Chapter 4. STUDY OF ALTERNATIVES AND SELECTION OF THE ALIGNMENT

The different alternatives evaluated for the execution of this project are discussed in this chapter. Among said alternatives the construction of a liquefied natural gas receiving terminal in the north of the island, the installation of tankers and buoys systems for the receipt, storage and regasification of liquefied natural gas and several terrestrial alignments for a natural gas pipeline were considered. Also analyzed were the alternative of using renewable energy sources technically available in the commercial sphere and the No Action alternative.

4.1 No Action

The No Action alternative, although considered, was found to be unfeasible due to the transcendence, importance and public well-being pursued by the project.

In Chapter 6, Impacts and Mitigation, of this Preliminary Environmental Impact Statement (DIA-P), the direct and indirect impacts associated to the construction of the natural gas pipeline are considered. If the project is not constructed, the following impacts are averted:

- The impact of the movement of earth which can produce soil erosion and sedimentation of bodies of water
- Temporary increase in noise levels
- Limited impact to forest reserves
- Temporary impact to wetlands, mangroves and other surface water bodies
- Temporary impact to agricultural land
- Temporary impact to water, highways and (possibly) telephone infrastructure
- Temporary traffic increase and readjustment
- Potential impact to archaeological sites
- Acquisition of land by expropriation

Most of these impacts, in case the selected alternative is constructed, although they cannot be avoided due to the project's construction specifications, can be minimized and mitigated with engineering measures and sedimentation and erosion control measures, supervision and the support of agencies and municipalities, among other measures.

No Action is not indicative of no impact, because faced with the No Action alternative PREPA will have to continue the production of electric energy by burning petroleum products that generate a greater amount of air polluting emissions. The use of natural gas represents a significant reduction in the criteria pollutant emissions and others such as carbon dioxide. This reduction of emissions, acquires greater importance if we consider that the new regulation of the Environmental Protection Agency (EPA), which

will become effective in 2020, requires an additional and compulsory reduction in the quantity of emissions of certain air pollutants. To achieve said reduction, PREPA would be forced to install emission control equipment, such as Electrostatic Precipitators (ESP) or Multiple Bag Collectors (Baghouses for the removal of particulate matter), catalytic converters (for the removal of nitrogen oxide, NOx), and Scrubbers (for the removal of sulphur dioxide, SO_2). This kind of equipment is very costly, which would require a great capital investment, and would result in an increase in the cost of the kilowatt/hour. In addition, this kind of equipment requires a lot of space, which would represent a difficulty to PREPA, because some of our power plants do not have the space necessary for its installation. The conversion of our units to use natural gas will have the impact of reducing emissions to the levels required by this new regulation, without the need to install this equipment, which requires an estimated capital investment cost of $200 million dollars, and at the same time providing a more economical fuel for the generation of electricity.

In addition, it is emphasized that the maintenance related to units that burn petroleum derivatives must be made frequently and with higher costs to insure the optimal functioning of the same. Continuing to burn petroleum derivatives has other implications, such as a greater frequency of deliveries of said fuels in our ports, which increases the erosion of the seabed and the probability of spills. The continued use of petroleum-derived fuels increases the cost of the electric energy service, which in its stead impacts negatively the Puerto Rican economy and results in a lower quality of life for its citizens. Of no less importance is the fact that the use of these fuels exposes PREPA to market value fluctuations, which creates instability in energy production costs and in the electric bills. All of the above, together with the impact of the new federal environmental regulations projected for 2020, force PREPA to establish a definite strategy to avoid a dislocation of the electrical system as a result of the installation of additional control equipment required by the EPA.

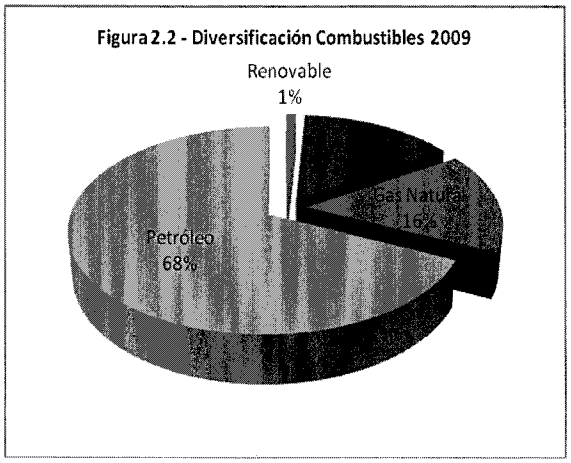
Recognizing that the Puerto Rican economy is directly related to the stability of PREPA, it is important for the company to comply with its strategic development plans and maintain a fixed cost structure that avoids sudden peak variations in the cost of the fuel purchased. Complying with these plans attests PREPA's vision, stability and commitment to its clients. In addition, it demonstrates the company's ability to evaluate complex global situations and develop strategies to diminish their impact, which facilitates broadening the fuel use options in the future.

After evaluating the local and global dynamic, PREPA developed a Strategic Corporate Plan 2009-2012. This Plan includes the following parameters, among others:

- Adding alternative energy sources to reduce the cost of fuel
- Protecting the environment
- Collaborating with all efforts to improve the quality of life in the Puerto Rican society

The construction of Via Verde is the largest fuel diversification project PREPA will be able to make in these times. This diversification guides PREPA to establish the actions required to comply with the new federal environmental regulations in a structured manner. Together with the above, there are important environmental considerations that will help PREPA to manage its energy costs effectively.

As shown in Figure 4.1, Puerto Rico depends on petroleum in a significant percent. At this moment, PREPA uses only No. 2 fuel oil (light distillate) and No. 6 (Bunker C) in its generating units and, at the same time, purchases the electricity produced in the AES co-generator in the Municipality of Guayama (coal) and EcoEléctica in the Municipality of Peñuelas (natural gas). With the introduction of the co-generators, we began to purchase electricity generated without the use of petroleum, but internally, PREPA still depends exclusively on it.



PREPA's goal is to reduce its dependence on the use of petroleum, which at present is 68%, approximately, for which reason the plan is to reduce it to close to 12% by 2014. For this, PREPA has to take action and identify alternative fuels that can supply the capacity its clients demand. Lack of action would only worsen the dependence on petroleum, and in times of embargo or high world demand, our island would not have viable alternatives to generate electricity. In addition, the No Action alternative leaves a latent impression that PREPA is affected by sudden changes in the cost of petroleum, which diminishes the agency's economic capacity and, in consequence, Puerto Rico's economy.

It is important to underscore that PREPA is limited by federal and state permits on the type of fuel it can burn in its units. The greater limitation is in the percentage of sulfur the fuel contains. This fuel is more expensive than fuel with higher sulfur percentages. If there is a scarcity of this type of fuel or if it is not possible to enter into purchase contracts with the suppliers, PREPA has two options: to cease generating electricity, which is not viable, or burn a cheaper fuel with a higher sulfur percentage than that established in the environmental permits and be exposed to fines and sanctions from the regulatory agencies.

The use of natural gas significantly reduces the atmospheric emissions of pollutants to the environment. No Action means that PREPA will maintain an investment of capital to reduce its emissions from petroleum, and will provide maintenance to its units instead of using that capital to develop a more efficient system that uses a cleaner fuel.

4.2. Liquefied Natural Gas Receiving Terminal in the San Juan Power Station

There are millions of miles of pipelines to transport natural gas throughout the world and over 1,500,00 of these are in the United States. This Nation has eight liquefied natural gas receiving terminals servicing it. Puerto Rico has one of these importation terminals, the EcoEléctrica Co-generator in the Municipality of Peñuelas, which has the capacity to supply our needs. Even so, the alternative of constructing an importation terminal near one of our installations with the purpose of eliminating part of the environmental impact associated with the construction of trenches for the natural gas pipelines was considered. Among the three power plants in the North area where the use of natural gas to generate electricity is contemplated, the San Juan Steam Plant (SJSP) was selected because it is the only one next to an existing fossil fuel receiving dock (see: Figure 4.2, San Juan Thermoelectric Power Plant). The dock has the infrastructure to transport diesel and Bunker C to two power plants, San Juan and Palo Seco. The other power plants don't have appropriate infrastructure next to the power plant.

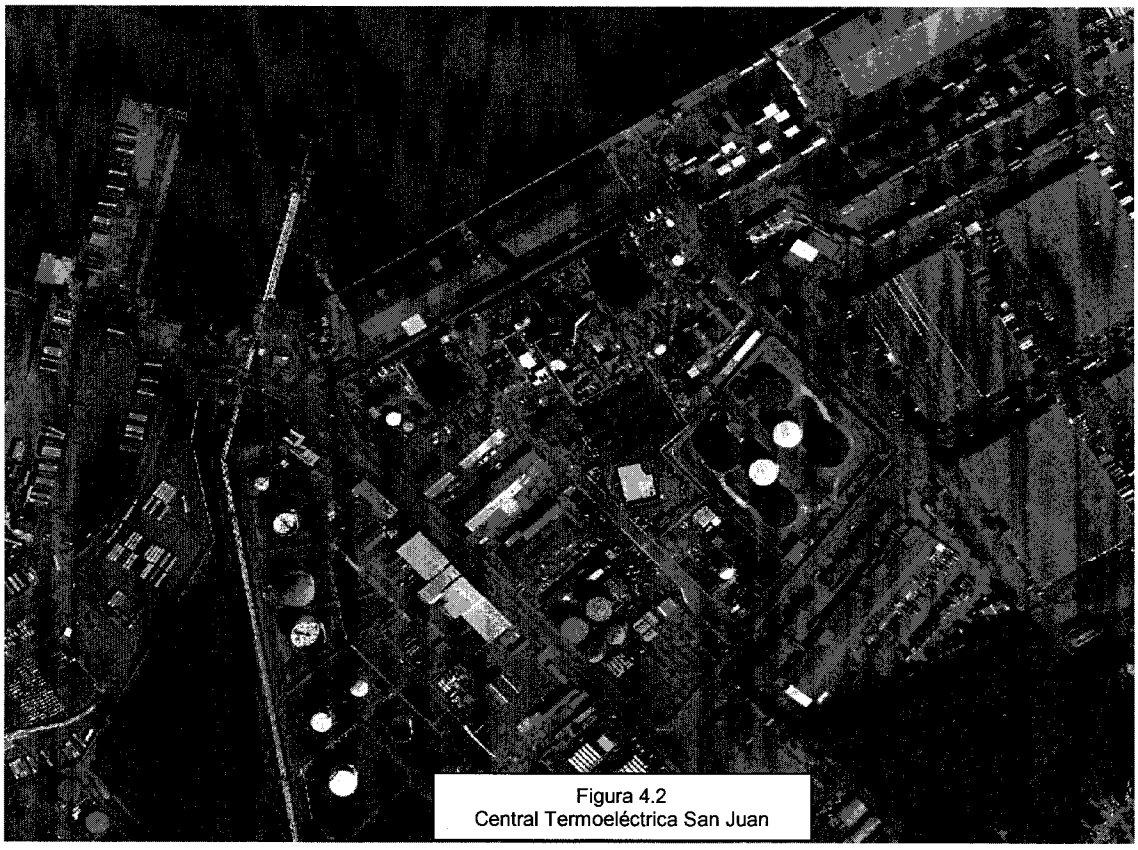


Figura 4.2
Central Termoeléctrica San Juan

When we use by way of example the importation terminal existing in Puerto Rico, the

terminal to be constructed must possess the capacity to receive, unload and store an approximate maximum amount of 160,000 cubic meters of liquid natural gas imported over the high seas; in addition to installations to gasify and handle the same. The construction of such terminal would imply an environmental impact associated with the different stages of the construction and operation of the same, among which would be included:

- Constructing, repairing or expanding, as the case may be, a dock for the receipt of liquid natural gas.

- Increase in the traffic of ships, which has an impact on the ships that supply us with the products we import, as well as on the tourism cruisers that use San Juan Bay regularly.

- Construction of a storage tank for liquid natural gas and a gasification plant. This would occupy an area of approximately 25 acres, in addition to an exclusion zone in accordance with the regulations in effect.

- Conditioning the navigation channels to support the transit of tankers, which would imply dredging and disposing of the dredged material.

The selection of a place for the construction of a natural gas receiving and regasification terminal requires the existence of deep ports to minimize the environmental impact associated with the development and operation of such terminal and the existence of areas of low population density suitable for an industrial development.

Three criteria were used to determine whether constructing an importation terminal near our installation was a viable alternative: location-specific factors, maritime operations and environmental issues.

- Location-specific factors

  - Availability of the land area: the location must have sufficient space available to accommodate the proposed installation and all the safety components required by the regulations of the Federal Department of Transportation (49 CFR Part 193), the United States Coast Guard (33 CFR Part 127) and the National Fire Protection Association (NFPA, NFPA 59A); in addition it must comply with the regulatory distance between the gasification plant and the liquid natural gas storage tank. The land facilities would occupy an area of approximately 25 acres (101,173 m^3). They would include, among other components: a double containment tank 167 feet tall and 269 feet in diameter, with a storage capacity of 1,000,000 barrels (160,000 cubic meters) of liquid natural gas at a temperature of -260°F and pressure of 2.0 psig; vaporization or gasification systems to

gasify the liquid natural gas so it can be transported to the turbines in the power plants. Other factors to consider associated with the location are the activities, external and adjacent to the terminal, and the distance or separation the terminal must observe to these areas of activity and to densely populated areas (49 CFR Parts 193.2055, 193.2057 and 193.2059).

- Availability of coastal area: the location must have available an area of maritime dock with anchoring facilities for tankers 950 feet long, 140,000 cubic meters capacity and minimum draft of 40 feet. The criteria used to evaluate whether a port or dock has the capacity for this type of project are the depth of the navigation channels (over 40 feet), the extension of the obstacle clearance height (greater than 180 feet) and its proximity to the liquid natural gas storage and gasification terminal. The dock must be approximately 30 feet wide by 1,700 feet long and possess, among others, equipment to secure the tanker to the dock, a two-level platform at the end, 40 feet wide by 100 feet long in the lower level and 20 feet wide by 76 feet long on the upper level, and a spill collection basin in case of emergencies.

- Dredged material disposal site: an area must be located for the disposal of the material to be dredged to create an appropriate navigational channel that will permit an increase in maritime traffic and the receipt of tankers with liquid natural gas and to dispose of the material generated by the routine maintenance dredging required for the appropriate flow of ships.

- Infrastructure: the importation terminal will require an adequate infrastructure that includes a reliable source of energy and appropriate highways or roads, especially for emergency response, as well as an access for tankers for the receipt of construction materials.

• Maritime operations

- Increase in the traffic of ships: the transit of tanker ships is subject to more restrictive federal regulations than general maritime traffic, which could influence the traffic of other ships and increase the risk of affecting other users of the navigation channel.

- Access to the navigation channel: the sooner a tanker can arrive at the terminal, unload, and return to sea, the better the economy of the area will be. In addition, a shorter channel would diminish the effect in traffic for other ships due to the maritime traffic restrictions on tanker ships. This is achieved with the availability of a navigation channel next to the storage and gasification terminal and with sufficient depth, width and obstacle

clearance height for the operation of a typical tanker ship, which would be in the rank of 950 feet long by 150 feet wide and which would require a minimum depth of 40 feet in the navigation channel and an obstacle clearance height of 180 feet.

- Turning area (amplitude and proximity): a typical liquefied natural gas tanker ship would require a turning basin with a minimum diameter of 1,200 feet and a depth greater than 40 feet.

• Environmental issues

- Environmental consequences: minimize the environmental impact by using sites within a previously impacted area, including the site for the dock and areas zoned for that use.

- Compatibility with regional plans: the location must be compatible with the future development of the adjacent properties.

- Zoning and land use: one of the goals of the project is to avoid or minimize adverse impacts on the environment due to development. The site must be located within an area zoned for industrial development to help confine any environmental impact in previously industrialized areas.

- Distance to populated areas: the location would be catalogued depending on its distance from populated areas or residences. Avoiding populated areas will help towards ensuring compliance with the location criteria of the DOT (49 CFR 193.2055, 193.2057 and 193.2059), which regulates in regard to the establishment of an exclusion zone, or an area where a terminal cannot be constructed due to population density. Respect for the distance established in this exclusion zone minimizes the negative public perception of safety issues normally associated with liquid natural gas terminals.

The tanker ships commonly used to transport liquid natural gas have a capacity ranging from 125,000 m^3 to 140,000 m^3. The longer ships range from 950 to 1,000 feet in length, with a typical draft of 38 to 40 feet. To insure that liquid natural gas tanker ships don't run aground easily or frequently, an additional depth of 2 feet under keel clearance is required. This implies that tanker ships require a maritime access and a docking and turning basin area in bodies of water with depths of more than 40 feet.

The SJ consists of 32.85 acres (132,941 m^3). It receives fossil fuel from the dock located to the west of it, in the San Juan port zone. Said dock is located on the Puerto Nuevo navigation channel, east of the Army Terminal dock (see Figures 4.2 and 4.3). This maritime area was prepared for the navigation of fuel vessels, among others. Currently, the tankers that service PREPA unload the fuel at the dock on the Puerto

Nuevo navigation channel.

According to the bathymetric charts, the anchorage area for the tankers that serve PREPA has a depth of little more than 30 feet. The maximum depth of the Army Terminal turning basin is, in just one point, of 40 feet, fluctuating mostly between 35 and 37 feet. This basin connects with the Army Terminal channel which is the one that reaches the Anegado Channel. This last one joins the channel that serves as the entrance for every ocean-going vessel to the San Juan bay, the Bay Channel (see Figures 4.3 and 4.4).

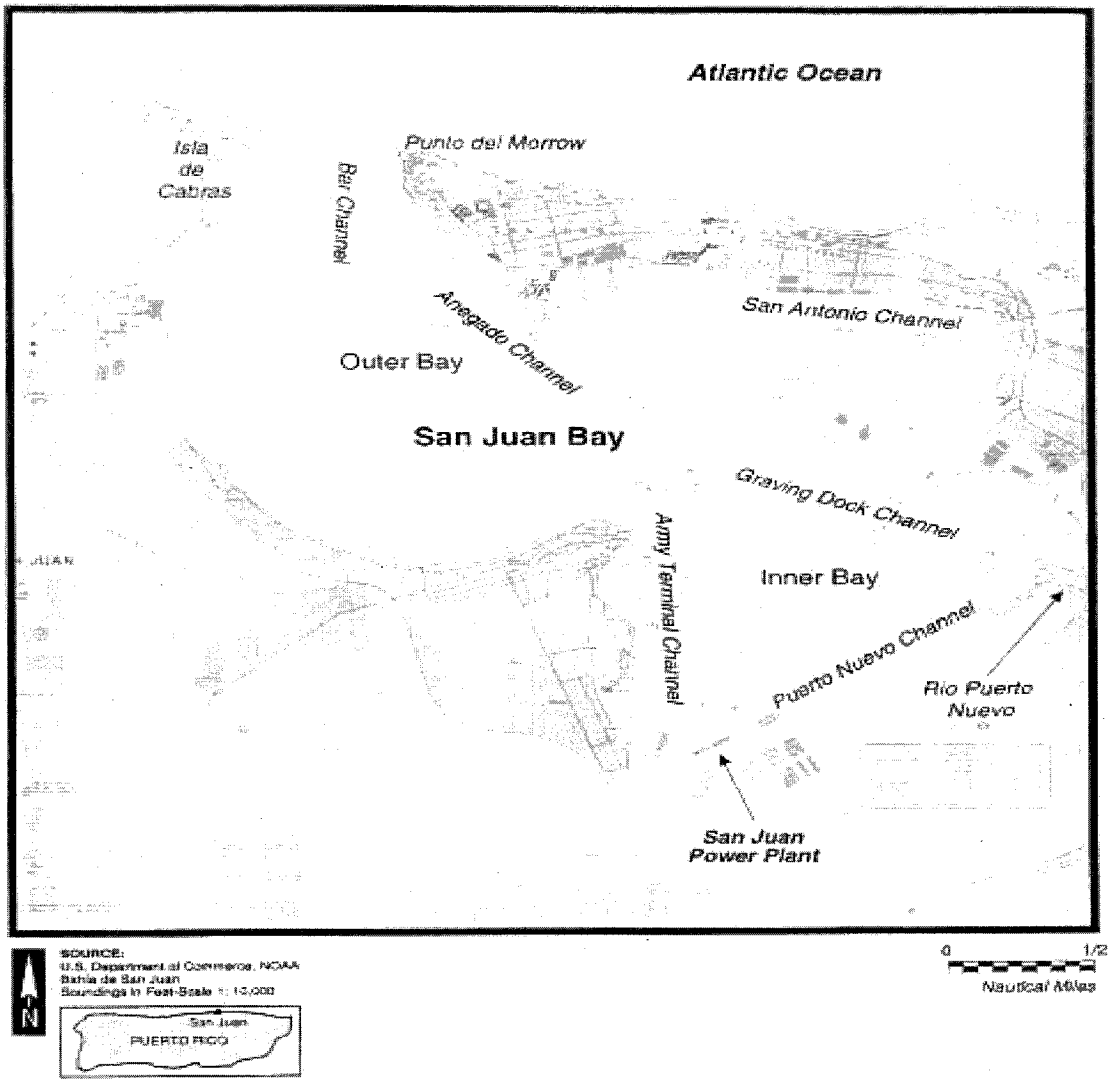
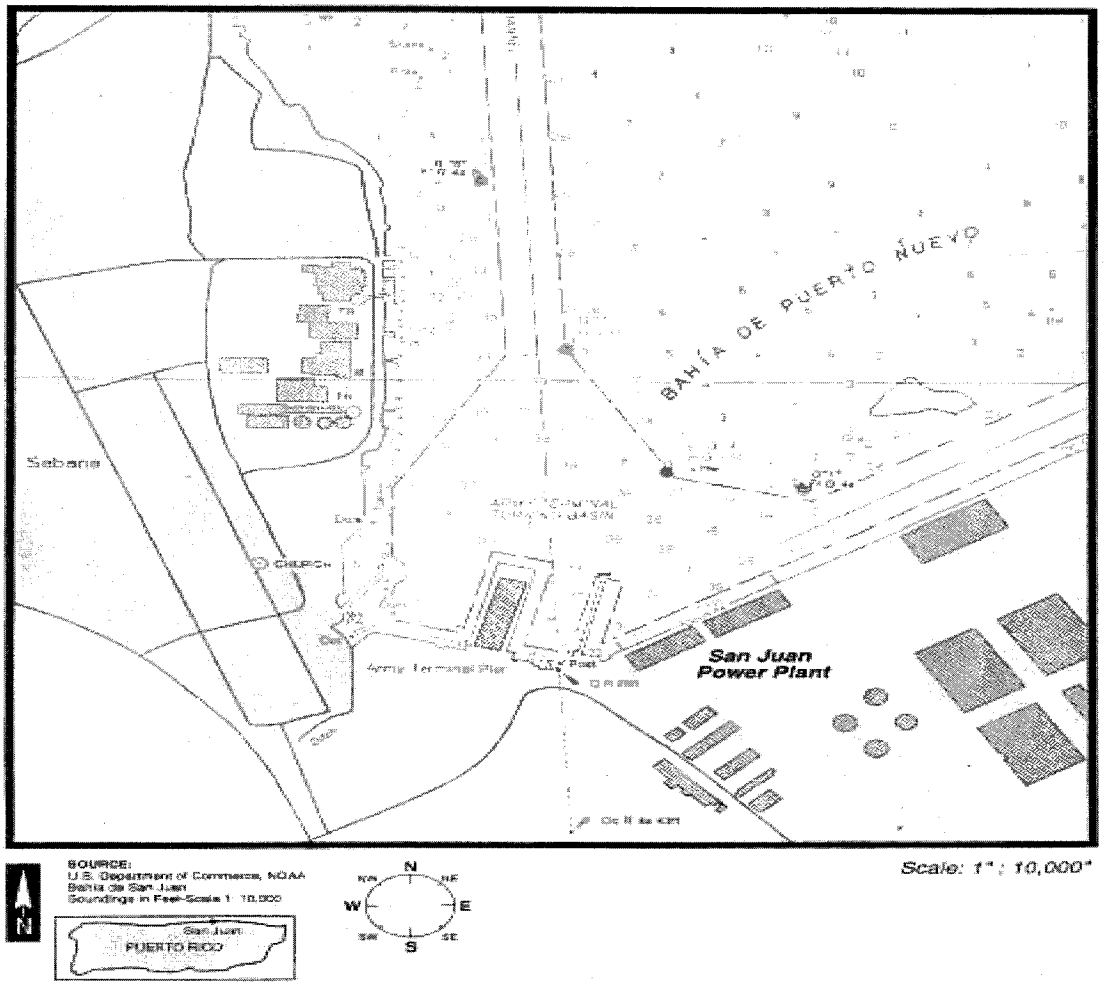


FIGURE 4.3
Approximate Location of San Juan Power Plant
and San Juan Bay Shipping Channels



Bathymetry of Bahia de P[illegible] FIGURE 4.4 [illegible]r San Juan Power Plant

To prepare the maritime area to receive tanker ships, the navigation channels and the existing turning basin would have to be dredged to reach a depth of 40 feet and for the navigation channels to reach a minimum width of 300 feet. The disposal of this dredged material would present the problem of finding an adequate site for its disposal in a way that would not represent a harmful impact on the environment. At present, Puerto Rico does not have land sites with the capacity to receive or process the amount of material that would be generated during dredging of such magnitude. Historically, it has been demonstrated that the majority of land sites for disposal of dredged material are not appropriate for industrial or commercial development, which would disable the area for future uses and development.

The disposal of the dredged material would have to be offshore, in an ocean disposal site. This presents several inconveniences. The area would have to be sufficiently large so the amount of material to be disposed of does not have an adverse impact on the area's benthic community or the impact is minimal. In addition, it should have the capacity to receive material from the routine maintenance dredging necessary to avoid interrupting the continuous flow of receipt of liquid natural gas. The initial effect of the disposal operations would be a high concentration of sediments near the surface (due to the suspended sediments). Carried by the ocean currents, this material would not necessarily reach the bottom of the ocean disposal site, for which reason the benthic area impacted would be larger than the estimated. It is underscored that the use of this disposal option is highly limited, because at present there isn't an approved ocean dumping area near the San Juan bay.

The dredging operations would produce a degradation of water quality due to the fine suspended sediments, since the dredging activities would take months. The turbidity plume would affect daily during working hours and up to two hours after the same, before the sedimentation of suspended material. This would affect the water quality and, consequently, the parameters of water quality required in the environmental permits which govern the SJSP, especially the turbidity, sedimentation and suspended solids.

The docks and ports of San Juan Bay receive annually 80% of the products imported into Puerto Rico and they play a crucial part in the export process of all kinds of products. The Port of San Juan Bay is number 17 by size in the world. Over 1.3 million tourists visit in cruise ships. It receives an average of 700 cruise ships annually. Over one thousand fishermen use the system every year, with an average catch of 350,000 pounds of fresh fish.[1] All the maritime traffic in the bay uses the Bay and Anegado common channels. In addition, the majority of the imported goods cargos that arrive in this bay, arrive at the Army Terminal dock, so they use the channel to reach that dock. It is estimated that a liquid natural gas importation terminal would increase maritime traffic in the San Juan Bay area at the rate of 25 to 60 crossings yearly, depending on the size of the liquid natural gas tankers used. The tankers would have to use these three channels until they reach the discharge point of the liquid natural gas in the dock of the Puerto Nuevo Channel. This represents an increase in maritime traffic that would affect our economy and tourism disproportionally, for diverse reasons. Among these reasons are: the high security restrictions on maritime traffic, which preclude other users from using the navigation channels or the dock simultaneously with the tanker ships.

The San Juan Bay Estuary (EBSJ) is composed of several bodies of water. Of these, one of the most important is the San Juan Bay. The EBSJ offers food and shelter to: 8 animal and 17 plant species in danger of extinction such as the West Indian Manatee

[1] http://www.estuario.org/

(Trichechus manatus) and several species of marine turtles, among them the hawksbill turtle *(Eretmochelys imbricata*) and the leatherback turtle *(Dermochelys coriacea*); 160 species of bird, such as the brown pelican (*Pelecanus occidentalis)* and the great egret *(Egretta alba egretta)*; 19 species of reptiles and amphibians, such as the coqui frog (*Eleutherodactylus coqui*) and the Puerto Rican boa *(Epicrates inornatus)*; 124 species of fish, such as the tarpon *(Megalops atlanticus)* and the snook *(Centropomus undecimalis)*; 300 species of wetland plants. The estuarine system sustains resident and migratory species and also external species that exit through one of the system's three outlets to the ocean.[2]

The body of water nearest to the SJSP is the Puerto Nuevo Bay, which is part of the San Juan Bay. An area of microalgae exists near the turning basin for vessels in the Army Terminal dock. The existence at that location of mats of *Gracilaria Sp.*, and, in lesser quantities, of *Enteromorpha sp.*, were reported. Associated with these microalgae, the presence of an abundant population of invertebrates was reported, among which are: tube worm *(Onuphia sp.)*, blue crab *(Callinectes sp.)* and some classes of bivalves (*Corbula contracta* and *Diplodonta semiaspera*). There is no evidence of coral reefs in the SJSP area.

The area of the Constitution Bridge and the entrance to the Martin Peña Canal, which are part of the EBSJ, were designated as costal Critical Wildlife Areas. The same are near the shores of the SJSP. However, there is no mangrove growth in the vicinity of the power plant.

Among the mega invertebrates are: *Callinectes sp.*, *Micropanope sp.*, and the pink shrimp (*Pemaeus duorarum*). Although no fish studies have been conducted in the vicinity of the SJSP, it is reasonable to expect that the same are those found in the San Juan Bay. Among the fish found in this bay are: tarpon (*Megalops atlantica*), guppy (*Lebistes reticulatus*), *Lepomis macrochirus*, *Elops saurus*, *Eleotris pisonis* and *Ictalurus punctatus.* No species of vertebrate wildlife, protected or endangered, are perceived near the SJSP.

However, in studies that cover the coastline from Punta Las Marías to Punta Boca Juana (the mouth of the La Plata River), which includes the San Juan Bay (see Figure 4.5), threatened and endangered species were seen, such as: green turtle *(Chelonia mydas*), hawksbill turtle (*Eretmochelys imbricata*), leatherback turtle (*Dermochelys coriacea*), West Indian Manatee *(Trichechus manatus*), the brown pelican (Pelecanus occidentalis) -recently removed from the endangered species list- and an as yet unidentified school of dolphins. These turtles and manatees were not seen in the lagoons, canals or the bays that were in the study area or near the SJSP, although the brown pelican was seen near this power plant.[3]

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[2] http://www.estuario.org/

[3] Section 316(a) and (b), Demonstration, San Juan Power Plant; ENSR; July,

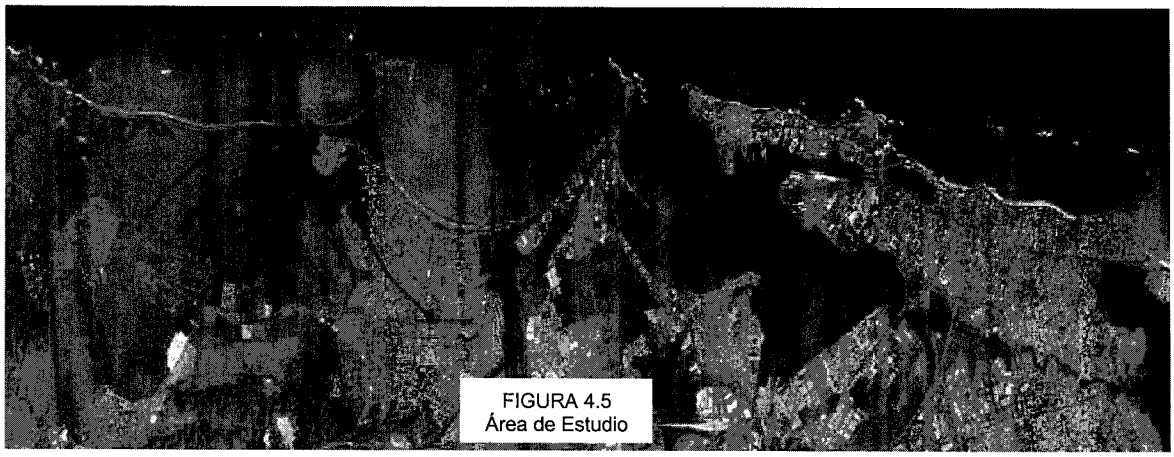


FIGURA 4.5
Área de Estudio

It is anticipated that an importation terminal, in combination with the existing SJSP system, will cause an impact on the water temperature in the Puerto Nuevo Bay, the body receiving the cooling and discharge waters of the power plant. The temperature of the discharged waters of the importation terminal would exceed the water's ambient temperatures, especially during the winter and spring months. This would produce a warming of the waters adjacent to the discharge structure during these months.

In addition, the extraction of marine water for the importation terminal's cooling system, added to the present extraction of the SJSP, would have a cumulative effect on the benthic community of the Puerto Nuevo Bay and, in consequence, the San Juan Bay, especially on the community of microalgae. It is to be expected that a loss of these would have an impact on the local populations of invertebrates and fish, added to the impact that the already mentioned turbidity and sedimentation associated with dredging would have on these species. Also, the rise in the discharge temperature would affect water quality and, consequently, the water quality parameters required in the environmental permits which govern the SJSP, specifically temperature.

The installation of the components of an importation terminal in the SJSP area would occupy a surface area of 25 acres, approximately. The SJSP covers 32.85 acres and does not have any free space (see Figure 4.1). The space is totally occupied by its diverse systems, among which are included: generating units, service and fuel reserve tanks, plants to demineralize and treat water, water storage tanks, cooling towers, buildings for warehouses, offices and laboratories. An importation terminal must comply with the regulations that regulate, among other things, the spaces that must be kept between the different elements inside the terminal (such as the distance between the liquid natural gas storage tank and the vaporizers) and the space that must be kept between the terminal itself and populated areas (exclusion zone). This, in compliance

with regulations 49 CFR 193, 33 CFR 127 and NFPA 59A. Locating the different elements of the importation terminal in the areas around the SJSP, outside of it, would not comply with these standards, not only because of how distant they would be from each other, but also because there isn't enough free and available space in the surroundings. Also the exclusion zone required by regulations would be unavailable, because the SJSP is located in one of the most densely populated areas of Puerto Rico.

The alternative of constructing an importation terminal in or near the SJSP is not a viable one to comply with the purpose of eliminating the environmental impact associated with the construction of trenches for the natural gas pipeline. Even if the construction of the importation terminal were to materialize, it would be necessary to carry natural gas to the other power plants in the north area, Palo Seco and Cambalache. This would have to be by the construction and installation of a pipeline to transport natural gas. The construction, installation and operation of said terminal does not exclude the environmental impact the construction and installation of a pipeline to transport natural gas would bring.

In addition to the environmental factors, costs and space limitations for the construction of an importation terminal in or near the SJSP, we have to consider that the process of construction and operation of a natural gas importation terminal is complex. Obtaining the permits and endorsements for the same are regulated by the Federal Energy Regulatory Commission (FERC). Taking by comparison the importation terminal existing in Puerto Rico, EcoEléctrica, the process of studies and permits together with the construction and beginning of operations can take between 6 and 7 years. The previously featured data of the time to obtain the permits and the construction of these facilities are supported by information obtained from projects recently developed in the United States, which are described in the table illustrated below:

Evaluated Area	Information Collection Time	Permits Approval Time	Construction Time	Average Total Time
Gulf	1 year	1.5 years	3 years	5.5 years
East	1 year	2-3 years	3 years	6 to 7 years
West	1 year	2-3 years	3 years	6 to 7 years

Through this observation, PREPA doesn't pretend to circumvent the permit processes before the federal agencies. The purpose of evaluating the times it takes to establish this type of project is to identify an option that could respond to the energy infrastructure crisis in an opportune and diligent manner.

This reality would turn the alternative of constructing an importation terminal into a

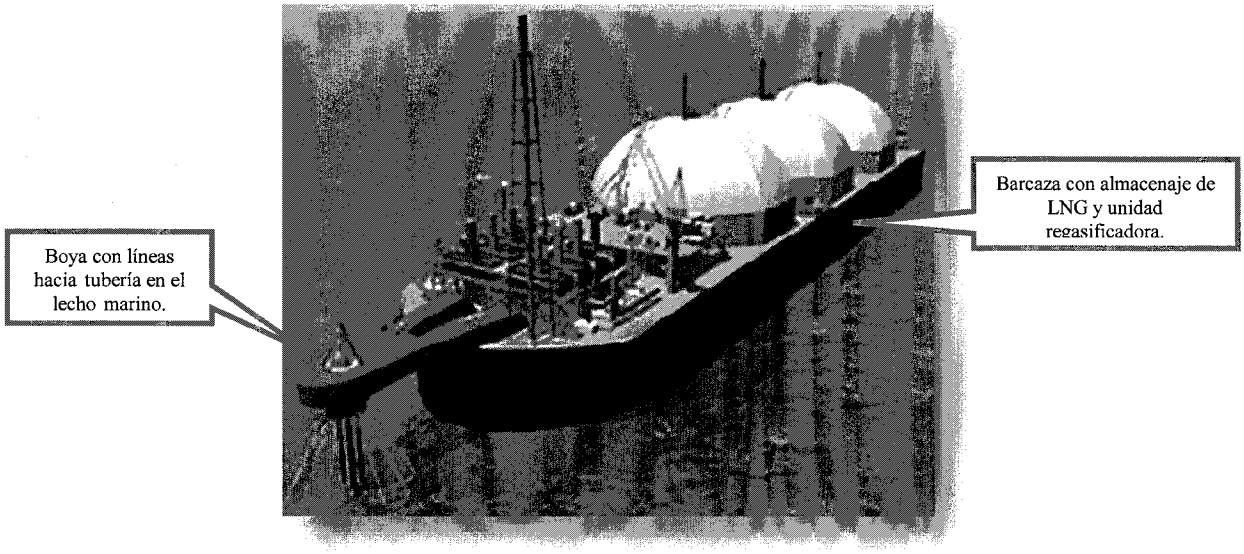
medium-term project, which would not satisfy our need for an immediate project to bring about the transition from petroleum to renewable sources of energy. The construction cost of the existing terminal was over $570 million in 1995 dollars. When we consider the cost of the present dollar and add the cost, as we indicated before, of the construction of a pipeline to transport natural gas which would connect the power plants of the north of the island, the project would be too onerous because it would surpass a billion dollars. Being a project of the Government of Puerto Rico, it would have to be financed through bond issues, which limits the savings in the electric energy bills.

The construction of an importation terminal inside or near the grounds of the SJSP as an alternative is not viable when the physical situation of the area is compared with the physical conditions required by this type of terminal. In addition, the environmental consequences in the area would be adverse and above all the time required to complete the approval of permits, as well as the construction time, would not permit a response to the energy infrastructure crisis in the least possible time. When the evaluation criteria were applied to this project, together with the previously described data, deficiencies were found that make it little or not viable at all. Although there is a maritime dock area, as opposed to the other power plants in the north area, it does not comply with the depth requirements or with the capacity for the anchorage of tanker ships of this kind. Were this alternative to materialize, there is no area for the disposal of dredged material and the dredging activity would be adverse to the area's benthic system and it would affect the water quality parameters the SJSP must comply with. Maritime traffic would be highly compromised because there is only one entrance channel to the San Juan Bay (Bay Channel) and the Anegado Channel is the only passageway to the tankers' discharge area. This would greatly affect the local economy, as well as the tourism industry.

4.3 Tankers and Buoys System

PREPA considered the installation and operation of a system of tankers and monobuoy for the receipt, storage, regasification and transport of natural gas to each one of the north area power plants as one of the alternatives to the project.

These systems of tankers and buoy, known as Deepwater Ports, suppose the construction of a receiving terminal for compressed natural gas (CNG) in the vicinity of each one of the power plants. This terminal would receive the gas from a station located some 5 km offshore, in which a tanker bringing the natural gas from its exportation point would anchor and couple. Said tanker would have a regasification unit that would couple to a buoy that holds and keeps afloat the connection lines from the tanker to the pipeline lying on the ocean floor and will transport the compressed gas to the receiving terminal near the power plant. The CNG receiving terminals require a minimum area of 2,500 m^2.



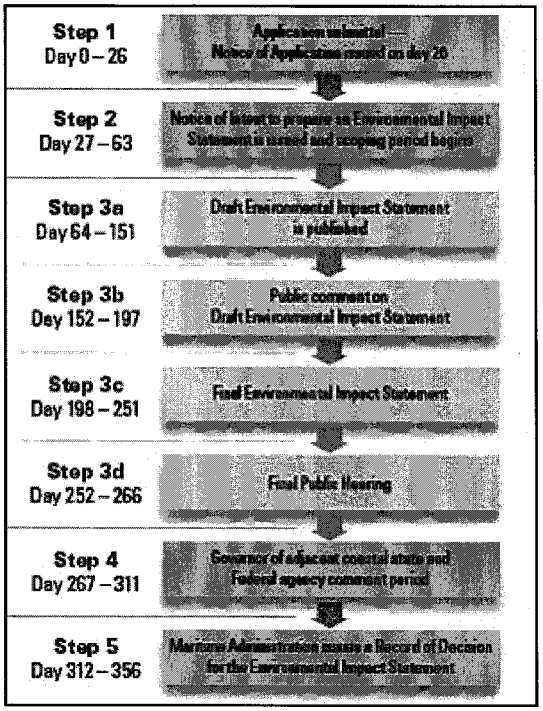
The construction, installation and operation of these tankers and buoys systems are regulated by two leading agencies: the Maritime Administration (MARAD), ascribed to the Federal Department of Transportation, and the US Coast Guard, under their Deepwater Ports Standards division. Other federal agencies with jurisdiction over the construction, installation and operation of these systems are: Advisory Council on Historic Preservation (ACHP), Council on Environmental Quality (CEQ), Department of Energy (DOE), Department of State, Environmental Protection Agency (EPA), Federal Energy Regulatory Commission (FERC), Minerals Management Service (MMS), National Marine Fisheries Service (NMFS), Department of Commerce under its National Oceanographic and Atmospheric Administration (NOAA), Pipeline and Hazardous Material Safety Administration (PHMSA), US Army Corps of Engineers (USACE), US Fish and Wildlife Service (FWS), and the White House Energy Streamlining Task Force. At the state level the agencies with jurisdiction are: Office of the Governor, Department of Natural and Environmental Resources (DRNA), Puerto Rican Culture Institute (ICP), State Historic Preservation Office (SHPO), Ports Authority, Public Service Commission (CSP), Environmental Quality Board (JCA), Urban Planning Board (JPU) and the Electric Power Authority (AEE).

PREPA would request a private company experienced in the matter, to design, construct and operate the tankers and buoy system. This would have an approximate annual cost to PREPA of 70 to 80 million dollars, subject to signing a contract with said company for a term of not less than 20 years. At the end of the 20 years, the total cost would be some 1.6 billion dollars.

The process to obtain the permits for the construction and operation of these systems begins by filing an application with the MARAD. The authority to grant licenses for the construction and operation of the tanker systems which was conferred on the Federal

Secretary of Transportation under the Deepwater Port Act, as amended, was delegated on this office in 2002. The temporary regulation 33 CFR, Parts 148, 149 and 150, which govern the license application process for the construction and operation of these systems, arises under this law.

The license application process starts with a pre-application phase during which the applicant discusses the project with the concerned agencies, both at the state and federal levels. Then the application is filed and a 356-day term is activated within which the MARAD has to issue a Record of Decision (ROD), in accordance with what is set forth in the diagram on the right, taken from MARAD's internet web page.[4]



After the publication of the ROD, the applicant must have its installation completely operational before the MARAD grants the license. This process usually takes from two to four years.

In parallel form to the process before the MARAD, the applicant must comply with the requirements of the National Environmental Policy Act (NEPA), which usually takes some 240 days from the moment in which the application notification is issued. During this 240-day period, other agencies intervene and the Environmental Impact Statement is produced. Also in parallel form the permits and endorsements from the state sphere are procured. The Environmental Impact Statement generated under the NEPA process, as well as the data and studies which supplement the same, can be used also to satisfy the requirements of the state's Environmental Public Policy Act.

Given that the ownership of the system will be in private hands, one of the most important aspects MARAD considers before issuing the required license is the applicant's financial capacity to construct and operate the tankers and buoys system under consideration. Moreover, the private applicant must have the financial capacity to post a bond sufficient to cover the expenses of the complete removal of the system, once the license expires or is revoked.

In addition, the private applicant must prove that the tankers and mono-buoy system is in the national interest and that it is consistent with the federal public policies on national security, energy independence and environmental quality, among others.

[4] http://www.marad.dot.gov/ (March, 2010)

Neither can the system interfere with international navigation and other reasonable uses of the high seas, as defined in treaties, agreements or in the customary international law. At the state level the authorization of the governor of the state adjacent to the project is required.

The public must be kept informed of the whole process by means of the Federal Register and through the publication of all the related documents in the Federal Docket Management System: www.regulations.gov. In addition, processes under NEPA, as well as the state processes, provide for holding public hearings through which citizen participation is assured, similar to the processes established by the Environmental Quality Board in the applicable regulations (which are designed as what is denominated as a "NEPA- like process").

The environmental impacts of this alternative are similar to those analyzed for the previous alternative. Despite not having to dredge to permit accommodating the great draft of the tankers, a submarine line would have to be built from the buoy to the CNG tank and that would have an impact on an ecologically sensitive area such as the San Juan Bay and its estuary, or in the north coast areas which are considered as critical habitat for five species of coral in danger of extinction, such as the acropora.

PREPA evaluated the viability of the construction of these systems in three areas: San Juan, Toa Baja and Arecibo. The criteria considered in said evaluation were environmental impact, costs, space, time to start operations, permits, security, environmental justice, and past experiences in Puerto Rico and in the United States.

4.3.1 System Analysis for the San Juan Power Plant

The annual rental cost would be some $70 to $80 million dollars. The power plant does not have available space to locate the CNG receiving terminal. It is estimated that the time required to make the system operational, in compliance with all the applicable state and federal legislation, will be between 5 and 8 years. The permit process is complicated and costly, which together with the area's physical limitations, limits keeping this alternative as a viable one to respond to the energy infrastructure crisis. The pipeline on the ocean floor to the area of the San Juan Power Plant would run through an area of intense maritime traffic, which would raise safety and Homeland Security issues, this being a national and international port. There are low-income communities near the project which could be affected, for which reason in an environmental justice analysis the project would probably not be favored. The San Juan Power Plant is in the vicinity of CAPECO where there was an explosion on October 23 of 2009 that affected the nearby communities, which is still very recent in their memories and could support the opposition's position, even if it is an allegation lacking in merit. The project would entail impacts on San Juan Bay and its estuary. For all the reasons set forth above, the construction of the system for the San Juan Power Plant within the time frame required for the action under consideration was discarded. As a consequence, the supply of natural gas to this power plant will have to be

unavoidably through a natural gas pipeline.

4.3.2. System Analysis for the Palo Seco Power Plant in Toa Baja

The annual rental cost would be some $70 to $80 million dollars. The power plant does not have available space to locate the CNG receiving terminal. It is estimated that the time required to make the system operational, in compliance with all the applicable state and federal legislation, will be between 5 and 8 years. The permits process is complicated and costly. In the area of the Palo Seco Power Plant there are low-income communities near the project which could be affected, for which reason in an environmental justice analysis the project would probably not be favored. The Palo Seco Power Plant is in the vicinity of CAPECO where there was an explosion on October 23, 2009 that affected the nearby communities, a situation that is still very recent in their memories and could support the opposition's position, even if it is an allegation lacking in merit. Another aspect which must be taken in consideration during the analysis of this option is the fact that the energy of the Atlantic Ocean is significant, which possibly would require specialized construction techniques for the mono-buoy system in said area. The construction of this alternative would have an environmental impact on the Boca Vieja Bay. For all the reasons set forth above, the construction of the system for the Palo Viejo Power Plant within the time frame required for the action under consideration was discarded. As a consequence, the supply of natural gas to this power plant will have to be unavoidably through a natural gas pipeline.

4.3.3. System Analysis for the Cambalache Power Plant in Arecibo

The annual rental cost would be some $70 to $80 million dollars. The power plant does not have available space to locate the CNG receiving terminal. It is estimated that the time required to make the system operational, in compliance with all the applicable state and federal legislation, would be 5 to 8 years. The permits process is complicated and costly. There are low-income communities near the project that could be affected, for which reason in an environmental justice analysis the project would probably not be favored. Another factor that must be taken in consideration during the analysis of this option is the fact that the energy of the Atlantic Ocean is significant, which would probably require specialized construction techniques for the mono-buoy system in said area. As a point of reference, at present the delivery of fuel to the Cambalache facility owned by PREPA is affected by marine conditions an average of 3 to 4 months a year, this supports the facts and concerns previously expressed. For all the reasons set forth above, the construction of the system for the Cambalache Power Plant within the time frame required for the action under consideration was discarded. As a consequence, the supply of natural gas to this power plant will have to be inevitably through a natural gas pipeline.

4.4 Use of Renewable Energy

The structured integration of renewable energy sources, intermittent in nature, to electrically isolated, low-inertia systems, such as the one in Puerto Rico, requires specialized and scientific studies to evaluate its impact on the levels of stability and reliability of the electric grid. This is so because this type of system permits a maximum limit of interconnected sources of intermittent energy before its stability and reliability are affected. The Electric Power Research Institute (EPRI), recognized world-wide for its experience in the development of advanced studies in the analysis of power systems, completed a highly specialized study of this kind for PREPA in August, 2009.

One of the main objectives of the EPRI study is to provide PREPA with guidelines and technical recommendations that would allow us to integrate, in an orderly, structured, responsible and scientific manner, intermittent renewable energy sources into the electric grid, considering the critical aspects of safety and stability inherent to the operation and the dynamic nature of electrically isolated and low-inertia power systems. The following conclusions were reached based on the scientific studies of power system analysis conducted by PREPA and EPRI teams in charge of planning in the company:

a) At present, the proposed renewable energy projects of an intermittent nature submitted for our consideration could present challenges in what has to do with the maximum penetration limits considered in the EPRI study. This, in view that the reserve requirements in rotation and control considered by EPRI are significantly higher than the actual operational requirements, for which reason the equivalent penetration limits studied by EPRI are considerably lower than the penetration levels under consideration at PREPA.

b) Because of this, and in order to safeguard the electric system's stability and reliability, we must evaluate the integration into the electric grid of additional projects of renewable energy sources of an intermittent nature, regardless of their location in the electric system, until the additional studies recommended by EPRI are conducted.

c) The required studies must consider the present projections of demand for electric power, the corresponding dispatch schemes, the integration of solar parks, the location of the renewable energy projects under contract and the fuel conversion plans, among other aspects. An update of the pending studies must be complemented with the acquisition of specialized analysis tools for high level power systems and with the pertinent technical training. In this manner we guarantee that the study areas of PREPA's power systems can provide continuity to the evaluations required to transform our electric grid in harmony with Our Strategic Corporate Plan 2009 - 2012 and with Law 82 of 2010.

d) Establish, on the basis of scientific criteria for the analysis of power systems, a strategic plan for the structured integration of renewable energy sources of an intermittent nature, that do not place the stability and reliability of Puerto Rico's electric system at risk. We must establish inviolable limits and percentages of geographical penetration, which must be safeguarded in a consistent manner for the well-being and socioeconomic development of Puerto Rico.

In addition, PREPA prepared the following table in which the generating capacity from some renewable sources that could be acquired is compared with what would be invested in the installation of generating infrastructure for Via Verde, $450 MM.

Comparative Generation Table

Technology Considered	Computation Base	Equivalent Generation	Capacity Factor	Adjusted Generation	Generation with Via Verde	Estimated Time for Permits and Construction
Photovoltaic Panels	$6/Watt	75 MW	32%	24 MW	1,542 MW	1-2 years
Wind Turbines	$2/Watt	225 MW	38%	86 MW	1,542 MW	1-2 years
Solar Heaters	$2/Watt	225 MW	32%	72 MW	1,542 MW	1-2 years

When considering the data in the previous table, we conclude that the use of renewable energy technologies exhibits higher costs than those obtained by generating electricity with Vía Verde. In view of this technological reality, PREPA proposes the use of the Vía Verde infrastructure as an orderly and effective transition to the integration of these renewable technologies. This will achieve furthering the island's economic development which will in its stead permit investment in new renewable technologies. In this way, Vía Verde will spare Puerto Rico from committing the tactical error Spain committed by fomenting the construction of wind turbine projects and technologies by means of the approval of credit and economic incentives. This action led Spain to not having the capacity to repay those credits, which affected the viability of the Spanish economy.

In accordance with the previous cost analysis and the recommendations made on the basis of the EPRI study, we conclude that the use of these technologies in Puerto Rico's base generation of electricity is not cost effective and does not permit an immediate response to the energy infrastructure crisis. At the same time, this

compromises the island's economy and affects the quality of life and the well-being of the citizenry in general.

Although the technologies to use renewable energy sources represent zero emissions of air pollutants, the installation and operation of these is not exempt of adverse environmental impact. In fact, projects of this type presented in the island generated great controversies and concerns related to the environmental impact (deforestation of extensive areas, impacts on the flora and fauna, impact to critical habitats, loss of agricultural lands, among others).

4.5. Natural Gas Pipeline

The principal reasons which sustain this determination are:

1. There is a liquefied natural gas receiving terminal in Puerto Rico at EcoEléctrica, which is located in the Municipality of Peñuelas, which avoids the investment required to construct a terminal. This is one of eight importation terminals for this product in the whole United States. In addition, there are some six export terminals, also in the United States. In fact, there is one in Alaska, a state with a high incidence of seismic activity.

2. The historic and projected price of natural gas, according to data published by the Federal Energy Office, is lower than light distilled (No. 2), which is the most expensive fuel used by PREPA. In addition, the projection indicates that natural gas will be cheaper than residual No. 6, which historically had a price similar to, or lower than natural gas in the past.

3. The maintenance cost of the units is reduced because natural gas is a cleaner fuel, as shown below:

ESTIMATED SAVINGS ON GENERARTING UNITS MAINTENANCE USING NATURAL GAS

I. COMBUSTION TURBINES (DIESEL FUEL)

A. CAMBALACHE PLANT: Three Units of 83 MW ea

Fuel	Maintenance Frequency	Inspection Intervals	Cost	Amount of Inspections in 10 Years	Cost of Inspections in 10 Years
Diesel	18,000 hrs	40 months	$9,750,000	3	$29,250,000
Natural Gas	24,000 hrs	60 months	$10,050,000	2	$20,100,000

Approximate Savings on Maintenance is $27,450,000 in 10 years (30%). Se mejora la

confiabilidad.

B. UNITS 5 AND 6 OF THE COMBINED CYCLE - SAN JUAN: Two Units of 148MW ea

De acuerdo al manufacturero, el ahorro aproximado en mantenimiento es de 30%. Los intervalos de mantenimiento se alargan por un factor de 1.3 veces. Se mejora la confiabilidad.

II. STEAM TURBINES (BUNKER C FUEL)

A. PALO SECO STEAM PLANT: Two Units of 216MW ea

Fuel	Environmental Maintenance Frequency	Environmental Maintenance Cost	Auxiliary Steam for Fuel Heating	Fuel Used for Auxiliary Steam for Fuel Heating in 24 hrs	Annual Cost Fuel Used for Auxiliary Steam for Fuel Heating in 24 hrs
Bunker C	18 months	$1MM	3,900#/hr	102,123 barriles	$788,440
Natural Gas	Not Necessary	$0	0	0	0

Approximate Savings on Environmental Savings: $2MM each 18 months

B. SAN JUAN STEAM PLANT: Four Units of 100MW ea

Fuel	Environmental Maintenance Frequency	Environmental Maintenance Cost	Auxiliary Steam for Fuel Heating	Fuel Used for Auxiliary Steam for Fuel Heating in 24 hrs	Annual Cost Fuel Used for Auxiliary Steam for Fuel Heating in 24 hrs
Bunker C	18 months	$1MM	1,950#/hr	51,061 barrels	$394,220
Natural Gas	Not Necessary	$0	0	0	0

Approximate Savings on Environmental Savings: $4MM each18 months

4. The existing units are prepared, or can be modified to use natural gas as their principal fuel without affecting their generating capacity.

5. Natural gas is a cleaner fuel. Its use will help PREPA maintain sustained compliance with environmental regulations to protect the environment. In addition, it will help achieve the greatest and most significant reduction of

fuel emissions in our island's history and will allow the agency to comply with the new emissions criteria promulgated by the EPA for the year 2020. (See Section 6.18)

6. The technology to generate energy with natural gas is well-developed and tested worldwide. At the end of Chapter 2 we present data that demonstrate the use of natural gas in the United States, the number of pipelines and the terminals for natural gas. Also, we present a table from which we conclude that close to 25% of electricity generation in the United States is based on natural gas.

7. There are proven reserves in different parts of the world. The federal Department of Energy's (DOE) internet page has the most up-to-date information on the availability of the world's natural gas reserves in their electronic address, as recovered on October 21, 2010: http://tonto.eia.doe.gov/cfapps/ipdbproject/IEDIndex3.cfm?tid=3&pid=3&aid=6. The data included there show that there are natural gas reserves in all parts of the world that at present amount to some 6,609,346 trillion cubic feet. They also show that there are gas providers as close to Puerto Rico as Trinidad and Tobago. PREPA, through the processes provided by law and by its regulations, will seek to purchase natural gas from the providers available in the market in such a way that its cost is the most economical, always in compliance with its quality specifications.

For this analysis we used some components of PREPA's property study made under contract by Power Technologies Corporation (PTC) in 2006, *Corridor and Alternative Routes Selection Study*.

The PTC study was comprehensive, since it took in consideration the whole island. One thousand (1,000) meter corridors were evaluated and the following criteria were used for said evaluation: topography, land use, existing corridors and the sensitive areas. With these parameters, 4-km-long segments were generated for analysis under the criteria of existing rights of way or land routes outside the existing rights of way.

Then, 100-meter corridors were created to be used as route alternatives, which were associated with different values and different weights of limiting factors. The route alternatives associated with the least limiting factors were analyzed by experts familiar with the route selection criteria for this kind of project. Restriction maps were created in the final round of analysis, which were used to identify different corridor options. Then, the corridor options were refined with other factors such as: individual residences, minor topographic variations, sensitive habitats identified during the field visits, construction methodology in areas of greater difficulty, such as: steep slopes, bridges and densely populated areas.

Finally, PTC identified for PREPA several routes to carry natural gas to different points

in the island. Among these are our installations in Arecibo, San Juan and Palo Seco, which are Vía Verde's focal points.

This study suggested two alignments to transport the natural gas from EcoEléctrica to the Cambalache Power Plant:

- **South-North Alignment A**

Starting at EcoEléctrica, with a northeast route cross-country until the Municipality of Ponce and then through the right of way of PR-10, continuing through the Municipality of Adjuntas and the Municipality of Utuado. In the Municipality of Utuado the trajectory veers away from the PR-10 corridor, but continues parallel to it until it reaches the Municipality of Arecibo. In said municipality it runs through the northern plains until it reaches the Cambalache Power Plant. This alignment traverses a total of 45.1 miles. This alignment was denominated the I-10 Overland alignment.

- **South-North Alignment B**

Starting at EcoEléctrica, and taking one of two options to reach PR-10. One of the options is the right of way projected for the Southern Gas Pipeline from the Municipality of Ponce; the other is to take the PR-10 right of way from the Municipality of Guayanilla, through the Municipality of Peñuelas. Both options reach the west of the Municipality of Ponce, from where they enter the PR-10 right of way until the Municipality of Arecibo and connect with the Cambalache Power Plant. This alignment traverses a total of 36.8 miles. The study called this alignment DOT Route.

In addition, the study suggested two viable alignments to transport the natural gas from Cambalache to the San Juan and Palo Seco Power Plants:

- **West-East Alignment A**

From the Municipality of San Juan, through Levittown, it takes a trajectory to the west and crosses the municipalities of Toa Baja, Dorado, Vega Alta, Vega Baja, Manatí and Barceloneta until it reaches the Municipality of Arecibo. This alignment traverses a total of 44.6 miles. The study called this alignment the Overland Corridor.

- **West-East Alignment B**

From the Municipality of Cataño, it occupies PR-22's right of way until it reaches the Municipality of Arecibo. The same crosses the municipalities of Toa Baja, Dorado, Vega Alta, Vega Baja, Manatí and Barceloneta. The study mentions that they will have to investigate whether this alignment interferes with the Superaqueduct's right of way. This alignment traverses a total of 45.6 miles. The study called this alignment the DOT Corridor.

For our analysis, in addition to the previously mentioned alignments, a third alignment was included for both sections that were not contemplated in the PTC study. Thus, a total of three alignments were studied for each section. The alignments considered were: South-North Alignment A (SNA), South-North Alignment B (SNB), South-North Alignment C (SNC), West-East Alignment A (OEA), West-East Alignment B (OEB) and West-East Alignment C (OEC).

Among the previously mentioned segments, the best alternative was selected for each one of the sections. When both selected sections were joined, we obtained the terrestrial alignment with the greater development potential.

4.5.1. Terrestrial Alignments

4.5.1.1. Selection of alignment with the greater development potential

The purpose of this stage of our analysis is to select a final alignment for Vía Verde. The two alignments suggested in the PTC study in the EcoEléctrica to Cambalache section and the two alignments in the section from Cambalache to the Palo Seco and San Juan power stations were selected. In addition, a third alternative was analyzed for both sections that was not contemplated in the PTC study.

The environmental criteria listed below were selected for the evaluation of these six segments of alignment. In Addendum 4.1, Criteria Maps, you will find a map with the illustration of each criterion.

- Land use
- Bodies of water impacted
- Miles of forest or nature reserves impacted
- Endangered species
- Archaeological finds
- Highway crossings
- Zoning or ratings
- Nearby residences

The source of information used, mostly, was the GIS technology database, which offers environmental information in a computerized manner. Each environmental criterion was evaluated as follows:

- **Land use**

An analysis was made of the different kinds of land use throughout the alignment. Non-residential, public, industrial, agricultural and commercial uses were defined as land uses favorable to the construction. Land for residential use and environmentally sensitive lands were defined as land uses unfavorable to the construction. The

extension of the alignment that ran through land for all the uses was measured and then the extension of the uses unfavorable for the construction was deducted from the favorable uses and a final value was obtained. A positive (+) value was assigned to the alignment that obtained the highest value.

- **Bodies of water**

Crossings of bodies of water increase the difficulty in the pipeline's construction because to be able to cross a body of water special construction methods will have to be implemented to avoid adverse impacts to them. This increases the cost of the projects. All the bodies of water intercepted by the construction were counted. A positive (+) value was assigned to the alignment with the least number of intercepted bodies of water.

- **Forests or nature reserves**

The forests and nature reserves are protected areas for their high ecological value. One of the criteria considered for the selection of the Vía Verde alignment is to avoid or minimize, as much as possible, impact on these areas. The extension of the alignment that crossed through the different forests or reserves was measured. A positive (+) value was assigned to the alignment that crossed through less areas of forests and reserves.

- **Endangered species**

In Puerto Rico there are several species of fauna and flora listed as protected or endangered. The habitats for such species are highly protected by state and federal regulations. One of the criteria considered for the selection of the Vía Verde alignment is to avoid or minimize as much as possible the impact to these habitats. The extension of the alignment that crossed through the protected habitats was measured. A positive (+) value was assigned to the alignment that crossed the least protected habitats.

- **Archaeological and architectural finds**

Areas with archaeological and architectural finds are protected due to their historic, social and cultural value. They are protected by state and federal laws. All the archaeological and architectural finds which would be intercepted by the alignment were counted. A positive (+) value was assigned to the alignment with the least finds.

- **Highway crossings**

Highway crossings increase the difficulty in the construction of the pipeline because to cross them, special construction methods must be implemented. This is so as to not affect the integrity of the infrastructure and vehicular congestions, which increases the

cost of the project. All the highways that would be intercepted by the alignment were counted. A positive (+) value was assigned to the alignment that ran through less crossings.

- **Zoning**

An analysis was made of the different land zonings or ratings along the alignment. Non-residential, public, industrial, agricultural, commercial and not zoned lands were defined as favorable to the construction. Residential, forested, conservation zones and historical sites were defined as land zones unfavorable to the construction. The extension of the alignment that ran through land of all zones was measured and then the extension that ran through zones unfavorable to the construction was subtracted from the favorable zoning and a final value was obtained. A positive (+) value was assigned to the alignment with the highest value.

- **Residences**

Due to its limited geographic extension, its high population density and its topography, Puerto Rico has abundant residential conglomerates, especially on its coastal plains. In addition, opposition to a similar project was conceived in the past due to a mistaken perception by the citizenry that the transport of natural gas is an unsafe operation. By the statistics of accidents with natural gas transmission lines, according to the National Transportation Safety Board (NTSB), that perception is not true. Nevertheless, to promote greater trust in the project, this criterion was incorporated in the alignment's selection process. For that reason, the criterion with greater weight in the project's planning was minimizing the number of residences in the vicinity of the alignment. The residences intercepted by the alignment were counted. A positive (++) value was assigned to the alignment with less residences.

4.5.1.2 Matrix for alignment selection

In this stage three alternatives were compared for the south-north section and three alternatives for the west-east section. For this we compared the percentage of each alignment or the number of times the alignment would affect the environmental criterion being evaluated, according to each case. A (+) was awarded to the alignment that would least impact each criterion. Then the amount of (+) each alignment had in its favor was added and the alignment with the most criteria in its favor was selected. The analysis is summarized in the matrix in Addendum 4.2, Matrix for Alignment Selection.

4.5.1.3. Selected alignment

After developing and analyzing the matrix for the environmental criteria considered, we found that the South-North C alignment was the most favorable. It obtained nine positive points, while the South-North B alignment obtained three positive points and the South-North A alignment obtained only one positive point. Also, the criterion of

impact to residences in the South-North C alignment obtained the highest positive value of the three possible alignments for this section.

For the West-East section the analysis of the matrix revealed that the best alignment is West-East C. It obtained six positive points, while the West-East B alignment obtained five positive points and the West-East A alignment only received one positive point. Also, the criterion of impact to residences in the West-East C alignment obtained the highest positive value of the three possible alignments for this section.

By joining the alignments with the most positive value for each section, we obtained the terrestrial alignment with the greater development potential. That is the alignment about which the environmental evaluation presented in this DIA-P was made.

4.5.2. Variations to the selected alignment

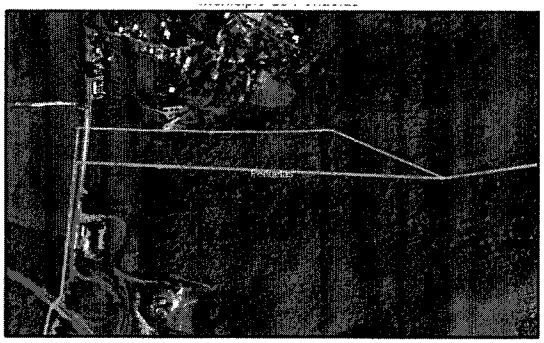
The development of the selected alignment evolved to incorporate necessary changes due to different reasons: impact the communities in the least, avoid or minimize environmental impacts, economic factors, and factors associated to the construction. In the determination of the variations, the main emphasis was on finding the shortest viable alignment in terms of construction which would have the least environmental impact and, principally, to be as far away from the communities as possible. The variations we show below led to the alignment presented in this document, Vía Verde. The illustrations of the variations that appear below contain the original alignment in orange and the varied alignment in green.

4.5.2.1. Variations to avoid communities

The criterion that carried the most weight in planning the project was to minimize the number of residences in the vicinity of the alignment. During the planning of the project we found that the initial alignment selected in the study of alternatives ran near certain communities. For that reason, we determined to displace the alignment inasmuch as possible so that no communities would be affected for a distance of 150 feet on both sides of the alignment.

The following variations were made to avoid impacting the communities.

4.5.2.1.1. Variation at Seboruco Community, Peñuelas



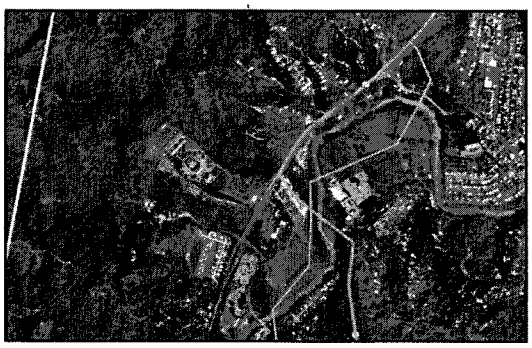
Initially, the alignment was some 300 feet from this community. We made the decision to move the line away some 300 feet to the south, because there was space available. In addition, this change did not affect other communities. Finally, the present alignment is at a distance of some 600 feet away from

this community.

4.5.2.1.2. Variation at Urbanización Monte Santo, Peñuelas

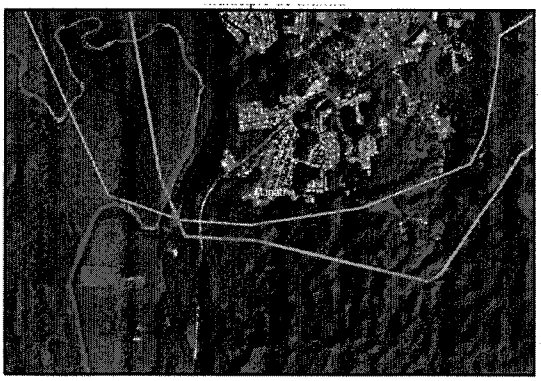
Initially, the alignment ran on the east side of Urbanización Monte Santo. With this alignment, four residences were less than 150 feet away from the alignment. By making this change, it was reduced to only one residence.

4.5.2.1.3. Variation at Universidad de la Montaña, Utuado



Initially, the alignment impacted land belonging to Universidad de La Montaña. By incorporating this variation, the alignment diminishes the impact to these lands and now it is more than 800 feet away from the university's buildings.

4.5.2.1.4. Variation at Urbanización Jardines de Mónaco, Manatí



The alignment was some 400 feet away from this urbanization and affected several residences in the nearby communities. It was decided to move the line away an additional 400 feet because there was space available. In addition, this change benefitted the adjacent houses which were within a distance of 150 feet from the project. Finally, the present alignment is some 800 feet away from the Jardines de Mónaco communities.

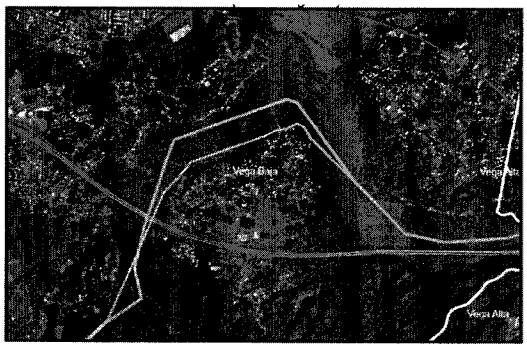
4.5.2.1.5. Variation at La Grúa Sector and El Polvorín Ward, Manatí

Initially, the alignment impacted the La Grúa Sector, cutting directly across it. Nine residences would be affected. By making this change we were able to avoid this community and at present it is more than 3,000 feet away.

4.5.2.1.6. Variation at Bethel Sector, Pugnado Afuera Ward, Vega Baja

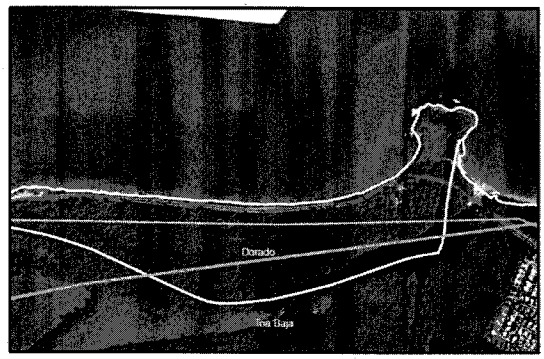
Initially, the alignment affected the Bethel Sector. Several residences would be within 150 feet of this alignment. By incorporating this variation, we were able to move the alignment more than 300 feet away.

4.5.2.1.7. Variation at El Indio Sector, Almirante Norte Ward, Vega Baja



Initially, the alignment impacted more than ten residences in the El Indio Sector. By making this change, we were able to avoid impacting these residences. We were able to move the proposed alignment more than 300 feet away from this community.

4.5.2.1.8. Variation at Mameyal Playa Community, Toa Baja



Initially, the alignment affected the Mameyal Playa Sector. Several residences in this sector were within 150 feet of this alignment. By incorporating this variation, we were able to move the alignment to more than 300 feet away.

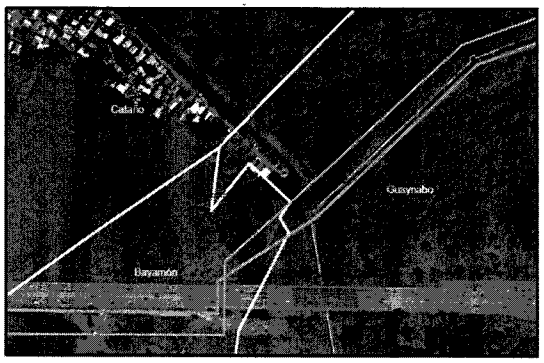
4.5.2.1.9. Variation at Levittown Communities, Toa Baja

Initially, the alignment affected several urbanizations in the Levittown area. Several residences in these communities would be within 150 feet of this alignment. By incorporating this variation, we were able to move the alignment to more than 500 feet away.

4.5.2.1.10. Variation at Villa Aurora Urbanization, Cataño

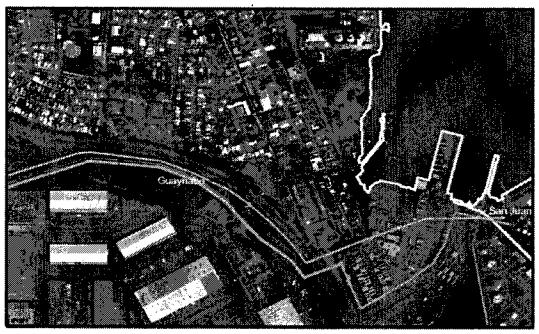
Initially, the alignment affected this urbanization. Twelve residences of this sector would be within 150 feet of this alignment. By incorporating this variation we were able to keep these residences more than 200 feet away.

4.5.2.1.11. Variation at Puente Blanco Community, Cataño-Guaynabo



Initially, the alignment affected the Puente Blanco community, Several residences in this sector would be within 150 feet of this alignment. By incorporating this variation we were able to keep these residences more than 150 feet away.

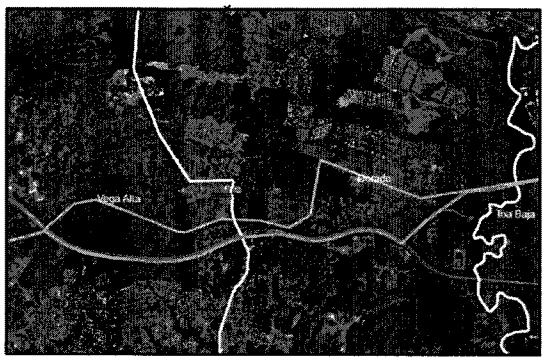
4.5.2.1.12. Variation at Miraderos de Sabana Walk-ups and the Sabana Ward, Guaynabo



Initially, the alignment affected the Sabana Sector and the Miraderos de Sabana Walk-ups. These would be within 150 feet of this alignment. By incorporating this variation we were able to keep the Walk-ups more than 200 feet away and the Sabana Sector residences more than 250 feet away.

4.5.2.2. Variations to minimize the project's economic impacts

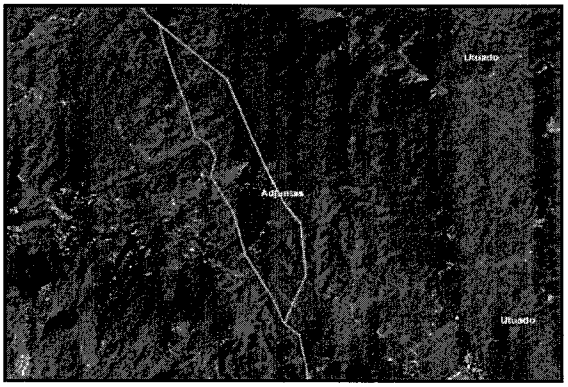
4.5.2.2.1. Variation at PR-22, in the Municipalities of Vega Alta and Dorado



Initially, the alignment impacted 5 miles of private lands in the municipalities of Vega Alta and Dorado, which would represent a high cost in the acquisition of the right of way for this alignment. By incorporating this variation, we were able to use the Highways Authority right of way in PR-22, resulting in substantial savings in the project's cost.

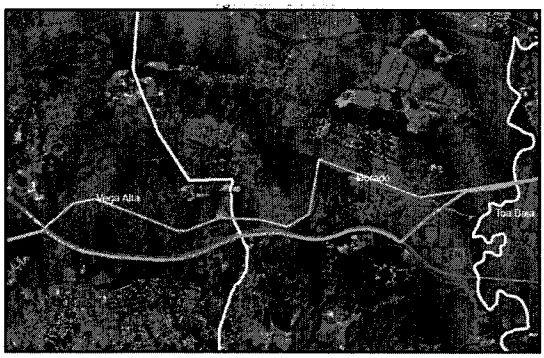
4.5.2.3. Variations to minimize environmental impacts

4.5.2.3.1. Variation in Bosque del Pueblo, Adjuntas



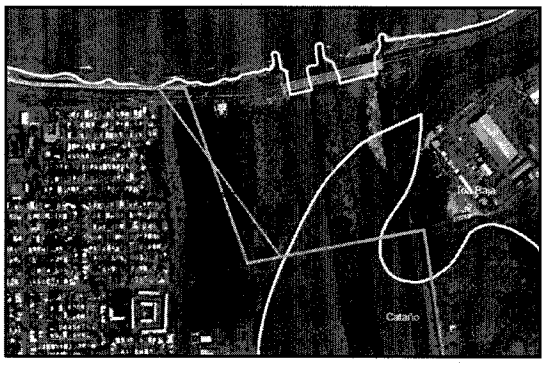
Initially, the alignment crossed a small area of Bosque del Pueblo in the Municipality of Adjuntas. To avoid this impact the alignment was located farther to the west.

4.5.2.3.2. Variation in PR-22 in the Municipalities of Vega Alta and Dorado



Initially, the alignment impacted the north portion of the La Vega forest in the Municipalities of Vega Alta and Dorado. By incorporating this variation the impact to this resource was diminished by 30%.

4.5.2.3.3. Variation at La Candelaria Shrine, Toa Baja



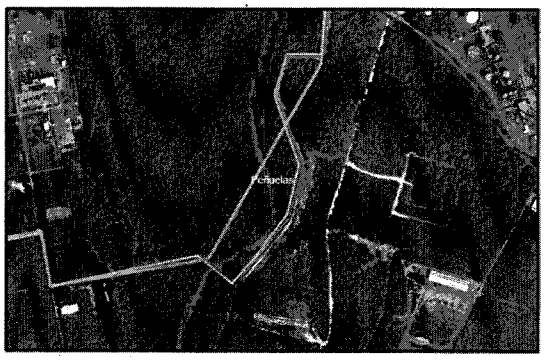
Initially, the alignment impacted the structure of historic value directly. By incorporating this variation we were able to move the alignment out of this area and thus avoid the impact.

4.5.2.4. Variations due to construction reasons

4.5.2.4.1. Variation at the EcoEléctrica Canal, Peñuelas

Initially, the alignment crossed the discharge canal at a 90° angle. To use the HDD method, it was decided to reduce this angle because 90° angles are not recommended for this method.

4.5.2.4.2. Variation at the Tallaboa River, Peñuelas



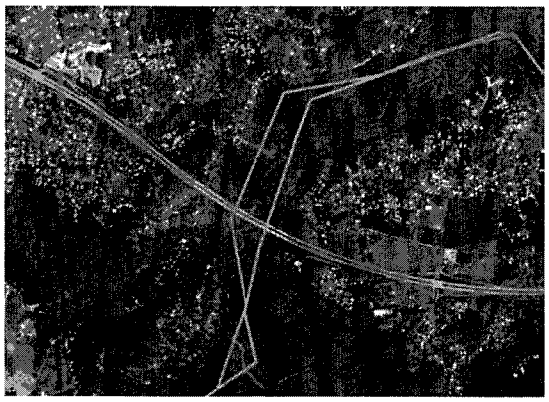
Initially, the alignment crossed the Tallaboa River in two sections at a 90° angle. To use the HDD method, it was decided to reduce this angle because 90° angles are not recommended for this method.

4.5.3. Changes to the Proposed Alignment

After collecting the comments of the diverse agencies and the general public to the DIA-P Draft, the changes to the proposed alignment were incorporated to address said comments and recommendations. These changes respond to various reasons, among which there are: environmental considerations, keeping it away from existing communities and future developments. Other changes respond to construction reasons.

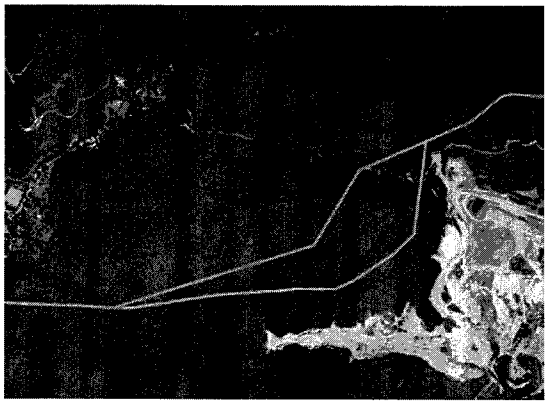
4.5.3.4. Changes for environmental considerations

To address recommendations from the UPR, and to move away from the historical archaeological area of the shrine in the Municipality of Toa Baja.

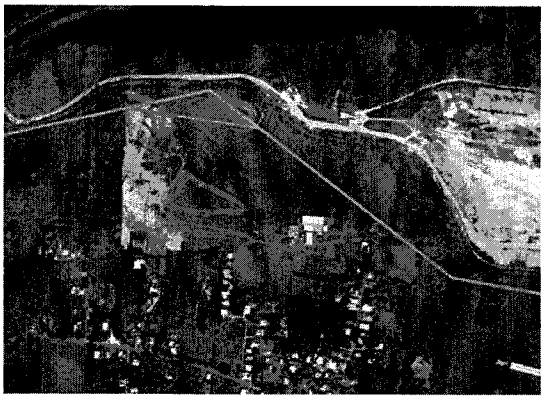


With this change the number of times the alignment crosses the El Indio River in the Municipality of Vega Baja is reduced.

To avoid impacting mangrove areas in the Punta Salinas sector of the Municipality of Toa Baja.

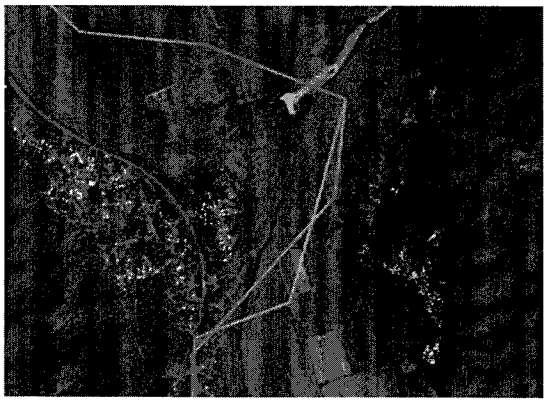


To move away from the area of the industrial landfill located in the Municipality of Peñuelas.



To move away from the lagoon of lixiviates on the municipal landfill in the Municipality of Arecibo.

To facilitate the crossing of the Arecibo River at the height of the Municipality of Utuado using the HDD technique so as to avoid impacting this body of water.



To facilitate the crossing of the Arecibo River at the height of the Municipality of Arecibo using the HDD technique so as to avoid impacting this body of water.

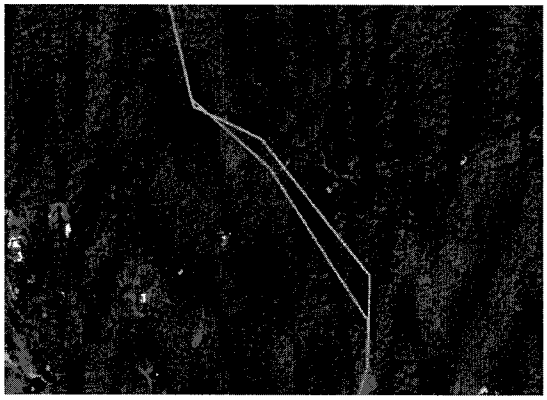
4.5.3.5. Changes to keep the alignment away from communities and future projects

In the vicinity of Urbanización Levittown in the Municipality of Toa Baja, the alignment will be at a depth of 60 feet and the HDD technique will be used to cross the area which will prevent the impact associated with open trench excavations.

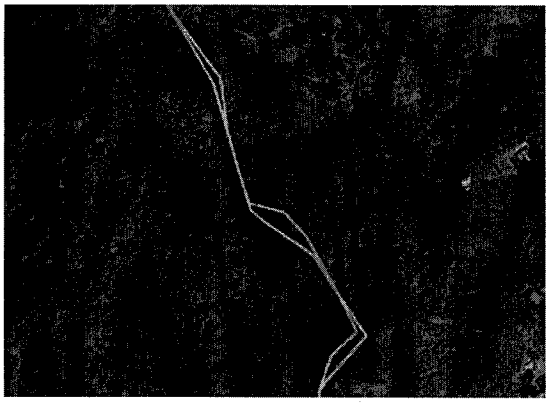
To move away from a future development in the Municipality of Vega Baja that already has approved permits from the Planning Board.

4.5.3.6. Changes for construction reasons

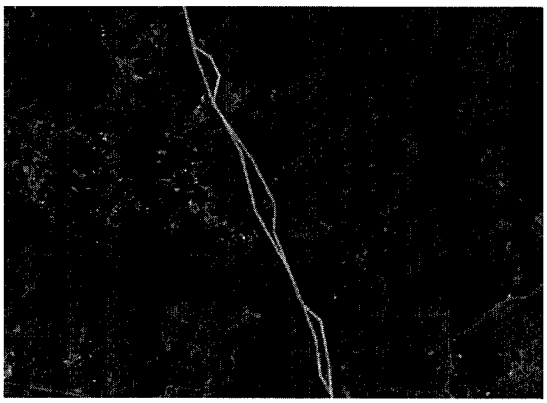
The following changes to the alignment respond to construction factors due to the steepness of the topography in the center of the island in the mountainous area or to difficulties in the use of the HDD technology.



Municipality of Peñuelas



Municipality of Peñuelas



Municipality of Adjuntas

Municipality of Utuado

Municipality of Arecibo

6. IMPACTS

The impacts of this project may be direct, indirect or cumulative. Next we evaluate these impacts on the different resources that could be affected by the project. The cumulative impact will only be analyzed for those sensitive or critical resources. The cumulative impact could result from the combination of different effects the project could have on the same ecosystem or from the combination of different projects in the same space and time frame.[1] Thus, the absence of other projects (past, concurrent or future) is not the only source of cumulative impacts that could result from the implementation of Vía Verde.

The construction of Vía Verde will have impacts on the environment. The project is a lineal excavation that covers 92 miles and affects some 1,191.3 acres of land, most of these temporarily.

During the studies phase we tried as much as possible to avoid areas of ecological value, and to avoid significant impacts. For this we consulted with the regulatory agencies to receive their recommendations before the proposed alignment was determined.

In cases where the impact is unavoidable, the impact will be analyzed and measures designed to minimize the negative effects that could develop will be established. The impacts, although they may have been minimized, will be mitigated, in accordance with the recommendations of the experts that participated in the project's study phase and in coordination with the regulatory agencies. In other cases, and due to the project's nature, the impact cannot be avoided or minimized. In those cases the magnitude of mitigation will be greater and will require a more sophisticated design.

Next we will discuss the project's impacts and the measures that will be implemented to avoid, minimize and mitigate the same.

6.1. Avoided Impacts

6.1.1. Communities

One of the criteria with more weight in the planning of the project was minimizing the number of residences in the vicinity of the alignment. During the planning phase we found that the alignment selected initially in the study of alternatives was close to certain communities. For that reason it was determined to establish a right of way in such a manner that communities would not be affected within a distance of 150 feet

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1 Consideration of Cumulative Impacts in EPA Review of NEPA Documents, U.S. Environmental Protection Agency, Office of Federal Activities (2252A), EPA 315-R-99-002/May 1999.

from the alignment. Among the communities that were avoided are: Seboruco in Peñuelas, Jardines de Mónaco and Sector La Grúa in Manatí, Sector Bethel and El Indio in Vega Baja, Mameyal Playa Community in Toa Baja, Urbanización Villa Aurora and Puente Blanco Community in Cataño, Miraderos de Sabana Walk Ups and Sector Sabana in Guaynabo.

6.1.2. Areas of Ecological Value

The impact to Bosque del Pueblo Reserve and several parcels dedicated to perpetual conservation in Adjuntas was avoided due to their high ecological value.

6.1.3. Bodies of Water, Mangroves and Woody Wetlands

The impact to several canals, rivers and all the mangroves and woody wetlands was avoided through the use of the dry crossing technology known as Horizontal Direct Drilling (HDD). Among these bodies of water that will be crossed with HDD are: two canals, one forested wetland and the Tallaboa River in Peñuelas; three canals, one herbaceous palustrine wetland and Río Grande de Arecibo in Utuado; one flood control project, four canals, Río Grande de Arecibo and the Tanamá river in Arecibo; three canals and the Río Grande de Manatí in Manatí; Río Indio in Vega Alta; two wetlands (estuarine forested and palustrine forested), one flood control project, La Plata River and Cocal River in Toa Baja; two canals, two estuarine forested wetlands and the Cocal River in Dorado; one flood control project, two canals and the Bayamón River in Cataño.

6.1.4. Structures of Cultural Value

Direct impact to the La Candelaria Shrine in Toa Baja was avoided.

6.1.5. Infrastructure

The highways and roads in the following table will be crossed with the boring technique to avoid impact on the infrastructure an on traffic.

Carretera	MP Entrada	MP Salida
PR-127	3.09	3.11
Camino sin Nombre	3.34	3.36
PR-2	3.68	3.72
PR-385	3.92	3.94
PR-132	8.25	8.27
PR-520	9.53	9.55
PR-391	10.50	10.52
PR-391	11.11	11.13
PR-123	15.66	15.68

Carretera	MP Entrada	MP Salida
Carretera Portugués	15.89	15.91
PR-143	16.41	15.91
Carretera Valdes	17.52	17.53
Camino sin Nombre	19.36	19.38
PR-524	20.76	20.78
Camino sin Nombre	22.72	22.74
Camino sin Nombre	22.99	23.01
Camino sin Nombre	23.49	23.51
PR-10	25.35	25.37
PR-111	25.84	25.86
PR-10	27.25	27.27
PR-123	29.80	29.82
PR-10	30.09	30.11
PR-621	30.59	30.61
Camino sin Nombre	34.69	34.71
Camino sin Nombre	35.86	35.88
PR-22	40.93	40.97
PR-2	42.18	42.22
Camino sin Nombre	47.05	47.07
PR-681	53.09	53.11
PR-616	54.96	54.98
PR-616	55.45	55.47
PR-22	55.65	56.62
PR-2	57.32	57.36
PR-149	59.26	59.28
PR-672	62.67	62.69
PR-137	64.76	64.77
Calle Mario López	66.11	66.13
Calle Rogue Cancel	66.21	66.23
PR-674	67.12	67.14
PR-22	68.24	68.28
PR-160	69.18	69.19
PR-676	71.02	71.04
PR-22	71.20	71.24
PR-690	71.69	71.70
PR-2	71.80	71.82
Elevados	74.21	74.23
PR-694/Rampas	74.68	74.72
PR-6659	75.92	75.94
PR-22/Superacueducto	76.15	76.21
PR-694	76.77	76.78

Carretera	MP Entrada	MP Salida
PR-693	77.07	77.09
PR-854	77.72	77.73
PR-165	78.39	78.41
PR-867	79.35	79.37
Boulevard de Levittown	83.10	83.11
PR-165	84.92	84.94
PR-22	87.34	87.38
PR-22	88.88	88.93
PR-24	90.18	90.22
PR-165	90.33	90.38

6.1.6. Future Projects

Proposed projects with consultations approved by the Planning Board were identified, according to that same agency's database. The original alignment impacted two of these projects (a commercial project in Vega Alta-Dorado and a residential project in Vega Baja). Said alignment was modified to avoid the same.

6.2. Impacts by Deforestation

One of the project's first impacts will be reflected in the vegetation due to the clearing and leveling of the right-of-way phase. A 100 feet wide construction area will be needed. In crossings of bodies of water and highways the right-of-way could be from 100 to 300 feet wide. It is estimated that 1,191.3 acres of land will be impacted, most of them (approximately 66%) temporarily. With the exception of protected species or habitat of interest for conservation, all the trees and vegetation in this area will be removed. This impact is not avoidable due to the project's construction specifications. Vegetation in wetland areas that is impacted with open trenches will be allowed to be restored in natural form or by mitigation in a proportion of 3:1, as required. In agricultural areas, planting of crops that don't have deep roots will be permitted. In the rest of the project reforestation will be allowed to take place in natural form or through mitigation plans coordinated with the Department of Natural and Environmental Resources (DRNA), except for the growth of trees with deep roots within the 50-foot operation right-of-way (25 feet on each side of the pipeline, whenever possible). The mitigation plans required by DRNA include reforestation in a 3:1 proportion of the trees removed.

To determine the impact of Vía Verde on areas covered by arborescent vegetation, we took the following in consideration:

- Nearly 21% of the route will traverse through highway rights-of-way (i.e.: Highways PR-10 and PR-22) and places impacted by previous activities

(i.e.: CAPECO right-of-way in Guaynabo and Union Carbide in Peñuelas);

- Two point three percent (2.3%) of the route is on woody wetlands that will not be impacted because the HDD method will be used (that is, a curved subterranean perforation well below the root systems);
- Four percent (4%) of the alignment runs through land populated by bushes (mainly leucaena, sp) of early ecological succession; and
- Fifty-three percent (53%) of the proposed alignment will run through flat land, floodplains and agricultural lands free of arborescent vegetation.

This leaves us with a total of 20% of the proposed alignment (that is 20% of 92 miles = 18 miles) that is covered with arborescent vegetation. To obtain the amount in *cuerdas* (a unit of land area of approximately 3,930 square meters or 0.971 acres) of the area that will be impacted, we multiply 18 miles times 30 meters wide (temporary construction right-of-way) which makes a total of 221 *cuerdas*. If we take in consideration that of the 30 meters of construction right-of-way, 15 meters will be reforested, we can conclude that half of the impact on areas of arborescent vegetation will be temporary and that the permanent impact will be on some 110.5 *cuerdas*. Said impact will be compensated at a ratio of three to one through the acquisition of land, reforestation of public areas or any combination of measures the DRNA deems necessary.

Finally, we propose to reforest the construction right-of-way temporarily impacted with native species that provide habitat to the fauna species of the impacted region. The Péndula (*Cytharexylum fructicosulum*) and the Úcar (*Bucida buceras*) are examples of species that provide food to wildlife (birds) and that will be taken in consideration in the planting and reforestation plan that will be made even though the AEE is exempt from compliance with Planning Regulation No. 25 (Puerto Rico Tree Cutting, Pruning and Forestation Regulation) in its rights-of-way.

The measures that will be taken to minimize the loss of vegetation are discussed below:

- The construction area will be clearly defined to avoid damage in other zones.

- Inasmuch as possible, the land will be restored to its original state. Although the AEE will acquire a 150 foot wide right-of-way, it will only keep free of deep roots a width of 50 feet (operation right-of-way).

- The AEE, in coordination with the regulatory agencies, will try to avoid the loss of species of ecological value. However, if such loss is unavoidable, a mitigation plan will be designed for those cases in which it is not possible to replant in the operation right-of-way.

- Areas near the project's site will be reforested in a proportion of 3:1 per affected individual. This will be done in coordination with the concerned agencies and in strict compliance with the applicable regulations. In terms of its location, the

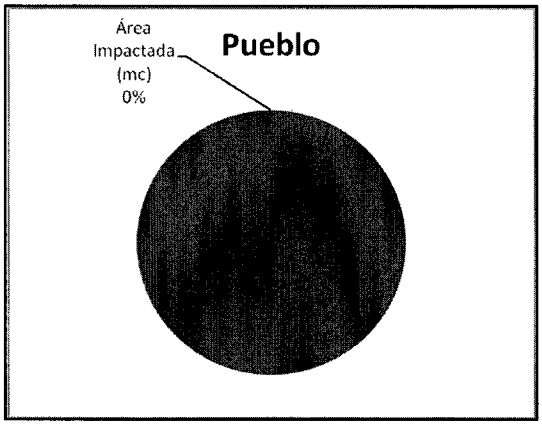
mitigation will be of two kinds: *in situ* and by acquisition of land, preferably contiguous and of equal or similar ecological value to the impacted site. In like manner, in terms of its type, the mitigation will be made in kind or with different species that bring about an improvement of the ecosystem, for example, using trees that provide more food for birds, which will be selected in coordination with the DRNA.

6.2.1. Forests

Puerto Rico has several forests, some of which are near the project. The original alignment selected crossed through three forests: Bosque del Pueblo, Bosque Río Abajo and Bosque Vega.

To avoid causing an impact on these forests, the design of the alignment was varied in such a manner that:

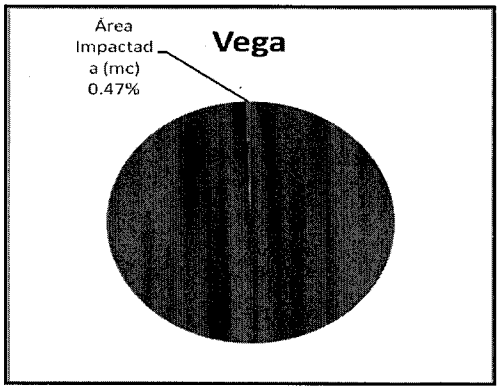
- Bosque del Pueblo was totally avoided by moving the original alignment further to the west and away from it. The total area of this forest is 1.61 square miles (4,169,880 square meters).



- Bosque Río Abajo will not be impacted because Vía Verde will use the existing and already impacted right-of-way of PR-10 in that zone. The total area of this forest is 8.90 square miles (25,050,900 square meters). This forest was fragmented by the construction of PR-10. Vía Verde uses 8.4 miles (13.52 kilometers) of this highway's right-of-way, it avoids further fragmentation of the forest, and does not add to the impacts such as mortality of organisms, the movement of species and the introduction of invasive species.

- Bosque Vega is the only forest that will receive a direct impact with this project. This reserve is fragmented in six portions. Vía Verde will impact one of them. However, the impact will be minimal. The total area of this

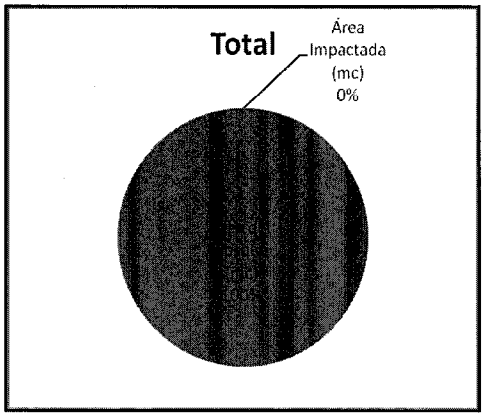
forest is 1.85 square miles (4,791,480 square meters). The portion that will be impacted is 0.46 square miles (1,191,390 square meters). Of these, only 0.0086 square miles (22,274 square meters) will be impacted. These 0.0086 square miles (22,274 square meters) correspond to a length of 0.43 miles (0.69 kilometers) of pipeline that lie in the forest, times the 100 feet width (30.5 meters) of the construction area. This constitutes only 0.47% of the forest that will be impacted temporarily. Of the 100 feet (30.5 meters) of the construction area, 50 feet (15.25 meters) will be reforested, and only 50 (15.25 meters) will be maintained as an operation right-of-way, for which reason the permanent impact is even less and it corresponds to 0.0043 square miles (11,137 square meters) or 0.235%. According to the study titled: *Incorporating Biodiversity Considerations Into Environmental Impact Analysis Under the National Environmental Policy Act*[2], minimizing fragmentation is an important factor in promoting biodiversity. Large areas are better in promoting biodiversity than small areas and connected portions are better than isolated portions. Vega Forest is fragmented into six small portions, of which one will be impacted by Vía Verde. To mitigate that impact on one of these portions, the AEE proposes acquiring land contiguous to some of the portions to connect two isolated portions. This reduces the genetic isolation of the individual species, promotes the natural flow of species, energy, water and nutrients critical to the survival of the ecosystem and improves its ability to tolerate changes. The growth of trees native to this area will be promoted or it will be reforested with arboreal species that improve the ecosystem by providing better sources of food. These land will be dedicated to conservation. This whole process will be conducted in coordination with the DRNA.



- The total area of forests near the project is 12.36 square miles. The total area to be impacted by the project is 0.0086 square miles, or 0.07%. This

[2] Published by the Council on Environmental Quality, 1993.

percentage is graphically imperceptible.



6.3 Impact on Wetlands and Mangroves

Of the 1,191.3 total acres (4,821,070 square meters the project will occupy, 1,494, 416.65 square meters or 369.3 acres of wetlands were identified and delimited over which the U.S. Army Corps of Engineers has jurisdiction. (See Section 3.5.4 of this document). This means that 33% of the alignment will cross over wetland areas. The greater portion of these wetlands is located in the north segment of the alignment, from Arecibo to Guaynabo.

The Project's route in Caño Tiburones will traverse areas of herbaceous wetland, which have been significantly impacted in the past. Herbaceous species predominate in this wetland, identified as invasive species undesired by the federal agencies (for example, *Typha domingensis*). The gas pipeline installation method in these areas will permit that, once the installation is completed, the vegetation that existed before the construction will be substituted by desired species.

The project crosses on the north and northwest side of San Pedro Marsh (Municipality of Toa Baja), where it is associated with the mouth of the Cocal River. In this section the gas pipeline will be installed beneath the root zone of the mangrove trees found in the north of it. The herbaceous areas of this marsh which could be affected by the pipeline construction, are (or have recently been) used for commercial lawn planting.

The project crosses outside the Natural Reserve of the Las Cucharillas Marsh. There will be no filling over the wetlands. The 50 feet wide operation right-of-way allows for the colonization and development of herbaceous and arbustive species, although not of trees, for which reason it is expected that the vegetation adjacent to the operation right-of-way will recolonize this strip after the Project's construction phase. As proposed, the Project will not include the removal of trees in the wetlands. On the occasions in which the rout runs in arboreal wetland areas, the installation of the gas pipeline will be made under the root zone of the trees, using an HDD system. In this manner, once the gas

pipeline is installed, the topographic contours will be returned to conditions that existed before the construction to avoid affecting the hydrology and the natural nutrient movement cycles or patterns.

In the case of wetlands the impact is temporary, during the installation of the pipeline that transports natural gas. As proposed, the Project does not entail permanent impact in the wetlands, so it is not related to cumulative impacts that result from other actions.

The pipeline's installation in the forested areas of Punta Salinas will be made mostly with HDD, which crosses under the trees' root zones. In the other forested areas, which are not in wetlands, where the installation of the pipeline will not be by HDD, the open trench method will be used. The mitigation plan for the Project's impacts will include the necessary measures to compensate for the loss of forest.

It is important to state that the impact on the wetlands will have a temporary effect only during the construction process, because immediately after the pipeline has been installed, the original conditions will be restored. No permanent impact is expected that will be detrimental to the wetlands. Because the nature of wetlands is complex, it is necessary to establish first the subject of the impact, which can be the vegetation, the hydrology, or the soil of the wetland, or the group of species developing in it. The following discussion is in regard to the possible impact to the hydrology of the wetlands due to the installation of the 24-inch diameter pipeline and the anchoring structures necessary to prevent flotation. Wetlands are nourished mainly from direct rainfall, from surface runoff and from the underlying underground water.

Direct rainfall, although it is easy to quantify with the help of a pluviometer, is generally the lesser contributor to the wetland in relation to the water runoff and the subterranean contribution. The amount of water feeding the wetland from the surface runoff and the underground water is a function of the rainfall and the catchment area. Most of the wetlands receive the surface runoff in the form of laminar surface water flow, emerging water courses, man-made ditches, ravines and rivers. The rainfall percolating underground maintains the hydraulic gradient of the underground water that determines the wetland. It is important to mention that wetlands lose water in quantities similar to the direct rainfall, as its area exposed to sunlight is on the one hand, and by plant transpiration on the other. In relation to direct rainfall, the project does not interfere with rain falling on the wetland, all the areas are exposed to rainfall without alteration of the natural condition. The surface runoff will not be impacted either by the installation of the pipeline. Almost all the project is underground, so there will not be any structures on the terrestrial surface that will have the potential to interfere with the surface runoff. Therefore, the inflow of water to the wetlands from surface runoff will not suffer alterations detrimental to the wetlands' hydrology. Although minimally, the flow of underground water feeding the wetlands could be affected by the installation of the pipeline. Appropriate mitigation measures are envisioned for this possibility.

The project's impact on the wetlands area will be reflected in soil disturbances, which

will increase water turbidity, there will be temporary loss of vegetation, and impact to migratory and resident species.

The aquatic species will be impacted by the increase in water turbidity, which diminishes the amount of dissolved oxygen. Although the species can move to other areas of the wetland, it is presumed that there will be some mortality in the excavation area, an impact that is not considered significative. The migratory bird species will be temporarily impacted because the noise of the machinery and the activity of the workmen will keep them away from the area of the project, but they will be able to move to very broad neighboring areas (such as Caño Tiburones and forested land on 41% of the island) and use other areas for rest, food and mating.

On the other hand, the use of motor vehicles could impact the wetland if there are spills of oil or other liquids.

The following measures will be taken to minimize impacts on the wetland:

- Clearing the right-of-way will require the removal of the vegetable cover (including trees) throughout the length of the area at a width of 100 feet. This vegetation will be removed from the area to prevent accumulation and putrefaction. It will be disposed of as non-hazardous solid waste.

- The right-of-way will be demarcated to restrict the removal of vegetation and avoid impact to the wetland outside of this area.

- Erosion and sedimentation control measures will be placed to avoid or minimize entrainment of sediment to other areas of the wetland.

- Vehicles leaking of oil or other liquids that could pollute the wetland will not be permitted. If any spills were to occur during the construction, spill kits will be used to clean the material and the equipment will be removed from the work area.

- Special techniques for construction in wetlands will be used (see Project Description, Construction in Wetlands and Mangroves)

To mitigate the impacts where it is not possible to minimize,

- The AEE proposes to mitigate for the loss of vegetation on site after conducting the hydrostatic test.

- A Mitigation Plan will be prepared and the recommendations of the concerned agencies will be followed.

6.3.1. Forested Wetlands (Mangroves)

The construction area for the project is 100 feet wide. An area 200 feet wide was covered for the flora and fauna studies. Within these 200 feet, an throughout the 92 miles of the alignment, four mangrove areas were found, two in Peñuelas, one in Toa Baja and another one in Guaynabo. Mangrove areas are important to prevent coastline erosion (the protection depends on the tree density), as habitat, nesting sites, recycling nutrients and food for marine organisms. They also filter water and maintain the quality and clarity of the same. Neither the alignment, nor the construction area will impact on this resource because measures have been taken to avoid it. To those effects the alignment was varied in the four mangrove areas so it would not run over the same.

6.4. Impacts Caused by Soil Movement

The movement of soil for the construction of the project is approximately 1,181,966 cubic meters. The major impact of activities that involve deforestation and soil movement is soil erosion and the subsequent sedimentation in the bodies of water. The soil that reaches the bodies of water can degrade water quality by an increase in turbidity, entrainment of pollutants and reduction of the amount of dissolved oxygen, which can interfere with the respiration of aquatic organisms. To minimize this impact incidental to the impact caused by deforestation and removal of the vegetable cover, the AEE will establish an Erosion and Sedimentation Control Plan (CES Plan) and a Stormwater Pollution Prevention Plan (SWPPP), in compliance with the regulations the Environmental Quality Board (JCA) and the EPA have promulgated to those effects. (See Section 6.1.2). The CES Plan is an indispensable requirement for the General Consolidated Permit that will be obtained for the construction of Vía Verde, once we have the certification of compliance with Article 4.B.3. of the Environmental Public Policy Act, Law No. 416 of September 22, 2004 (Law 416).

The movement of soil also generates emissions of fugitive dust that reduce visibility in the atmosphere, transports pollutants and could exacerbate respiratory conditions in susceptible persons. To those effects the AEE will adopt adequate controls to control fugitive dust in compliance with the regulation the Environmental Quality Board (JCA) promulgated to those effects. (See Section 6.1.1). These controls are indispensable requirements for the General Consolidated Permit that will be obtained for the construction of Vía Verde, once we have the certification of compliance with Article 4.B.3. of the Environmental Public Policy Act, Law No. 416 of September 22, 2004 (Law 416).

Although the necessary measures for the control of fugitive dust will be established, there may be a cumulative impact, because it is impossible to eliminate the emissions completely. In certain areas of the project there may be constructions that coincide with the construction of Vía Verde and contribute to increase fugitive dust in the air.

In agricultural areas the movement of soil can cause adverse impacts on agriculture, if there is poor management of the nutrient-rich top soil. There is also soil compaction

due to the traffic of heavy machinery, which could reduce the soil's absorption capacity.

The removal of vegetation increases the potential for the introduction and establishment of invasive species and reduces the habitat available to fauna.

Next we discuss the general measures that will be taken to minimize the impacts of soil movement. The specific measures will be presented with the request of the General Consolidated Permit.

6.4.1. Fugitive dust emissions

The construction of Vía Verde will cause the emission of fugitive dust in all the stages of the project: clearing and leveling of the right-of-way, excavation of trenches and restoration. There will also be emissions during the preparation and operation of the project's Operations Center and the additional work areas. In addition, there could be emissions due to the transport of surplus soil to the landfills.

The following measures will be established to minimize these impacts:

- We will request a construction permit for source of fugitive dust from the Environmental Quality Board.

- We will file a Notice of Intent before the Federal Environmental Protection Agency and we will prepare a Stormwater Pollution Prevention Plan (SWPPP). This SWPPP will be prepared using the EPA guide, Developing a Stormwater Pollution Prevention Plan: A guide for Construction Operators and the accompanying template. This Plan includes the following sections: Site Evaluation and Planning, Best Management Practices to control erosion and sediments, Best Management Practices to control refuse, Best Management Practices for post-construction controls, Inspections, Registration and Record Keeping, Training and Final Stabilization.

- Water sprinkler trucks will be used to sprinkle the construction areas. This includes the right-of-way, soil mounds and Operations Center. This way the soil is kept moist and the amount of fugitive dust dispersed is minimized.

- It will be required that haul trucks use covers to avoid the emission of fugitive dust during the transport of material over the roadways. The covers will be in good conditions and they will be appropriately secured to avoid their coming loose and being moved from their place by the wind.

The following measures will be taken to minimize the impact that soil erosion and sedimentation will have on bodies of water:

- An erosion and Sedimentation Control Plan (CES Plan) will be prepared and filed with the Environmental Quality Board for approval. This Plan will identify the drainage patterns and the areas where control measures such as hay bales and filtering mesh will be installed.

- A Notice of Intent will be filed before the Federal Environmental Protection Agency and a Stormwater Pollution Prevention Plan will be prepared. This Plan will be prepared using the EPA guide, Developing a Stormwater Pollution Prevention Plan: A Guide for Construction Operators and the accompanying template. This Plan includes the following sections: Site Evaluation and Planning, Best Management Practices for erosion and sediment control, (slope stabilization, sediment traps, rip-rap, geotextile mesh fabric, curbs and gutters, velocity dissipation devises); Best Management Practices for post-construction controls; Inspections; Registration and Record Keeping; Training and Final Stabilization.

- The AEE will file a written notice of commencement of activities with the JCA. This notification will be made no later than the fifth (5) working day following the commencement of any activity contemplated in the CES Plan.

- The AEE will file with the JCA progress reports of the implementation of the CES Plan and the development of its activities. The progress reports will be submitted to the Environmental Quality Board monthly, starting with the commencement of the implementation of the CES Plan. Said reports will be prepared and certified by an inspector in accordance with the Regulations for the Certification of Drawings and Documents before the Environmental Quality Board. The Environmental Quality Board may require the filing of reports in different periods than those specified, if they deem it necessary in their judgment.

The Erosion and Sedimentation Control Plan

- The construction right-of-way will be delimited to avoid impact to other areas.

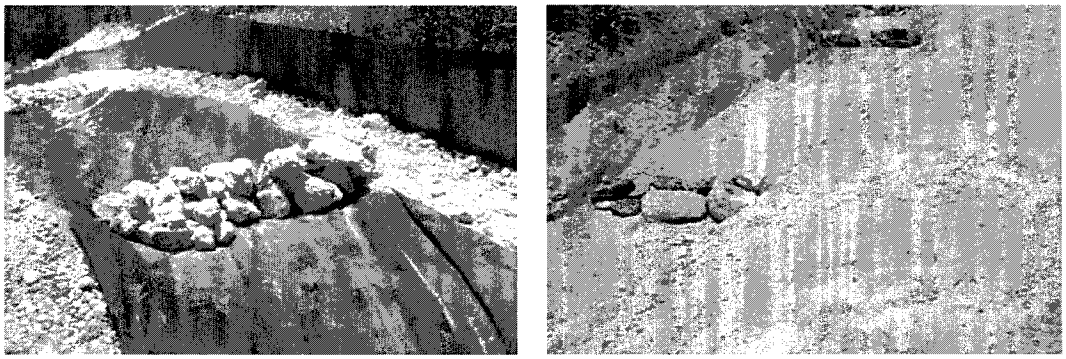
- The bodies of water that could be affected by the construction will be identified to protect them.

- Drainage patterns to the body of water will be identified.

- Slope stabilization (terraces) to reduce the velocity of runoff water and minimize erosion. Geotextile fabric will be installed to prevent erosion by rain or wind.

Terraces and geotextile

- Velocity dissipation devices will be installed to help minimize the erosion. These structures are constructed with gravel, rocks, sandbags, treated lumber or hay bales.



Velocity dissipation devices

- Protective blankets made of straw, jute, wood or other plant fibers will be used. This control method is used in areas with a high potential for erosion, such as steep slopes and canals, to protect the soil from the impact of rain and erosive runoffs while facilitating the growth of vegetation.

- The soil mounds accumulated when clearing the right-of-way will be covered with geotextile and a silt fence and hay bales will be placed around them. This material will be stored adjacent to the trenches and, as soon as the pipeline is laid, it will be reused to fill the same. The remainder will be carried to an authorized landfill.

- Longitudinal and transversal furrows and velocity dissipation devices will be constructed to redirect the water and reduce its velocity in mountainous areas.

Longitudinal/transversal furrows and velocity dissipation devices

- Rip rap of large boulders will be installed to protect the soil from erosion in areas of greater runoffs.

- Sediment traps will be installed at runoff discharge points in the construction area. To construct the trap a catchment area will be prepared and rocks of different sizes will be placed in it to control the runoff discharge.

Sediment Trap

- Geotextile will be installed as a separator between the soil and the rip raps to maintain a solid base.

- The vegetable cover removed during the right-of-way clearing and leveling stage will be mechanically shredded and reused as wood chips for erosion control in slopes, as allowed by Law 70 of September 18, 1992, Puerto Rico Solid Wastes Reduction and Recycling Act, as amended. The machinery to be used for shredding is a Morbark wood grinder and it will be placed near the work areas in the construction right-of-way. The shredded material will be stored at the work site and it will be covered with tarpaulin and hay bales will be placed around the mound to prevent it from dispersing in case of rain or wind. It will be used in near the areas where it was shredded to implement erosion control, together with other measures.

- A silt fence will be installed together with rectangular hay bales in the perimeter of the right-of-way to contain the entrainment of sediments.

- Tire washing stations will be constructed to avoid the transport of sediments to the public roadways.

Tire washing station

- Entries to Operation Centers will be stabilized.

- Hay bales will be used to protect storm drains, where applicable.

- An Inspection Program will be established to insure that the measures that are installed are functioning adequately. Deteriorated measures will be replaced or reconditioned. Inspections will be made weekly and after rain events.

With the implementation of all these measures and others, which are identified as necessary by the project's Environmental Coordinator at the moment of construction, it is estimated that the impact to bodies of water will be minimal.

6.5. Impact on the Karst Zone and other Geologically Vulnerable Zones

Although efforts were made to avoid crossing through the Karst zone, where you find sinkholes or caves in porous rock or soils eroded by water, a small part of the project will cross through some portions of said zone. The protected Karst zone in Puerto Rico is some 151 square miles according to the shapefile of this resource for the ArcGIS ArcMap 9.2 software program, of the Department of Natural Resources (August, 2010). Of these total of square miles, Vía Verde will cross through some 0.08 square miles. This is equivalent to a construction area 100 feet wide, along a swathe 3.91 miles long in the Karst zone. In percentage terms, Vía Verde will cross through 0.05% of the Karst zone protected in Puerto Rico.

The Karst zone is a habitat for unique plant and animal species, so all possible measures will be taken to avoid impact to protected species and in the case of non-

protected species there will be mitigation. To ensure that no protected species is disturbed, there will be a biologist in the project at all times during construction in the Karst zone. This biologist will carefully evaluate the area before the introduction of personnel or construction equipment in the same and will adopt measures to avoid and minimize impacts on the Karst physiography, such as the relocation of species, realignment of the pipeline and drilling through the mogotes, instead of making a cut across them.

The construction process will be carried out so that only light, Bobcat-type equipment enter the Karst zone to minimize the possibilities of damage to the same. Erosion and sedimentation controls adequate to the area will be established to protect the surrounding areas and prevent the sediment from reaching underground water. This Plan will be filed at the moment of requesting the Consolidated General Permit and it will comply with what is set forth in Section 6.1.2. The operation centers or auxiliary construction spaces will be located outside of the Karst zone and the installation of the pipeline will be made using the pulling method to minimize the presence of heavy equipment in the zone. The backfill material will be adequate to permit the soil's hydraulic capacity, since the same material removed will be used to refill the trenches. In case additional material is required, the same will be selected in accordance with the geotechnical studies of the area. These studies will be completed before finalizing the design of the project. Vegetation will be planted in the area surrounding the 50-foot operation right-of-way. Said vegetation will consist of native grasses and trees and it will be made immediately after having covered the trenches in a 3:1 proportion.

During the operation phase, the project areas in the Karst zone will be inspected, as part of the pipeline patrolling program. Nevertheless, special attention will also be given to the soil conditions so that any erosion that can be observed or detected is corrected. In addition, through the observance of the previously mentioned control measures, no deterioration to the mogotes will be caused, so the hydraulic function of the Karst zone will not be affected.

Vía Verde will traverse through geologically vulnerable areas with geologic limitations. According to the geologic information that has been evaluated for the project these geologic limitations do not represent major challenges or problems to the project. This is so because the same can be addressed during the design and construction stages.

To be able to address the geologic limitations, what is most important is to identify them, evaluate their location with regard to the project and know their characteristics. This is the essential information for planning the project, because it determines the subsequent studies that must be carried out before completing the design and during the construction. The geological limitations can be addressed in two ways at the design stage: either they are avoided by realigning the pipeline in those sections that could be impacted by some geologic condition or process, or engineering measures are provided to minimize or eliminate the geologic risk. Once these risks have been addressed during the design stage and the construction stage has commenced, they are observed

and the geologic and geotechnical information is documented. This has a double purpose: confirming that the conditions of the subsoil coincide with those on which the design was based, particularly in sections that require engineering controls, and it facilitates a rapid response to any finding of unfavorable conditions of the subsoil during this stage.

The geologic limitations that are being evaluated, and which were commented during the Public hearings at the JCA are:

1. Slide-prone soils[3]; several sections, which include the Cordillera Central, run through terrain whose geology and topography make them susceptible to slides.

2. Sinkholes - two sections of the alignment cross parts of Puerto Rico's Northern Karst Zone.

3. Liquefaction - a section in the south coast and one in the north cross through young soils (in geologic terms) which are saturated by the watertable. These include sandy soils of little compaction that are susceptible to liquefaction during a strong earthquake.

4. Geologic faults - the alignment crosses the Great Southwestern Puerto Rico Fault Zone.

5. Soft soils - along the section that runs south of Caño Tiburones and locally in alluvial valleys and costal plains of the route.

6. Erosion - The alignment crosses 10 named rivers and many secondary stream beds that are subject to erosion during rising waters. Likewise, the costal sections could be exposed to marine erosion, particularly considering the rise in the ocean level that started at the end of the last glacial period and which is compounded by global warming.

The potential impact of these limitations is variable and is described in the following paragraphs, together with a general discussion of available measures to minimize or eliminate its possible effects.

Slides

3

To the effects of this document, the term 'slide' refers to all downslope movements of masses of soil, rocks and/or a mixture of both. A variety of types of slides occur in Puerto Rico which are distinguished by the velocity of the movement and by the manner in which the affected terrain is displaced, for example: falls, rolls, flows or translational movements.

The presence of deep residual soils, highly fractured rocks and a multitude of moderate to severe slopes are favorable conditions for the occurrence of gravitational movements, for which reasons slides are ubiquitous throughout the Cordillera Central, since it is the principal agent of geomorphic evolution in the region. For this reason any construction project in this area must take in consideration, in a greater or lesser degree, the potential for slides.

The greatest danger slides present to Vía Verde is a break in the pipeline due to the supporting ground giving way, and sliding, flowing or collapsing downhill. Since the pipeline will be buried at a depth of 4 feet at the minimum, which protects it from material that could fall from above, the impact of a slide occurring at a higher elevation of the alignment would tend to be limited to the pipeline access and maintenance works. At the same time, the project does not require the construction of significative cuts and once completed, it does not create a condition of increase in the susceptibility to slides, except in the measure the trench could affect the infiltration of water into the subsoil, a situation that is addressed through its design and construction. In fact, the pipeline weights less than the soil it displaces, so that contrary to most construction works, it does not produce an increase of the loads on the subsoil.

Soon to commence is a study of photointerpretation and field recognition to evaluate the potential for slides along the route of Vía Verde. This entails the identification of old slides, some of which could continue to be active or could reactivate, and sections whose geology and topography indicate the potential of instability if the project proceeds without adequate controls. The study will cover the following sections: the crossing of Seboruco Hills, the ridges and hills of the piedmont south of the Cordillera, and the mountains of the Cordillera between Peñuelas and Utuado. Also to be evaluated are three short stretches where the alignment crosses one of the limestone cliffs that form the banks of the Grande de Arecibo and Manatí rivers and Río Indio in Vega Baja.

In case any stretches were to be found on old slides or in terrain with potential for instability, we will proceed to evaluate the options of realigning the route or implement engineering measures to stabilize the soil. One variant of the realignment is to deepen the line with Horizontal Directional Drilling (HDD) to cross beneath the unstable soil. There will be cases in which the final decision will require additional geological evaluations and detailed geotechnical studies, which would in turn provide the criteria to implement the HDD option or to design stabilization measures. Regarding the latter, they seek to improve the balance between the forces that resist the movement of a mass of soil and/or rock and the forces that induce it to move. There is extensive literature on the diverse techniques and structures to achieve this improvement, many of which have already been applied in Puerto Rico. The decision on realignment and the stabilization works to be used will depend on the geologic and geotechnical characteristics particular to each section of interest.

Sinkholes

The Geotechnical, Geological and Geophysical Engineering techniques allow us to study sinkholes in depth and in consequence to make recommendations, be it for highways or rights-of-way (AAA or AEE). In this manner it is possible to design these projects so that the flow into the sinkhole is never blocked. Therefore, the soil where the sinkhole is located is never compacted or covered, rather it is habilitated to continue receiving stormwater runoff.

Usually the term 'compact' is used as a synonym for refilling with processed allochtonous material, which in typical cutting and filling projects has relatively low permeabilities. The case at hand is not a typical cut and fill project. The sinkhole is habilitated with filters designed to permit the flow of water whenever the project requires it.

Techniques in geotechnical, geologic engineering and geophysics allow us to model the sinkholes in two and three dimensions. This permits us to evaluate and analyze the sediments naturally accumulated in the bottom of the sinkholes and the limestone rocks underlying the sinkhole, which are at the same time the walls of the sinkhole.

Studies made during the 80's, 90's and 2000 decades have contributed to our knowledge of the formation and the hydraulic mechanics of sinkholes. This includes the detection of cavities in the sediments and cavities in the limestone rocks.

Regarding the publication "Karst Formation in Puerto Rico, a Vital Resource", the three problems they mention (differential compaction, suffusion and cavity collapse) have been considered in projects already made in Puerto Rico during the past 30 years (i.e.: PR-10 between Arecibo and Utuado) and will be considered in the Vía Verde project.

Hydrology and hydraulics techniques, added to water injection tests in water injection wells, all of it monitored by water flow and amount of precipitation gauges at different periods of recurrence, has allowed us (since the 1980's) to establish: a)the sinkhole's filtration capacity, and b)the filtration capacity of the same sinkhole after habilitating it with filters designed to permit (and not restrict) the flow of water into them.

This type of design is a multidisciplinary one in which Geotechnical Engineering is combined with the design of pipelines, highways, hydrology-hydraulics of each sinkhole, Geophysics (including surface seismic refraction, seismic refraction inside a drill-hole (Vertical Seismic Profiling, Down-hole Seismic Refractions, Cross-Hole Seismic Refraction)), electrical conductivity and resistivity, magnetism studies, micro-gravity studies, radar, dye tests between sinkholes, and studies of fractures in the Karst at a regional level (Fracture Analysis Using Remote Sensing Techniques).

Figures 1 and 2 show an example of projects designed and constructed in Puerto Rico. These studies were conducted during the 80's and 90's, with what was known as "State

of the Art". **Figures 3,4,5, and 6** show interpretations made with the same methods, but now with new techniques that allow us to visualize the sinkhole in three dimensions.

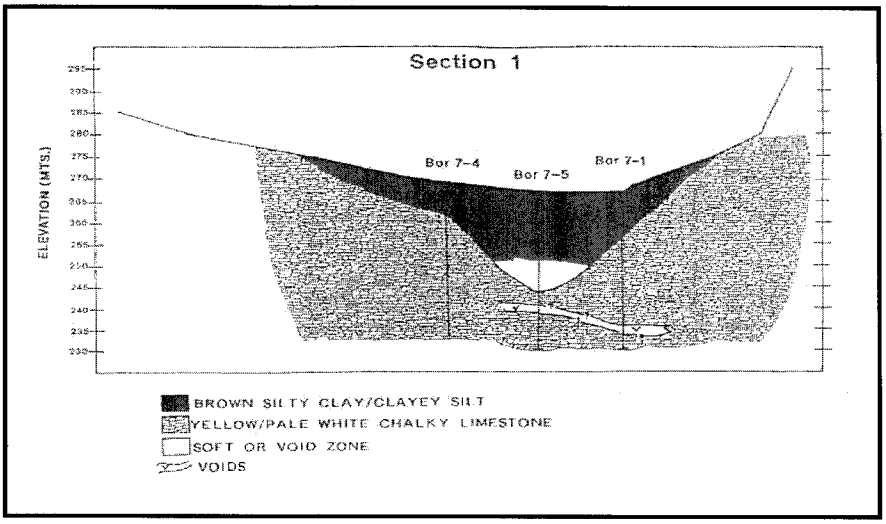


Figure 1 - Example of the interpretation of a sinkhole with geotechnics and geophysics.
1983 to 1990. (Rodríguez & Vázquez - 1999)

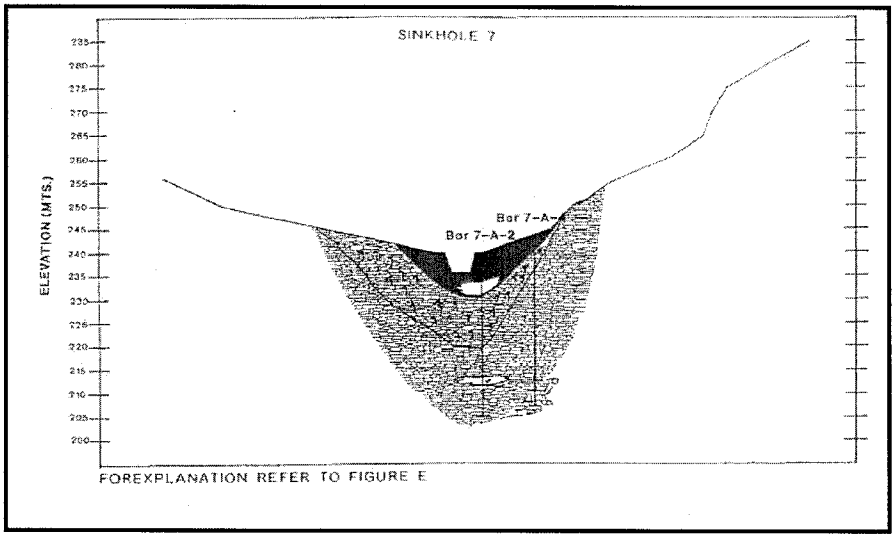


Figure 2 - Example of the interpretation of a sinkhole with geotechnics and geophysics.
1983 to 1990 (Rodríguez & Vázquez - 1999)

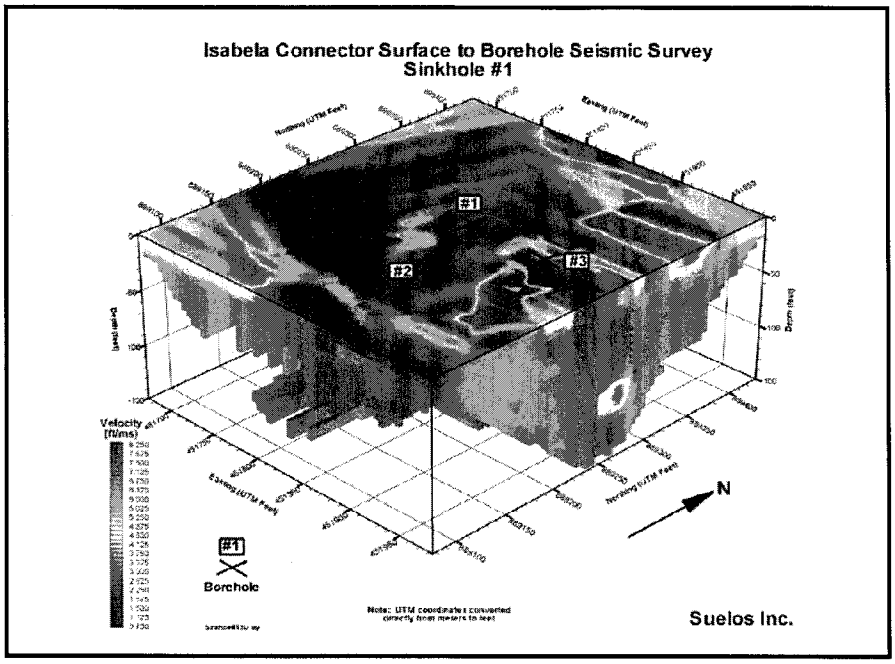


Figure 3 - Example of the interpretation of a sinkhole with geotechnics and geophysics. 2005

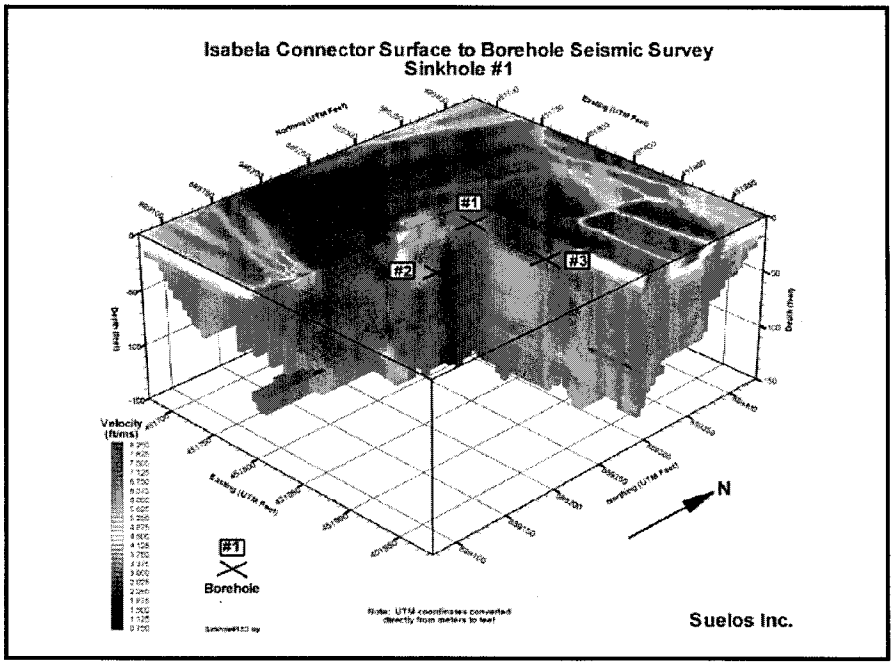


Figure 4 - Example of the interpretation of a sinkhole with geotechnics and geophysics. 2005

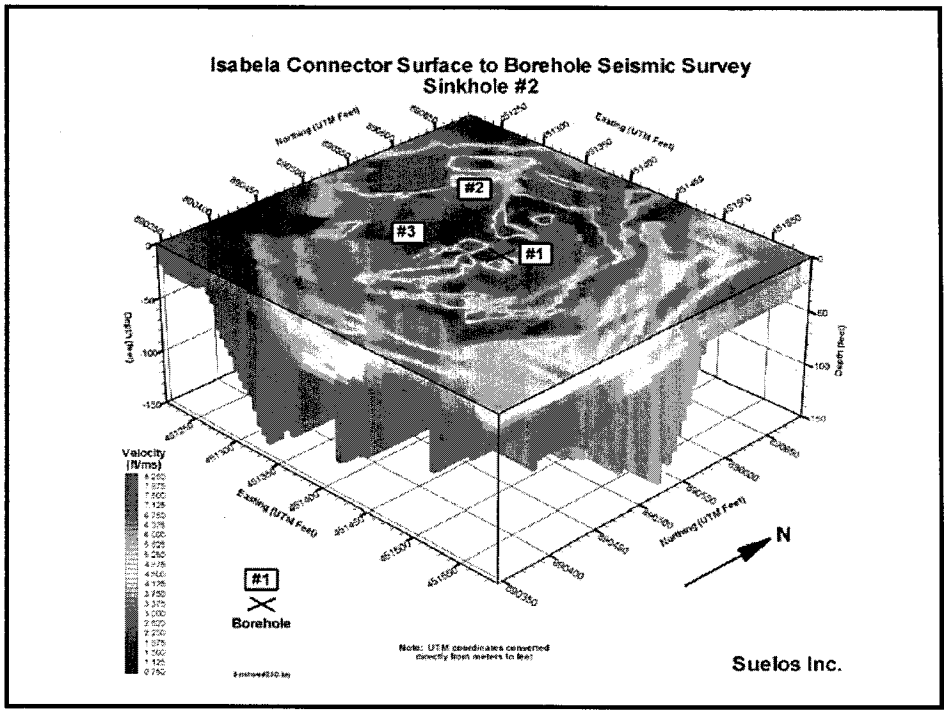


Figure 5 - Example of the interpretation of a sinkhole with geotechnics and geophysics. 2005

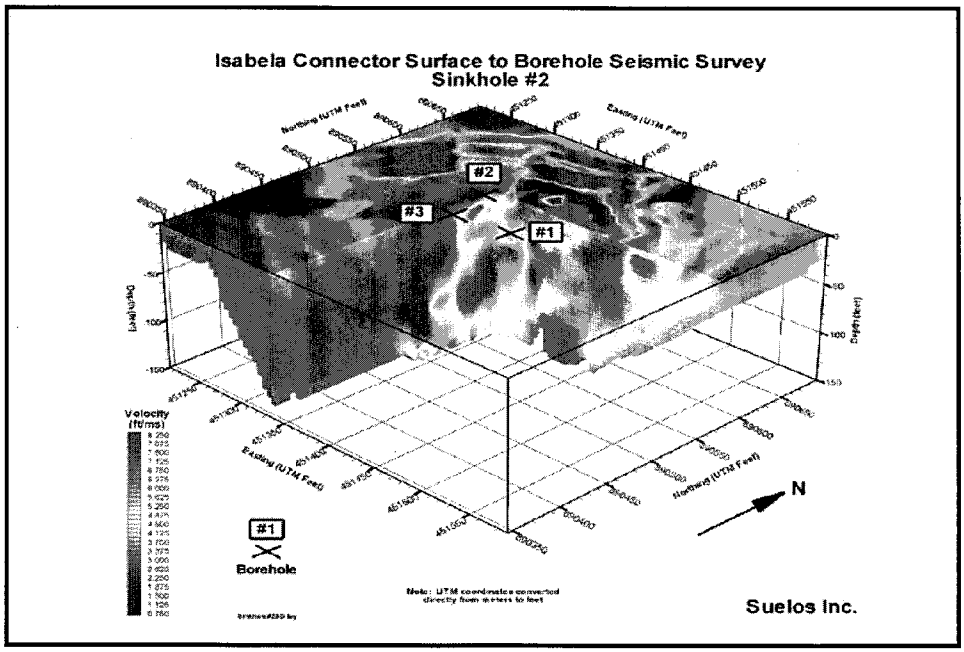


Figure 6 - Example of the interpretation of a sinkhole with geotechnics and geophysics. 2005

Figures 7 and 8 show sections of recommendations for said sinkholes. The objective was to issue the free flow of stormwater runoff using inverted filters and instrumentation to monitor the behavior of the filter during the construction of a highway.

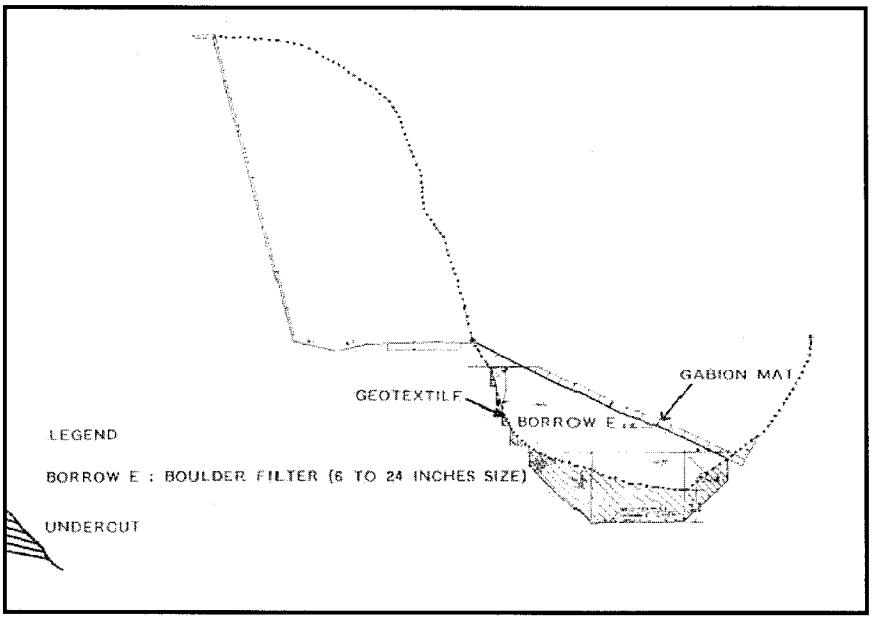


Figure 7 - Remediation by habilitation of sinkholes with inverted filter. (Rodríguez & Vázquez 1999)

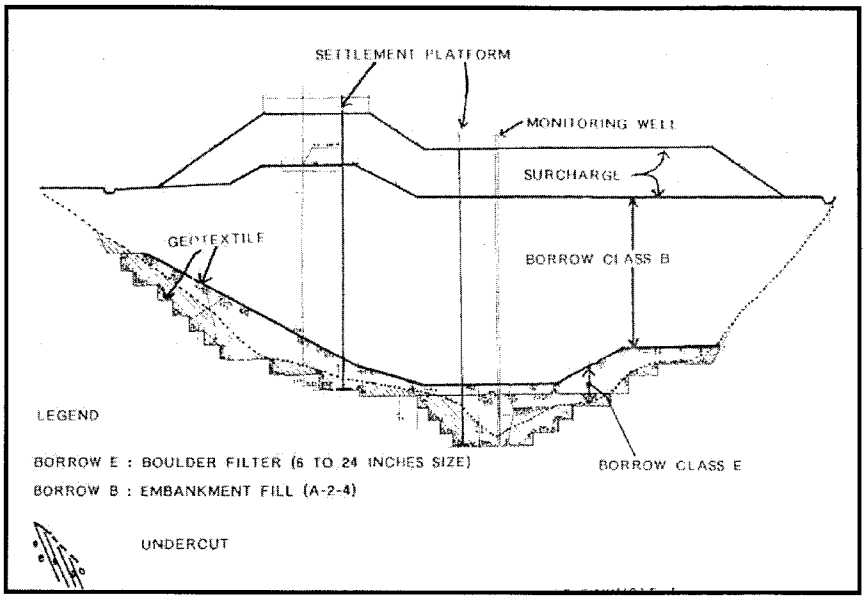


Figure 8 - Remediation by habilitation of sinkholes with inverted filter. (Rodríguez & Vázquez 1999)

These are some of several alternatives that will be evaluated to optimize the installation of the pipeline and reduce to a minimum the impacts on sinkholes.

The Vía Verde project does not compare with PR-10 between Arecibo and Utuado in the magnitude of Vía Verde. While earth movements of great magnitude were made in PR-10 to accommodate the highway and the embankments, in the case of Vía Verde the construction is for the installation of a 24-inch diameter pipeline. The habilitation of sinkholes would be considerably much less than that of a highway like PR-10 or the Isabela Connector (where 5 sinkholes adjacent to the already constructed and operating Connector were habilitated).

Another alternative to be evaluated is moving the alignment around the edges of the mogotes. Also, the use of the HDD installation method can be combined with a layer of filter. In that way we can explore the alternative of drilling through the walls of t he sinkhole at a minimal elevation which would allow us to install a minimum of filters.

The alternative selected after all the required studies mentioned before will be evaluated including the technical and the economical aspects.

The route presently is located over large part of the Karst platform in the north of Puerto Rico from where it crosses PR-10 near the Dos Bocas Reservoir. From then on, it will be located along the highway's right-of-way. The highway and the right-of-way were treated during the 90's during the construction of PR-10 between Arecibo and Utuado, through the habilitation of 12 active sinkholes. These 12 active sinkholes were treated and habilitated as in the examples shown in **Figures 1 thru 4**.

There will be no negative effect in the already constructed treatment of these 12 sinkholes. In those portions in which it crosses over the filter treatment, the pipeline's effect on the sinkholes' filtering capacity will be practically negligible. This effect can be calculated and balanced over the capacities for which they were originally designed.

The project will not affect the mitigation measures taken for the construction of PR-10 in what concerns the Karst zone. Geotechnical and geophysical studies will be conducted to avoid impacting sinkholes or aquifers, or the integrity of the project. Projects of the magnitude of PR-10 were constructed under the full-time supervision of geotechnical engineers, geologists and biologists. Vía Verde will also have that type of full-time supervision on the critical zones.

Liquefaction

The stretch of Vía Verde that runs from the EcoEléctrica terminal to the Tallaboa River valley in Peñuelas and that extends from the area known as El Cocal to the Bayamón River in Toa Baja, traverse over land that contains sandy soils susceptible to become liquefied during a strong earthquake. Liquefaction is a phenomenon that occurs mostly in fine loose sands (poorly compacted) that are saturated, that is, that have the spaces

between the grains (voids) full of water. What happens is that during the earthquake, the grains of sand tend to be compacted and rearranged. The collapse of the soil compresses the water present in the voids, which not being able to drain quickly, exerts an opposite pressure against the grains. Where this pressure is equated to the weight of the grains, the sand loses all frictional resistance and behaves like a fluid. The greatest danger this represents to Vía Verde is the dislocation of sections of the pipeline in stretches in which the soil surrounding it liquefies, or if it sinks or slides over a deeper deposit of liquefied sand.

In the Levittown Coast stretch, the pipeline will be installed through the HDD technology. This will permit locating it at depths greater than 50 to 60 feet. Soil at these depths exhibits greater compaction, therefore they are more stable and not prone to liquefaction. In this way, the risk of a possible liquefaction of the costal soils affecting the pipeline's stability is eliminated.

Geological Faults

Between Peñuelas and Adjuntas, the route crosses the Great Southwestern Puerto Rico Fault Zone, one of the principal structural features of the geology of the Island. Comments have been raised about the possible activity that the faults comprising this system, and the impact they could have on the pipeline, both in the sense of some fault breaking the ground surface and/or producing an earthquake near the pipeline.

The concept of the activity of geological faults is one of which there is no precise definition. On the contrary, there are multiple definitions, many of which are codified in regulations and protocols of governmental entities. Most of them are based on the following criteria:

1. That there is historical and/or geological evidence of a break along the fault in recent times, for which different entities specify different periods, such as the Holocene Epoch (the past 10,000 to 20,000 years) or the Quaternary Period (the past 2 million years, which includes the Holocene). The geological evidence can be of several types, including Holocene or Quaternary soil or rock that has faulted, and a range of geomorphic traits produced by movements along the faults, such as fault scarps, lineal valleys and river or coastal terraces, among others.
2. Seismic information of adequate precision that relates the seismic activity with the fault in question.
3. That the fault has a structural relationship to another fault that complies with one of the previous criteria.

It is instructive to look at the time some regulators use in the definition of activity. The Federal Government's Nuclear Regulatory Commission uses the past 500,000 years as the evaluation criteria for the construction of nuclear power plants, structures on which

the impact of a fault movement could be catastrophic. The U.S. Army Corps of Engineers uses a term of 35,000 years for the construction of dams, another type of structure whose stability is critical for thousands of citizens. On the other hand, the State of California stipulates a term of 11,000 years (Holocene) as a zoning element. The construction of most structures for dwelling or extended use by humans is prohibited within a 30-meter strip of any active fault, but the construction of other types of structures is not restricted as long as they are designed and constructed with the necessary provisions to insure the safety of citizens.

The Great Southwestern Puerto Rico Fault Zone consists of a series of geologic faults generally oriented from southeast to northwest that were identified by the Federal Geologic Service (USGS) in the 60's and 70's when the region's geologic quadrangle maps were prepared.[4] The maps illustrate the traces of the faults with thick lines whose continuity indicates the reliability of the location shown: a continuous line represents a fault located with a fair amount of certainty, a broken line indicates an approximate location and a dotted line, which means that the presence of a fault is inferred, which fault is presumed to be buried by soil or rocks of lesser age and cannot be observed directly. Throughout the Great Southwestern Fault Zone, the continuous and broken lines occur in rocks that date from the Cretaceous to the Miocene, that is, rocks that were formed more than 5 million years ago. Where the trace crosses alluvial sediments of the Quaternary period (which comprises the past 2 million years), the faults are identified with dotted lines. This indicates that the faults have not impacted the recent sediments. Nor is there geomorphic or seismological evidence that points to some recent activity, for which reason the faults are considered as inactive or incapable of seismic movement. Nevertheless, and to ensure the safety of the people, the AEE will evaluate and document the geology of the excavation in the stretches that cross the charted faults to confirm their inactivity.

On a related matter, the evaluation of the seismicity of the Vía Verde route in relation with the pipeline's seismic-resistant design, has been questioned. Regarding this, the pipeline will be designed and constructed in accordance with the requirements of the Puerto Rico Construction Code and the applicable state and federal rules. It bears pointing out that typically, the cases of damage to underground pipelines that have occurred during earthquakes are due to some type of flaw in the soil in which they are

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One of the comments made during the Public Hearings questions the validity of the geologic maps because they were prepared 50 to 60 years ago. Although they suffer changes related to meteorization or possible erosion or sedimentation, the soils and rocks present in a place are generally the same as those that were there 50 or 60 years ago, unless the site had been impacted by a major event such as a great landslide or a break and displacement along a geologic fault, events we know have not occurred since the maps were made (we could also include human activities related to the excavation and fill as possible agents of change). On the other hand, the USGS maps are official documents used for planning processes by the concerned state and federal governmental entities.

buried, for example, landslides, liquefaction, settling, or break of a geologic fault, problems that are addressed with the previously mentioned studies.

Soft Soils

As mentioned before, the weight of the pipeline and its contents is less than that of the soil removed to place it in. This nulls the settling problem characteristic of soft soils, therefore the presence of weak soils is more a construction than a design problem, particularly in relation to the movement of construction equipment and the project's personnel.

Erosion

There are 3 aspects to the erosion problem that are being evaluated. The first one is the potential of erosion that could undermine the pipeline at river crossings. The preliminary design of Vía Verde provides that the pipeline will pass under the bed of all the rivers and major ravines of the route, for which reason it is understood that the erosion of the channel and riverbed that could occur in those bodies of water will not have an impact on it. These sections of the project will be constructed using the HDD technique in which the drilling begins at a safe distance from the channel and runs under the riverbed at an adequate depth, which is determined through a subsoil exploration program with geotechnical drilling, an activity that is being currently undertaken.

The second aspect is the potential of erosion by the action of the waves in the stretch that runs near the Atlantic Ocean coastline. This is the stretch between El Cocal and the Bayamón River in Toa Baja. Soon will commence a photogrammetry evaluation that will evaluate the stability of these stretches of coastline during the past 70 to 80 years in terms of erosion and sedimentation, and it will serve as the basis to determine the need to implement protection measures against erosion caused by ocean waves. It bears mentioning that these stretches are generally the same in which the presence of liquefiable soils was identified, and that to minimize the potential of liquefaction and costal erosion, the pipeline will be installed by HDD at depths of 50 feet or more, which will protect the pipeline from the action of the waves. For this reason, Vía Verde will not affect the dunes or the coastline, therefore, during the construction and operation phases there will be no impact in the Levittown Coast stretch.

Finally, and certainly the AEE's greatest concern, is the potential of erosion in soils exposed by stormwater runoffs during the project's construction phase and subsequently in the long term. This will be addressed through the incorporation of strict short and long-term control measures in the design and the specifications for the project's construction, and a meticulous inspection of the functioning of these during and after the construction.