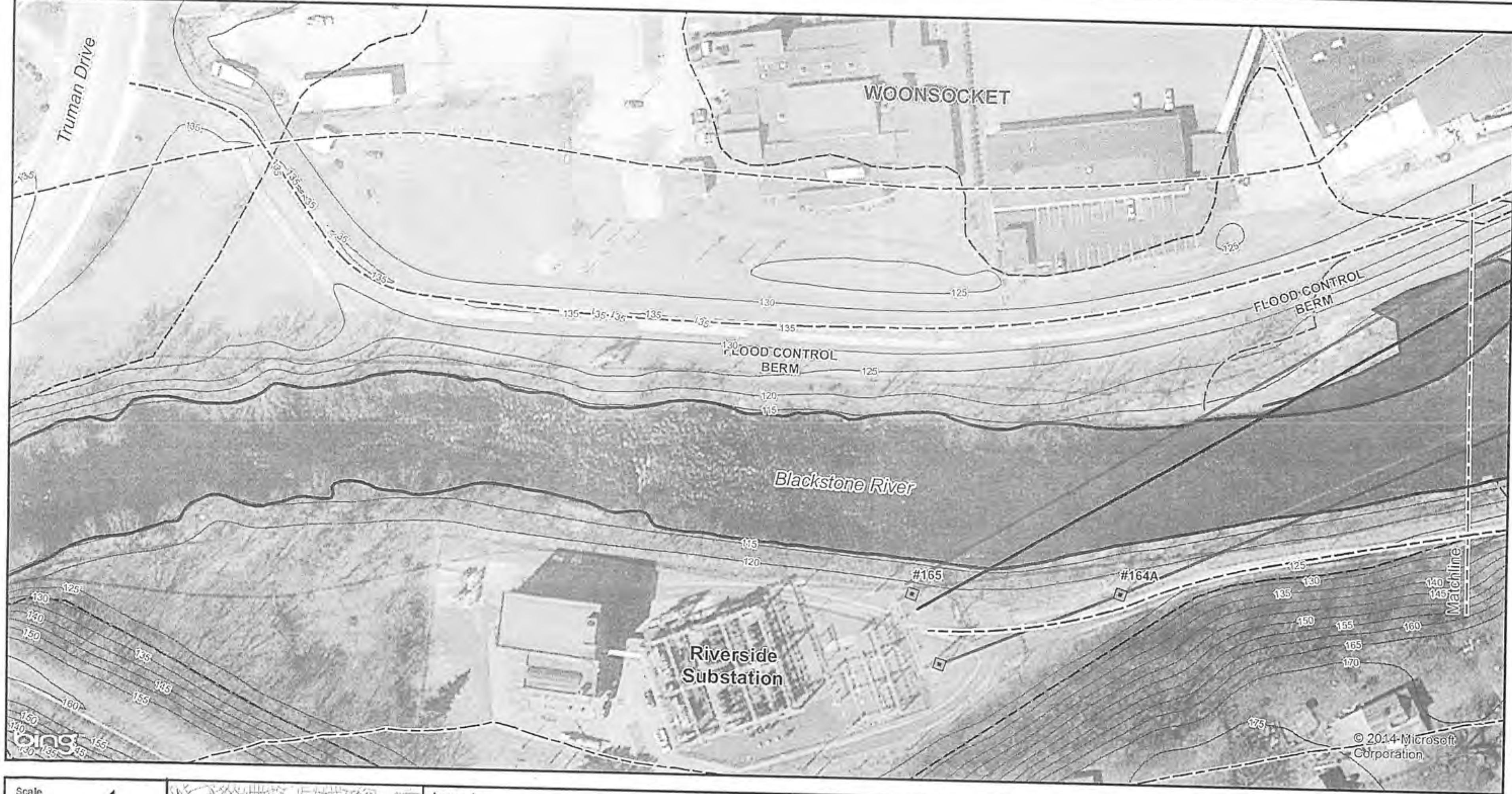

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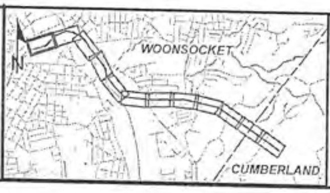
Feet

1 inch = 80 feet



Legend

- Right-of-Way
- Structure
- H17 Line
- R9 Line
- J16 Line
- Access
- Town Line
- Matting
- Workpad
- Compost Filter Sock
- Delineated Wetland Edge
- Approximate Wetland Edge
- ASSF
- 50' Perimeter Wetland
- 200' Riverbank Wetland
- Culvert
- Fence
- FEMA 100-Year Floodplain

J16 115KV TRANSMISSION LINE RECONDUCTORING PROJECT
WOONSCOKET AND CUMBERLAND, RHODE ISLAND

Plans

Sheet 3 of 14

Source:
Bing Maps (Aerial Imagery)
Nation Grid (Right-of-Way)
VHB (GPS Located Wetlands)

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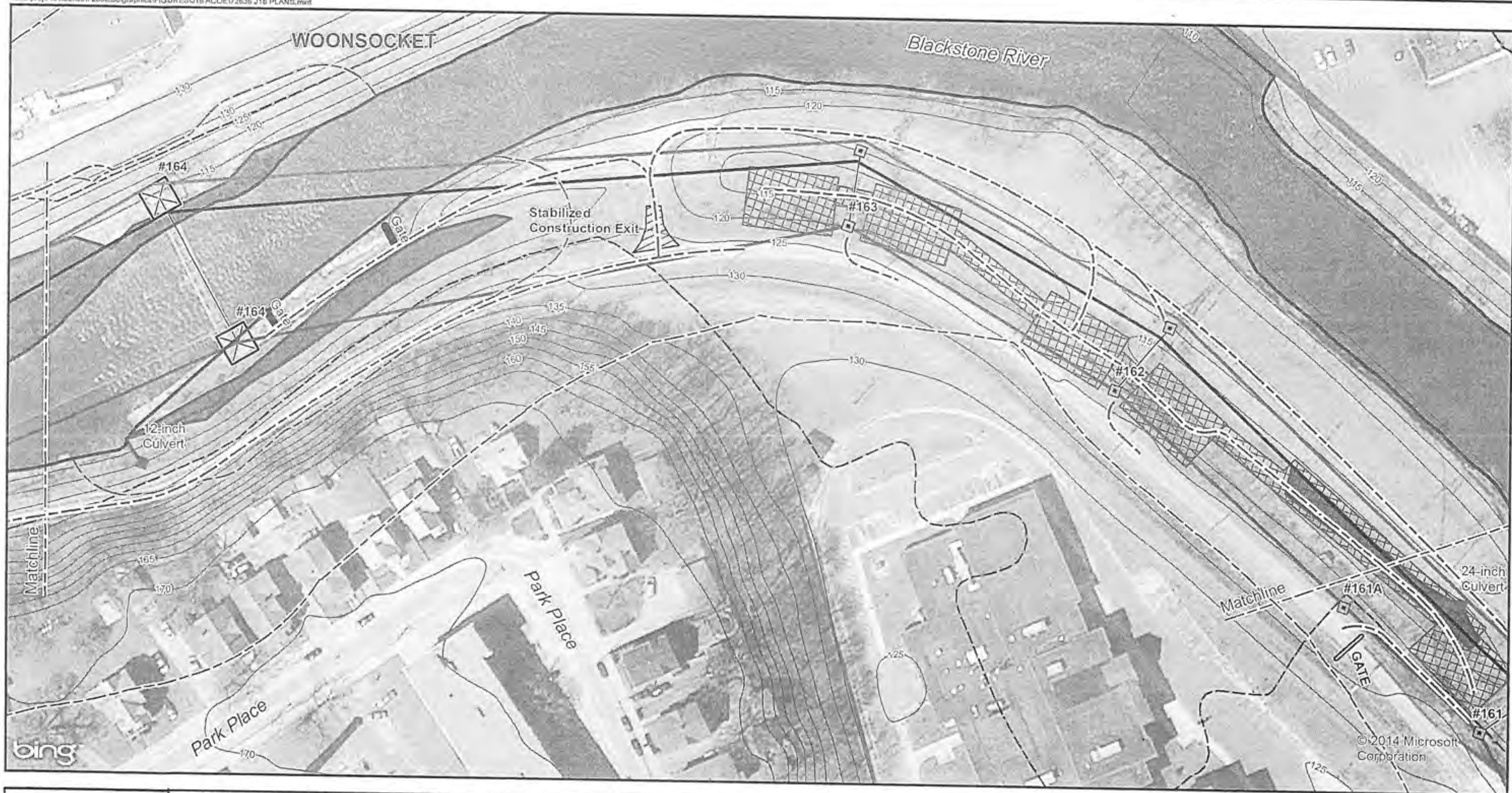

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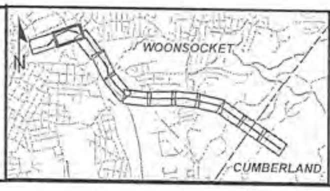

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WOONSCOKET AND CUMBERLAND, RHODE ISLAND

Plans
Sheet 4 of 14

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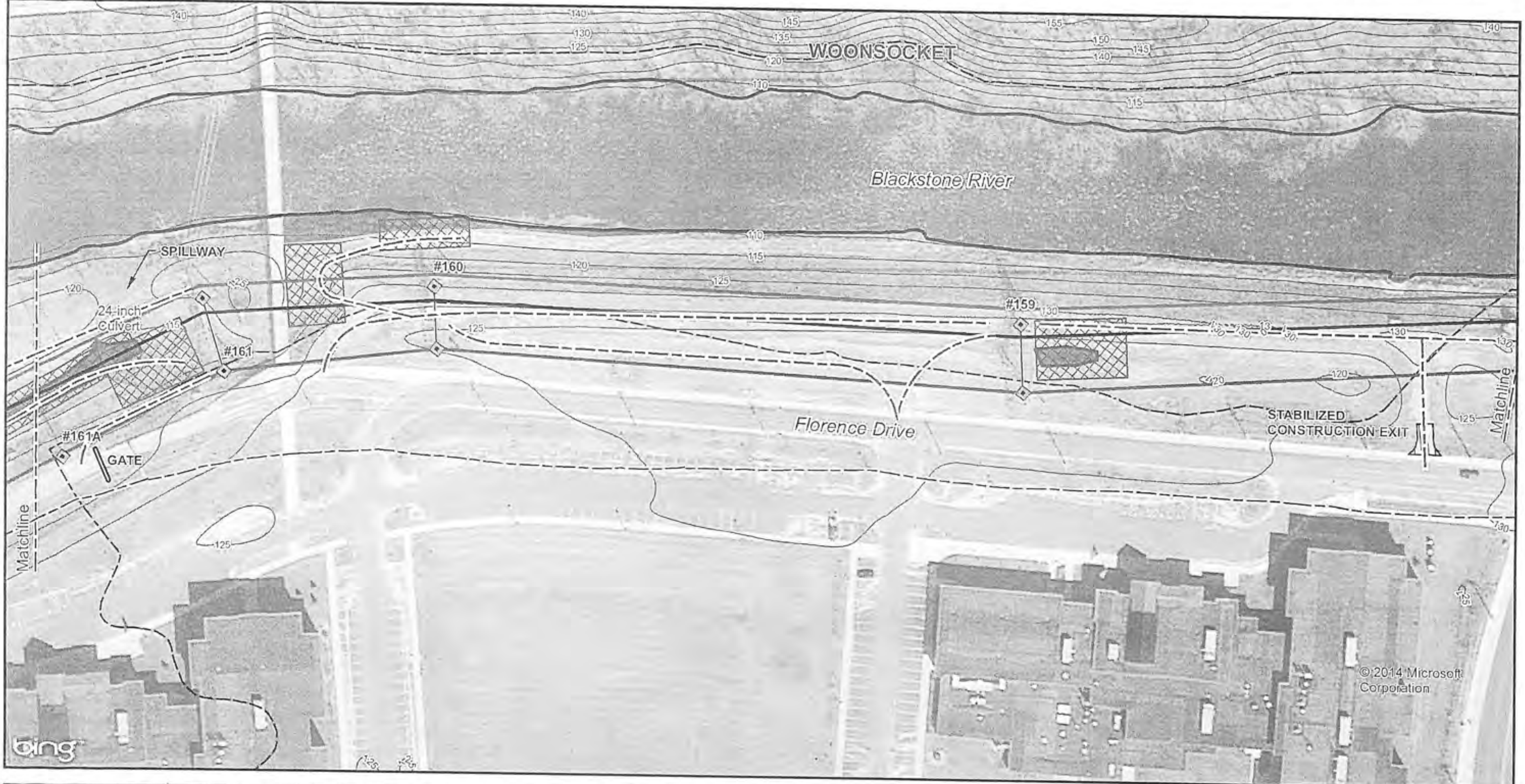

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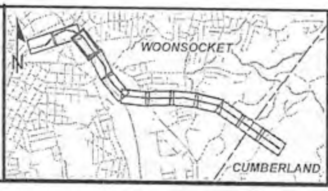

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WOONSCOKET AND CUMBERLAND, RHODE ISLAND

Plans
Sheet 5 of 14

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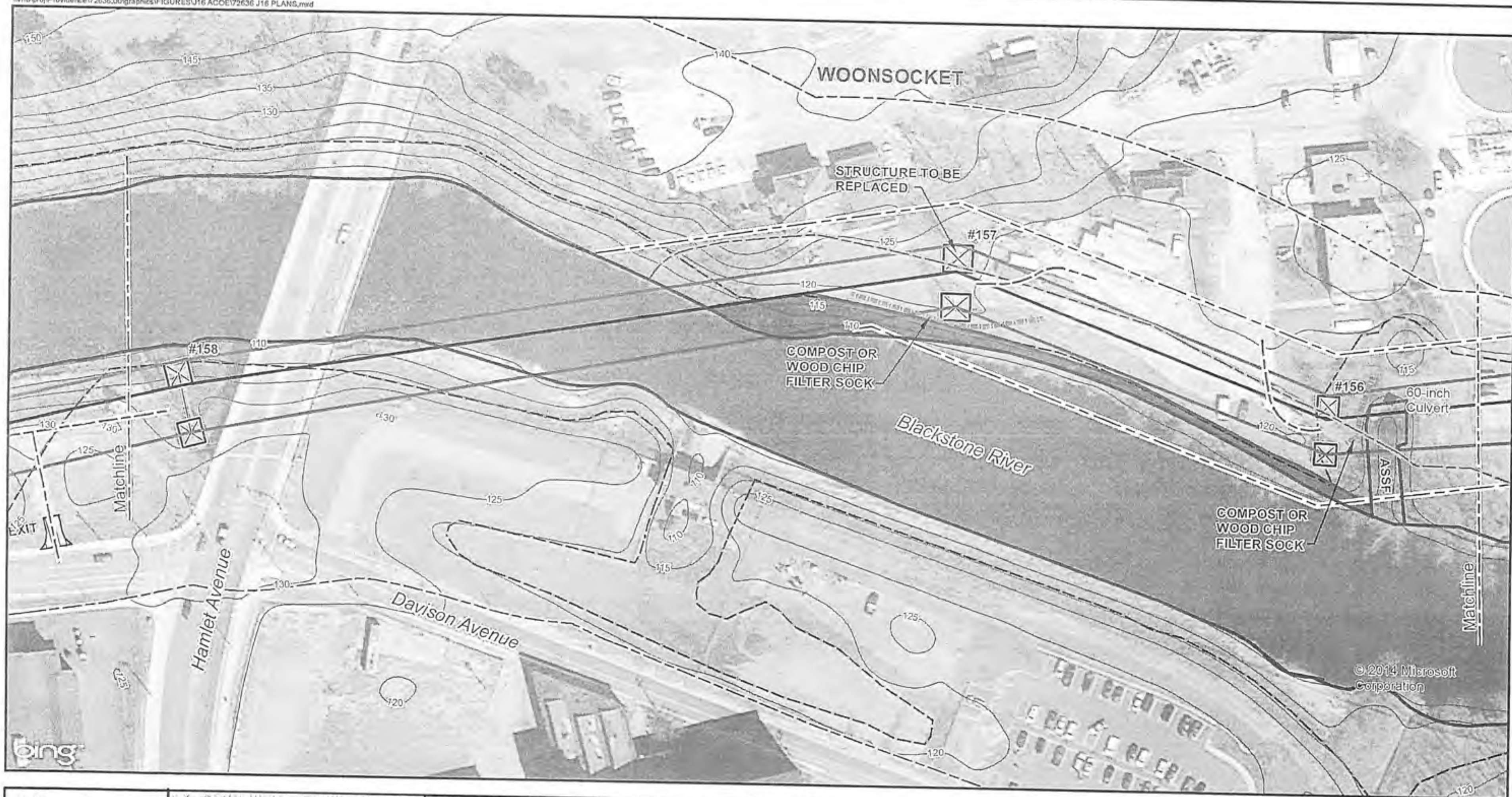

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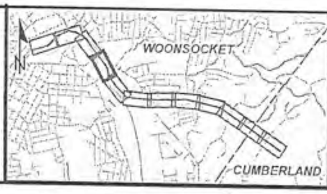

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WOONSCOKET AND CUMBERLAND, RHODE ISLAND

Plans
Sheet 6 of 14

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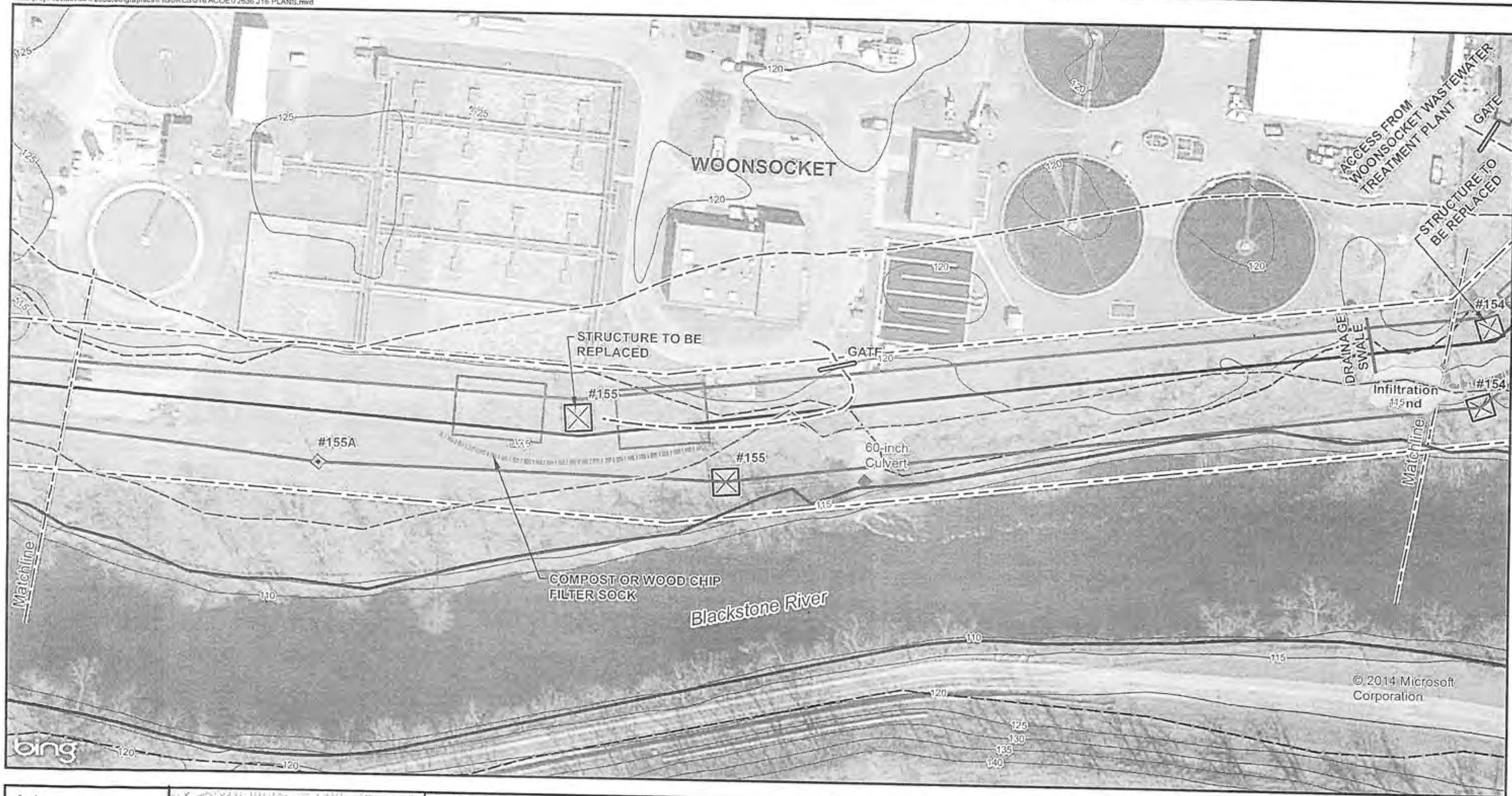

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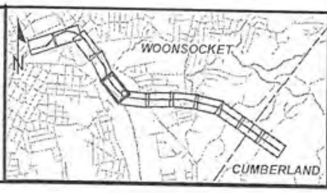

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Plans

Sheet 7 of 14

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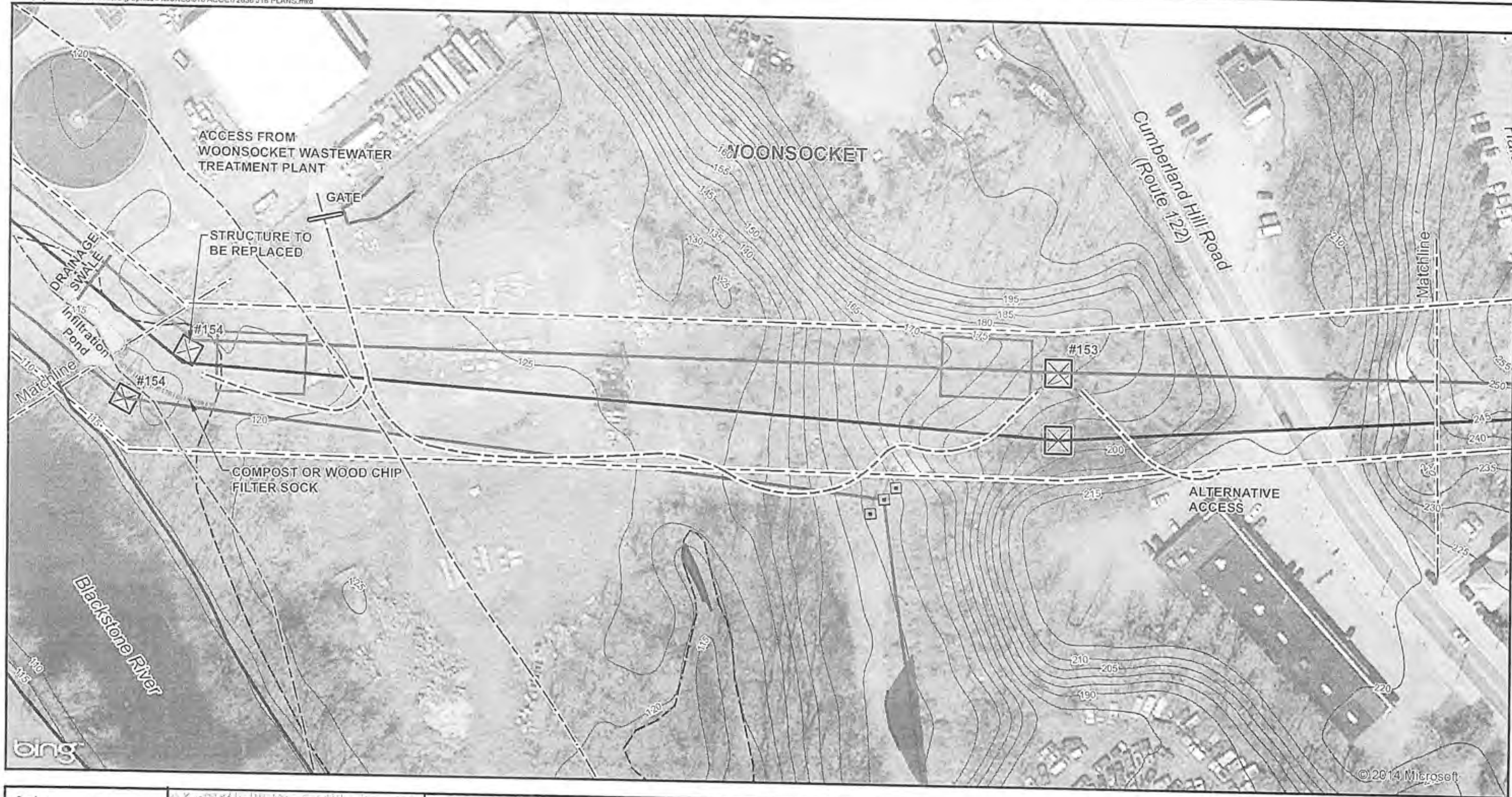

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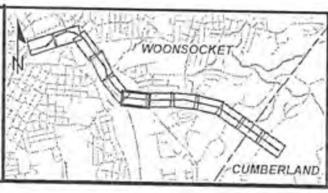

Legend

- Right-of-Way
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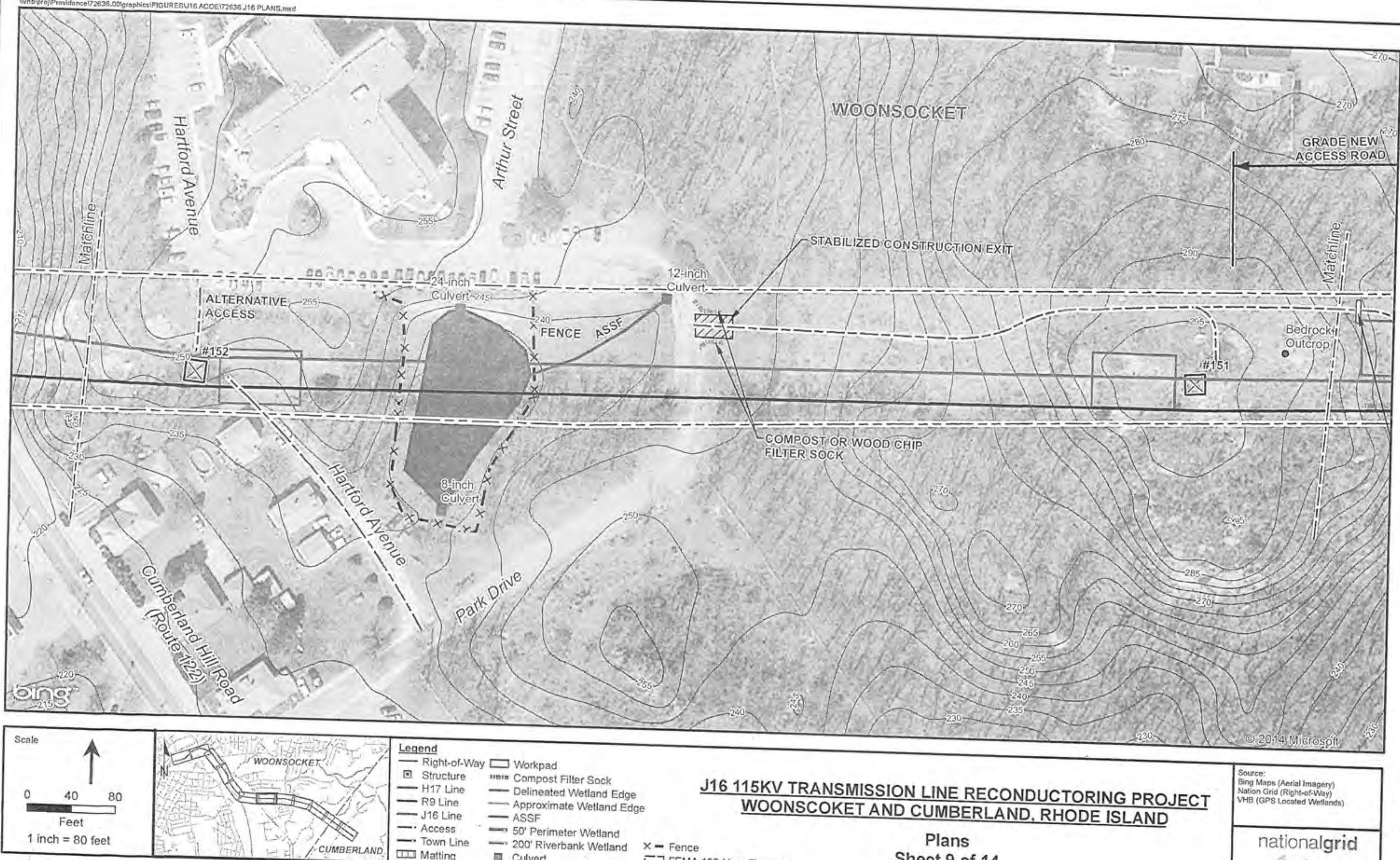
J16 115KV TRANSMISSION LINE RECONDUCTORING PROJECT
WOONSCOKET AND CUMBERLAND, RHODE ISLAND

Plans
Sheet 8 of 14

Source:
Bing Maps (Aerial Imagery)
Nation Grid (Right-of-Way)
VHB (GPS Located Wetlands)

nationalgrid
vhb

THIS DOCUMENT IS INTENDED FOR GENERAL PLANNING & INFORMATION PURPOSES ONLY. ALL MEASUREMENTS & LOCATIONS ARE APPROXIMATE



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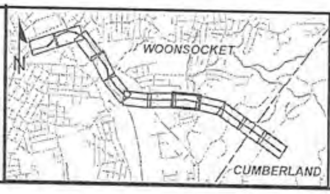

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J16 115KV TRANSMISSION LINE RECONDUCTORING PROJECT WOONSCOKET AND CUMBERLAND, RHODE ISLAND

Plans
Sheet 10 of 14

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J16 115KV TRANSMISSION LINE RECONDUCTORING PROJECT
WOONSCOKET AND CUMBERLAND, RHODE ISLAND

Plans
Sheet 11 of 14

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vhb

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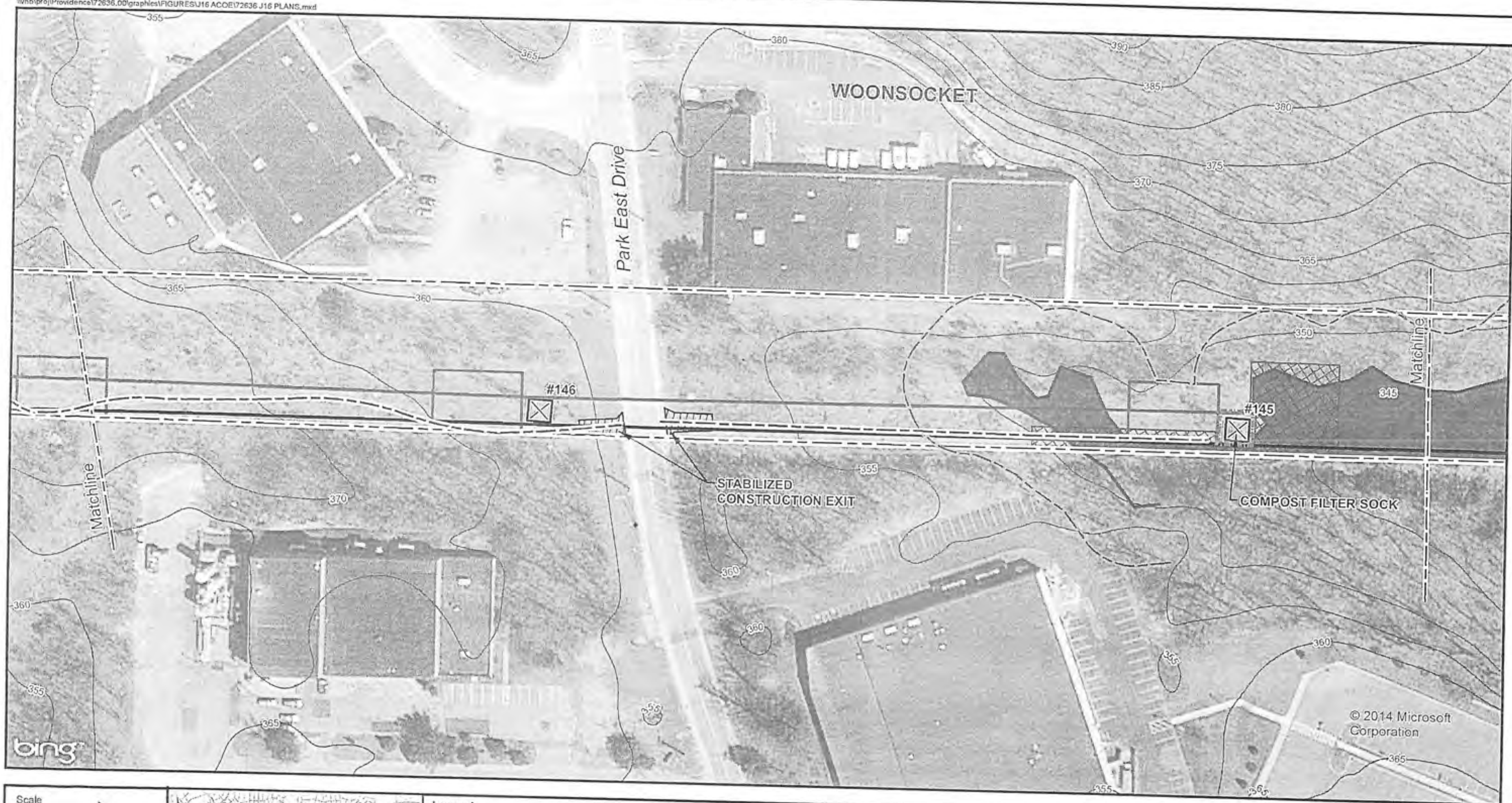

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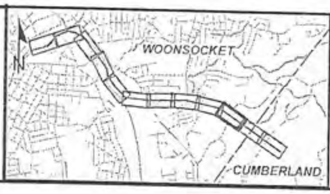

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WOONSCOKET AND CUMBERLAND, RHODE ISLAND

Plans
Sheet 12 of 14

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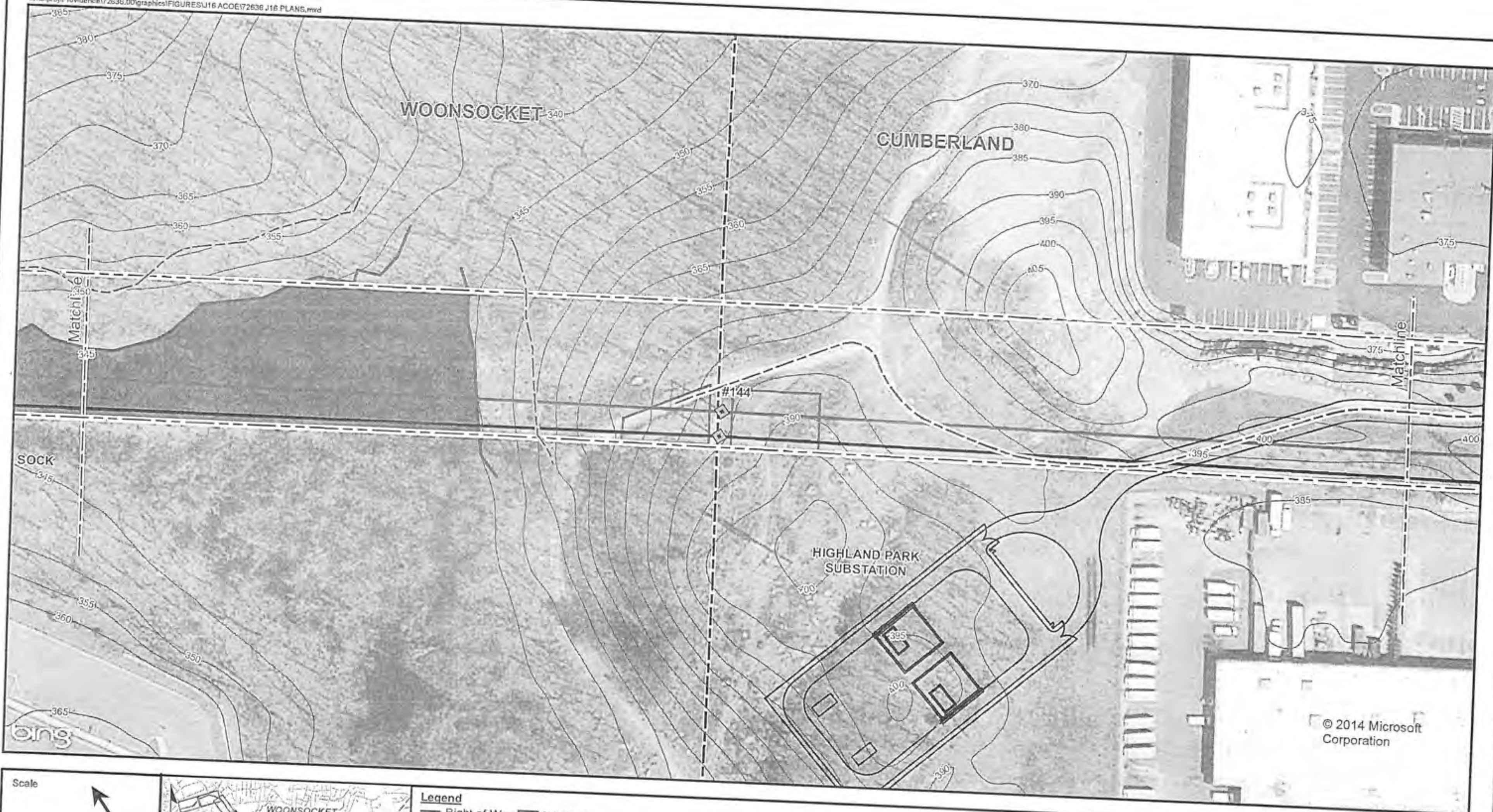

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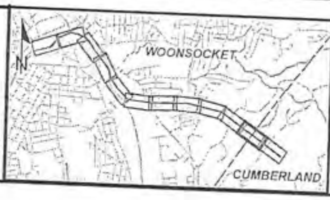

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WOONSCOKET AND CUMBERLAND, RHODE ISLAND

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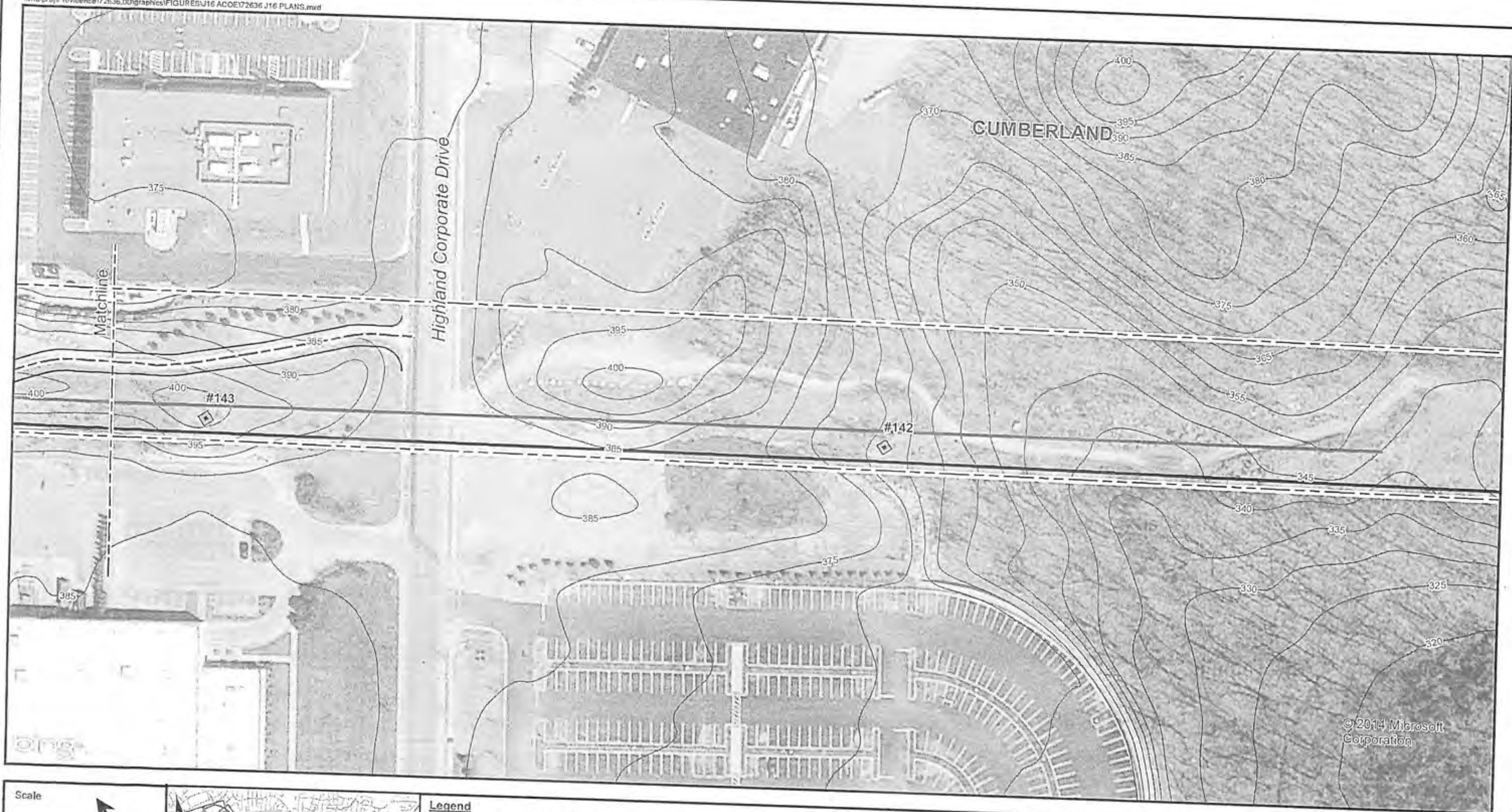

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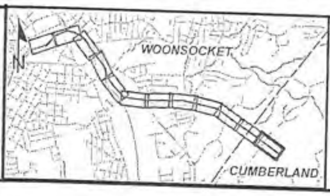

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NAE-2014-2243

New #

swamp mats

Cat 2

www.vhb.com

vhb

December 17, 2014

Ref: 72636.00

Mr. Michael Elliott
Regulatory Branch
New England District, Corps of Engineers
696 Virginia Road
Concord, MA 01742

Re: The Narragansett Electric Company - WO 90000115586
J16 115kV Transmission Line Reconductoring Project
Riverside Substation, Woonsocket to Highland Park Substation, Cumberland, Rhode Island

Dear Mr. Elliott,

On behalf of our client, The Narragansett Electric Company d/b/a National Grid (TNEC), VHB respectfully submits this application for authorization to conduct maintenance on the existing J16 115kV Transmission Line (J16 Line) located in Woonsocket and Cumberland, Rhode Island. TNEC is proposing to reconductor the J16 Line which is situated within the ROW south of the Riverside Substation off Florence Drive Extension in Woonsocket and extends southeasterly to the Highland Park Substation off Highland Corporate Drive in the Town of Cumberland, a distance of approximately 2.2 miles. Reconductoring involves replacing the conductors (wires) of an existing transmission line with new larger conductors which are capable of carrying more power. In many cases it is necessary to replace existing structures as part of a reconductoring project. The Project will include replacement of 4 of 23 existing steel supporting structures, the installation of one new steel pole structure, and the replacement of existing conductors with larger conductors.

The transmission system is designed to avoid loading equipment above the Long-Term Emergency (LTE) rating. A recent review of the need for transmission upgrades, as document in the Highland Drive Transmission Solution Study Report, indicates that the section of the J16 Line between Highland Park Substation and the Riverside Substation requires upgrade to avoid thermal overloads. As further detailed in the Highland Drive Transmission Solution Study Report, the option to reconductor J16 Line has been recommended as the preferred alternative to address the potential thermal condition, to comply with performance standards, and to maintain reliability of the transmission system.

The J16 Line is within an approximately 125-foot wide right-of-way (ROW) and shares the cleared portions of the ROW with the R9 115kV Transmission Line and, in sections, the H-17 115kV Transmission Line and a sub-transmission line. Wetland areas within this cleared ROW have been delineated with consecutively numbered polyvinyl flags following methodology provided by the Regional Supplement to the Corps of

Engineers | Scientists | Planners | Designers

10 Dorrance Street
Suite 400
Providence, Rhode Island 02903
P 401.272.8100
F 401.273.9694

Engineers Wetland Delineation Manual: Northcentral and Northeast Region (2012). These wetlands are located in the Peters River-Blackstone River watershed (HUC-12: 010900030208).

The scope of the Project involves replacing the existing 465.4 MCM AAAC "Ragout" conductors with new 477 MCM 26/7 ACSS (Aluminum Conductor Steel Supported) "Hawk" conductors. Existing insulator and hardware assemblies on all structures will be reused. Additionally, the existing 3/8-inch extra high strength (EHS) steel shieldwire will be replaced with 3#5 Copperweld shieldwire.

To support the proposed reconductoring, it has been determined that four double-circuit steel lattice deadend structures will need to be replaced with double-circuit steel single pole deadend structures to provide the necessary strength and ground clearances required for the new larger conductors. Additionally, one new direct embed intermediate double-circuit steel two-pole davit arm suspension structure is needed to provide adequate clearance for the reconductored line. The remaining existing steel structures were found to be sufficient to support the proposed new conductors, and will therefore remain in place. Each of the four double-circuit structures being replaced will require a new concrete caisson foundation.

Some minor tree trimming will be performed along the existing ROW in conjunction with the Project. The proposed modifications will not significantly change the appearance of the existing ROW or the J16 Line.

None of the structures to be replaced occur within Palustrine Wetland. Structures 154, 155, and 157 occur within the state regulated 200-Foot Riverbank Wetland and Structures 154 and 155 also occur within the 100 year Floodplain associated with the Blackstone River. Both Structure 149 to be replaced and the new intermediate structure are located within unregulated upland.

During reconductoring, five structures will require access through wetlands, or a work pad within wetlands to provide a sufficient work area around the structure. To minimize soil disturbance, 4 foot by 16–foot timber mats (swamp mats) will be placed along the wetland access routes and within wetlands where work will be performed. All wetlands to be accessed are in the maintained transmission line ROW that TNEC owns rights to operate and maintain. Cumulatively, approximately 15,232 square feet (0.35 acres) of wetland will be temporarily "filled" by the placement of swamp mats. Following the installation of swamp mats, compost or wood chip mulch filter sock barriers will be installed downgradient of work areas. These barriers will be installed prior to the commencement of any earthwork. The project will proceed in a sequential manner and once work is completed in one area typically mats will be removed and deployed at the next crossing. All mats will be removed following completion of construction and wetland vegetation will be allowed to recover naturally. It is anticipated that approximately six months will be needed to complete the maintenance activity.

The four replacement structures will be installed within 35-feet of their existing locations and will require new reinforced concrete caisson foundations. These foundations will measure up to approximately 50 feet in depth, and up to 10 feet in diameter. Installation of foundations will include foundation excavation, steel caisson installation, rebar work and concrete placement. The new 2-pole direct embedment structure will require excavations approximately 15 feet in depth and ranging from three to six feet in diameter. Steel casings may be used to support the sides of the foundation excavations. Following the completion of foundation construction, excavated soil, clean gravel or concrete will be used to backfill around the foundation. The transmission structures are then erected upon the completed foundations. Once the new directly embedded structure has been properly positioned and plumbed within the hole, the excavation will be backfilled with the native soil or clean gravel, and tamped to provide structural integrity. Excavated material will be temporarily stockpiled next to the excavations and will not be placed directly into resource areas. If a stockpile is located in close proximity to wetlands, it shall be enclosed by an erosion and sediment control device. Any remaining excavated materials are then spread over unregulated upland areas and stabilized or removed from the site. Old structures will be removed from the Project site and disposed of appropriately. The old concrete lattice tower footings will be cut off 18 inches below grade and the resulting void will be backfilled with topsoil. Once work is complete, any disturbed soils will be seeded with a conservations seed mix, consisting of native non-invasive species, and mulched. Mown work areas will be left to naturally revegetate. Temporary non-biodegradable erosion control devices will be removed following the stabilization of disturbed areas.

The temporary placement of swamp mats within Waters of the United States is considered wetland fill, and therefore, this Project requires Army Corps of Engineers (ACOE) authorization under Sections 404 and 401 of the Clean Water Act. In accordance with Conditions 16 and 17 of the Programmatic General Permit (PGP) No. NAE-2011-2042 for Rhode Island, this work appears to be eligible for review as a Category 2 activity.

No existing wetland will be permanently filled and/or converted to upland as a result of the maintenance activity. The temporary installation of swamp mats is not expected to cause any long-term adverse impacts to wetland resources as the mats will minimize ground disturbance and be removed following the proposed work. Additionally, staked compost or wood chip mulch filter sock will be installed between work areas and wetland resources to minimize sedimentation if necessary.

Please note that this maintenance project subject to this application will be completed consistent with Rules 6.01 (General Conditions for Exempt Activities), 6.03N, and 6.03O (Limited Maintenance and Repair Activities) of the RIDEM Rules. In accordance with the Rhode Island PGP since the project is exempt from state permitting requirements, TNEC is seeking authorization from the ACOE to install temporary swamp mats within wetland to conduct maintenance work. No new fill will remain within wetlands after the maintenance activity is completed.

The Rhode Island Geographic Information System (RIGIS) Rare Species Coverage does not identify any "Estimated Habitat and Range of Rare Species and Noteworthy Natural Communities" polygons within or adjacent to the project area.

Enclosed for your review are the following items:

1. This letter describing the Project;
2. Completed Application for Department of Army Permit form; and
3. Site location map and Site Plans depicting the proposed maintenance activities.

Should you have any questions or require additional information, please do not hesitate to contact me at (401) 457-2072. Thank you for your attention to this matter.

Sincerely,

Adam E. Rosenblatt, CPESC
Project Manager

cc: Laura Ernst, TNEC

US Army Corps of Engineers®
New England District

GENERAL PERMIT WORK-START NOTIFICATION FORM

(Minimum Notice: Two weeks before work begins)

****
* MAIL TO: U.S. Army Corps of Engineers, New England District *
* Policy Analysis/Technical Support Branch *
* Regulatory Division *
* 696 Virginia Road *
* Concord, Massachusetts 01742-2751 *
****

Corps of Engineers Permit No. 2014-2643 was issued to the Narragansett Electric Company dba National Grid. The project purpose is to conduct maintenance on the existing J16 115kV Transmission Line in Woonsocket and Cumberland, Rhode Island. They are authorized to temporarily place swamp mats for construction equipment access. They will reconductor the J16 line including replacing the conductors (wires), replacing 4 of 23 existing steel structures and installing 1 new steel pole structure. The swamp mats will result in a total cumulative temporary wetland impact of approximately 15,232 square feet (0.35 acres).

The people (e.g., contractor) listed below will do the work, and they understand the permit's conditions and limitations.

PLEASE PRINT OR TYPE

Name of Person/Firm: ______________________________

Business Address: ______________________________

____

____

____

Telephone Numbers: (____) ______________ (____) ______________

Proposed Work Dates: **Start:** ______________ **Finish:** ______________

Permittee/Agent Signature: ______________________ **Date:** ______________

Printed Name: ______________________ **Title:** ______________

Date Permit Issued: ______________________ **Date Permit Expires:** ______

****

FOR USE BY THE CORPS OF ENGINEERS

PM: M. Elliott **Submittals Required:** No

Inspection Recommendation: ______________________________

US Army Corps
of Engineers ®
New England District

(Minimum Notice: Permittee must sign and return notification within one month of the completion of work.)

COMPLIANCE CERTIFICATION FORM

Permit Number: 2014-2643

Project Manager: M. Elliott

Name of Permittee: Narragansett Electric Company dba National Grid

Permit Issuance Date: January 29, 2015

Please sign this certification and return it to the following address upon completion of the activity and any mitigation required by the permit. You must submit this after the mitigation is complete, but not the mitigation monitoring, which requires separate submittals.

****
* MAIL TO: U.S. Army Corps of Engineers, New England District *
* Permits and Enforcement Branch B *
* Regulatory Division *
* 696 Virginia Road *
* Concord, Massachusetts 01742-2751 *
****

Please note that your permitted activity is subject to a compliance inspection by an U.S. Army Corps of Engineers representative. If you fail to comply with this permit you are subject to permit suspension, modification, or revocation.

I hereby certify that the work authorized by the above referenced permit was completed in accordance with the terms and conditions of the above referenced permit, and any required mitigation was completed in accordance with the permit conditions.

____
Signature of Permittee

____
Date

____
Printed Name

____
Date of Work Completion

(______)______________________
Telephone Number

CITY OF WOONSOCKET, Rhode Island
DEPARTMENT OF PLANNING AND DEVELOPMENT
DIVISION OF ZONING, BUILDING INSPECTION & CONSTRUCTION

April 17, 2015

VHB
10 Dorrance Street, Suite 400
Providence, RI 02903

Re: Narragansett Electric Company J16 Transmission Line
Soil Erosion and Sediment Control Ordinance

To Whom It May Concern;

Our office along with the Woonsocket Engineering Division has reviewed the submitted plans for the NGrid J16 Transmission Line Improvement Project for applicability to the City Soil Erosion and Sediment Control Ordinance.

Our findings are as follows:

-The required work falls under the City of Woonsocket Code of Ordinances.

-Per Section 7 ½-9 Enforcement a performance bond is required. Our office estimates the bond amount to be $5,000. This will be sufficient for the work along the Blackstone River. The bond will be issued before the work commences.

-All aspects of the City of Woonsocket Code of Ordinances Chapter 7 ½ Erosion and Sediment Control along with Chapter 7 ¾ Post Construction are enforceable by the City and to be followed by NGrid and any of their subcontractors.

-All aspects of the required work are covered in the packet supplied and found to be satisfactory acceptable to the City.

The work, pending any local or State permits required, is approved to commence. Please notify our office 24 hours before work is scheduled to begin.

Should you have any comments or concerns please feel free to contact my office at 767-9238 or the Woonsocket Engineering Division at 767-9213.

Sincerely,

Lawrence G. Desormier Jr.
Building & Zoning Official City of Woonsocket, RI

Cc: Woonsocket Engineering Division

STATE OF RHODE ISLAND AND PROVIDENCE PLANTATIONS
HISTORICAL PRESERVATION & HERITAGE COMMISSION
Old State House • 150 Benefit Street • Providence, R.I. 02903-1209
TEL (401) 222-2678 FAX (401) 222-2968
TTY (401) 222-3700 Website www.preservation.ri.gov

9 March 2015

Deborah C. Cox
President
Public Archaeology Laboratory
26 Main Street
Pawtucket, Rhode Island 02860

RE: National Grid Line J16 Riverside Substation to Highland Park Substation
115kV Line Reconductoring
Structures within the Blackstone Canal Historic District
Woonsocket, Rhode Island

Dear Ms. Cox:

The Rhode Island Historical Preservation and Heritage Commission staff has reviewed the information that you provided for the above-referenced project. National Grid is proposing to carry out foundation repair work on six tower structures that are located within the bounds of the Blackstone Canal Historic District, which is listed in the National Register of Historic Places.

Structures 158, 159, 161, 162, 163, and 164 are located between the Riverside Substation and the Hamlet Avenue Bridge. The repairs consist of concrete patching and painting and will be contained within 30 inches of the foundation edges. Only Structure 164 has part of its foundation in the Blackstone River. Repair work at this structure will be limited to areas above the river surface.

Based on our review of the information that you supplied, we have concluded that the proposed project will have no adverse effects on historic resources. Therefore, we have no objections to the project.

These comments are provided in accordance with Section 106 of the National Historic Preservation Act. If you have any questions please contact Jeffrey Emidy, Project Review Coordinator of this office.

Very truly yours,

FOR Edward Sanderson
Executive Director
Deputy State Historic Preservation Officer

150309.06jde

STATE OF RHODE ISLAND AND PROVIDENCE PLANTATIONS
HISTORICAL PRESERVATION & HERITAGE COMMISSION
Old State House • 150 Benefit Street • Providence, R.I. 02903-1209
TEL (401) 222-2678 FAX (401) 222-2968
TTY / Relay 711 Website www.preservation.ri.gov

13 February, 2015

Alan Leveillee
PAL, Inc
26 Main Street
Pawtucket, RI 02860

Re: Phase I Archaeological Survey
Line J16, Structure #151, Woonsocket RI

Dear Mr. Leveillee,

The Rhode Island Historical Preservation and Heritage Commission has reviewed the results of the above-referenced survey. We concur with PAL's conclusion that in as much as no evidence for RI 1847, or any other potentially significant cultural material, was located in the area surveyed, no further archaeological investigations are required prior to the construction of Structure #151.

These comments are provided in accordance with Section 106 of the National Historic Preservation Act. If you have any questions, please contact Charlotte Taylor, Senior Archaeologist at this office.

Very truly yours,

Charlotte Taylor for!

Edward F. Sanderson
Executive Director
State Historic Preservation Officer

Cc: John Brown, NTHPO
Laura Ernst, NGRID

150213.01