Appendix A
Air Quality

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Appendix A
Air Quality

A.1 SITE PREPARATION AND CONSTRUCTION

Air emissions will result from the construction at new SPR sites, the expansion of existing SPR sites, the construction of pipelines in pipeline rights-of-way (ROWs), and the construction of other associated facilities. Air emissions will also result from the operation and maintenance of the SPR sites. The greatest potential for air quality impacts is associated with construction when emission of fugitive particulate matter (PM) results from large-scale cut-and-fill operations. Other potential impacts resulting from air emissions are related to evaporative non-methane hydrocarbon (NMHC) emissions from the brine ponds associated with cavern development and filling. In addition, construction equipment is generally powered by onsite internal combustion engines, which emit additional air pollutants, including nitrogen oxides (NOx), PM, carbon monoxide (CO), and NMHC. Emissions during the site preparation and construction phases are best described in four areas: emissions from off-road equipment used by the work crews, emissions from on-road utility trucks used by the work crews, fugitive dust from construction activity at new buildings, and NMHC emitted during cavern development and filling. This appendix describes how emission estimates in these four areas were developed for this assessment.

In addition to the criteria air pollutants, the construction and operation of the SPR will generate greenhouse gas emissions. Details appear at the end of this appendix on how such emissions were determined for the analysis.

A.2 OFF-ROAD EQUIPMENT EMISSIONS

The NONROAD model (EPA 2002) is the EPA standard method for preparing emissions inventories for mobile sources that are not classified as being related to on-road traffic, railroads, air traffic, or water-going vessels. As such, it is the starting place for quantifying emissions from construction-related equipment. The NONROAD model uses the following general equation to estimate emissions separately for CO, NOx, PM (essentially all of which is PM2.5 from construction sources), and total hydrocarbons (THC), nearly all of which are NMHC[1]:

$$EMS = EF * HP * LF * Act * DF$$

Where:

EMS = estimated emissions
EF = emissions factor in grams per horsepower hours
HP = peak horsepower
LF = load factor (assumed percentage of peak horsepower)
Act = activity in hours of operation per period of operation
DF = deterioration factor

The emissions factor is specific to the equipment type, engine size, and technology type. The technology type for diesel equipment can be “base” (before 1988), “tier 0” (1988 to 1999), or “tier 1” (2000 to 2005). Tier 2 emissions factors could be applied to equipment that satisfies 2006 national standards (or slightly earlier California standards). The technology type for two-stroke gasoline equipment can be “base” (before 1997), “phase 1” (1997 to 2001), or “phase 2” (2002 to 2007). Equipment for phases 1 and 2 can

[1] A factor of 0.991 was used for 2-stroke and 0.984 was used for diesel to convert from THC to NMHC.

have catalytic converters. For this study, all diesel equipment was assumed to be tier 1 and all two-stroke diesel equipment was assumed to be phase 2 without catalytic converters.

The load factor is specific to the equipment type in the NONROAD model regardless of engine size or technology type, and it represents the average fraction of peak horsepower at which the engine is assumed to operate. NONROAD model default values were used in all cases. The deterioration factor was used to estimate increased emissions due to engine age. Conservatively, all equipment was assumed to be fully aged, which can represent different numbers of hours of operation for different equipment types, and the maximum deterioration factor was used.

Using this methodology, it is possible to make a conservative estimate of emissions from off-road equipment if the types of equipment and durations of use are known (see section A.5).

A.3 ON-ROAD UTILITY TRUCKS

Each work crew was assumed to have one truck for every four people. Emissions were estimated assuming that each crew had a gasoline-fueled truck similar to a Ford F-150 Supercab meeting tier 1 emission standards with at least 50,000 miles (80,000 kilometers) of use (between 5 and 10 years old). Such a truck fits into the heavy light-duty truck classification in the heaviest weight category. Table A.3-1 gives the emissions standards for such a truck. Each truck was assumed to be in use for a full 8-hour day traveling a total of 40 miles (64 kilometers) during this period.

Table A.3-1: Emissions from a Single, Fully-Aged (50,000 miles) Crew Truck

	THC	NMHC	CO	NOx	PM
Grams/mile	0.8	0.56	7.3	1.53	0.12
Grams/day	32	22.4	292	61.2	4.8

Source: EPA MOBILE6 Model (EPA, 2003)

A.4 FUGITIVE DUST

Emission rates for fugitive dust were estimated using guidelines outlined in the Western Regional Air Partnership (WRAP) fugitive dust handbook (WRAP 2004). Although these guidelines were developed for use in western states, they assume standard dust mitigation best practices activities of 50% from wetting; therefore, they were deemed applicable but conservative for the Gulf Coast. The WRAP handbook offers several options for selecting factors for PM10 (coarse PM) depending on what information is known. Table A.4-1 shows the possible emission factors and basis for choosing them. However, in addition all roads and earth movement activities are subject to some natural mitigation because of rainfall and other precipitation. To estimate the additional factor for natural mitigation EPA's AP-42 (EPA 2003a) suggests that the PM10 emission factor is multiplied by (365-D)/365, where D is the number of days per year with measurable[2] precipitation. In cities like Jackson, MS, the average value for D is 108 and the additional natural mitigation reduction is 30%. Thus, additional emission reduction through natural mitigation was included specifically for each facility location to account for the more moist Gulf Coast setting.

After PM10 is estimated, the fraction of fugitive dust emitted as PM2.5 is estimated, the most recent WRAP study (MRI 2005) recommends the use of a fractional factor of 0.10 to estimate the PM2.5 portion of the PM10.

[2] Daily precipitation of 0.01 inch or more.

For site preparation activities, only the areas of disturbance and approximate durations were known; therefore, the first factor with average conditions was used in the analysis. After completion of soil stabilization and compaction analysis, fugitive dust emissions were estimated for activities involving major earth moving (road building and pipeline construction). In the case of pipeline construction, the second set of factors was used on a per-month basis. The work area was calculated using the easement width multiplied by the length of pipeline laid in a month. The volume of onsite cut-and-fill was calculated assuming a trench 10 feet (3 meters) wide by 5 feet (1.5 meters) deep multiplied by the length of pipeline laid in a month. The volume of earth hauled offsite was assumed to be zero because all earth would be used to refill the trench and cover the pipeline. A pipeline crew with two backhoes was assumed to be capable of digging about 30,000 cubic yards (23,000 cubic meters) of earth per month, and then of refilling the trench after pipe was laid. At this rate, a single crew could be expected to prepare 3 miles (4.8 kilometers) of pipeline trench per month.

Table A.4-1: PM10 Emissions Factors Recommended by the WRAP Handbook

Basis for Emission Factor	Recommended PM10 Emission Factor
Only area and duration known	0.11 ton/acre/month (average conditions) or 0.22 ton/acre/month (average, no mitigation) or 0.43 ton/acre/month (worst-case conditions)
Volume of earth moved known	0.011 ton/acre/month for general construction plus 0.059 ton/1000 yard^3 for onsite cut-fill plus 0.22 ton/1000 yard^3 for offsite cut-fill
Equipment usage known	0.13 pounds/acre/work-hour for general construction plus 49 pounds/scraper-hour for onsite haulage plus 94 pounds/hour for offsite haulage

Source: WRAP, 2004

1 ton/acre = 0.5999 kilograms/meter^2
1 ton/1000 yard^3 = 1.1865 metric tons/1000 meter^3
1 pound/acre = 112 kilograms/kilometers^2
1 pound = 0.45359 kilograms

A.5 SITE DEVELOPMENT

Site preparation can be divided into four sequential phases: clearing and grubbing, rough grading, soil (lime) stabilization, and embankment placement and compaction. Likely equipment needs for these activities are listed in Table A.5-1. All of these activities will be necessary to develop new sites (DOE 1992a, 2-18) and clearing and grubbing activities will be necessary for the entire facility to enable operational surveillance. Existing sites will need elements from each of these activities depending upon existing conditions. Additionally, sites such as Bayou Choctaw, Chacahoula, and Clovelly will only require clearing as they are located in wetlands, but will require other activity phases associated with walkway construction. Results for each of these activities for each facility are given in the body of the report.

Table A.5-1: Typical Equipment Used for Site Preparation at a New SPR Site

Phase	Equipment	Type	HP	Number	% Use
Clearing and grubbing	Chain saw	2-stroke	5	26	50
	Brush cutter	2-stroke	5	26	50
	Chipper	2-stroke	10	4	50
	Backhoe	Diesel	100	8	25
Rough grading	Dozer	Diesel	300	2	100
	Scraper	Diesel	200	2	100
Soil stabilization	Dozer	Diesel	150	4	100
	Grader	Diesel	150	4	100
Embankment compaction	Scraper	Diesel	200	2	100
	Plate compactor	Diesel	5	12	100

HP = Horsepower
% use = the average fraction of time that the equipment is operating during a work day
Source: Clovelly and Chacahoula Cost Estimate (DOE, 2004c; DOE 2004e)

Facility construction consists of five phases: foundation pouring, building construction, electrical installation, pipe installation, and road construction. These phases can overlap somewhat. Of these activities, only road construction is expected to result in significant fugitive particulate emissions while they all will produce fuel combustion related emissions. Some of these activities will be unnecessary or relatively brief for expansion sites depending upon existing infrastructure, but all will be necessary at new sites. The equipment that may be used in each phase of facility construction is given in Table A.5-2. Results for each of these activities for each facility are given in the body of the report.

Table A.5-2: Equipment Used for Proposed New SPR Facility Construction

Phase	Equipment	Type	HP	Number	% Use
Foundation pouring	Cement mixer	Diesel	350	2	100
	Roller compactor	Diesel	100	4	50
	Spreader	Diesel	100	4	50
Building construction	50 ton crane	Diesel	170	1	50
	Welder	Diesel	50	12	100
Electrical installation	50 ton crane	Diesel	170	1	25
	12 ton crane	Diesel	40	1	25
	Bucket truck	Diesel	200	1	100
Pipe installation	Excavator	Diesel	240	1	100
Road construction	Dozer	Diesel	200	1	100
	Spreader	Diesel	100	1	100
	Steel roller	Diesel	100	1	30
	Wheel roller	Diesel	100	1	30

HP = Horsepower
% use = the average fraction of time that the equipment is operating during a work day
Source: Clovelly and Chacahoula Cost Estimate (DOE, 2004c; DOE 2004e)

Cavern drilling will require using up to four 500 horsepower diesel-powered boring drills working 24 hours per day. All lead holes (initial holes for cavern development) are expected to be drilled during facility construction, even if solution mining for some of the caverns will begin at a later date.

New and existing SPR facilities may require extensive pipeline construction for both oil and brine transport. These pipes range in diameter from 16 to 48 inches (0.4 to 1.2 meters) and are assumed to be buried using a conventional land lay method whereby ditches are excavated with backhoes with the trench dug 5 feet (1.5 meters) deep and 10 feet (3.0 meters) across and then backfilled. This land lay method is conservative for air quality analysis as it requires the most construction equipment and activity, except at locations that are swampy or underwater. Because the majority of pipeline construction occurs offsite, pipeline construction can begin at the start of site preparation and can continue for up to three years, depending upon the site. Equipment likely to be used in pipeline construction is listed in Table A.5-3

Table A.5-3: Equipment Used by a Single Pipeline Construction Crew

Phase	Equipment	Type	HP	Number	% use
Pipeline Construction	Backhoe	Diesel	100	2	100
	12 Ton Mobile Crane	Diesel	40	1	30
	Grader	Diesel	150	1	30

HP = Horsepower
% use = the average fraction of time that the equipment is operating during a work day
Source: Clovelly and Chacahoula Cost Estimate (DOE, 2004c; DOE 2004e)

A.6 CAVERN DEVELOPMENT AND FILLING

During the cavern solution mining process, small amounts of hydrocarbons are present in the brine pumped out of the caverns and subsequently released into the atmosphere. If it is assumed that these hydrocarbons are completely volatilized to the atmosphere during the solution mining process, the following equation can be used to estimate atmospheric emissions of NMHC (DOE 1981, appendix C.2):

$$\text{NMHC Emissions} = \text{NMHC in Brine (parts per million} \times 10^{-6}) \times \text{Pumping Rate (barrels per day)} \times \text{(42 gallons per barrel)} \times \text{Brine Density (pounds per gallon)}$$

Using the assumption that the brine density as measured at the Bryan Mound caverns is fairly constant at the value of 10.0 pounds/gallon (1.2 kilograms/liter) and representative of all SPR caverns, table A.5-1 gives an example NMHC emission rate estimate for 10 cavern facilities each with 10-million barrel (MMB) storage capacity where all caverns are developed simultaneously.

For each new cavern development project, the values in this table were used to predict durations and annual emissions associated with these activities. Durations for solution mining and solution mining/fill activities were estimated by scaling with the peak brine-production rate and maximum added capacity for each site. Annual emissions for these two activities were scaled using only the peak brine-production rate. For the final fill, durations and emissions were scaled using the maximum added capacity only.

Table A.6-1: NMHC Emissions Associated with Cavern Development (100 MMB)

Activity	Duration	Brine Production	Brine NMHC Concentration	Short-Term Emissions (grams/second)	Annual Emissions (tons)
Solution Mining	638 days	1.0 MMBD	0.26 ppm	0.57	19.9
Solution Mining/Fill	539 days	1.0 MMBD	1.0 ppm[a]	2.25	78.2
Final Fill[b]	200 days	0.3 MMBD	2.6 ppm	1.72	32.8

Source: DOE, 1992b

[a] Based on average solubility during solution mining and fill (midpoint) starting from zero based on current cavern development approach; for endpoint used measured data from appendix C.2 (table C.2-1) (DOE, 1981), four of the five measurements >90% full (end of process) and vapor partial fraction of 0.85.
[b] The original tables (table 7.1-1, pg 7-18) in DOE (1992b) reported emission rates of 1.15 g/s and 21.9 ton per year for final fill, but these were found to be in error, and corrected values are shown in this table.

ppm = parts per million
MMBD = million barrels per day

A.7 GREENHOUSE GAS EMISSIONS CALCULATIONS

The most important greenhouse gases (GHG) that result from activities at the SPR expansion are carbon dioxide (CO_2) and methane (CH_4). The most significant source of GHG emissions are CO_2 emissions associated with combustion sources and CH_4 during cavern solution mining. All combustion engines, including gasoline and diesel, emit large quantities of CO_2. Emissions of nitrous oxide (N_2O) and CH_4 from gasoline and diesel engines are much smaller, and therefore, only CO_2 was considered from combustion sources. Solution mining of salt from cavern development emits trapped CH_4 in addition to the other NMHC discussed in section 3.4. The brine pumped from the caverns also contains some CO_2; however, because CO_2 is soluble in water and the concentrations of CO_2 in the brine are well below equilibrium concentrations found in sea water, the CO_2 will remain in the sea water. Thus, this analysis considers only the CH_4 emissions from cavern solution mining.

Emissions of CO_2 from both spark-ignition and compression-ignition off-road construction equipment was estimated based on assumed fuel consumption rates. EPA's NONROAD model provides a fleet-average fuel consumption rate for diesel as well as two-stroke and four-stroke spark-ignition engines based on technology level and engine size (EPA 2004a, all; EPA 2004b, all). Given these data, the following equation was used to calculate CO_2 emissions:

$$CO_2 = (BSFC*453.6 - HC)*0.87*(44/12)$$

Where:

> *CO_2* is the CO_2 emission rate for off-road equipment in grams per horsepower hour;
>
> *BSFC* is the in-use brake-specific adjusted-fleet-average fuel consumption in pounds per horsepower hour;
>
> *453.6* is the conversion from pounds (mass) to grams;
>
> *HC* is hydrocarbon emissions in grams per horsepower hour;
>
> *0.87* is the carbon mass fraction of fossil fuels; and
>
> *44/12* is the ratio of CO_2 mass-to-carbon mass.

Emission from motor vehicles can be determined in an analogous manner to those from off-road equipment using an assumed fuel consumption rate for gasoline. The CO_2 vehicle emission rate for commuter vehicles can be determined by the following equation:

$$CO_2V = (FUELD*453.6/FE-THC) *0.87*(44/12)$$

Where:

CO_2V is the CO_2 vehicle emission rate in grams per mile;

FUELD is the fuel density of 6.1 pounds per gallon (0.73 kilograms per liter) of gasoline;

FE is the fuel economy of 21 miles per gallon (8.9 kilometers per liter);

THC is the total hydrocarbon emission in grams per mile (from MOBILE6.2);

0.87 is the carbon mass fraction of fossil fuels; and

44/12 is the ratio of CO_2 mass-to-carbon mass.

Total emissions of CO_2 were then calculated based on miles traveled determined from mean driving distance. Local population centers within 50 miles (80 kilometers) of each proposed site were assumed to contribute a share of the workforce proportional to their populations, yielding a population-weighted average commute distance. Conservatively, each worker was assumed to make 250 round trips per year (50 weeks, 5 days per week, no carpooling). Then, using employment information on the total number of workers for each facility, a total CO_2 emission rate was estimated for each facility.

Solution mining of the salt domes causes emissions of CH_4 to be pumped out with the concentrated brine. A methodology based on several cavern development studies prepared for the 1981 Environmental Impact Statement (DOE 1981), similar to that previously used to determine NMHC emissions, was used to estimate CH_4 emission rates. Equilibrium brine concentrations of CH_4 were calculated based on measurements taken at different stages of cavern development. The vapor partition factor (the ratio of solution escaping to the atmosphere over total solution dissolved from the cavern along with the brine) was assumed to be the same as NMHC as most NMHC emissions were light hydrocarbons (C2–C5 paraffins) (ethane through n-pentane). Throughout all phases emissions were calculated based on the brine removal rate, the concentration of CH_4 in brine, and the vapor partition factor.

Emissions during the initial solution mining were computed from the data of seven Bryan Mound samples studied in 1981 during early stages of cavern and roof development. During the solution mining/fill phase, it was assumed that the concentration of CH_4 in brine varied linearly between the late stages of cavern roof development and the maximum equilibrium concentration in brine. During the final fill, CH_4 was assumed to be at the maximum equilibrium (DOE 1981 p. C.2-9 – C.2-18).

REFERENCES

Midwest Research Institute (MRI). 2005 “Analysis of the Fine Fraction of Particulate Matter in Fugitive Dust” conducted for the Western Governors Association Western Regional Air Partnership (WRAP), MRI Project No. 110397, October, 2005.

United States Department of Energy (DOE). 1981. "Final Supplement to Final Environmental Impact Statements. Strategic Petroleum Reserve: Phase III Development Texoma and Seaway Group Salt Domes (West Hackberry and Bryan Mound Expansion, Big Hill Development): Cameron Parish, Louisiana and Brazoria and Jefferson Counties, Texas." (DOE/EIS-0021,0029).

United States Department of Energy (DOE). 1992. "Draft Environmental Impact Statement on the Expansion of the Strategic Petroleum Reserve, Alabama, Louisiana, Mississippi, Texas." (DOE/EIS-0165-D). Washington, DC.

United States Environmental Protection Agency (EPA). 2002. "User's Guide for the EPA Emissions Model Draft NONRoad 2002." (EPA-454/B-95-003a).

United States Environmental Protection Agency (EPA). August 2003. "User's Guide to MOBILE6.1 and MOBILE6.2: Mobile Source Emission Factor Model." (EPA420-R-03-010).

United States Environmental Protection Agency (EPA). 2004a. "Exhaust and Crankcase Emission Factors for Nonroad Engine Modeling – Compression Ignition." (EPA420-P-04-009).

United States Environmental Protection Agency (EPA). 2004b. "Exhaust Emission Factors for Nonroad Engine Modeling – Spark Ignition." (EPA420-P-04-010).

Western Regional Air Partnership (WRAP). 2004. "WRAP Fugitive Dust Handbook." Woodland Hills, CA.

Appendix B
Floodplains and Wetlands Assessment

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Appendix B
Floodplains and Wetlands Assessment

B.1 I NTRODUCTION

The Department of Energy's (DOE) proposed action is to develop one or two new strategic petroleum reserve (SPR) sites and to expand petroleum storage capacity at two or three existing SPR sites in accordance with section 303 of the Energy Policy Act (EPACT). Under the proposed action, DOE would develop one new site at either Clovelly or Chacahoula in Louisiana; Richton or Bruinsburg in Mississippi; Stratton Ridge in Texas; or a combination of both Clovelly and Bruinsburg. In addition to developing a new site or a combination of two new sites, DOE would expand two or three of the existing SPR sites at West Hackberry and Bayou Choctaw in Louisiana and Big Hill in Texas. For a more detailed discussion of the proposed action and candidate alternatives, see chapter 2 of the Draft Environmental Impact Statement (EIS).

DOE has prepared this floodplain and wetlands assessment in compliance with DOE requirements as codified in 10 CFR Part 1022. Executive Order (E.O.) 11988—Floodplain Management (May 24, 1977; 10 CFR Part 1022[1])—requires Federal agencies to ensure that the potential effects of any action that may be taken in a floodplain are evaluated and that agency planning programs and budget requests reflect consideration of flood hazards and floodplain management. The E.O. further requires Federal agencies to "consider alternatives to avoid adverse effects and incompatible development in the floodplain." If no "practicable alternative" exists to locating a project in a floodplain, an agency must "design or modify its action in order to minimize potential harm to or within the floodplain..." Similarly, E.O. 11990 (May 24, 1977) requires Federal agencies to avoid construction in wetlands unless "there is no practicable alternative" and "all practicable measures to minimize harm" are included. Thus, both Executive Orders require that the Federal agency proposing an action go through a process of selection that compares the proposed action's potential impact on floodplains and wetlands to other practicable alternatives that may exist. It is important to note that the term "floodplain action" "…means any DOE action that takes place in a floodplain, including any DOE action in a wetland that is also within the floodplain…" (DOE 2003). Conversely, "wetland action means any DOE action related to new construction that takes place in a wetland not located in a floodplain…"

This Draft EIS considers impacts at eight sites—five sites where new facilities would be developed and three sites where existing capacity would be expanded.

B.2 DEFINITIONS

In 10 CFR 1022.4, a floodplain is defined as "lowlands adjoining inland or coastal waters…and relatively flat areas and floodprone areas of offshore islands." The "base floodplain" means "the 100-year floodplain, that is, a floodplain with a 1.0 percent chance of flooding in any given year." The "critical action floodplain" means, "at a minimum, the 500-year, that is, a floodplain with a 0.2 percent chance of flooding in any given year." A "critical action" means a "DOE action for which even a slight chance of flooding would be too great. Such actions may include, but are not limited to, the storage of highly volatile, toxic, or water reactive materials." Because petroleum, lubricants, and hazardous materials would be used during the construction phase of this proposed project, both the base floodplain and the critical action floodplain are considered in this assessment.

[1] See http://www.eh.doe.gov/nepa/

Natural and beneficial floodplain values to be protected include moderation of floods, groundwater recharge, water quality maintenance, support of biological resources (marshes, fish, and wildlife), cultural richness (archeological, historical, recreational, and scientific), and agricultural and forestry production.

A wetland is defined in 10 CFR 1022.4 as "an area that is inundated or saturated by surface water or ground water at a frequency and duration sufficient to support, and that under normal circumstances does support, a prevalence of vegetation typically adapted to life in saturated soil conditions, including swamps, marshes, bogs, and other similar areas." Wetlands serve a variety of functions in an ecosystem, such as water quality preservation, flood protection, erosion control, biological productivity, and wildlife habitat, including nesting, spawning, and rearing sites for many sensitive and other species. The primary functions and values of wetlands are summarized below:

- **Water Quality.** Wetlands help maintain and improve the water quality of rivers, lakes, and estuaries. Because wetlands are located between uplands and water resources, many wetlands can intercept runoff from the land before it reaches open water. Wetlands remove or transform pollutants through physical, chemical, and biological processes associated with stormwater runoff.

- **Flood Protection.** Wetlands help protect adjacent and downstream properties from potential flood damage by receiving and temporarily storing water during periods of high runoff or high flows in adjacent streams. Wetlands within and upstream of urban areas are particularly valuable for flood protection because the impervious surface in urban areas greatly increases the rate and volume of runoff, thereby increasing the risk of flood damage on human safety, health, and welfare. In addition, wetlands provide protection from ocean wave and tidal surges associated with strong storms and hurricanes.

- **Erosion Control.** Riparian wetlands, salt marshes, and marshes located at the margin of oceans, lakes, and rivers protect shorelines and streambanks against erosion. Wetland plants hold the soil in place with their roots, absorb wave energy, and reduce the velocity of stream or river currents.

- **Biological Productivity.** The dynamic nature of many wetlands produces a great diversity of habitat that, in turn, supports a great diversity of plant and animal species. Numerous species of microorganisms, plants, insects, amphibians, reptiles, birds, fish, and other wildlife depend in some way on wetlands for at least part of their life cycles. Wetland plants play an integral role in the ecology of the watershed by providing breeding and nursery sites, resting areas for migratory species, and refuge from predators.

- **Fish and Wildlife Habitat.** Diverse species of plants, insects, amphibians, reptiles, birds, fish, and mammals depend on wetlands for food, habitat, or temporary shelter. Many bird species use wetlands as a source of food, water, nesting material, or shelter. Migratory waterbirds rely on wetlands for staging areas, resting, feeding, breeding, or nesting grounds.

- **Cultural Value.** Wetlands often have diverse archaeological, historical, and cultural values. Societies have traditionally formed along bodies of water, and artifacts found in wetlands provide information about these societies.

- **Aesthetic Value.** Many people enjoy the scenic, pastoral, and aesthetically pleasing properties of wetlands. Historically, painters and writers have used wetlands as subject matter.

- **Economic Value.** More than half of all adults in the United States hunt, fish, birdwatch, or photograph wildlife in wetlands.

Floodplain and wetland protection is of particular concern in the Gulf Coast region because of recent hurricane activity and the resulting devastation caused by flooding.

B.3 METHODOLOGY

Several information sources were used in this assessment to identify the floodplains and wetlands in the project area and characterize the existing environmental conditions, including the U.S. Geological Survey (USGS) topographic maps, Federal Emergency Management Agency (FEMA) Flood Insurance Rate Maps, National Wetlands Inventory (NWI) data, aerial photographs, limited field investigations, and consultations with several state and Federal agencies.

Based on conceptual designs, DOE identified the wetland areas and floodplains within the proposed footprint of the development or expansion of storage sites and their associated infrastructure. These are wetlands and floodplains that could be temporarily disturbed or permanently removed by proposed construction activities. The areas examined for this analysis include all construction-related areas, including the proposed storage sites and associated facilities, such as terminals, raw water intake (RWI), brine injection well fields, pipeline and power line rights-of-way (ROWs), equipment laydown, staging areas, and access roads.

Wetlands were identified initially by NWI data. DOE performed a site walk-over for each proposed new storage site to verify and directly observe the wetland and floodplain conditions. DOE consulted with Federal and state agencies to identify unique or sensitive wetlands. Once DOE selects an alternative, other than the no-action alternative, DOE would conduct a field delineation of jurisdictional wetlands and waters of the United States as part of the Section 404/401 permit application of the Clean Water Act. DOE would conduct the delineation in accordance with the U.S. Army Corps of Engineers (USACE) 1987 Wetland Delineation Manual (USACE 1987) and would submit the wetland delineation to the appropriate USACE District (New Orleans, LA; Galveston, TX; Mobile, AL; and Vicksburg, MS) for review and jurisdictional determination.

For this assessment, DOE calculated the area of each wetland type and the 100-year and 500-year floodplain area that would be affected by construction activities and operations and maintenance after the proposed new or expansion storage site and associated infrastructure are built. For ROWs, DOE estimated the permanent and temporary wetland impacts by distinguishing between the permanent easement and the temporary construction easement. The type and nature of the impact to plant communities and wetlands would depend on whether the affected area is located within a permanently maintained easement (about 50 feet [13 meters] wide per pipeline) or within a temporary construction easement. Additional detail on the width and purpose of the permanently maintained easements and temporary construction easements is provided in section 2.3.9. Section 3.7.2.1.2 provides further information on how construction would be completed in the different types of wetlands.

Three types of wetland impacts were calculated for this assessment. First, the filling of wetlands for storage site or other associated facilities during construction would constitute a permanent removal of wetlands, which would destroy the functions and values of the wetland. Second, forested and scrub-shrub wetlands within the permanently maintained ROW easements and storage site security buffers would be permanently converted to emergent wetlands. This type of impact would destroy some wetland functions and values, but others such as flood attenuation, groundwater recharge, and erosion control would not be lost. The last category of wetland impact is the temporary impact to wetlands within the construction easement portion of the ROW and security buffer impacts to emergent wetlands. Preconstruction contours within the ROWs and security buffers would be re-established to restore hydrology and allow emergent wetlands to revegetate within the permanent and temporary construction easements within the ROW and the site security buffers. Forested and scrub-shrub wetlands would be allowed to revegetate within the temporary construction easements; however, re-establishment of the plant community would take at least 5 to 25 years depending on the type of community affected.

For floodplain impacts from the proposed ROWs, DOE calculated the total length of the impact in miles (kilometers) because there would be no permanent impact area. The area would be regraded and no aboveground structures would exist; therefore, floodplain storage capacity and floodplain benefits would not be permanently impacted.

The 100-year and 500-year floodplain impacts were evaluated. The placement of fill or construction of structures in a floodplain would potentially affect the flood storage capacity and destroy most of the benefits of floodplains.

Acreage calculations for the wetland and floodplain acreages were based primarily on NWI data and FEMA Flood Insurance Rate Maps. Wetland acreages for each proposed storage sites were modified based on DOE's site walk-over. Acreages presented in this assessment are estimates only as no formal wetland delineations of these areas have been conducted. For each site, DOE used the construction footprint and ROW for the pipelines, power lines, and access roads presented in chapter 2 to calculate the acreage of wetland types and floodplains associated with each proposed SPR alternative. Five hundred year floodplain areas are reported as the area outside the 100-year floodplain per the Flood Insurance Rate Maps. A 500-year flood event would flood both the 100-year and 500-year floodplain.

This process may have overestimated the impacts on wetlands and floodplains from the pipeline and power line corridors because specific construction measures that would be used to avoid wetlands were not addressed by this approach. For example, as described in section 2.3.9, DOE would use directional drilling for pipeline installation under larger streams and wetlands, which would avoid surface disturbance to the resources. In addition, many proposed ROWs would follow existing utility and road corridors and canals to minimize the impact to high quality, undisturbed wetlands. NWI data, used for the Geographic Information System (GIS) analysis, may have also overestimated wetlands in some areas and underestimated wetlands in other areas. The best NWI data available are over 20 years old for some regions. Wetlands accounted for in these regions may no longer exist or may have been misidentified. Alternatively, because NWI data are created from satellite images, some forested wetlands may have been misidentified as upland forests and therefore not accounted for in this analysis. These data, however, do provide a good general estimate and a basis for comparing the construction and operations and maintenance impacts associated with the proposed alternatives.

To summarize the major types of wetland systems, DOE consolidated the categories of the NWI data into the categories presented in table B.3-1 below.

Table B.3-1: Wetland Types and Description

Wetlands Type	Description
Palustrine – forested	Tidal and nontidal wetlands dominated by woody vegetation greater than or equal to 16 feet in height, and wetlands that occur in tidal areas in which salinity due to ocean-derived salts is below 5 parts per thousand. Total vegetation coverage is greater than 20 percent. This wetland category includes fresh-water swamps and bottomland hardwood forest.
Palustrine – scrub-shrub	Tidal and nontidal wetlands dominated by woody vegetation less than 16 feet in height, and wetlands that occur in tidal areas in which salinity due to ocean-derived salts is below 5 parts per thousand. Total vegetation coverage is greater than 20 percent. The species present could be true shrubs, young trees and shrubs, or trees that are small or stunted due to environmental conditions.

Table B.3-1: Wetland Types and Description

Wetlands Type	Description
Palustrine – emergent	Tidal and nontidal wetlands dominated by persistent emergent vascular plants, emergent mosses or lichens, and wetlands that occur in tidal areas in which salinity due to ocean-derived salts is below 5 parts per thousand. Plants generally remain standing until the next growing season. Total vegetation cover is greater than 80 percent. This category is also referred to as fresh-water marsh.
Estuarine – forested	Tidal wetlands dominated by woody vegetation greater than or equal to 16 feet in height, and wetlands that occur in tidal areas in which salinity due to ocean-derived salts is equal to or greater than 5 parts per thousand. Total vegetation coverage is greater than 20 percent.
Estuarine – scrub-shrub	Tidal wetlands dominated by woody vegetation less than 16 feet in height, and wetlands that occur in tidal areas in which salinity due to ocean-derived salts is equal to or greater than 5 parts per thousand. Total vegetation coverage is greater than 20 percent.
Estuarine – emergent	Tidal wetlands dominated by erect and rooted plants that can live in water, excluding mosses and lichens. Wetlands that occur in tidal areas where salinity due to ocean-derived salts is equal to or greater than 5 parts per thousand and that are present for most of the growing season in most years. Perennial plants usually dominate these wetlands. Total vegetation cover is greater than 80 percent. This wetland category includes saltwater marsh.
Palustrine – aquatic bed	Tidal and nontidal wetlands and deepwater habitats in which salinity due to ocean-derived salts is below 5 parts per thousand and that are dominated by plants that grow and form a continuous cover principally on or at the surface of the water. These include algal mats, detached floating mats, and rooted vascular plant assemblages. Total vegetation cover is greater than 80 percent.
Lacustrine	These include wetlands and deepwater habitats with all of the following characteristics: (1) situated in a topographic depression or a dammed river channel; (2) lacking trees, shrubs, persistent emergents, emergent mosses, or lichens with greater than 30 percent areal coverage; and (3) total area exceeds 20 acres.
Riverine	These include all wetlands and deepwater habitats contained in natural or artificial channels periodically or continuously containing flowing water or water that forms a connecting link between the two bodies of standing water. Upland islands or palustrine wetlands may occur in the channel, but they are not part of the riverine system.
Marine	Open ocean and high energy coastlines with salinities exceeding 30 parts per thousand and little or no dilution except outside the mouths of estuaries.
Palustrine – unconsolidated bottom	These include wetlands and deepwater habitats with at least 25 percent cover of substrate particles smaller than stones and a vegetative cover less than 30 percent. Water regimes are restricted to permanently flooded, intermittently exposed, and semi-permanently flooded. Characterized by the lack of large stable surfaces for plant and animal attachment. Salinity is below 5 parts per thousand.
Palustrine – open water	Small, shallow bodies of open fresh water lacking significant emergent vegetative cover.

1 foot = 0.305 meters; 1 acre = 0.405 hectares

B.4 REGULATORY AND PERMITTING REQUIREMENTS

For the selected alternative, other than the no-action alternative, DOE would conduct a delineation of waters of the United States, including wetlands in accordance with the USACE Wetland Delineation Manual (1987) and subsequent regulatory guidance. A wetland delineation is a survey conducted by a qualified person to determine the extent of a jurisdictional wetland and the types of wetland that would be affected by a project. A jurisdictional wetland must exhibit water tolerant vegetation, hydric soils, and wetland hydrology. Wetlands would be delineated on the selected new and expansion sites, along all ROWs, and at all locations for proposed ancillary facilities such as storage terminals and brine disposal well fields. Only wetlands that are regulated under Sections 404 and 401 of the Clean Water Act would be delineated. Isolated wetlands are generally not considered within the jurisdiction of the USACE. DOE would coordinate with the appropriate USACE District to secure a jurisdictional determination (or confirmation) of the delineation.

DOE would prepare the appropriate permit application for a Section 404 Permit from the USACE and the 401 Water Quality Certificate from the relevant state agency. This permit process requires a comprehensive analysis of alternatives to avoid impacts to jurisdictional wetlands and waters of the United States, an analysis of measures taken to minimize impacts, and a compensation plan to mitigate for unavoidable impacts to jurisdictional waters of the United States, including wetlands. Avoidance and minimization strategies could include measures such as refinement or modification of facility footprints to avoid wetlands, minimization of slopes in fill areas, use of geotechnical fabric under wetland fills to minimize mudwave potential, and restoration of the disturbed wetlands outside the permanent footprint of the SPR facility. DOE would prepare the compensation plan and submit it with the permit application. Compensation for unavoidable impacts to jurisdictional wetlands could take the form of preservation, restoration, or creation of wetlands in the project area or within the affected watersheds. DOE could also use payment of an lieu-of fee where the USACE and state would allow such payment or the purchase of mitigation credits from an approved wetland mitigation bank in the appropriate service area (region or watershed). The compensation plan would include provisions for protecting the mitigation site through a conservation easement or similar mechanism and postconstruction mitigation monitoring to evaluate the success of the mitigation. Additional detail on the compensation plan is included in section 3.7.2.1.3.

The USACE and state agency would review and approve the wetland compensation plan through the Section 404/401 permit process. DOE's mitigation plan would be consistent with the EPA and USACE proposed rulemaking on wetland mitigation entitled *Compensatory Mitigation for Losses of Aquatic Resources, Proposed Rule* (33 CFR Parts 325 and 332). DOE's mitigation actions would partially fulfill the compliance requirements of E.O. 11990 on Wetlands Protection and 10 CFR Part 1022, which are DOE's implementing regulations for the E.O. Dredge spoils, if generated, would be disposed of in a manner approved by the USACE. DOE would identify beneficial uses for the dredge spoil, (such as wetland restoration) as appropriate. In addition, DOE would secure Section 10 permits wherever required for proposed obstructions in navigable waterways that are regulated by the U.S. Coast Guard and USACE under the Rivers and Harbors Act.

For the selected alternative, DOE would comply with all Federal, state, and local regulations for floodplain protection. In most cases, floodplain regulations have been delegated to the local government through adoption of an ordinance that is consistent with the National Flood Insurance Program (NFIP). In most cases, the floodplain regulations apply only to the 100-year floodplain. The floodplain protection compliance requirements would be initiated during the design process for the selected alternative. DOE would prepare a site plan or engineering drawings that would be submitted to the appropriate state agency (e.g., Mississippi Floodplain Management Bureau of the Mississippi Emergency Management Agency) responsible for the NFIP. The floodplain protection requirements typically require floodproofing of buildings or raising the base of the building above the base flood elevation. In most cases, DOE would have to complete hydrologic modeling or calculations to demonstrate that fill or aboveground structures would not increase the base flood elevation downstream.

B.5 PROJECT DESCRIPTION

This section is an overview of the proposed project development in floodplains and wetlands. It assesses several elements that are common to developing each proposed new and expansion site, including the following:

- Storage caverns, each of which involves construction of a well pad on the ground surface above the cavern site, short onsite pipelines from the wellhead to onsite pumping facilities, onsite pumping capacity for water and brine management during cavern excavation, and oil management during facility operation;
- RWI facilities, including pumps located near the raw water source (generally offsite), and pipelines running from the source location to the storage facility;
- Crude oil intake and distribution facilities, including a series of onsite pipelines and pumps and offsite pipelines connecting to an existing oil distribution network;
- Brine disposal facilities, including onsite brine pumps, brine pipelines from the storage facilities to offsite brine disposal points, and offsite brine disposal facilities (either offshore diffusers in the Gulf of Mexico or underground injection wells);
- Support facilities including offices, control facilities, roads, platforms, and other related infrastructure, which typically would occupy a 35,000 square foot (3,300 square meter) area;
- Storage site and RWI access roads;
- Onsite package wastewater treatment plant; and
- Power lines.

B.6 SITE-SPECIFIC PROJECT DESCRIPTIONS AND FLOODPLAIN AND WETLAND IMPACTS

This section describes the effects to floodplains and wetlands at each proposed new site and expansion site.

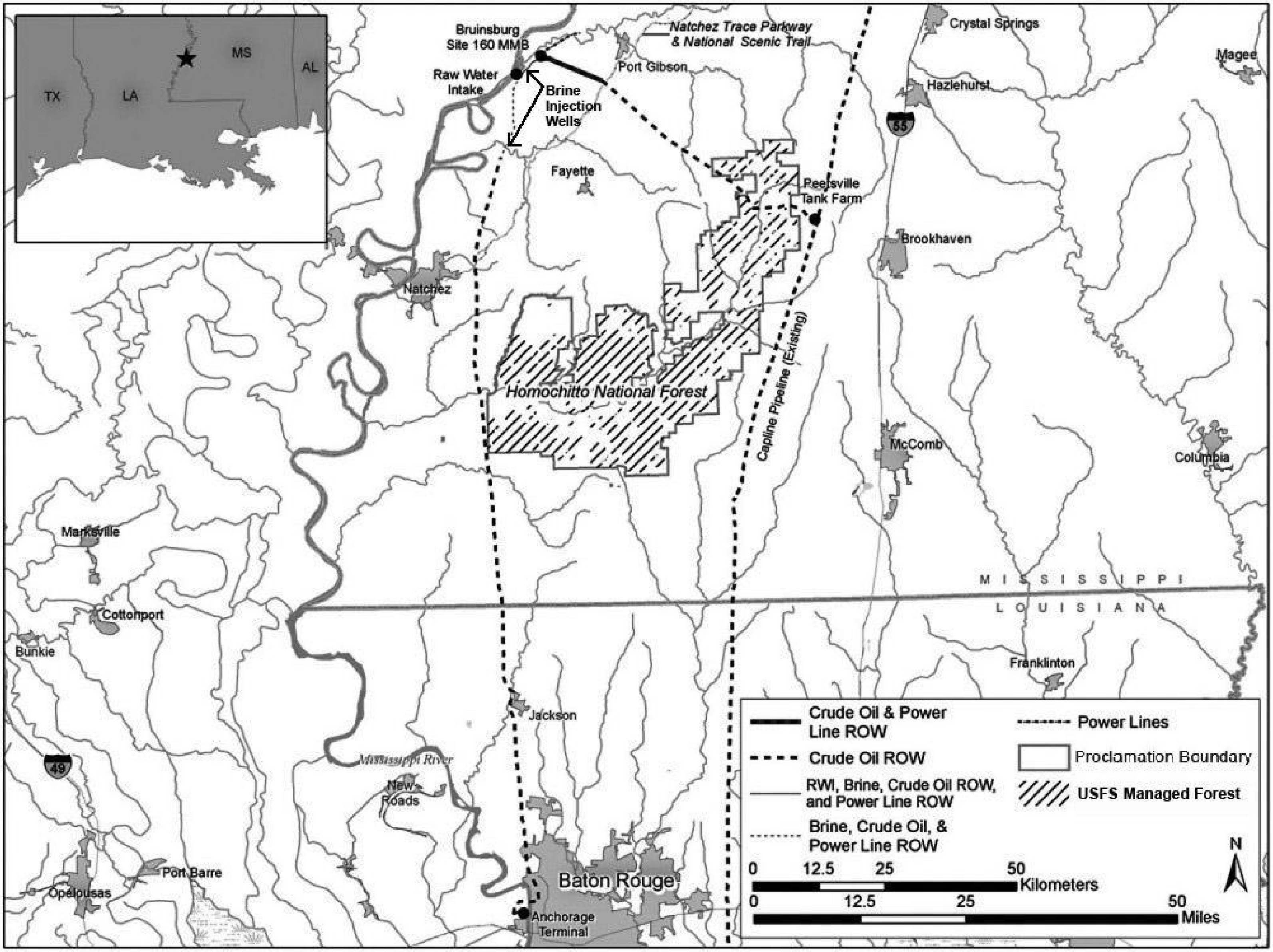
B.6.1 Bruinsburg Storage Site and Associated Infrastructure

The Bruinsburg site would be located 10 miles (16 kilometers) east of Port Gibson, MS (40 miles [64 kilometers] southwest of Vicksburg) in Claiborne County, MS (see figure B.6.1-1). This proposed new site would consist of 16 new caverns with a total capacity of 160 MMB. A security buffer would be cleared extending 300 feet (91 meters) from the perimeter fence. The first six maps in an attachment to this appendix, which is a separate volume, show the NWI mapped wetlands for the proposed Bruinsburg storage site and associated infrastructure.

The Bruinsburg site and associated facilities would consist of the following:

- Sixteen new caverns and associated storage site infrastructure,
- New RWI structure and associated pipeline,
- Two new terminals at Peetsville, MS, and Anchorage, LA,

Figure B.6.1-1: Proposed Bruinsburg Storage Site and Associated Facilities



Note: A 15-mile (24-kilometer) brine disposal pipeline with brine injection wells spaced 1,000 feet (305 meters) apart would be located along the crude oil pipeline to Baton Rouge, LA.

- 60 injection wells spaced at 1,000 feet intervals and an associated pipeline parallel to the ROW to Anchorage,
- Power lines, and
- New access roads to the facility and to the brine injection wells.

B.6.1.1 Floodplain Impacts

The extent of 100-year and 500-year floodplain was determined based on the FEMA Flood Insurance Rate Maps covering the project area. The Bruinsburg site would be located in a predominantly undeveloped area that has numerous floodplains associated with the Mississippi River and Bayou Pierre and their tributaries. Drainage is generally to the west toward the Mississippi River. Table B.6.1-1 summarizes the floodplain area that would be affected by this site and its associated facilities.

Table B.6.1-1: Floodplain Impacts for the Proposed Bruinsburg 160 MMB Storage Site and Associated Facilities

Description	100-Year Floodplain (acres)	500-Year Floodplain (acres)
Storage site/access road	158	17
RWI structure/access road	1	0
Anchorage terminal	0	0
Peetsville terminal	0	0
Brine injection well pads/access road	82	4
Total	**241**	**21**

1 acre = 0.405 hectares

The Bruinsburg 160 MMB site storage area and associated facilities would affect approximately 241 acres (98 hectares) of 100-year floodplain and 21 acres (9 hectares) of 500-year floodplain and would include fill and construction of some aboveground structures (figure B.6.1-2). The Peetsville and Anchorage terminals would not affect 100-year or 500-year floodplains (figures B.6.1-3 and B.6.1-4).

The Bruinsburg 160 MMB storage site and associated facilities would have the potential to increase future downstream flooding due to proposed fill and construction of aboveground structures within the floodplain including well pads, roads, and wellheads. DOE placed most of the proposed onsite buildings, including administrative buildings and other onsite facilities, to the east and located them out of the floodplain (figure B.6.1-2). The structures in the floodplain may have the potential to increase downstream flooding; however, the impacts would be minimal due to the overall size of the floodplain system and compliance with the flood protection requirements of local, state, and Federal floodplain regulations. After selection of an alternative other than no-action and prior to construction, hydrological modeling would be conducted to ensure that base flood elevations would not increase from the proposed fill/structures. No floodplains would be affected by the Peetsville or Anchorage terminals (figures B.6.1-3 and B.6.1-4).

Any structures located within the floodplain would be designed in accordance with the NFIP requirements for nonresidential buildings and structures located in special flood hazard areas. The NFIP regulations require vulnerable structures to be elevated above the 100-year flood elevation or to be watertight. DOE would coordinate with and secure approval from the Mississippi Floodplain Management Bureau of the Mississippi Emergency Management Agency or the local government, if it has adopted the NFIP program, during the design stage/site plan process.

Figure B.6.1-2: Floodplain Map for Proposed Bruinsburg 160 MMB Storage Site

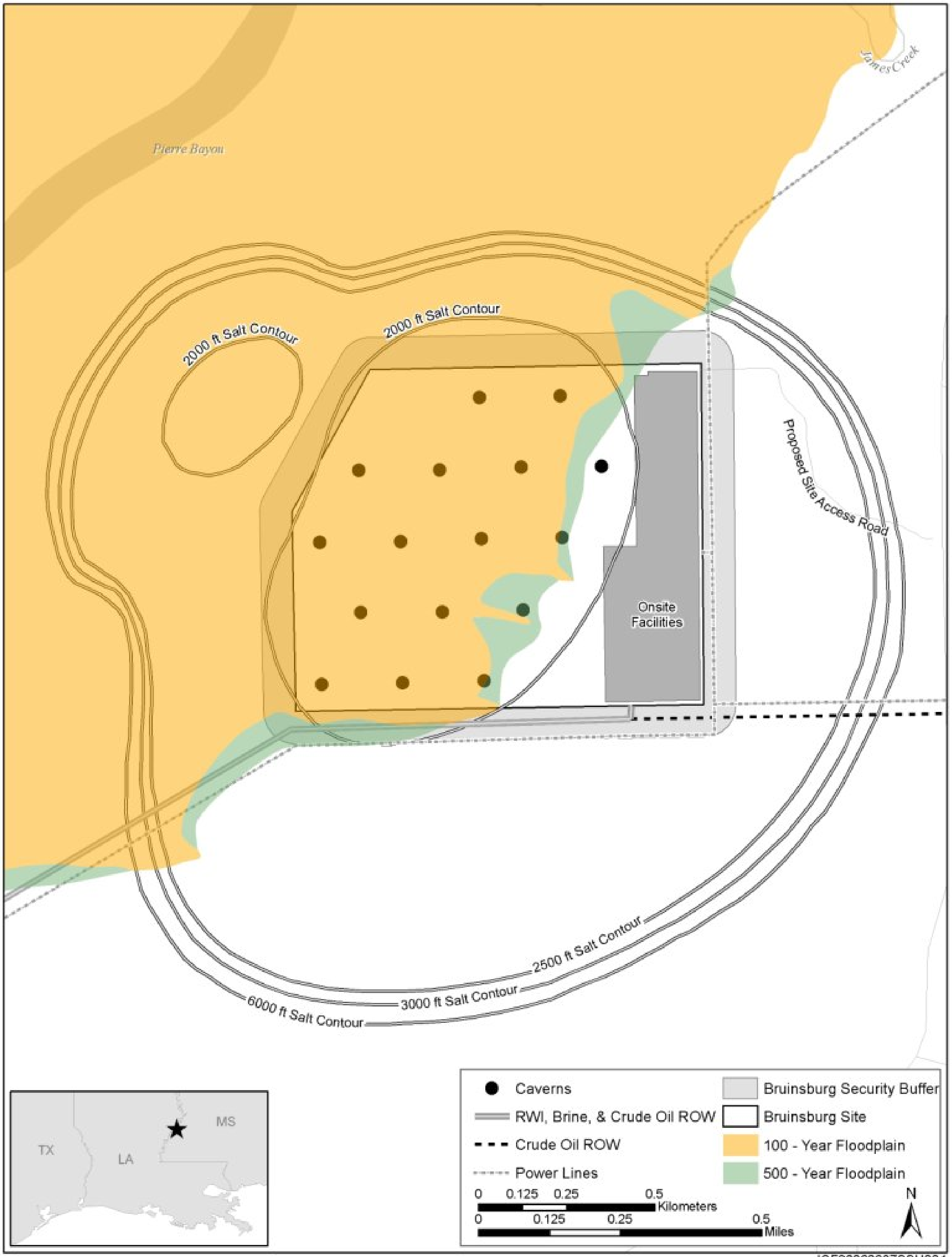


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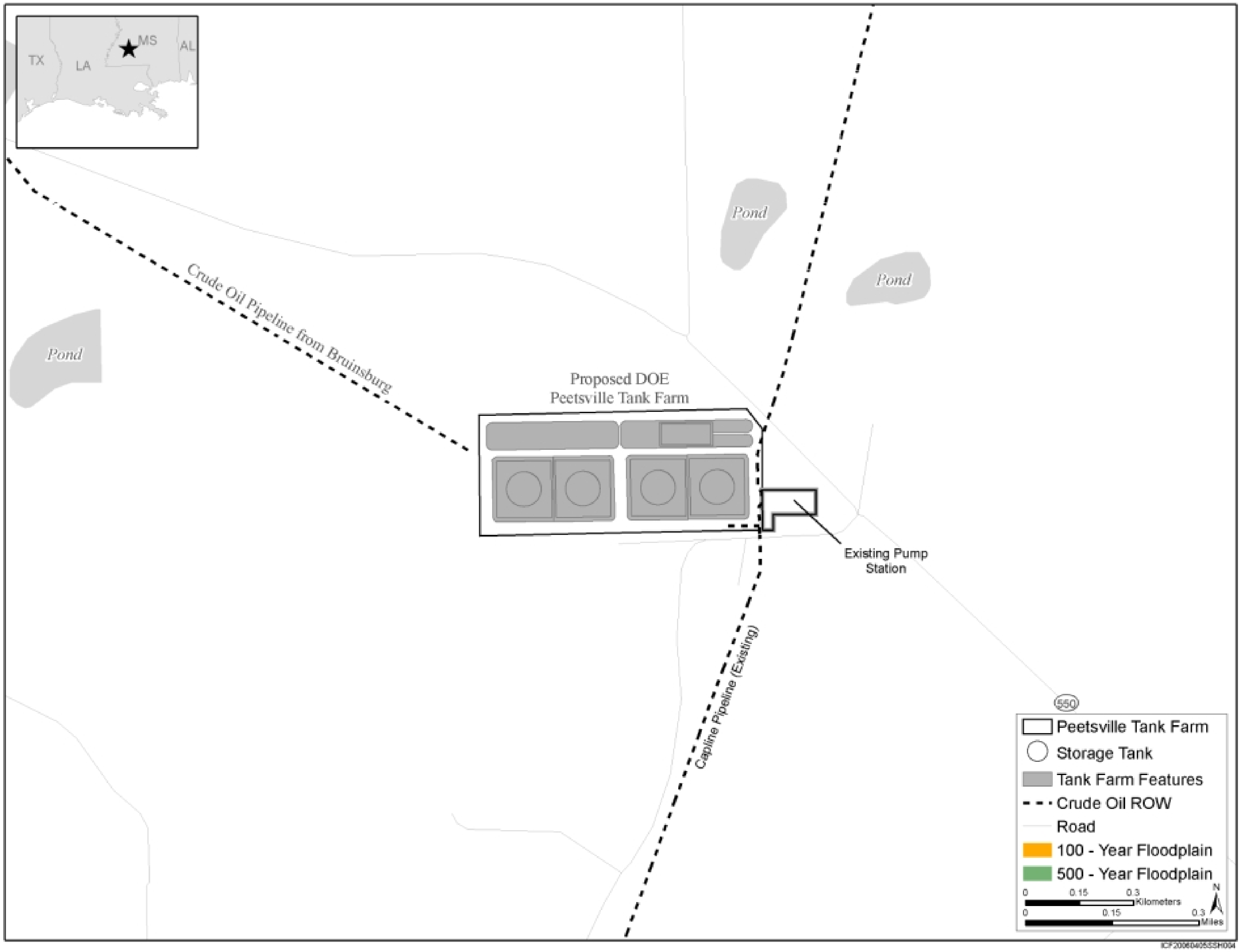
Figure B.6.1-3: Floodplain Map for Anchorage Terminal

Figure B.6.1-4: Floodplain Map for Peetsville Terminal



The Bruinsburg 160 MMB pipeline and power line ROWs would cross and temporarily affect about 30 miles (48 kilometers) of 100-year floodplain and 4 miles (6 kilometers) of 500-year floodplain. The impacts to floodplains associated with the construction of the ROWs would be temporary because the preconstruction contours would be re-established and no aboveground fill or structures would exist following the completion of the construction activities. Therefore, no significant increased risk of flooding or change in base flood elevation would be expected from ROW construction because there would be no net loss of flood attenuation capacity compared to the existing conditions. There would be a minor increase in flood stage during the construction activities because some staging materials and construction equipment may be located in the floodplain. Power poles and other associated fill would be located outside of floodplain areas to the maximum extent practical. These structures would not be expected to significantly increase base flood elevations.

Due to the unique geology and location of the salt dome, the water dependency of the RWI, and the long ROWs for the site, floodplains could not be completely avoided. DOE has considered the practicable alternatives to siting in a floodplain and has prepared a conceptual design to minimize the impact to floodplains. DOE shifted the administrative buildings and other vulnerable structures where practicable to a location outside of the floodplain at the proposed Bruinsburg storage site. Proper design and compliance with the required regulatory programs would reduce the impacts of the structures on floodplains to a level where they would not significantly change the base flood elevation. Section B.7 discusses in more detail the avoidance and minimization measures that DOE would use to reduce the effects to floodplains located in the project area.

B.6.1.2 Wetland Impacts

The construction and operations and maintenance associated with the proposed Bruinsburg 160 MMB storage site and related facilities would have temporary and permanent impacts on wetlands as described in the methodology. Table B.6.1-2 identifies the wetlands that would be affected by the proposed ROWs and table B.6.1-3 summarizes the wetlands that would be affected by the new storage site, ROWs, and ancillary facilities.

The wetlands at the Bruinsburg storage site are predominantly palustrine forested wetlands comprised of mature cypress trees (see figure B.6.1-5). Although the forested wetlands are adjacent to actively managed cotton fields, they contain large cypress trees that indicate that the wetlands have been relatively undisturbed for several decades. This important type of fresh-water ecosystem generally provides functions that include nutrient transformation, flood storage, wildlife habitat, and timber production. Construction of the permanent structures such as the storage site and brine injection wells would permanently fill approximately 102 acres (41 hectares) of palustrine forested wetlands. The NWI data did not identify wetlands at the proposed Peetsville terminal, the Anchorage terminal, or the RWI. The maintenance of the security buffer around the 300-foot (91-meter) storage facility would permanently convert 18 acres (7 hectares) forested and scrub-shrub wetlands to emergent wetlands or open water. The security buffer would require the clearing of woody vegetation and periodic maintenance to suppress or clear woody species.

The power line and pipeline ROWs associated with the Bruinsburg 160 MMB storage site would cross and permanently or temporarily affect 335 acres (136 hectares) of wetlands. Table B.6.1-2 summarizes the wetland impacts per ROW that would result from this proposed development. Construction of all the ROWs would affect 151 acres (61 hectares) of wetlands within the permanent easement and 184 acres (75 hectares) of wetlands within the temporary easement (see table B.6.1-3). Pre-existing hydrology and elevations would be restored and the affected plant communities would be allowed to re-establish depending on location within the temporary and permanent easement. DOE would promote the growth of

Table B.6.1-2: Wetland Impacts for the Proposed Bruinsburg 160 MMB Storage Site ROWs[a]

Cowardin Wetland Classification	ROW from Site to Anchorage (acres)		ROW from Anchorage ROW to RWI (acres)		ROW from Site to Peetsville (acres)		Power Line ROWs (acres)	
	Temporary easement	Permanent easement	Temporary easement	Permanent easement	Temporary easement	Permanent easement	Temporary easement	Permanent easement
Palustrine – forested[b]	100	63	3	2	6	3	NA	39
Palustrine – scrub-shrub[b]	25	15	0	0	0	0	NA	4
Palustrine – unconsolidated bottom[c]	2	1	0	0	2	1	NA	0
Riverine[c]	45	22	1	1	0	0	NA	0
Totals	**172**	**101**	**4**	**3**	**8**	**4**	**NA**	**43**

Notes:

[a] This table presents only the wetland types that are present within the ROW according to NWI data.

[b] Forested and scrub-shrub wetlands would be cleared of woody vegetation and permanently converted to and maintained as emergent wetlands within the permanent easement of all ROWs. Within the temporary construction easement, woody vegetation would be cleared but would be allowed to re-establish within the easement. DOE would follow any required wetland compensation for these temporary impacts that is required by the Section 404/401 permit. At a minimum, DOE would restore original contours, replace the original hydric topsoil back in the disturbed area (where practical), and seed with native species. Re-establishment of the scrub-shrub or forested wetland may take 5-25 years depending on the type of community affected.

[c] Impacts to these wetlands would be temporary and they would return to the pre-existing conditions shortly after construction is completed.

1 acre = 0.405 hectares; NA means no temporary easement

Table B.6.1-3: Summary of Wetland Impacts for the Proposed Bruinsburg 160 MMB Storage Site and Associated Facilities[a]

Cowardin Wetland Classification	Storage Site (acres)		ROWs[b] (acres)		Brine Injection Wells (acres)	Totals (acres)
	Filled wetlands	Permanent conversion	Temporary easement	Permanent easement	Filled wetlands	All affected wetlands
Palustrine – forested	85	18	109	107	17	**336**
Palustrine – scrub-shrub	0	0	25	19	9	**53**
Palustrine – unconsolidated bottom	0	0	4	2	0	**6**
Riverine	0	0	46	23	0	**69**
Total	**85**	**18**	**184**	**151**	**26**	**464**

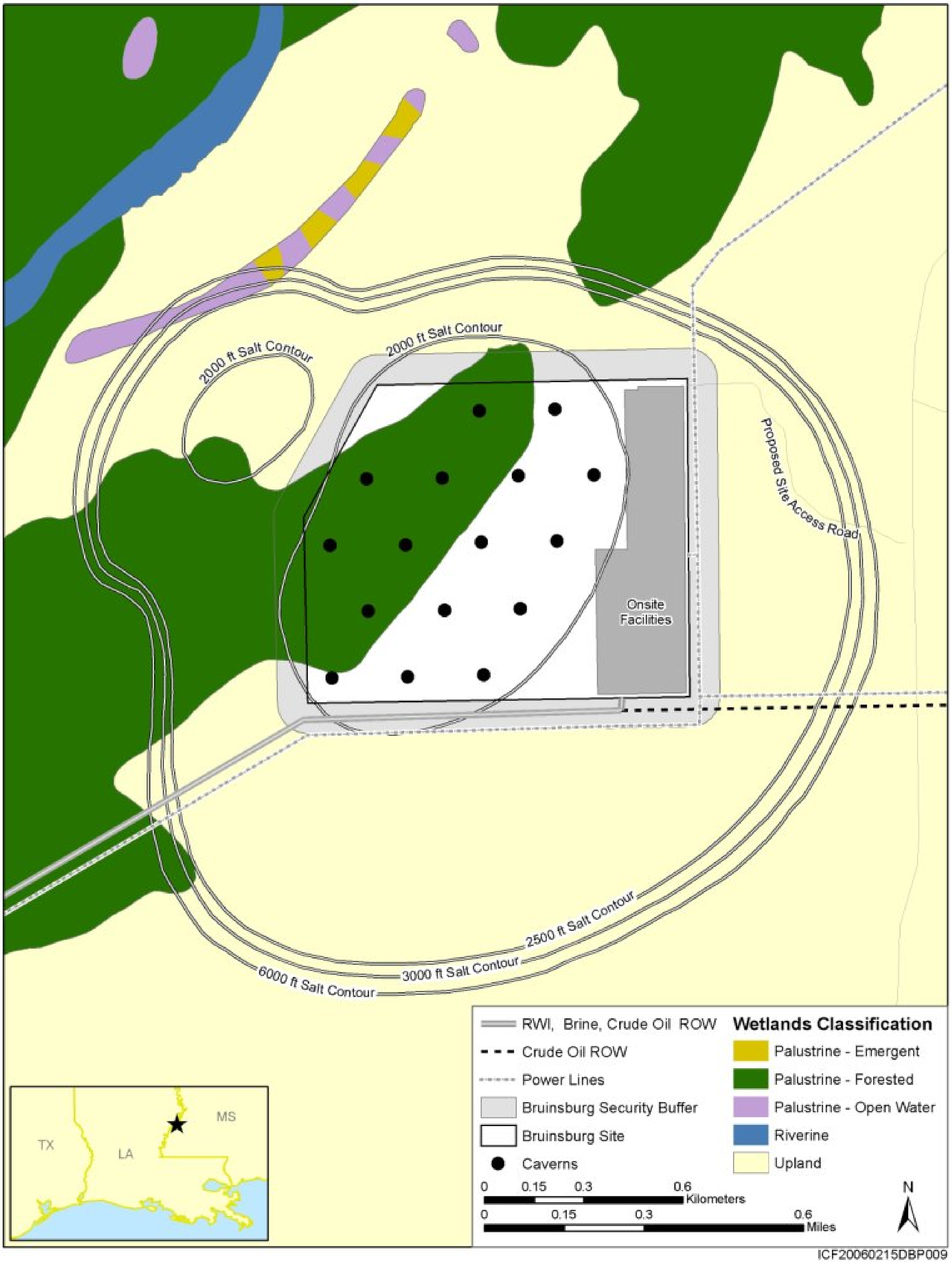
Notes:

[a] This table presents only the wetland types that are present within the proposed footprint according to NWI data. Facilities were omitted if no wetlands were present within the footprint.

[b] Forested and scrub-shrub wetlands would be cleared of woody vegetation and permanently converted to and maintained as emergent wetlands within the permanent easement of all ROWs. Within the temporary construction easement, woody vegetation would be cleared but would be allowed to re-establish within the easement. DOE would follow any required wetland compensation for these temporary impacts that is required by the Section 404/401 permit. At a minimum, DOE would restore original contours, replace the original hydric topsoil back in the disturbed area (where practical), and seed with native species. Re-establishment of the scrub-shrub or forested wetland may take 5-25 years depending on the type of community affected. Impacts to all other wetlands would be temporary and they would return to the pre-existing conditions shortly after construction is completed.

1 acre = 0.405 hectares

Figure B.6.1-5: NWI Wetlands at the Proposed Bruinsburg 160 MMB Storage Site



emergent or forested vegetation in the temporary construction easement. The impacts to wetlands within the temporary easement would last between 2 to 3 years for emergent wetlands and at least 10 to 25 years for forested wetlands. DOE would prohibit the regrowth of woody vegetation within the permanent easement to protect pipelines and to allow overflight inspections. Therefore, forested and scrub-shrub wetlands in the permanent easement would be permanently converted to emergent wetlands. Although the converted wetlands would provide different habitat than before construction, other important wetland functions, such as flood storage and nutrient filtration, would be maintained within the emergent wetlands.

According to available NWI data, the proposed Peetsville tank farm and Anchorage terminal would not affect wetlands (figures B.6.1-6 and B.6.1-7).

The entire Bruinsburg 160 MMB development, which includes the site, the associated facilities, and ROWs, would affect approximately 464 acres (187 hectares) of wetlands associated with the filling activities required for new structures and facilities and temporary and permanent clearing for new power lines and pipelines. The construction activities would permanently fill approximately 111 acres (45 hectares) of forested wetlands associated with the storage site and brine injection wells (see table B.6.1-3). The storage site would permanently destroy about 85 acres (34 hectares) of palustrine forested wetlands characterized as bald cypress forest. The impact to this relatively rare and important type of forested wetland would be a potential adverse effect, which would be mitigated by the compensation plan for jurisdictional wetland impacts.

Due to the geology and location of the salt dome, the water dependency of the RWI, and the long ROWs, impacts to wetlands and waters of the United States could not be avoided by this site development. All filling of and discharges to jurisdictional wetlands would require a Section 404/401 permit from the USACE and the Mississippi Department of Environmental Quality. The permit application would require a comprehensive alternatives analysis that demonstrates avoidance and minimization of wetland impacts. The permit would contain conditions to minimize the impact on wetlands during construction and would require compensation for unavoidable impacts to jurisdictional wetlands. Section B.7 discusses in more detail the avoidance, minimization, and mitigation measures that would be used to reduce, avoid, and compensate for the impacts to wetlands.

B.6.2 Chacahoula Storage Site and Associated Infrastructure

The Chacahoula salt dome site is located in Lafourche Parish, southwest of Thibodaux, LA, as illustrated in figure B.6.2-1. This proposed new site would consist of 16 new caverns with a total capacity of 160 MMB. A security buffer zone would be cleared extending 300 feet (91 meters) from the perimeter fence. Five maps in the attachment to this appendix show the NWI mapped wetlands and the proposed Chacahoula site storage, ROWs, and associated facilities.

The Chacahoula site and associated facilities would consist of the following:

- Sixteen new caverns and associated storage site infrastructure,
- New RWI structure and associated pipeline,
- Crude oil pipelines to Clovelly, LA, and to St. James Terminal, LA,
- Brine disposal pipeline to the Gulf of Mexico,
- Power lines, and
- New access roads to the facility and to the RWI structure.

Figure B.6.1-6: NWI Wetlands at the Proposed Peetsville Terminal

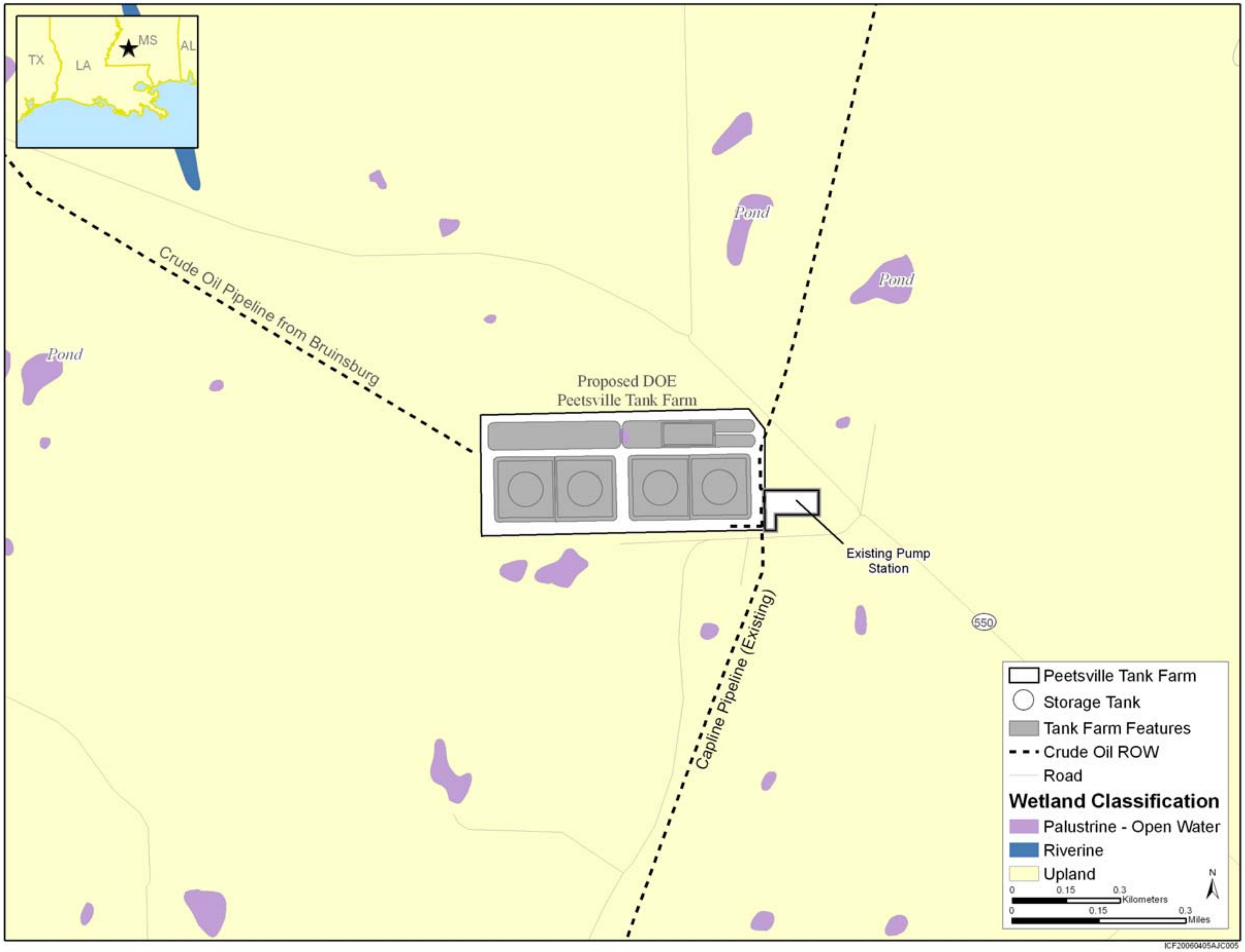


Figure B.6.1-7: NWI Wetlands at the Proposed Anchorage Tank Farm

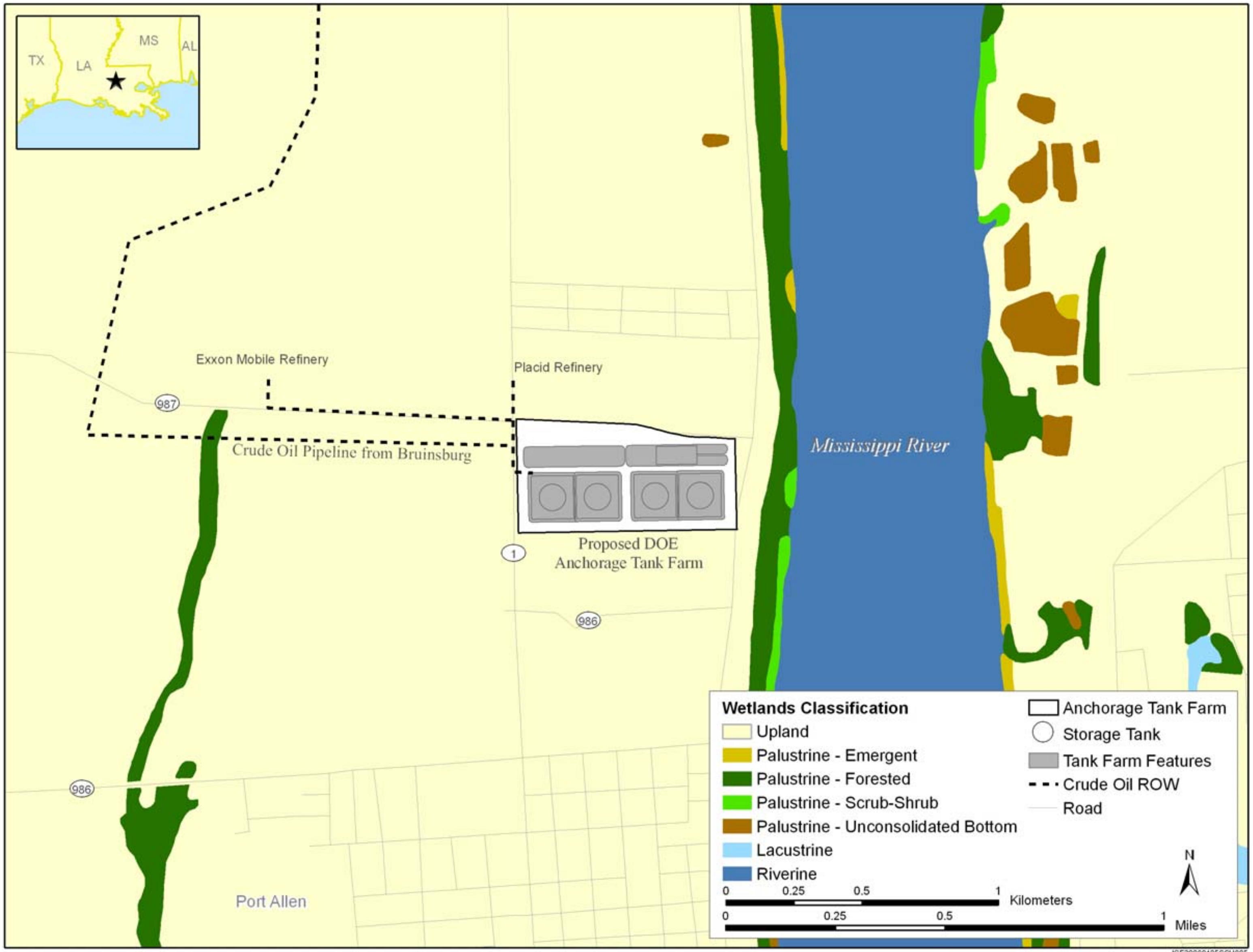
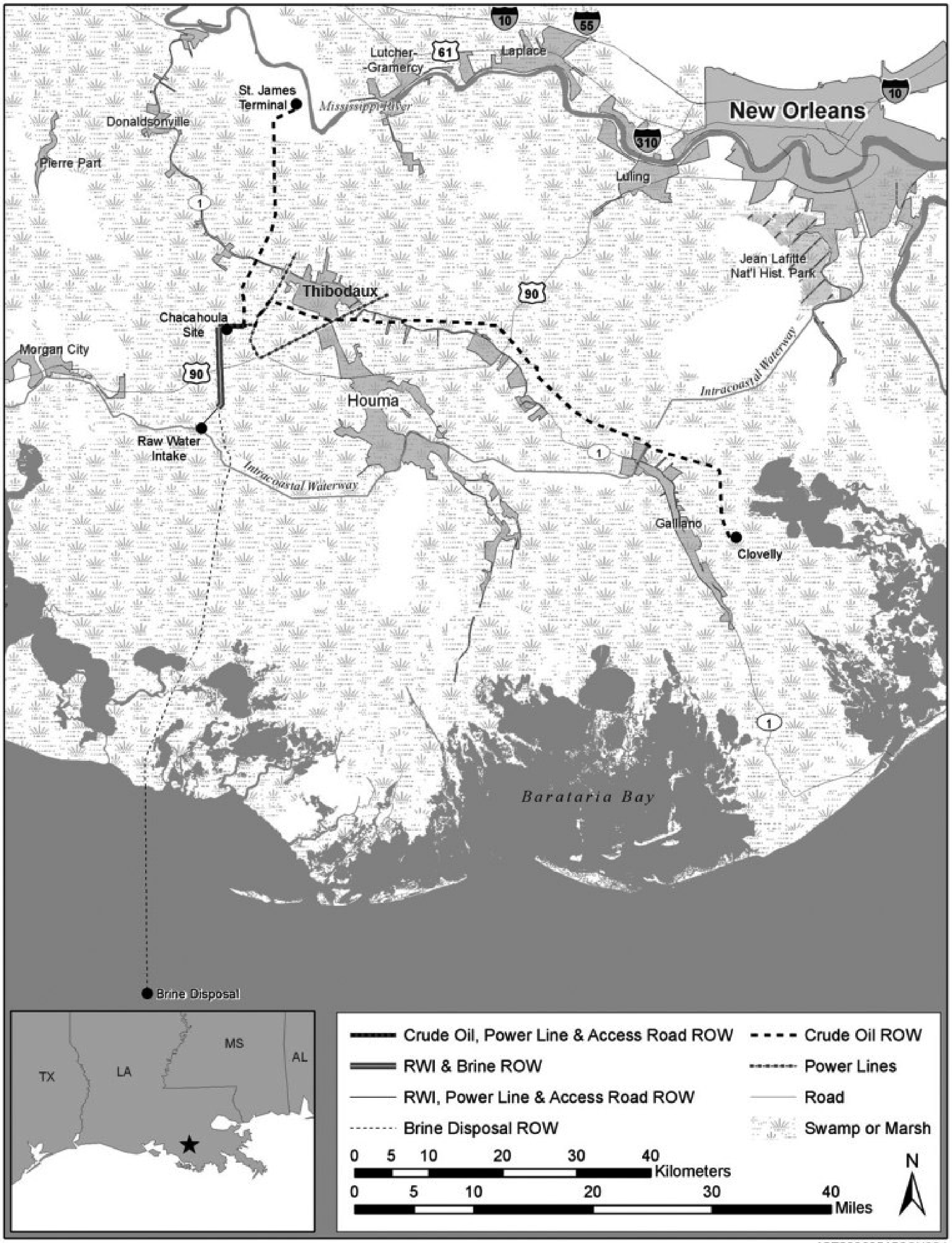


Figure B.6.2-1: Proposed Chacahoula Storage Site and Associated Facilities



B.6.2.1 Floodplain Impacts

The extent of 100-year and 500-year floodplain was determined based on the FEMA Flood Insurance Rate Maps covering the project area. The Chacahoula storage site would be located in a predominantly undeveloped, flooded wetland. The entire site is within the 100-year floodplain (see figures B.6.2-2 and B.6.2-3). Table B.6.2-1 summarizes the floodplain area that would be affected at this site.

Table B.6.2-1: Floodplain Impacts for the Proposed Chacahoula and Associated Facilities

Description	100-Year Floodplain (acres)	500-Year Floodplain (acres)
Storage site/access road	126	0
RWI structure/access road	10	0
Total	**136**	**0**

1 acre = 0.405 hectares

The floodplain where the proposed Chacahoula storage site would be located extends over hundreds of square miles (square kilometers) and is part of the Louisiana Western Gulf Coastal Plain Province. The Chacahoula storage site and RWI would disturb about 136 acres (55 hectares) of 100-year floodplain, which would include fill and construction of aboveground structures such as well pads, roads, administrative buildings, and the RWI structure itself.

Because the proposed Chacahoula storage site is located entirely within the 100-year floodplain, it would have the potential to increase future flooding due to the proposed fill and construction of aboveground structures within the floodplain, including buildings, well pads, roads, and wellheads. Portions of inundated forested wetlands would be filled for administrative buildings, pump stations, and other structures. A berm would be placed around the facility boundary to support a security fence and road. Although the proposed site is 227 acres (92 hectares), only 126 acres (51 hectares) would be filled. The berm would contain culverts to maintain hydrological functions and reduce flooding in nearby upland areas. The floodplain impacts are expected to be moderate due to the overall size of the floodplain system and compliance with the flood protection requirements of local, state, and Federal floodplain regulations. After selection of an alternative other than no-action and prior to construction, hydrological modeling would be conducted to ensure that base flood elevations would not be increased by the proposed fill/structures.

All structures would be designed in accordance with the NFIP requirements for nonresidential buildings and structures located in special flood hazard areas. The NFIP regulations are designed to require vulnerable structures to be constructed above the 100-year flood elevation or to be as watertight. DOE would coordinate with and secure approval from the floodplain coordinator at the Louisiana Department of Transportation and Development or the local government, if it has adopted the NFIP program, during the design stage/site plan process.

The associated power line and pipeline ROW would temporarily affect approximately 91 miles (147 km) of 100-year floodplain and less than 1 mile (2 kilometers) of 500-year floodplain (see figure B.6.2-2). The impacts on floodplains associated with the pipeline and power line ROWs would be temporary because no aboveground fill or structures would be built, the preconstruction contours would be re-established, and all disturbed areas would be allowed to revegetate following the completion of the construction activities. Therefore, no significant increased risk of flooding or change in base flood elevation would be expected from the pipeline and power line ROWs because there would be no net loss of floodplain attenuation capacity compared to the existing conditions. There would be a minor increase

Figure B.6.2-2: Floodplain Map for Proposed Chacahoula Site and Proposed Facilities

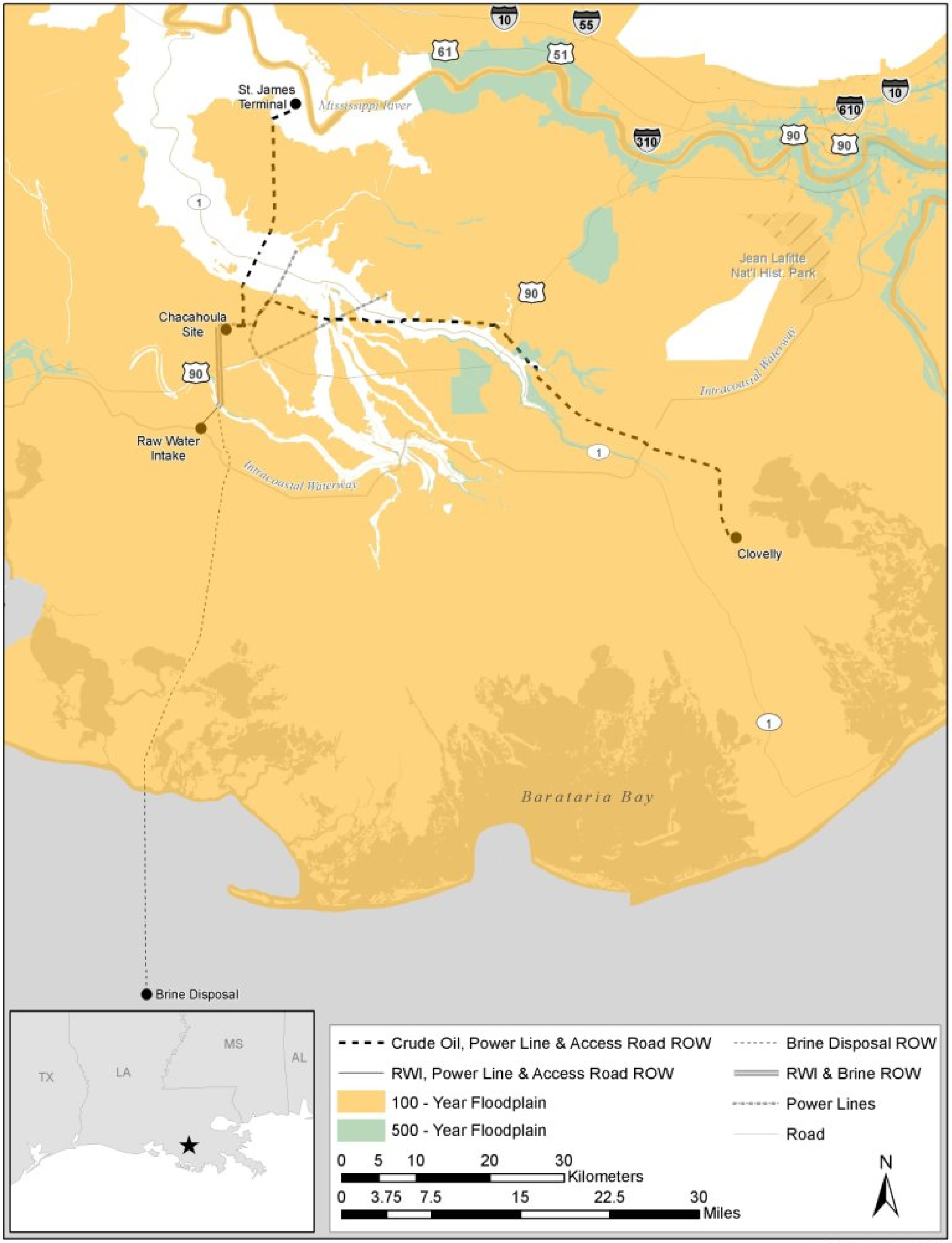


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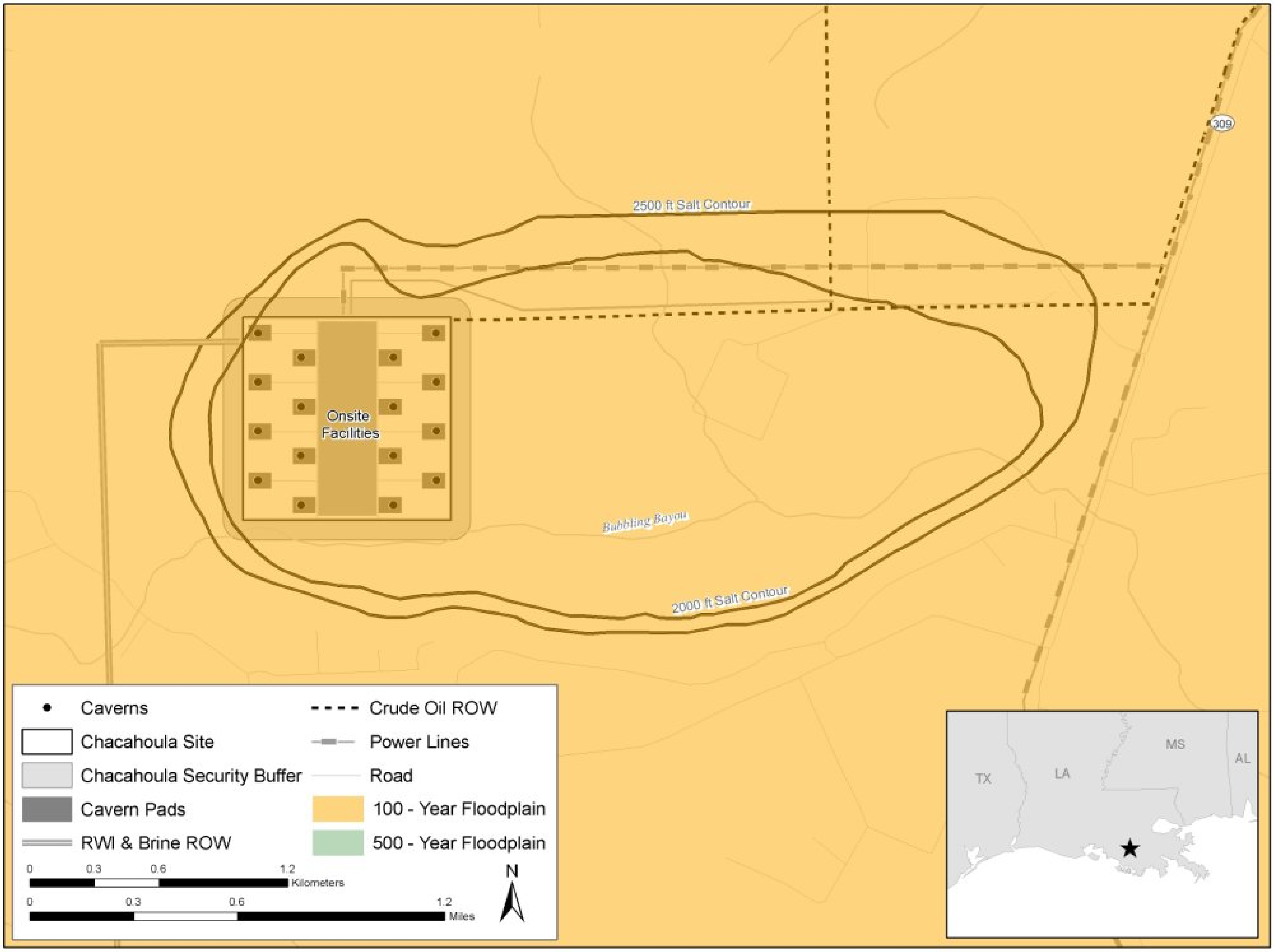
Figure B.6.2-3: Floodplain Map for Proposed Chacahoula Storage Site



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in flood stage during the construction activities because some staging materials and construction equipment may be located in the floodplain. Power poles and other associated fill would be located outside of floodplain areas to the maximum extent practical. These structures would not be expected to significantly increase flood stage levels.

Due to the area geology and location of the salt dome, water dependency of the RWI, and the long ROWs, floodplains could not be avoided by this site development. DOE has considered the practicable alternatives to placing the storage site in a floodplain and has prepared a conceptual design to minimize the impact to floodplains. Proper design and compliance with the required regulatory programs would reduce the impacts of these structures on floodplains to such an extent that there would be no significant change in the base flood elevation. Section B.7 discusses in more detail the avoidance and minimization measures that would be used to reduce the effects to floodplains located in the project area.

B.6.2.2 Wetland Impacts

The construction and operations and maintenance associated with the proposed Chacahoula storage site and associated facilities would have temporary and permanent impacts on wetlands as described in the methodology. Table B.6.2-2 presents the wetlands that would be affected by ROW and table B.6.2-3 summarizes the wetlands that would be affected by this alternative.

The proposed Chacahoula storage site would be located in a relatively large contiguous patch of inundated palustrine forested wetlands comprised of cypress and tupelo trees (figure B.6.2-4). This swamp has areas of oil and gas development, but it is largely undisturbed. This important type of fresh-water ecosystem generally provides functions that include nutrient transformation, flood storage, wildlife habitat, and timber production.

Construction of the Chacahoula storage site and RWI would affect about 349 acres (142 hectares) of palustrine forested and emergent wetlands. The permanent fill and conversion of wetlands would be associated with the construction of the storage site and RWI and the clearing and maintenance of a 300-foot (91-meter) security buffer around the new storage site (see figure B.6.2-4). Approximately 126 acres (50 hectares) of the proposed storage site would be filled for administrative buildings, well heads, pumps, and other facilities. The remaining portion of the enclosed site and the 300-foot (91-meter) security buffer would be cleared of woody vegetation and converted into emergent wetlands or open-water. Periodic maintenance would take place to suppress or clear woody vegetation regrowth within these areas.

The power line and pipeline ROWs associated with the Chacahoula storage site would cross and permanently or temporarily affect approximately 1,907 acres (770 hectares) of wetlands. Table B.6.2-3 provides a summary of the wetland impacts per ROW that would result from this alternative. Construction of the ROWs would affect 1,100 acres (445 hectares) of wetlands within the permanent easement and 807 acres (327 hectares) within the temporary easement. Pre-existing hydrology and elevations would be restored and the affected plant communities would be allowed to re-establish depending on location within the temporary and permanent easement. DOE would promote the growth of emergent or forested vegetation in the temporary construction easement. The impacts to wetlands within the temporary easement would last between 2 to 3 years for emergent wetlands and at least 10 to 25 years for forested wetlands. DOE would prohibit the regrowth of woody vegetation within the permanent easement to protect pipelines and to allow weekly overflight inspections. Therefore, forested and scrub-shrub wetlands in these areas would be permanently converted to emergent wetlands.

Table B.6.2-2: Wetland Impacts for the Proposed Chacahoula Storage Site ROWs[a]

Cowardin Wetland Classification	ROW from Site to Clovelly (acres)		ROW from Clovelly ROW to St. James (acres)		ROW from Site to Gulf of Mexico (acres)		ROW from Gulf of Mexico ROW to RWI Structure (acres)		Power Line ROWs (acres)	
	Temporary easement	Permanent easement	Temporary easement	Permanent easement	Temporary easement	Permanent easement	Temporary easement	Permanent easement	Temporary easement	Permanent easement
Estuarine	104	51	0	0	171	84	0	0	NA	0
Lacustrine[c]	6	3	0	0	33	17	0	0	NA	0
Marine[c]	0	0	0	0	2	1	0	0	NA	0
Palustrine – aquatic bed	2	1	0	0	2	1	0	0	NA	0
Palustrine – emergent	69	34	1	1	157	78	10	5	NA	16
Palustrine – forested[b]	178	91	152	75	148	94	18	9	NA	213
Palustrine – scrub-shrub[b]	24	12	0	0	7	3	0	0	NA	0
Palustrine – unconsolidated bottom[c]	0	0	0	0	3	2	0	0	NA	8
Riverine[c]	4	2	0	0	6	3	0	0	NA	0
Other	0	0	0	0	3	1	0	0	NA	2
Totals	**387**	**194**	**153**	**76**	**532**	**284**	**28**	**14**	**NA**	**239**

Notes:

[a] This table presents only the wetland types that are present within the ROW according to NWI data.

[b] Forested and scrub-shrub wetlands would be cleared of woody vegetation and permanently converted to and maintained as emergent wetlands within the permanent easement of all ROWs. Within the temporary construction easement, woody vegetation would be cleared but would be allowed to re-establish within the easement. DOE would follow any required wetland compensation for these temporary impacts that is required by the Section 404/401 permit. At a minimum, DOE would restore original contours, replace the original hydric topsoil back in the disturbed area, and seed with native species. Re-establishment of the scrub-shrub or forested wetland may take 5-25 years depending on the type of community affected.

[c] Impacts to these wetlands would be temporary and they would return to the pre-existing conditions shortly after construction is completed.

1 acre = 0.405 hectares; NA means no temporary easement

Figure B.6.2-4: NWI Wetlands at the Proposed Chacahoula Storage Site

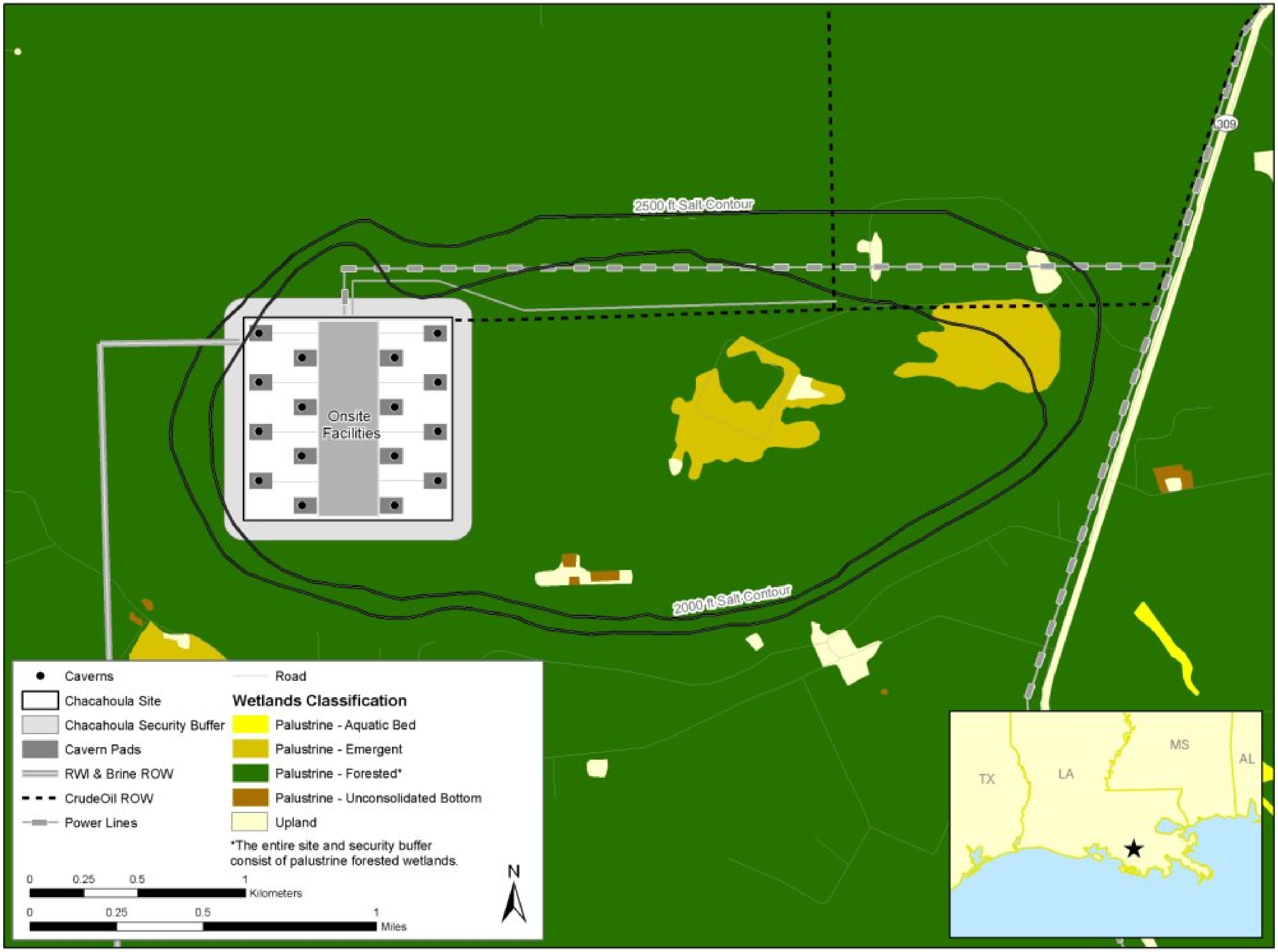

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Table B.6.2-3: Summary of Wetland Impacts for the Proposed Chacahoula Storage Site[a]

Cowardin Wetland Classification	Storage Site/Access Road (acres)		ROWs[b] (acres)		RWI Structure/ Access Road (acres)	Totals (acres)
	Filled wetlands	Permanent conversion	Temporary easement	Permanent easement	Filled wetlands	All affected wetlands
Estuarine	0	0	275	135	0	**410**
Lacustrine	0	0	39	20	0	**59**
Marine	0	0	2	1	0	**3**
Palustrine – aquatic bed	0	0	4	2	0	**6**
Palustrine - emergent	0	0	237	134	3	**374**
Palustrine – forested	126	213	496	482	6	**1,323**
Palustrine – scrub-shrub	0	0	31	15	0	**46**
Palustrine – unconsolidated bottom	0	0	3	10	0	**13**
Riverine	0	0	10	5	0	**15**
Other	0	0	3	3	1	**7**
Totals	**126**	**213**	**1,100**	**807**	**10**	**2,256**

Notes:

[a] This table presents only the wetland types that are present within the proposed footprint according to NWI data. Facilities were omitted if no wetlands were present within the footprint.

[b] Forested and scrub-shrub wetlands would be cleared of woody vegetation and permanently converted to and maintained as emergent wetlands within the permanent easement of all ROWs. Within the temporary construction easement, woody vegetation would be cleared but would be allowed to re-establish within the easement. DOE would follow any required wetland compensation for these temporary impacts that is required by the Section 404/401 permit. At a minimum, DOE would restore original contours, replace the original hydric topsoil back in the disturbed area, and seed with native species. Re-establishment of the scrub-shrub or forested wetland may take 5-25 years depending on the type of community affected. Impacts to these wetlands would be temporary and they would return to the pre-existing conditions shortly after construction is completed.

1 acre = 0.405 hectares

Although the converted wetlands would provide different habitat than before construction, other important wetland functions, such as flood storage and nutrient filtration, would be maintained within the emergent wetland. DOE would compensate for the permanent impacts on jurisdictional wetlands that are unavoidable by this alternative. DOE would monitor the ROW areas of temporary and permanently impacts to wetlands to ensure that wetland hydrology and plants are re-established.

The entire Chacahoula storage site and associated facilities, which includes the site, RWI, and ROWs, would affect approximately 2,256 acres (914 hectares) of wetlands associated with the filling activities required for new structures and facilities and temporary and permanent clearing for new power lines and pipelines (see table B.6.2-3). The construction activities would permanently fill approximately 136 acres (55 hectares) of forested wetlands, including cypress-tupelo dominated wetlands, associated with the storage site, RWI, and access roads. The impact to this relatively rare and important type of forested wetlands would be a potential adverse effect, which would be mitigated by the compensation plan for jurisdictional wetland impacts.

Due to the geology and location of the salt dome, the water dependency of the RWI, and the long ROWs, impacts to wetlands and waters of the United States could not be avoided by this site and its infrastructure. All filling of and discharge to jurisdictional wetlands would require a Section 404/401 permit from the USACE and the Louisiana Coastal Management Division of the Department of Natural Resources. The permit application would require a comprehensive alternatives analysis that demonstrates avoidance and minimization of wetland impacts. The permit would contain conditions to minimize the impact to wetlands during construction and would require compensation for unavoidable impacts on jurisdictional wetlands. Section B.7 discusses in more detail the avoidance, minimization, and mitigation measures that would be used to reduce, avoid, and compensate for the potential impacts to jurisdictional wetlands and waters of the United States.

B.6.3 Clovelly Storage Site and Associated Infrastructure

The Clovelly salt dome is located east of Galliano, LA, in Lafourche Parish at the site of Louisiana Offshore Oil Port's (LOOP's) Clovelly Dome Storage Facility,[2] as illustrated in figure B.6.3-1. Co-located with LOOP's existing storage caverns, DOE would construct a 16-cavern, 120 MMB storage site that would use most of LOOP's existing infrastructure for cavern solution mining, brine disposal, and electrical power distribution.

The proposed Clovelly storage site and associated facilities would consist of the following:

- Sixteen new caverns,
- New RWI,
- Use of existing onsite infrastructure and offsite pipelines and power lines, and
- One new administrative building located 4 miles (6 kilometers) from the storage facility.

B.6.3.1 Floodplain Impacts

The extent of 100-year and 500-year floodplain was determined based on the FEMA Flood Insurance Rate Maps covering the project area. The Clovelly storage site would be located in a previously developed area associated with the existing LOOP Clovelly Dome Storage Terminal. The proposed site encompasses portions of the Barataria Bay estuary between the Mississippi River and Bayou Lafourche. The proposed storage site is entirely within the 100-year floodplain and consists of maintained open water canals and estuaries (figure B.6.3-2). DOE also would construct an off-dome administrative facility 4 miles (6 kilometers) to the west of the storage site that would also be located in a 100-year floodplain (see figure B.6.3-2). Table B.6.3-1 summarizes the floodplain area that would be affected by this development.

Table B.6.3-1: Floodplain Impacts for the Clovelly Storage Site

Description	100-Year Floodplain (acres)	500-Year Floodplain (acres)
Storage Site/RWI Structure/Access Roads	2	0
Dredge Area [a]	15	0
Off Site Administrative Building	4	0
Total	**21**	**0**

Notes:

[a] Dredging would not cause a permanent impact on the base flood elevation because no fill would be placed in the floodplain.

1 acre = 0.405 hectares

[2] LOOP is a private deepwater port operating off the coast of Louisiana. It is operated by Louisiana Offshore Oil Port, Inc., a consortium of oil and gas producers.

Figure B.6.3-1: Proposed Clovelly Storage Site and Associated Facilities

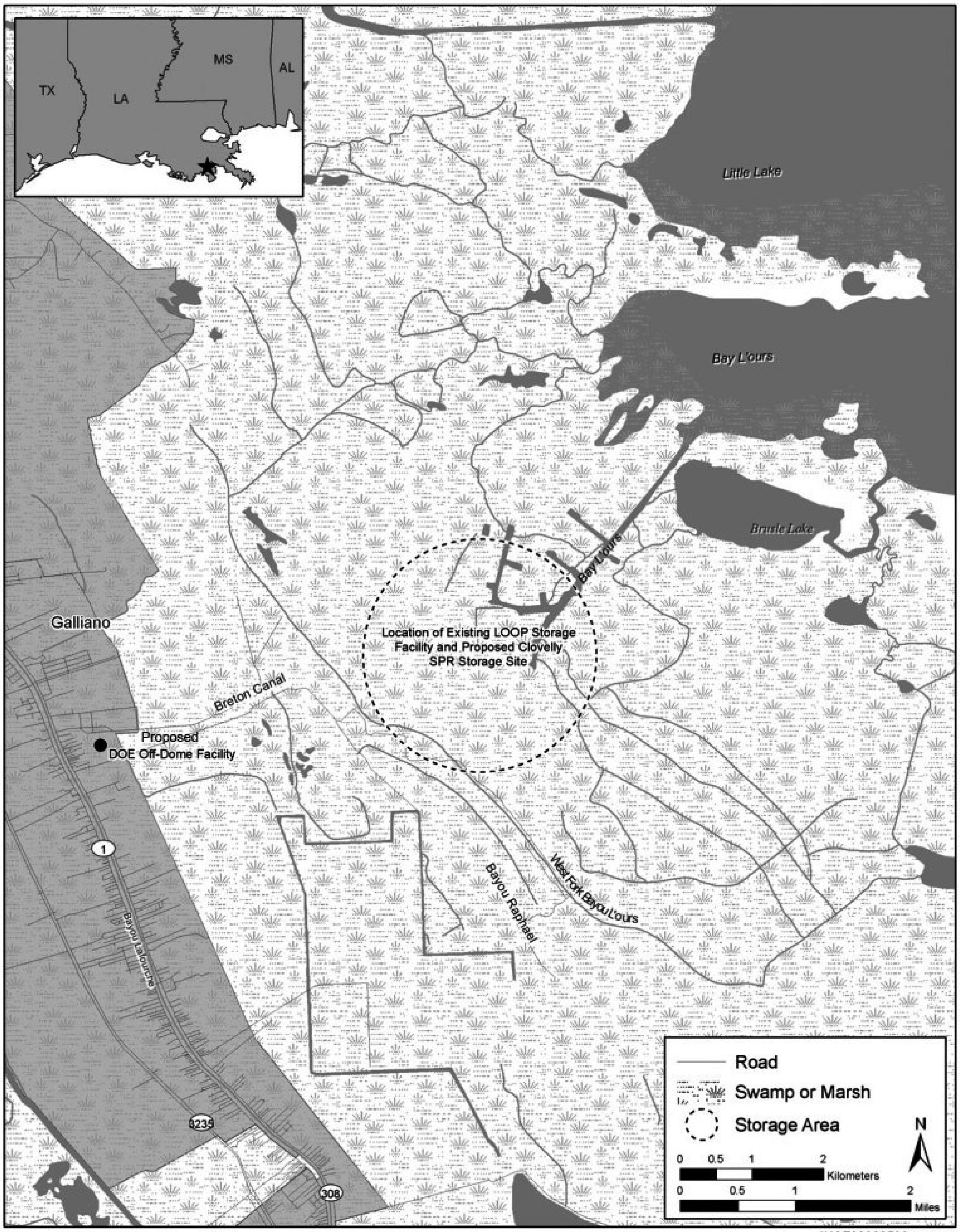

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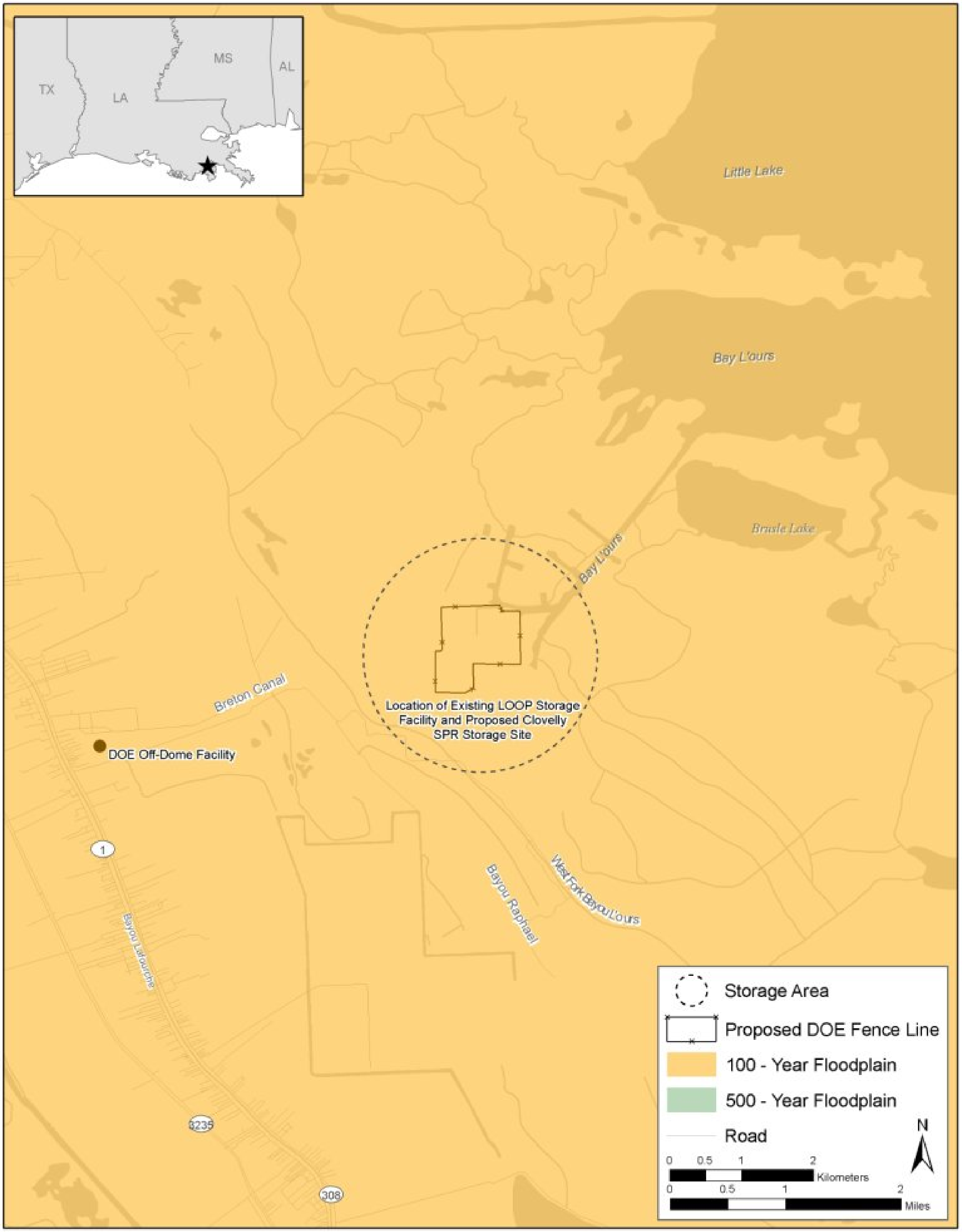
Figure B.6.3-2: Floodplain Map for Proposed Clovelly Storage Site and Associated Facilities



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No new pipelines or power lines would be needed; therefore, no impacts to floodplains would occur from development of ROWs.

The Clovelly storage site would take advantage of most of the existing infrastructure at the LOOP storage facility, reducing the area required for new construction and operations. DOE would construct 16 new caverns as well as a new RWI on a canal within the existing LOOP property boundary. The Clovelly storage site, RWI, and offsite administrative building would affect approximately 21 acres (9 hectares) of 100-year floodplain, including the area required for developing the new caverns and associated infrastructure.

The Clovelly storage site and associated facilities would have a small potential to increase future downstream flooding due to the proposed fill and construction of aboveground structures within the floodplain. The impacts from the storage site are expected to be minimal due to the overall size of the floodplain system, the small amount of aboveground construction, the use of elevated platforms to support most infrastructure, and compliance with local, state, and Federal floodplain regulations. After the selection of an alternative other than no-action and prior to construction, hydrological modeling would be conducted to ensure that base flood elevations would not be increased from the proposed fill/structures.

Any structures located within the floodplain would be designed in accordance with the NFIP requirements for nonresidential buildings and structures located in special flood hazard areas. The NFIP regulations are designed to require vulnerable structures to be constructed above the 100-year flood elevation or to be watertight. DOE would coordinate with the floodplain coordinator at the Louisiana Department of Transportation and Development or the local government, if it has adopted the NFIP program, during the design stage/site plan process.

Due to the location and geology of the salt dome, floodplains could not be avoided by this site development. Proper design and compliance with the required regulatory programs would ensure that floodplain impacts would be minor. DOE has considered the practicable alternatives to placing the storage site in a floodplain and has prepared a conceptual design to minimize the impact on floodplains. Proper design and compliance with the required regulatory programs would reduce the impacts of these structures on floodplains to a level where there would be no significant change in the base flood elevation. Section B.7 discusses in more detail the avoidance and minimization measures that DOE would use to reduce the effects to floodplains located in the project area.

B.6.3.2 Wetland Impacts

The construction and operations and maintenance activities associated with the proposed Clovelly storage site would have temporary and permanent impacts on wetlands as described in the methodology. The entire Clovelly site is located within an area classified as estuarine wetlands by the Cowardin wetland classification. The site consists of maintained open water canals among vegetated dredge spoil piles, which renders the wetland habitat of marginal quality. Most of the wetlands that would be affected have been disturbed by past dredging and have been invaded by exotic species such as the Chinese tallow tree. The aquatic environment is tidally influenced by about one foot. Table B.6.3-2 summarizes the wetlands that would be affected by this site development.

Because existing infrastructure for distribution pipelines, power lines, and brine discharge would be used, construction impacts would be limited to those associated with cavern development and RWI construction.

Table B.6.3-2: Summary of Wetland Impacts for the Proposed Clovelly Storage Site[a]

Cowardin Wetland Classification	Storage Site (acres)		RWI Structure/Access Road (acres)		Totals (acres)
	Filled wetlands	Dredged wetlands	Conversion (platform)	Filled wetlands	All affected wetlands
Estuarine	0	8	0	0	**8**
Other	1	0	1	0	**12**
Totals	**1**	**8**	**1**	**0**	**10**

Notes:

[a] This table presents only the wetland types that are present within the proposed footprint according to NWI data. Facilities were omitted if no wetlands were present within the footprint.

1 acre = 0.405 hectares

The Clovelly area has a long history of oil and gas related activity, which has affected the existing wetlands and open water. DOE would dredge and fill and thereby permanently remove, approximately 10 acres (4 hectares) of estuarine and other wetlands associated with the construction of the 16 new storage caverns and the new RWI structure (see figure B.6.3-3). The RWI structure would be built on a platform over approximately 1 acre (0.4 hectares) of wetlands, which would convert the area to open water. The proposed off-dome administrative facilities would not affect wetlands (see figure B.6.3-4).

Due to the geology and location of the salt dome and the water dependency of the RWI, impacts to wetlands could not be avoided by this site development. All filling of jurisdictional wetlands would require a Section 404/401 permit from the USACE and the Louisiana Coastal Maintenance Division of the Department of Natural Resources. The permit application would require a comprehensive alternatives analysis that demonstrates avoidance and minimization of wetland impacts. The permit would contain conditions to minimize the impact to wetlands during construction and would require compensation for unavoidable impacts to jurisdictional wetlands. Section B.7 discusses in more detail the avoidance, minimization, and mitigation measures that DOE would use to reduce, avoid, and compensate for the potential impacts to jurisdictional wetlands and waters of the United States.

B.6.4 Clovelly and Bruinsburg Storage Sites

Under the Clovelly 80 MMB and Bruinsburg 80 MMB or the Clovelly 90 MMB and Bruinsburg 80 MMB alternatives, the development of the Clovelly site would be similar to the 120 MMB option, except that 12 caverns would be constructed instead of 16 caverns. The 80 or 90 MMB facility layout at Clovelly would have the same construction and operational impacts to wetlands and floodplains and is therefore not discussed separately. The development of the 80 MMB Bruinsburg site would be similar to the 160 MMB site, but 8 not 16 caverns would be constructed. Therefore, fewer brine injection wells and a smaller RWI would be required. Crude oil would be distributed by a new crude oil pipeline to the Vicksburg Entergy plant and a new crude oil pipeline to a terminal in Jackson, MS, rather than to Anchorage, LA, and Peetsville, MS (see figure B.6.4-1). Three maps in an attachment to this appendix show detailed NWI mapped wetlands and the proposed storage sites, ROWs, and associated facilities.

The Clovelly and Bruinsburg sites and infrastructure would consist of the following:

- 12 new caverns at Clovelly and 8 new caverns at Bruinsburg,
- RWI structures at Clovelly and Bruinsburg and associated pipeline,
- Offsite administrative building at Clovelly,
- Crude oil pipeline from Bruinsburg to Vicksburg Entergy plant and a new terminal in Jackson, MS,

Figure B.6.3-3: NWI Wetlands Map for Proposed Clovelly Storage Site

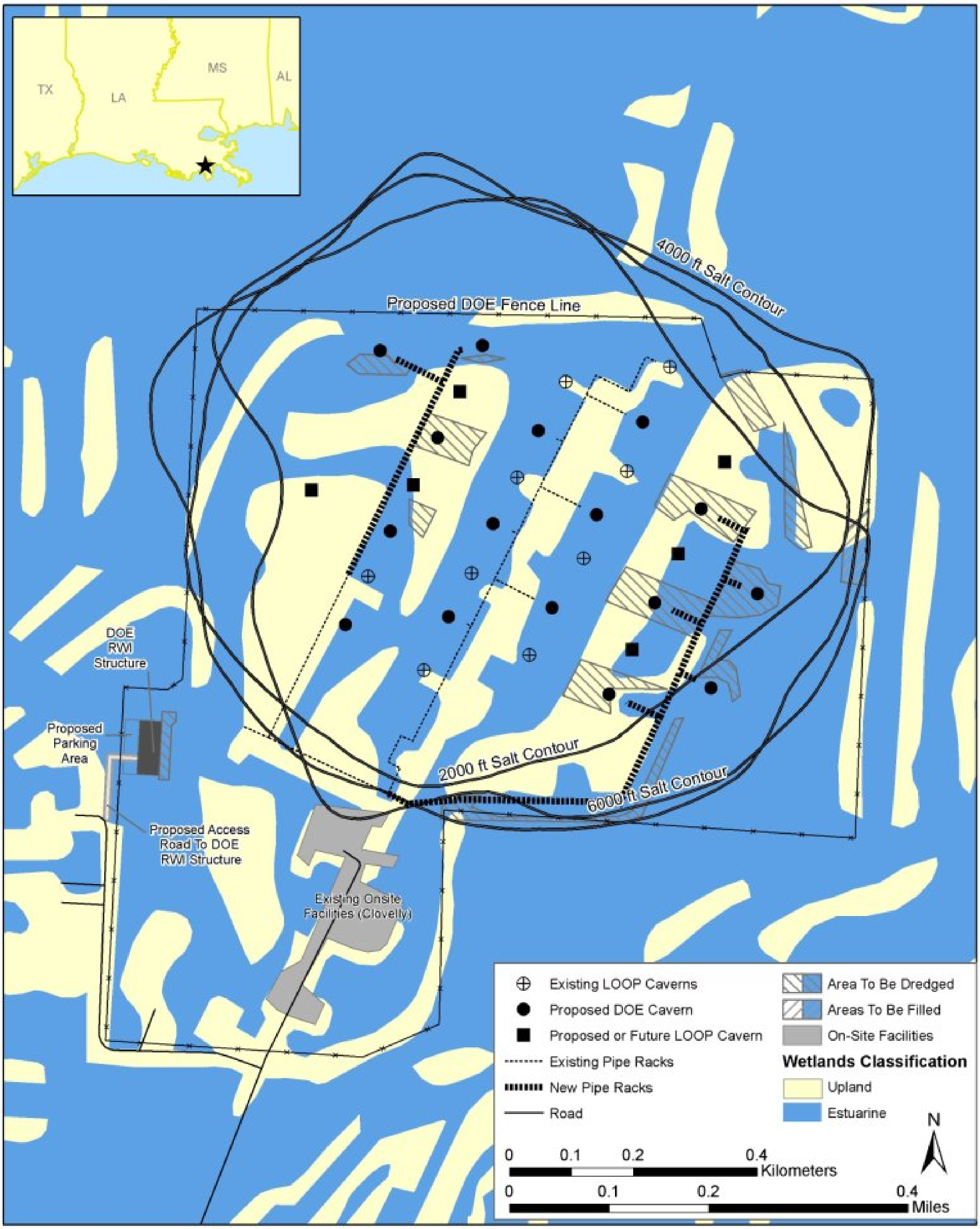

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Figure B.6.3-4: NWI Wetlands Map for the Proposed Off-Dome Administrative Facilities

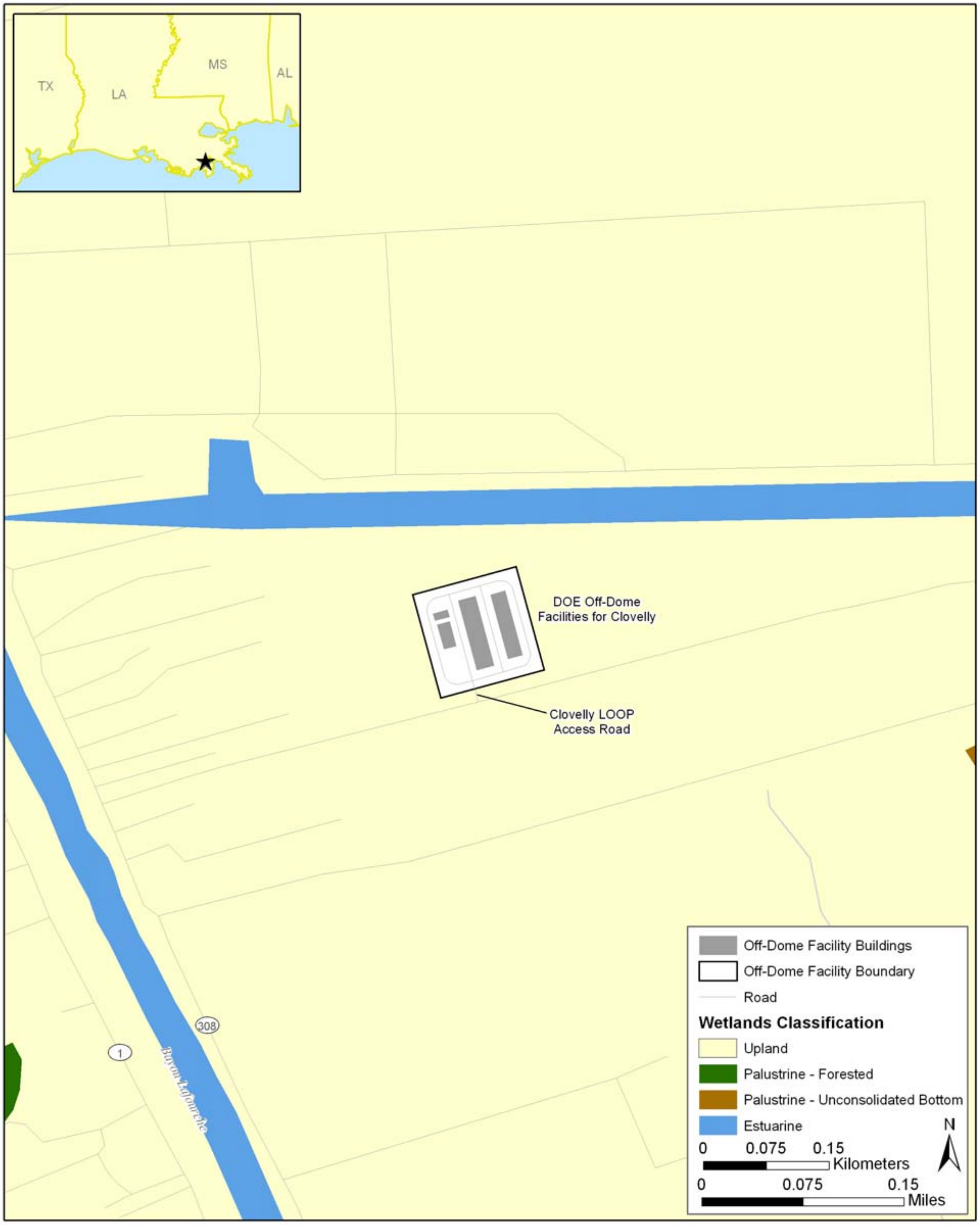

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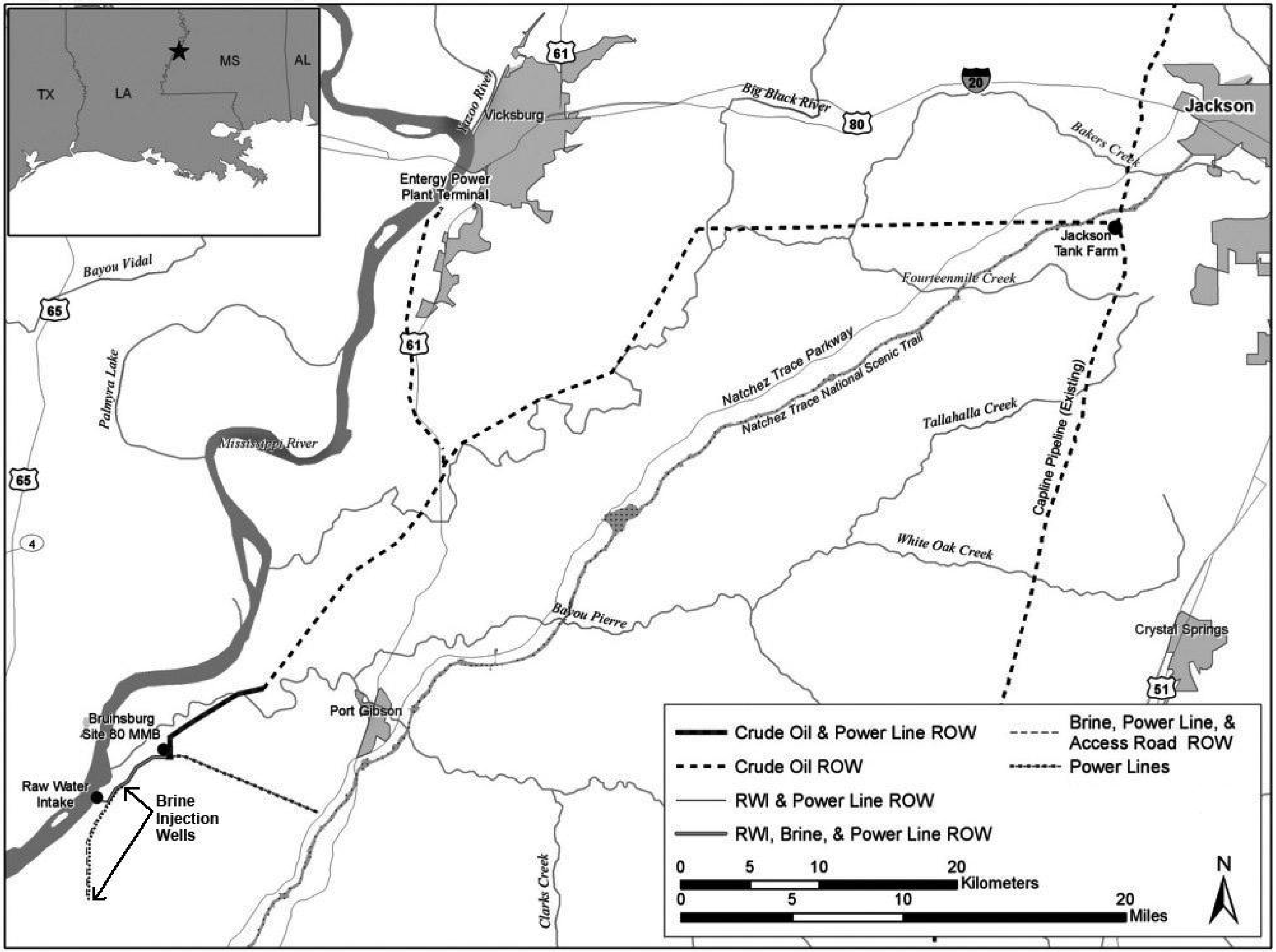
Figure B.6.4-1: Proposed Bruinsburg 80 MMB Storage Site and Associated Facilities



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- 30 brine injection wells and associated pipeline extending southwest from Bruinsburg storage site,
- Power lines associated with the Bruinsburg storage site, and
- A Bruinsburg facility access road and brine well access road.

B.6.4.1 Floodplain Impacts

The extent of 100-year and 500-year floodplain impacts was determined based on the FEMA Flood Insurance Rate Maps covering the project areas. As described under the Bruinsburg 160MMB option, the proposed Bruinsburg storage site is located in a predominantly undeveloped area that has numerous floodplains associated with the Mississippi River and Bayou Pierre and their tributaries (see figure B.5.4-2). Drainage is generally to the west toward the Mississippi River. The proposed Clovelly 80 MMB (or 90 MMB) storage site is located within the developed LOOP storage facility and encompasses portions of the Barataria Bay estuary between the Mississippi River and Bayou Lafourche. Table B.6.4-1 summarizes the floodplains that would be affected by this site development.

Table B.6.4-1: Floodplain Impacts for the Clovelly and Bruinsburg Storage Sites and Associated Facilities

Description	100-Year Floodplain (acres)	500-Year Floodplain (acres)
Bruinsburg storage site/access roads/RWI	62	17
Bruinsburg brine injection wells/access road	27	4
Jackson terminal	1	0
Clovelly	6	0
Total	**101**	**21**

1 acre = 0.405 hectares

The Clovelly and Bruinsburg sites, the terminals, the brine injection wells, access roads, and RWI structures would disturb approximately 101 acres (41 hectares) of 100-year floodplain and 21 acres (9 hectares) of 500-year floodplain.

The Bruinsburg 80 MMB storage site and associated facilities would have the potential to increase future downstream flooding due to proposed fill and construction of aboveground structures within the floodplain. DOE placed most the proposed onsite buildings, including administrative buildings and parking lots, to the east and located them out of the floodplain (figure B.6.4-2). The remaining structures in the floodplain might have the potential to increase downstream flooding; however, the impacts would be expected to be minimal due to the overall size of the floodplain system and compliance with local, state, and Federal floodplain regulations. The proposed Jackson tank farm would affect about 6 acres (2 hectares) of 100-year floodplain (figure B.6.4-3). After selection of an alternative other than no-action and prior to construction, hydrological modeling would be conducted to ensure that base flood elevations would not be increased from the proposed fill/structures.

The Clovelly storage site and associated facilities would have a small potential to increase future downstream flooding due to the proposed construction of aboveground structures within the floodplain. The impacts would be minimal due to the overall size of the floodplain system, the use of elevated platforms for most infrastructure, the small amount of above ground construction, and compliance with local, state, and Federal floodplain regulations. As with the Bruinsburg site, hydrological modeling would be conducted to ensure that base flood elevations are not increased from the proposed fill/structures.

Figure B.6.4-2: Floodplain Map for the Proposed Bruinsburg 80 MMB Storage Site

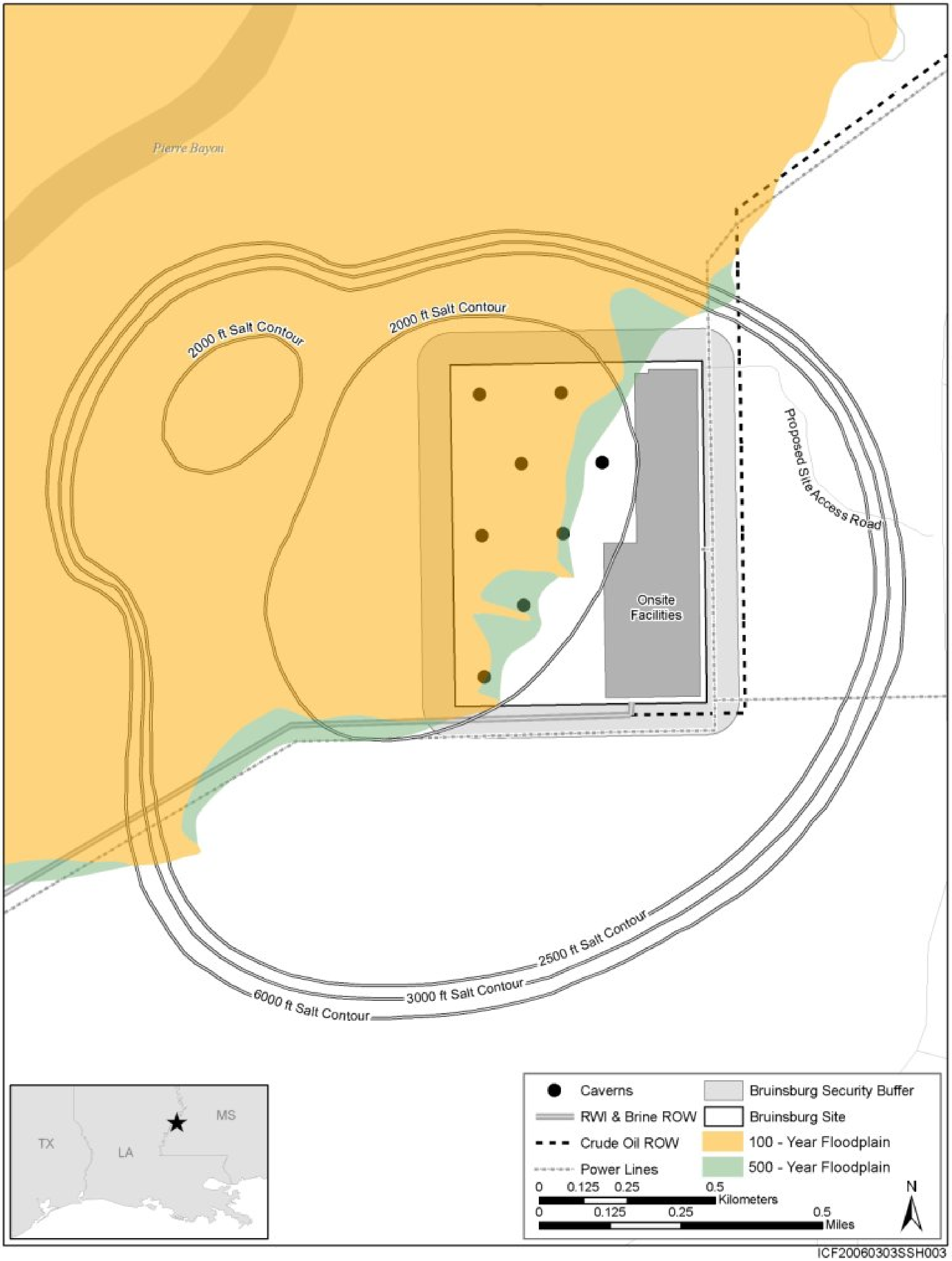
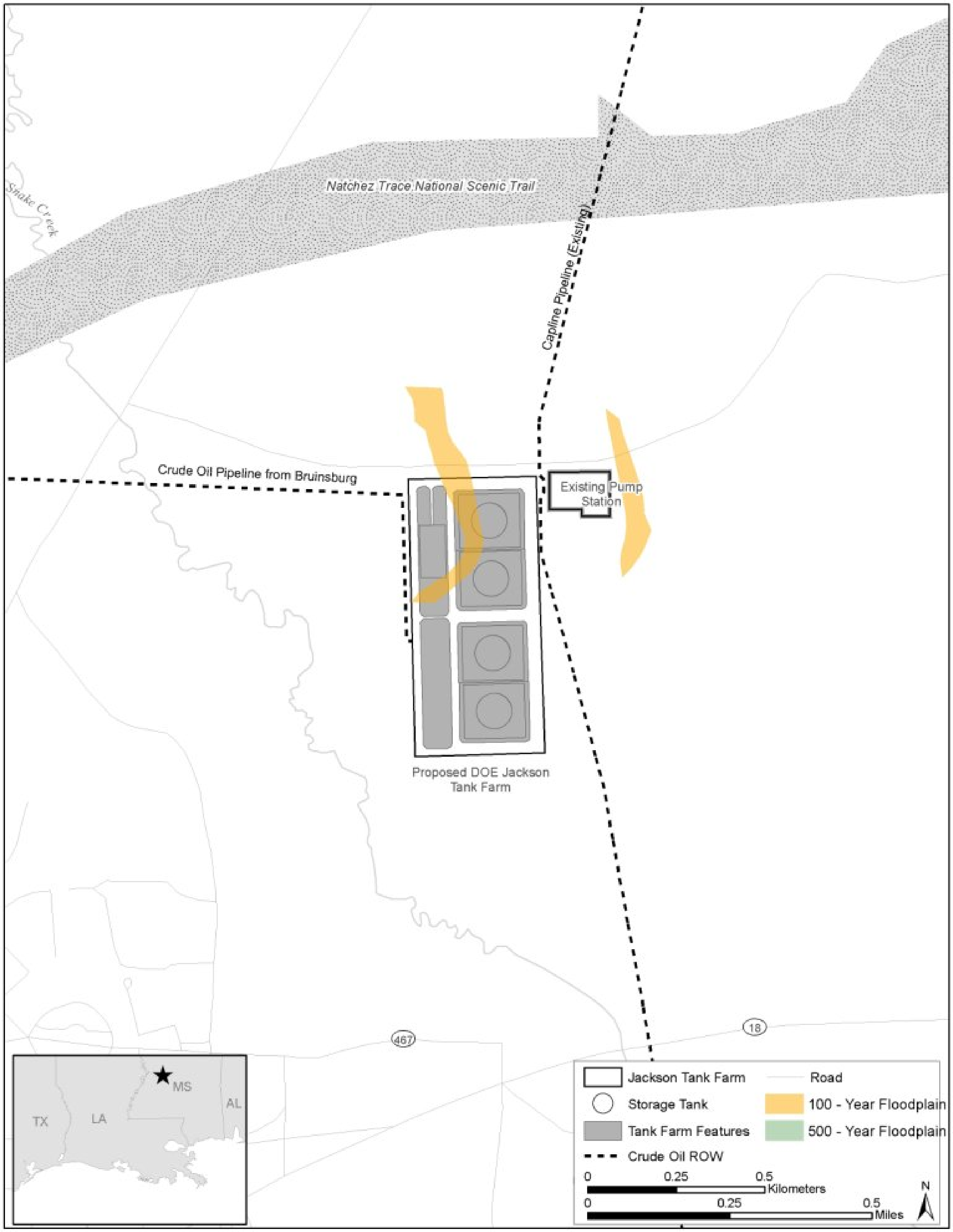


Figure B.6.4-3: Floodplain Map for the Proposed Jackson Tank Farm



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Any structures located within the floodplain would be designed in accordance with the NFIP requirements for nonresidential buildings and structures located in special flood hazard areas. The NFIP regulations are designed to require vulnerable structures to be constructed above the 100-year flood elevation or to be watertight. DOE would coordinate with the state floodplain coordinators or local governments, if they have adopted the NFIP program, during the design state/site plan process.

Pipeline and power line ROWs associated with the Bruinsburg site would cross and potentially affect about 37 miles (60 kilometers) of 100-year floodplain and 4 miles (6 kilometers) of 500-year floodplain. The impacts on floodplains associated with the construction of the Bruinsburg ROWs would be temporary in nature because the preconstruction contours would be re-established and no aboveground fill or structures would exist following the completion of the construction activities. Therefore, no significant increased risk of flooding would be expected from ROW construction because there would be no net loss of flood attenuation capacity compared to the existing conditions. There would be a minor increase in flood stage during the construction activities because some staging materials and construction equipment may be located in the floodplain. Power poles and other associated fill would be located outside of floodplain areas to the maximum extent practical. These structures would not be expected to significantly increase flood stage levels.

Due to the area geology and location of the salt dome, water dependency of the RWI, and the long ROWs, floodplains could not be avoided by this site development. DOE has considered the practicable alternatives to placing the storage sites in floodplains and has prepared a conceptual design to minimize the impact to floodplains. Proper design and compliance with the required regulatory programs would reduce the impacts of these structures on floodplains to a level where there would be no significant change in the base flood elevation. Section B.7 discusses in more detail the avoidance and minimization measures that DOE would use to reduce the effects to floodplains located in the project area.

B.6.4.2 Wetland Impacts

The construction and operations and maintenance of the Clovelly 80 or 90 MMB and Bruinsburg 80 MMB storage sites and associated facilities would have temporary and permanent impacts on wetlands as described in the methodology. Table B.6.4-2 identifies the types of wetlands that would be affected by ROWs and table B.6.4-3 summarizes the wetlands that would be affected by these sites and their infrastructure.

Construction of the Clovelly and Bruinsburg storage sites and associated facilities would affect a total of approximately 534 acres (215 hectares) of wetlands, including 47 acres (19 hectares) of permanent wetland impact due to filling or dredging at the storage sites, Jackson terminal, brine injection field at Bruinsburg, and the RWI. About 16 acres (6 hectares) of palustrine forested wetlands would be converted to emergent wetlands due to the clearing for the security buffer. The permanent fill and conversion of wetlands are associated with the construction of the storage sites, RWIs, terminals, brine injection well pads, and the clearing and maintenance of a 300-foot (91-meter) security buffer around the new Bruinsburg storage site (see figure B.6.4-4). The security buffer would be cleared of woody vegetation and any forested or scrub-shrub wetlands would be converted into emergent wetlands. Periodic maintenance would take place to suppress or clear woody vegetation.

Figure B.6.4-5 shows the NWI mapped wetlands at the proposed Jackson tank farm. Figure B.6.4-6 shows the NWI mapped wetlands at the proposed Clovelly 80 MMB site storage area.

Table B.6.4-2: Wetland Impacts for the Proposed Bruinsburg 80 MMB Storage Site ROWs[a]

Cowardin Wetland Classification	ROW from Site to RWI (acres)		ROW between Brine Injection Wells (acres)		ROW from Site to Vicksburg (acres)		ROW from Vicksburg ROW to Jackson (acres)		Power Line ROWs (acres)	
	Temporary easement	Permanent easement	Temporary easement	Permanent easement	Temporary easement	Permanent easement	Temporary easement	Permanent easement	Temporary easement	Permanent easement
Lacustrine[c]	0	0	0	0	8	4	0	0	NA	0
Palustrine – aquatic bed[c]	0	0	0	0	1	0	0	0	NA	0
Palustrine – emergent	0	0	0	0	3	1	1	0	NA	0
Palustrine – forested[b]	40	26	20	10	68	42	110	54	NA	38
Palustrine – scrub-shrub[b]	2	1	0	0	0	0	0	0	NA	1
Palustrine – open water[c]	0	0	0	0	0	0	2	1	NA	0
Palustrine – unconsolidated bottom[c]	0	0	0	0	1	1	3	1	NA	0
Riverine[c]	1	1	0	0	2	1	2	1	NA	0
Other	0	0	1	0	11	7	0	0	NA	1
Totals	**43**	**28**	**21**	**10**	**94**	**56**	**118**	**57**	**NA**	**40**

Notes:

[a] This table presents only the wetland types that are present within the ROW according to NWI data. No new ROW would be needed at the Clovelly site.

[b] Forested and scrub-shrub wetlands would be cleared of woody vegetation and permanently converted to and maintained as emergent wetlands within the permanent easement of all ROWs. Within the temporary construction easement, woody vegetation would be cleared but would be allowed to re-establish within the easement. DOE would follow any required wetland compensation for these temporary impacts that is required by the Section 404/401 permit. At a minimum, DOE would restore original contours, replace the original hydric topsoil back in the disturbed area, and seed with native species. Re-establishment of the scrub-shrub or forested wetland may take 5-25 years depending on the type of community affected.

[c] Impacts to these wetlands would be temporary and they would return to the pre-existing conditions shortly after construction is completed.

1 acre = 0.405 hectares; NA means no temporary easement

Table B.6.4-3: Summary of Wetland Impacts for the Proposed Clovelly and Bruinsburg Storage Sites[a]

Cowardin Wetland Classification	**Storage Sites (acres)**		**ROWs[b] (acres)**		**RWI Structures (acres)**	**Jackson Terminal (acres)**	**Brine Injection Wells (acres)**	**Totals (acres)**
	Filled/dredged wetlands	**Permanent conversion**	**Temporary easement**	**Permanent easement**	**Filled wetlands**	**Filled wetlands**	**Filled wetlands**	**All affected wetlands**
Estuarine	3	0	0	0	0	**0**	**0**	**3**
Lacustrine	0	0	8	4	0	**0**	**0**	**12**
Palustrine – aquatic bed	0	0	1	0	0	**0**	**0**	**1**
Palustrine - emergent	0	0	4	1	0	**0**	**0**	**5**
Palustrine – forested	20	16	238	170	0	**10**	**12**	**466**
Palustrine – scrub-shrub	0	0	2	2	0	**0**	**0**	**4**
Palustrine – open water	0	0	2	1	0	**0**	**0**	**3**
Palustrine – unconsolidated bottom	0	0	4	2	0	**1**	**0**	**7**
Riverine	0	0	5	3	0	**0**	**0**	**8**
Other	0	0	12	8	1	**0**	**0**	**21**
Totals	**23**	**16**	**276**	**191**	**1**	**11**	**12**	**530**

Notes:

[a] This table presents only the wetland types that are present within the proposed footprint according to NWI data. Facilities were omitted if no wetlands were present within the footprint.

[b] Forested and scrub-shrub wetlands would be cleared of woody vegetation and permanently converted to and maintained as emergent wetlands within the permanent easement of all ROWs. Within the temporary construction easement, woody vegetation would be cleared but would be allowed to re-establish within the easement. DOE would follow any required wetland compensation for these temporary impacts that is required by the Section 404/401 permit. At a minimum, DOE would restore original contours, replace the original hydric topsoil back in the disturbed area, and seed with native species. Re-establishment of the scrub-shrub or forested wetland may take 5-25 years depending on the type of community affected. Impacts to these wetlands would be temporary and they would return to the pre-existing conditions shortly after construction is completed.

1 acre = 0.405 hectares

Figure B.6.4-4: NWI Wetlands at the Proposed Bruinsburg 80 MMB Storage Site

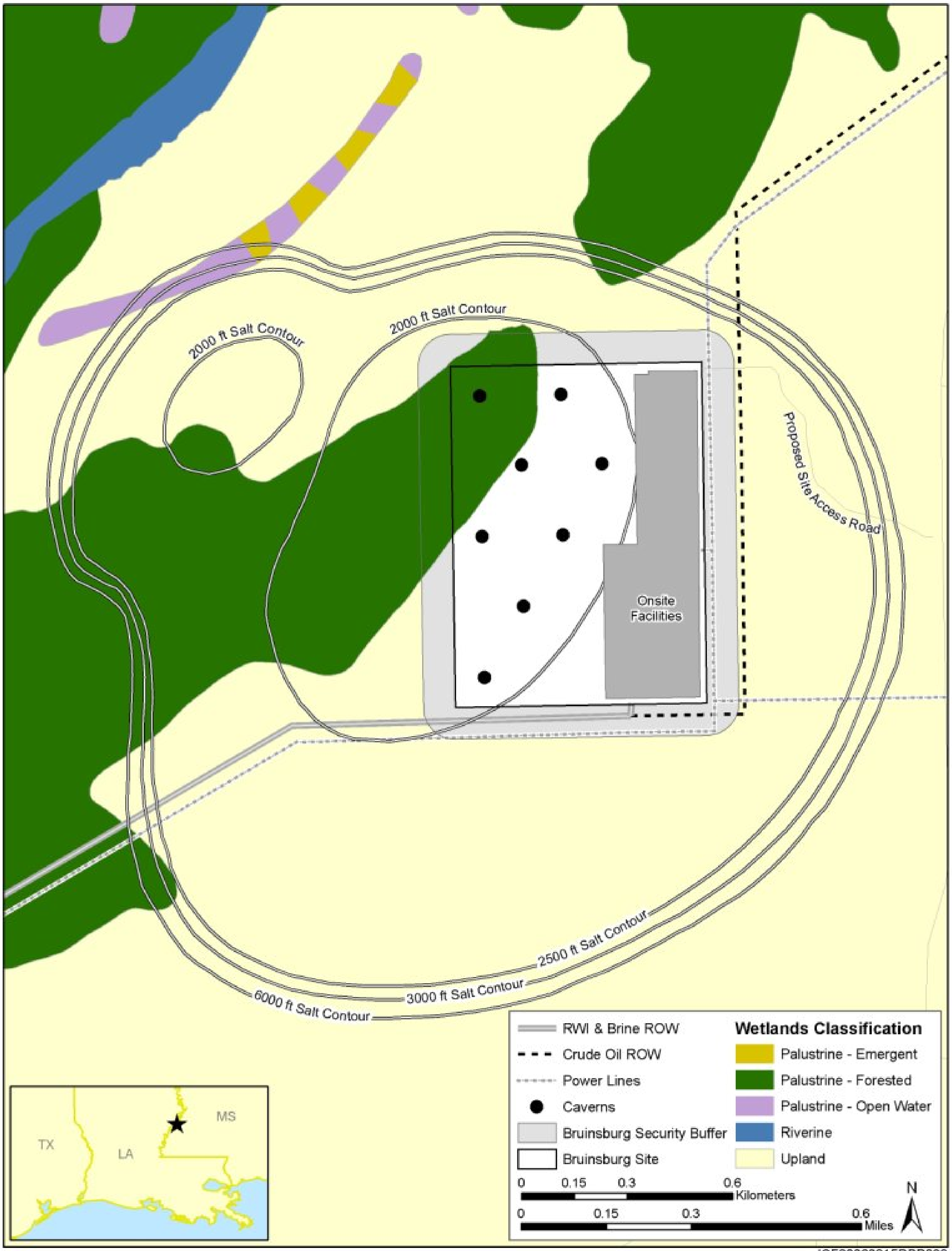

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Figure B.6.4-5: NWI Wetlands at the Proposed Jackson Tank Farm

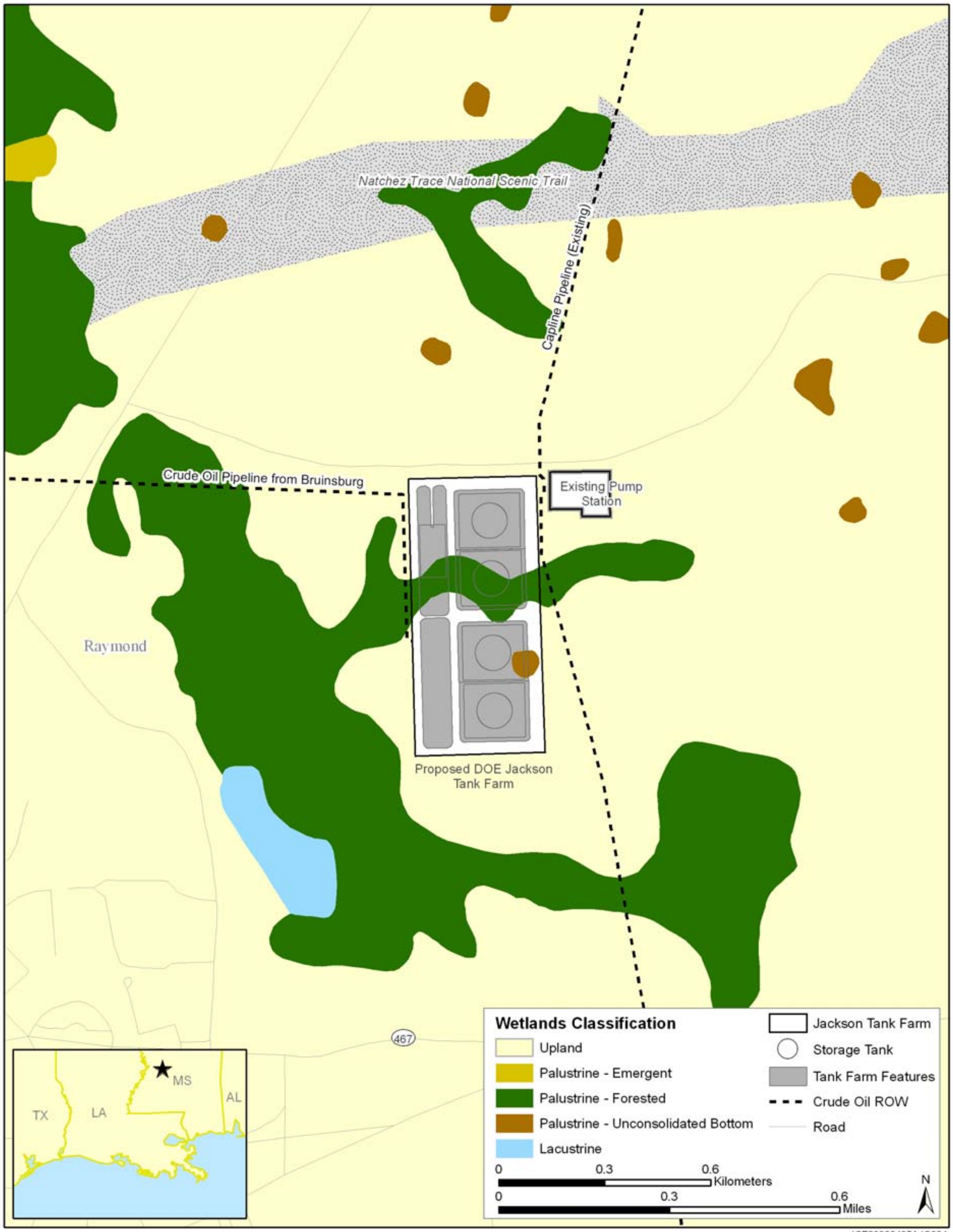
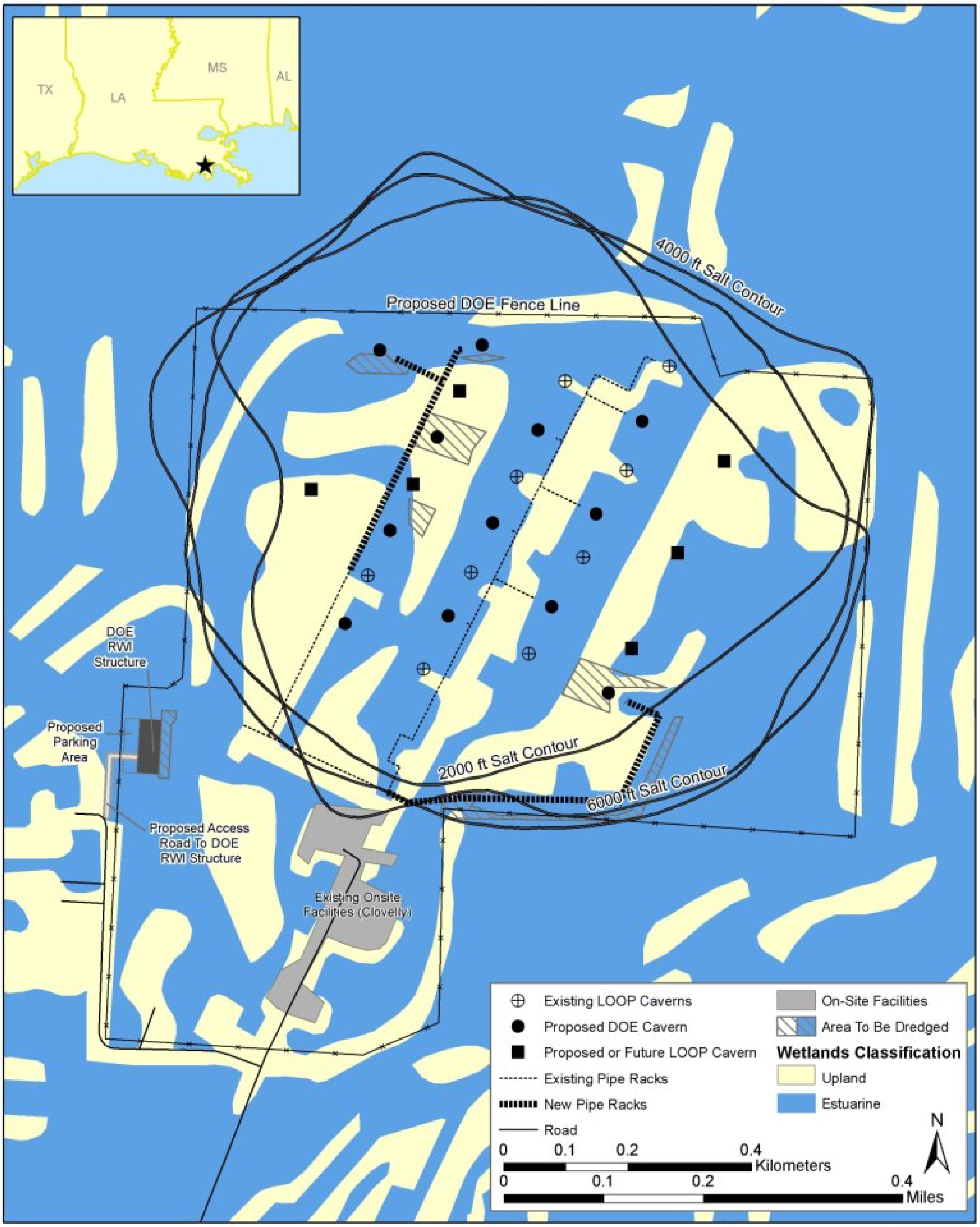


Figure B.6.4-6: NWI Wetlands at the Proposed Clovelly 80 MMB Storage Site



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The power line and pipeline ROWs associated with the Bruinsburg 80 MMB storage site would cross and permanently or temporarily affect a total of approximately 467 acres (189 hectares) of wetlands. No new ROWs would be needed for the Clovelly site. Table B.6.4-2 provides a summary of the wetland impacts per ROW that would result from this alternative. Construction of the ROWs would affect 276 acres (112 hectares) of wetland within the permanent easement and 191 acres (78 hectares) within the temporary easement. Pre-existing contours would be restored and the some affected vegetative communities would be allowed to re-establish depending on location within the temporary and permanent easement. DOE would promote the growth of emergent or forested vegetation in the temporary construction easement. The impacts to wetlands within the temporary easement would last between 2 to 3 years for emergent wetlands and at least 10 to 25 years for forested wetlands. DOE would suppress regrowth of woody vegetation within the permanent easement to protect pipelines and to allow overflight inspections. Therefore, forested and scrub-shrub wetlands in these areas would be permanently converted to emergent wetlands. Although the converted wetlands would provide different habitat than before construction, other important wetland functions, such as flood storage and nutrient filtration, would be maintained within the emergent wetland. DOE would compensate for the permanent impacts on jurisdictional wetlands that are unavoidable by this alternative and would monitor the areas of temporary and permanently converted wetlands to ensure that wetland hydrology and wetland plants are re-established.

The Clovelly and Bruinsburg option, which includes the storage sites, the associated facilities, and ROWs, would affect a total of approximately 530 acres (215 hectares) of wetlands associated with the filling activities required for new structures and facilities and temporary and permanent clearing for new power lines and pipelines. The construction activities would permanently fill approximately 47 acres (19 hectares) of wetlands associated with the storage sites, RWI, access road and brine injection wells, including ecologically important bald cypress forest. The impact on this relatively rare and important type of forested wetlands at the proposed Bruinsburg storage site would be a potential adverse effect, which would be mitigated by the compensation plan for jurisdictional wetland impacts.

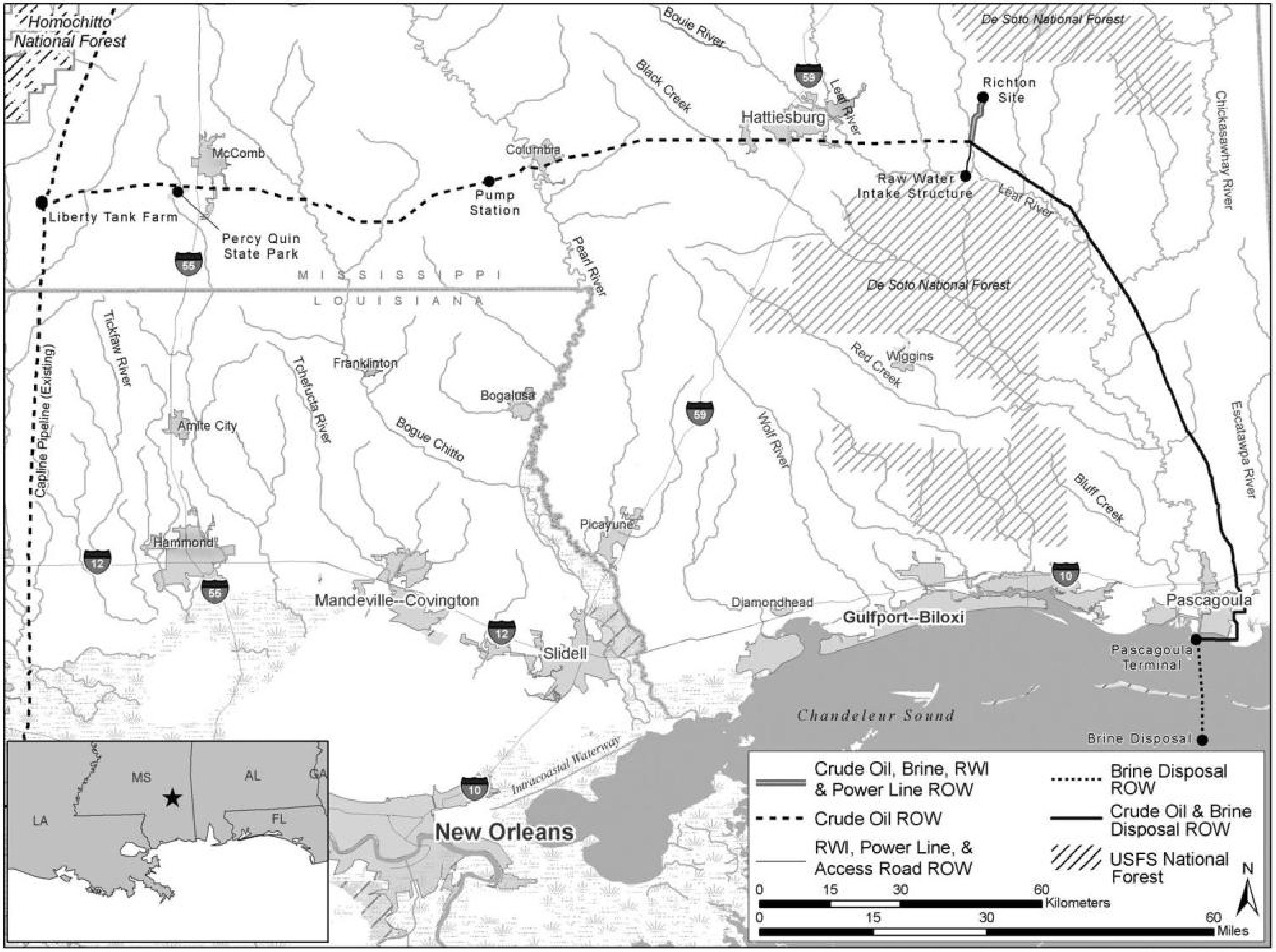
Due to the geology and location of the salt dome, the water dependency of the RWI, and the long ROWs, impacts on wetlands and waters of the United States could not be avoided by this side development. All filling of and discharge to jurisdictional wetlands would require a Section 404/401 permit from the USACE and the Mississippi Department of Environmental Quality and the Louisiana Department of Environmental Quality. The permit application would require a comprehensive alternatives analysis that demonstrates avoidance and minimization of wetland impacts. The permit would contain conditions to minimize the impact on wetlands during construction and would require compensation for unavoidable impacts to jurisdictional wetlands. Section B.7 discusses in more detail the avoidance, minimization, and mitigation measures that DOE would use to reduce, avoid, and compensate for the potential impacts to jurisdictional wetlands and waters of the United States.

B.6.5 Richton Storage Site and Associated Infrastructure

The Richton salt dome is located in Perry County, MS, 18 miles (29 kilometers) east of Hattiesburg and 3 miles (4.8 kilometers) northwest of the town of Richton (figure B.6.5-1). This proposed new site would consist of 16 new caverns with a combined capacity of 160 MMB. The Richton storage site and associated facilities would consist of the following:

- Sixteen new caverns,
- New RWI on the Leaf River,
- RWI pipeline from the Richton site to the RWI,
- Crude oil pipeline to Liberty, MS,
- Two, dual-purpose crude oil/brine pipelines to Pascagoula, MS,

Figure B.6.5-1: Proposed Richton Storage Site and Associated Facilities



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- Pascagoula and Liberty terminals,
- Power lines,
- New site access roads and RWI access road, and
- Brine disposal pipeline from Pascagoula to the Gulf of Mexico.

Eight maps for the Richton 160 MMB storage site and infrastructure are included in an attachment to this appendix. They show detailed NWI mapped wetlands.

B.6.5.1 Floodplain Impacts

The extent of 100-year and 500-year floodplain was determined based on the FEMA Flood Insurance Rate Maps covering the project area. The proposed Richton storage site is currently an active pine plantation. It has an intermittent stream that drains the site and runs south to Pine Branch. The proposed storage site is not located within the 100-year or 500-year floodplain (see figure B.6.5-2). All 63 acres (26 hectares) of the Pascagoula terminal would be located within a 100-year floodplain (figure B.6.5-3).

Some of the proposed pipeline ROWs would be located within floodplains. The associated power line and pipeline ROWs would cross and temporarily affect approximately 27 miles (43 kilometers) of 100-year floodplain and 3 miles (5 kilometers) of 500-year floodplain. The pipelines would intersect several floodplains associated with various streams mostly in the Pascagoula or Pearl River drainage system. The impacts on floodplains associated with the construction of the ROWs would be temporary because the preconstruction contours would be re-established and no aboveground fill or structures would exist following the completion of the construction activities. No significant increased risk of flooding would be expected from ROW construction because no net loss of flood attenuation capacity would occur compared to the existing conditions. There would be a potential minor increase in flood stage during the construction activities because some staging materials and construction equipment may be located in floodplains. Power poles and other associated fill would be located outside of floodplain areas to the maximum extent practical. These structures would not be expected to significantly increase flood stage levels.

Due to the geology and location of the salt dome, the water dependency of the RWI, and the long ROWs, floodplains could not be completely avoided with this site development. Proper design and compliance with the local, state, and Federal regulatory programs would reduce the impacts to floodplains to a level where there would be no significant change in the base flood elevation. All disturbed areas within the floodplains would be restored to preconstruction contours. Section B.7 discusses in more detail the avoidance and minimization measures that DOE would use to reduce the effects to floodplains in the project area.

B.6.5.2 Wetland Impacts

The wetlands at the proposed Richton storage site are palustrine forested wetlands comprised of 15 to 20 year-old deciduous hardwoods, and are associated with a small intermittent stream originating on the site. In addition, a small area of palustrine forested wetlands is located adjacent to a small manmade pond along the western edge of the proposed site. Because the proposed Richton storage site is a managed pine plantation, harvesting of the pine trees continuously disturbs the small wetland area. These wetlands provide limited wildlife habitat and assist in filtering nutrients and runoff from the harvested/cleared areas.

Figure B.6.5-2: Floodplain Map for the Proposed Richton Storage Site

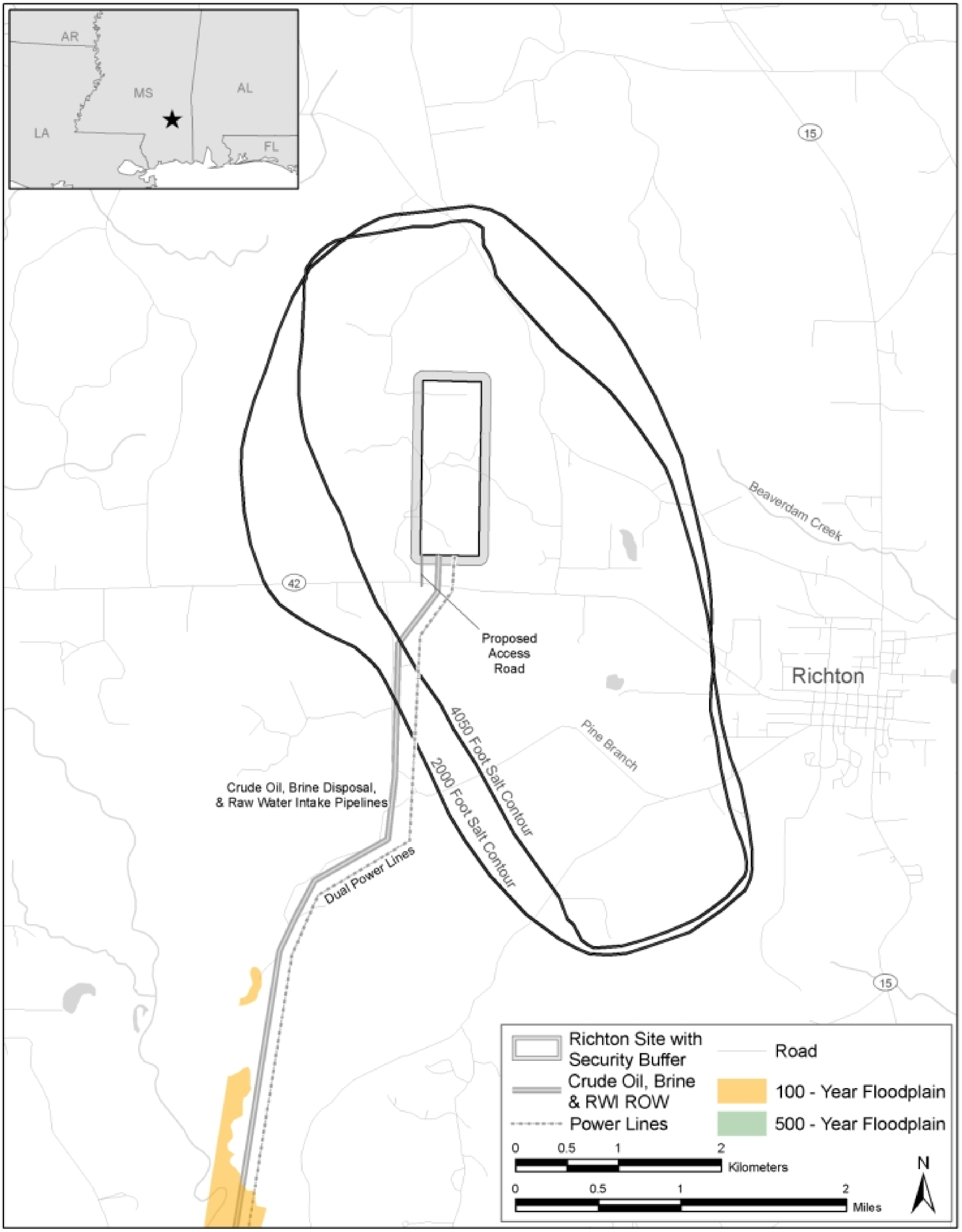

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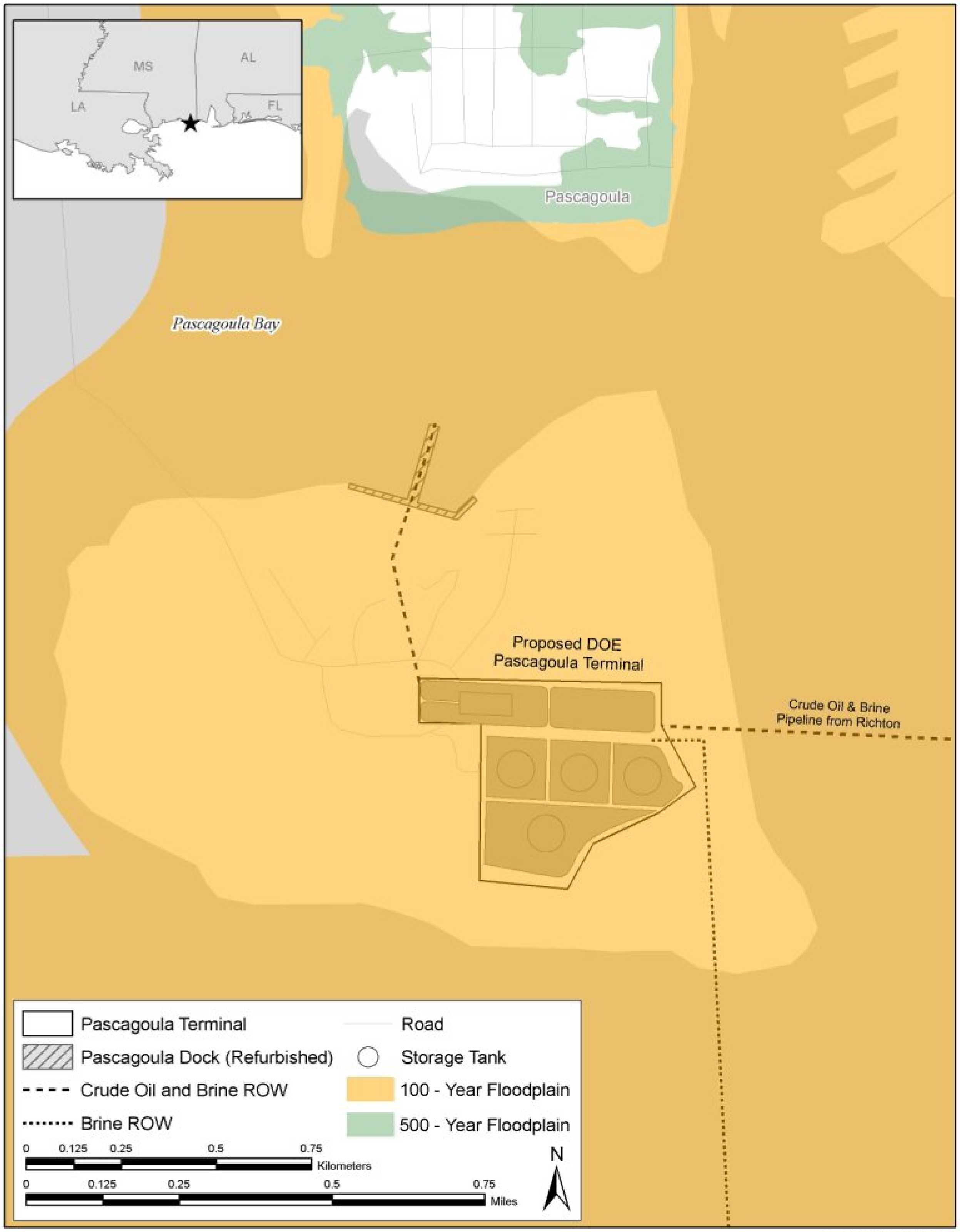
Figure B.6.5-3: Floodplain Map of the Proposed Pascagoula Terminal



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Construction of the Richton storage site and associated facilities would affect about 53 acres (21 hectares) of wetlands. The permanent fill and conversion of wetlands are associated with the construction of the storage site, terminal, RWI, and maintenance of security buffers around the new facilities (see figure B.6.5-4). Most of the wetland impacts (35 acres [14 hectares]) are associated with the proposed terminal in Pascagoula, which is located on an island created by USACE dredging activities (figure B.6.5-5). The maintenance of the security buffer around the storage facility would permanently convert about 2 acres (0.8 hectares) of forested wetlands to emergent wetlands. The security buffer would require the clearing of woody vegetation and periodic maintenance to suppress or clear woody species. The proposed Liberty terminal would affect 2 acres (0.8 hectares) of wetlands (figure B.6.5-6).

The power line and pipeline ROW associated with the Richton storage site would cross and permanently or temporarily affect 1,252 acres (507 hectares) of wetlands. Table B.6.5-1 summarizes the wetland impacts per ROW that would result from this alternative. Construction of the ROWs would affect 467 acres (189 hectares) of wetland within the permanent easement and 785 acres (318 hectares) of wetland within the temporary easement. Pre-existing contours would be restored and some affected vegetative communities would be allowed to re-establish depending on the location within the temporary and permanent easement. The impacts to wetlands within the temporary easement would last between 2 to 3 years for emergent wetlands and 10 to 25 years for forested wetlands. DOE would suppress the growth of woody vegetation within the permanent easement to protect pipelines and to allow weekly overflight inspections. Therefore, forested and scrub-shrub wetlands in these areas would be permanently converted to emergent wetlands. Although, the converted wetlands would provide different habitat than before construction, other important wetland functions, such as flood storage and nutrient filtration, would be maintained within the emergent wetland.

The entire Richton storage site and associated facilities, which include the site, the terminals, RWI, and ROWs, would affect approximately 1,305 acres (529 hectares) of wetlands associated with the filling activities required for new structures and facilities and temporary and permanent clearing for new power lines and pipelines. The construction activities would permanently fill approximately 49 acres (20 hectares) of wetlands associated with the construction the storage site, RWI, and terminals. The proposed ROW would result in the clearing of about 786 acres (318 hectares) of palustrine forested wetlands, including 467 acres (189 hectares) within the permanent easement. This would be a potential adverse effect because of the regional and ecological importance of this wetland type (see table B.6.5-2).

Due to the geology and the location of the salt domes, the long ROWs, and the water dependency of the RWI structure, impacts to wetlands and waters of the United States would be unavoidable for this site development. All filling of and discharge to jurisdictional wetlands would require a Section 404/401 permit from the USACE and the Mississippi Department of Environmental Quality. The permit application would require a comprehensive alternatives analysis that demonstrates avoidance and minimization of wetland impacts. The permit would contain conditions to minimize the impact on wetlands during construction and would require compensation for unavoidable impacts to jurisdictional wetlands. Section B.7 discusses in more detail the avoidance, minimization, and mitigation measures that DOE would use to reduce, avoid, and compensate for the potential impacts to jurisdictional wetlands and waters of the United States.

Figure B.6.5-4: NWI Wetlands at the Proposed Richton Storage Site

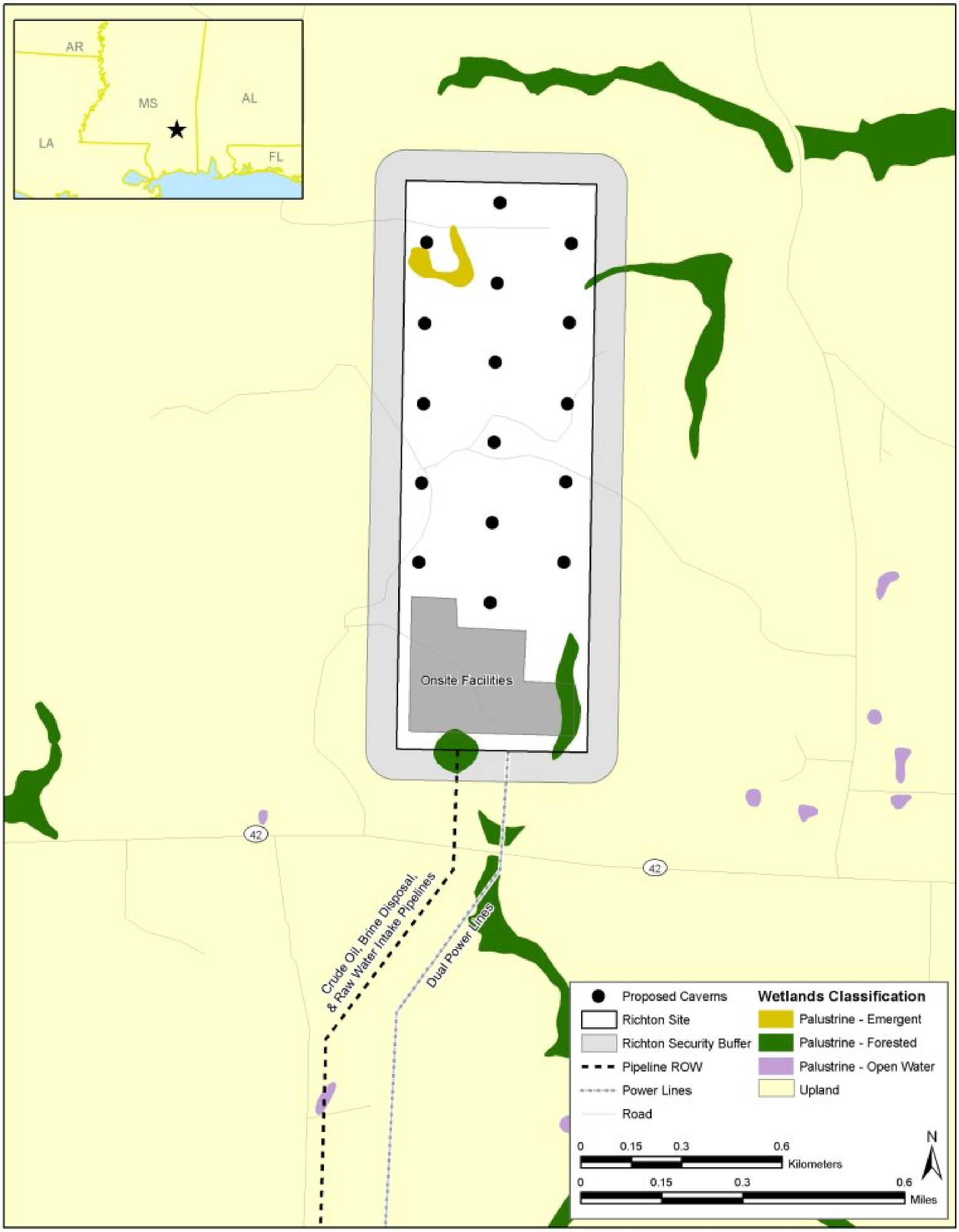

Figure B.6.5-5: NWI Wetlands at the Proposed Pascagoula Terminal

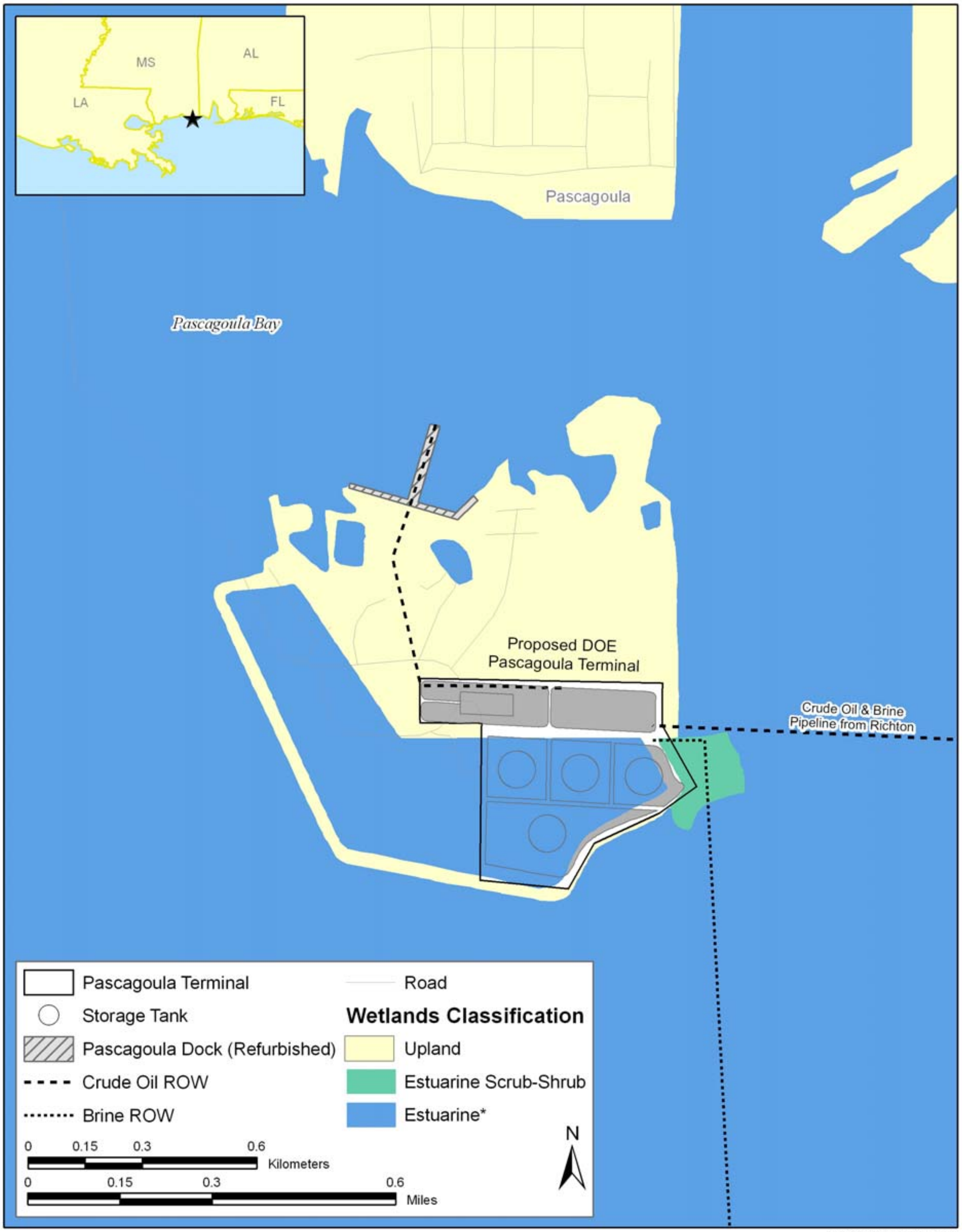

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Figure B.6.5-6: NWI Wetlands at the Proposed Liberty Tank Farm

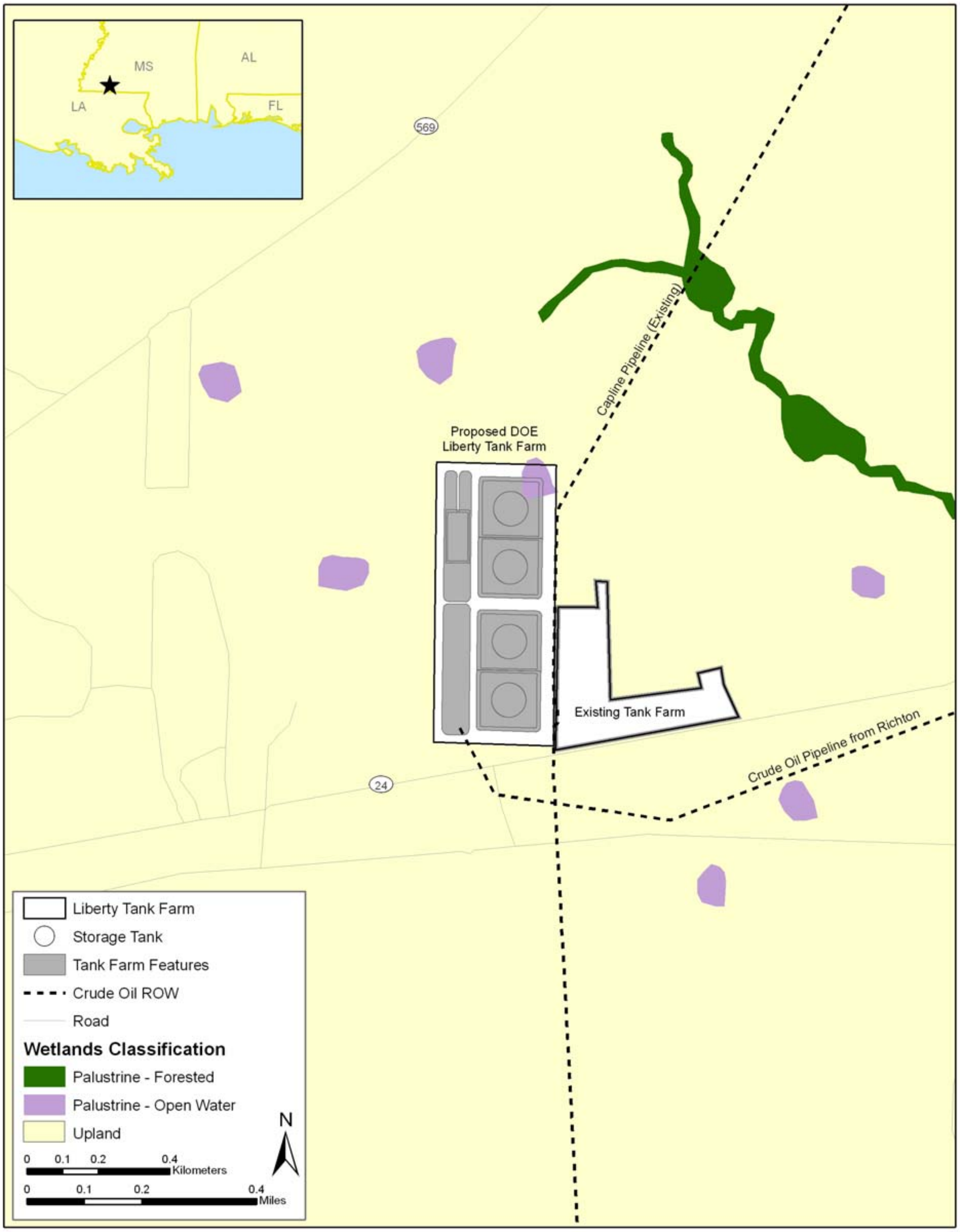

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Table B.6.5-1: Wetland Impacts for the Proposed Richton Storage Site ROWs[a]

Cowardin Wetland Classification	ROW from site to RWI (acres)		ROW from RWI ROW to Pascagoula terminal (acres)		ROW from RWI ROW to Liberty terminal (acres)		Power Line ROWs (acres)	
	Temporary easement	Permanent easement	Temporary easement	Permanent easement	Temporary easement	Permanent easement	Temporary easement	Permanent easement
Estuarine	0	0	94	62	0	0	NA	0
Estuarine – scrub-shrub	0	0	2	1	0	0	NA	0
Lacustrine	0	0	11	8	0	0	NA	0
Palustrine – aquatic bed	0	0	1	1	0	0	NA	0
Palustrine – emergent	0	0	24	16	0	0	NA	0
Palustrine – forested[b]	18	12	392	191	87	43	NA	43
Palustrine – scrub-shrub[b]	0	0	109	71	2	1	NA	0
Palustrine – open water	1	1	6	1	4	2	NA	0
Palustrine – unconsolidated bottom	0	0	13	3	9	4	NA	3
Riverine	0	0	5	1	4	2	NA	0
Other	1	0	1	0	1	0	NA	1
Totals	**20**	**13**	**658**	**355**	**107**	**52**	**NA**	**47**

Notes:

[a] This table presents only the wetland types that are present within the ROW according to NWI data.

[b] Forested and scrub-shrub wetlands would be cleared of woody vegetation and permanently converted to and maintained as emergent wetlands within the permanent easement of all ROWs. Within the temporary construction easement, woody vegetation would be cleared but would be allowed to re-establish within the easement. DOE would follow any required wetland compensation for these temporary impacts that is required by the Section 404/401 permit. At a minimum, DOE would restore original contours, replace the original hydric topsoil back in the disturbed area (where practical), and seed with native species. Re-establishment of the scrub-shrub or forested wetland may take 5-25 years depending on the type of community affected.

[c] Impacts to these wetlands would be temporary and they would return to the pre-existing conditions shortly after construction is completed.

1 acre = 0.405 hectares; NA means no temporary easement

Table B.6.5-2: Summary of Wetland Impacts for the Proposed Richton Storage Site[a]

Cowardin Wetland Classification	Storage Site (acres)		ROWs[b] (acres)		RWI Structure (acres)	Liberty Terminal	Pascagoula Terminal (acres)	Totals (acres)
	Filled wetlands	Permanent conversion	Temporary easement	Permanent easement	Filled wetlands	Filled wetlands	Filled wetlands	All affected wetlands
Estuarine	0	0	94	62	0	0	34	**190**
Estuarine – scrub-shrub	0	0	2	1	0	0	1	**4**
Lacustrine	0	0	11	8	0	0	0	**19**
Palustrine – aquatic bed	0	0	1	1	0	0	0	**2**
Palustrine - emergent	3	0	24	16	0	0	0	**43**
Palustrine – forested	6	2	497	289	5	0	0	**799**
Palustrine – scrub-shrub	0	0	111	72	0	0	0	**183**
Palustrine – open water	0	0	11	4	0	2	0	**16**
Palustrine – unconsolidated bottom	0	0	22	10	0	0	0	**32**
Riverine	0	0	9	3	0	0	0	**12**
Other	0	0	3	2	0	0	0	**5**
Totals	**9**	**2**	**785**	**467**	**5**	**2**	**35**	**1,305**

Notes:

[a] This table presents only the wetland types that are present within the ROW according to NWI data.

[b] Forested and scrub-shrub wetlands would be cleared of woody vegetation and permanently converted to and maintained as emergent wetlands within the permanent easement of all ROWs. Within the temporary construction easement, woody vegetation would be cleared but would be allowed to re-establish within the easement. DOE would follow any required wetland compensation for these temporary impacts that is required by the Section 404/401 permit. At a minimum, DOE would restore original contours, replace the original hydric topsoil back in the disturbed area, and seed with native species. Re-establishment of the scrub-shrub or forested wetland may take 5-25 years depending on the type of community affected. Impacts to these wetlands would be temporary and they would return to the pre-existing conditions shortly after construction is completed.

1 acre = 0.405 hectares

B.6.6 Stratton Ridge Storage Site and Associated Infrastructure

The Stratton Ridge salt dome is located in Brazoria County, TX, 3.0 miles (4.8 kilometers) east of Clute and Lake Jackson and 6.0 miles (9.7 kilometers) north of Freeport (figure B.6.6-1). This proposed site would consist of 16 new caverns with a combined storage capacity of 160 MMB. Two maps of the Stratton Ridge 160 MMB storage site and infrastructure, included as an attachment to this appendix, show the NWI mapped wetlands.

The Stratton Ridge storage would consist of the following:

- Sixteen new caverns and associated storage site infrastructure,
- New RWI structure and associated pipeline,
- One new terminal at Texas City,
- New crude oil pipeline to the Texas City terminal,
- Brine disposal pipeline to offshore diffuser in Gulf of Mexico,
- Power lines, and
- New access roads to the facility and to the brine injection wells.

B.6.6.1 Floodplain Impacts

The extent of 100-year and 500-year floodplain was determined based on the FEMA Flood Insurance Rate Maps covering the project area. The new storage facilities are located entirely within the 100-year and 500-year floodplains (see figure B.6.6-2 and B.6.6-3). The proposed Texas City tank farm would be located entirely in a 100-year floodplain (figure B.6.6-4). Table B.6.6-1 summarizes the floodplains that would be affected by this storage site and associates facilities.

Table B.6.6-1: Floodplain Impacts for the Stratton Ridge Storage Site and Associated Facilities

Description	100-Year Floodplain (acres)	500-Year Floodplain (acres)
Storage site/access road	86	186
RWI structure	1	0
Texas City tank farm	37	0
Total	**124**	**186**

1 acre = 0.405 hectares

The proposed Stratton Ridge storage site lies completely within the 100-year and 500-year floodplains. All onsite construction, therefore, would be within either a 100-year or a 500-year floodplain. This floodplain is large, extending over hundreds of square miles (square kilometers) and is part of the San Jacinto-Brazos Coastal Basin. Construction of the storage site would disturb approximately 124 acres (50 hectares) of 100-year floodplain and 186 acres (75 hectares) of 500-year floodplain associated with the site infrastructure.

The Stratton Ridge storage site and associated facilities would have the potential to increase future downstream flooding due to proposed fill and construction of aboveground structures within the floodplain, including administrative buildings, a tank farm, RWI, well pads, roads, and wellheads. The impacts would be minimal due to the overall size of the floodplain system and compliance with local, state, and Federal floodplain regulations. After selection of an preferred alternative other than no action

Figure B.6.6-1: Proposed Stratton Ridge Storage Site and Associated Facilities

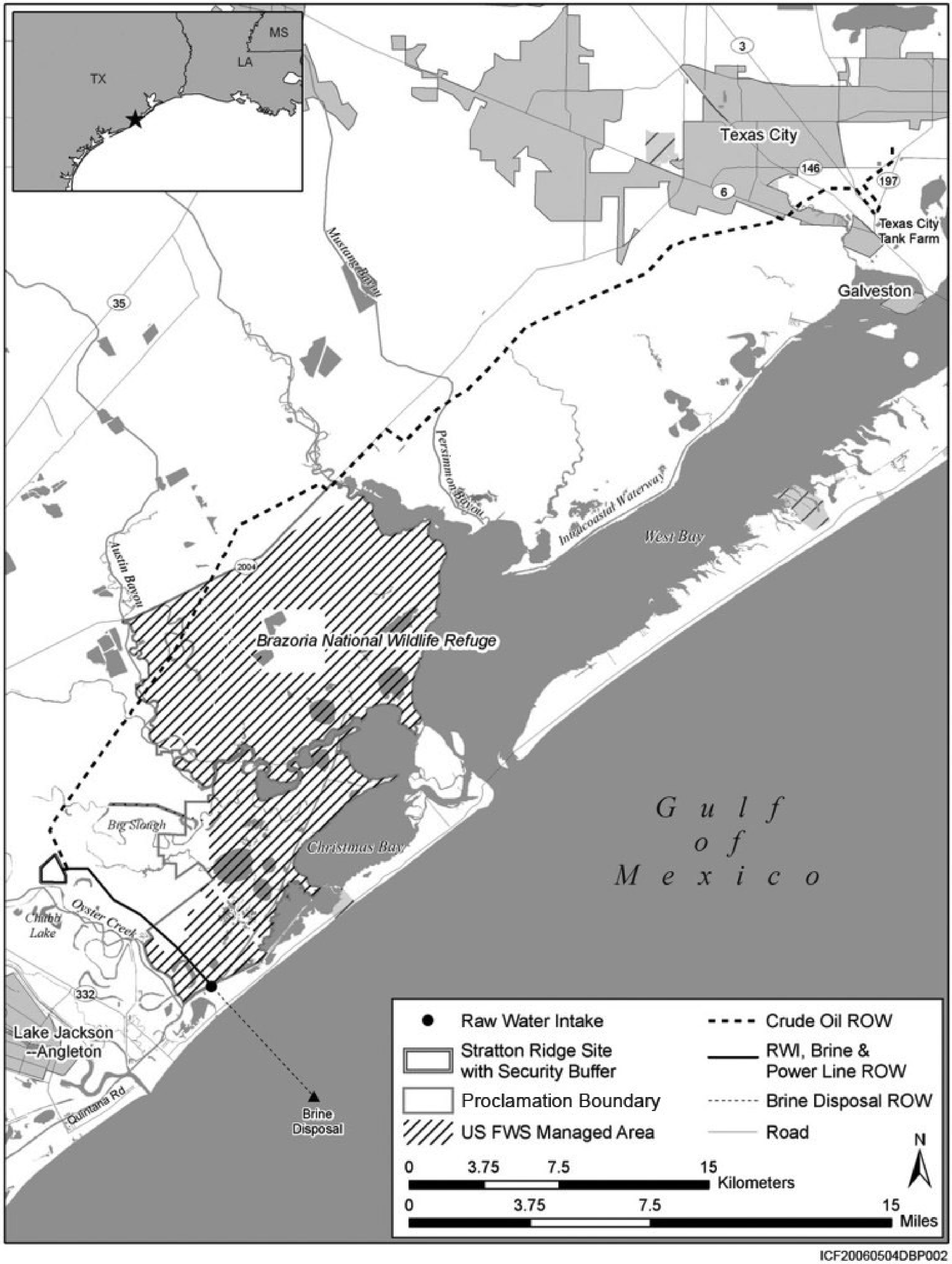

Figure B.6.6-2: Floodplain Map for Proposed Stratton Ridge Site and Associated Facilities

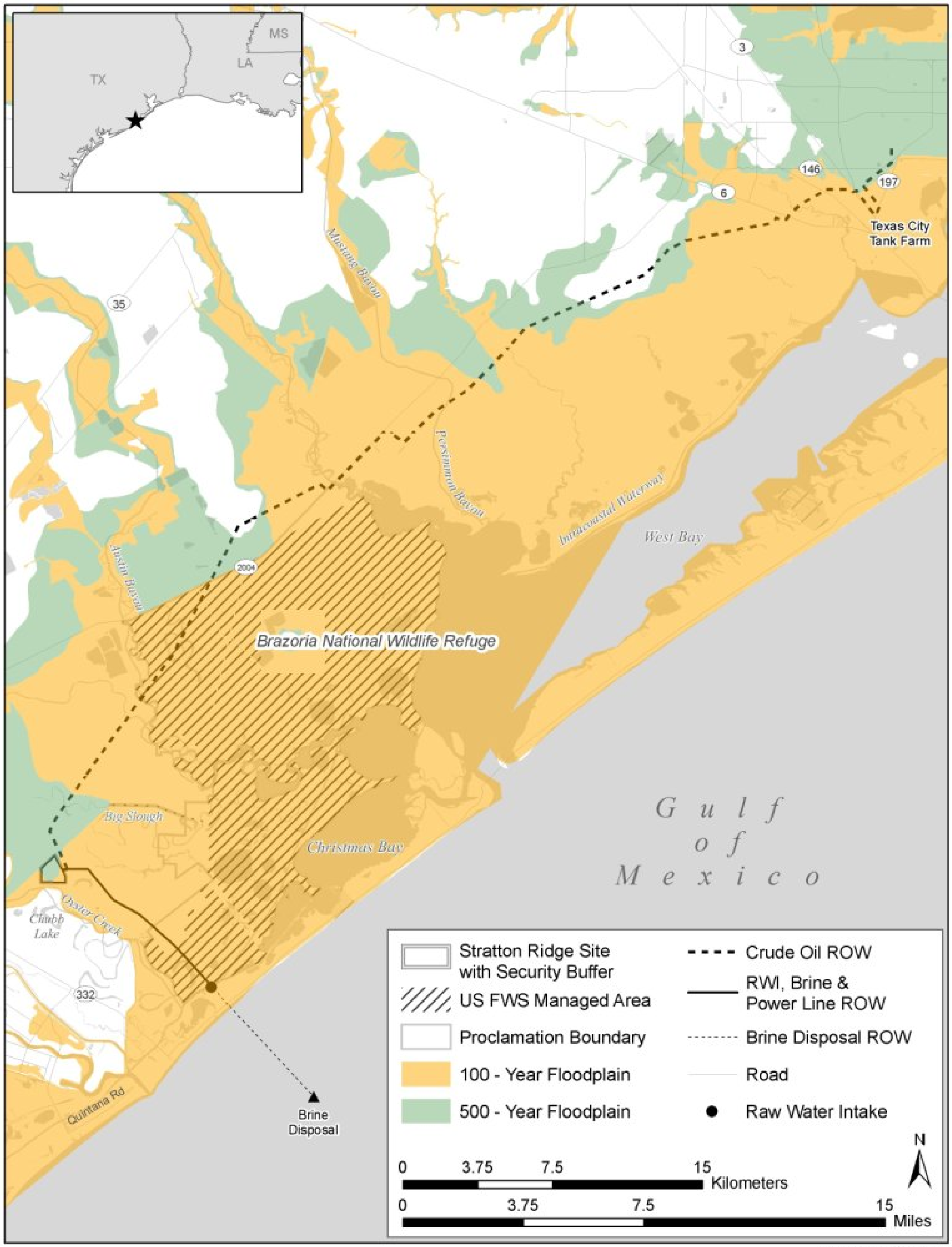

Figure B.6.6-3: Floodplain Map for Proposed Stratton Ridge Storage Site

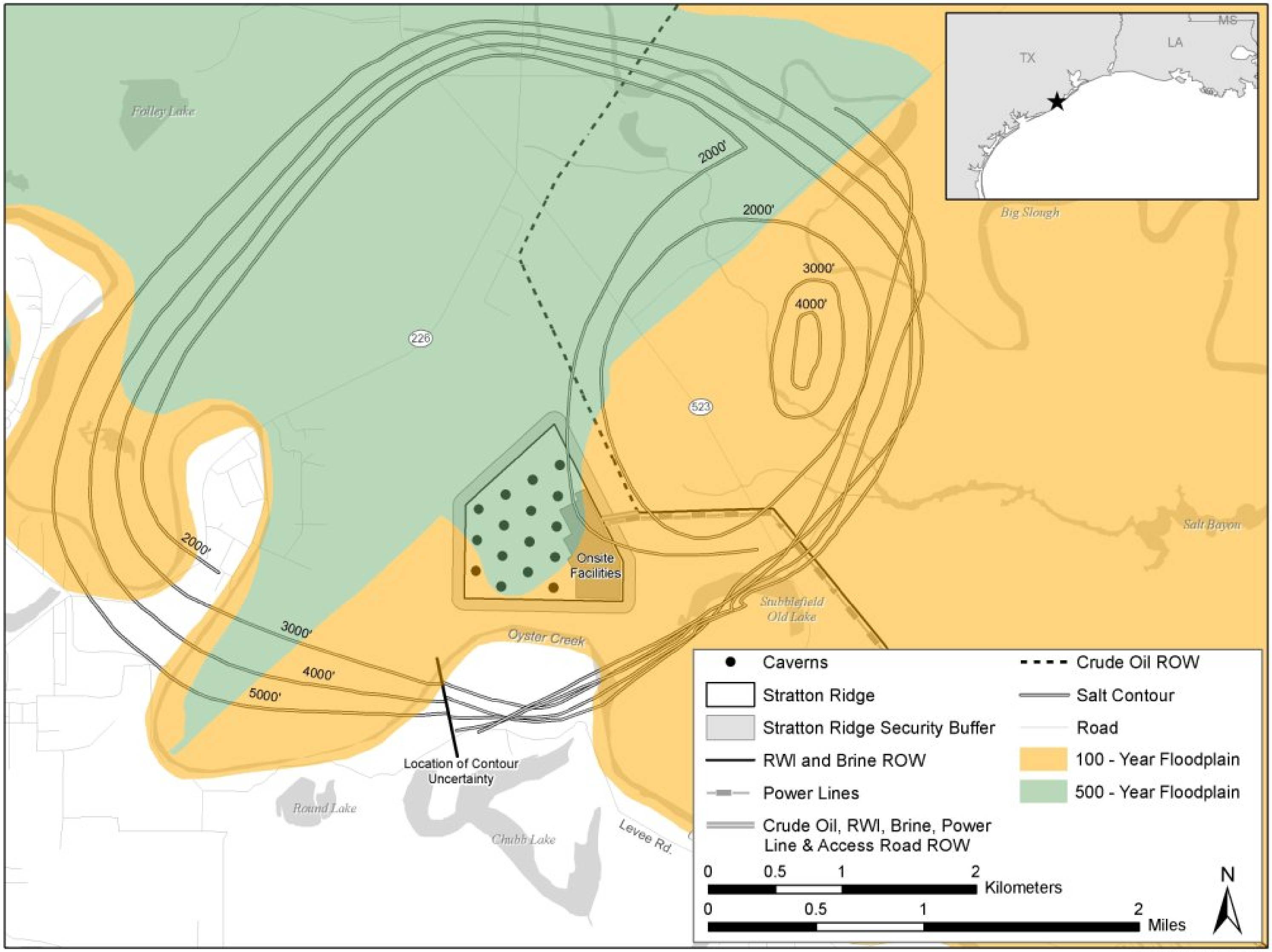

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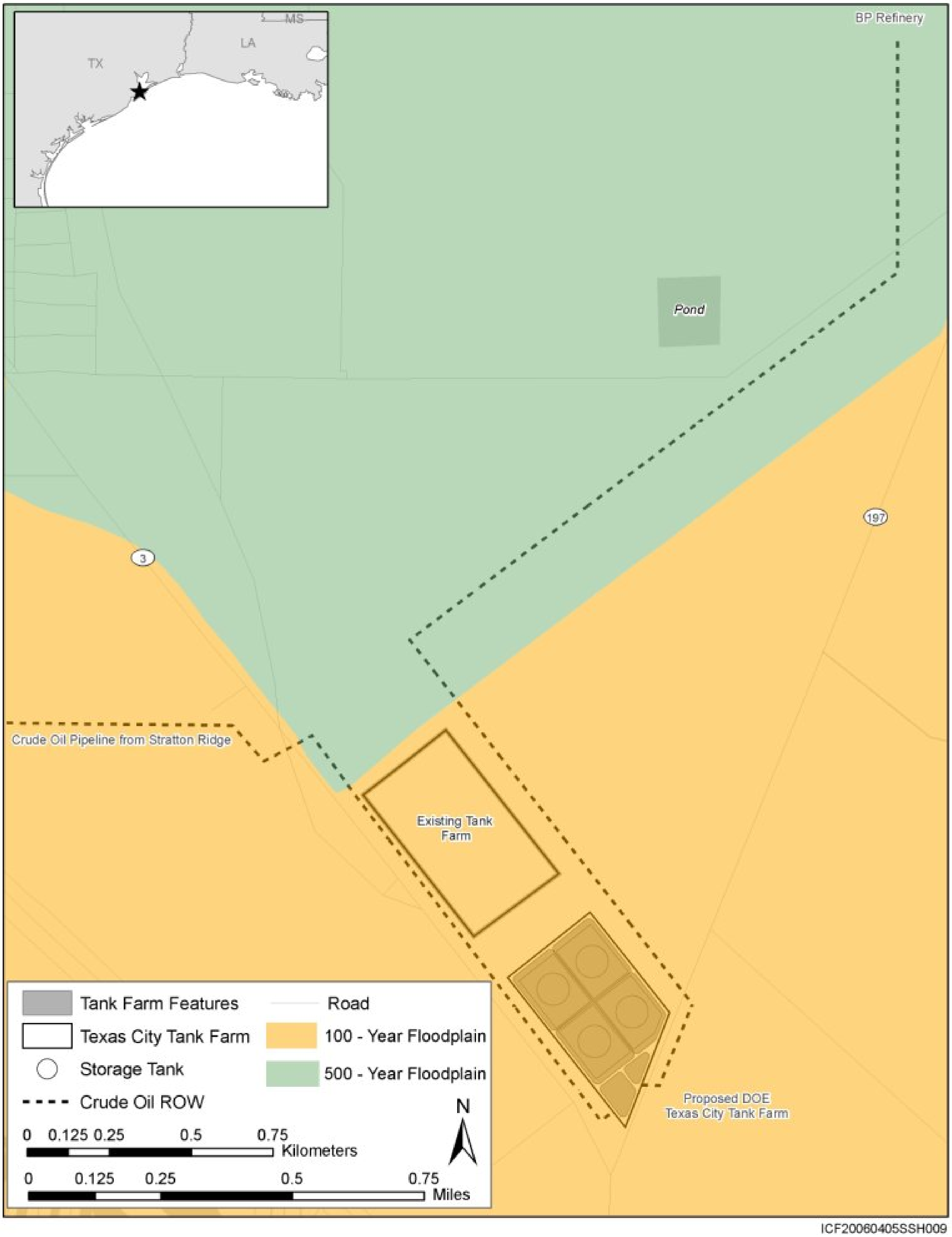
Figure B.6.6-4: Floodplain Map for Proposed Texas City Tank Farm



prior to construction, hydrological modeling would be conducted to ensure that base flood elevations would not be increased by the proposed fill structures.

Any structures located within the floodplain would be designed in accordance with the NFIP requirements for non-residential buildings and structures located in special flood hazard areas. The NFIP regulations are designed to require vulnerable structures to be elevated above the 100-year flood elevation or to be watertight. DOE would coordinate with and secure approval from the floodplain coordinator at the Texas Commission on Environmental Quality or the local government, if it has adopted the NFIP, during the design stage/site plan process.

The proposed Stratton Ridge power line and pipeline ROWs would cross and temporarily affect approximately 41 miles (66 kilometers) of 100-year floodplain and 8 miles (13 kilometers) of 500-year floodplain. The impacts on floodplains associated with the construction of the ROWs would be temporary because the preconstruction contours would be re-established and no aboveground fill or structures would exist following the completion of the construction activities. Therefore, no significant increased risk of flooding would be expected from ROW construction because there would be no net loss of flood attenuation capacity compared to the existing conditions. There would be a potential minor increase in flood stage during the construction activities because some staging materials and construction equipment may be located in a floodplain. Power poles and other associated fill would be located outside of floodplain areas to the maximum extent practical. These structures would not be expected to significantly increase flood stage levels.

Due to the geology and location of the salt dome, the water dependency of the RWI, and the long ROWs, floodplains could not be avoided with this site development. DOE has considered the practicable alternatives to siting in a floodplain and has evaluated the proposed design and modifications to minimize the impact to floodplains. Proper design and compliance with the required regulatory programs would reduce the impacts of these structures on floodplains to a level where there would be no significant change in the base flood elevation. Section B.7 discusses in more detail the avoidance and minimization measures that would be used to reduce the effects to floodplains located in the project area.

B.6.6.2   Wetland Impacts

The construction and operations and maintenance activities associated with the proposed Stratton Ridge site development would have temporary and permanent impacts on wetlands as described in the methodology. Tables B.6.6-2 and B.6.6-3 summarize the wetlands that would be affected by the new storage site, ROWs, and associated facilities.

The Stratton Ridge site is comprised predominantly of palustrine forested wetlands with areas of palustrine emergent wetlands and upland deciduous forest. Construction of the storage site and related facilities would fill 225 acres (91 hectares) of wetlands. The 192 acres (78 hectares) of palustrine forested wetlands on the Stratton Ridge site are also known as a bottomland hardwood forest, which is an ecologically diverse and greatly threatened ecosystem in the United States (see figure B.6.6-5). These ecosystems provide wildlife habitat and play important roles in maintaining water quality and retaining flooding waters. The Stratton Ridge site has been disturbed and fragmented by human activities and introduced animals and plants. The maintenance of the security buffer around the storage facility would convert 73 acres (30 hectares) of wetlands to emergent or open water. The security buffer would require the clearing of woody vegetation and periodic maintenance to suppress or clear woody species. The proposed Texas City tank farm would permanently impact 11 acres (4 hectares) of palustrine wetlands (see figure B.6.6-6).

Table B.6.6-2: Wetland Impacts for the Proposed Stratton Ridge Storage Site ROWs[a]

Cowardin Wetland Classification	ROW from Site to Gulf of Mexico (acres)		ROW from Site to Texas City (acres)		Power Line ROWs (acres)	
	Temporary easement	Permanent easement	Temporary easement	Permanent easement	Temporary easement	Permanent easement
Estuarine	35	22	6	3	NA	19
Lacustrine	0	0	2	1	NA	0
Palustrine – emergent	19	13	84	41	NA	12
Palustrine – scrub-shrub[b]	0	0	1	1	NA	0
Palustrine – unconsolidated bottom[c]	0	0	17	8	NA	0
Riverine[c]	0	0	2	1	NA	0
Other	0	0	0	0	NA	0
Totals	**54**	**35**	**112**	**55**	NA	**31**

Notes:

[a] This table presents only the wetland types that are present within the ROW according to NWI data.

[b] Forested and scrub-shrub wetlands would be cleared of woody vegetation and permanently converted to and maintained as emergent wetlands within the permanent easement of all ROWs. Within the temporary construction easement, woody vegetation would be cleared but would be allowed to re-establish within the easement. DOE would follow any required wetland compensation for these temporary impacts that is required by the Section 404/401 permit. At a minimum, DOE would restore original contours, replace the original hydric topsoil back in the disturbed area, and seed with native species. Re-establishment of the scrub-shrub or forested wetland may take 5-25 years depending on the type of community affected.

[c] Impacts to these wetlands would be temporary and they would return to the pre-existing conditions shortly after construction is completed.

1 acre = 0.405 hectares; NA means no temporary easement

Table B.6.6-3: Summary of Wetland Impacts for the Proposed Stratton Ridge Storage Site[a]

Cowardin Wetland Classification	Storage Site (acres)		ROWs[b] (acres)		RWI Structure (acres)	Texas City Terminal (acres)	Totals (acres)
	Filled wetlands	Permanent conversion	Temporary easement	Permanent easement	Filled wetlands	Filled wetlands	All affected wetlands
Estuarine	0	0	41	44	2	0	**87**
Lacustrine	0	0	2	1	0	0	**68**
Palustrine – emergent	20	3	103	66	0	4	**196**
Palustrine – forested	192	66	0	0	0	2	**260**
Palustrine – scrub-shrub	12	0	1	1	0	4	**18**
Palustrine – unconsolidated bottom	0	2	17	8	0	1	**28**
Riverine	0	0	2	1	0	0	**3**
Other	1	2	0	0	0	0	**3**
Totals	**225**	**73**	**166**	**121**	**2**	**11**	**598**

Notes:

[a] This table presents only the wetland types that are present within the proposed footprint according to NWI data. Facilities were omitted if no wetlands were present within the footprint.

[b] Forested and scrub-shrub wetlands would be cleared of woody vegetation and permanently converted to and maintained as emergent wetlands within the permanent easement of all ROWs. Within the temporary construction easement, woody vegetation would be cleared but would be allowed to re-establish within the easement. DOE would follow any required wetland compensation for these temporary impacts that is required by the Section 404/401 permit. At a minimum, DOE would restore original contours, replace the original hydric topsoil back in the disturbed area, and seed with native species. Re-establishment of the scrub-shrub or forested wetland may take 5-25 years depending on the type of community affected. Impacts to these wetlands would be temporary and they would return to the pre-existing conditions shortly after construction is completed.

1 acre = 0.405 hectares

Figure B.6.6-5: NWI Wetlands for Proposed Stratton Ridge Storage Site

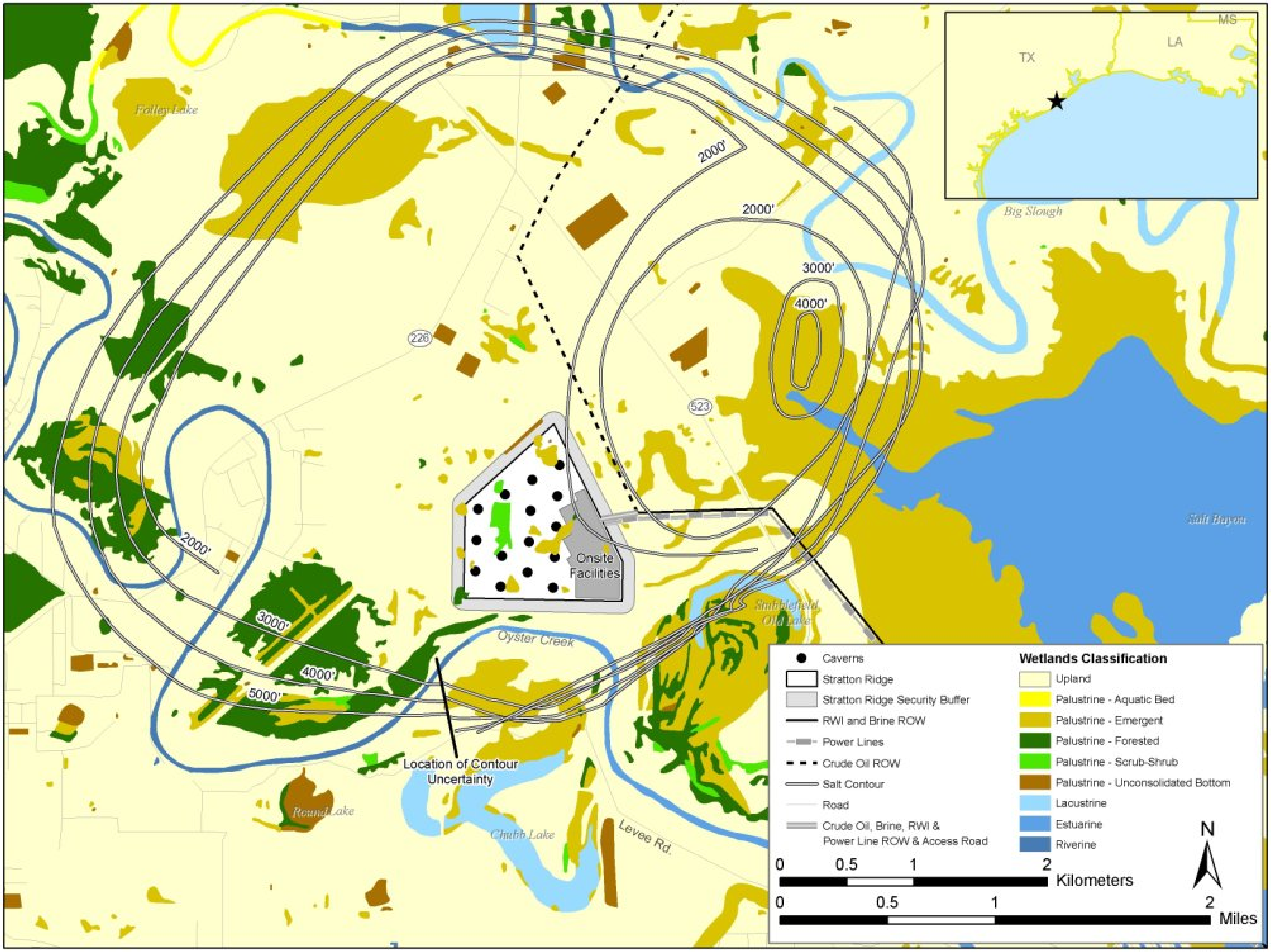


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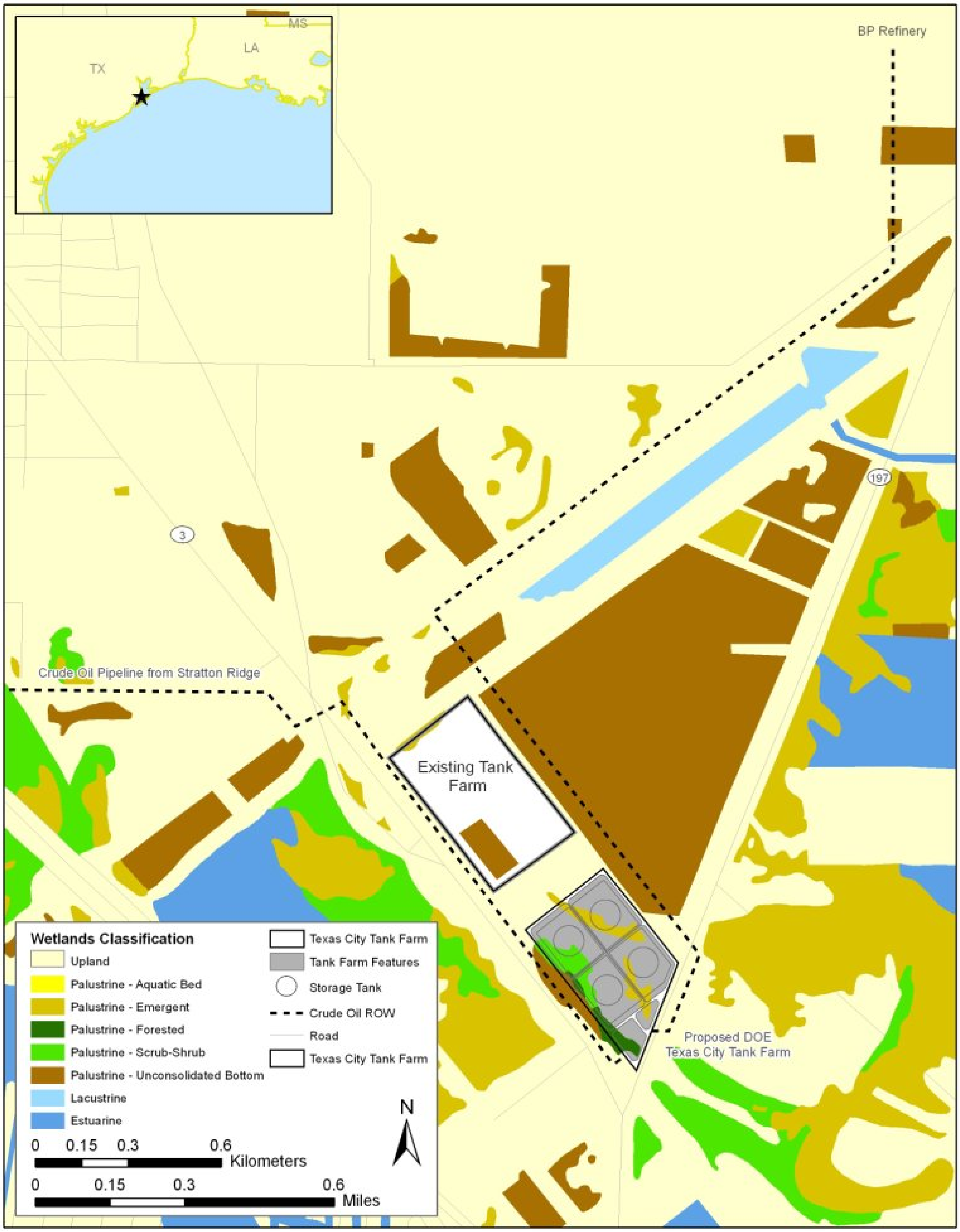
Figure B.6.6-6: NWI Wetlands for Proposed Texas City Tank Farm



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The power line and pipeline ROWs associated with the Stratton Ridge storage site and associated facilities would cross and permanently or temporarily affect 287 acres (116 hectares) of wetlands. Table B.6.6-2 provides a summary of the wetland impacts per ROW that would result from this site development. Construction of the ROWs would affect 121 acres (49 hectares) of wetlands within the permanent easement and 166 acres (67 hectares) within the temporary easement. Pre-existing contours would be restored and the affected plant communities would be allowed to re-establish depending on location within the temporary and permanent easement. DOE would promote the growth of the emergent or forested vegetation in the temporary construction easement. The impacts on wetlands within the temporary easement would last between 2 to 3 years for emergent wetlands and 10 to 25 years for forested wetlands. DOE would suppress the growth of woody vegetation within the permanent easement to protect pipelines and to allow weekly overflight inspections. Therefore, forested and scrub-shrub wetlands in these areas would be permanently converted to emergent wetlands. Although the converted wetlands would provide different habitat than before construction, other important wetland functions such as flood storage and nutrient filtration would be maintained with the emergent wetlands.

The Stratton Ridge alternative, which includes the site, the ancillary facilities, and ROWs, would affect approximately 598 acres (242 hectares) of wetlands associated with the filling activities required for new structures and facilities and permanent and temporary clearing for new power lines and pipelines. The construction activities would permanently fill approximately 238 acres (96 hectares) of wetlands associated with the storage site, Texas City terminal, and RWI (see table 6.6-3). About 260 acres (105 hectares) of palustrine forested wetland would be temporarily or permanently cleared. The impact on this relatively rare and important type of forested wetland would be a potential adverse effect, which would be mitigated by the compensation plan for jurisdictional wetland impacts.

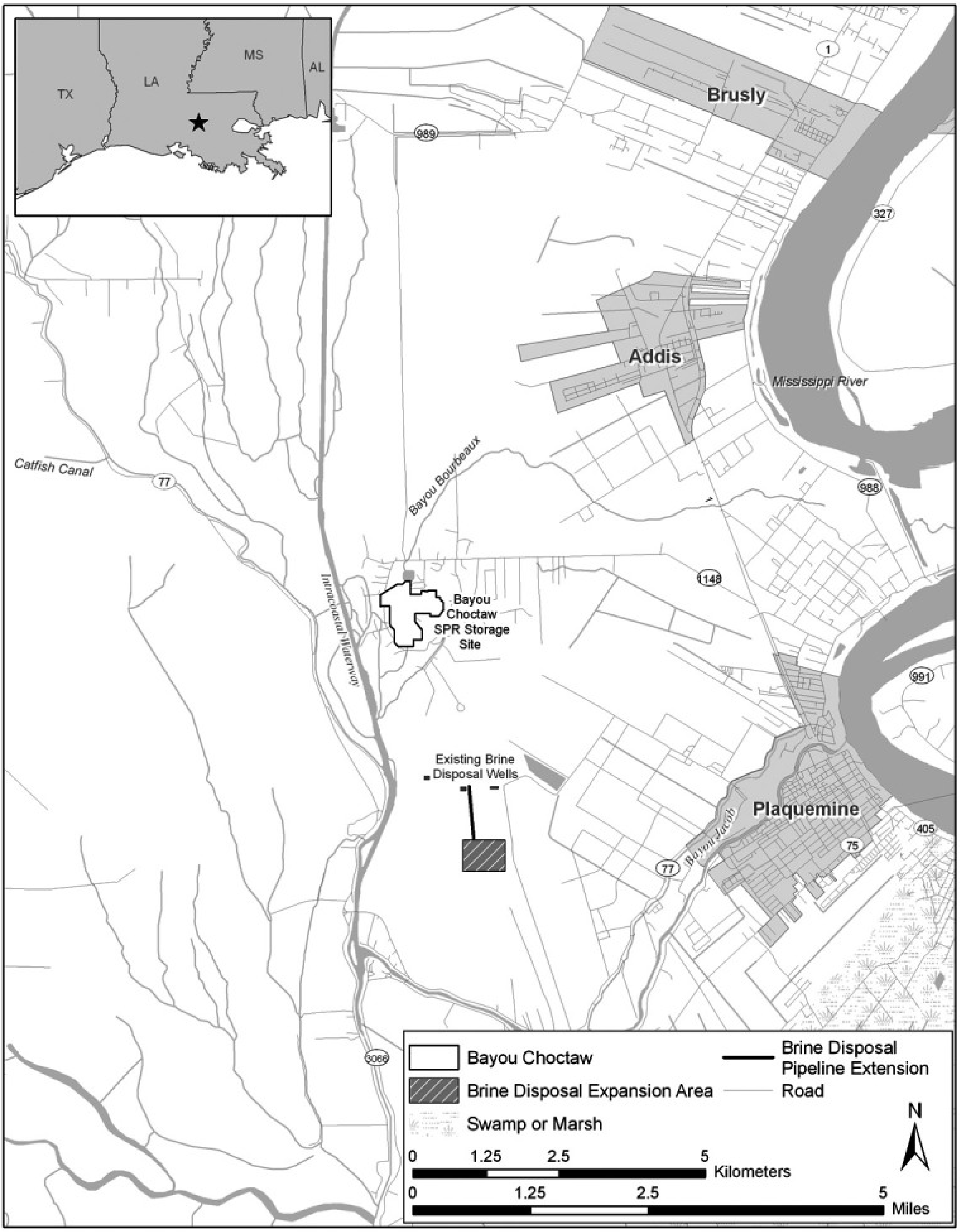
Due to the geology and location of the salt dome, the water dependency of the RWI, and the long ROWs, impacts to wetlands and waters of the United States could not be avoided by this site development. All filling of and discharge to jurisdictional wetlands would require a Section 404/401 permit from the USACE and the Texas Commission of Environmental Quality. The permit application would require a comprehensive alternatives analysis that demonstrates avoidance and minimization on wetland impacts. The permit would contain conditions to minimize the impact to wetlands during construction and would require compensation for unavoidable impacts to jurisdictional wetlands. Section B.7 discusses in more detail the avoidance, minimization, and mitigation measures that DOE would use to reduce, avoid, and compensate for the potential impacts to jurisdictional wetlands and waters of the United States.

B.6.7 Bayou Choctaw Expansion Site and Associated Infrastructure

The Bayou Choctaw expansion site occupies a 360-acre (140-hectare) site in Iberville Parish, LA, located about 12 miles (19 kilometers) southwest of Baton Rouge (figure B.6.7-1). The Mississippi River is located about 4 miles (6 kilometers) east of the dome and the Port Allen Canal, an extension of the ICW, is located about one quarter of a mile (0.4 kilometers) to the west.

The existing storage facility consists of 6, approximately 12.5 MMB capacity caverns with a combined storage capacity of 76 MMB. Raw water is supplied from an intake facility on Cavern Lake located north of the site. Brine is disposed of via underground injection wells south of the storage site. The disposal wells are connected to the site by a 2.3-mile (3.7-kilometer) pipeline. Oil is moved to and from the site through the St. James terminal on the Mississippi River or through the Placid Refinery pipeline.

Figure B.6.7-1: Location of Bayou Choctaw Expansion Site and Associated Facilities



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The expansion of Bayou Choctaw storage site and associated facilities would consist of the following:

- Development of two new 10 MMB caverns and possible acquisition of one existing 10 MMB cavern,
- Minor upgrades to existing infrastructure,
- New offsite brine pipeline, and
- Six new offsite brine injection wells.

B.6.7.1 Floodplain Impacts

The Bayou Choctaw expansion site is located in the east-central portion of Iberville Parish and the Louisiana portion of the Western Gulf Coastal Plain Province. This low-lying area, approximately 5 feet (1.5 meters) above mean sea level, is composed of the Mississippi River floodplain, coastal marshes, and a series of Pleistocene terraces and low hills.

Bayou Bourbeaux and several small canals drain surface water from the site into Bull Bay and wetlands in the southern portion of the site that extend to the south. These water bodies drain into the ICW (also called Bayou Choctaw) to the west and to the marsh to the south via drainage streams.

The Bayou Choctaw expansion site would use the existing property and would require no new land acquisition for construction of additional storage caverns. DOE would purchase and use approximately 20 acres (8 hectares) of land south of the storage site for 6 new brine injection wells. A 3,000-foot (914-meter) brine disposal pipeline ROW would be required to connect the existing brine injection wells to the new disposal area. Because the entire site is located within the 100-year floodplain (figure B.6.7-2), all new construction would occur within floodplains. The expansion site would affect approximately 187 acres (76 hectares) of 100-year floodplain associated with the site storage facility expansion and the expansion of the brine disposal area. The site expansion would use existing onsite and offsite infrastructure to the maximum extent practicable. Table B.6.7-1 summarizes the floodplain area that would be affected by this expansion.

Table B.6.7-1: Floodplain Impacts for Bayou Choctaw Expansion Site

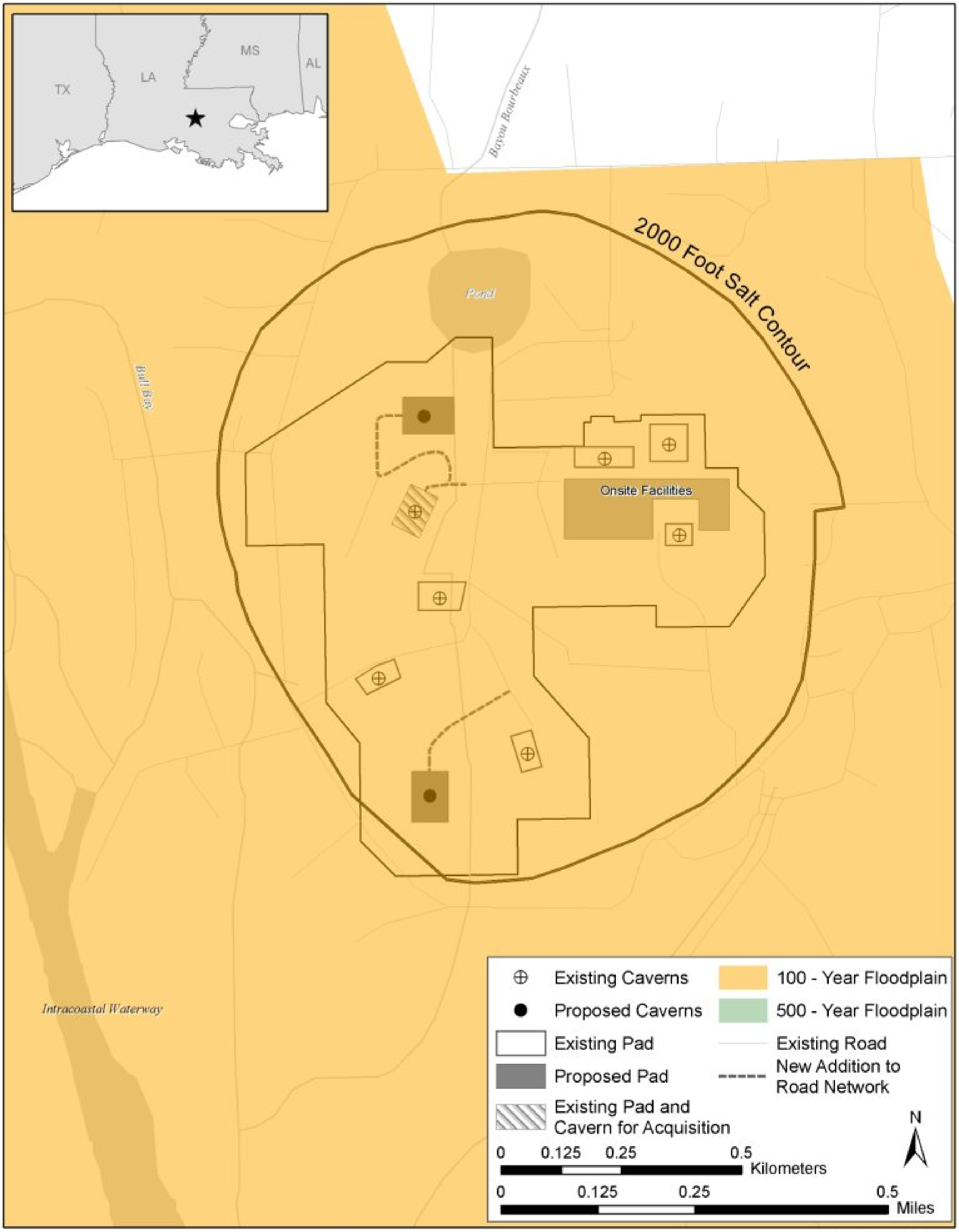
Description	100-Year Floodplain (acres)	500-Year Floodplain (acres)
Caverns/road	4	0
Brine Disposal Expansion	20	0
Total	**24**	**0**

1 acre = 0.405 hectares

The Bayou Choctaw storage site expansion would have a small potential to increase future downstream flooding due to proposed construction of aboveground structures within the floodplain, including well pads, access roads, and wellheads. The impacts are expected to be minimal due to the overall size of the floodplain system, small amount of construction, and compliance with local, state, and Federal floodplain regulations. After selection of an alternative other than no-action and prior to construction, hydrological modeling would be conducted to ensure that base flood elevations would not be increased from the proposed fill structures.

Any structures located within the floodplain would be designed in accordance with the NFIP requirements for nonresidential buildings and structures located in special flood hazard areas. The NFIP regulations are designed to require vulnerable structures to be constructed above the 100-year flood elevation or to be watertight. DOE would coordinate with and secure approval from the floodplain coordinator at the

Figure B.6.7-2: Floodplain Map for Bayou Choctaw Expansion Site



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Louisiana Department of Transportation and Development or the local government, if it has adopted the NFIP program, during the design stage/site plan process.

The brine pipeline would cross and temporarily affect 0.5 miles (0.8 kilometers) of 100-year floodplain during its construction. The impacts to floodplains associated with construction of the brine disposal pipeline ROW would be temporary because the preconstruction contours would be re-established and no aboveground fill or structures would exist following the completion of the construction activities. Therefore, no significant increased risk of flooding would be expected from ROW construction because there would be no net loss of flood attenuation capacity compared to the existing conditions. There would be a potential minor increase in flood stage during the construction activities because some staging materials and construction equipment might be located in a floodplain.

B.6.7.2 Wetland Impacts

The construction and operations and maintenance associated with the expansion of the Bayou Choctaw storage site would have temporary and permanent impacts on wetlands as described in the methodology. Table B.6.7-2 summarizes the wetlands that would be affected by the expansion site, ROWs, and brine injection wells.

Table B.6.7-2: Summary of Wetland Impacts for the Proposed Bayou Choctaw Storage Site and Associated Facilities[a]

Cowardin Wetland Types	Storage Site (acres)		Brine Pipeline ROW (acres)		Brine Injection Wells (acres)	Totals (acres)
	Filled wetlands	Permanent conversion	Temporary easement	Permanent easement	Filled wetlands	All affected wetlands
Palustrine – Forested[b]	4	0	7	3	20	**34**

Notes:

[a] This table presents only the wetland types that are present within the proposed footprint according to NWI data. Facilities were omitted if no wetlands were present within the footprint.

[b] Forested and scrub-shrub wetlands would be cleared of woody vegetation and permanently converted to and maintained as emergent wetlands within the permanent easement of all ROWs. Within the temporary construction easement, woody vegetation would be cleared but would be allowed to re-establish within the easement. DOE would follow any required wetland compensation for these temporary impacts that is required by Section 404/401 permit. At a minimum, DOE would restore original contours, replace the original hydric topsoil back in the disturbed area, and seed with native species. Re-establishment of the scrub-shrub or forested wetland may take 5-25 years depending on the type of community affected.

The wetlands at the Bayou Choctaw storage site and brine disposal expansion area are palustrine forested (figure B.6.7-3 and figure B.6.7-4). This important type of fresh-water ecosystem generally provides functions that include nutrient transformation, flood storage, wildlife habitat, and timber production. The wetlands at the site have been disturbed by past facility construction and operations and maintenance. Expansion of the Bayou Choctaw storage site and associated facilities would affect approximately 24 acres (10 hectares) of wetlands. The permanent fill and conversion of wetlands are associated with the construction of the storage facility and brine injection well pads.

The brine pipeline ROW associated with the Bayou Choctaw expansion site would cross and permanently or temporarily affect 10 acres (4 hectares) of wetlands. Table B.6.7-2 summarizes the potential wetland impacts from the proposed ROW. Pre-existing contours would be restored within the ROW and the affected plant communities would be allowed to re-establish depending on location within the temporary and permanent easement. DOE would promote the growth of emergent or forested vegetation in the

Figure B.6.7-3: NWI Wetlands at the Bayou Choctaw Expansion Site

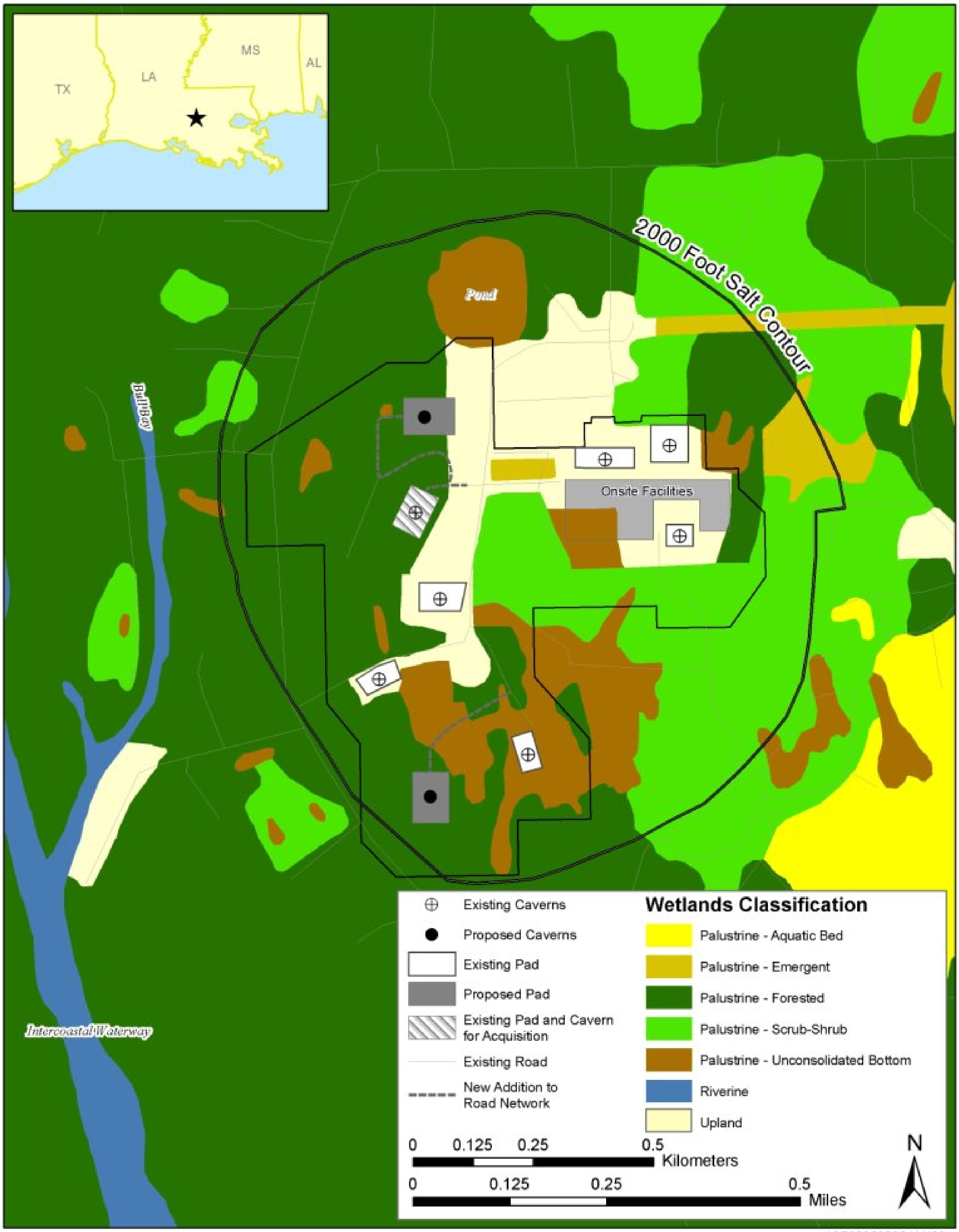

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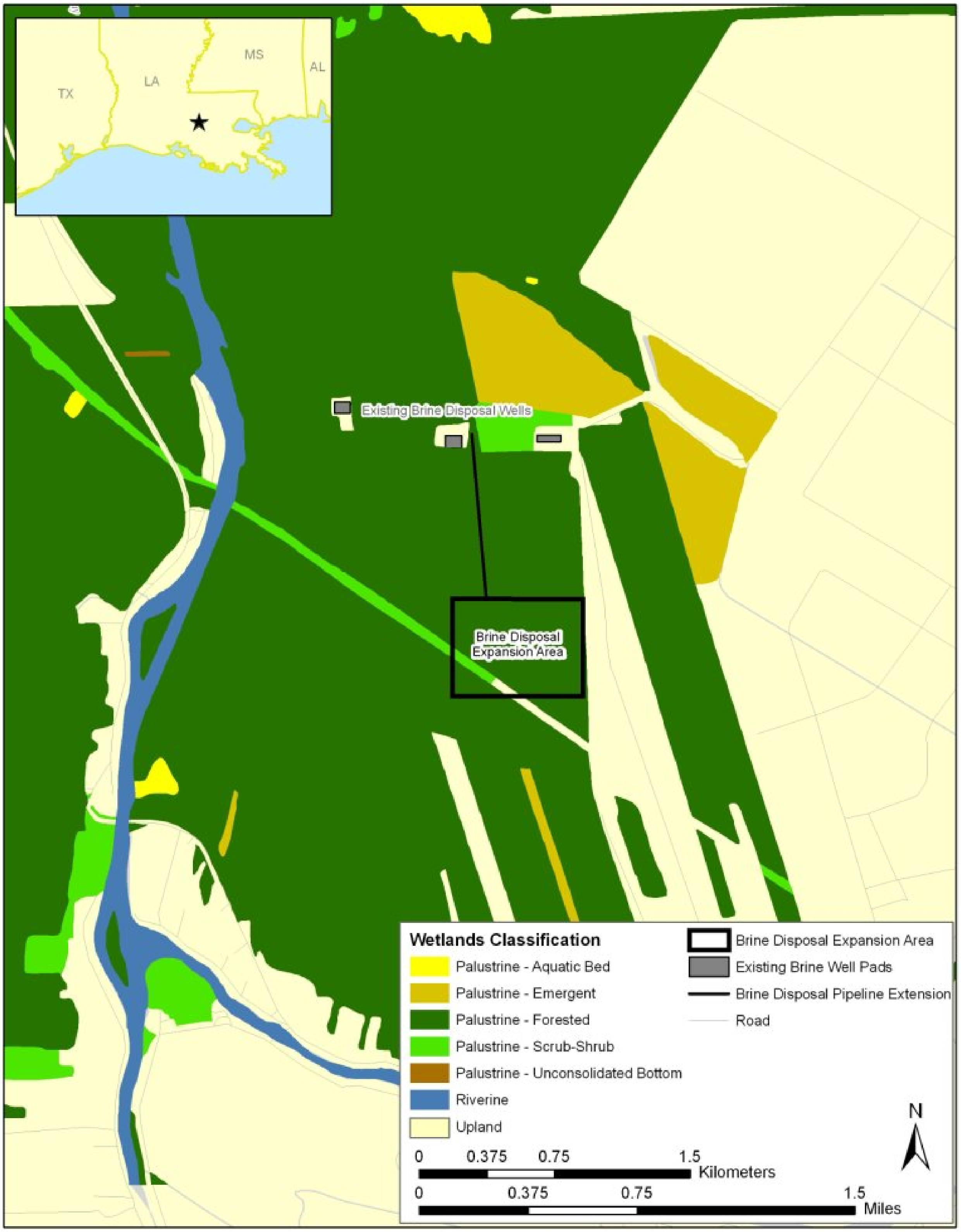
Figure B.6.7-4: NWI Wetlands at the Expansion Site Brine Disposal Wells



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temporary construction easement. The impacts to wetlands within the temporary easement would last between 10 to 25 years for forested wetlands. DOE would suppress the growth of woody vegetation within the permanent easement to protect the pipeline and to allow weekly overflight inspections. Therefore, forested wetlands in these areas would be permanently converted to emergent wetlands. Although the converted wetlands would provide different habitat than before construction, other important wetland functions, such as flood storage and nutrient filtration, would be maintained within the emergent wetlands.

The entire Bayou Choctaw site development, which includes the expansion site, the brine disposal expansion area, and the ROWs, would affect approximately 34 acres (14 hectares) of wetlands associated with the filling activities required for new structures and temporary and permanent clearing for new power lines and pipelines. The construction activities would permanently fill approximately 24 acres (10 hectares) of wetlands associated with the expansion area and brine injection wells. The clearing of palustrine forested wetlands for the brine injection would affect an important ecological resource. These impacts would be mitigated by the compensation plan for jurisdictional wetland impacts.

Due to the location and geology of the salt domes and the long ROW, impacts to wetlands and waters of the United States could not be avoided by this site development. All filling of and discharge to jurisdictional wetlands would require a Section 404/401 permit from the USACE and the Louisiana Coastal Management Division of the Department of Natural Resources. The permit application would require a comprehensive alternatives analysis that demonstrates avoidance and minimization of wetland impacts. The permit would contain conditions to minimize the impact to wetlands during construction and would require compensation for unavoidable impacts to jurisdictional wetlands. Section B.7 discusses in more detail the avoidance, minimization, and mitigation measures that would be used to reduce, avoid, and compensate for the potential impact to jurisdictional wetlands and waters of the United States.

B.6.8 Big Hill Expansion Site and Associated Infrastructure

The Big Hill storage site is located in Jefferson County, TX, 17 miles (27 kilometers) southwest of Port Arthur and 70 miles (113 kilometers) east of Houston.

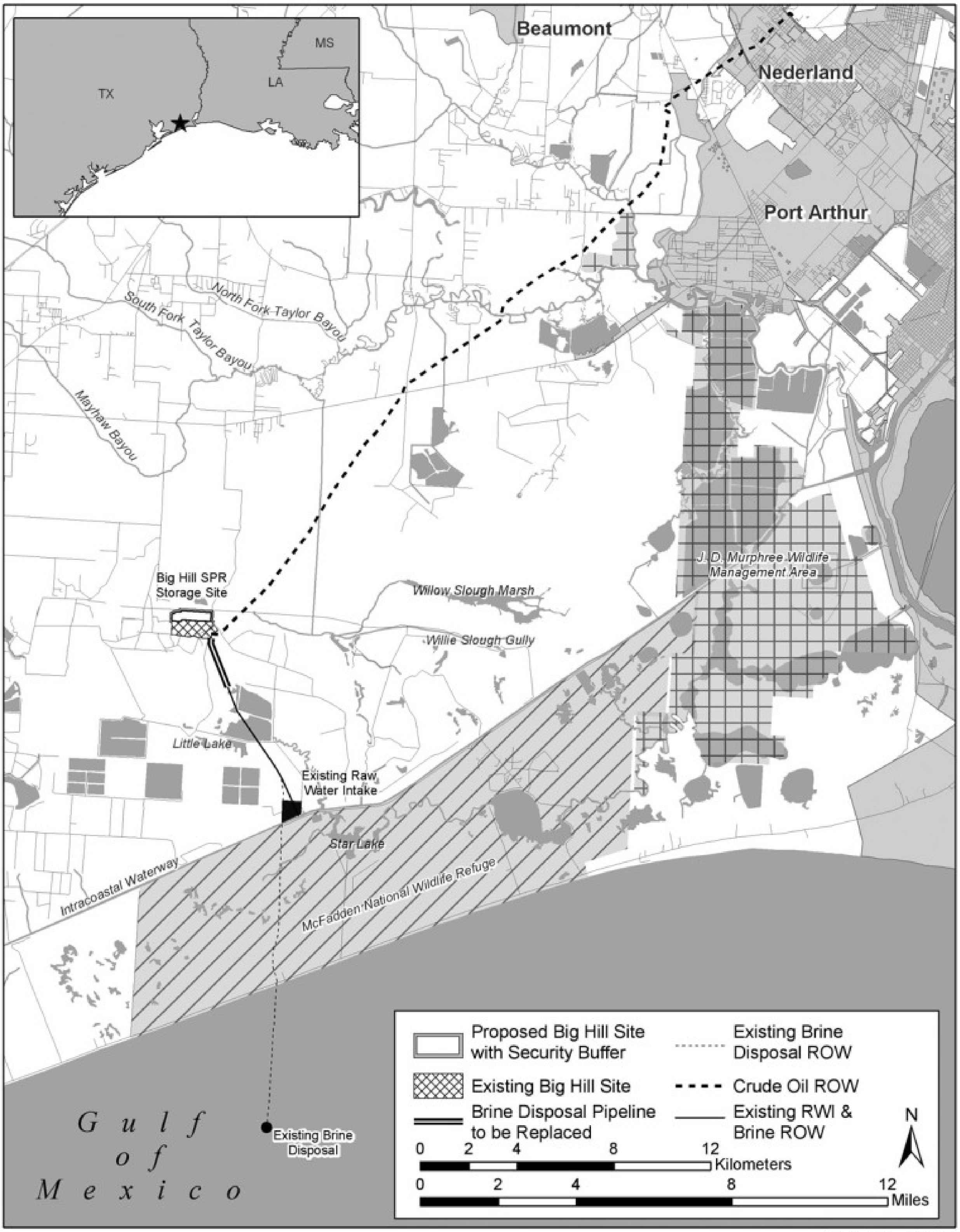
The existing Big Hill storage site consists of 14 crude oil storage caverns with a combined capacity of 170 MMB, a brine disposal system, an RWI system, and a crude oil distribution system (figure B.6.8-1). The site also has various support facilities, including a heliport, diesel oil storage, and several administration buildings. The caverns are located in the central portion of the salt dome and are arranged in two rows of five caverns and one row of four caverns.

The Big Hill expansion would consist of the following:

- Up to nine new caverns with a capacity of up to 108 MMB,
- Crude oil pipeline to the Sun terminal,
- Refurbishment of the 7,000 feet (2,134 meters) brine disposal pipeline, and
- New fencing, roads, onsite pipelines, and new anhydrite settling pond.

A map for the Big Hill Expansion storage site and associated facilities, included as an attachment to this appendix, shows detailed NWI mapped wetlands.

Figure B.6.8-1: Location of Big Hill Expansion Site and Associated Facilities



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B.6.8.1 Floodplain Impacts

The extent of 100-year and 500-year floodplain was determined based on the FEMA Flood Insurance Rate Maps covering the project area. The proposed Big Hill expansion site is located in a predominantly undeveloped, extensive floodplain system (see figures B.6.8-2 and B.6.8-3).

The Big Hill expansion site would take advantage of the existing infrastructure, reducing the area required for new construction and operations. The proposed expansion would consist of the construction of up to nine new caverns immediately north of the existing facility. A large percentage of this expansion site (about 73 percent) would be located outside of the 100-year and the 500-year floodplain. The expansion site would affect 11 acres (5 hectares) of 100-year floodplain and approximately 27 (11 hectares) of 500-year floodplain.

The Big Hill expansion site would have some potential to increase future downstream flooding due to the proposed fill construction of aboveground structures within the floodplain including well pads, roads, and ponds. The impacts would be minimal due to the overall size of the floodplain system, the small impact area, and compliance with local, state, and Federal floodplain regulations. After selection of an alternative other than no-action and prior to construction, hydrological modeling would be conducted to ensure that base flood elevations would not be increased from the proposed fill structures.

Any structures located within the floodplain would be designed in accordance with the NFIP requirements for nonresidential buildings and structures located in special flood hazard areas. The NFIP regulations require vulnerable structures to be constructed above the 100-year flood elevation or to be watertight. DOE would coordinate with and secure approval from the floodplain coordinate at the Texas Commission on Environmental Quality or the local government, if it has adopted the NFIP, during the design stage/site plan process.

The proposed crude oil pipeline ROWs would cross and affect 18 miles (29 kilometers) of 100-year floodplain and 3 miles (4.8 kilometers) of 500-year floodplain. The impacts on floodplains associated with the pipeline ROWs would be temporary because the preconstruction contours would be re-established and no fill or aboveground structure would exist following the completion of the construction activities. Therefore, no significant increased risk of flooding would be expected from the pipeline ROWs because there would be net loss of floodplain storage capacity compared to the existing conditions. There would be a potential minor increase in flood stage during the construction activities because some staging materials and construction equipment may be located in the floodplain.

Due to the geology and location of the salt dome and the long ROWs, floodplains could not be avoided with this site development. DOE has considered the practicable alternatives to siting in a floodplain and has evaluated the proposed design and modifications to minimize the impact to floodplains. Proper design and compliance with the required regulatory programs would reduce the impacts of these structures on floodplains to a level where there would be no significant change in the base flood elevation. Section B.7 discusses in more detail the avoidance and minimization measures that DOE would use to reduce the effects to floodplains located in the project area.

Figure B.6.8-2: Floodplain Map for Bill Hill Expansion and Associated Facilities

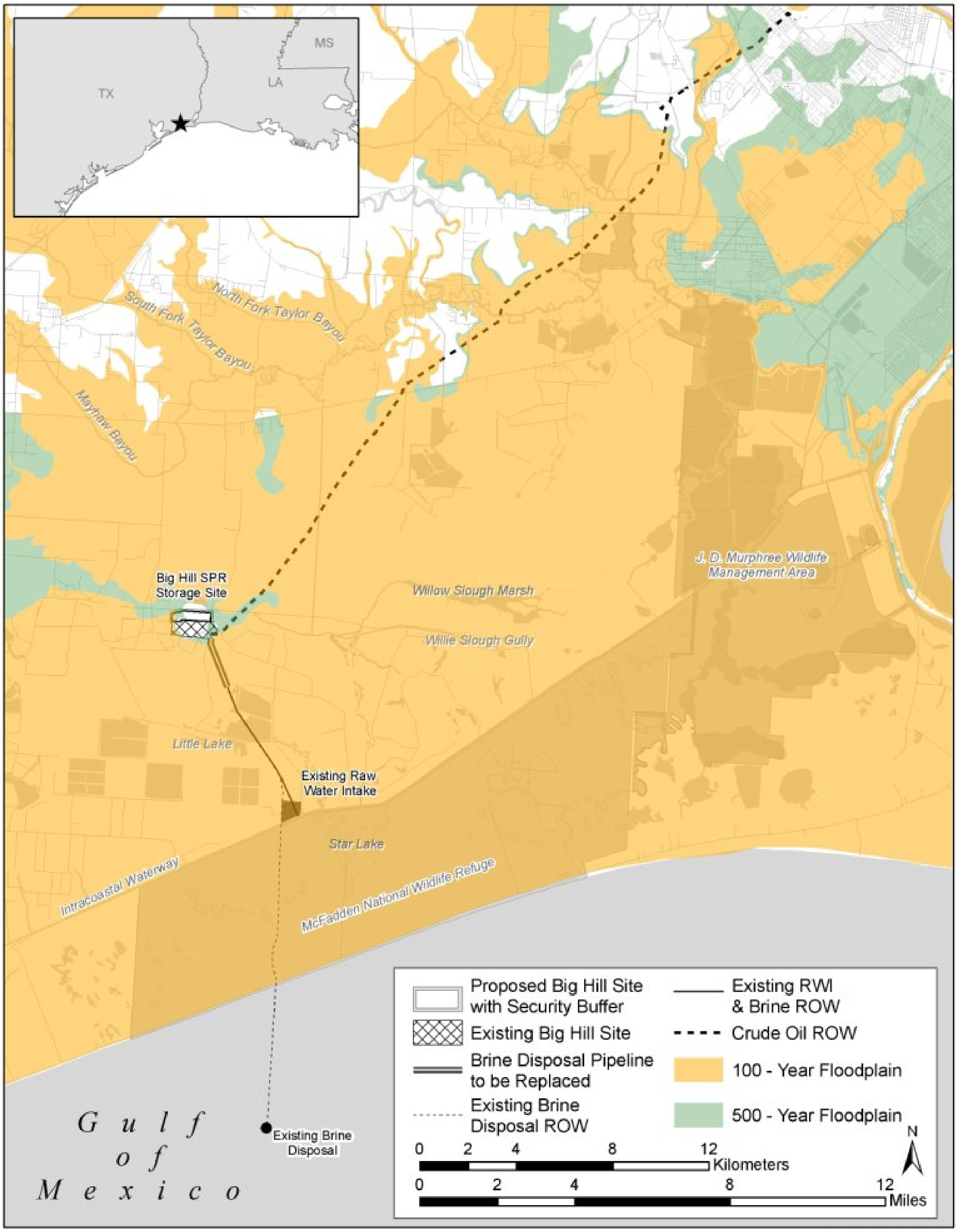

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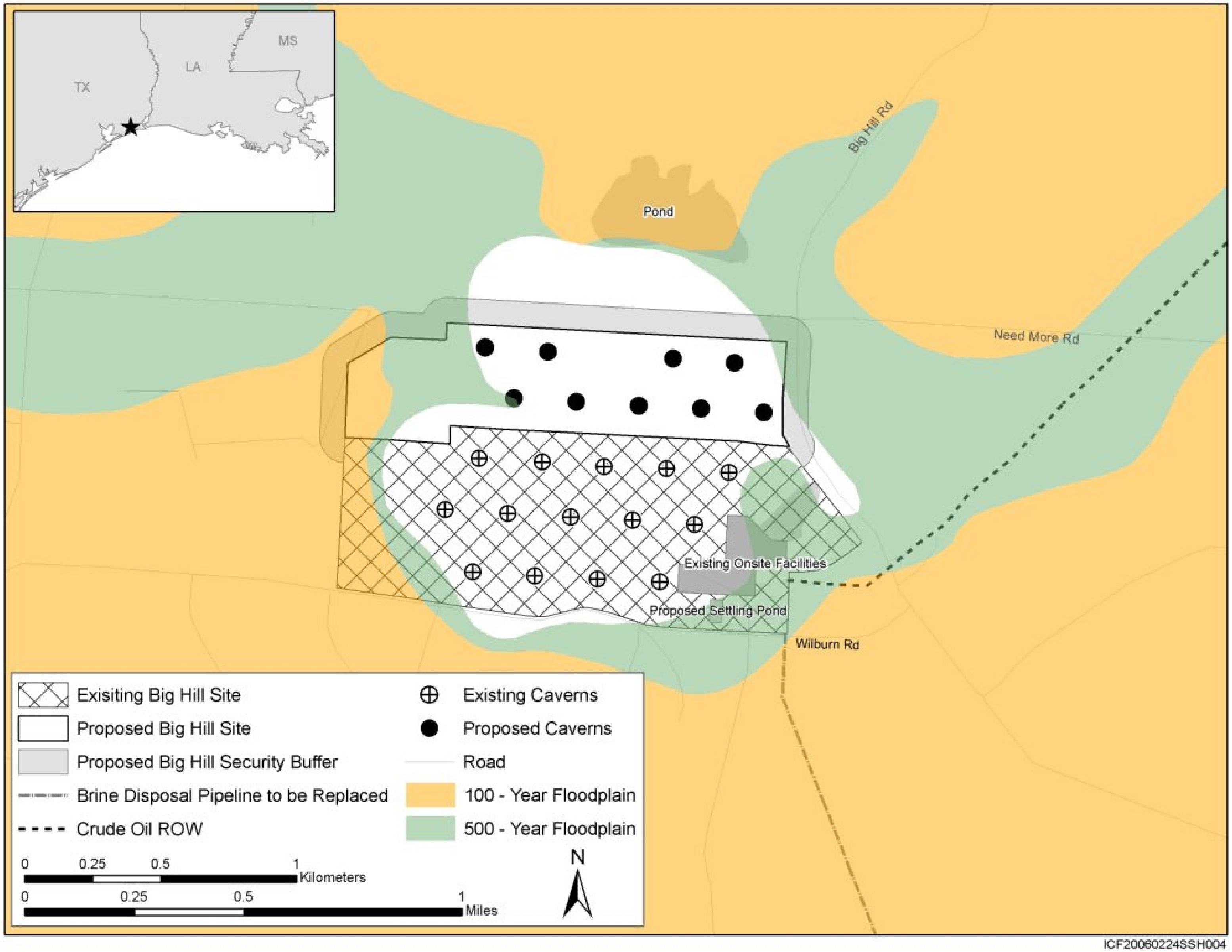
Figure B.6.8.3: Floodplain Map for Big Hill Expansion Site



B.6.8.2 Wetland Impacts

The construction and operations and maintenance activities associated with the proposed Big Hill expansion site would have temporary and permanent impacts on wetlands as described in the methodology. Table B.6.8-1 summarizes the wetlands that would be affected by expansion of capacity at the site.

Table B.6.8-1: Summary of Wetland Impacts for the Proposed Big Hill Expansion Site[a]

Cowardin Wetland Types	Storage Site (acres)		ROW to Sun Terminal[b] (acres)		Brine Pipeline to be Replaced[b] (acres)		Totals
	Filled wetlands	Permanent conversion	Temporary easement	Permanent easement	Temporary easement	Permanent easement	All affected wetlands
Lacustrine	0	0	5	3	3	1	**12**
Palustrine – emergent	6	0	92	45	4	2	**149**
Palustrine – forested	9	0	2	1	0	0	**12**
Palustrine – scrub-shrub	0	0	0	0	3	2	**5**
Palustrine – unconsolidated bottom	0	2	3	2	0	0	**7**
Riverine	0	0	2	1	0	0	**3**
Other	0	0	1	0	0	0	**1**
Totals	**15**	**2**	**105**	**52**	**10**	**5**	**189**

Notes:

[a] This table presents only the wetland types that are present within the proposed footprint according to NWI data. Facilities were omitted if no wetlands were present within the footprint.

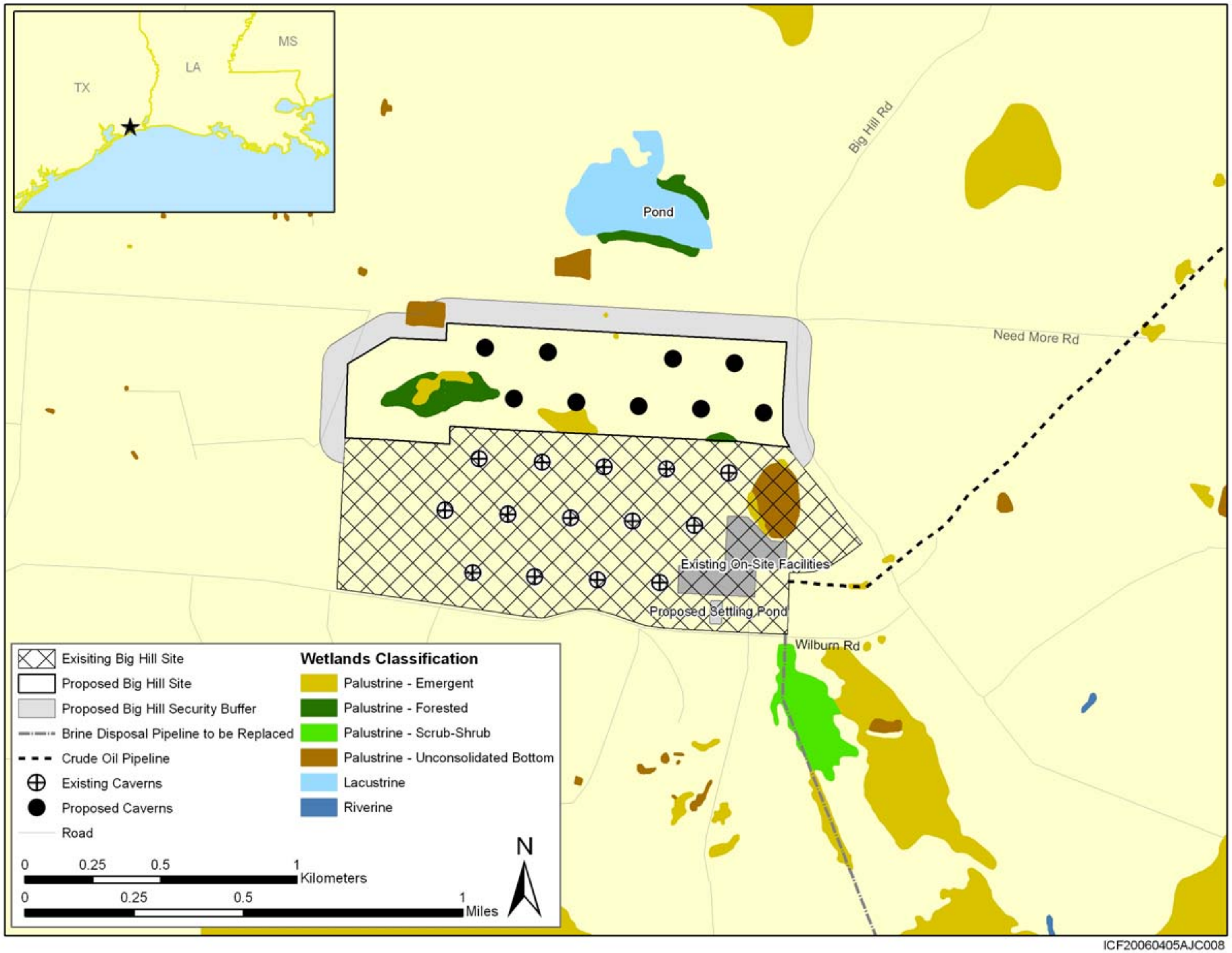
[b] Forested and scrub-shrub wetlands would be cleared of woody vegetation and permanently converted to and maintained as emergent wetlands within the permanent easement of all ROWs. Within the temporary construction easement, woody vegetation would be cleared but would be allowed to re-establish within the easement. DOE would follow any required wetland compensation for these temporary impacts that is required by the Section 404/401 permit. At a minimum, DOE would restore original contours, replace the original hydric topsoil back in the disturbed area, and seed with native species. Re-establishment of the scrub-shrub or forested wetland may take 5-25 years depending on the type of community affected. Impacts to these wetlands would be temporary and they would return to the pre-existing conditions shortly after construction is completed.

1 acre = 0.405 hectares

The expansion area is located immediately north of the existing Big Hill SPR facility. Much of the area proposed for expansion has been disturbed from past construction activities associated with the existing storage site and other oil development in the region. Construction of the Big Hill expansion site would fill approximately 15 acres (6 hectares) of wetlands. The permanent fill and conversion of wetlands would be associated with construction of the expansion site and the maintenance of a security buffer around the new facilities (see figure B.6.8.4). Wetlands within the security buffer would be permanently converted from forested and scrub-shrub wetlands to emergent wetlands or open water. The security buffer would require the clearing of woody vegetation and periodic maintenance to suppress or clear woody species.

The replacement of 7,000 feet (2,134 meters) of the brine pipeline and new crude oil pipeline associated with the Big Hill expansion site would cross and permanently or temporarily affect 172 acres (70 hectares) of wetlands. Construction of the ROWs would affect 115 acres (47 hectares) of wetlands within the temporary easement and 57 acres (23 hectares) of wetlands within the permanent easement. Pre-existing contours would be restored and the affected plant communities would be allowed to re-establish depending on the location within the temporary and permanent easement. DOE would promote the regrowth of emergent vegetation or forested vegetation within the temporary construction easement. The impacts on wetlands within the temporary easement would last between 2 to 3 years for emergent

Figure B.6.8-4: NWI Wetlands at the Proposed Big Hill Expansion Site



wetlands and 10 to 25 years for forested wetlands. DOE would suppress the regrowth of woody vegetation within the permanent easement to protect the pipeline and to allow weekly overflight inspections. Therefore, forested wetlands in these areas would be permanently converted to emergent wetlands. Although the converted wetlands would provide different habitat than before construction, other important wetland functions, such as flood storage and nutrient filtration, would be maintained within the emergent wetlands.

The entire Big Hill expansion site alternative, which includes the expansion area and the ROWs, would affect approximately 189 acres (76 hectares) of wetlands associated with the filling activities required for new structures and facilities and permanent and temporary clearing new pipelines. The construction would permanently fill approximately 15 acres (6 hectares) of wetland associated with the expansion site (table B.6.8-1). The impact to wetlands would not be adverse because the wetlands have been disturbed in the past. The impact would be mitigated by the compensation plan for jurisdictional wetland impacts.

Due to the geology and location of the salt dome, the water dependency of the RWI, and the long ROWs, impacts to wetlands and waters of the United States could not be avoided by this site development. All filling of and discharge to jurisdictional wetlands would require a Section 404/401 permit from the USACE and the Texas Commission of Environmental Quality. The permit application would require a comprehensive alternatives analysis that demonstrates avoidance and minimization of wetland impacts. The permit would contain conditions to minimize the impact to wetlands during construction and would require compensation for unavoidable impacts to jurisdictional wetlands. Section B.7 discusses in more detail the avoidance, minimization, and mitigation measures that DOE would use to reduce, avoid, and compensate for the potential impacts to jurisdictional wetlands and waters of the United States.

B.6.9 West Hackberry Expansion Site and Associated Infrastructure

The West Hackberry site occupies approximately 570 acres (230 hectares) in Cameron and Calcasieu Parishes in southwestern Louisiana (figure B.6.9-1). The site is located approximately 20 miles (32 kilometers) southwest of the City of Lake Charles and 16 miles (26 kilometers) north of the Gulf of Mexico.

The existing SPR storage facility consists of 22 caverns with a combined capacity of 227 MMB. DOE would use the existing oil distribution pipelines, RWI, and brine disposal for the proposed expansion.

The West Hackberry expansion site consists of the following:

- Acquisition of three existing caverns with a total of 15 MMB of capacity,
- Use of existing infrastructure, and
- New access road, fencing, and onsite pipelines connecting acquired caverns to the existing DOE site.

B.6.9.1 Floodplain Impacts

The proposed expansion at West Hackberry would involve the acquisition of three existing storage caverns adjacent to the existing SPR site. DOE would acquire, but not develop, a large property containing the storage caverns. Only a small portion of the acquired land would be located within a floodplain. The proposed construction area that contains the three existing storage caverns would be outside of this floodplain; therefore, the West Hackberry expansion site would not affect floodplains (see figure B.6.9-2).

Figure B.6.9-1: Location of West Hackberry Expansion Site and Associated Facilities

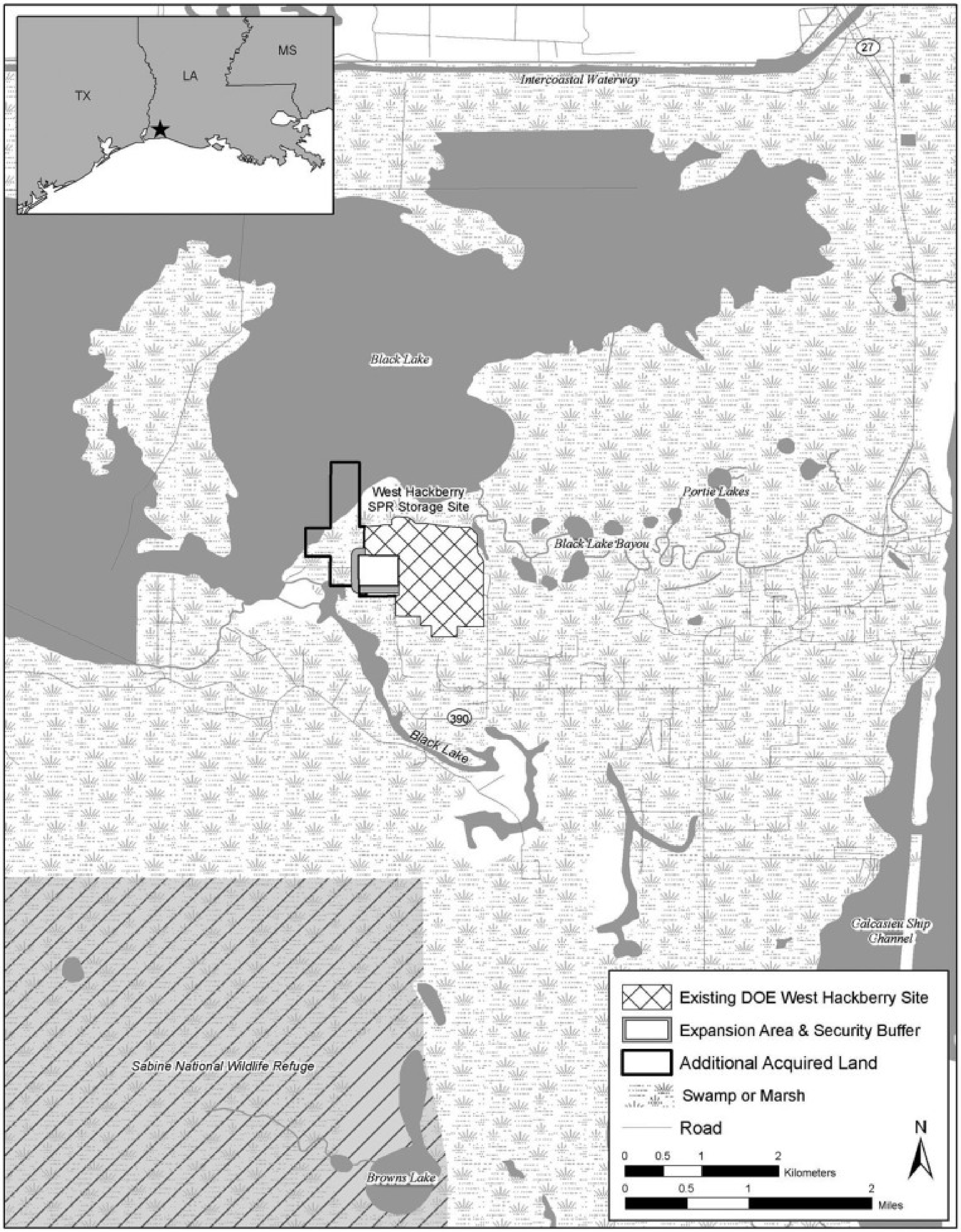


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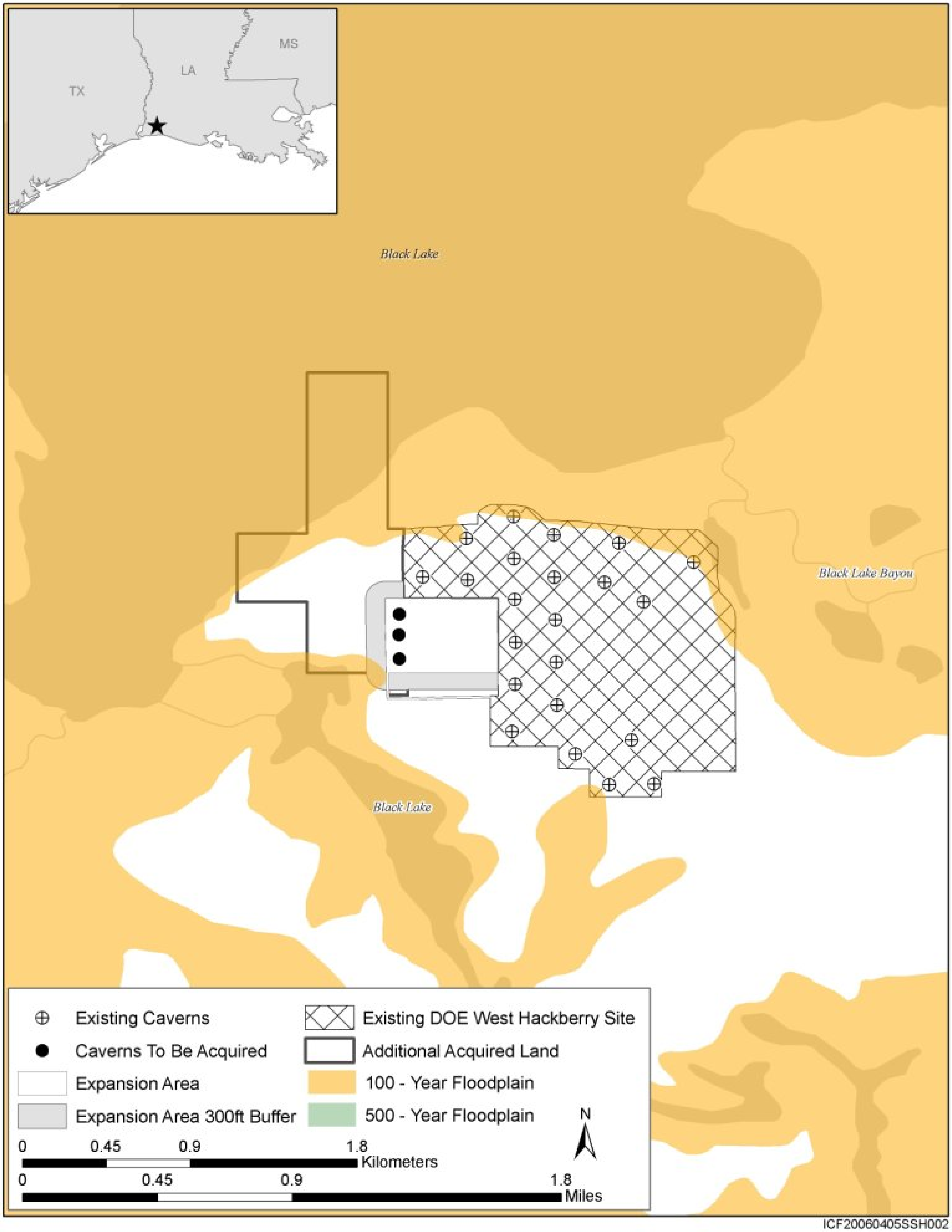
Figure B.6.9-2: Floodplain Map for West Hackberry Expansion



B.6.9.2 Wetland Impacts

The construction and operations and maintenance associated with the proposed West Hackberry expansion would have temporary and permanent impacts on wetlands as described in the methodology. Table B.6.9-1 summarizes the wetlands that would be affected by this expansion. Figure B.6.9-3 shows the wetlands located at the expansion site.

Table B.6.9-1: Summary of Wetland Impacts for the Proposed West Hackberry Expansion Site[a]

Cowardin Wetland Types	Storage Site (acres)		Totals (acres)
	Filled wetlands	Permanent conversion	All affected wetlands
Palustrine – scrub-shrub[b]	0	5	**5**

Notes:

[a] This table presents only the wetland types that are present within the proposed facility footprint according to NWI data. Facilities were omitted if no wetland were present within the footprint.

[b] Forested and scrub-shrub wetlands would be cleared of woody vegetation and permanently converted to and maintained as emergent wetlands within the security buffer. DOE would follow any required wetland compensation for these temporary impacts that is required by Section 404/401 permit. At a minimum, DOE would restore original contours, replace the original hydric topsoil back in the disturbed area, and seed with native species

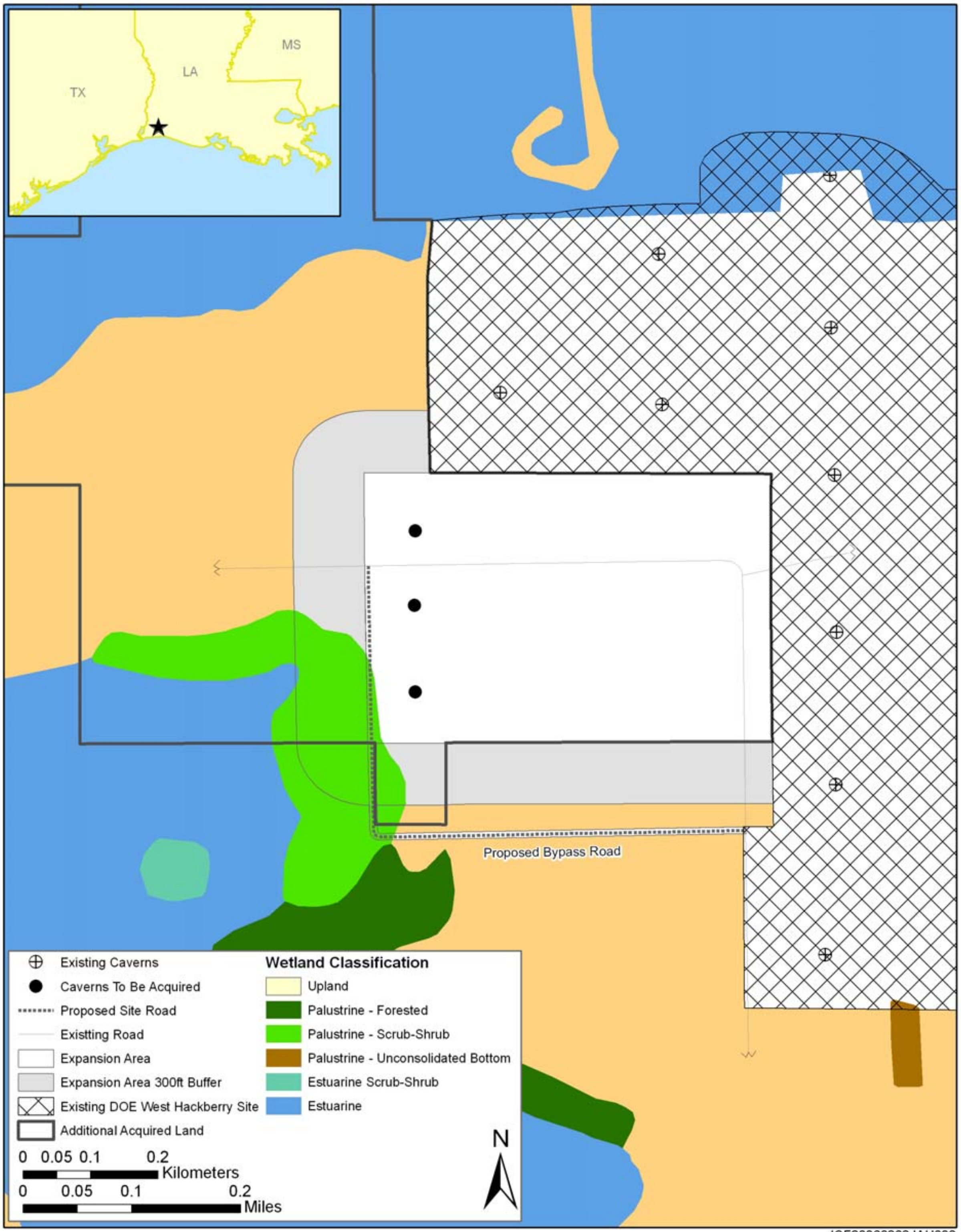
Numerous canals and natural waterways bisect the area where the West Hackberry storage site is located. This region consists of estuaries associated with the Louisiana coast. Natural ridges in the area typically support grass and trees and affect water flow through the marshes. Construction and operations and maintenance of the West Hackberry expansion site would permanently convert approximately 5 acres (2 hectares) of scrub-shrub wetlands to emergent wetlands. These wetland impacts are associated with the expansion area 300-foot (91-meter) site security buffer. This area would be permanently maintained for security purposes, converting the existing scrub-shrub wetlands to emergent wetlands. No additional wetland impacts are anticipated to result from the West Hackberry expansion.

Due to the location and geology of the salt domes, impacts to wetlands could not be avoided by this alternative. All impacts of jurisdictional wetlands would require a Section 404/401 permit from the USACE and from the Louisiana Coastal Management Division of the Department of Natural Resources. The permit application would require a comprehensive alternatives analysis that demonstrates avoidance and minimization of wetland impacts. The permit would contain conditions to minimize the impact to wetlands during construction and would require compensation for unavoidable impacts to jurisdictional wetlands. Section B.7 below discusses in more detail the avoidance, minimization, and mitigation measures that DOE would use to reduce, avoid, and compensate for the jurisdictional wetland impacts.

B.7 ALTERNATIVES, MINIMIZATION, AND MITIGATION

This discussion is not site-specific because alternatives, avoidance, minimization, and mitigation efforts that DOE pursues would be similar regardless of which site is chosen. Once DOE has selected an alternative other than the no-action alternative, a more detailed analysis of avoidance and minimization would be conducted as part of the design and Section 404/401 permit process. In addition, a compensation plan for all unavoidable impacts to jurisdictional wetlands would be prepared. If required by the USACE, the compensation plan would include a functional assessment of affected jurisdictional wetlands in order to establish appropriate compensation ratios.

Figure B.6.9-3: NWI Wetlands at the West Hackberry Expansion Site



B.7.1 Alternatives Consideration for Floodplains and Wetlands

DOE has taken into consideration alternatives to avoid adverse effects and incompatible development within floodplains and wetlands, to the maximum extent practicable. DOE has concluded there are no practicable alternatives to construction within floodplains or wetlands for the individual proposed SPR sites. Site locations, the location of onsite facilities, and site access roads are dictated by the location and configuration of the salt domes, which constitute a unique geologic setting. In addition, DOE needs a raw water source that is adequate for solution mining of storage caverns. Similarly, because the salt dome sites are largely located in lowland areas surrounded by wide expanses of floodplain and/or wetlands, there are no practicable alternatives to the location of the pipelines running to and from these sites within floodplains and wetlands. RWI structures and their pipeline ROWs also are water dependent because of their function and therefore cannot be located outside of the floodplain associated with the water source. Pipelines, power lines, and roads are long by nature and cannot avoid crossing waterways, wetlands, and the associated floodplains.

As discussed in the foregoing sections, the facilities to be constructed for the SPR expansion are not expected to significantly impact floodplain values or the base flood elevation—particularly in view of the impact minimization and mitigation measures that would be employed. The project would avoid "adverse effects and incompatible development within the floodplain," regardless of the alternative selected.

From the standpoint of the overall SPR expansion program, DOE considered alternatives for minimizing the impact of pipeline and power line ROWs in floodplains and wetlands. Selecting pipeline and power line ROWs along existing ROWs was the primary approach that DOE employed in selecting pipeline ROWs. The Gulf Coast consists of a large number of gas and oil fields and associated facilities, which offer a network of existing pipeline and power line ROWs. This network of utilities enabled DOE to minimize the potential impacts to floodplains and wetlands. Table B.7-1 summarizes the percentage of the length of proposed SPR pipeline ROWs that would follow existing ROWs for each proposed new or expanded storage site.

Table B.7-1: Percentage of Proposed ROW Located In Existing ROWs

Storage Site	Total ROW Required (miles)	Total Proposed ROW Following Existing ROW (miles)	Percent in Existing ROW
Bruinsburg	206	77	37
Chacahoula	146	77	55
Clovelly	No pipelines or power lines	No pipelines or power lines	No pipelines or power lines
Clovelly-Bruinsburg	122	37	30
Richton	222	92	41
Stratton Ridge	48	37	78
Bayou Choctaw	1	N/A	0
Big Hill	24	24	100
West Hackberry	No pipelines	No pipelines	No pipelines

1 mile = 1.61 kilometers; N/A = not applicable

As shown in table B.7.1, a significant portion of the length of the proposed ROWs would use existing ROWs. The use of the existing ROWs would minimize the floodplain and wetland impacts associated with project construction and operation and would help prevent fragmentation of the natural environment.

B.7.2 Mitigation of Site Construction Impacts on Floodplains

To comply with E.O. 11988 and existing regulations, DOE would follow the U.S. Water Resources Council's (1978) *Floodplain Management Guidelines for Implementing Executive Order 11988* and FEMA's *Unified National Program for Floodplain Management* (FEMA 1986, 1994) while planning its mitigation strategy for the selected SPR site. Those actions would include the following:

- The use of minimum grading requirements to save as much of the site from compaction as possible;
- Returning the site and ROWs to original contours where feasible;
- Preserving free natural drainage when designing and constructing roads, fills, and large built-up centers;
- Maintaining wetland and floodplain vegetation buffers to reduce sedimentation and discharge of pollutants to nearby water bodies where feasible;
- Constructing stormwater management facilities (where appropriate) to minimize any alteration in natural drainage and flood storage capacity;
- Limiting the practice of clear-cutting and amount of fill placed within wetlands where feasible;
- Directional drilling of larger wetland and stream crossings where feasible;
- Locating buildings above the base flood elevation or flood proofing;
- Complying with the floodplain ordinance/regulations for the jurisdiction where the selected alternative is located; and
- Performing a hydrological demonstration (using the Hydrologic Engineering Center Hydrologic Modeling System or an approved floodplain model) that proposed fill and structures within the floodplain would not increase the base flood elevation. The proposed facility would be designed and constructed to avoid increasing the base flood elevation.

B.7.2.1 Additional Alternatives Considered for Wetlands

DOE would follow established practices to avoid dredging and filling in wetlands, or where there is no practicable alternative, to minimize the wetland and compensating for unavoidable wetland losses. DOE has initiated actions to identify the least environmentally damaging practicable alternative (LEDPA) for the routing of the ROWs and the storage sites and associated facilities. DOE would further refine the conceptual design for the selected alternative to minimize the construction and operations impacts, and finally mitigate for unavoidable impacts to jurisdictional wetlands. Suggested best practices to limit or avoid pipeline construction and operation impacts in wetlands are presented in section B.7.3.

DOE used geospatial data to identify the LEDPA route for ROWs where possible. DOE used a GIS software tool to assign weights to data features in order to compute a cost-weighted distance between two points, which represents the ease of movement between two points (Theobald 2003). For example, one often thinks of the distance to an object in terms of both measured distance and the time it will take to travel through obstacles such as steep slopes. A cost-weighted distance takes into consideration the obstacles as well as the distance. This geospatial tool is often used to locate a new road or hiking trail (Theobald 2003). DOE used this approach to identify alternative routes for proposed ROWs that would use existing corridors and would avoid high value wetlands to the extent possible.

To find potential ROWs, DOE used data on existing pipeline and power line ROWs along with wetland data acquired from USFWS NWI. Existing ROWs and non-wetland areas were assigned the lowest weights, open water and emergent wetlands were moderately weighted, while forested wetland areas not along an existing ROW were heavily weighted. In this way, DOE identified the shortest path between two points that would avoid wetlands or certain wetland types and would maximize distance along existing ROWs.

DOE was able to apply this tool to the proposed sites at Stratton Ridge and Chacahoula. At Stratton Ridge, the tool did not find a practicable alternative to the refined proposed ROWs. The cost-weighted shortest path went through heavily developed areas or was longer than what was considered practicable. Before application of the cost-weighted path, DOE had already adjusted the ROWs at Stratton Ridge to maximize distance along existing ROWs and shorten distance through wetland areas, particularly Brazoria National Wildlife Refuge. These proposed alignments are shown on figure B.7.2-1.

The tool also did identify practicable alternatives to the ROWs at Chacahoula. After application of the tool, the ROWs were moved to follow existing pipeline ROWs that reduced the distance through wetlands and reduced the overall distance between points. Figure B.6.7.2-2 shows the proposed ROWs before and after application of the cost-weighted shortest path tool.

Due to limited availability of digital wetland data in Mississippi, DOE was not able to use this tool for the Richton or Bruinsburg sites and their infrastructure. Instead, DOE used USGS maps to align proposed ROWs along existing pipeline or power line ROWs. Aligning ROWs with existing ROWs was more challenging in Mississippi due to the relative lack of pipeline or power line infrastructure as compared to the coastal areas in Louisiana and Texas. Additionally, the Bruinsburg pipeline ROWs were limited by the rolling terrain in the area.

Wetland impacts would be unavoidable for any alternative other than no action. Site selection for the oil storage caverns depends on the location of the salt domes designated by EPACT. Therefore, in cases where wetlands exist above the salt domes designated by EPACT criteria, development could not avoid impacts to wetlands. In addition, all of the proposed new sites would require a new source of raw water for solution mining. Therefore, the impacts to wetlands would be unavoidable, except under the no-action alternative, due to the water dependency of the project.

B.7.3 Mitigation of Site Construction Impacts on Wetlands

DOE will comply with Section 404/401 of the Clean Water Act, E.O. 11990, the National No Net Loss Policy, and 10 CFR Part 1022 when planning its mitigation strategy for the wetland impacts from the selected alternative. Although some impacts to wetlands cannot be avoided (e.g., removal of vegetation during site or pipeline construction), the impacts would be partially mitigated through the use of appropriate engineering designs and good operating procedures. In addition to selecting the LEDPA, DOE would mitigate impacts throughout construction by using the following:

- Impact avoidance and minimization, which in addition to the LEDPA approach described above, includes ongoing infrastructure siting refinements and low-impact construction methods and containment measures.

- Restoration, which includes replanting, restoration, and other postconstruction compensation. Mitigation of impacts to wetlands would be specified in the Clean Water Act Section 404/401 Water Quality Certificate for the selected alternative.

Figure B.7.2-1: Alternative ROWs Considered for the Proposed Stratton Ridge Site

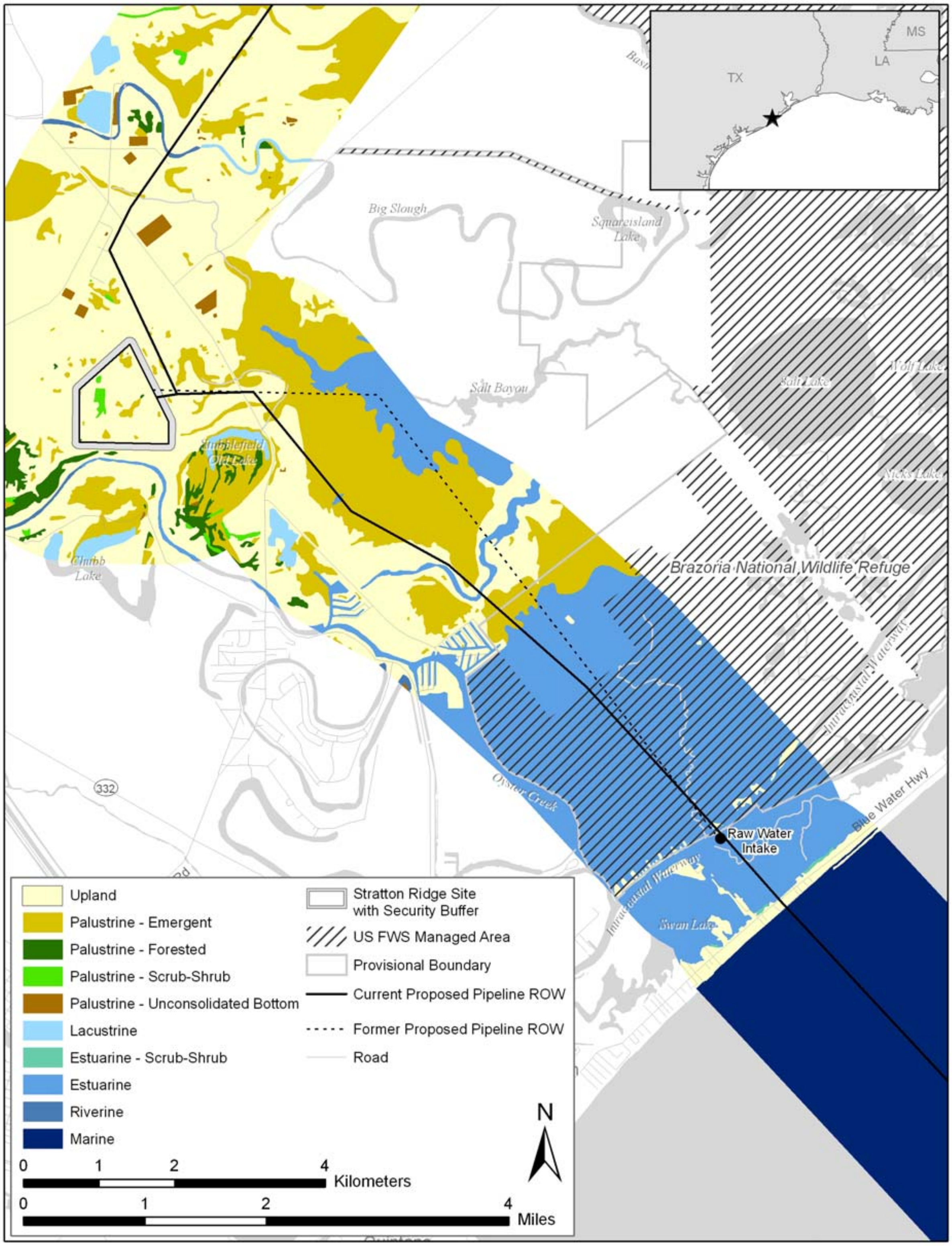


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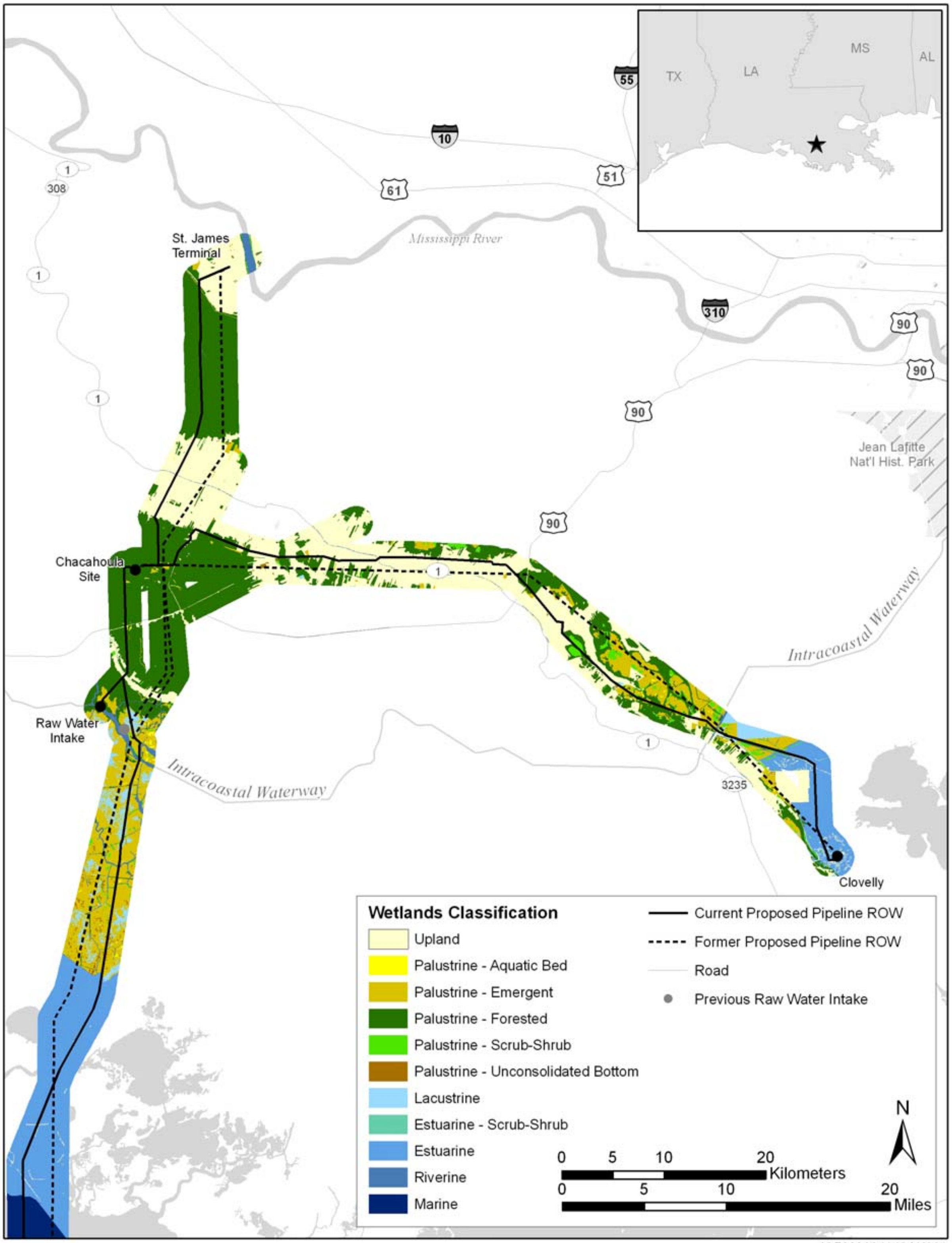
Figure B.7.2-2: Alternative ROWs Considered for the Proposed Chacahoula Site



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B.7.4 Impact Avoidance and Minimization

DOE's primary mitigation measure for wetland impacts would be avoidance and minimization. As described in chapter 2 and in the preceding text of this appendix, DOE would locate temporary access roads and staging areas in upland areas or would use temporary floating staging areas, as appropriate. Larger wetlands (about 100 feet [30 meters] or wider) would be directionally drilled wherever practicable. DOE would continue to refine the concept plans for the site storage areas and terminals to avoid placing aboveground structures and fill in wetlands as much as practicable. Where the security buffers around the storage areas or permanent ROW easements extend into wetlands, DOE would preserve emergent wetlands and would allow herbaceous species to re-establish themselves within the forested and scrub-shrub wetlands that would be cleared.

Within the temporary construction easements of the ROWs, DOE would promote the restoration and re-establishment of the existing plant community by stockpiling and reusing the hydric soils (and their diverse seed bank) from the disturbed wetlands. In this way, some wetland functions and values would be preserved and wetlands would be restored more quickly if there was a temporary impact to wetlands or permanent conversion from forested to emergent wetlands. For wetland impacts that cannot be avoided, DOE would implement one or more of the following mitigation measures:

- As described in chapter 2, DOE would install trench plugs (using low-permeability clay placed around the pipe) at intervals to prevent the unintentional draining of water from the wetlands or mixing of fresh-water and marine wetland systems.

- Excess dredged material would be disposed of in consultation and in accordance with permits issued by USACE and the state. Dredge spoils would be used for wetland creation or restoration activities wherever possible.

- Where possible, power line poles would not be placed in wetlands.

- If the wetlands are forested, tree stumps and root mass from all plants would be left intact, except where this would interfere with excavation of the pipeline trench.

- For wetlands that are not inundated or that have shallow standing water, equipment would be supported on timber mats or on prefabricated equipment mats. Spoil from the trench would be stored within the ROW on the nonworking side of the pipeline ROW. Topsoil would be stored separately, where appropriate. Stockpiling of soil would be interrupted at appropriate intervals to prevent change of surface water flow (sheet flow). If the bottom of the pipeline trench would be at a lower elevation than the wetlands, a permanent trench plug of impervious clay would be placed into the trench at the wetland boundaries. If a fresh-water marsh (palustrine emergent wetlands) would likely be exposed to brackish or marine water by connection with these water sources via the pipeline trench, then temporary trench plugs would be used during construction and permanent trench plugs would be installed after the pipe is lowered into the trench. The trench plugs would be installed between the fresh-water marsh (palustrine emergent wetlands) and any adjacent body of water with a higher salinity.

- Excavated wetlands would be backfilled with either the same hydric topsoil removed or a comparable material capable of supporting similar wetlands vegetation. Original wetland elevations would be restored and adequate material would be used so that following settling and compaction of the material, the proper preconstruction elevation would be attained. After backfilling, DOE would implement erosion protection measures to stabilize and revegetate the site and prevent further wetland degradation.

- DOE would remove all construction-related materials, such as timber mats, rip rap, silt fence, prefabricated equipment mats, and geotextile fabric, upon completing construction. Where the pipeline trench may drain wetlands, DOE would construct trench breakers and/or seal the trench bottom as necessary to maintain the original wetland hydrology. For each wetland area crossed, DOE would install a permanent slope breaker and a trench breaker at the base of the slopes near the boundary between the wetlands and the adjacent upland areas. The trench breaker would be located immediately upslope of the slope breaker. DOE would not use fertilizer, lime, or mulch along the ROW within wetlands, nor immediately upslope from wetlands. Reseeding efforts would use a seed mix of native wetland species. For ongoing ROW maintenance, DOE would limit vegetation in a narrow corridor over the pipeline and to either side to facilitate periodic pipeline corrosion and leak surveys. DOE would not use herbicides or pesticides in or within 100 feet (30 meters) of wetlands. DOE would conduct a postconstruction monitoring program of the disturbed wetlands within the ROWs to ensure that the hydrology and wetland plant community is re-establishing. The monitoring would follow approved procedures contained in the USACE Section 404 permit. If the monitoring showed that wetland plants and hydrology were not successfully re-established, DOE would implement corrective action.

- Other potential mitigation measures or best management practices that DOE would consider during permit application and design include the following:
    - Other than the construction ROW, only use pre-existing roads within wetlands. Do not construct new access roads through wetlands.
    - Assemble the pipeline in an upland area and use the push technique to place the pipe in the trench where water and other site conditions allow.
    - Minimize the duration of construction-related disturbance within wetlands.
    - Schedule the construction-related disturbance during the dry season.
    - Limit construction equipment operating in wetland areas to equipment needed to clear the ROW, dig the trench, fabricate and install the pipeline, backfill the trench, and restore the ROW.
    - Cut vegetation off at ground level, leaving existing root systems in place, except within the path of the pipe trench.
    - Do not pile woody vegetation within wetlands.
    - Do not store hazardous materials, chemicals, fuels, or lubrication oils, or perform concrete coating activities in wetlands or within 30 yards (9 meters) of any wetland boundary.
    - Attempt to refuel all construction equipment in an upland area at least 30 yards (9 meters) outside a wetland boundary. If construction equipment must be refueled within wetlands, follow fueling procedures outlined in project-specific spill prevention or contingency plans.
    - Do not use rock, soil imported from outside the wetlands, tree stumps, or brush rip rap to stabilize the ROW.
    - If standing water or saturated soils are present, use low-ground-weight construction equipment or operate normal equipment on timber mats or prefabricated equipment mats.
    - Do not cut trees outside the construction ROW to obtain timber for equipment mats.
    - Do not discharge hydrostatic test water into wetlands.

B.7.5 Wetland Compensation

DOE would compensate for unavoidable wetland impacts by creating, restoring, and/or preserving wetlands, paying an in-lieu of fee, or buying credits from an approved mitigation bank. DOE would develop and submit the compensation plan as part of the Section 404/401 permit process. Wetland creation would typically involve alteration of an upland (generally though excavation) to create the proper hydrology for wetlands and planting of wetland species at the site. Restoration typically involves the modification of a previously disturbed wetland that may no longer function as a wetland because it has been ditched or drained. The wetland hydrology is restored and wetland species are planted at the site. Wetland preservation typically involves the purchase and preservation of existing wetlands in perpetuity.

Compensation credits and a compensation ratio would be established based on the functions and values of the affected wetland, the acreage of wetland impacts, and the type of compensation offered. Because the compensation ratio would be based on the functions and values of the wetlands and the type of mitigation proposed, one compensation credit does not necessarily equate to one acre of wetlands. Thus, the type of mitigation is important in determining how many acres would need to be preserved, created, or restored to equal one compensation credit. For example, the compensation required for preservation of wetlands would be much higher than that for wetland restoration to reach one compensation credit.

The type of wetland affected and its rarity would be important in determining the compensation ratio. The filling of palustrine forested wetlands would cause a complete loss of functions and values of a relatively rare and ecologically important resource. This type of impact would require the highest compensation ratio, such as 5:1 or 7:1. On the other hand, impacts to emergent wetlands within the permanent easement for pipeline corridors would cause only a temporary loss of the wetland functions and values and would probably require compensation at the lowest ratio.

Representative mitigation ratios for unavoidable impacts to jurisdictional wetlands are presented in table B.7-2 Wetland Mitigation Ratios. If required by the USACE, the compensation ratios would be determined through a formal assessment of wetland functions and values, which would be completed during the permit application stage. The Vicksburg, Mobile, and New Orleans Districts of USACE indicated that they would probably require DOE to use the USACE Charleston District methodology for determining wetland compensation credits (USACE Charleston District 2002).

Table B.7-2: Approximate Wetland Mitigation Ratios

State	Approximate Compensation Requirements		
	High Wetland Functions and Values	**Moderate Wetland Functions and Values**	**Low Wetland Functions and Values**
Louisiana	5:1	3:1	2 to 1:1
Mississippi	5:1	3:1	2 to 1:1
Texas	7:1	5:1	3 to 1:1

Notes:

These are estimates of the compensation ratios that may be required by regulatory agencies. The actual requirements would depend on several factors, including existing wetland conditions and their functions and values. If required for the selected alternative, a formal assessment of affected wetland functions and values would be completed to determine appropriate compensation ratios.

Source: U.S. Army Corps of Engineers, New Orleans, Vicksburg, Galveston, and Mobile Districts

B.8 SUMMARY

Table B.8-1 summarizes and compares the floodplain and wetland impacts associated with each proposed new and expansion site; table B.8-2 summarizes and compares the floodplain and wetland impacts by alternative.

Table B.8-1: Summary of Floodplain and Wetland Impacts for Each Proposed New and Expansion Site

Storage Site	Storage Site and Associated Facilities Floodplain Impacts (acres)		ROW Floodplain Impacts (miles)		Storage Site, Associated Facilities, and ROW Wetland Impacts (acres)
	100-year	500-year	100-year	500-year	
Bruinsburg	241	21	30	4	464
Chacahoula	136	0	91	<1	2,256
Clovelly	21	0	0	0	10
Clovelly and Bruinsburg	101	21	37	4	530
Richton	63	0	27	3	1,305
Stratton Ridge	124	186	41	8	598
Bayou Choctaw	24	0	<1	0	34
Big Hill	11	27	18	3	189
West Hackberry	0	0	0	0	5

1 acre = 0.405 hectares; 1 mile = 1.61 kilometers

Table B.8-2: Summary of Floodplain and Wetland Impacts by Alternative with Three Expansion Sites

Alternative	Storage Site and Associated Facilities Floodplain Impacts (acres)		ROW Floodplain Impacts (miles)		Storage Site, Associated Facilities, and ROW Wetland Impacts (acres)
	100-year	500-year	100-year	500-year	
Bruinsburg	276	48	48	7	692
Chacahoula	171	27	109	3	2,484
Clovelly	56	27	18	3	238
Clovelly 80 MMB and Bruinsburg 80 MMB	136	48	55	7	758
Clovelly 90 MMB and Bruinsburg 80 MMB	136	48	55	7	758
Richton	98	27	45	6	1,533
Stratton Ridge	159	213	59	11	826
No-action	0	0	0	0	0

1 acre = 0.405 hectares; 1 mile = 1.61 kilometers

All of the alternatives presented in table B.8-2, with the exception of Clovelly and no-action, could be developed with the expansion of two sites (Big Hill and Bayou Choctaw) or the expansion of three sites (Big Hill, Bayou Choctaw, and West Hackberry). With only two expansion sites developed, the total acres of wetlands impacted under each alternative would be reduced by five acres (2 hectares) because West Hackberry would not be expanded.

A substantial portion of the proposed storage sites and associated infrastructure would be located in the 100-year and 500-year floodplain. The amount of onsite construction would vary by site, with the greatest amount of floodplain disturbance at Stratton Ridge and Bruinsburg. Richton would have no floodplain disturbance due to onsite construction activities. Offsite pipeline construction would affect floodplains only during construction, and areas would be brought back to grade following construction. Pipeline construction associated with the Chacahoula project crosses the largest area of floodplains. There would be no impact to floodplains from pipeline construction at Clovelly.

Because most of the infrastructure on the affected floodplains would be built below ground, the impacts would be lessened. The main impacts on flood storage and flooding attenuation would result from constructing some aboveground structures and placing fill at the new cavern facilities at Chacahoula, Bayou Choctaw, Stratton Ridge, and Big Hill. These fill areas, however, would be insignificant in comparison the total areas of the floodplains in which where they are located. The Bruinsburg, Chacahoula, Richton, Stratton Ridge, and Big Hill sites are located in floodplains that extend over hundreds of acres (hectares) in coastal basins. The Bayou Choctaw site also is located in an extensive floodplain area. Thus, fill areas developed as part of the proposed action at these sites would have insignificant impact on the flood storage capacity or hydraulic function of the related floodplains.

DOE would comply fully with applicable local and state guidelines, regulations, and permit requirements regarding floodplain construction. In general, DOE would be required to evaluate the impact of placing fill or structures in the 100-year floodplain and to demonstrate that the proposed fill/structures would not increase the base flood elevation. Based on these factors, DOE expects that overall impacts to floodplain hydraulic function, and therefore to lives and property, would not be significant.

As shown in table B.8-2, the relative order of impacts on wetlands from least to most by alternative would be as follows:

- Clovelly alternative,
- Bruinsburg, Clovelly 80 or 90 MMB and Bruinsburg 80 MMB alternatives,
- Stratton Ridge alternative,
- Richton alternative, and
- Chacahoula alternative.

The Clovelly alternative would result in the least impacts on wetlands because the new site would be developed at an existing crude oil storage and distribution facility and no new offsite infrastructure or pipelines would be required. The relative impacts on wetlands (fill, conversion, and temporary disturbance) associated with the Clovelly 80 MMB and Bruinsburg 80 MMB, Clovelly 90 MMB and Bruinsburg 80 MMB, and Bruinsburg alternatives would be approximately the same. Relatively rare and ecologically important bald cypress forested wetlands would be filled or converted at Bruinsburg under the Clovelly 80 MMB and Bruinsburg 80 MMB, the Clovelly 90 MMB and Bruinsburg 80 MMB, and the Bruinsburg alternatives. The impacts on wetlands under the Stratton Ridge alternative would involve filling and converting relatively rare and ecologically important bottomland hardwood forest at the Stratton Ridge site.

The Richton alternative would affect almost double the amount of wetland (over 600 acres [243 hectares]), in terms of permanent impacts, compared to the Bruinsburg alternative. The majority of the wetland impacts associated with the Richton alternative result from the long ROWs (over 200 miles [322 kilometers]). The Chacahoula alternative has the most impacts on wetlands (over 1,000 acres [405 hectares]). Relatively rare and ecologically important bald cypress forested wetlands would be filled and converted at Chacahoula, and the majority of each ROW would pass through the extensive wetlands located throughout southern Louisiana.

B.9 REFERENCES

Federal Emergency Management Agency (FEMA). 1986. "A Unified National Program for Floodplain Management." Document FEMA 100. Federal Interagency Floodplain Management Task Force. FEMA 248. 1994. (As cited in DOE 2003).

Federal Emergency Management Agency (FEMA). 1994. "A Unified National Program for Floodplain Management." Document FEMA 248. Federal Interagency Floodplain Management Task Force. (As cited in DOE 2003).

Reid, S.M. and P.G. Anderson. "Effects of Sediment Released During Open-cut Pipeline Water Crossings." Alliance Pipeline. Accessed January 4, 2006 at www.alliancepipeline.com/contentfiles/45EffectsofSediment.pdf

Theobald, D.M. 2003. "GIS Concepts and ArcGIS Methods." Conservation Planning Technologies. Fort Collins, CO.

United States Army Corps of Engineers. 1987. "Wetland Delineation Manual." Accessed at http://www.wetlands.com/regs/tlpge02e.htm

United States Department of Energy (DOE). 1992. "Draft Environmental Impact Statement on the Expansion of the Strategic Petroleum Reserve, Alabama, Louisiana, Mississippi, Texas." (DOE/EIS-0165-D). Washington, DC.

United States Department of Energy (DOE). 2003. "Compliance With Floodplain and Wetland Environmental Review Requirements." *Federal Register. 68*(166):51429-51436. Office of NEPA Policy and Compliance, Washington, DC.

United States Water Resources Council. 1978. "Floodplain Management Guidelines for Implementing Executive Order 11988." *Federal Register. 40*:6030. (As cited in DOE 2003).

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Appendix C:
Brine Plume Modeling of Strategic Petroleum Reserve Expansion Sites

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Appendix C
Brine Plume Modeling of Strategic Petroleum Reserve Expansion Sites

C.1 INTRODUCTION

The Department of Energy (DOE) is evaluating development of new Strategic Petroleum Reserve (SPR) sites and expansion of existing sites to increase the overall SPR capacity. At each of the sites, brine would be generated from cavern formation and during oil drawdown events over the operational life of the facility. Brine from three of these sites (Bruinsburg, Bayou Choctaw, and West Hackberry) would be injected into the deep subsurface through injection wells. At the remaining five sites in the following list, brine would be discharged into the Gulf of Mexico through diffusers. Brine discharge to the Gulf of Mexico would occur at the following proposed sites:

- Richton, MS (new site);
- Chacahoula, LA (new site);
- Clovelly, LA (new site, but brine would be discharged through an existing diffuser at the LOOP facility);
- Big Hill, TX (expansion of existing SPR site; brine would be discharged through an existing diffuser); and
- Stratton Ridge, TX (new site).

The impacts of brine discharge into the Gulf of Mexico have been studied at operating sites including Bryan Mound, TX, and West Hackberry, LA. Based on field measurements of elevated salinity around these diffuser sites, DOE developed an empirical model. The model was run for the five above-listed proposed brine diffuser sites to estimate the impacts of brine discharge to the Gulf of Mexico for each of the proposed sites. Take note that West Hackberry is an existing SPR facility that in the past discharged brine to the Gulf of Mexico, but the diffuser is no longer being used; the proposed plan for expansion would use injection wells to dispose of brine. In addition to this modeling effort, EPA will require use of the CORMIX model to further predict the extent of the brine plume as part of the permitting process prior to operation of a brine diffuser.

C.1.1 Objectives

The objective of this study is to predict the areal extent of the brine plumes, the above-ambient salinity contours, and the vertical extent of the brine jets emanating from the proposed diffuser locations at the proposed new and expansion sites. The empirical brine plume model developed by Randall and Price (1985a, 1985d), which is described later, was used to estimate potential impacts of the proposed sites. Figure C.1.1-1 shows the proposed locations of the brine diffuser sites for the new and expansion sites.

C.1.2 Description of Proposed Diffusers

Brine from the SPR sites would be pumped to the Gulf of Mexico through a buried pipeline to a multiport diffuser. A schematic of the diffuser system is provided in figure C.1.2-1. The brine lines would range up to 4.0 inches (10 centimeters) with up to 75 proposed diffuser ports, 3.0 inches (7.6 centimeters) in diameter, spaced 60 feet (18 meters) apart at each diffuser location. A flexible hose extending 4.0 feet (1.2 meters) above the mudline would be attached to each port. The water depths at the proposed diffuser locations range from 30 feet (9.1 meters) to 47 feet (14 meters). As the brine exits from the diffuser ports, it is diluted as a result of jet mixing. Subsequently, it sinks to the bottom as a result of its greater density,

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Figure C.1.1-1: Proposed Locations of SPR Brine Diffusers in the Gulf of Mexico

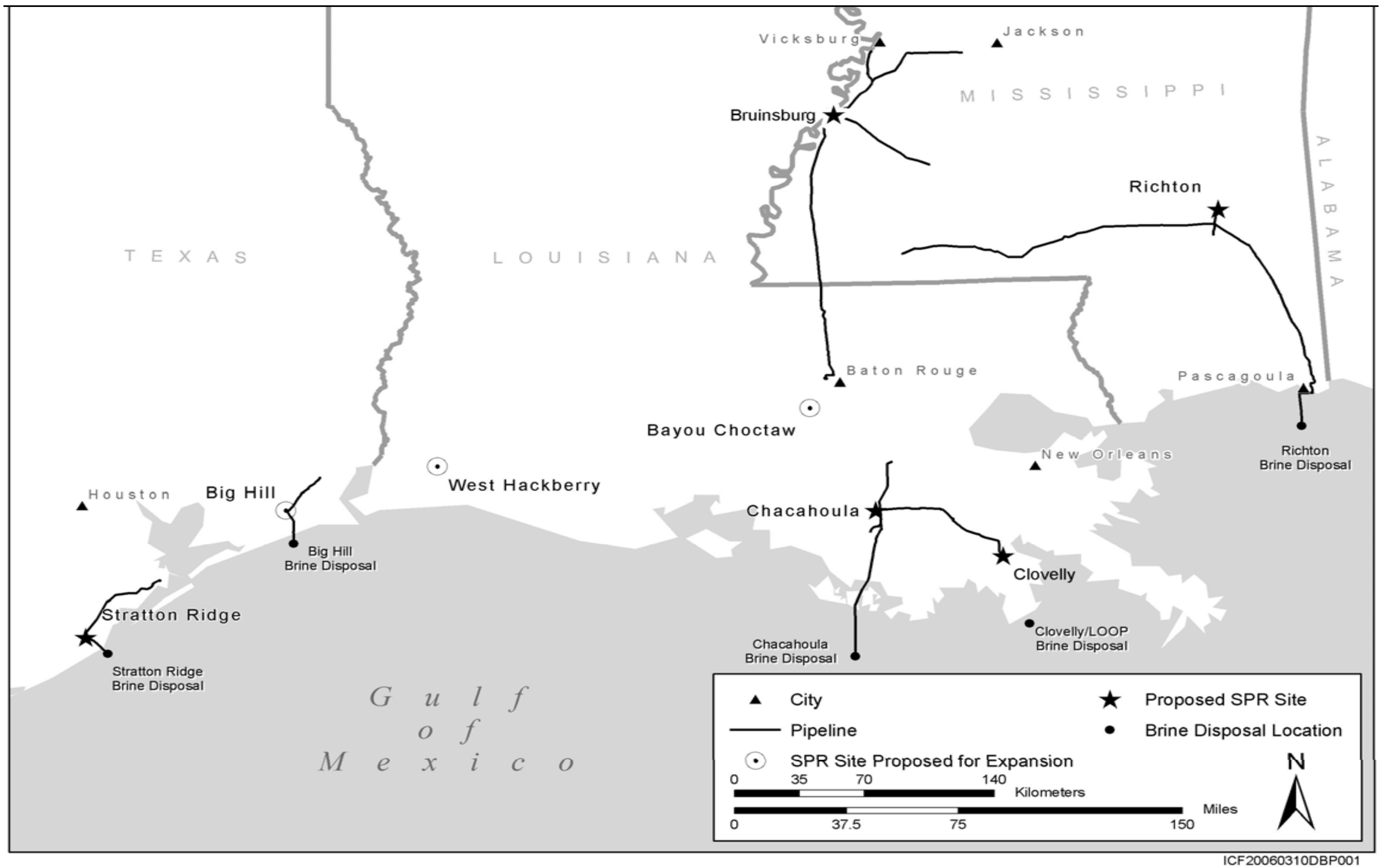
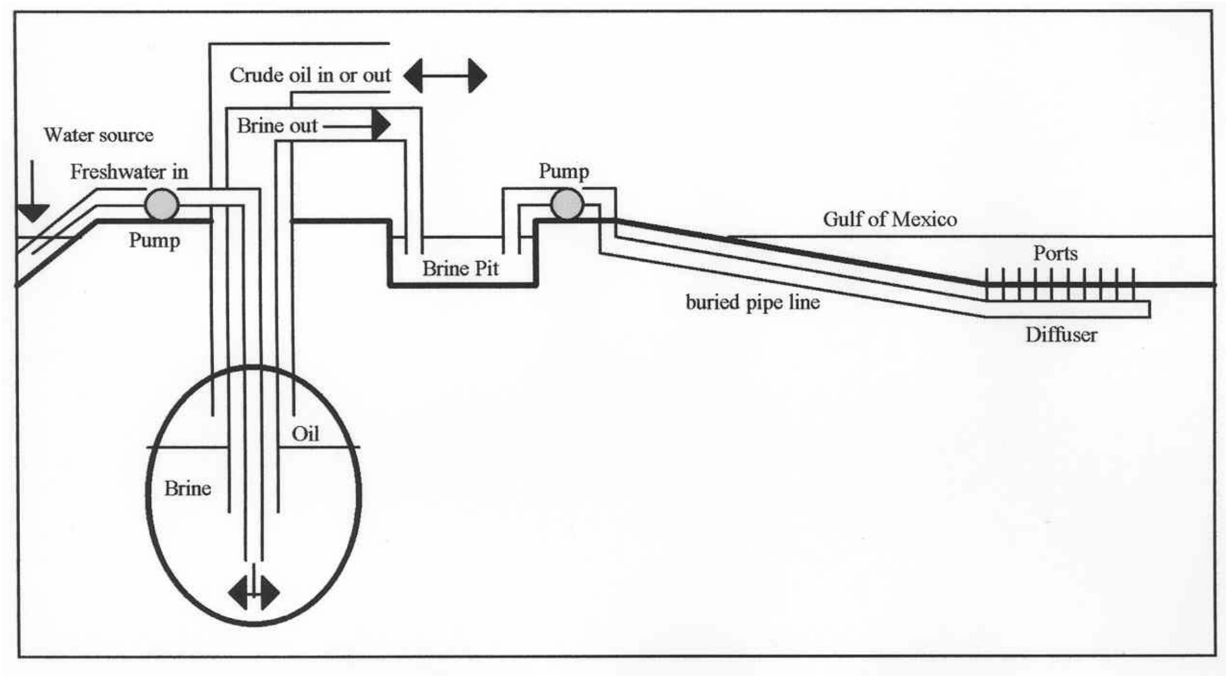


Figure C.1.2-1: Example Brine Diffuser Site and Schematic of the Brine Discharge Operation



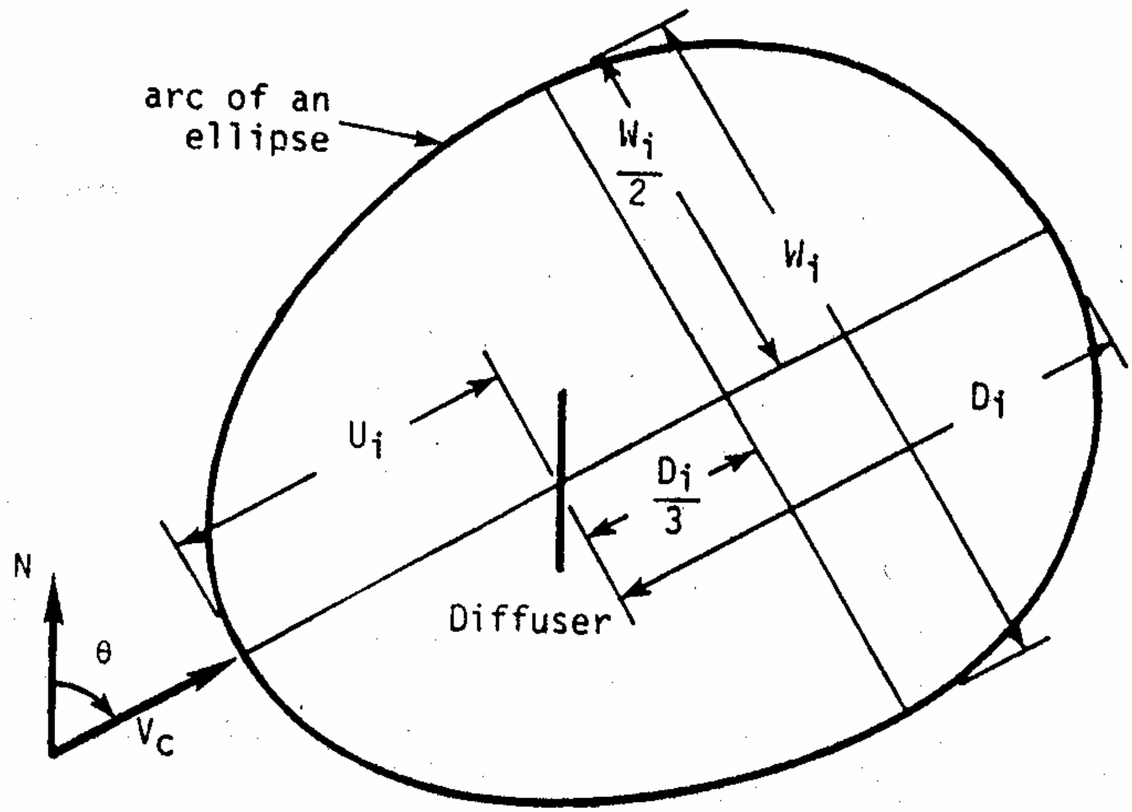
and it simultaneously spreads laterally. The plume is then dispersed by advection due to currents and diffusion due to turbulence.

C.2 DESCRIPTION OF BRINE PLUME MODEL

Experimental results of Tong and Stolzenbach (1979), a numerical model by Adams et al. (1975), and field measurements at Bryan Mound and West Hackberry diffuser sites, indicated there were certain parameters that are important in describing the plume behavior. These parameters are bottom-current speed (V_c) and direction, brine salinity (S_b), ambient bottom salinity (S_a), brine exit velocity (V_e), and brine discharge rate (Q). Empirical equations using dimensionless groupings of the above parameters were developed to estimate the brine plume areal extent, general dimensions (downstream length, width, and upstream length), maximum above-ambient bottom salinity, and the number of above-ambient salinity contours.

During field investigations at operating SPR brine diffusers, the brine plume was measured using a conductivity sensor mounted 10 inches (25 centimeters) above the sea floor in a towed sled. The measured brine plume data indicated that an ellipse was a reasonable estimate of the above-ambient bottom salinity contours. Therefore, empirical equations were determined to relate the upstream length (U_i), downstream length (D_i), and maximum width (W_i) of the plume to the dimensionless groups of physical parameters affecting the plume formation. The two lengths and the width define the axes of an ellipse as illustrated in figure C.2-1. The upstream length (U_i) is measured from the center of the diffuser in the opposite direction of the average bottom current to the desired above-ambient bottom salinity contour. The downstream length (D_i) is the distance measured in the direction of the bottom current from the center of the diffuser to the desired above-ambient bottom salinity contour. The width (W_i) is measured normal to the direction of the bottom current, and it is bisected by the line extending through the center of the diffuser in the direction of the bottom current. Plume measurements indicate that the

Figure C.2-1: Schematic of the Ellipse Used to Predict the Areal Extent of the Brine Plume



maximum width of the plume is usually located approximately one-third of the distance downstream of the diffuser, and therefore, the width is displaced a distance $D_i/3$ from the diffuser center. The ends of the lines U_i, D_i, and W_i are then connected with arcs of an ellipse that define the estimated above-ambient bottom salinity contour.

Note: Where U_i is the upstream length, D_i is downstream length, and W_i is the maximum width. The empirical relationship that fits the data best is

$$D_i, U_i \text{ or } W_i = M\,(Q/V_c)^{1/2}(S_b/S_a) + B \tag{1}$$

where Q, V_c, S_b and S_a are the brine discharge rate in units of cubic feet per second (cubic meters per second), average bottom current in units of cubic feet per second (meters per second), and brine salinity and ambient bottom salinity in units of parts per thousand, respectively. An empirical equation of similar form,

$$A_i = (1/M)(Q/V_c)(S_b/S_a) + B \tag{2}$$

is the best fit for predicting the areal extent. The units of the plume dimensions (D_i, U_i, and W_i) are feet (meters) and acres (hectares) for the area (A_i).

DOE began discharging brine at the Bryan Mound SPR site through a multiport diffuser in 71 feet (22 meters) of water located 11 nautical miles (20 kilometers) offshore of Freeport, TX, in March 1980. Field measurements of the resulting brine plumes are described in several reports (Randall, 1981; Randall, 1982; Randall and McLellan, 1983; Randall and Price, 1984a, 1985b).

Brine discharge began in May 1981 through the West Hackberry multiport diffuser located in 32 feet (9.8 meters) of water and 5.4 nautical miles (10 kilometers) offshore of Holly Beach, LA (the West Hackberry brine diffuser is no longer operated). The West Hackberry brine plume was also measured and the results were reported (Randall, 1983; Randall and Price, 1984b, 1985c).

The brine plume field measurements from the Bryan Mound and West Hackberry sites were used to develop empirical models for predicting the brine plume areal extent, brine jet vertical extent, and the above-ambient salinity contours. The models are described in the reports mentioned earlier and by Randall and Price (1985a, 1985d).

The measured brine plume data and bottom-current data from the West Hackberry diffuser site location, and the West Hackberry brine diffuser site operating data for the period May 1981 through November 1983 were used to determine the coefficients (*M* and *B*) for equations 1 and 2. The resulting coefficients and the correlation coefficients for the resulting equations are tabulated in table C.2-1. The scatter of the data about the regression line as discussed by Randall and Price (1985a, 1985d), and the low correlation coefficients indicate that the predictive equations are a reasonable estimate. The natural variation of salinity in the vicinity of the brine discharge contributes to the scatter. Also, the bottom currents change in magnitude and direction over the approximate 8-hour period of the plume measurement. Variations in the brine discharge rate and salinity during the measurement period are also factors contributing to the data scatter. Randall and Price (1985a, 1985d) conclude that the empirical equations are a best estimate of the plume characteristics in a variable ocean environment.

In addition to the plume dimensions and areal extent, the number of above-ambient bottom salinity contours must be determined. The maximum above-ambient bottom salinity is a function of the brine salinity, ambient bottom salinity, bottom current, port exit velocity, port diameter, brine density, and ambient bottom water density. Laboratory experiments conducted by Tong and Stolzenbach (1979) showed the maximum above-ambient bottom salinity could be estimated by

$$\Delta S = 0.5\, \Delta S_m\, V_r\, (F^2)^{-0.67} \qquad (3)$$

where ΔS is the bottom salinity minus the ambient salinity in units of parts per thousand, ΔS_m is the brine salinity minus the ambient salinity in units of parts per thousand, $V_r = V_c/V_e$, V_c is the bottom current in units of feet per second (meters per second), V_e is the jet exit velocity in units of feet per second (meters per second), $F = V_c/[g((\rho_b - \rho_a)/\rho_a)D]^{0.5}$, g is 9.81 feet per second (meters per second), ρ_b is the brine density in units of pounds per cubic feet (grams per cubic centimeters), ρ_a is the ambient sea water density in units of pounds per cubic feet (grams per cubic centimeters), and *D* is the port inside diameter in units of feet (meters).

The brine plume, brine discharge, and physical oceanography current meter data collected from the Bryan Mound and West Hackberry brine disposal operations were used to determine an empirical relationship similar to equation 3 using linear regression techniques (Randall and McLellan, 1983). The result has a correlation coefficient of 0.89, indicating a good fit to the data. Equation 4 is used to estimate the

Table C.2-1: Coefficients for Brine Plume Prediction Equations Based on Data for West Hackberry Brine Diffuser Site

Equation Type	Coefficient M	Coefficient B	Correlation Coefficient
Area			
A_1	10.3	3.02	0.20
A_2	17.9	1.04	0.20
A_3	34.0	0.21	0.22
A_4	56.2	0	0.17
A_5	127.4	0	0.06
A_6	196.3	0	0.01
Width			
W_1	71.1	1804	0.47
W_2	59.9	1045	0.53
W_3	41.0	629	0.52
W_4	34.7	186	0.54
W_5	18.7	55	0.28
W_6	13.8	52	0.33
Downstream Length			
D_1	56.5	1051	0.26
D_2	41.3	683	0.16
D_3	32.5	406	0.1
D_4	27.0	332	0.42
D_5	22.3	289	0.36
D_6	19.7	177	0.62
Upstream Length			
U_1	39.7	0	0.66
U_2	28.0	0	0.75
U_3	20.5	0	0.74
U_4	15.1	0	0.74
U_5	13.0	0	0.52
U_6	12.4	0	0.82

Note: Subscripts indicate the above-ambient salinity contour.
Source note: Randall and Price 1985a, 1985d.

maximum above-ambient bottom salinity, and this value is truncated to the nearest part per thousand to determine the number of above-ambient bottom salinity contours for the plume prediction.

$$\Delta S = 0.444\ \Delta S_m\ V_r\ (F^2)^{-0.533} \tag{4}$$

The prediction of the plume is for an 8-hour period because this is the approximate time required to measure the plumes. The prediction model does not account for a sloping bottom, but the West Hackberry data used to evaluate the coefficients for the plume prediction equations were taken from a site that has a small cross-shelf slope (1 to 2,500). A computer program has been developed that inputs the necessary physical data and uses these data to compute the plume physical dimensions, areal extent, and above-ambient bottom salinity contours for each 8-hour period. Comparisons of predicted and measured results are described by Randall and Price (1985a, 1985d).

The plume prediction model in equations 1 and 2 and the maximum above-ambient bottom salinity prediction in equation 4 assume the vertical salinity distribution is constant. Stable stratification (increasing salinity with increasing depth) frequently is observed at water depths ranging from 30 to 40 feet (9.1 to 12 meters) in this area of the Gulf of Mexico; however, vertical salinity gradients in the range of 5 to 10 parts per thousand have been observed (Kelly et al., 1982, Randall and Kelly, 1982). When these vertical salinity gradients are present, the dilution of the brine is greater, and consequently, the maximum above-ambient bottom salinity is less than that predicted by equation 4. There are also fewer above-ambient salinity contours and smaller areal extent, and consequently, the model is conservative when salinity stratification is present.

The vertical extent of negatively buoyant jets has been investigated using laboratory and field experiments as reported by Tong and Stolzenbach (l979), Turner (1966), and Randall and McLellan (1983). The vertical extent of the brine jets depends on the exit velocity, port diameter, brine density, and ambient density of the receiving waters. A relationship has been determined by experimental procedures as reported by previously mentioned researchers. The general form of the equation developed is

$$Z/D = C\,V_e/[g((\rho_b - \rho_a)/\rho_a)D]^{1/2} \qquad (5)$$

where Z is maximum height of brine jet above the port , D is inside port diameter, V_e is port exit velocity, g is gravitational acceleration constant, ρ_b is the brine density, ρ_a is the ambient sea water density, and C is a proportional constant. Randall and McLellan (1983) determine a value of C equal to 2.2.

C.3 MODEL APPROACH

The empirical brine plume prediction model described earlier was used to predict the negatively buoyant brine plumes for the proposed new and expansion diffuser locations. Input parameters representative of baseline oceanographic conditions at each of the proposed brine diffuser sites were estimated based on available data from various field studies at similar depths and distances from shore in the Gulf of Mexico.

The direction and magnitude of bottom currents at the diffuser sites are primary determinants of the extent of the resultant brine plumes. The resultant high salinity plume is largest at low bottom-current velocities; thus, analyses are limited to the low bottom-current velocity of 1.2 inches per second (3.0 centimeters per second) (identified as the “maximum plume” scenario) and moderate bottom-current velocity 3.5 inches per second (9.0 centimeters per second) (identified as the “typical plume” scenario). These bottom-current velocities were chosen based on review of monitoring data from the operating Big Hill and West Hackberry SPR sites and other available data from the proposed Richton diffuser location area.

For each site, analyses and maps represent the following three scenarios:

1. The first map depicts the maximum potential impact area showing the plume extent resulting from the low bottom-current velocity of 1.2 inches per second (3.0 centimeters per second), and it shows the predominant current direction along the shoreline.

2. The second map depicts the area of impact assuming a “typical” bottom-current velocity of 3.5 inches per second (9.0 centimeters per second), and it shows the predominant current direction.

3. The third map depicts the area of impact also assuming a "typical" bottom-current velocity of 3.5 inches per second (9.0 centimeters per second), but it shows the second most predominant current direction.

Probable bottom-current velocities and directions are based on available oceanographic data for the diffuser sites and surrounding areas. This background information is summarized as follows.

Representative data from the Big Hill site is provided in tables C.3.1-1 and C.3.1-2. Table C.3.1-1 shows that bottom-current velocities may range from below 1.2 inches per second (3.0 centimeters per second) up to greater than 15.7 inches per second (40 centimeters per second) over the course of a 9-month monitoring program at the Big Hill diffuser location. At Big Hill, bottom-current velocities between 2.4 and 4.7 inches per second (6.0 and 12 centimeters per second) were most prevalent (table C.3.1-1). For the modeling effort, 3.5 inches per second (9.0 centimeters per second) was identified as typical bottom-current velocity. Table C.3.1-2 shows bottom-current direction in terms of percentage of time over a 9-month period. The direction of bottom currents in these areas has been recorded in all directions, but the predominant direction is along and parallel to the coastline.

Table C.3-1: Summary of Percentage of Occurrence of Bottom-Current Magnitudes at Big Hill Site

Month	Bottom-Current Magnitude Range (cm/s)								
	0–3	3–6	6–12	12–15	15–20	20–25	25–30	30–40	40+
DEC 77	3.8	14.4	25.9	12.8	18.6	13.4	5.4	5.7	0.0
JAN 78	2.6	7.7	25.6	13.8	19.4	12.5	9.3	6.9	2.3
FEB 78	1.0	8.9	24.0	13.8	20.8	15.0	9.2	5.1	2.1
MAR 78	7.1	16.9	42.4	13.6	11.0	5.5	3.1	0.4	0.0
APR 78	4.6	10.6	25.2	15.6	23.9	10.3	4.9	4.7	0.4
MAY 78	15.3	16.7	23.3	12.0	14.9	9.9	5.8	1.9	0.1
JUN 78	10.1	18.2	36.7	13.3	12.5	5.6	2.2	1.4	0.0
JUL 78	15.1	20.8	41.5	12.4	7.9	2.0	0.3	0.0	0.0
AUG 78	14.5	22.3	42.7	7.3	6.6	1.5	1.2	1.2	2.7
AVERAGE	8.2	15.2	31.9	12.7	15.1	8.4	4.6	3.0	0.8

Note: Based on current joint frequency distribution of Big Hill secondary site bottom-current data for December 1977 through August 1978.

cm/s = centimeter/second

Source note: Randall and Kelly (1982).

Table C.3-2: Summary of Percentage of Occurrence of Bottom-Current Directions at Big Hill Site

Month	N	NE	E	SE	S	SW	W	NW
DEC 77	1.8	22.5	8.8	2.6	8.4	30.4	21.6	3.9
JAN 78	4.8	16.8	5.5	1.7	11.0	16.1	38.4	5.5
FEB 78	6.4	20.8	9.2	3.9	11.3	16.2	24.7	7.4
MAR 78	9.0	21.6	7.0	6.2	7.4	18.1	21.8	8.9
APR 78	3.1	11.7	8.3	5.8	11.9	34.2	18.2	6.8
MAY 78	2.8	19.0	15.9	2.7	4.7	26.6	25.5	2.7
JUN 78	6.8	15.6	23.6	9.6	12.8	18.1	8.69	5.0
JUL 78	12.8	25.0	15.7	7.5	8.9	9.9	10.9	9.3
AUG 78	5.9	18.4	16.4	6.9	9.8	16.8	18.3	7.5
AVERAGE	5.9	19.0	12.3	5.2	9.6	20.7	20.9	6.3

Note: Based on current joint frequency distribution of Big Hill secondary site bottom-current data for December 1977 through August 1978.

Source note: Randall and Kelly (1982).

Data for the West Hackberry diffuser site (Kelly et al., 1982) show that the predominant bottom-current velocity during the year is 2.0 to 5.9 inches (5.0 to 15 centimeters) per second, representing the modeled "typical plume." The low velocities resulting in the modeled "maximum plume" occur only 10.4 percent of the year. The bottom-current direction is in all directions, and the preferred bottom-current direction is to the west (parallel to the coastline) 26 percent of the time.

Oceanographic data from the area of the proposed Richton diffuser location are available in Dinnel (1988), Eleuterius (1973), Kjerfve and Sneed (1984), and Vittor and Associates (1985). In addition, an environmental impact statement by the U.S. Army Corps of Engineers and the U.S. Navy (1991), a feasibility report (USACE, 1984) for a nearby dredged material disposal area offshore Horn Island, and a U.S. Army Corps of Engineers study of the Mississippi Sound (USACE, 1980) were used to evaluate values for ambient bottom salinity, ambient bottom temperature and bottom-current velocities.

Table C.3.1-3 shows bottom-current magnitudes for the typical and maximum case plumes and the preferred bottom-current direction, based on data from Kjerfve and Sneed (1984). The data show that bottom currents representing the maximum plume extent, in the range of 0 to 1.6 inches per second (0 to 4 centimeters per second), occurred 34 percent of the time. Bottom currents representing typical plumes, in the range of 3.2 to 5.5 inches per second (8.0 to 14 centimeters per second), occurred 22 percent of the time. Bottom currents in the north-northeast direction occurred 19 percent of the time, and those in the northeast-east direction occurred 26 percent of the time.

Table C.3-3: Summary of Percentage of Occurrence of Bottom-Current Magnitudes and Directions at Richton Area

	Bottom-Current Magnitude (cm/s)							
Range	0–4	4–8	8–14	14–22				
Percentage of Time	34	34	22	10				
	Bottom-Current Direction							
Range	N-NE	NE-E	E-SE	SE-S	S-SW	SW-W	W-NW	NW-N
Percentage of Time	19	26	13	6	6	7	9	14

Note: Based on joint frequency distribution of offshore Mississippi sound site bottom-current data.

cm/s = centimeters/second

Source note: Kjerfve and Sneed, 1984.

C.4 DEFINITION OF MODEL INPUT PARAMETERS

Ambient conditions for the "typical" and "maximum" oceanographic conditions were determined to be similar at each of the proposed brine diffuser locations, based on review of the existing body of oceanographic data for this area, as described earlier. These conditions are summarized in table C.4-1. Salinity and water temperature are expected to be similar for typical and maximum conditions because the diffusers will be placed at similar water depths. The resultant plumes for a "typical" scenario and a low bottom-current velocity "maximum" scenario were evaluated for each diffuser location. The potential impacts of all current directions, in addition to just the two most prevalent current directions, were evaluated.

Table C.4-1: Environmental Conditions for SPR Expansion Sites

Parameter	Big Hill, TX		Stratton Ridge, TX		Clovelly, LA		Chacahoula, LA		Richton, MS	
	Typical	Max.	Typical	Max.	Typical	Max.	Typical	Max.	Typical	Max.
Ambient Bottom Salinity (ppt)	31	25	31	25	31	25	31	25	31	25
Ambient Surface Salinity (ppt)	31	25	31	25	31	25	31	25	31	25
Ambient Bottom Temperature (°C)	20	15	20	15	20	15	20	15	20	15
Ambient Surface Temperature (°C)	20	15	20	15	20	15	20	15	20	15
Water Depth (ft)	33	33	30	30	36	36	30	30	47	47
Ambient Bottom Current (m/s)	0.09	0.03	0.09	0.03	0.09	0.03	0.09	0.03	0.09	0.03

ppt = parts per thousand; °C = degrees Celsius; ft = feet; m/s = meters/second
1 foot = 0.3048 meters

Table C.4-2 summarizes the input parameters including specific characteristics of the brine diffuser and discharge volume. The number of open diffuser ports is determined by assuming an exit velocity of 30 feet per second (9.1 meters per second) and the maximum brine discharge rate. The maximum brine salinity is chosen as 263 parts per thousand that corresponds to a saturated condition for 68 °Fahrenheit (20 °Celsius).

Table C.4-2: Characteristics of Brine and Brine Diffuser for SPR Expansion Sites

Parameter	Big Hill, TX	Stratton Ridge, TX	Clovelly, LA	Chacahoula, LA	Richton, MS
Brine Salinity (ppt)	263	263	263	263	263
Brine Temperature (°C)	20	20	20	20	20
Maximum Number of Ports	75	75	75	75	75
Number of Open Ports resulting in maximum brine discharge rate	57	53	22	45	45
Port Height above Bottom (ft)	4	4	4	4	4
Port Exit Velocity (ft/s)	30	30	30	30	30
Maximum Brine Discharge Rate (MMBD)	1.3	1.2	0.5	1.0	1.0
Port Diameter (inches)	3	3	3	3	3
Port Spacing (ft)	60	60	60	60	60

ppt = parts per thousand; °C = degrees Celsius; ft = feet; ft/s = feet/second; MMBD = million barrels per day
1 foot = 0.3048 meters; 1 inch = 2.54 centimeters

C.5 DISCUSSION

Table C.5-1 summarizes model results for each existing (Clovelly, Big Hill) and proposed (Chacahoula, Richton, Stratton Ridge) brine diffuser location. Additional data appear in attachment C-1.

Table C.5-1: Results of Brine Plume Prediction for SPR Expansion Sites

Parameter	Big Hill, TX	Stratton Ridge, TX	Clovelly, LA	Chacahoula, LA	Richton, MS
Brine Salinity (ppt)	263	263	263	263	263
Brine Temperature (°C)	20	20	20	20	20
Maximum Number of Ports	75	75	75	75	75
Number of Open Ports needed to reach maximum brine discharge rate	57	53	22	45	45
Port Height above Bottom (ft)	4	4	4	4	4
Port Exit Velocity (ft/s)	30	30	30	30	30
Maximum Brine Discharge Rate (MMBD)	1.3	1.2	0.5	1.0	1.0
Port Diameter (inch)	3	3	3	3	3
Port Spacing (ft)	60	60	60	60	60
Maximum Above-ambient Salinity (ppt)	4.3 (Typical) 4.7 (Maximum)	4.3 (Typical) 4.7 (Maximum)	4.3 (Typical) 4.7 (Maximum)	4.3 (Typical) 4.7 (Maximum)	4.3 (Typical) 4.7 (Maximum)
Maximum Vertical Extent of Brine Jets (ft)	18.5 (Typical) 18.4 (Maximum)	18.5 (Typical) 18.4 (Maximum)	18.5 (Typical) 18.4 (Maximum)	18.5 (Typical) 18.4 (Maximum)	18.5 (Typical) 18.4 (Maximum)
Water Depth	33	30	36	30	47
Downstream Length (nm) T – typical plume M – maximum plume	+1 – 1.9 T 3.4 M +2 – 1.3 T 2.5 M +3 – 1.0 T 1.9 M +4 – 0.8 T 1.5 M	+1 – 1.8 T 3.3 M +2 – 1.3 T 2.4 M +3 – 1.0 T 1.8 M +4 – 0.8 T 1.5 M	+1 – 1.4 T 2.3 M +2 – 1.0 T 1.75M +3 – 0.7 T 1.2 M +4 – 0.6 T 1.0 M	+1 – 1.7 T 3.1 M +2 – 1.2 T 2.2 M +3 – 0.9 T 1.7 M +4 – 0.7 T 1.4 M	+1 – 1.7 T 3.1 M +2 – 1.2 T 2.2 M +3 – 0.9 T 1.7 M +4 – 0.7 T 1.4 M

ppt = parts per thousand; °C = degrees Celsius; ft = feet; ft/s = feet/second; MMBD = million barrels per day; nm = nautical miles
1 foot = 0.3048 meters; 1 inch = 2.54 centimeters; 1 nautical mile = 1.85 kilometers

The typical plume assumes a moderate bottom-current velocity, resulting in the highest salinity, which would be 4.3 parts per thousand above ambient conditions. The typical plume would extend 0.8 nautical miles (1.5 kilometers) out from the diffuser, and the salinity rate would increase to 1.0 part per thousand for 1.9 nautical miles (3.5 kilometers) out from the diffuser.

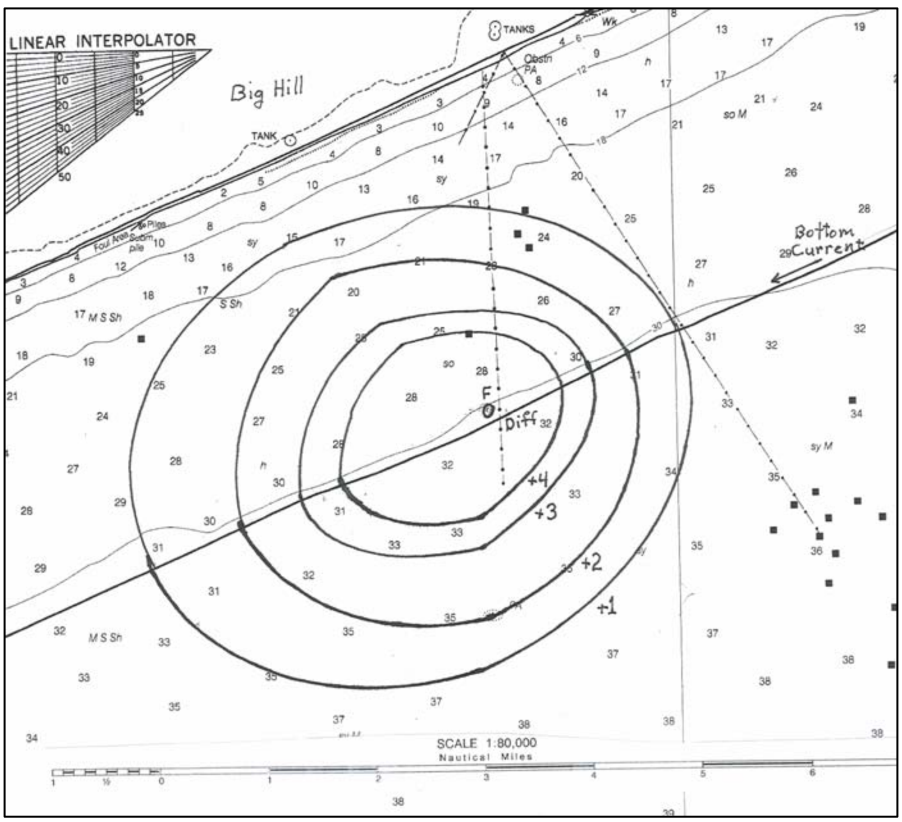
The maximum-plume scenario, which assumes a low bottom-current velocity, would have the highest increase of salinity above ambient conditions. The result would be 4.7 parts per thousand extending 1.5 nautical miles (2.8 kilometers) out from the diffuser. There would be an increase in salinity of 1.0 part per thousand extending out 3.4 nautical miles (6.3 kilometers) from the diffuser.

The maximum vertical extent of the brine jet would be approximately 19 feet (5.8 meters) for the typical plume and 18 feet (5.5 meters) for the large plume. For the Big Hill site, the maximum downstream length of the plume would be 3.4 nautical miles (6.3 kilometers) for the maximum plume scenario and 1.9 nautical miles (3.5 kilometers) for the typical plume scenario, which is the result of the largest brine maximum discharge rate of 1.3. The Clovelly site would have the smallest plume contours because the maximum brine discharge rate is the smallest (0.5 maximum brine discharge rate).

C.5.1 Big Hill

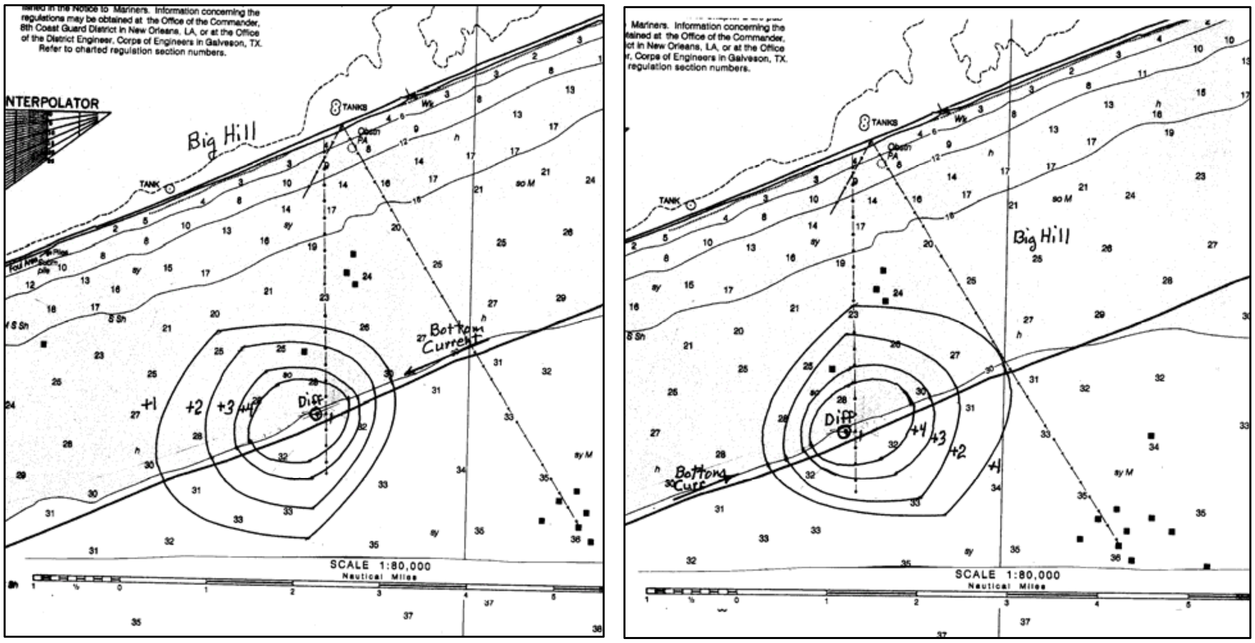
Figure C.5.1-1 shows the extent of the maximum elevated salinity plume showing the +1 through +4 parts per thousand contours for the proposed Big Hill site. Based on a review of the data presented in table C.3.1-2, this figure shows maximum plume conditions and assumes a low bottom-current velocity of 1.2 inches per second (3 centimeters per second) along the shore to the southwest.

Figure C.5.1-1: Big Hill - Empirical Brine Plume Prediction for Maximum Plume



The elliptical above-ambient salinity contours for the typical plume scenario assumes a bottom-current velocity of 3.5 inches per second (9 centimeters per second), shown on figure C.5.1-2 for the two most predominant current directions.

Figure C.5.1-2: Big Hill - Empirical Brine Plume Prediction for Typical Case Conditions for Bottom Currents Downcoast (left) and Upcoast (right)



The brine plume model estimates that the area inside the typical elliptical contour plumes is 7.2 square nautical miles (13 square kilometers) for the +1 parts per thousand contour, 4.0 square nautical miles (7.4 square kilometers) for the +2 parts per thousand contour, 2.0 square nautical miles (3.7 square kilometers) for the +3 parts per thousand, and 1.2 square nautical miles (2.2 square kilometers) for the +4 parts per thousand contour. For the maximum plume, estimated to occur on the average of 8 percent of the year, the model predicts the area inside the elliptical contours as 24, 14, 7.2, and 4.3 square nautical miles (45, 26, 13, and 8.0 square kilometers) for the +1, +2, +3, and +4 parts per thousand contours, respectively.

C.5.2 Stratton Ridge

The above-ambient salinity contours for +1 to +4 parts per thousand are shown on figure C.5.2-1 for the maximum plume scenario, which assumes a bottom-current velocity of 1.2 inches per second (3.0 centimeters per second) for the Stratton Ridge site. The bottom current is shown propagating down and parallel to the coast, which is the predominant current direction. The +1 part per thousand above-ambient contour overlaps the Freeport ship channel and thus some of the brine plume is predicted to enter the ship channel. The typical brine plume contours, which assume a bottom current of 3.5 inches per second (9.0 centimeters per second), are shown in figure C.5.2-2. Resultant plumes for the two most prevalent bottom currents are shown parallel to the shoreline. The predicted area inside the elliptical maximum plume contours are 22.8 square nautical miles (42 square kilometers) for the +1 parts per thousand contour, 14 square nautical miles (26 square kilometers) for the +2 contour, 6.7 square nautical miles (12 square kilometers) for the +3 parts per thousand, and 4.0 square nautical miles (7.4 square kilometers) for the +4 parts per thousand contour. The typical plume scenario predicts areas of 6.8, 3.7, 1.8, and 1.1 square nautical miles (13, 6.9, 3.3, and 2.0 square kilometers) respectively. The depth of the diffuser is 30 feet (9.14 meters) on the navigation chart. The diffuser for this proposed SPR expansion site is parallel to the brine line and nearly perpendicular to the coastline.

Figure C.5.2-1: Stratton Ridge - Empirical Brine Plume Prediction for Maximum Case Conditions for Downcoast Bottom Currents

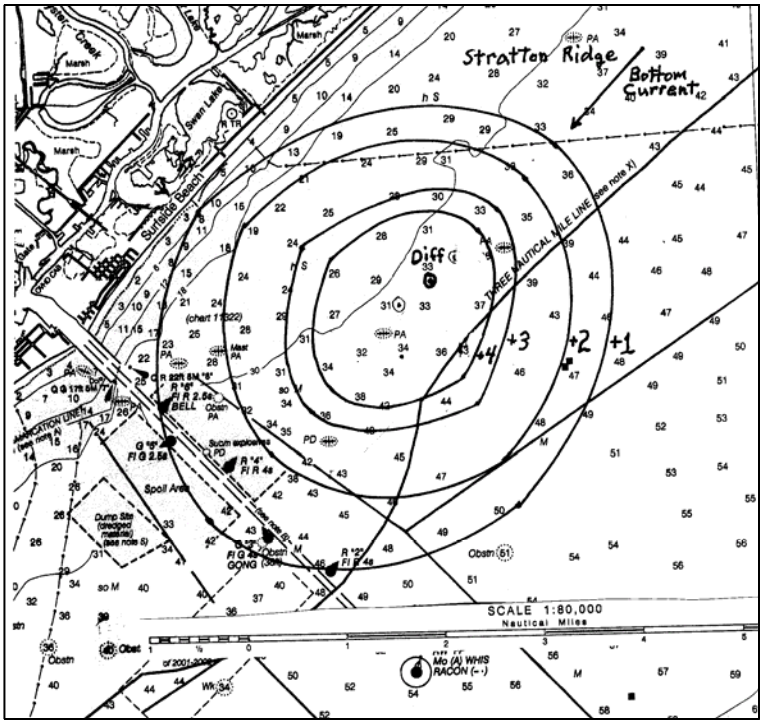
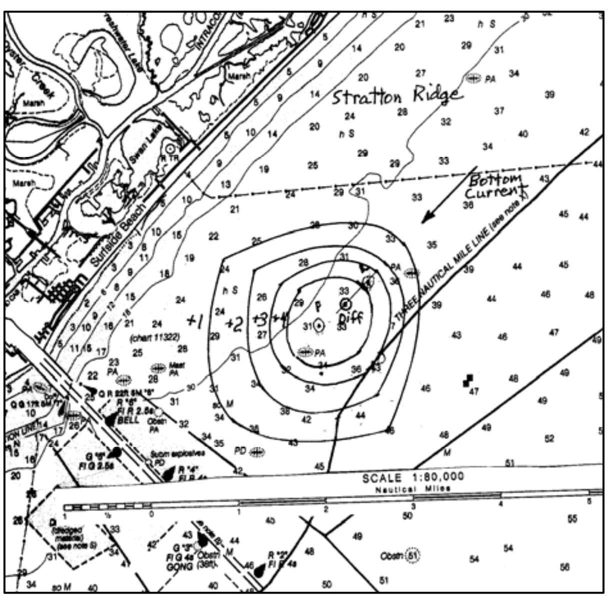
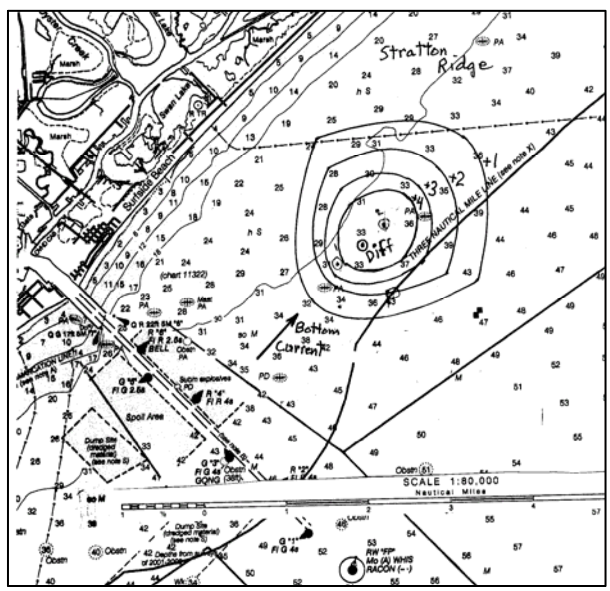


Figure C.5.2-2: Stratton Ridge - Empirical Brine Plume Prediction for Typical Case Conditions for Bottom Currents Downcoast (left) and Upcoast (right)





C.5.3 Clovelly

At the existing Clovelly diffuser site, the above-ambient salinity contours for +1 to +4 parts per thousand for the maximum plume case assume a bottom-current velocity of 1.2 inches per second (3.0 centimeters per second). The above-ambient plume contours for the typical case plume at the existing site assume a bottom-current velocity of 3.5 inches per second (9.0 centimeters per second).

The predicted area extent of the elliptical plumes for the typical plume would be 3.3, 1.7, 0.8, and 0.4 square nautical miles (6.1, 3.2, 1.5, and .75 square kilometers), respectively, for the +1 through +4 parts per thousand contours and 10, 5.5, 2.8, and 1.7 square nautical miles (19, 10.2, 5.2, and 3.2 square kilometers) for the maximum plume contours.

C.5.4 Chacahoula

The Chacahoula site's maximum plume, which assumes a bottom-current velocity of 1.2 inches per second (3 centimeters per second) above-ambient salinity contours for +1 to +4 parts per thousand, are illustrated in figure C.5.4-1. The diffuser for this expansion site is perpendicular to the brine line. Figure C.5.4-2 shows the typical plume, which assumes a bottom-current velocity of 3.5 inches per second (9 centimeters per second).

Figure C.5.4-1: Chacahoula - Empirical Brine Plume Prediction for Maximum Case Conditions for Westerly Bottom Currents

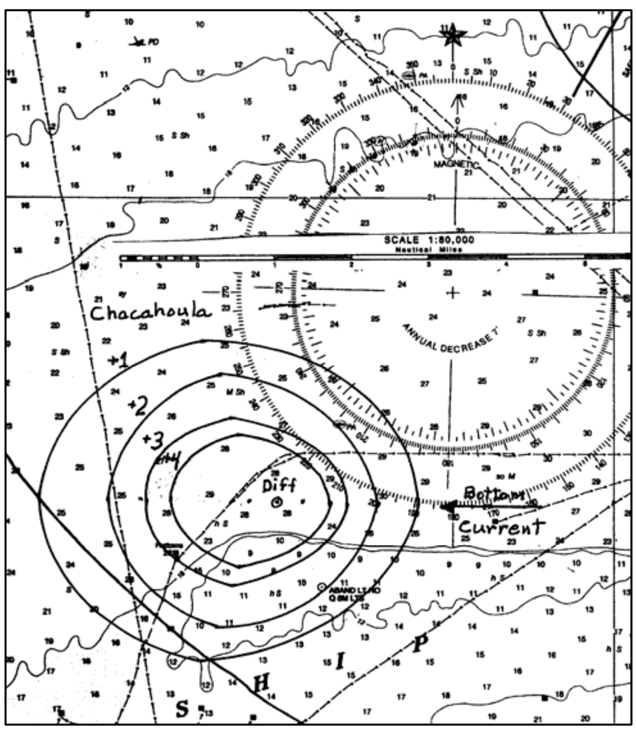
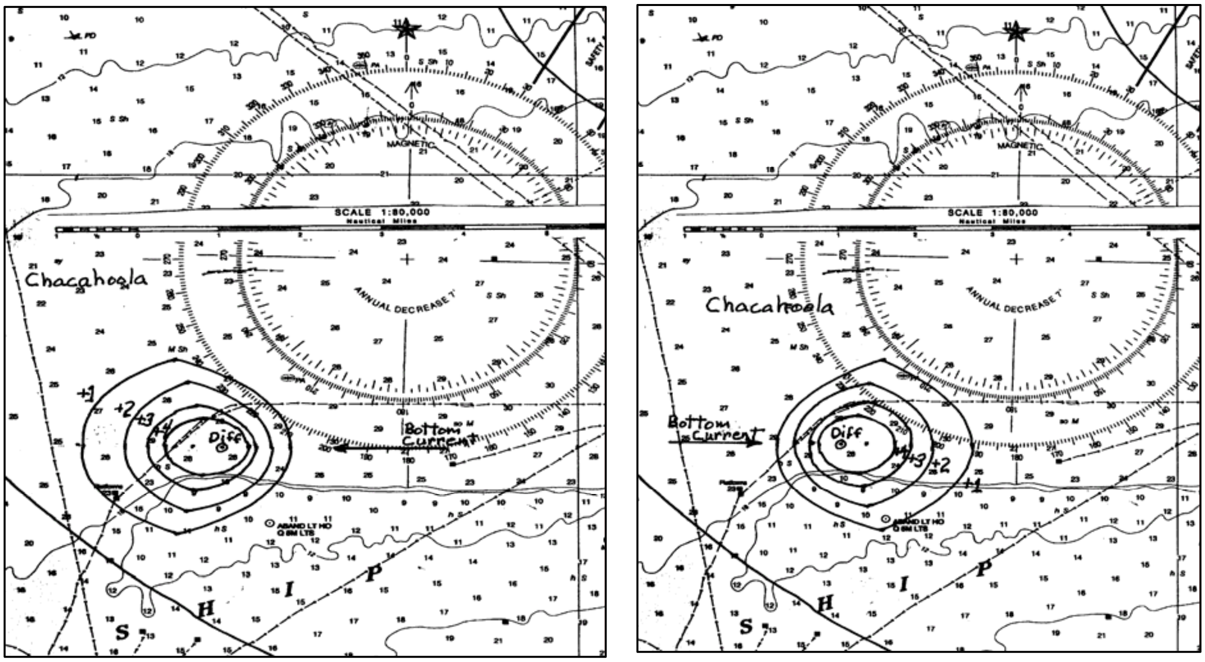


Figure C.5.4-2: Chacahoula - Empirical Brine Plume Prediction for Typical Case Conditions for Bottom Currents to the West (left) and East (right)



The diffuser is located at a depth of approximately 30 feet (9.1 meters), very close to Ship Shoal, which rises vertically from a depth of 20 feet (6.1 meters) to a depth of 10 feet (3.1 meters). Although the predicted above-ambient salinity contours for the maximum plume are shown to move onto Ship Shoal, the model is based on a nearly flat bottom, which cannot account for the bathymetry encounter at Ship Shoal. At Chacahoula, the brine plume movement is restricted by the increasing depth to the north (shoreward), west, and south (Ship Shoal). Flow along the bottom contours to the east is possible; however, the depth increases slightly in the easterly direction along Ship Shoal. The bottom bathymetry at the Chacahoula diffuser could lead to pooling of above-ambient salinity water near the bottom (approximately 2.0 feet (0.6 meters) thick), and inhibit dilution of brine. The bottom currents may not be strong enough to move the brine up the slopes shown on the chart.

C.5.5 Richton

The above-ambient salinity contours for +1 to +4 parts per thousand for the maximum plume case, which assumes a bottom-current velocity of 1.2 inches per second (3 centimeters per second) at the proposed Richton diffuser site, are shown in figure C.5.5-1. Figure C.5.5-2 shows the above-ambient plume contours for the typical case plume, which assumes an upshore and downshore direction bottom-current velocity of 3.5 inches per second (9 centimeters per second).

In the maximum case scenario, the model predicts the area inside the contours would be 19.5 square nautical miles (36 square kilometers) for the +1 parts per thousand contour, 11 square nautical miles (20.4 square kilometers) for the +2 contour, 5.7 square nautical miles (11 square kilometers) for the +3 parts per thousand, and 3.4 square nautical miles (6.3 square kilometers) for the +4 parts per thousand contour. The typical case scenario is predicted to have areas of 5.9, 3.2, 1.6, and 0.9 square nautical miles (11, 5.9, 3.0, and 1.7 square kilometers) respectively.

Figure C.5.5-1: Richton - Empirical Brine Plume Prediction for Maximum Case Conditions for North-Northeast Bottom Currents

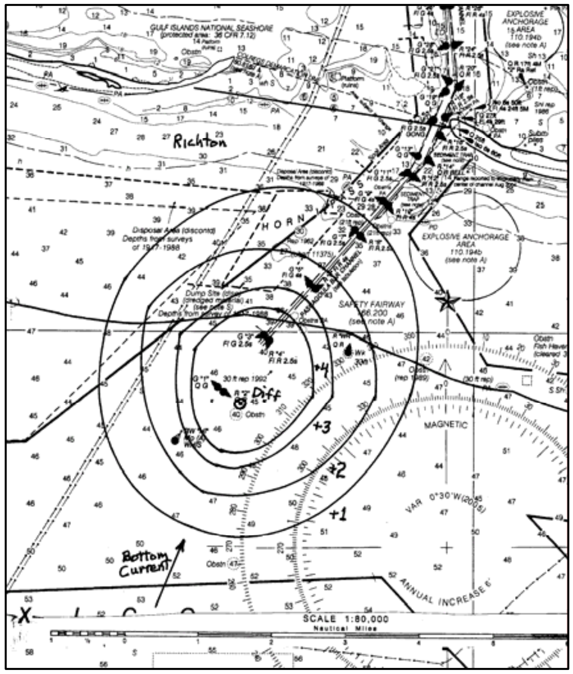
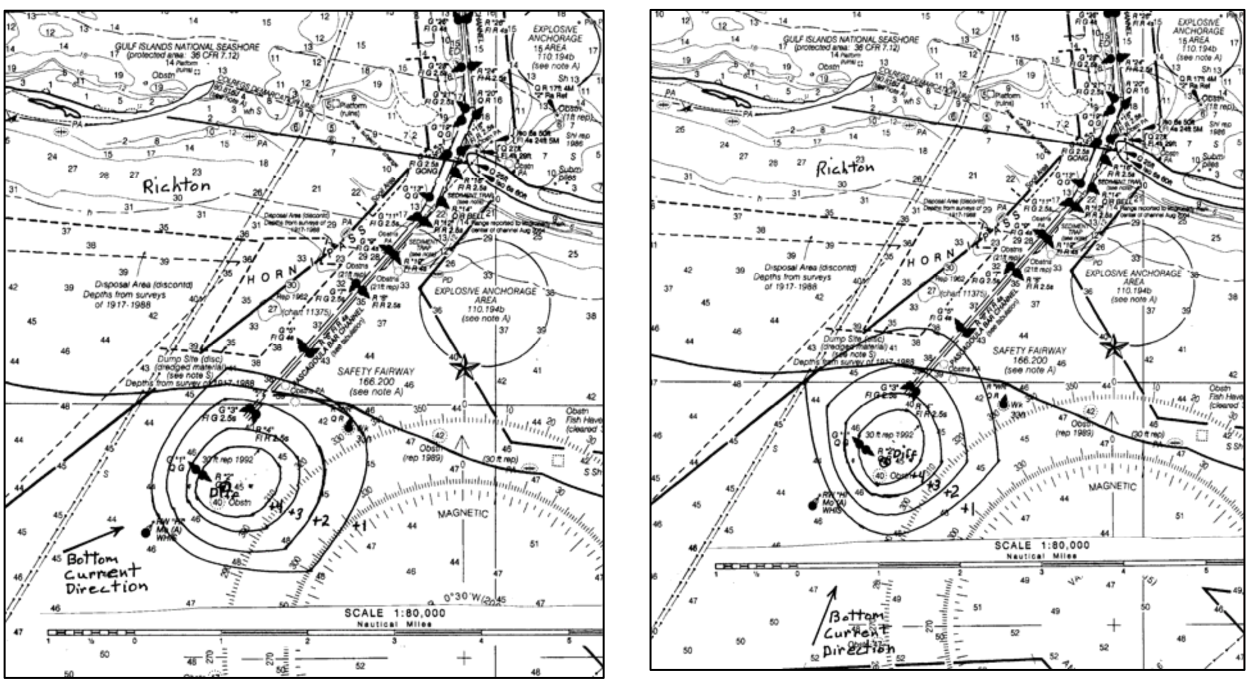


Figure C.5.5-2: Richton - Empirical Brine Plume Prediction for Typical Case Conditions



The diffuser location is approximately 1.0 nautical mile (1.9 kilometers) south of the entrance to the Pascagoula ship channel. The diffuser for this expansion site is parallel to the brine line and nearly perpendicular to the coastline. The maximum case plume, depicted in figure C.5.5-1, shows all of the above-ambient salinity contours located inside the ship channel. Figure C.5.5-2 shows the typical case contours of +1 and +2 parts per thousand entering the ship channel for two predominant bottom-current directions.

C.6 CONCLUSIONS

DOE used the empirical brine plume prediction model developed from the measured brine plume data from operating SPR brine diffuser sites to predict the plume characteristics for the SPR expansion diffuser sites at Big Hill, Stratton Ridge, Clovelly, Chacahoula, and Richton. The model was applied to five selected scenarios representing a range of expected environmental and disposal operational conditions. This report includes the results for typical and maximum case conditions.

Results show the maximum above-ambient salinity would be 4.3 parts per thousand and 4.7 parts per thousand for the typical and maximum case conditions. These above ambient salinity values are the same for all expansion sites because they all have the same brine salinity (263 parts per thousand) exit velocity of 30 feet (9.1 meters) per second, port diameter (3.0 inches [7.6 centimeters]), and ambient salinity and temperature profiles. The maximum vertical extent of the brine jets is approximately 19 and 18 feet (5.8 and 5.5 meters) for the typical and maximum case scenarios, respectively, and these are the same for all sites for the same reason described for the maximum above-ambient salinities. The maximum areal extent of the above-ambient contours is affected by the brine discharge rate, and the maximum areas occur for the Big Hill site, which has the largest brine discharge rate (1.3 maximum brine discharge rate). The Big Hill site appears to provide the best dilution and dispersion area for the brine discharge. The smallest brine plume areas occur at the Clovelly site where the brine discharge rate is the smallest (0.5 maximum brine discharge rate). The Stratton Ridge site plume predictions show portions of the brine plume entering the Freeport ship channel when the bottom current is downcoast, which is a common occurrence. The Chacahoula site shows the diffuser within 0.5 nautical miles (0.93 kilometers) of Ship Shoal. This bathymetry feature is not modeled by the empirical plume model, but it is expected that the brine plume dilution will be reduced due to shallower water depths to the south, west, and north of Ship Shoal. The proposed location of the Richton diffuser is approximately 1.0 nautical mile (1.9 kilometers) south of the entrance of the Pascagoula ship channel, and the model predicts the typical and maximum brine plumes would enter the ship channel.

REFERENCES

Adams, E.E., K.D. Stolzenbach, and D.R.F. Harleman. 1975. "Near and Far Field Analysis of Buoyant Surface Discharges into Large Bodies of Water." Department of Civil Engineering, Massachusetts Institute of Technology. Report No. 205. Cambridge, MA.

Dinnel, S.P. 1988. *Circulation and Sediment Dispersal on the Louisiana-Mississippi-Alabama Continental Shelf.* Dissertation. Louisiana State University, Baton Rouge, LA.

Eleuterius, C.K. 1973. "Mississippi Sound: Salinity Distribution and Indicated Flow Patterns." Mississippi-Alabama Sea Grant Consortium. (MASGP-76-023).

Kelly, F.J., R.E. Randall, and J.E. Schmitz. 1982. "West Hackberry Brine Disposal Project Predischarge Characterization." Chapter 2. L. R. DeRouen, R. W. Hann, Jr., D. M. Casserly, C.P. Giammona, and V.J. Lascara (Eds.). Final Report. *Physical Oceanography.* U.S. Department of Energy.

Kjerfve, B. and J.E. Sneed. 1984. “Analysis and Synthesis of Oceanographic Conditions in the Mississippi Sound Offshore Region.” Final Report. U.S. Army Corps of Engineers, Mobile District. Mobile, AL.

Randall, R.E. 1981. “Evaluation of Brine Disposal from the Bryan Mound Site of the Strategic Petroleum Reserve Program: Final Report of Twelve-Month Postdisposal Studies.” R.W. Hann, Jr. and R.E. Randall (Eds). *Analysis of the Discharge Plume.* U.S. Department of Energy. (DOE/P010114-4).

Randall, R.E. 1982. “Evaluation of Brine Disposal from the Bryan Mound Site of the Strategic Petroleum Reserve Program: Final Report of Eighteen-Month Postdisposal Studies.” R. W. Hann, Jr. and R.E. Randall (Eds). *Analysis of the Discharge Plume.* U.S. Department of Energy. (DOE/P010114-5).

Randall, R.E. and F.J. Kelly. 1982. “Memorandum Report on Brine Plume and Physical Oceanography Characteristics for the Proposed Big Hill Disposal Site.” Report to the U.S. Department of Energy, New Orleans, LA.

Randall, R.E. and T.N. McLellan. 1983. “Evaluation of Brine Disposal from the Bryan Mound Site of the Strategic Petroleum Reserve Program: Annual Report for September 1981 through August 1982.” R.W. Hann Jr. and R.E. Randall (Eds.). *Analysis of the Discharge Plume.* U.S. Department of Energy (DOE/P010114-6).

Randall, R.E. 1983. “West Hackberry Strategic Petroleum Reserve Site Brine Disposal Monitoring: Year 1 Final Report.” L.R. DeRouen, R.W. Hann, Jr., D.M. Casserly, C.P. Giammona, and V.J. Lascara. (Eds.). *Brine Plume Measurement.* U.S. Department of Energy.

Randall, R.E. and P.W. Price. 1984a. “Offshore Oceanographic and Environmental Monitoring Services for the Strategic Petroleum Reserve: Annual Report for the Bryan Mound Site from September 1982 to August 1983.” R.W. Hann, Jr., C.P. Giammona, and R.E. Randall (Eds.). *Brine Plume.* U.S. Department of Energy. (DOE/P010850-2).

Randall, R. E. and P.W. Price. 1984b. “Offshore Oceanographic and Environmental Monitoring Services for the Strategic Petroleum Reserve: Annual Report for the West Hackberry Site from November 1982 to November 1983.” R.W. Hann, Jr., C.P. Giammona, and R.E. Randall (Eds.). *Brine Plume.* U.S. Department of Energy (DOE/P010850-3).

Randall, R.E. and P.W. Price. June 1985a. “Empirical Modeling of Brine Plumes Emanating from a Submerged Multiport Diffuser.” 2nd Joint American Society of Civil Engineers/American Society of Mechanical Engineers Mechanics Conference. *Proceedings of the International Symposium on Modeling Environmental Flows*. Vol. No. 600290. American Society of Mechanical Engineers. New York.

Randall, R.E. and P.W. Price. 1985b. “Offshore Oceanographic and Environmental Monitoring Services for the Strategic Petroleum Reserve: Annual Report for the Bryan Mound Site from September 1983 to August 1984.” R.W. Hann, Jr., C.P. Giammona, and R.E. Randall (Eds.). *Brine Plume.* U.S. Department of Energy. (DOE/P010850-4).

Randall, R.E. and P.W. Price. 1985c. “Offshore Oceanographic and Environmental Monitoring Services or the Strategic Petroleum Reserve: Annual Report for the West Hackberry Site from November 1983 to November 1984.” R.W. Hann, Jr., C.P. Giammona, and R.E. Randall (Eds.) *Brine Plume.* U.S. Department of Energy. (DOE/P010850-5).

Randall, R.E. and P.W. Price. 1985d. "Offshore Oceanographic and Environmental Monitoring Services for the Strategic Petroleum Reserve; Response to Decision Makers' Questions: Brine Plume." Vol. 2. U.S. Department of Energy. (DOE/PO10850-4).

Tong, S.S. and K.D. Stolzenbach. 1979. "Submerged Discharges of a Dense Effluent." Department of Civil Engineering, Massachusetts Institute of Technology. (Report No. 243). Cambridge, MA.

Turner, J.S. 1966. "Jets and Plumes with Negative or Reversing Buoyancy." *Journal of Fluid Mechanics*. *Vol. 26,* Part 4.

United States Army Corps of Engineers (USACE). 1980. "Analysis and synthesis of oceanographic conditions in Mississippi Sound, April through October, 1980." Mobile District.

United States Army Corps of Engineers (USACE). 1984. "Mississippi Sound and adjacent areas: Dredged Material Disposal Study Feasibility Report." COE SAM/PD-N-84/013, COE SAM/PD-N-84/014, COE SAM/PD-N-84/015, Mobile District.

United States Army Corps of Engineers and U.S. Navy. June 1991. "Final Environmental Impact Statement for the Designation of Ocean Dredged Material Disposal Site Located Offshore Pascagoula, Mississippi." Submitted to EPA, Region IV, Atlanta, GA.

Vittor, B.A. and Associates Inc. 1985. "Tuscaloosa Trend Regional Data Search and Synthesis Study (Volume I—Synthesis Report)." Final Report submitted to Minerals Management Service. Metaire, LA.

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ATTACHMENT C-1:
Model Predictions for Brine Discharge Scenarios for the Strategic Petroleum Reserve Expansion Sites

Table C-1-1: Predicted Characteristics of Typical and Large Scenario Brine Plume at Big Hill Expansion Diffuser Site

	Big Hill (typical)	Big Hill (Maximum)
Amb. Bottom Sal.(o/oo)	31.00	25.00
Amb. Bottom Temp.(oC)	22.00	15.00
Depth(ft.)	33.00	33.00
Amb. Bottom Cur.(m/s)	.09	.03
Amb. Top of Sal.(o/oo)	31.00	23.00
Brine Sal.(o/oo)	263.00	263.00
Brine Temp.(oC)	20.00	20.00
Num. open ports	57.00	57.00
Jet Exit Vel.(ft/s)	30.00	30.00
Port Dia(in)	3.00	3.00
Brine discharge rate(m3/s) =	2.4	2.4
Brine discharge rate(barrel/day x 10-6)=	1.3	1.3
Maximum above ambient bottom salinity (o/oo)=	4.3	4.7
Vertical extent(m) =	5.7	5.6
Vertical extent(ft) =	18.5	18.4

Plume Areal Extent	(km2) typical	(nm2) typical	(acresx10e-3) typical	(km2) maximum	(nm2) maximum	(acresx10e-3) maximum
+1o/oo contour	24.8	7.2	6.1	83.9	24.4	20.7
+2o/oo contour	13.6	3.9	3.4	47.6	13.9	11.8
+3o/oo contour	6.8	2.0	1.7	24.7	7.2	6.1
+4o/oo contour	4.0	1.2	1.0	14.8	4.3	3.7

Plume Width	(km) typical	(nm) typical	(km) maximum	(nm) maximum
+1o/oo contour	4.9	2.6	8.5	4.6
+2o/oo contour	3.7	2.0	6.7	3.6
+3o/oo contour	2.4	1.3	4.5	2.4
+4o/oo contour	1.7	.9	3.4	1.9

Plume Downstream Length	(km) typical	(nm) typical	(km) maximum	(nm) maximum
+1o/oo contour	3.5	1.9	6.3	3.4
+2o/oo contour	2.5	1.3	4.6	2.5
+3o/oo contour	1.8	1.0	3.4	1.9
+4o/oo contour	1.5	.8	2.9	1.5

Plume Upstream Length	(km) typical	(nm) typical	(km) maximum	(nm) maximum
+1o/oo contour	1.7	.9	3.7	2.0
+2o/oo contour	1.2	.7	2.6	1.4
+3o/oo contour	.9	.5	1.9	1.0
+4o/oo contour	.7	.4	1.4	.8

°C = degrees Celsius; ft = feet; m/s = meters/second; ft/s = feet/second; in = inches; m^3/s = cubic meters/second; m = meters; km = kilometer; km^2 = square kilometers; o/oo = parts per thousand; nm = nautical miles; nm^2 = square nautical miles

Table C-1-2: Predicted Characteristics of Typical Scenario Brine Plume at Stratton Ridge Expansion Diffuser Site

Strattom Ridge (typical)	
Amb. Bottom Sal.(o/oo)	31.00
Amb. Bottom Temp.(oC)	22.00
Depth(ft.)	30.00
Amb. Bottom Cur.(m/s)	.09
Amb. Top of Sal.(o/oo)	31.00
Brine Sal.(o/oo)	263.00
Brine Temp.(oC)	20.00
Num. open ports	53.00
Jet Exit Vel.(ft/s)	30.00
Port Dia(in)	3.00
Brine discharge rate(m3/s) =	2.2
Brine discharge rate(barrel/day x 10-6)=	1.2
Maximum above ambient bottom salinity (o/oo)=	4.3
Vertical extent(m) =	5.7
Vertical extent(ft) =	18.5

Plume Areal Extent	(km2)	(nm2)	(acresx10e-3}
+1o/oo contour	23.2	6.8	5.7
+2o/oo contour	12.7	3.7	3.1
+3o/oo contour	6.3	1.8	1.6
+4o/oo contour	3.7	1.1	.9

Plume Width	(km)	(nm)
+1o/oo contour	4.8	2.6
+2o/oo contour	3.6	1.9
+3o/oo contour	2.4	1.3
+4o/oo contour	1.6	.9

Plume Downstream Length	(km)	(nm)
+1o/oo contour	3.4	1.8
+2o/oo contour	2.4	1.3
+3o/oo contour	1.8	1.0
+4o/oo contour	1.5	.8

Plume Upstream Length	(km)	(nm)
+1o/oo contour	1.7	.9
+2o/oo contour	1.2	.6
+3o/oo contour	.9	.5
+4o/oo contour	.6	.3

Strattom Ridge (Maximum)	
Amb. Bottom Sal.(o/oo)	25.00
Amb. Bottom Temp.(oC)	15.00
Depth(ft.)	30.00
Amb. Bottom Cur.(m/s)	.03
Amb. Top of Sal.(o/oo)	25.00
Brine Sal.(o/oo)	263.00
Brine Temp.(oC)	20.00
Num. open ports	53.00
Jet Exit Vel.(ft/s)	30.00
Port Dia(in)	3.00
Brine discharge rate(m3/s) =	2.2
Brine discharge rate(barrel/day x 10-6)=	1.2
Maximum above ambient bottom salinity (o/oo)=	4.7
Vertical extent(m) =	5.6
Vertical extent(ft) =	18.4

Plume Areal Extent	(km2)	(nm2)	(acresx10e-3}
+1o/oo contour	78.3	22.8	19.3
+2o/oo contour	44.4	12.9	11.0
+3o/oo contour	23.0	6.7	5.7
+4o/oo contour	13.8	4.0	3.4

Plume Width	(km)	(nm)
+1o/oo contour	8.2	4.4
+2o/oo contour	6.5	3.5
+3o/oo contour	4.3	2.3
+4o/oo contour	3.3	1.8

Plume Downstream Length	(km)	(nm)
+1o/oo contour	6.2	3.3
+2o/oo contour	4.4	2.4
+3o/oo contour	3.3	1.8
+4o/oo contour	2.8	1.5

Plume Upstream Length	(km)	(nm)
+1o/oo contour	3.6	1.9
+2o/oo contour	2.5	1.4
+3o/oo contour	1.9	1.0
+4o/oo contour	1.4	.7

°C = degrees Celsius; ft = feet; m/s = meters/second; ft/s = feet/second; in = inches; m^3/s = cubic meters/second; m = meters; km = kilometer; km^2 = square kilometers; o/oo = parts per thousand; nm = nautical miles; nm^2 = square nautical miles

Table C-1-3: Predicted Characteristics of Typical and Large Case Brine Plume Contours at Clovelly Expansion Diffuser Site

Chovelly (typical)	
Amb. Bottom Sal.(o/oo)	31.00
Amb. Bottom Temp.(oC)	22.00
Depth(ft.)	36.00
Amb. Bottom Cur.(m/s)	.09
Amb. Top of Sal.(o/oo)	31.00
Brine Sal.(o/oo)	263.00
Brine Temp.(oC)	20.00
Num. open ports	22.00
Jet Exit Vel.(ft/s)	30.00
Port Dia(in)	3.00
Brine discharge rate(m3/s) =	.9
Brine discharge rate(barrel/day x 10-6)=	.5
Maximum above ambient bottom salinity (o/oo)=	4.3
Vertical extent(m) =	5.7
Vertical extent(ft) =	18.5

Plume Areal Extent	(km2)	(nm2)	(acresx10e-3}
+1o/oo contour	11.4	3.3	2.8
+2o/oo contour	5.9	1.7	1.5
+3o/oo contour	2.8	.8	.7
+4o/oo contour	1.5	.4	.4

Plume Width	(km)	(nm)
+1o/oo contour	3.7	2.0
+2o/oo contour	2.7	1.4
+3o/oo contour	1.7	.9
+4o/oo contour	1.1	.6

Plume Downstream Length	(km)	(nm)
+1o/oo contour	2.6	1.4
+2o/oo contour	1.8	1.0
+3o/oo contour	1.3	.7
+4o/oo contour	1.1	.6

Plume Upstream Length	(km)	(nm)
+1o/oo contour	1.1	.6
+2o/oo contour	.8	.4
+3o/oo contour	.6	.3
+4o/oo contour	.4	.2

Chovelly (	
Amb. Bottom Sal.(o/oo)	25.00
Amb. Bottom Temp.(oC)	15.00
Depth(ft.)	36.00
Amb. Bottom Cur.(m/s)	.03
Amb. Top of Sal.(o/oo)	25.00
Brine Sal.(o/oo)	263.00
Brine Temp.(oC)	20.00
Num. open ports	22.00
Jet Exit Vel.(ft/s)	30.00
Port Dia(in)	3.00
Brine discharge rate(m3/s) =	.9
Brine discharge rate(barrel/day x 10-6)=	.5
Maximum above ambient bottom salinity (o/oo)=	4.7
Vertical extent(m) =	5.6
Vertical extent(ft) =	18.4

Plume Areal Extent	(km2)	(nm2)	(acresx10e-3}
+1o/oo contour	34.3	10.0	8.5
+2o/oo contour	19.0	5.5	4.7
+3o/oo contour	9.7	2.8	2.4
+4o/oo contour	5.7	1.7	1.4

Plume Width	(km)	(nm)
+1o/oo contour	5.9	3.2
+2o/oo contour	4.5	2.4
+3o/oo contour	3.0	1.6
+4o/oo contour	2.2	1.2

Plume Downstream Length	(km)	(nm)
+1o/oo contour	4.3	2.3
+2o/oo contour	3.1	1.7
+3o/oo contour	2.3	1.2
+4o/oo contour	1.9	1.0

Plume Upstream Length	(km)	(nm)
+1o/oo contour	2.3	1.2
+2o/oo contour	1.6	.9
+3o/oo contour	1.2	.6
+4o/oo contour	.9	.5

°C = degrees Celsius; ft = feet; m/s = meters/second; ft/s = feet/second; in = inches; m^3/s = cubic meters/second; m = meters; km = kilometer; km^2 = square kilometers; o/oo = parts per thousand; nm = nautical miles; nm^2 = square nautical miles

Table C-1-4: Predicted Characteristics of Typical and Large Case Scenarios of Brine Plume Contours at Chacahoula Expansion Diffuser Site

Chacahoula (typical)		Chacahoula	
Amb. Bottom Sal.(o/oo)	31.00	Amb. Bottom Sal.(o/oo)	25.00
Amb. Bottom Temp.(oC)	22.00	Amb. Bottom Temp.(oC)	15.00
Depth(ft.)	30.00	Depth(ft.)	30.00
Amb. Bottom Cur.(m/s)	.09	Amb. Bottom Cur.(m/s)	.03
Amb. Top of Sal.(o/oo)	31.00	Amb. Top of Sal.(o/oo)	25.00
Brine Sal.(o/oo)	263.00	Brine Sal.(o/oo)	263.00
Brine Temp.(oC)	20.00	Brine Temp.(oC)	20.00
Num. open ports	45.00	Num. open ports	45.00
Jet Exit Vel.(ft/s)	30.00	Jet Exit Vel.(ft/s)	30.00
Port Dia(in)	3.00	Port Dia(in)	3.00
Brine discharge rate(m3/s) =	1.9	Brine discharge rate(m3/s) =	1.9
Brine discharge rate(barrel/day x 10-6)=	1.0	Brine discharge rate(barrel/day x 10-6)=	1.0
Maximum above ambient bottom salinity (o/oo)=	4.3	Maximum above ambient bottom salinity (o/oo)=	4.7
Vertical extent(m) =	5.7	Vertical extent(m) =	5.6
Vertical extent(ft) =	18.5	Vertical extent(ft) =	18.4

Plume Areal Extent	(km2)	(nm2)	(acresx10e-3)	Plume Areal Extent	(km2)	(nm2)	(acresx10e-3)
+1o/oo contour	20.2	5.9	5.0	+1o/oo contour	66.9	19.5	16.5
+2o/oo contour	10.9	3.2	2.7	+2o/oo contour	37.8	11.0	9.3
+3o/oo contour	5.4	1.6	1.3	+3o/oo contour	19.6	5.7	4.8
+4o/oo contour	3.1	.9	.8	+4o/oo contour	11.7	3.4	2.9

Plume Width	(km)	(nm)	Plume Width	(km)	(nm)
+1o/oo contour	4.6	2.5	+1o/oo contour	7.7	4.2
+2o/oo contour	3.4	1.8	+2o/oo contour	6.0	3.3
+3o/oo contour	2.2	1.2	+3o/oo contour	4.0	2.2
+4o/oo contour	1.5	.8	+4o/oo contour	3.1	1.7

Plume Downstream Length	(km)	(nm)	Plume Downstream Length	(km)	(nm)
+1o/oo contour	3.2	1.7	+1o/oo contour	5.8	3.1
+2o/oo contour	2.3	1.2	+2o/oo contour	4.1	2.2
+3o/oo contour	1.7	.9	+3o/oo contour	3.1	1.7
+4o/oo contour	1.4	.7	+4o/oo contour	2.6	1.4

Plume Upstream Length	(km)	(nm)	Plume Upstream Length	(km)	(nm)
+1o/oo contour	1.5	.8	+1o/oo contour	3.3	1.8
+2o/oo contour	1.1	.6	+2o/oo contour	2.3	1.3
+3o/oo contour	.8	.4	+3o/oo contour	1.7	.9
+4o/oo contour	.6	.3	+4o/oo contour	1.3	.7

°C = degrees Celsius; ft = feet; m/s = meters/second; ft/s = feet/second; in = inches; m^3/s = cubic meters/second; m = meters; km = kilometer; km^2 = square kilometers; o/oo = parts per thousand; nm = nautical miles; nm^2 = square nautical miles

Table C-1-5: Predicted Characteristics of Typical Scenario Brine Plume Contours at Richton Expansion Diffuser Site

Parameter	Richton Dome (typical)	Richton Dome
Amb. Bottom Sal.(o/oo)	31.00	25.00
Amb. Bottom Temp.(oC)	22.00	15.00
Depth(ft.)	47.00	47.00
Amb. Bottom Cur.(m/s)	.09	.03
Amb. Top of Sal.(o/oo)	31.00	25.00
Brine Sal.(o/oo)	263.00	263.00
Brine Temp.(oC)	20.00	20.00
Num. open ports	45.00	45.00
Jet Exit Vel.(ft/s)	30.00	30.00
Port Dia(in)	3.00	3.00
Brine discharge rate(m3/s) =	1.9	1.9
Brine discharge rate(barrel/day x 10-6)=	1.0	1.0
Maximum above ambient bottom salinity (o/oo)=	4.3	4.7
Vertical extent(m) =	5.7	5.6
Vertical extent(ft) =	18.5	18.4

Richton Dome (typical)

Plume Areal Extent	(km2)	(nm2)	(acresx10e-3}
+1o/oo contour	20.2	5.9	5.0
+2o/oo contour	10.9	3.2	2.7
+3o/oo contour	5.4	1.6	1.3
+4o/oo contour	3.1	.9	.8

Plume Width	(km)	(nm)
+1o/oo contour	4.6	2.5
+2o/oo contour	3.4	1.8
+3o/oo contour	2.2	1.2
+4o/oo contour	1.5	.8

Plume Downstream Length	(km)	(nm)
+1o/oo contour	3.2	1.7
+2o/oo contour	2.3	1.2
+3o/oo contour	1.7	.9
+4o/oo contour	1.4	.7

Plume Upstream Length	(km)	(nm)
+1o/oo contour	1.5	.8
+2o/oo contour	1.1	.6
+3o/oo contour	.8	.4
+4o/oo contour	.6	.3

Richton Dome

Plume Areal Extent	(km2)	(nm2)	(acresx10e-3}
+1o/oo contour	66.9	19.5	16.5
+2o/oo contour	37.8	11.0	9.3
+3o/oo contour	19.6	5.7	4.8
+4o/oo contour	11.7	3.4	2.9

Plume Width	(km)	(nm)
+1o/oo contour	7.7	4.2
+2o/oo contour	6.0	3.3
+3o/oo contour	4.0	2.2
+4o/oo contour	3.1	1.7

Plume Downstream Length	(km)	(nm)
+1o/oo contour	5.8	3.1
+2o/oo contour	4.1	2.2
+3o/oo contour	3.1	1.7
+4o/oo contour	2.6	1.4

Plume Upstream Length	(km)	(nm)
+1o/oo contour	3.3	1.8
+2o/oo contour	2.3	1.3
+3o/oo contour	1.7	.9
+4o/oo contour	1.3	.7

°C = degrees Celsius; ft = feet; m/s = meters/second; ft/s = feet/second; in = inches; m^3/s = cubic meters/second; m = meters; km = kilometer; km^2 = square kilometers; o/oo = parts per thousand; nm = nautical miles; nm^2 = square nautical miles

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