Cambridge Energy

CE FLNG LNG Project

Docket No. PF13-11-000

Resource Report 10 – Alternatives

Draft Filing

May 2013

Resource Report 10 Filing Requirements	
Information	**Location in Resource Report**
Minimum Filing Requirements	
1. Discuss the "no action" alternative and the potential for accomplishing the proposed objectives through the use of other systems and/or energy conservation. Provide an analysis of the relative environmental benefits and costs for each alternative. § 380.12(l)(1)	Section 10.1 Section 10.2 Section 10.3
2. Describe alternative routes or locations considered for each facility during the initial screening for the project. § 380.12(l)(2)	Section 10.4 Section 10.7
(i) For alternative routes considered in the initial screening for the project but eliminated, describe the environmental characteristics of each route or site, and the reasons for rejecting it. Identify the location of such alternatives on maps of sufficient scale to depict their location and relationship to the proposed action, and the relationship of the pipeline to existing rights-of-way. § 380.12(l)(2)(i)	Section 10.7
(ii) For alternative routes or locations considered for more in-depth consideration, describe the environmental characteristics of each route or site and the reasons for rejecting it. Provide comparative tables showing the differences in environmental characteristics for the alternative and proposed action. The location of any alternatives in this paragraph shall be provided on maps equivalent to those required in paragraph (c)(2) of this section. § 380.12(l)(2)(ii)	Section 10.7

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LIST OF ACRONYMS AND ABBREVIATIONS

Bcf/d	billion cubic feet per day
C3MR	Propane Precooled Mixed Refrigerant
DMMP	dredged material management plan
DMR	Dual Mixed Refrigerant
CE FLNG	CE FLNG, LLC
CE	CE FLNG, LLC and CE Pipeline, LLC, collectively
DMMP	dredged material management plan
EEC	Elba Express Company, LLC
ELC	Elba Liquefaction Company, LLC
ELS 1	Excelerate Liquefaction Solutions I, LLC
FERC	Federal Energy Regulatory Commission
FLNG	Floating Liquefaction of Natural Gas
FLSO	floating liquefaction storage offloading
GLLC	Gulf LNG Liquefaction Company, LLC
HDD	horizontal direction drill
HPGT	High Point Gas Trasmission
HSDDRS	Greater New Orleans Hurricane and Storm Damage Risk Reduction System
Kenai	Kenai LNG Plant
LNG	liquefied natural gas
LNGC	LNG carrier
MP	milepost
M&R	metering and regulating
MTPA	million tons per annum
OSMR	Optimized Single Mixed Refrigerant
Project	CE FLNG LNG Project
Sabine Pass	Sabine Pass Liquefaction Project
SLNG	Southern LNG Company, LLC
SMR	Single Mixed Refrigerant
U.S.	United States

10.0 INTRODUCTION

This resource report describes the alternatives considered by CE FLNG, LLC and CE Pipeline, LLC (collectively referred to as CE) for the proposed Liquefaction Project (Project), as well as the alternatives for the pipeline route considered by CE Pipeline, LLC. The proposed Project facilities would consist of two floating liquefaction of natural gas (FLNG) vessels, each capable of producing up to 4 million tons per annum (MTPA) of liquefied natural gas (LNG), for a total capacity of 8 MTPA of LNG. The units would have an LNG storage capacity of 250,000 cubic meters (m^3) to enable the export of approximately 8 MTPA of LGN via LNG carriers (LNGCs). The Project facilities are currently planned for construction at the CE FLNG LNG Terminal (FLNG Terminal) in Plaquemines Parish, Louisiana (Figure 10-1). To deliver pipeline gas to the FLNG Terminal, CE proposes to construct a new CE pipeline parallel to the existing pipeline route owned by High Point Gas Transmission (High Point). The CE Pipeline Project would involve the construction of approximately 37 miles of 42-inch-diameter pipeline, and metering and regulating (M&R) stations (see Figure 10-1).

This report identifies the best method of accomplishing the Projects objective, starting with examination of the broadest feasible range of alternatives and narrowing those alternatives to the Project as currently proposed. Selection of the preferred sites and overall design for the Project was the result of a comprehensive evaluation process that involved weighing the potential environmental, logistical, economic, safety, and engineering costs and benefits of each aspect of the Project. As a result, the chosen FLNG Terminal site is considered the most environmentally acceptable, technologically feasible, and economically viable option for meeting the stated objective for the Project. Further, the most environmentally acceptable and economically viable option for supplying feed gas for the Project is constructing a new CE pipeline.

The purpose of the Project is to transport, liquefy, and sell domestic natural gas as LNG to the global market. Because the Project utilizes LNGCs to transport LNG safely and efficiently worldwide, the Project requires a marine berth for loading and unloading of FLNG vessels for waterborne transport of LNG. Therefore, for an alternative to be considered preferable to the Project, the alternative must

- Provide a significant environmental advantage over the Project as proposed;
- Provide access to waterborne transportation and maritime shipping channels;
- Meet the Project's objectives and schedule;
- Allow for compliance with Federal safety regulations for liquefaction and pipeline facilities; and
- Be technically and economically feasible and practicable.

Purpose of Report
The purpose of Resource Report 10 is to identify possible alternatives to the proposed Project.

Figure 10-1. Vicinity Map

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Organization

This resource report is organized into six major sections. Section 10.1 discusses the "No Action" alternative. Section 10.2 discusses alternative energy sources, while Section 10.3 provides a description of other potential system alternatives that could be implemented to meet the Project's objectives. Section 10.4 discusses dredged material placement alternatives and Section 10.5 discusses design alternatives. Section 10.6 discusses pipeline alternatives.

10.1 NO ACTION ALTERNATIVE

This section addresses the consequences of not constructing the proposed Project. Under the No Action Alternative, the proposed FLNG Terminal would not be constructed, a new turning basin and deep-draft access to the Mississippi River would not be dredged, and new pipelines connecting the FLNG Terminal to natural gas sources would not be installed. Potential adverse impacts associated with the Project (e.g., impacts on surface water quality, Essential Fish Habitat, wetlands, vegetation, soils, and air and noise quality) would be avoided under the No Action Alternative. However, selection of the No Action Alternative would also mean that the objectives of the Project would not be accomplished.

CE FLNG proposes to build, own, and operate two FLNG vessels. CE FLNG expects to take advantage of the existing infrastructure near the proposed FLNG Terminal to offer customers liquefaction services at attractive pricing. This added service would provide customers with an attractive option to source natural gas supply from the United States (U.S.) pipeline grid at prices indexed to Henry Hub. Further, selling natural gas as LNG at the proposed FLNG Terminal would:

- Stimulate the Louisiana state, regional, and national economies through job creation, particularly at local shipyards that may be in need of manufacturing opportunities in the energy industry, increased economic activity and tax revenues, including the direct creation of approximately 1,000 engineering and construction jobs during the course of the Project;
- Promote domestic production of petroleum and reduced reliance on foreign sources of oil;
- Raise domestic natural gas productive capacity and promote stability in domestic natural gas pricing;
- Promote liberalization of global natural gas trade through fostering of a global LNG market;
- Advance National security and the security of U.S. allies through diversification of global natural gas supplies; and
- Increase economic trade and ties with foreign nations, including neighboring countries in the Americas, and displacing environmentally damaging fuels in those countries.

10.2 ALTERNATIVE ENERGY SOURCES AND ENERGY CONSERVATION

The purpose of the Project is to export clean-burning natural gas to other countries in order to meet growing market demands because of the lower cost of natural gas compared to other energy sources. However, there are other alternative fossil fuel energy sources, such as coal and oil, that can be considered as part of the alternative selection process. Studies have shown that, when used to fire a power plant, natural gas and carbon dioxide emissions are approximately half as compared to conventional plants that utilize other

fossil fuels. Natural gas has also been termed a "bridge fuel" between the dominant fossil fuels used today and renewable energy sources proposed for the future because natural gas is clean burning and can reliably serve as a backup fuel to renewable energy facilities, which often provide power intermittently. Therefore, export of natural gas as an energy source is most sensible, both economically and environmentally.

Since the purpose of the Project is to export natural gas to other countries, energy conservation in foreign countries could result in a reduced natural gas demand in those countries and could be considered a potential alternative to the Project. Although energy conservation in foreign countries may slow the growth of global natural gas use and demand, energy efficiency and conservation alone is not expected to reverse the global demand for additional natural gas. Further, at this time it is not known which countries would receive LNG from this Project. Therefore, it is not practical to identify and evaluate energy conservation in foreign countries as an alternative to the proposed Project.

10.3 SYSTEM ALTERNATIVES

System alternatives are those alternatives that could replace all or part of the Project by making use of other existing or proposed natural gas export facilities or connecting pipelines.

10.3.1 Export System Alternatives

CE evaluated LNG export terminals that could serve as potential system alternatives. Potential alternatives are broken down into existing LNG export terminals, approved but not yet constructed LNG export terminals, proposed LNG export terminals, and potential LNG export terminals. Information on each alternative was obtained from the Federal Energy Regulatory Commission's (FERC) website (FERC 2013a, b, c, d), project dockets, various media announcements, and project websites. Other LNG export terminals that could be considered as potential alternatives are listed in Table 10-1 and summarized below.

Existing LNG Export Facilities

The only LNG export facility currently operating in North America is the Kenai LNG Plant (Kenai), constructed in the Cook Inlet Basin area in Alaska. Kenai provides for the liquefaction and storage of LNG and loading onto LNGCs for export to Japan. The order authorizing exportation of LNG was issued on April 19, 1967. The original export authorization has been amended and extended numerous times by the Department of Energy.

Because the Project would provide an outlet for domestically produced natural gas from shale formations in the lower 48 states and would bring LNG to markets in Europe and other locations in the Atlantic Basin, Kenai is not considered a viable alternative system because of its geographic location.

Approved LNG Export Facilities

Sabine Pass

Sabine Pass Liquefaction, LLC, and Sabine Pass LNG, L.P. have been approved by the FERC to construct the Sabine Pass Liquefaction Project (Sabine Pass) to add liquefaction capabilities to the existing Sabine Pass LNG import terminal in Cameron Parish, Louisiana. The FERC authorized the Sabine Pass Project on April 16, 2012, and the project is expected to begin export of LNG in 2015.

Table 10-1. LNG Export Terminals That Could be Considered Potential Alternatives to the CE FLNG LNG Project

Project Name	Location	Announced Volume (Bcf/d*)	FERC Docket Number	Expected In-Service Date
Cheniere Sabine Pass Liquefaction Project	Cameron Parish, Louisiana	2.6	CP11-72-000	2015
Freeport Liquefaction Project	Brazoria County, Texas	1.8	PF11-2-000	2017
Lake Charles Liquefaction Project	Lake Charles, Louisiana	2.4	PF12-8-000	2018
Cove Point LNG Liquefaction Project	Cove Point, Maryland	0.82	PF12-16-000	2017
Cameron LNG Liquefaction Project	Cameron Parish, Louisiana	1.7	PF12-13-000	2016
Jordan Cove Energy Project	Coos County, Oregon	0.9	PF12-7-000	2018
Oregon LNG Project	Warrenton, Oregon	1.3	PF12-18-000	2017
Cheniere Corpus Christi LNG Project	Corpus Christi, Texas	2.1	CP12-507-000	2017
Lavaca Bay LNG Project	Lavaca Bay, Texas	1.38	PF13-1-000	2017
Southern LNG Company	Elba Island, Georgia	0.35	PF13-3-000	2018
Gulf LNG Liquefaction	Pascagoula, Mississippi	1.5	PF13-4-000	2018
Magnolia LNG Project	Lake Charles, Louisiana	1.07	PF13-9-000	2018
Gulf Coast LNG Export Project	Brownsville, Texas	2.8	N/A	TBD
Golden Pass	Jefferson County, Texas	2.6	N/A	TBD
Pangea LNG	Ingleside, Texas	1.09	N/A	TBD

Source: http://www.fossil.energy.gov/programs/gasregulation/publications/export_applications_order_of_precedence.pdf FERC 2013c, 2013d
*Bcf/d = billion cubic feet per day

The Sabine Pass project would have export capacity of about 2.6 Bcf/d (or about 19.5 MTPA), and has announced contracts with four customers to sell substantially all of the LNG generated from the project. Therefore, there is not sufficient capacity from the Sabine Pass project to meet the proposed Project's objective. Thus, the Sabine Pass project is not a viable alternative to the proposed Project.

Proposed LNG Export Facilities

This section describes other LNG export facilities that have been formally proposed to the FERC and that could potentially serve as system alternatives to the CE FLNG LNG Project.

Freeport Liquefaction Project

The proposed Freeport Liquefaction Project is located in Brazoria County, Texas, and would add liquefaction and export capability to the existing Freeport LNG import terminal. The project entered the FERC's Pre-filing Process on January 5, 2011, and filed an application with the FERC in August 2012 (FERC Docket No. CP12-509-000). The project expects to begin exporting LNG in 2017.

The Freeport Liquefaction Project would have a total export capacity of about 13.2 MTPA, and Freeport has announced that it has contracted for one-third of this capacity. Therefore, there is not sufficient capacity from the Freeport Liquefaction Project to meet the proposed Project's objective.

Cheniere Corpus Christi LNG Project

The proposed Cheniere Corpus Christi LNG Project is located in San Patricio and Nueces Counties, Texas, and would be a new liquefaction and export facility at the site of Cheniere's previously proposed and approved LNG import terminal, which has not yet been constructed. The project entered the FERC's Pre-filing Process in December 2011 and Cheniere Corpus Christi LNG Project filed an application with the FERC in August 2012 (FERC Docket No. CP12-507- 000). The project expects to begin exporting LNG in 2017.

The Cheniere Corpus Christi LNG Project would have a total export capacity of 2.1 Bcf/d (or about 15.8 MTPA). The Cheniere Corpus Christi LNG Project might rely on the same sources of natural gas and might serve the same markets as those for the proposed Project. However, given the size of the market and the growing long-term availability of natural gas, this is not seen as an issue. If approved and constructed, the Cheniere Corpus Christi LNG Project would be complementary to, but not an alternative to the proposed Project. If the Cheniere Corpus Christi LNG Project was approved and constructed, additional U.S. gas would still be available for export, and additional foreign markets would still be available to consume the LNG produced by the proposed Project.

Jordan Cove Energy Project

The Jordan Cove Energy Project is a proposed LNG liquefaction and export project in Coos County, Oregon. The Jordan Cove Energy Project would have a total export capacity of 0.9 Bcf/d (or about 6.8 MTPA). Jordan Cove entered the FERC's Pre-filing Process on March 6, 2012 (FERC Docket No. PF12-7-000), and plans to file an application with the FERC in March 2013. The project could begin exporting natural gas in 2018.

The Jordan Cove Energy Project would receive natural gas sourced from Canada and the north-central region of the U.S, and its West Coast location is positioned geographically to serve other markets than those targeted by the proposed Project. Therefore, the Jordan Cove

Energy Project would not be an economically or practically feasible alternative for the proposed Project.

Lake Charles Liquefaction Project
The Lake Charles Liquefaction Project is a proposed LNG liquefaction and export project at the existing Trunkline LNG Lake Charles Terminal in Lake Charles, Louisiana. The Lake Charles Liquefaction Project would have a total export capacity of 2.4 Bcf/d (or about 18.0 MTPA). The project entered the FERC's Pre-filing Process on April 6, 2012 (FERC Docket No. PF12-8-000) and Lake Charles Liquefaction Project plans to file an application with the FERC in March 2013. Export of LNG could begin in 2018.

While the Lake Charles Liquefaction Project might potentially rely on the same sources of natural gas and might serve the same markets as those for the proposed Project, the proposed Project and the Lake Charles Liquefaction Project are connected to different pipeline systems and have geographically distinct primary gas sources. In addition, given the size of the market and the growing long-term availability of natural gas, even if the two projects share similar sources of natural gas, there would not be an adverse economic issue. If approved and constructed, the Lake Charles Liquefaction Project would be complementary to, but not an alternative to, the proposed Project. If the Lake Charles Liquefaction Project was approved and constructed, additional U.S. gas would still be available for export and additional foreign markets would still be available to consume the LNG produced by the proposed Project.

Cameron LNG Liquefaction Project
The Cameron LNG Liquefaction Project is proposed adjacent to the existing Cameron LNG Terminal in Cameron Parish, Louisiana. The project would be capable of exporting 12 million metric tons per year of LNG. Cameron LNG entered the FERC's Pre-filing Process on May 9, 2012 (FERC Docket No. PF12-12-000), and plans to file an application with the FERC in December 2012. The project expects to begin export of LNG in 2016.

The Cameron LNG Liquefaction Project would have a total export capacity of 1.7 Bcf/d (or about 12.8 MTPA). While the Cameron LNG Liquefaction Project might potentially rely on the same sources of natural gas and might serve the same markets as those for the proposed Project, the proposed Project and the Cameron LNG Liquefaction Project are connected to different pipeline systems and have geographically distinct primary gas sources. In addition, given the size of the market and the growing long-term availability of natural gas, even if the two projects share similar sources of natural gas, this would not be an adverse economic issue. If approved and constructed, the Cameron LNG Liquefaction Project would be complementary to, but not an alternative to, the proposed Project. If the Cameron LNG Liquefaction Project were approved and constructed, additional U.S. gas would still be available for export and additional foreign markets would still be available to consume the LNG produced by the proposed Project.

Cove Point LNG
The Cove Point LNG Liquefaction Project is proposed to occur adjacent to the existing Dominion Cove Point LNG Terminal located on the Chesapeake Bay in Lusby, Maryland. The Cove Point project began the Pre-filing Process with the FERC in June 2012 (FERC Docket PF12-16) and plans to file an application with the FERC in April 2013. The project expects to begin exporting natural gas in 2017.

The Cove Point LNG Liquefaction Project would have a total export capacity of 0.75 Bcf/d (or about 5.6 MTPA). Because of its location on the U.S. east coast, the Cove Point LNG Liquefaction Project would likely receive natural gas source from regions other than those from the proposed Project. The Cove Point LNG Liquefaction Project could serve the same markets that would be served by the proposed Project. If approved and constructed, the Cove Point LNG Liquefaction Project would be complementary to, but not an alternative to, the proposed Project. If the Cove Point LNG Liquefaction Project were approved and constructed, additional U.S. gas would still be available for export and additional foreign markets would still be available to consume the LNG produced by the proposed Project.

Oregon LNG Project

The Oregon LNG Project is a proposed new LNG peak-shaving, liquefaction, and export facility located on the Skipanon Peninsula in Warrenton, Oregon. The Oregon LNG Project is proposed to operate as a tolling facility, leasing peak-shaving and liquefaction capacity. The Oregon LNG Project began the FERC's pre-filing process in July 2012 (FERC Docket PF12-18), and Oregon LNG Project expects to file an application with the FERC in 2013 and begin operation in 2017.

The Oregon LNG Project would have a total export capacity of 1.3 Bcf/d (or about 9.7 MTPA). The Oregon LNG Project would receive natural gas sourced from Canada and the north-central region of the U.S., and its West Coast location is positioned geographically to serve markets other than those targeted by the proposed Project. Therefore, the Oregon LNG Project would not be an economically or practically feasible alternative for the proposed Project.

Lavaca Bay LNG Project

Excelerate Liquefaction Solutions I, LLC (ELS I) is proposing to construct, own, and operate the Lavaca Bay LNG Project located in Port Lavaca, Texas, using floating liquefaction storage offloading (FLSO™) vessel technology. The Lavaca Bay LNG Project would also require a new turning basin and berthing pockets, as well as the deepening and widening of the Matagorda Ship Channel. When completed, the Lavaca Bay LNG Project would be capable of producing up to 10 MTPA or 1.3 BCF/D. ELS I began the pre-filing process on November 20, 2012 (FERC Docket PF13-1-000) and expects to begin construction in April 2014.

The Lavaca Bay LNG Project may target the same markets to be served by the proposed Project. However, the Lavaca Bay LNG Project would be complementary to, but not an alternative to, the proposed Project. Even if the Lavaca Bay LNG Project were constructed, additional U.S. gas would be available for export and additional foreign markets would be available to consume the LNG produced by the proposed project. Finally, the Lavaca Bay LNG Project does not have adequate land available to expand its current design. As it is currently proposed, ELS I must create an additional 40 acres required for the facility through the use of dredge material from the construction of the turning basin. There are no apparent environmental advantages from the Lavaca Bay LNG project over the proposed Project.

Gulf LNG Project

Gulf LNG Liquefaction Company, LLC (GLLC) is proposing to construct, own, and operate the GLLC Liquefaction Project located in Pascagoula, Mississippi. The GLLC Liquefaction Project is designed as a two-phased project, with each phase to include a single liquefaction train with a nominal production capacity of 5 MTPA. Up to 10.5 MTPA of LNG would be produced from a natural gas feedstock rate of up to 1.5 bcfd. GLLC began the pre-filing process with the

FERC on December 5, 2012 (FERC Docket PF13-4-000), plans to commence construction in March 2015, and expects to begin operation in 2018.

The GLLC Liquefaction Project may target the same markets to be served by the proposed Project. However, the GLLC Liquefaction Project would be complementary to, but not an alternative to, the proposed Project. Even if the GLLC Liquefaction Project were constructed, additional U.S. gas would be available for export and additional foreign markets would be available to consume the LNG produced by the proposed Project. Finally, the GLLC Liquefaction Project does not appear to have adequate land available to expand with its current design. As it is currently proposed, the GLLC Liquefaction Project would be situated on a 50-acre site adjacent to the existing LNG Terminal in Jackson County, Mississippi. There are no apparent environmental advantages of the GLLC Liquefaction Project over the proposed Project.

Southern LNG Project

Southern LNG Company, LLC (SLNG), Elba Express Company, LLC (EEC), and Elba Liquefaction Company, LLC (ELC) propose to construct, own, and operate the Elba Liquefaction Project located near Savannah, Georgia. When completed, the Elba Liquefaction Project would be capable of an output capacity of 2.5 MTPA. The companies began the pre-filing process in December 2012 (FERC Docket PF13-3-000) and expect to begin construction in November 2014.

The Elba Liquefaction Project may target the same markets to be served by the proposed Project. However, the Elba Liquefaction Project would be complementary to, but not an alternative to, the proposed Project. Even if the Elba Liquefaction Project were constructed, as it is currently designed it does not appear to have adequate capacity to meet the purpose and need of the proposed Project.

Magnolia LNG Project

Magnolia is proposing to develop an LNG facility, located in Lake Charles, Louisiana, capable of producing a maximum of 8 MTPA of LNG using its patented Optimized Single Mixed Refrigerant (OSMR®) technology. The Magnolia LNG Project would receive natural gas via an existing pipeline that traverses the Magnolia LNG Project site. The natural gas would be treated, liquefied, and stored onsite. At full plant capacity, the Magnolia LNG Project would consist of four LNG trains, each with a nominal capacity of 2 MTPA of LNG. The LNG would be loaded onto LNGCs for export overseas; LNGCs and barges for marine distribution and the possibility of LNG bunkering; and LNG trucks for road distribution to LNG refueling stations in Louisiana and surrounding states.

The Magnolia LNG Project would have a total export capacity of 1.07 Bcf/d (or about 8 MTPA). The Magnolia LNG Project would receive natural gas sourced from various pipelines owned by Trunkline Gas Company, Kinder Morgan Louisiana Pipeline, Gulf South Pipeline Company, L.P., and Chevron Pipe Line Company. Magnolia LNG anticipates that the sources of natural gas would include Texas, Louisiana, and Mississippi producing regions, including recent shale gas discoveries in the Haynesville, Eagle Ford, Barnett, and Floyd-Neale/Conasauga shale plays. If approved and constructed, the Magnolia LNG Project would be complementary, but not an alternative to, the proposed Project. If the Magnolia LNG Project were approved and constructed, additional U.S. gas would still be available for export, and additional foreign markets would still be available to consume the LNG produced by the proposed Project.

Potential LNG Export Facilities
A number of additional potential LNG export facilities have been announced or have filed applications with the U.S. Department of Energy for LNG export authorizations. Applications for these projects have not been submitted to the FERC or U.S. Department of Transportation Maritime Administration at this time and the projects are therefore not considered to be feasible alternatives. However, CE will include information in a future draft of Resource Report 10 – Alternatives, as appropriate, if these projects file formal applications.

10.3.2 Pipeline System Alternatives

A pipeline system alternative would involve use of another pipeline system to meet the same project objectives as the pipeline proposed by CE. However, as discussed below, there is no alternative pipeline system that would allow the proposed Project to reach the existing interstate and intrastate natural gas pipeline systems without the addition of new pipeline infrastructure.

The purpose of the pipeline, as proposed by CE, is to provide access to natural gas supply from existing interstate and intrastate natural gas pipeline systems. To meet this objective a pipeline must run from the proposed site located in southern Plaquemines Parish, Louisiana, north to interconnect with existing pipelines, and southwest to interconnect with Targa. No such pipeline currently exists. If an existing interstate or intrastate pipeline were expanded to provide the necessary interconnects with the proposed Project, it would result in construction of a pipeline essentially similar to that proposed by CE. Because the pipeline proposed by CE would mostly be placed in existing pipeline corridors, the environmental impacts of an expanded interstate or intrastate pipeline would also be similar to the pipeline proposed by CE. Therefore, a pipeline system alternative would provide no environmental advantage over the pipeline described by the proposed Project.

10.4 LNG TERMINAL SITE ALTERNATIVES

CE FLNG evaluated locations for the proposed Project layout to assess the potential for minimizing environmental impact and maximizing utilization. Two alternate sites for the proposed Project were compared and evaluated (Figure 10-2).

10.4.1 Ostrica Site

The old Ostrica Terminal site, located on the east bank of the Mississippi River between mile markers 24 and 25 from the Head of Passes, is approximately 3 miles south of Empire, Louisiana. The old terminal was used as a hub that receives crude oil via pipelines from production facilities in the Gulf of Mexico. The old terminal, in turn, would send oil via pipelines and barges to various locations along the Gulf Coast. The site was considered as an alternative for the proposed FLNG Terminal (Figure 10-3). A variety of oil and gas pipelines cross the site, and existing infrastructure consists of a concrete berthing structure that was used for barges and other vessels. The site would allow two FLNG vessels to berth, but introduces challenges while LNGCs are loading and would present safety issues. The site could require remediation with the past owner and operator of the terminal regarding spilling issues. Use of the site would present construction challenges with the removal of structures and tanks if a marine facility were created. Use of this site would nearly triple the amount of time an LNGC spends on the Mississippi River, and would increase travel time to the Gulf of Mexico if the FLNG vessel moves because of a significant weather event (i.e., hurricane).

Figure 10-2. Alternative Sites

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Figure 10-3. Ostrica Area East Bank Alternative Site

10.4.2 Magnolia Plantation Site

The Magnolia Plantation site is located on the west bank of the Mississippi River, between mile marker 40 and 42 from the Head of Passes, near Empire, Louisiana. The site has sufficient land for either a land-based facility or FLNG facility, where the FLNG vessel would be docked on the east side of the Mississippi River (Figure 10-4).

The site would be a deep draft port. This presents a regulatory issue because it would likely be governed by the U.S. Maritime Administration, which has no experience with deep water export terminals, rather than FERC. The site has a variety of oil and gas pipelines that cross the site, and has infrastructure that consists of a concrete berthing structure that was used for barges and other vessels. The site has sufficient space to allow two FLNG vessels to berth, but introduces challenges while LNGCs are loading, and would present safety issues regarding the turning basin. The site would present construction difficulties with the need to relocate the Mississippi River flood protection levee (requiring a Section 408 analysis from the U.S. Army Corps of Engineers) and the need for additional dredging. Use of this site would significantly increase the time that an LNGC spends on the Mississippi River, and would increase travel time to the Gulf of Mexico if the FLNG vessel moves because of a significant weather event.

10.4.3 U.S. Regional Review

A primary factor in identifying the most suitable region within the U.S. for the proposed Project is access to existing interstate and intrastate natural gas pipelines for the purpose of delivery of natural gas into the systems. Readily available access to existing interstate and intrastate natural gas pipelines is required for the proposed Project to supply feed gas for liquefaction, storage, and export. As a result, the east and west coasts, as well as certain Gulf Coast states like Florida and Alabama, were eliminated due to the lack of interstate and intrastate pipeline infrastructure.

10.4.4 Site Review

The following screening criteria were used in selecting the proposed Project site as a preferred location for a new LNG terminal: (1) isolated location, (2) proximity to existing natural gas transmission project, and (3) distance from Head of Passes of the Mississippi River. Siting an LNG terminal away from populated areas would minimize land use conflicts, maximize project safety, and minimize community concern. Access to the existing Louisiana interstate and intrastate natural gas transmission systems is a critical consideration for the development of an LNG terminal. Port sites near existing natural gas pipelines would be more desirable than those located in areas without significant existing transmission infrastructure.

The proposed Project site located on the east bank of the Mississippi River in Plaquemines Parish, and 11 miles from the Head of Passes, meets all of the screening criteria for a new LNG facility, and is a viable and preferred port for development of a new LNG facility.

10.5 DREDGED MATERIAL PLACEMENT SITE ALTERNATIVES

Construction of the proposed Project would require dredging for the new turning basin and FLNG vessels' berth pockets. Dredging would also be required for channel improvements along the Mississippi River. CE is in the process of designing the turning basin and berth pockets and determining the volume of dredge material required to be removed for these facilities. Further, CE is conducting vessel simulation studies to determine the extent of Mississippi River channel

Figure 10-4. Magnolia Real Estate Alternative Site

improvements required, which would in turn determine the volume of material to be removed by dredging.

CE is developing a dredged material management plan (DMMP) that would include identification of preferred and alternative sites for placement of Project-related dredged material. The DMMP would be completed prior to the FERC application filing, and alternatives for dredged material placement evaluated in the DMMP would be summarized in the final Resource Report 10, to be included with the FERC application.

10.6 DESIGN AND OPERATION ALTERNATIVES

10.6.1 Traditional Land-Based Facility

A traditional land-based liquefaction and storage facility could not be constructed on the site adjacent to the proposed FLNG berths because the proposed site is surrounded by wetlands and open water. Filling wetlands and shallow open water bodies to create a land-based liquefaction and storage facility would have unnecessary and significant environmental impacts, reduce the possibility of beneficial use options, and require additional Project mitigation. CE does not consider this a viable alternative to its proposed Project because of the advantages of the FLNG design over a traditional land-based facility. The FLNG vessels would be constructed in a shipyard and then towed to the site, thus avoiding the complex and costly onshore civil construction works required for a land-based facility. Because the FLNG vessels would be built in the controlled environment of a shipyard, they can be brought online faster and more efficiently, contributing to a higher degree of quality on a tighter schedule.

10.6.2 Non-Self-Propelled Barges

During conceptual design of the FLNG vessels, CE considered the use of non-self-propelled barges. However, given the prevalence of cyclonic events in the Louisiana area and the lack of hurricane and storm damage risk reduction structures in lower Plaquemines Parish, CE determined that a self-propelled vessel would allow the avoidance of severe weather conditions that could cause substantial damage to the facilities. For this reason CE does not consider a non-self-propelled barge a reasonable alternative to the proposed FLNG vessels.

10.6.3 FLNG Position Alternatives

CE will include the FLNG alternative positions that were evaluated in the final Resource Report 10.

10.6.4 LNG Process Alternatives

CE evaluated three types of LNG process technology in selecting its proposed technology for use on the FLNG vessels and the CE FLNG LNG Project. The LNG process alternatives evaluated were:

- Single Mixed Refrigerant (SMR)
- Expander
- Nitrogen Refrigeration

CE applied the following criteria to each LNG process technology before selecting the preferred LNG liquefaction technology for onboard the FLNG vessels:

- Low equipment count - the number and size of each piece of equipment is a critical factor for a floating liquefaction facility with a limited surface footprint.

- Minimal complexity - the complexity of the process affects not only the overall cost, but also the ease of operation and maintainability. Complex processes require more staffing to operate and are more susceptible to unplanned shutdowns. A more streamlined process fits the floating facility better.
- Minimal rotating equipment - the rotating equipment is the largest cost and maintenance item in the LNG process. Minimizing the amount of rotating equipment results in a lower cost and more reliable facility.
- Insensitivity to motion - in a motion environment, such as a floating liquefaction facility, equipment that is shorter and has a lower center of gravity is less susceptible to motion impacts than tall or long equipment.
- Moderate to high efficiency - efficiency relates to the size and cost of the liquefaction equipment. A process with good efficiency helps in both minimizing equipment and module sizes while not increasing complexity.
- Ease of operation - due to the floating platform, processes that are stable and flexible with changing conditions are preferred.

A summary of the evaluation of each technology is below. CE has not pursued a Project-specific design for any technology other than the proposed process; therefore, it has not evaluated potential Project-specific environmental impacts from the alternative technologies.

10.6.4.1 Single Mixed Refrigerant (SMR)

The SMR Process is the workhorse of the LNG industry and is used in the vast majority of liquefaction installations around the world. This process depends on a single refrigeration system (loop) to perform the liquefaction. The process is highly efficient, with LNG yields of over 98 percent with motor drivers and 92 percent with gas turbine drivers. Because the system uses a mixture of refrigerant components, it is the most flexible of all the liquefaction systems. The system requires only one compression system and, therefore, has the highest reliability. The refrigerant makeup is minimal during operation and typically represents less than 2 percent of the plant operating cost.

CE has selected the SMR Process as the preferred liquefaction process for the FLNG vessels used for the proposed Project. In comparison to other available liquefaction processes, the SMR Process has:

- The lowest equipment count with a single refrigerant loop;
- The least overall complexity due to process simplicity;
- Fewer compressor bodies and less rotating equipment;
- The least sensitivity to motion due to short, compact equipment;
- Good overall efficiency; and
- Ease of operation due to the process simplicity of the single refrigeration system.

The proposed Project would use the PRICO® SMR Process. The PRICO® Process is one of the leading SMR systems in use in the LNG industry, with 18 projects in operation and 14 additional projects under development. The PRICO® Process uses a single refrigerant mixture of nitrogen through iC5. The refrigerant mixture is developed to match the plant conditions for the gas being liquefied, and the mixture can be modified to accommodate changes in the plant feed gas or environmental conditions. The process uses plate fin heat exchanger modules as the main exchanger rather than a single large spiral wound unit. This modular approach provides advantages in both cost and operating flexibility not found with the spiral wound design, and is highly desirable on a floating application with a limited footprint.

10.6.4.2 Expander Process

The Expander Process uses a gas phase refrigeration system comprising a large main compressor and two stages of expansion (resulting in three rotating equipment systems) to produce the low temperature needed for liquefaction. The Expander Process uses feed gas for the refrigeration medium, which adds the complication that the cooling medium can contain components such as carbon dioxide and heavier hydrocarbons, which can freeze at LNG temperatures.

The Expander Process is useful when a large volume of gas is being let down from a high pressure to a low pressure gas distribution system, and can be applied with no or minimal compression, which is advantageous in reducing power requirements. However, the process works by processing a large volume of feed gas to liquefy only about 15 percent of the gas, and is therefore of low efficiency. CE did not select the Expander Process for application on the FLNG because of complexity, high equipment count and site footprint, cost, and low efficiency of the process.

10.6.4.3 Nitrogen Process

The Nitrogen Process is very similar to the Expander Process in that is uses a gas phase refrigeration system comprising a large main compressor and two stages of expansion (resulting in three rotating equipment systems) to produce the low temperature needed for liquefaction. The Nitrogen Process is a simplified Expander Process that utilizes nitrogen as the refrigeration medium. This use of a relatively inert medium is one of the attractive features of the process.

As with the Expander Process, the nitrogen process is highly inefficient, and has a high equipment count and large footprint, and the related high complexity and cost. Therefore, CE did not select the Nitrogen Process for application on the FLNG.

10.7 PIPELINE ALTERNATIVES

CE selected its proposed pipeline route according to the following criteria:

- Shortest reasonable route between the proposed LNG terminal facility and multiple interstate and intrastate natural gas pipelines, ending in the Venice area.
- Follow existing utility rights-of-way to the extent practicable.
- Avoid developed residential areas.
- Avoid or minimize crossings of sensitive or regulated resources such as wetlands, waterbodies, and habitats for protected species.

In selecting its proposed route, CE evaluated the following alternatives. CE will continue to gather environmental data and evaluate the proposed pipeline route and potential alternatives. If additional alternatives are identified, details of the additional alternatives and comparison of alternatives and corresponding segments of proposed route will be provided in the final Resource Report 10 included with CE's application to FERC.

10.7.1 Northern Alternative

The Northern Alternative includes starting the pipeline at Toca and continuing the pipeline route in a south and southeast direction using the High Point Gas Transmission (HGT) System (formerly the SONAT pipelines) running parallel to the right-of-way for the HGT System to the LNG terminal (Figure 10-5 and Appendix 10-A). This route impacts wetlands and waterbodies.

Figure 10-5. Alternative Pipeline Routes

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The primary difference between the selected route and the Northern Alternative is the potential effects on sensitive resources between Pointe A La Hache and Toca, including a crossing of the Greater New Orleans Hurricane and Storm Damage Risk Reduction System (HSDRRS) levee and floodwall. The Northern Alternative would involve more distance to the north than the proposed route, approximately 21 additional miles from the connection of TGP Gate 6 Vicinity Point A La Hache. The greatest impact is that this pipeline route would affect the HSDRRS levee and floodwall and require Section 408 review and analysis by the U.S. Army Corps of Engineers. Both the proposed and Northern Alternative routes would cross previously disturbed land on the east side of the Mississippi River moving from TGP Gate 6 to Toca. The human resource impact would be greater with the Northern Alternative route, including closer proximity to existing residential developments on the eastern side of the Mississippi River. Therefore, there would be a larger number of residences within 500 feet of the Northern Alternative pipeline route.

10.7.2 Western Alternative

The Western Alternative includes starting the pipeline at TGP Gate G and crossing over the Mississippi River in the vicinity of Port Sulfur, and moving the route in a south and southwest direction to the Venice Processing Plant (see Figure 10-5 and Appendix 10-A). While this route also impacts wetlands and waterbodies, the route would make use of some of the TGP right-of-way to the TGP processing plant, but would require more right-of-way approval along the route toward Venice. The primary difference between the proposed route and the Western Alternative route is potential effects on sensitive resources between Port Sulfur and Toca, including the New Orleans to Venice Levee flood protection system, residential areas, and commercial areas. In addition, the Western Alternative would require two river crossings. The first crossing would occur at Port A La Hache, and the second would occur after the interconnections at the Venice Processing Facility to the FLNG Facility on the east bank. The primary difference between the proposed route and the Western Alternative route is that the Western Alternative route involves more distance for construction (approximately 40 miles), from the connection of TGP 500 processing facility to the Venice Processing plant. The greatest impact is that the pipeline could affect the levee of the flood protection system and require a Section 408 review and analysis by the U.S. Army Corps of Engineers. In addition, this route would not meet the total gas requirements of the project. This route would cross previously disturbed land on the west bank side of the Mississippi River moving from TGP 500 to the Venice Processing Plant. The human resource impact would be greater with the Western Alternative route, including increased proximity to existing residential developments on the west bank side of the Mississippi River. Therefore, there would be a larger number of residences within 500 feet of the Western Alternative pipeline route.

10.8 REFERENCES

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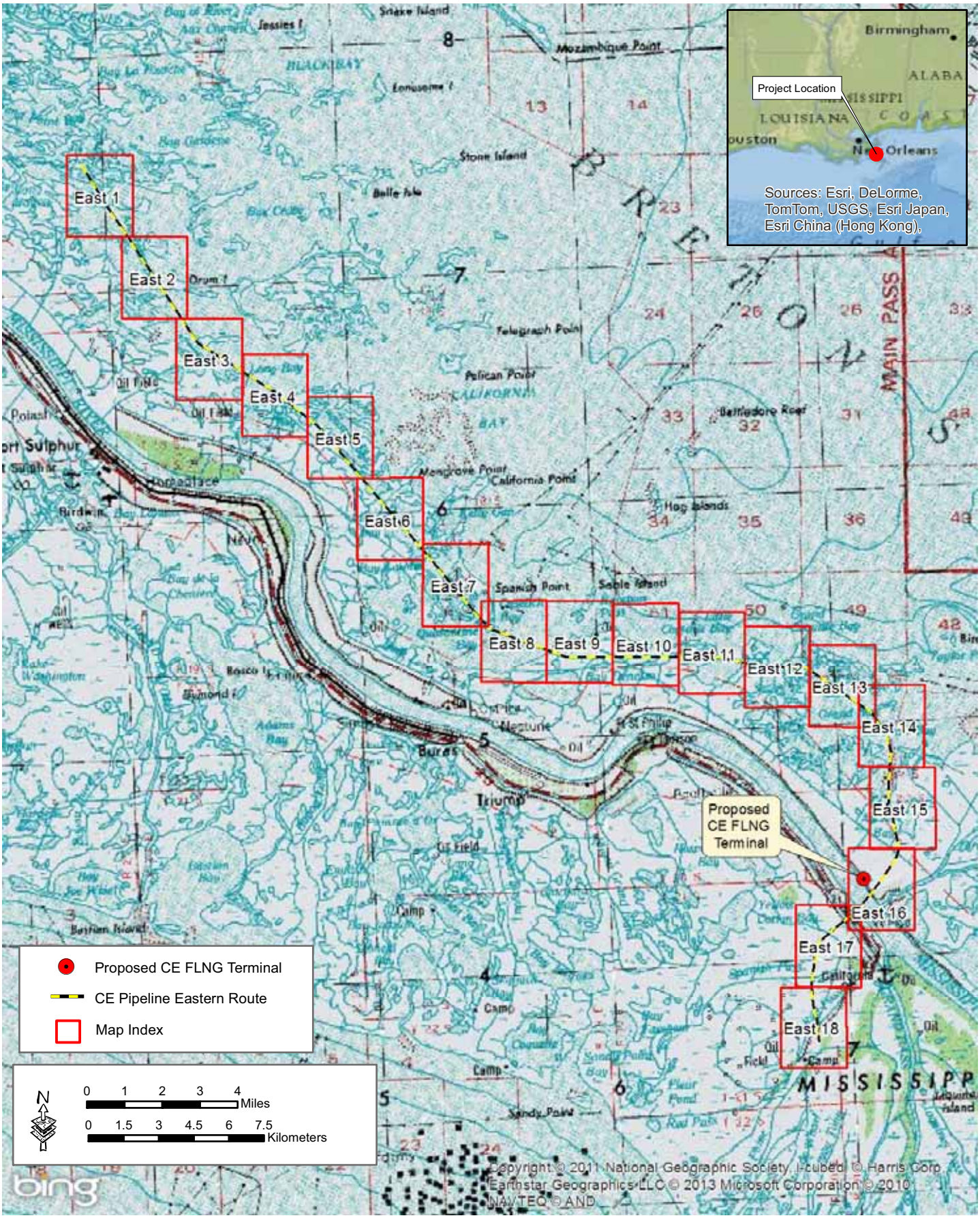
APPENDIX 10-A
PIPELINE CORRIDOR MAPS



Index Map for Eastern Pipeline Route

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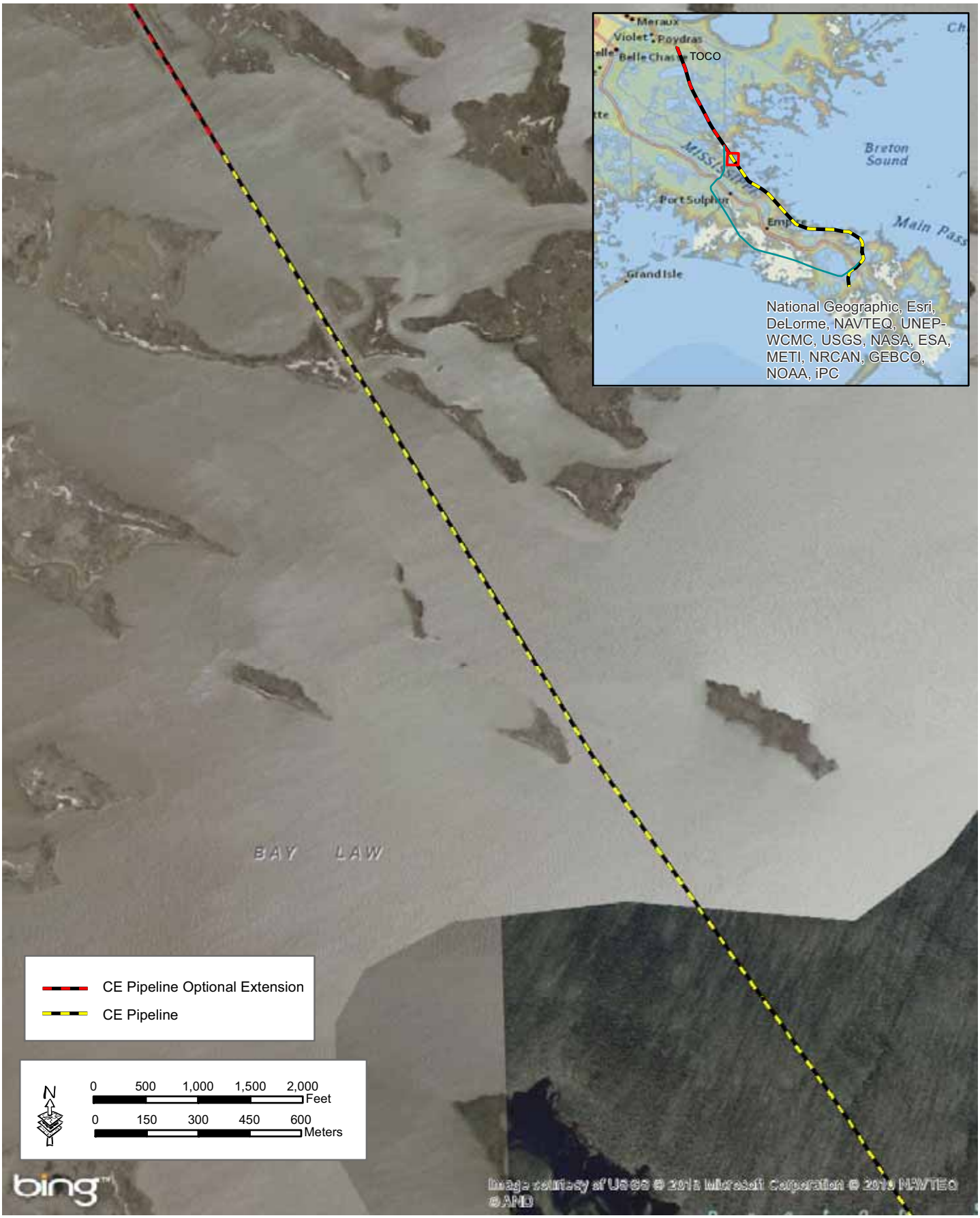

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CE Pipeline Route - East 3

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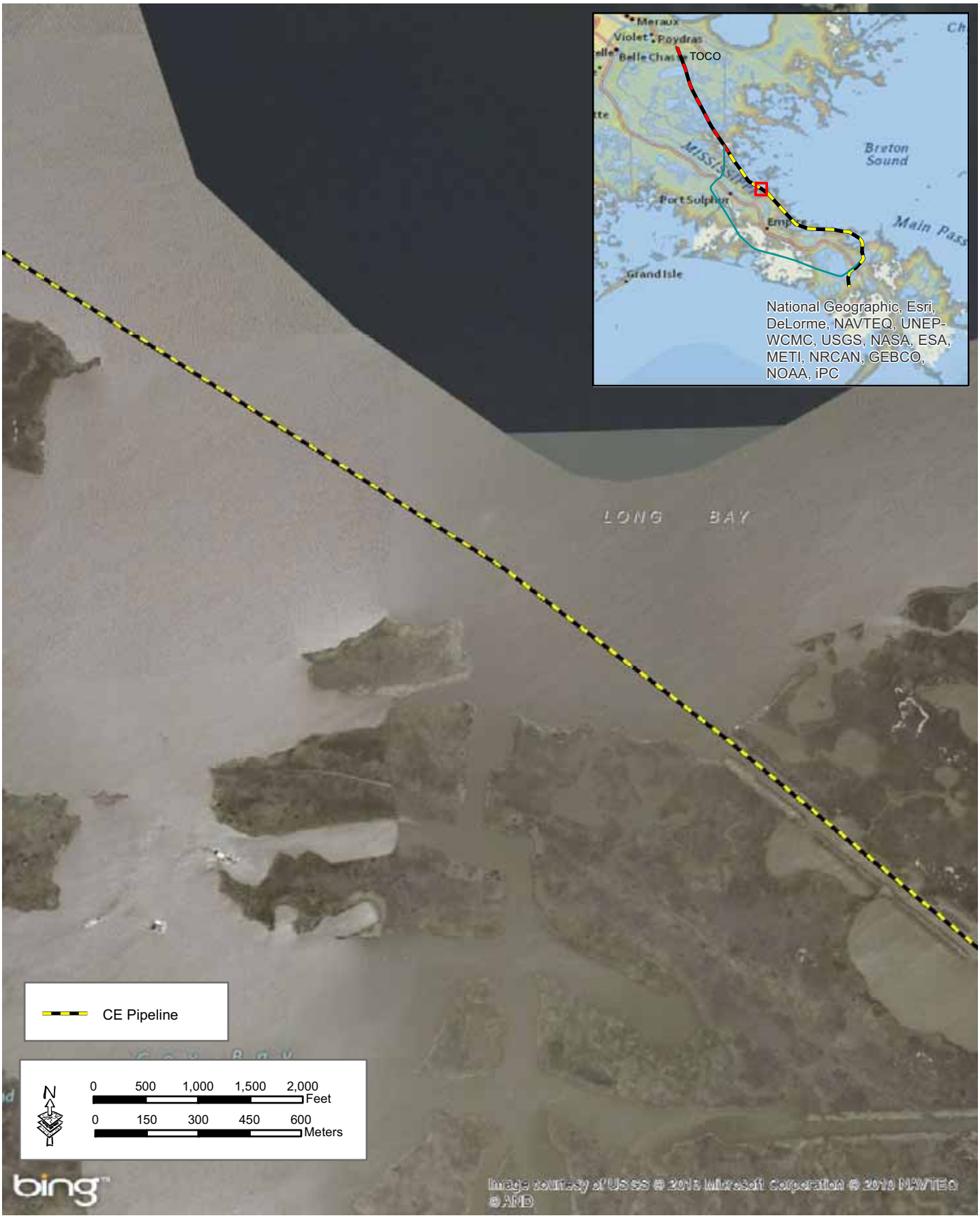

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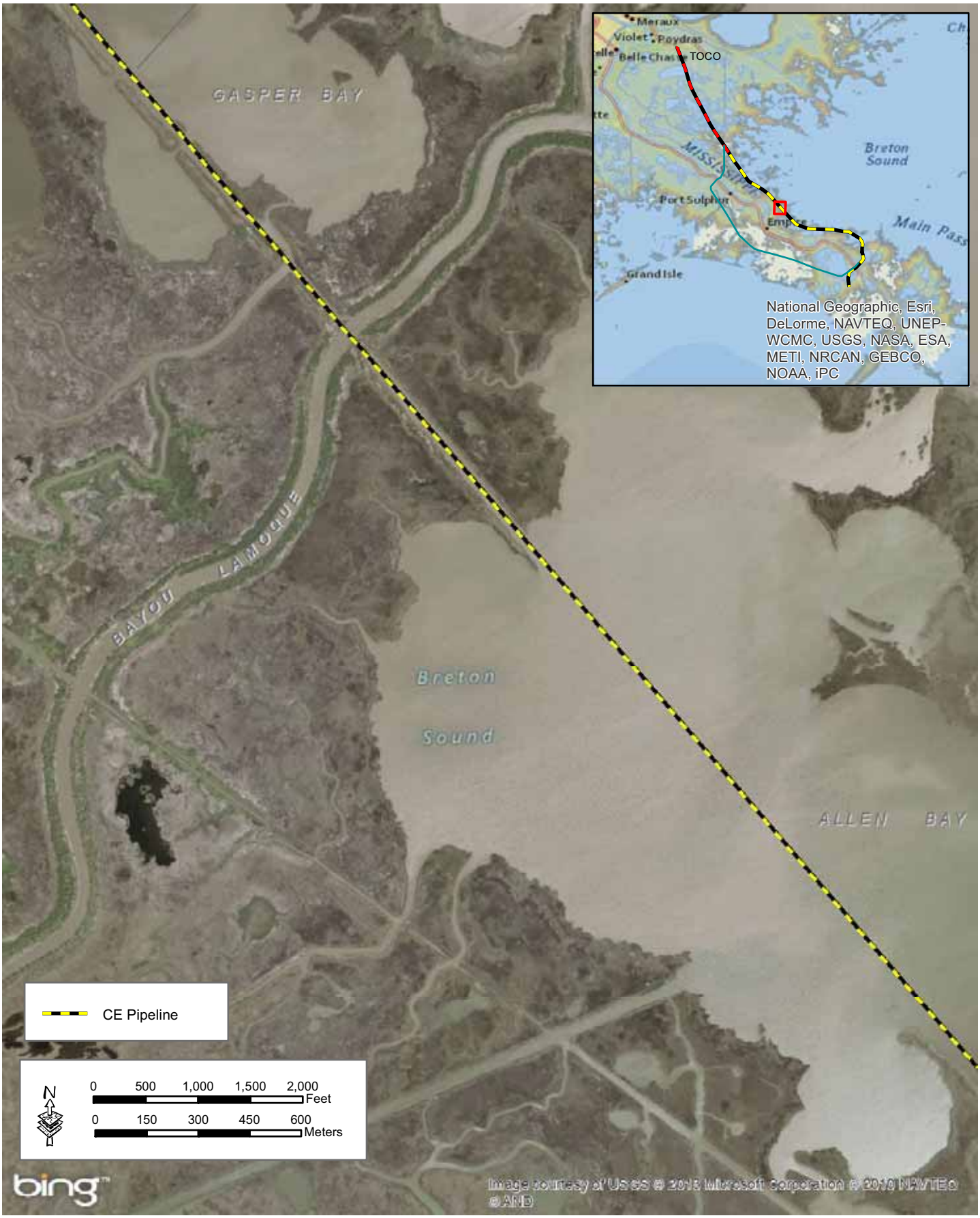

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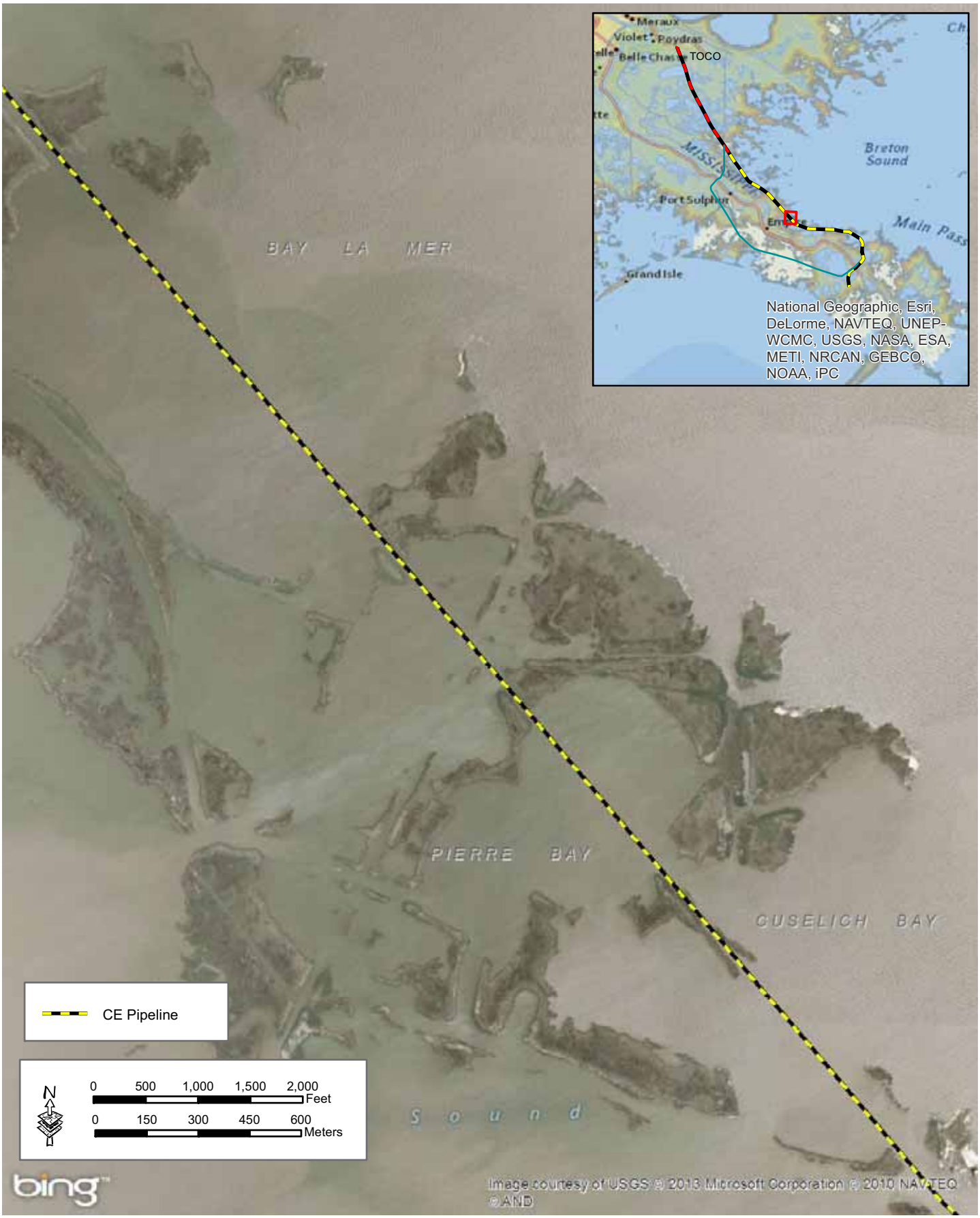

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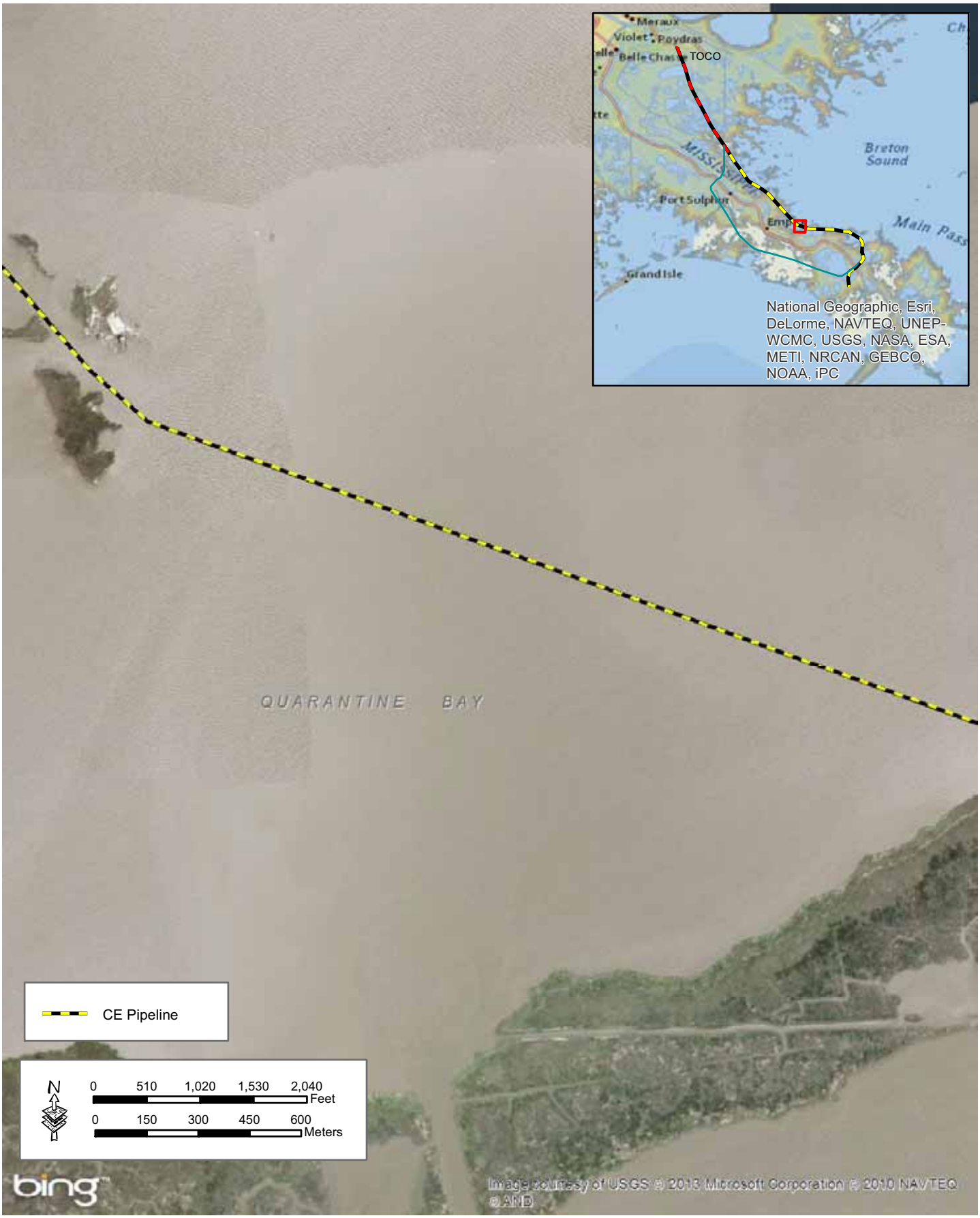

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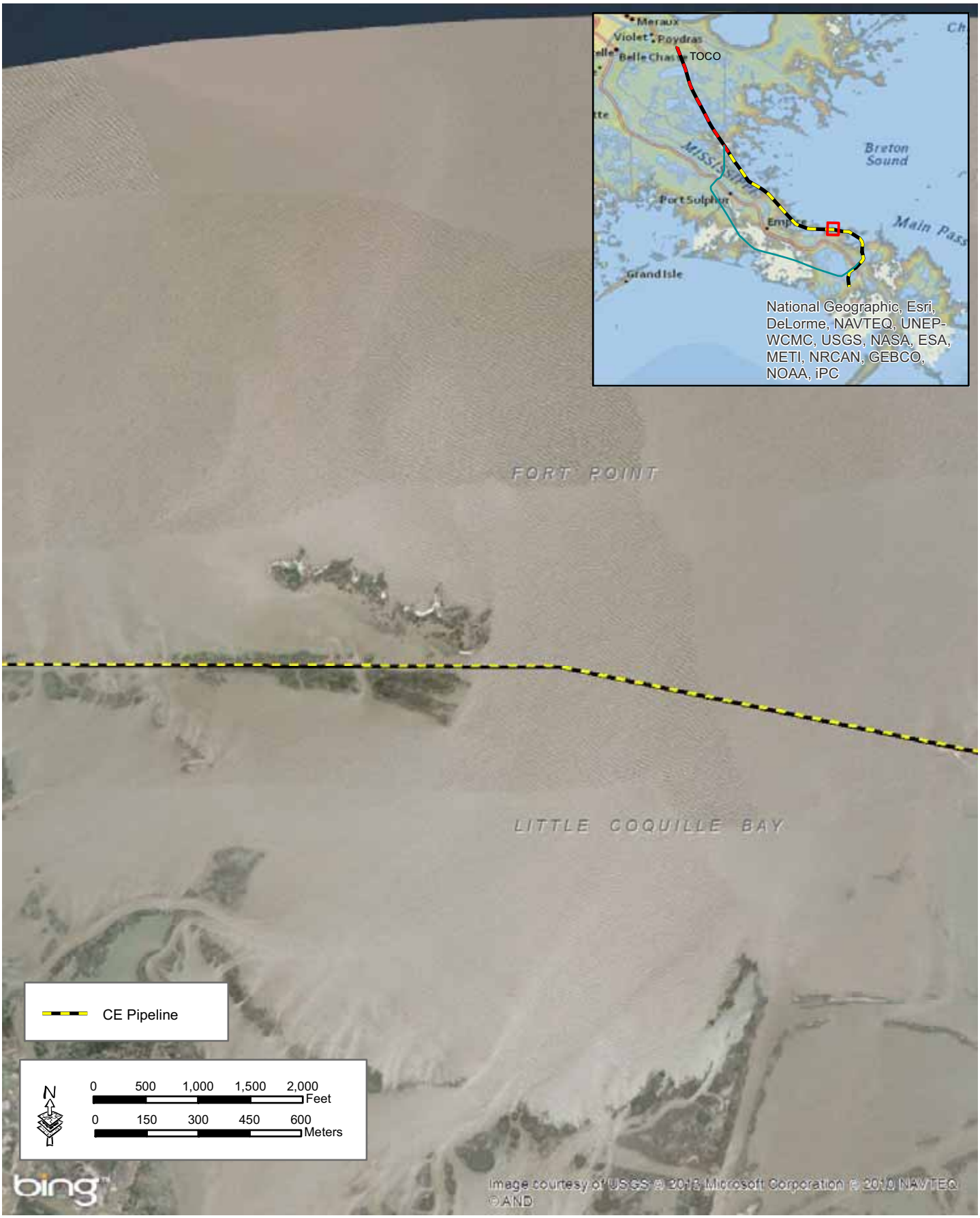

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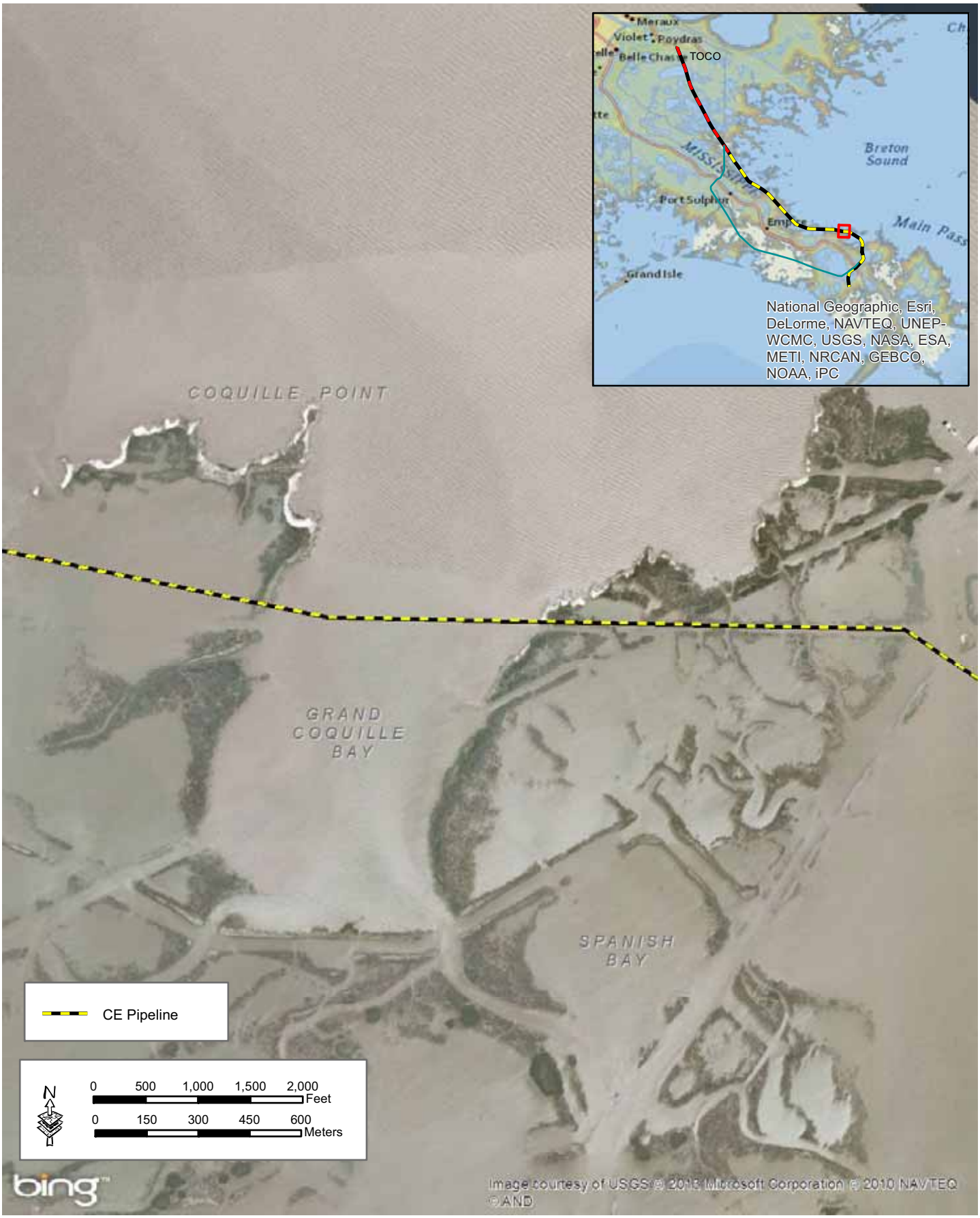

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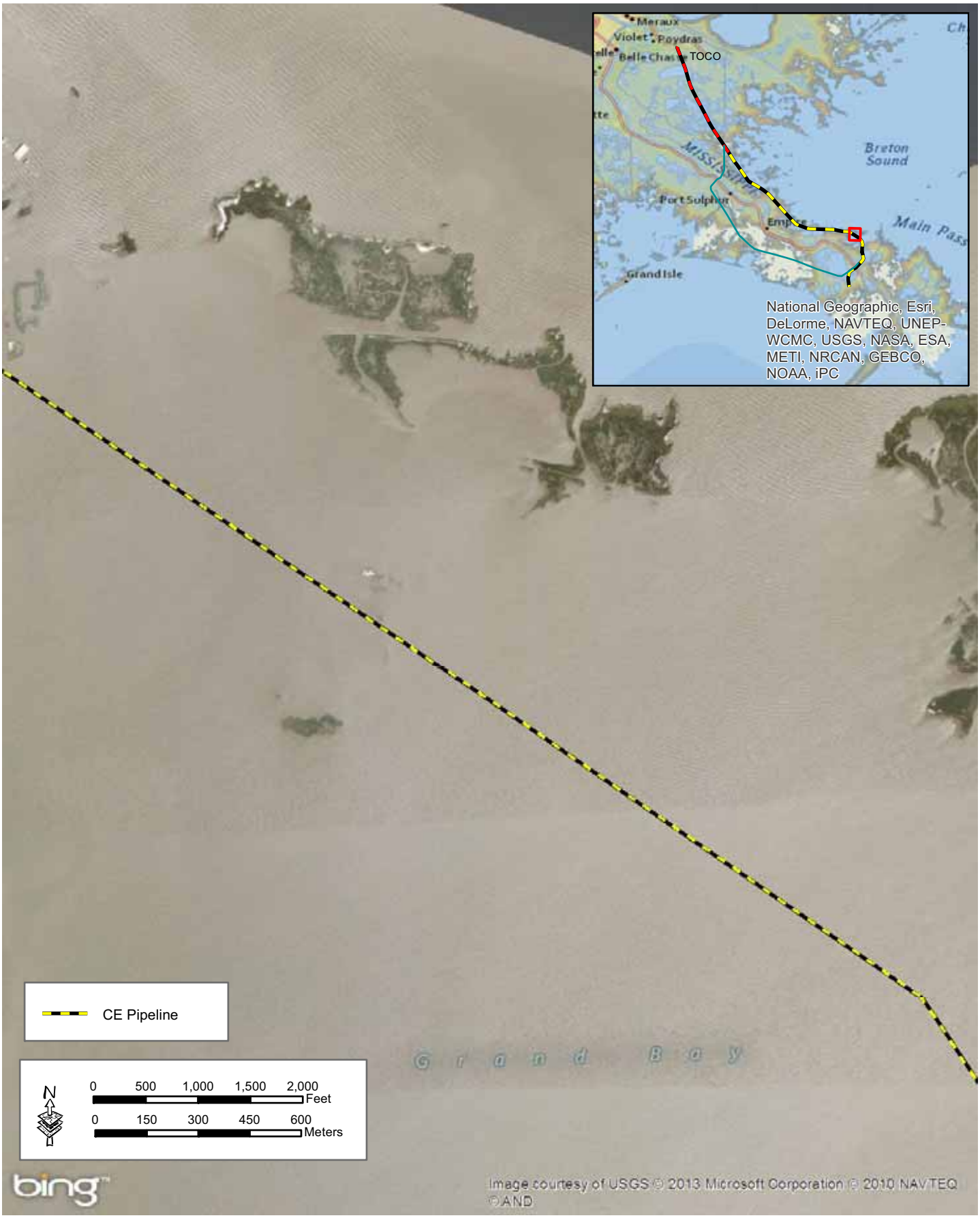

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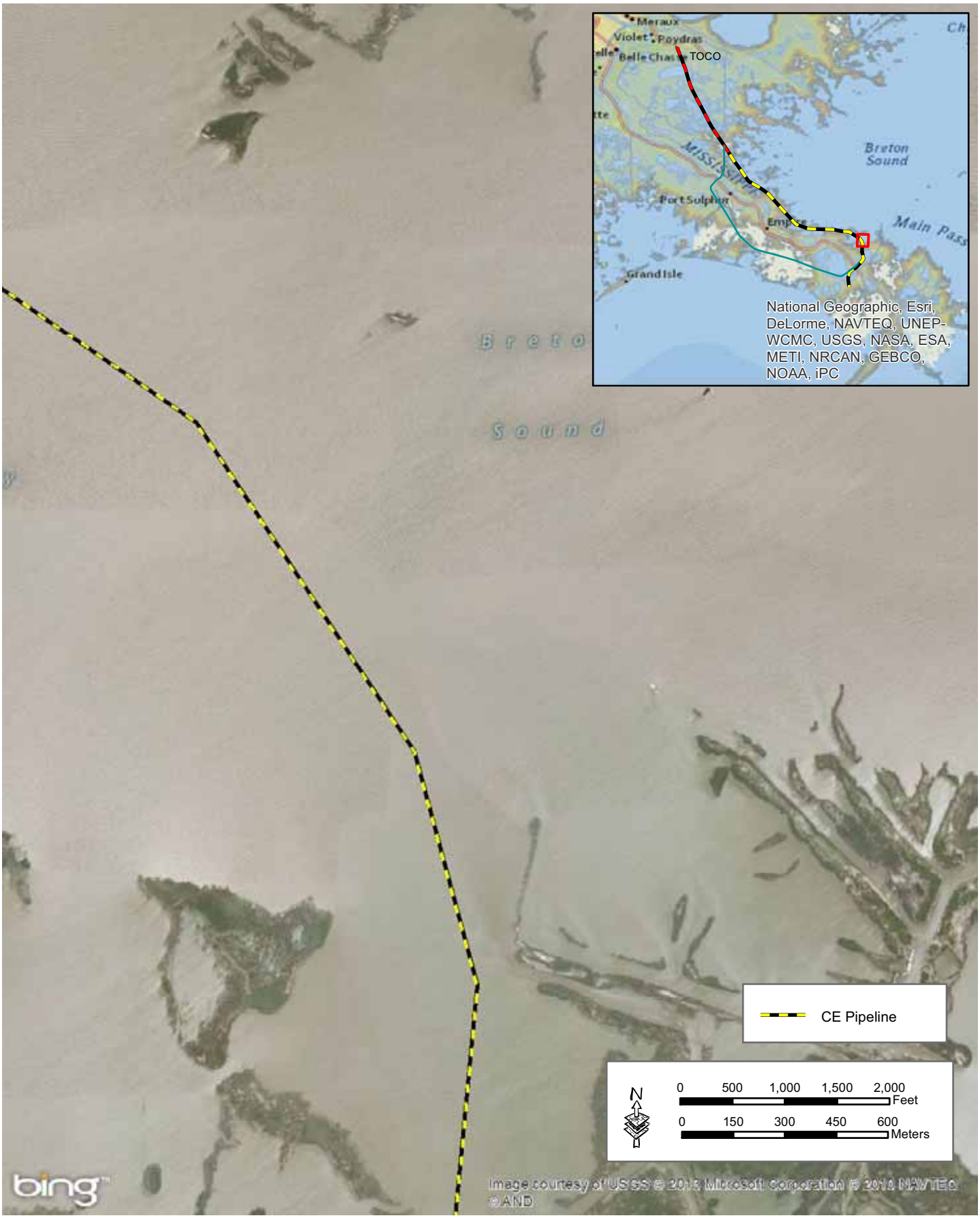

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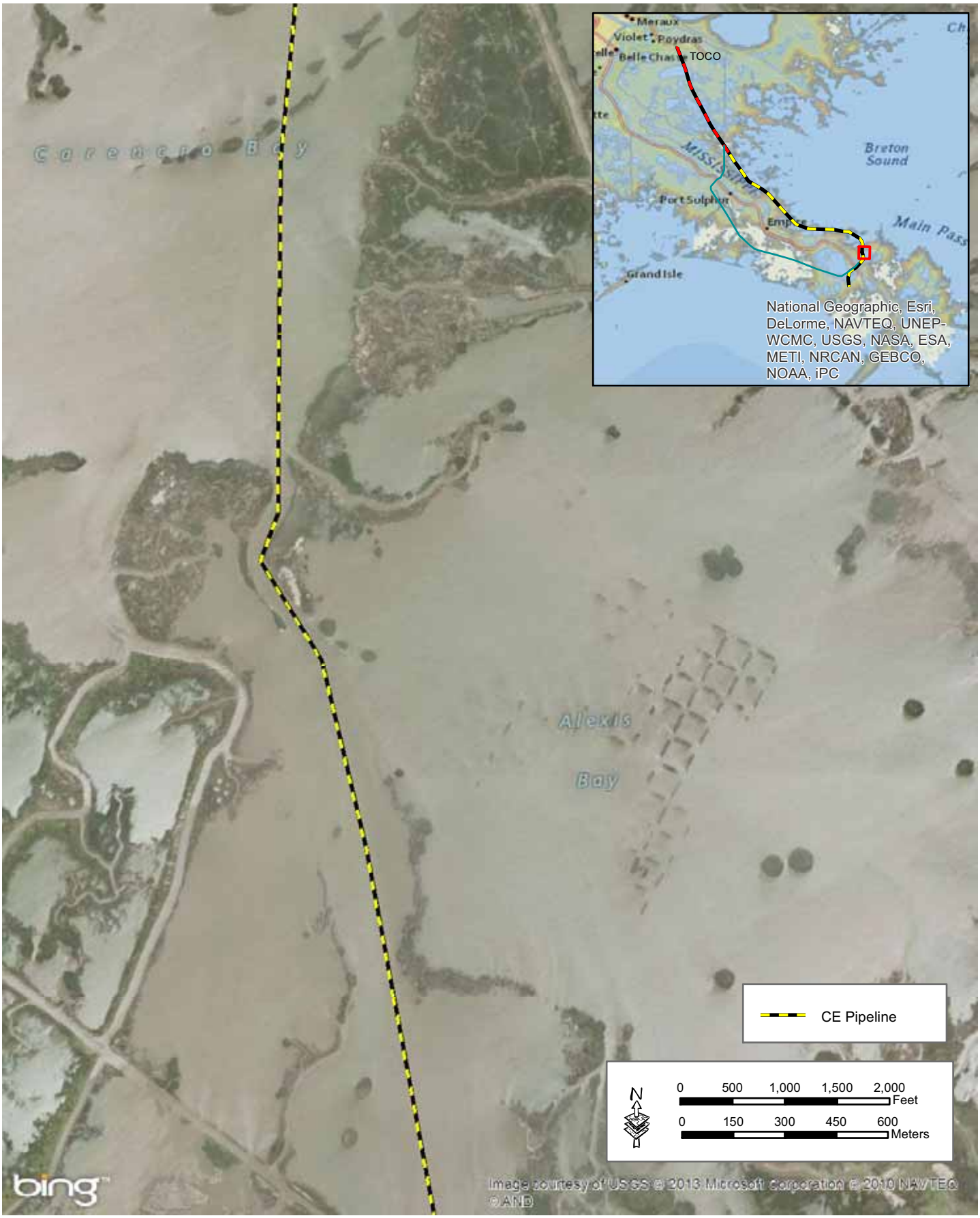

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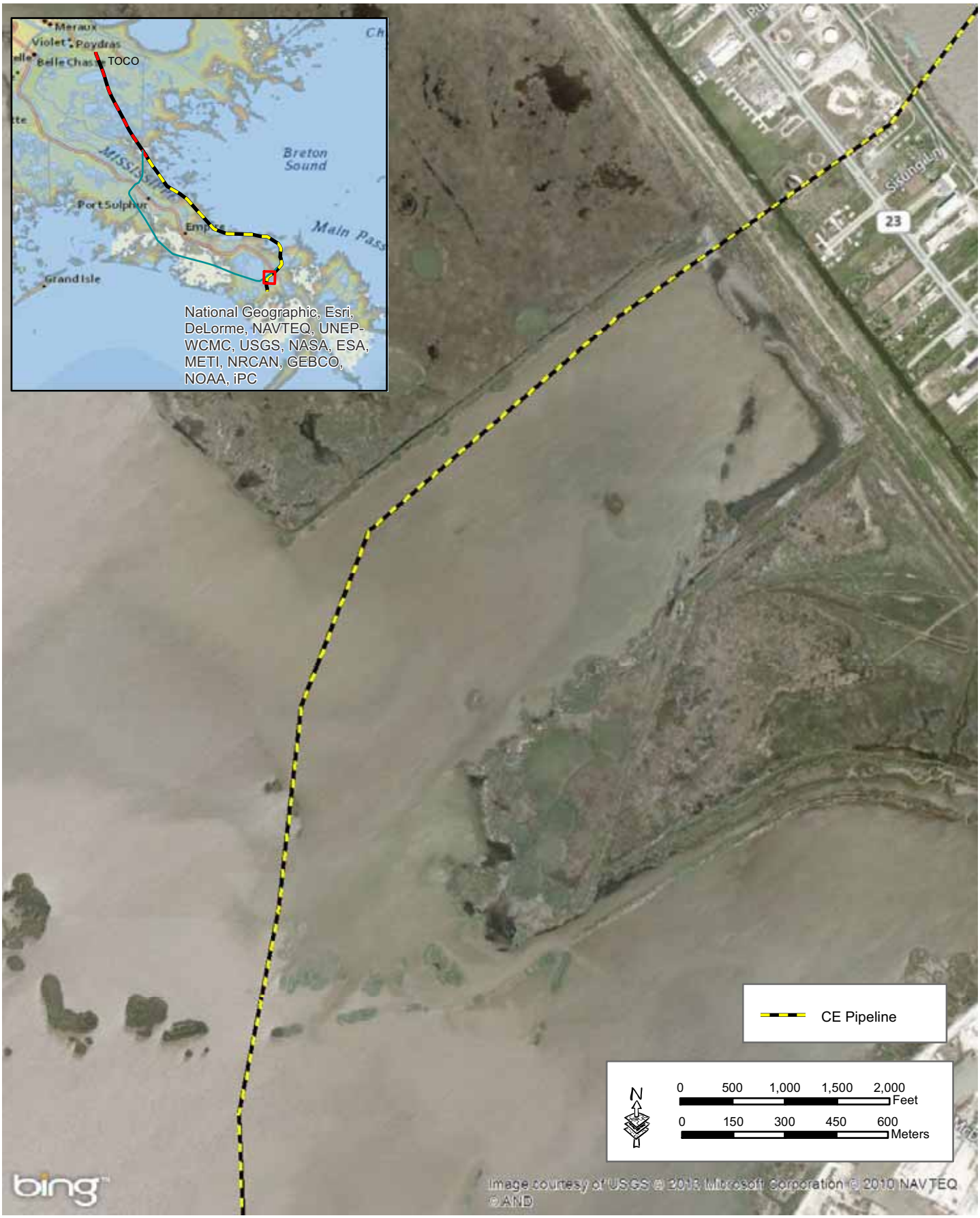

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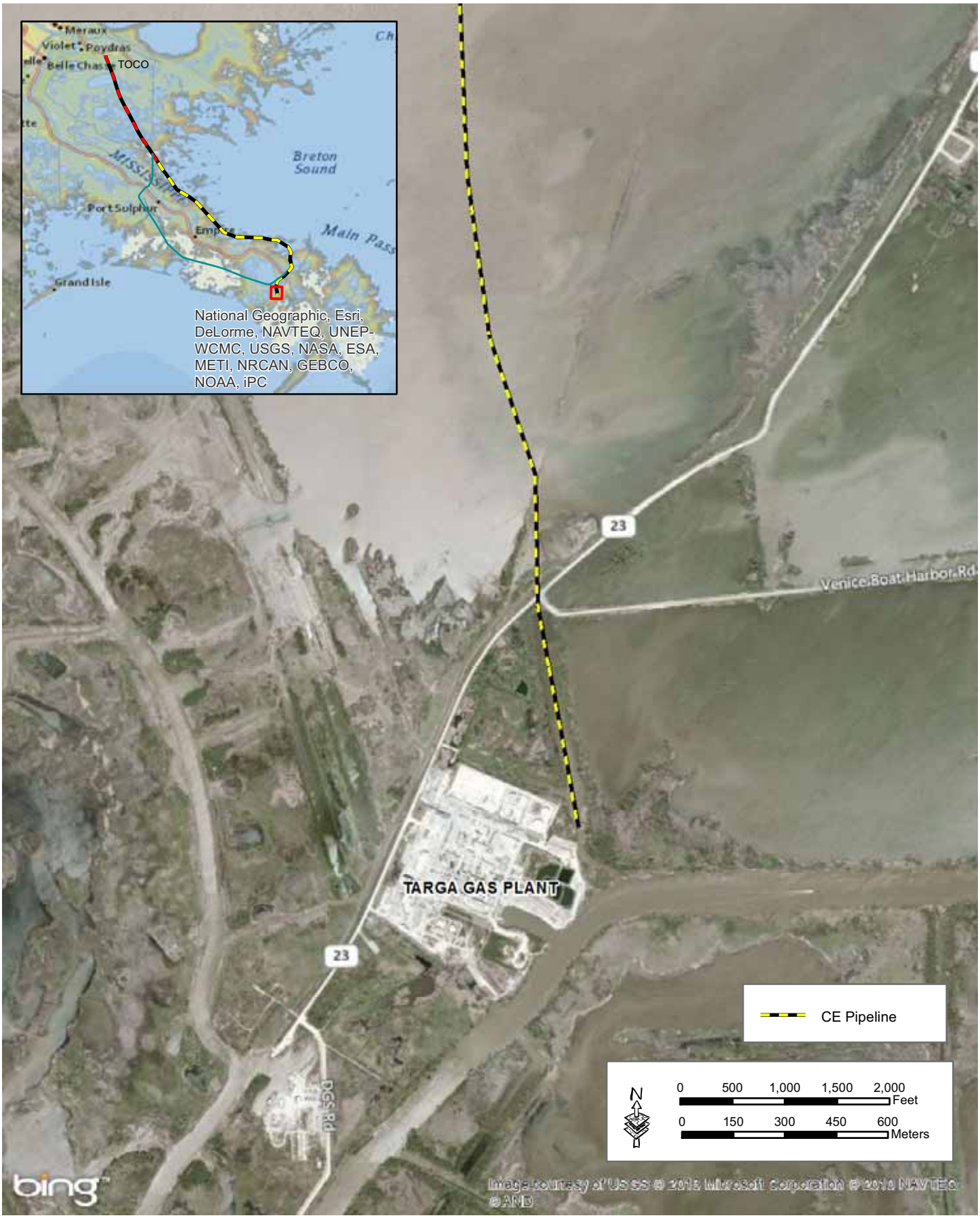

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Index Map for Western Pipeline Route

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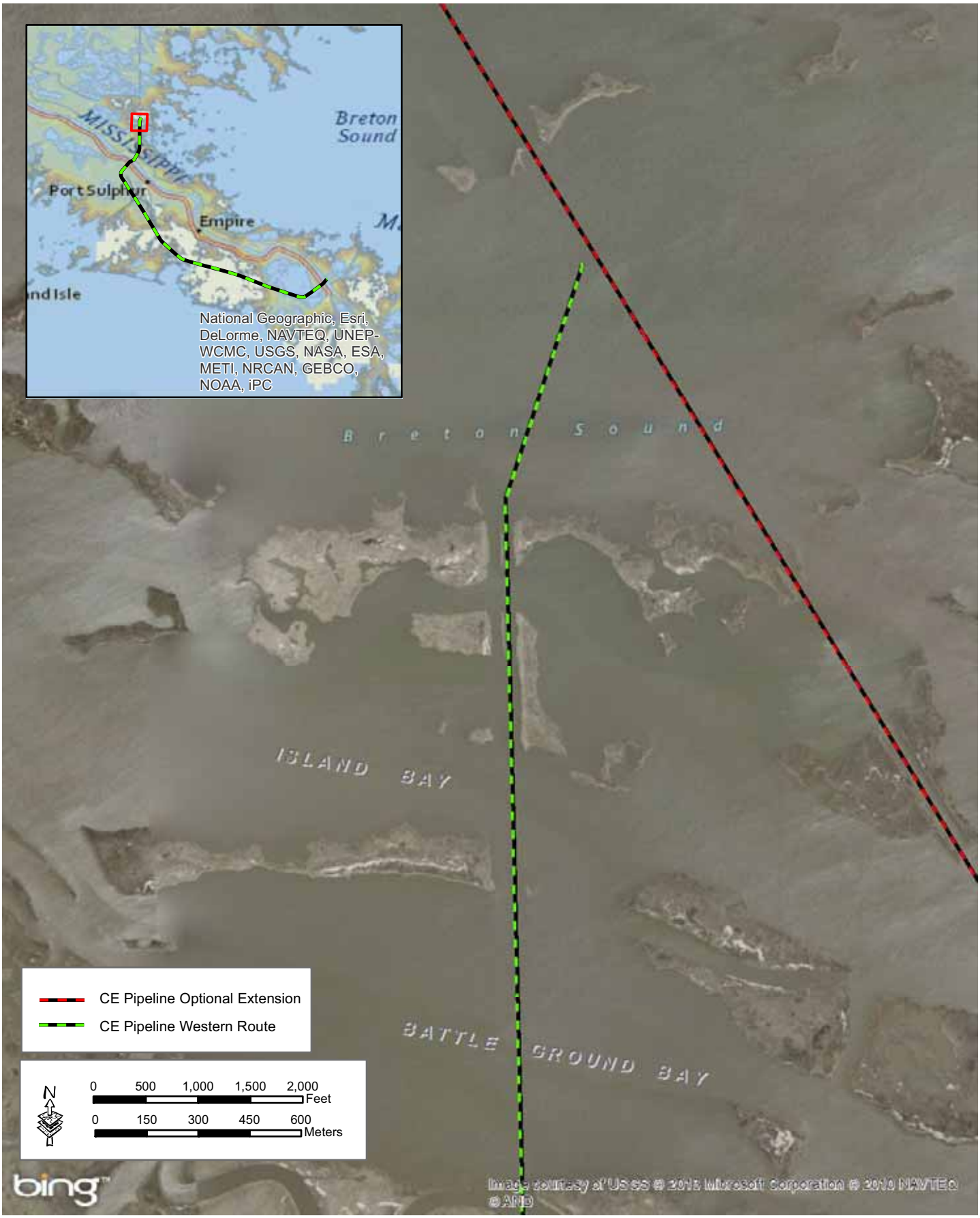

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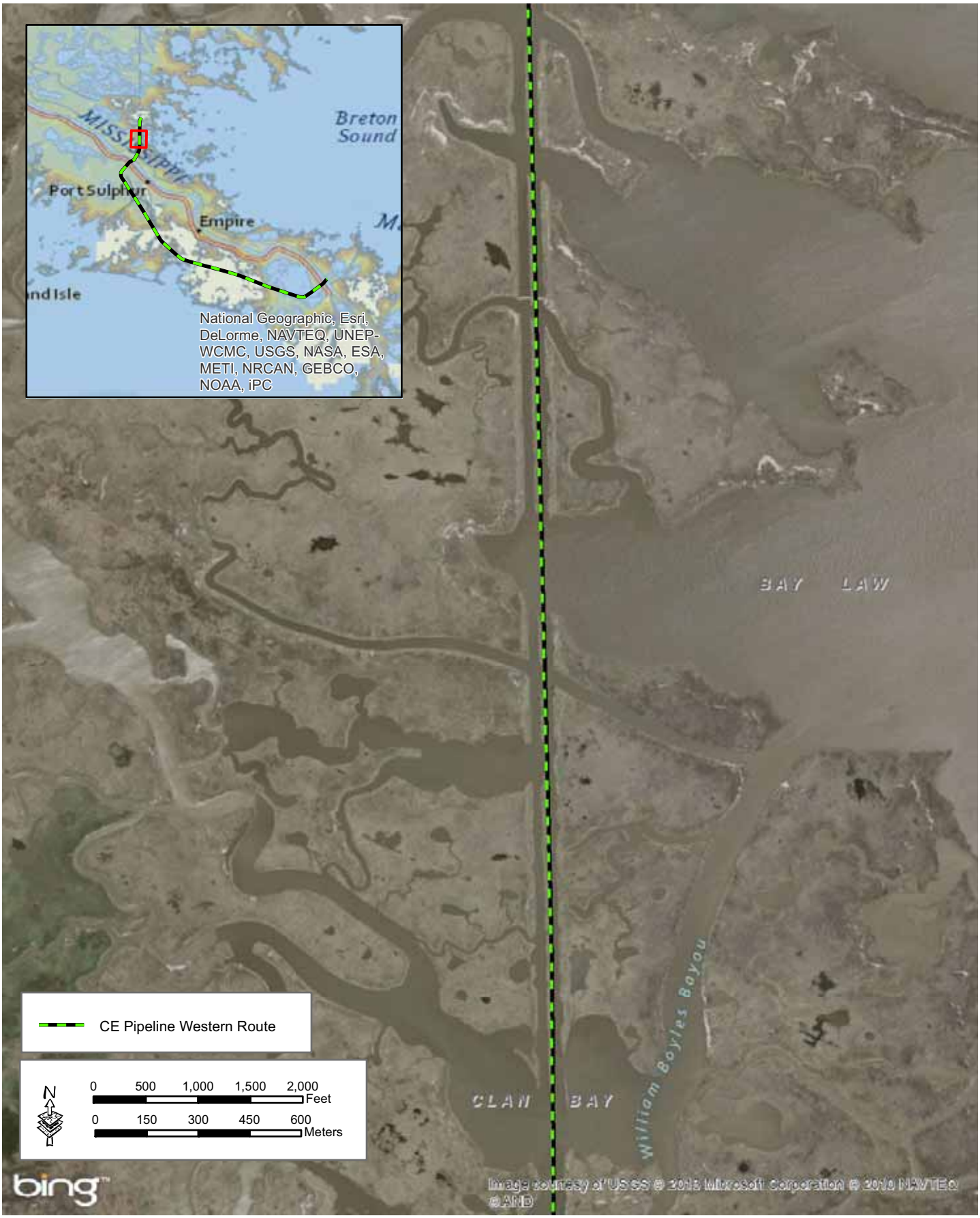

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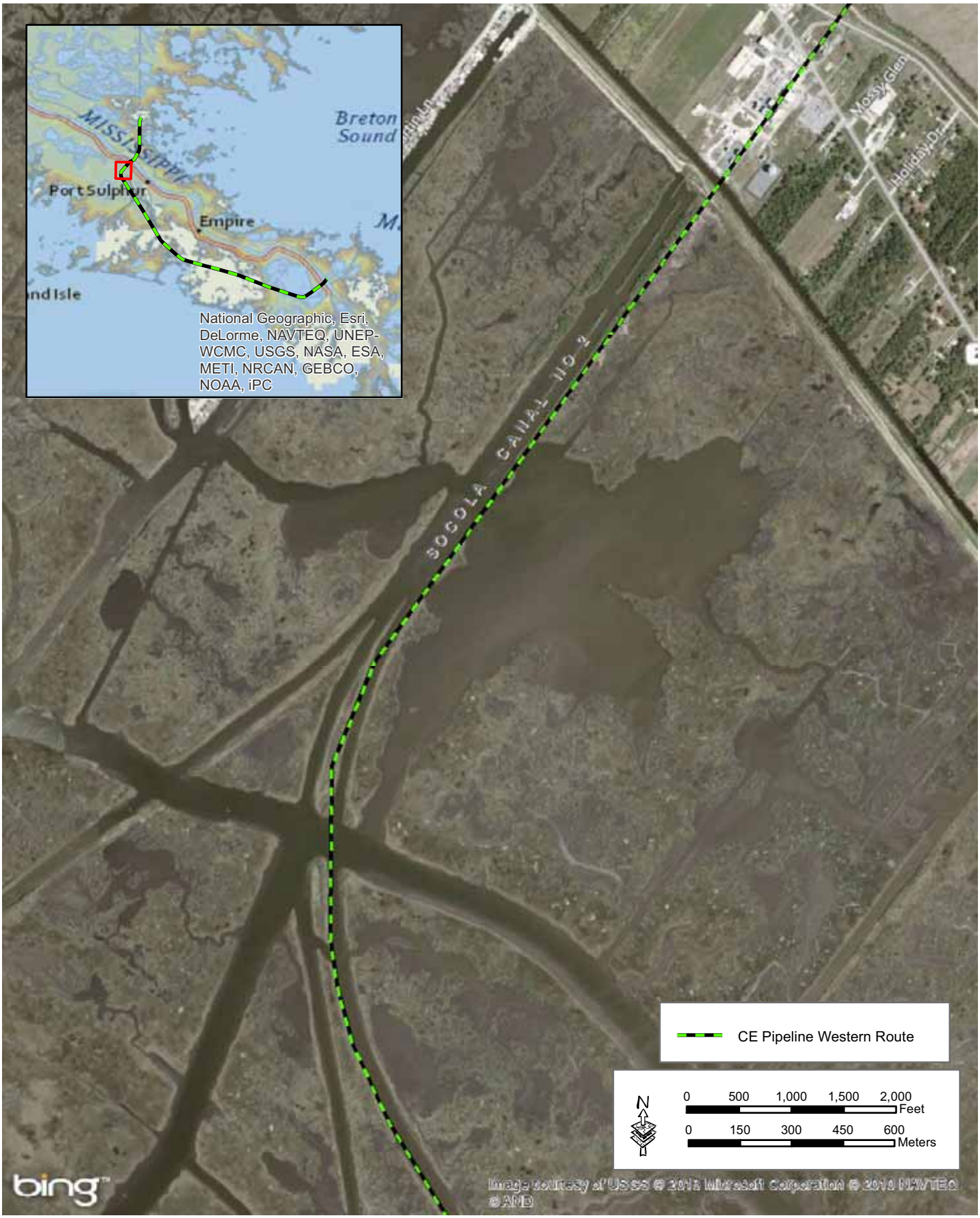

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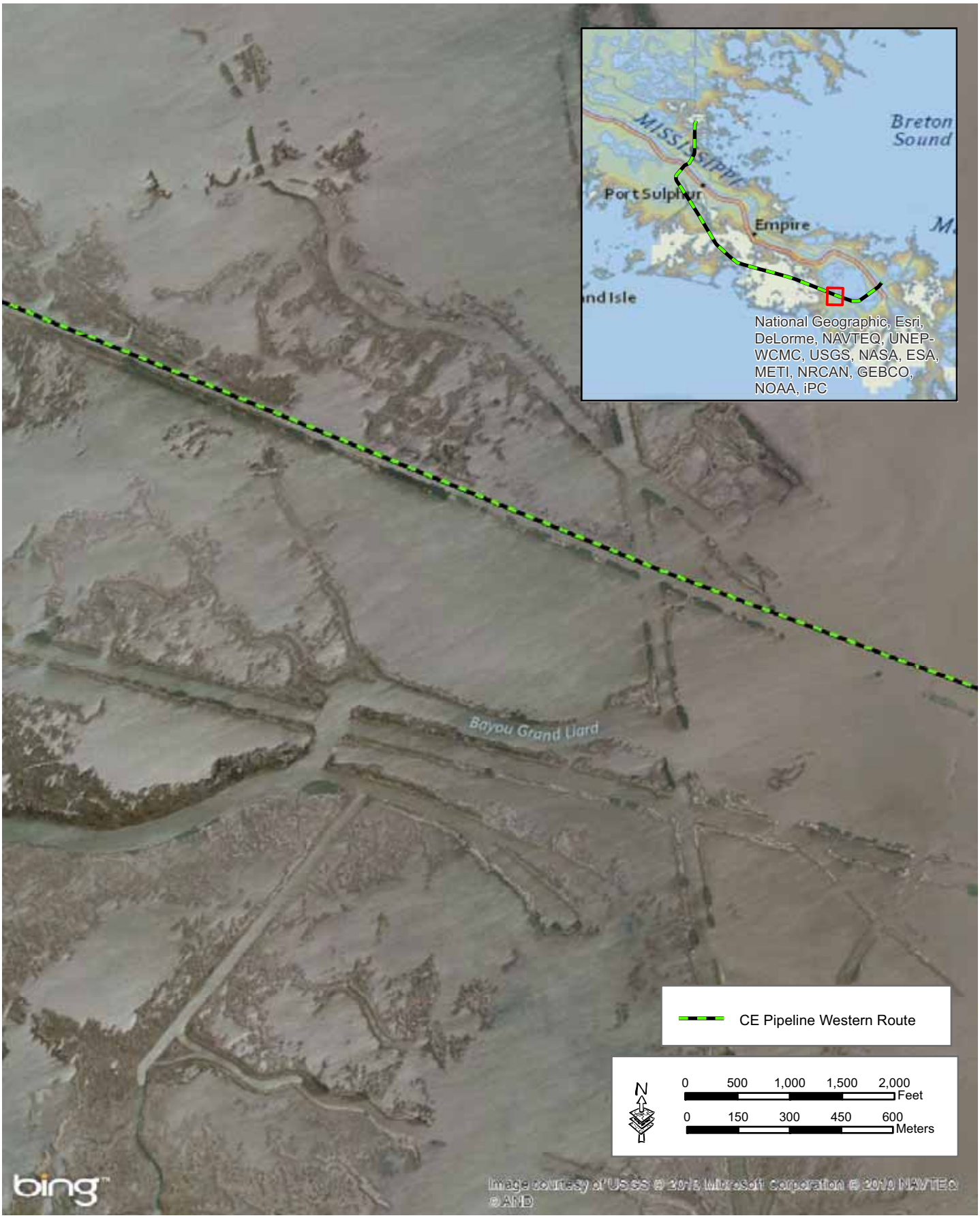

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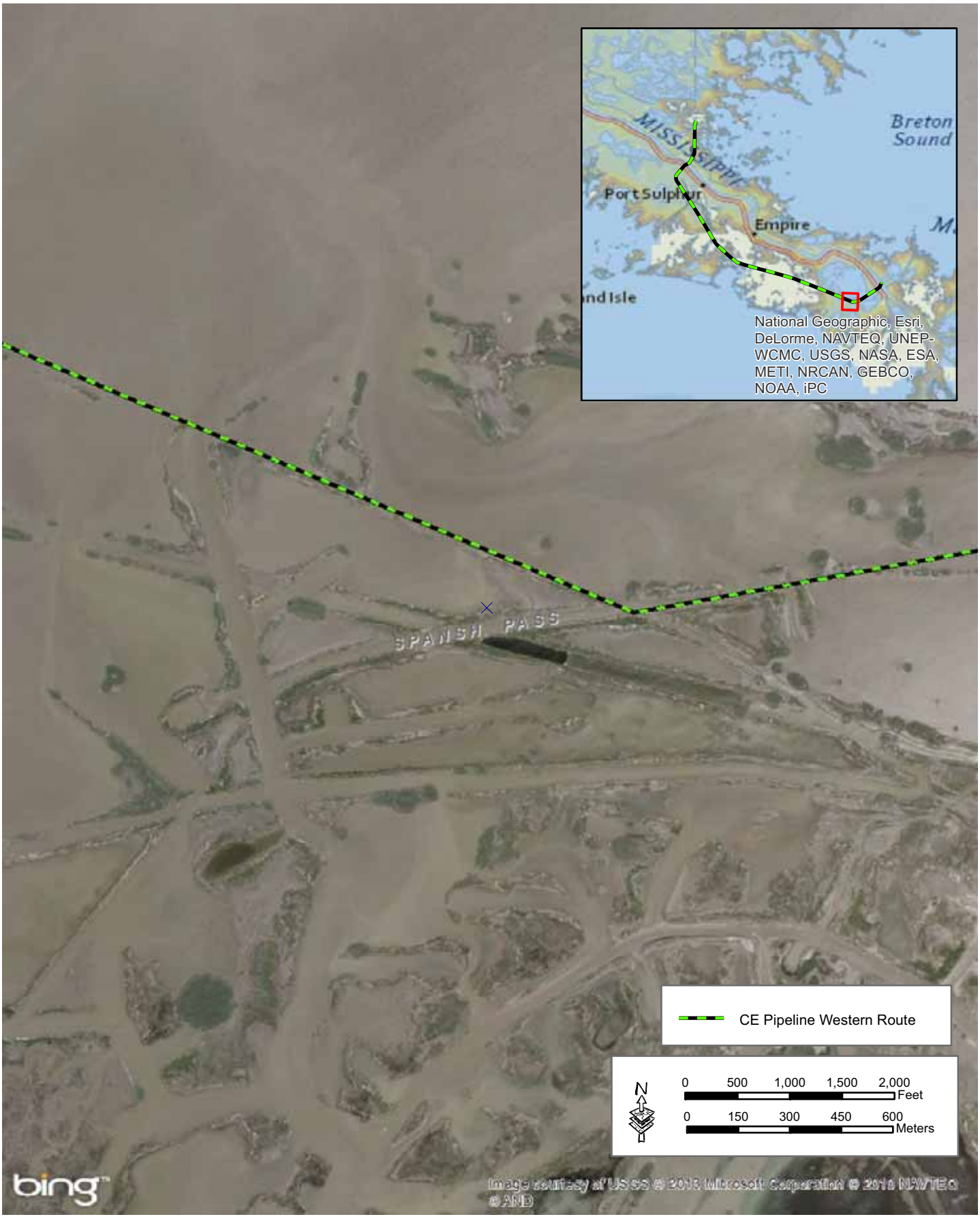

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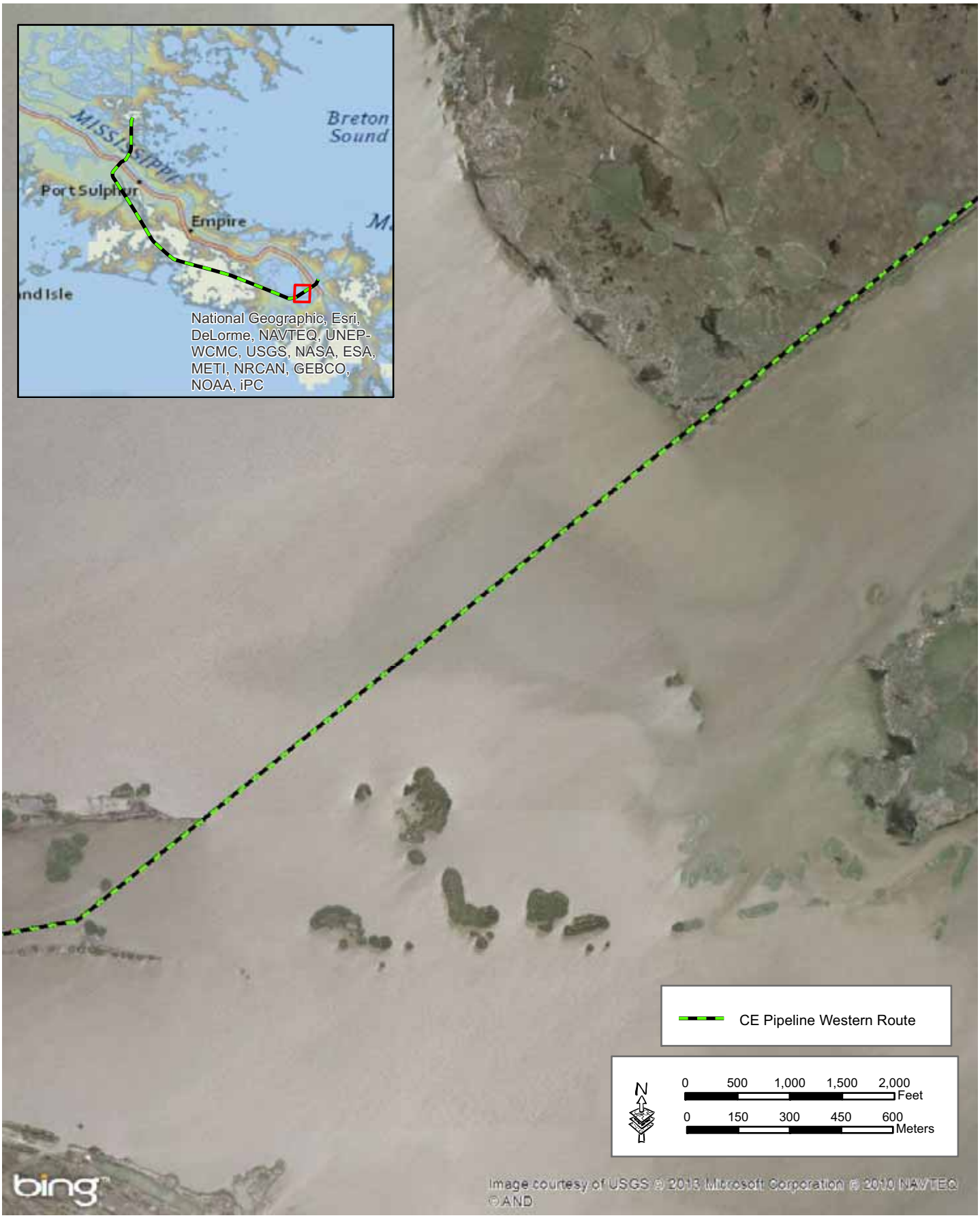

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