PDVSA

6.0 SITE STUDY

PDVSA

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This section presents PDVSA's rationale for the selection of the three sites, namely, Jose, Anaco and Güiria, to be considered for this study. Evaluation and study results for the three selected sites are also included.

6.1 PDVSA'S RATIONALE FOR SELECTING THE THREE SITES

PDVSA are evaluating two sources of natural gas supply to a GTL plant: "associated" and "non-associated" gas. The associated natural gas is expected to be cheaper than the non- associated gas.

Venezuela expects to have a surplus of natural gas coming from the fields located in the eastern part of the country. A shortage of gas is being forecast for the western part of the country. Thus a logical location for a GTL plant would be in Eastern Venezuela.

The crude oil production plan for PDVSA focuses on the development of the production facilities located in the eastern part of the country, in the Monagas and Maturin states. The crude oil produced from these fields has a relatively high gas to oil ratio with the consequent production of associated gas. The Anaco hub is where most of the oil from these production facilities is gathered. Thus Anaco was considered as a possible site for a GTL plant.

All the crude produced in the eastern part of the country is transported to the main shipping terminals and upgrader plants located at Jose and Puerto La Cruz. Environmental restrictions for Puerto La Cruz make this location unattractive for the addition of process plants. On the other hand, the Jose site has a high level of infrastructure that could be evaluated for synergy with a potential GTL Plant. Thus, Jose was also considered as a possible site for a GTL plant.

Venezuela has extremely high, non-associated gas reserves, located in the eastern part of the country, specifically at the Golfo de Paria, in the state of Sucre. PDVSA plan to build an LNG processing plant at Güiria. This LNG plant,

when implemented, could have a lot of synergy with a potential GTL plant at that site. This made Güiria an attractive area to be evaluated as a potential site for a GTL plant.

Additional information for each site follows.

6.1.1 Anaco

- Anaco is the natural gas hub in Eastern Venezuela. All commercial gas pipelines start at Anaco (i.e. Anaco-Caracas-Barquisimeto pipeline system, Anaco-Puerto Ordaz system and Anaco-Jose-Puerto La Cruz system)
- If there is a surplus of associated gas in Venezuela, this gas has to pass through Anaco.
- The proven reserves of associated gas in Eastern Venezuela are estimated to be 103 TCF.
- For associated gas, now and in the future, the natural gas price at Anaco is lower than that at other locations.
- PDVSA produce crude oil in the Anaco area. Hence there is a possibility for some synergy. For example, the GTL plant could sell synthetic crude to PDVSA.

6.1.2 Jose

- Jose has the same characteristics regarding the supply of natural gas as Anaco, except that the natural gas price is around 0.10 $/MMBTU higher than in Anaco.
- In Jose, there are possible synergies with the Puerto La Cruz refinery, the heavy crude oil up-grading plants, and the LPG fractionation plant.
- In Jose, there could be other technical synergies (i.e. electricity and water).
- In Jose, the GTL plant could keep its products segregated from petroleum derived products, export them, and realize the premiums associated with the GTL products.

6.1.3 Güiria

- Güiria will be a natural gas hub for non-associated gas production in the future. All natural gas from Paria and Orinoco Delta fields will probably go to Güiria.
- The proven reserves of non-associated gas in offshore areas are estimated at 13 TCF.
- In Güiria there could be technical synergies with a future LNG plant.
- If a surplus of associated gas were not available in the future, Güiria would be the only site for a GTL plant fed by non-associated gas.

6.2 KEY PARAMETERS FOR SITE SELECTION

The following parameters were considered in selecting the best site:

- Geographic information.
- Geotechnical data.
- Construction issues.
- Available infrastructure and related facilities.
- Utilities.
- Synergy opportunities.
- New infrastructure requirements.

The information was gathered from different sources. It includes data provided by PDVSA, retrieved from previous projects in the area (COSA's files on developed projects or general knowledge), public information or literature, and information gathered during a visit to one of the sites.

The data for the Jose site was, for the most part, provided by PDVSA's Jose Condominium Management. It covered the current situation and future development of the Jose Industrial Complex in sufficient detail to make a site visit unnecessary.

The data for the Anaco site were obtained from the ACCRO Phase III/IV Management and from previous information available from COSA's files involving the San Joaquín Extraction Plant, together with a site visit to Anaco (including meetings with operating personnel from the plant and from the pipeline systems in the area).

With respect to the Güiria site, considering that no facilities are currently in place, part of the data was gathered from previous information available from COSA's file regarding the TAP (Terminal de Aguas Profundas) Project. This project is currently on hold. The rest of the data were gathered from the SUCRE GAS Management who are responsible for the development of the LNG Project, also currently on hold.

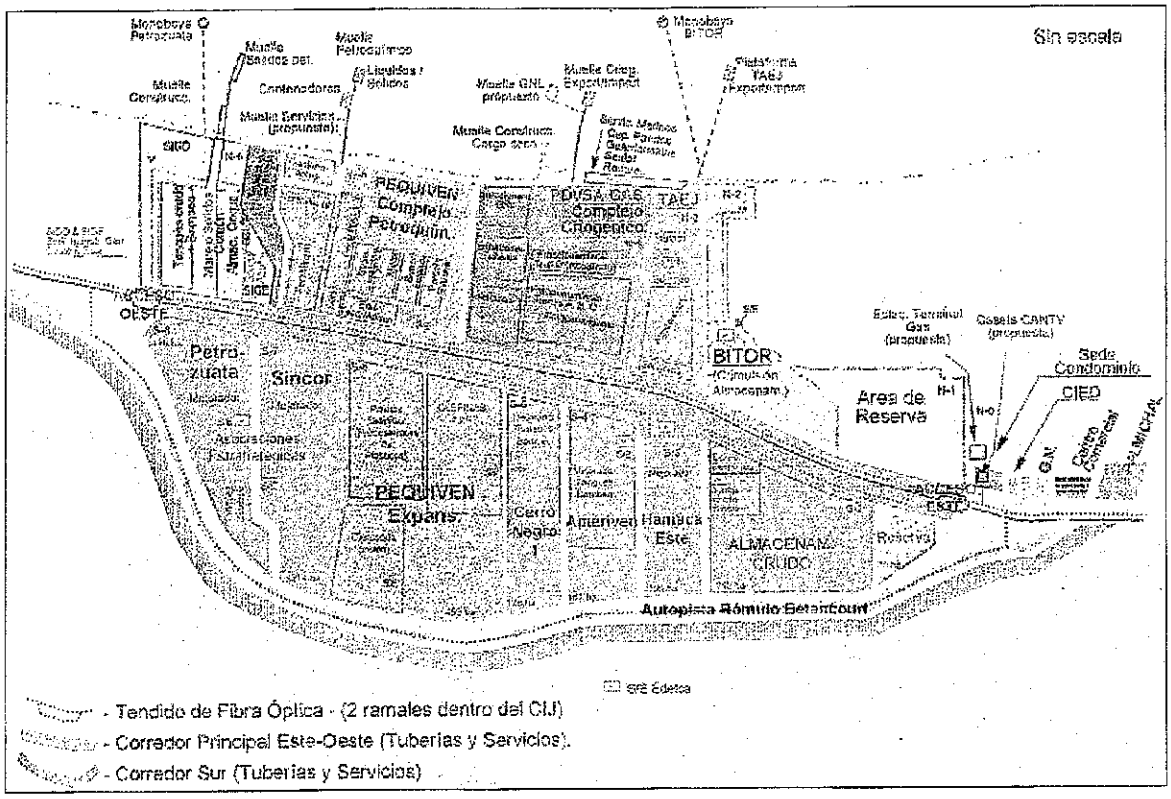
6.3 INDIVIDUAL SITE RELATED INFORMATION

6.3.1 Jose

Following is the site analysis and evaluation of the Jose site. The data and related information correspond to the area of the Jose

Industrial Complex (see Figure 6-1 provided by PDVSA). The site is located near the seashore, on the northeastern coast of Venezuela, in Anzoategui State, between the cities of Barcelona (30 Km away by road) and Piritu.

Fig. 6-1 **Jose Industrial Complex**



6.3.1.1 Geographic Information

6.3.1.1.1 General Description of Terrain.

Relatively flat terrain, gently sloping towards the sea. It is located beside the coastline (Gulf of Cariaco). Vegetation is comprised mostly of bushes and low forest, of the arid type.

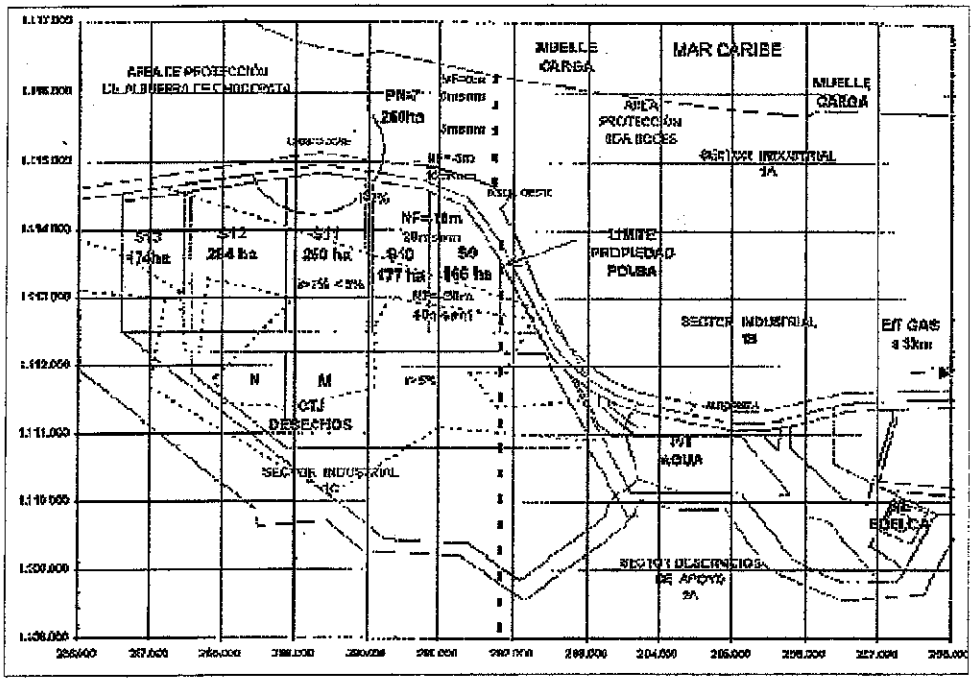
6.3.1.1.2 Elevation of the Area.

Elevations range from + 50 m at the southern edge of the complex, to a + 9 m at the main crossing road, to +1 m near the coastline. Mean elevation is +10m above sea level.

6.3.1.1.3 Availability and Cost of Land.

Land is available in lots S-9 to S-13, located Southwest of the Jose Industrial Complex (CIJ), outside the property limits of PDVSA, in an area known as Desarollos Industriales Petroleros y Petroquimicos (DIPP). Lots sizes vary from 166 to 284 Ha (hectares). The lots in the DIPP area have not yet been developed (see Fig. 6-2).

Fig. 6-2 **Location Options for GTL Project**



Lots must be bought as whole parcel, regardless of actual need, but could be subdivided later.

Cost of land inside the CIJ area is 8.00 US$/$m^2$, developed with basic services (roads, water, gas, electricity, telecommunications) nearby. Cost of land in the DIPP area is less, but additional expenditure will be needed for site preparation and to develop services. For the GTL study, a cost of 8.00US$/$m^2$ will be used.

6.3.1.1.4 Ambient Conditions.

Temperature (dry bulb):

- Maximum : 27.6 °C

- Mean : 26.5 °C

- Minimum : 25.4 °C

Mean relative humidity of 77%, with summer maximum of 100%.

Mean annual rainfall of 900 mm.

Prevailing winds coming from the Northeast, with some local winds (due to sea-land interface), coming mostly from the North (daytime) and South (at night).

Design wind load and exposure, per ASCE 7-93:

- Basic wind speed of 85 Km/hr.

- Exposure type D.

6.3.1.2 Geotechnical Data

6.3.1.2.1 Qualitative Description of Soil.

Highly variable site stratigraphy. The soils consist of about 1 meter of loose sandy and clayey silts with soft to firm sandy/silty clays. This layer is followed by better foundation soils comprised of stiff to hard silty/sandy clays, underlaid by dense to very dense silty/clayey/gravely sands and silty gravel.

6.3.1.2.2 Site Preparation Requirements.

Removal/replacement of the loose upper soil (1 m below original grade) is needed. Fill material will be required for light grading and terracing. After the mentioned site preparation, the soil conditions are suitable to support structures on either shallow or deep foundations, depending on the load. Piling will only be required for very heavy structures.

6.3.1.2.3 Soil Bearing Pressure.

According to the previous soil survey on the PETROZUATA site[1], soil bearing pressure is 2 Kg/cm^2 for spread footings on natural soil, and 1.5 Kg/cm^2 on structural fill.

6.3.1.2.4 Availability of Sand and Gravel.

Readily available near the site (less than 5 Km).

6.3.1.2.5 Drainage Characteristics.

Poor drainage with some areas likely to be flooded. Exposed soils easily eroded and susceptible to loss of strength if they become saturated.

6.3.1.2.6 Water Table Depth.

From 6 to 7 m below existing grade.

6.3.1.2.7 Seismicity.

According to Venezuelan COVENIN 1756 code: Zone 6, with acceleration of 0.35 g.

6.3.1.3 Construction Issues

6.3.1.3.1 Heavy Construction Equipment Sources.

Due to recent construction activity in Jose and the surrounding areas (Barcelona, Puerto La Cruz), large construction companies, with heavy equipment and experience in world class process plants, are available.

6.3.1.3.2 Labor.

High availability of skilled labor and subcontractors. The labor rate during September 1999 was about 12,800 Bs./hour which translates to 20.5 US$/hour, using the exchange rate of 625 Bs/US$ that prevailed at that time. The rate includes light equipment and tools. A labor camp is not needed, due to the proximity of several cities (Piritu, Barcelona, Puerto La Cruz) with a diverse economic base.

6.3.1.3.3 Construction Dock and Transport to Site.

At Guanta, adjacent to Puerto La Cruz, there are well developed port facilities for general cargo, although this harbor will have load restrictions since it will have to pass through cities before arriving at the complex.

The Jose condominium has two construction docks. One located in the PDVSA Gas Cryogenic Complex, capable of handling up to 350 MT, and the other located in the PETROZUATA Solids Facilities, capable of handling up to 1000 MT. Those docks can serve Roll-On Roll-Off (RORO) ships. A general cargo dock is also being built at the new TAE (Terminal de Almacenamiento y Embarque) dock belonging to PEQUIVEN, in the complex. The 1000 MT construction dock which will have to be extended to accommodate the draft requirement of heavier ships. No limitation is foreseen in transporting heavy equipment to a nearby site.

6.3.1.4 Available Infrastructure and Related Facilities

6.3.1.4.1 Roads.

Jose is well connected by highway to Barcelona, Puerto La Cruz and the port of Guanta. The main national road (highway) between Puerto La Cruz and Caracas crosses the complex. The internal roads serving the complex are very good.

6.3.1.4.2 Shipping Facilities.

The Jose Industrial Complex is served by the following marine export shipping facilities:

- The Cryogenic Complex pier (two berths), handling NGL/LPG (and planned extension for LNG).
- Monobuoys for handling the products from BITOR and PETROZUATA.
- PEQUIVEN's TAE pier (Terminal de Almacenamiento y Embarque), handling petrochemicals (solids, cryogenic, and liquids).

Three offshore platforms (TAEJ), handling crude oil.

Extensive storage facilities are included and some of those piers could easily handle the GTL needs, with little incremental investment.

The Guaraguao terminal, located near the Puerto La Cruz refinery (35 Km northeast of Jose), has its own export handling piers (six berths) for crude oil and refined products, with some interconnecting lines to the Jose complex.

6.3.1.4.3 Crude or Product Pipelines.

All the pipelines reaching Jose transport heavy crude oil from the Orinoco Belt Upgrader projects or Orimulsion from inland production areas. Those reaching the Guaraguao terminal handle the normal oil production originating from tank farms located in their corresponding districts (San Tomé, Anaco and North Monagas).

DELTAVEN has a product (gasoline, diesel, kerosene, jet fuel) pipeline, operating in batch mode (part of the SISOR project), originating in Puerta La Cruz and feeding distribution stations in San Tomé, Pto. Ordaz and Maturín, but cannot be used for northward flow of product from Anaco.

6.3.1.4.4 Proximity to Existing Process Plants.

The Northern part of the complex (from the main east-west crossing road) is already populated by the following plants:

- PETROZUATA's solids handling facilities.
- PEQUIVEN's petrochemical plants, including:
  - Super Octanos (MTBE).
  - Super Metanol (methanol).
  - METOR (methanol).
  - FertiNitro (ammonia and urea), under construction.
- The Jose Cryogenic Complex (of PDVSA Gas), involving NGL fractionation.

- Storage tanks and handling facilities for crude and Orimulsion (PDVSA EP and PDVSA BITOR).

The Southern part of the complex already has, or will include, the following plants:

- PETROZUATA, SINCOR, CERRO NEGRO AND HAMACA Upgrader Plants.
- The planned MOBIL/PEQUIVEN olefins complex, with an expansion area for future projects.

6.3.1.5 Utilities

6.3.1.5.1 Proximity to Electric Power Grid.

The electric power needs of the Jose Industrial Complex are directly supplied by EDELCA from the Guri hydroelectric plants and main 400 kV transmission system, at 115 kV transformed level. EDELCA will have the capability of supplying up to 600 MW of power by the year 2001. Price of electricity supply was given as 20 mills/KWH (applicable after December 1998 at the 115kV voltage level).

With a substation located inside the Jose Industrial Condominium area, only a short interconnection will be required to allow excess power to be exported from the GTL plant to the distribution grid.

6.3.1.5.2 Water.

Pretreated raw water requirement for the whole complex is provided by a company called Aguas Industriales de Jose (a BOO partnership between PEQUIVEN and EARTH-TECH). Water availability is sufficient to cover the complex's needs with no limitations foreseen. Water is supplied from the Turimiquire Reservoir, with increased supply to come from the future Hoces Reservoir and Unare River. Plans are to have a capacity of 3,100 LPS (liters per second) by the year 2004. Indicated cost is 0.52 US$/$M^3$ (for less than 1,300 LPS use).

6.3.1.5.3 Disposal of Liquid Wastes.

Aguas Industriales de Jose, for a fee (unknown yet), could provide liquid waste treatment for Condominium clients, with all treated liquid wastes collected and discharged to the sea. However, due to the particular wastes related to a GTL Plant, it is suggested that this cost be considered as part of the GTL investment requirements.

6.3.1.6 Synergy Opportunities

Of the three sites under consideration, the Jose location offers the most favorable siting for a GTL project because of the planned industrial condominium complex developing there. Some of the existing and/or planned projects which will provide excellent synergy opportunities with a GTL plant are:

- Heavy oil projects producing a low cetane diesel product.
- Pequiven's Chloralkali plant with high power demand.
- Pequiven's ammonia-based fertilizer plant and Supermethanol project for synergy in syngas production.
- PDVSA Gas' cryogenic LPG and LNG facilities.
- Pequiven's ethylene complex.

Possible areas of synergy are highlighted below for evaluation during the next phase of the project.

- Export excess power from the GTL plant to the grid or to other plants. Although no "short term" limitation of supply is foreseen from EDELCA, in the "long term", total demand will grow beyond the present supply capability of 600 MW, providing a ready market for by-product electricity.

  A buying price for export of electricity, could not be obtained from the site. As mentioned before, for Study purposes, it will be estimated from the corresponding selling price (20 mills/KWH)), multiplied by a factor

of 0.7 to account for distribution and marketing costs, giving a price of 14 mills/KWH.

- Export excess steam from the GTL plant to other plants. The whole Jose complex is a potential steam user, but the existing plants and those currently planned most probably have their needs covered. Synergy could be established for the new projects being considered, such as the LNG Plant, the MOBIL/PEQUIVEN Olefins Complex or the HAMACA (PDVSA, Arco, Phillips and Texaco) Upgrader Plant (still in the early stages of engineering). However, no steam demand is foreseen for the "short term".

- Recover the LPG range material from the GTL plant and export it as feedstock to petrochemical facilities, such as Pequiven's ethylene plant

- Buy hydrogen "across the fence" from the large hydrogen plants that will be part of the heavy oil upgrader projects, such as Sincor, for use in the "product workup" section of the GTL plant

- Import excess syngas from the large Steam Methane Reformers (SMR's) being installed as part of the Hydrogen Production Units in the Heavy Oil Upgrading projects. Import carbon dioxide from the ammonia plant under construction. Feed these streams to a Reverse Shift Unit to produce a syngas with H_2/CO ratio of 2.0 that can then be fed to the Fischer-Tropsch unit of the GTL plant.

- If Partial Oxidation is used for syngas production, add and modify units to enable gasification of coke. It could provide a way of getting rid of some of the large amounts of coke that will be produced by the Petrozuata and Sincor projects. This coke could present an environmental problem in its disposal and hence could have a high negative value.

  Coke derived syngas can also be used to advantage as a supplement to syngas derived from natural gas. This can be achieved by using lower cost Steam Methane Reforming to produce a high H_2/CO ratio syngas from natural gas, and gasification of coke to produce a low H_2/CO ratio syngas.

The two streams can be blended to produce a syngas with a suitable H_2/CO ratio for Fischer-Tropsch synthesis.

- Use syngas capacity from existing and planned plants in the Jose complex, such as the methanol and ammonia plants to reduce the cost of syngas generation for the GTL plant. A complementary use forproduced syngas could be established with the following facilities, to be located in the complex, if the designs can be coordinated:

  - METOR's planned expansion of methanol capacity (second train), from the current 803,000 TPA to 1,715,000 TPA, to be completed by the middle of the year 2004.

  - FertiNitro's future expansion plans for ammonia and urea production. The initial plants, currently under construction (with startup in the year 2000), will produce 1,300,000 MTA of ammonia and 1,500,000 MTA of urea.

- Sell naphtha from the GTL project as diluent makeup for the Heavy Oil Upgrading projects, such as Petrozuata and Sincor .

- Sell oxygen from the GTL plant's air separation unit to increase the capacity of the sulfur plants in the Petrozuata and Sincor projects or lower the investment required for future sulfur plants.

- Sell nitrogen from the GTL plant to the condominium for distribution to other projects.

- The Jose Cryogenic Complex could provide fractionation capability for any LPG produced in the GTL plant.

- The Puerto La Cruz refinery, located relatively close, could provide further synergy opportunities related to product work-up.

6.3.1.7 New Infrastructure Requirements

The new supporting facilities and infrastructure needed to be provided at the site, directly related to the installation of the GTL plant, will be the following:

- Short feeder interconnections from nearby existing supply points, for natural gas, electricity, and water. If sited on the outside lots, the distance to the interconnecting points will be longer.
- Short product pipeline interconnections to a marine pier and new dedicated loading arms.

6.3.2 Anaco

The analysis and evaluation of the Anaco site is discussed in the following paragraphs. The data and related information is for the area around PDVSA Gas' San Joaquín Extraction Plant. The site is located near the city of Anaco (10 Km away), about 100 Km inland and to the Southeast of Jose, in Anzoategui State.

6.3.2.1 Geographic Information

6.3.2.1.1 General Description of Terrain.

The terrain is relatively flat with small hills. The area has light to medium vegetation of the Savanna type. The main economic activity is geared to oil production and services, with some cattle raising.

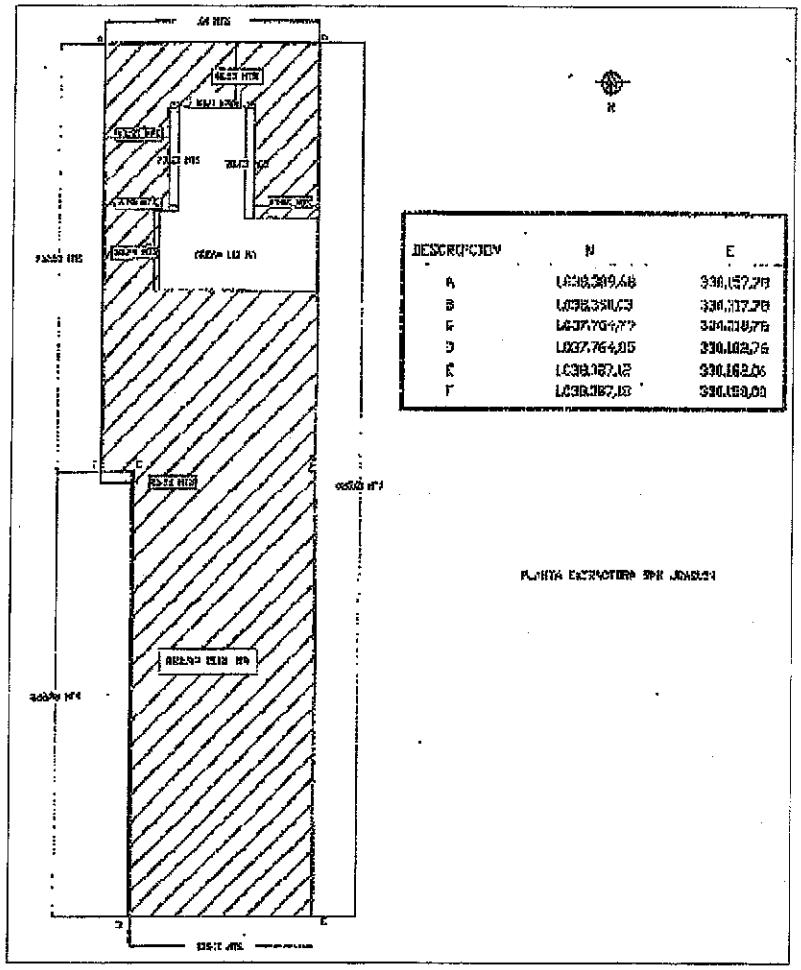
6.3.2.1.2 Elevation of the Area.

Mean elevation of + 153 m above sea level.

6.3.2.1.3 Availability and Cost of Land.

The area around the San Joaquin Fractionation Plant is lightly populated. The current ACCRO Phase III/IV expansion is west of the plant, but land availability in that direction is limited by the main access road. Further expansion of the San Joaquin Fractionation plant will have to be to the east. The land immediately east of the existing plant site and contiguous with it has been reserved for the planned expansion of the Fractionation plant, such as the Ethane Extraction Project. The GTL plant will, therefore, have to be located east of this reserved land. For plot layout of the area, see Figure 6-3. Current (September 1999) cost of land is 400 Bs/m^2 (undeveloped).

Fig. 6-3 **Plot Layout**



6.3.2.1.4 Ambient Conditions.

Temperature (dry bulb):

- Maximum : 37.8 °C
- Mean : 27.1 °C
- Minimum : 25.1 °C

Mean relative humidity of 82%, with summer maximum of 100%

Mean annual rainfall of 1000 mm.

Prevailing winds are from the Northeast, with some afternoon or night wind from the South.

Design wind load and exposure, per ASCE 7-93:

- Basic wind speed of 90 Km/hr.

- Exposure type C.

6.3.2.2 Geotechnical Data

6.3.2.2.1 Qualitative Description of Soil.

On the surface is a sandy fill of low resistance and high permeability (up to 1.5 m). This is followed by highly stratified sandy clays and high plasticity clays. The presence of expansive clays is a problem.

6.3.2.2.2 Site Preparation Requirements.

Heavy soil conditioning will be needed to replace expansive clays with proper granular material. Cut and fill will be required for grading in the hilly terrain. Wider use of deep foundations and piling will be needed for most moderate to heavy load structures.

6.3.2.2.3 Soil Bearing Pressure.

According to previous soil survey made for the ACCRO Phase III/IV project site[(2)], after proper soil conditioning, 1.5 to 2.0 Kg/cm^2, depending on use of fill.

6.3.2.2.4 Availability of Sand And Gravel.

Available about 10 Km from site.

6.3.2.2.5 Drainage Characteristics.

Very good drainage.

6.3.2.2.6 Water Table Depth.

No groundwater detected in soil exploration borings.

6.3.2.2.7 Seismicity.

According to Venezuelan COVENIN 1756 code: Zone 5, with acceleration of 0.30 g.

6.3.2.3 Construction Issues

6.3.2.3.1 Heavy Construction Equipment Sources.

Anaco has a number of medium sized construction companies, experienced in upstream oilfield facilities.

6.3.2.3.2 Labor.

Skilled labor and subcontractors are readily available at Anaco. The labor rate is about 20 % higher than the corresponding rate at Jose, resulting in a value of 24.6 US$/hour (including light equipment and tools). Due to the proximity of the town of Anaco, with its oil based economy, a labor camp will not be needed.

6.3.2.3.3 Construction Dock and Transport to Site.

Anaco is an inland location, so heavy equipment must be handled through a construction dock at Jose and transported by road (110 Km) to the site. There are transport companies, specializing in heavy lifts, located in Barcelona and Puerto La Cruz. Consultation with the largest one (Faga & Bovinelli), indicated that they have carried loads to Anaco, up to 330 Tons, using special transporters. Heavier loads are not allowed due to bridge limitations (except for the area around the Jose site).

6.3.2.4 Available Infrastructure and Related Facilities

6.3.2.4.1 Roads.

From Barcelona to San Mateo (about 40 Km) there is a toll highway, followed by a good national road to Anaco. There is heavy traffic on this road, since it

is the main artery between Caracas and Barcelona to points in the southeast part of the country (San Tomé and the Guayana region).

6.3.2.4.2 Crude or Product Pipelines.

There are no refined product pipelines originating at Anaco or surroundings that are capable of transporting liquids towards the Jose or Guaraguao marine terminals.

The products of the nearby San Roque refinery are transported to market by truck.

The San Joaquín Extraction Plant delivers NGL to the Jose Cryogenic Complex, via a dedicated 16"-diam. pipeline, 112-Km long.

The following pipeline systems transport crude oil produced by PDVSA E&P (Exploration & Production) from the Anaco or San Tomé districts, to the Guaraguao (with connection to the Puerto La Cruz refinery) or Jose marine terminals. They either originate or pass through the Anaco Tank Farm (PTA) located about 10 Km away from the NGL plant). Existing facilities were reviewed for possible transportation or dilution of syncrude produced by a GTL plant located at Anaco [3]:

- The Anaco Wax system has a 16"-diam., 100-Km long pipeline that originates at PTA and ends at Guaraguao. It handles a 41.5 °API mixture of paraffinic crude and condensate produced in the Anaco district, together with additional crude oil received along the way. Currently it handles around 50,000 BPD, but has a capacity of up to 110,000 BPD.

- The Anaco Mesa system consists mainly of a 16"-diam., 100 Km long pipeline that originates at PTA and ends at Guaraguao It handles a 30 °API mixture of Oficina crude (coming in from the San Tomé PTO tank farm), together with Mesa and Leona crude from PTA. Currently it handles around 45,000 BPD of crude, but has a capacity of up to 80,000 BPD.

- The Merey system has g a 30"-diam., 155-Km long pipeline that originates at PTO and ends at Guaraguao with a connection to the Jose terminal. It has booster stations at PTA and at the Km 52 point. It handles a 16.5 °API

mixture of Merey and Leona crudes, produced in the San Tomé district. Currently it handles around 180,000 BPD, but has a capacity of up to 310,000 BPD.

The following can be said about the mentioned pipeline systems:

- As a transportation alternative, the Anaco Wax system is the most compatible one to receive the waxy syncrude, having facilities for injection of heated gasoil to resolve plugging problems. However, since it is operated in a continuous mode, the syncrude will also be diluted with the other crudes.

- As a diluent alternative, existing operating procedures, together with commercial specifications and marketing commitments for the produced crudes, will preclude this option.

- In all cases, the current spare capacity of these pipelines has been reserved to handle the planned expansion of oil production.

The following pipelines transport the extra heavy oil produced in the Orinoco Belt projects to the Jose upgrader plants. Although one of them passes near Anaco, they are independent systems. They do not seem to offer any synergy opportunities to a GTL plant located in Anaco.

- The common Petrozuata and Sincor system originates at San Diego de Cabrutica. It consists of a 36" diameter crude line and a 20" diameter diluent return line. This system does not pass near Anaco.

- The common Cerro Negro and Hamaca system originates at PTO. It consists of a 42" diameter crude line and a 20" diameter diluent return line. This system passes near Anaco.

6.3.2.4.3 Proximity to Existing Process Plants.

The area considered as a potential site for a GTL plant is close to an NGL Extraction Plant located at San Joaquín. The plant has a current capacity of 1,000 MMSCFD of rich gas and 45 MBPD of liquids. It is in the process of being expanded to 1,400 MMSCFD of rich gas and 67 MBPD of liquids, as part of the ACCRO III/IV project (by early 2001). Additionally, new gas

processing (dehydration) and ethane recovery facilities are planned, with the first stage to be in operation by the year 2004, and the second stage by the year 2008. The ethane will feed the new olefins complex at Jose, and will be delivered through a new dedicated ethane pipeline system.

The Santa Rosa Extraction Plant located about 20 Km northeast of the city of Anaco is an older and smaller plant, having a capacity of 250 MMSCFD of rich gas and 4 MBPD of liquids.

Neither plant has facilities for LPG fractionation.

Also worth mentioning is the small (5,400 BPD) San Roque refinery, located about 35 Km Southwest of the city of Anaco, mostly used for dewaxing the highly paraffinic crude oil produced in the surrounding fields.

6.3.2.5 Utilities

6.3.2.5.1 Proximity to Electric Power Grid.

The existing San Joaquín Extraction Plant and current expansion is fed from two on-site 20 MW gas-turbine generators (at 13.8 kV level), supplemented by a 69 kV feeder from the Mapire substation near Anaco. There are current "short term" limitations in supply, but EDELCA is improving facilities for the "short and long terms", with new transmission lines and substations to serve the Anaco district.

The current price of electricity is 71.8 mills/KWH, basically due to self-generation and reflecting the existing limitations. However, this price will drop significantly in the "short term", and is expected to reach the same price as that at the Jose site (20 mills/kWh).

With a substation located inside the San Joaquín Plant area, only a short interconnection will be required to allow a GTL plant to export excess power to the distribution grid.

6.3.2.5.2 Water.

Makeup and service water needs for all installations in the Anaco district, including the San Joaquín Extraction Plant, are supplied from wells, since

there are no other sources of ground water nearby. There is a big aquifer in the Anaco area, located at a depth of 80 to 100 m, with good wells producing a maximum of 20 LPS (but typically 10 LPS).

Being process related, makeup water requirements will depend on the size of the GTL plant and the cooling system used. At this site, due to the water shortage, air-cooling must be maximized to reduce makeup water requirements.

The cost of raw water (untreated, for a supply greater than 1,000 M^3/Month) is 272,000 Bs/Month + 432 Bs/M3 consumed during the month. Considering an exchange rate of 625 Bs/US$ (applicable during September 1999), the cost of raw water is around 0.70 US$/$M^3$, reflecting a limited supply coming from wells (with electric motor driven pumps). The tariff is geared mostly for a supply of less than 1,000 M^3/Month.

6.3.2.5.3 Disposal of Liquid Wastes.

Due to its inland location and regulations, excess waste water must be injected into underground deep wells with all treatment provided by the GTL plant.

6.3.2.6 Synergy Opportunities

The Anaco site does not have any significant industry that could provide synergy opportunities for a GTL plant, The only industrial facilities in reasonable proximity to the proposed location are:

- NGL extraction plants at San Joaquin (adjacent) and Santa Rosa (20 km away).
- LPG fractionation plant at San Joaquin.
- A small (4500 BPD) refinery, about 35 km away at San Roque. This refinery mainly dewaxes the highly paraffinic crude produced in the area.

Possible areas of synergy are:

- Use of a common air separation plant to produce oxygen for the GTL plant and nitrogen for injection into oil production wells for "pressure maintenance".
- Send rich gases from the GTL plant to the extraction plant to supplement its production.
- Use the "hydrocarbon condensate" from the Fischer-Tropsch synthesis unit for crude blending.
- Export electricity from the GTL plant.
- Although no "long term" limitation of supply is foreseen from EDELCA, which is in the process of improving facilities in the Anaco area, it is assumed that excess electricity would be received.

As mentioned earlier, a buying price for exported power could not be obtained from the site. For study purposes, it should be estimated from the corresponding selling price, multiplied by a factor of 0.7 to account for distribution and marketing costs. Power exported should be valued at 14 mills/kWh at Anaco.

No market for excess steam was identified at the Anaco site, because of the following:

- The existing or planned expansion of the San Joaquín Extraction Plant is based on hot oil process heating, and hence has no need for steam.
- The oil producing fields in the Anaco district do not use steam injection for secondary recovery.

6.3.2.7 New Infrastructure Requirements

The following facilities and incremental investment in infrastructure would be required:

- Investment and operating cost of water supply from wells together with the corresponding water treatment plant.

- Pumping plant and wells for reinjecting excess water underground.
- Since no use is foreseen for steam, export of energy must only be in the form of electricity.
- If a GTL plant is geared only to syncrude production, a new 110 Km long pipeline to the export terminal at Jose will be required.
- If a GTL plant is geared to produce a range of high quality products, then the following will be required:
  - New individual 110Km lines for specific high production rate products.
  - Land transportation, by truck, of lower production rate products. The cost of trucking liquids, from Anaco to Jose, currently (September 1999) is 3,240 Bs/1000 Liters. Typical tank trucks carry 40,000 Liters.A multiple product trunkline could also be considered as an option.
- Additional storage tank capacity at the marine terminal, together with pumping and transfer facilities.
- Costs of interconnections and modifications to an export pier at Jose.

6.3.3 Güiria

The site analysis and evaluation of the Güiria site follows. The data and related information are for the area close to the location of the future LNG plant. The site is located approximately 6 Km northeast of the city of Güiria, near the Gulf of Paria coastline in the state of Sucre. Some geographic and general site information was taken from data related to the nearby TAP (Terminal de Aguas Profundas) Project, currently on hold.

6.3.3.1 Geographic Information

6.3.3.1.1 General Description of Terrain.

The selected area for the future LNG Plant is relatively flat, undulated, with medium sloped terrain (towards the sea), located besides the seashore. This area has medium to light vegetation, mostly arid.

6.3.3.1.2 Elevation of the Area.

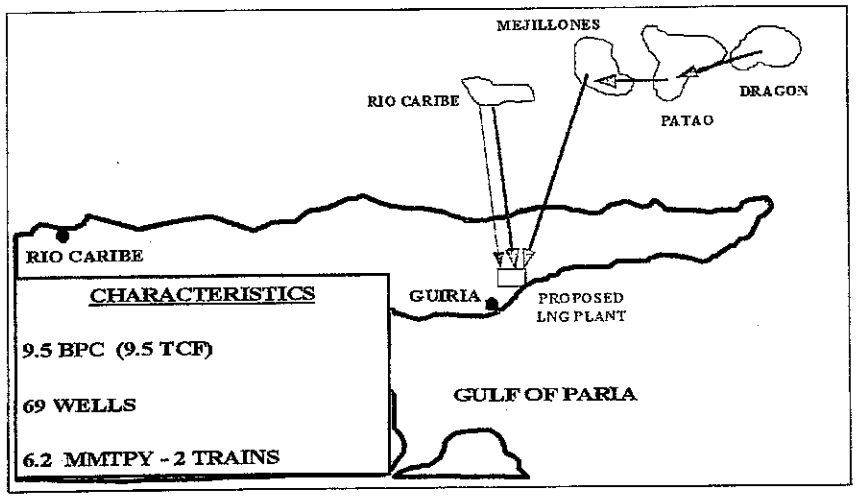
From + 45 m inland (northern edge) sloping towards + 1 m at the coastline (southern edge). The mean elevation can be assumed to be +15 m above sea level.

6.3.3.1.3 Availability and Cost of Land.

PDVSA has already bought land for the TAP project, with ample space available for other needs. Although land has not yet been bought for the LNG Project, there is also ample space available. Current (September 1999) cost is 400 Bs/m^2 (0.64 US$/square meter), undeveloped.

No coordinates of the LNG site are available yet. For a general location of the area, see Figure 6-4.

Fig. 6-4 General Location for the LNG Project



6.3.3.1.4 Ambient Conditions.

Temperature (dry bulb):

- Maximum : 31.8 °C

- Mean : 27.2 °C

- Minimum : 22.8 °C

Summer maximum relative humidity is100%.

Mean annual rainfall of 970 mm.

Prevailing winds are from the East and the Northeast.

Design wind load and exposure, per ASCE 7-93:

- Basic wind speed of 83 Km/hr.

- Exposure type D.

6.3.3.2 Geotechnical Data

6.3.3.2.1 Qualitative Description of Soil.

On the surface (1 m to 2 m), sandy clays of medium plasticity, followed by very dense clays of high plasticity (but non-expansive, due to high soil humidity and presence of cracks).

6.3.3.2.2 Site Preparation Requirements.

Due to the presence of potentially expansive clays, replacement of the first 1,5 m with proper granular material, will be required. Because of sloping terrain, heavy terracing, with imported fill, will be needed. Most structures could then be supported on shallow foundations, with deep foundations or piling only for very heavy structures.

6.3.3.2.3 Soil Bearing Pressure.

According to the previous soil survey made for the TAP project site [4], can use 3 Kg/cm^2.

6.3.3.2.4 Availability of Sand and Gravel.

Completely dependent on imports, from a long distance, due to lack of granular material in the area.

6.3.3.2.5 Drainage Characteristics.

Very good drainage.

6.3.3.2.6 Water Table Depth.

No groundwater detected in soil exploration borings, up to 20 m below grade.

6.3.3.2.7 Seismicity.

According to Venezuelan COVENIN 1756 code: Zone 7 (highest), with acceleration of 0.40 g.

6.3.3.3 Construction Issues

6.3.3.3.1 Heavy Construction Equipment Sources.

Güiria has few construction companies, only for light work.

6.3.3.3.2 Labor.

Güiria is the nearest town, but lacks an experienced construction workforce, which must be imported from other parts (Barcelona or Anaco). The labor rate is 50 % higher than that at Jose, due to premiums and extras, giving a value of 30.8 US$/hour (including light equipment and tools). A labor camp at the site, with full facilities, will have to be provided.

6.3.3.3.3 Construction Dock and Transport to Site.

The port of Güiria is only suitable for light cargo and mostly handles fishing boats. As part of the TAP project, a construction dock suitable for shallow draft RORO ships is contemplated. The LNG Project is also slated to have its own construction dock, to be built according to its special needs, that could be used by the GTL Project. Thus, no limitations are foreseen, using special transporters, since the dock will be adjacent to the site.

6.3.3.4 Available Infrastructure and Related Facilities

6.3.3.4.1 Roads.

Connected by a national road to Caripito and the rest of Sucre State, but not as good as the one to Anaco. This road passes near the TAP site before reaching the city of Güiria. The LNG site is not yet connected by road.

6.3.3.4.2 Crude or Product Pipelines.

No crude or product pipelines currently reach or originate from Güiria or environs. However, as part of the suspended TAP Project, a 36"-diam. crude oil pipeline will connect the Caripito tank farm, with the new facilities (tank farm and marine export terminal) at Güiria. This pipeline will traverse marshes and also have a submarine segment.

6.3.3.4.3 Shipping Facilities.

Except for the port in the city of Güiria, there are currently no suitable shipping facilities to handle crude or products. Once the TAP Project is reactivated, new shipping facilities will be available to export crude oil (to be received from Caripito via pipeline, or from Pedernales via barge), through new piers that could handle tankers up to 150,000 DWT. The LNG Project also plans to have its own shipping facilities for LNG export.

6.3.3.4.4 Proximity to Existing Process Plants.

There are no process or related facilities in the area at the present time. Initial plans are to reactivate the TAP Project crude oil terminal. For the "long term", plans are to also reactivate the LNG Project.

6.3.3.5 Utilities

6.3.3.5.1 Proximity to Electric Power Grid.

Presently, the supply and reliability of electric power in the area has serious limitations. Supplying any new demand in the area, will require the use of on-site generation (which was also selected for the TAP Project, using gas turbines). The LNG Project also plans to use on-site power generation, so some synergy opportunities exist.

For the "long term", it is estimated that the city of Güiria and surroundings will develop an electricity demand greater than 50 MW.

Price of electricity was not available, but would correspond to one provided by self-generation, estimated at 30 mills/kWh.

6.3.3.5.2 Utilities - Water.

There is a serious shortage in the supply of raw water, due to the lack of groundwater sources and the arid climate. The TAP Terminal was only planning a small use for service water from one or two wells. The LNG Project personnel are considering the use of desalted seawater for their makeup water needs, with once-through seawater cooling to complement their basic air cooling use. Thus, there is an opportunity for synergy, if the corresponding designs could be coordinated. No price for raw water could be provided, since it would be based on the investment and operating costs of a desalting plant.

6.3.3.5.3 Disposal of Liquid Wastes.

As at the Jose site, after proper treatment, excess waste water would be discharged to the sea.

6.3.3.6 Synergy Opportunities

The Güiria site is barren and currently has no support facilities or infrastructure. PDVSA have approved an offshore project to produce non-associated gas, convert it to LNG, and export it in that form. The current design concept is based on using gas turbines as compressor drivers. Air cooling will be maximized and used together with once-through seawater cooling.

Possible synergy aspects of the LNG project with a large capacity GTL plant should be evaluated on the following issues:

- Develop common support facilities and infrastructure including power grid, ship loading, water supply (desalination), other utilities, telecommunication, roads etc.
- Gas treatment facility.

- Export of power and steam from the GTL plant to the LNG plant. If designs could be coordinated, an excellent opportunity exists to use by-product electricity from the GTL plant to cover the large power needs of the LNG plant, optimizing both projects.

- A buying price for export of electricity, could not be obtained from the site. As mentioned before, for study purposes it will be estimated, in this case, from typical values corresponding to self-generated power (perhaps around 21 mills/kWh).

- Common marine facility. Some synergy could be realized with the TAP Project for common use of the marine pier to export the products from the GTL plant. The marine pier would have to be extended and provided with dedicated loading arms for GTL products. However there would be some cost savings on the common access to deepwater.

- Use of waste heat from the GTL plant for sea water desalination.

6.3.3.7 New Infrastructure Requirements

The infrastructure requirements for a GTL plant in Güiria will be typical for a grassroots facility of its size, including offsites, tankage and dedicated marine pier (considering the diversity and volume of products to be handled). It will take advantage of its location near the coastline to use seawater as cooling medium or raw water source.

If the GTL and LNG Projects are developed together, savings and synergy will be realized through complementary uses of electric power, steam and raw water. The access infrastructure to the deepwater piers (separate for each one) could be shared.

If the GTL plant is developed as an independent project, it would have to justify the charges for:

- A desalting plant to provide the raw water supply,

- Facilities to export excess energy as electricity to the national grid,

- Laying an interconnecting line to the city of Güiria.

As mentioned before, some savings could be realized in the total cost of the marine pier, if the GTL plant is located near the TAP facilities.

6.3 SUMMARY TABLE

Table 6-1 summarizes the information for the three sites.

Table 6-1 **Summary of Site Information**

ASPECT		JOSE SITE	ANACO SITE	GÜIRIA SITE
GEOGRAPHIC	General Location	Seashore, 30 Km West of Barcelona	Inland, 110 Km South East of Jose	Seashore, 6 Km Northeast of Güiria
	Particular Location	Inside Jose Industrial Complex (JIC)	Adjacent to San Joaquín NGL Extraction Plant	Adjacent to future LNG Plant
	Terrain	Flat	Flat, with small hills	Flat, sloped to the sea
	Mean Elevation	+ 10 m asl	+ 153 m asl	+ 15 m asl
	Land Availability	Ample, at lots S-9 to S-13	Ample	Ample
	Cost of Land	8.00 US$/m2 (developed)	400 Bs/m2 (undeveloped)	400 Bs/m2 (undeveloped)
	Basic Wind Speed	85 Km/hr	90 Km/hr	83 Km/hr
	Wind Exposure Type	D	C	D

(Table to be continued on next page)

Table 6-1 **Summary of Site Information** (Cont'd)

ASPECT		JOSE SITE	ANACO SITE	GÜIRIA SITE
GEOTECHNICAL	Particular Problems		Expansive clays	Import of sand & gravel
	Bearing Pressure	2.0 Kg/cm2	1.5 Kg/cm2	3.0 Kg/cm2
	Drainage	Poor	Very good	Very good
	Water Table Depth	Shallow	Deep	Deep
CONSTRUCTION	Seismicity	Zone 6, acceler: 0.35 g	Zone 5, acceler: 0.30 g	Zone 7, acceler: 0.40 g
	Availability	Very good	Good	Poor, need labor camp
	Labor Rate	20.5 US$/hr	24.6 US$/hr	30.8 US$/hr
	Dock	Yes, two	No	Future
	Inland Transport		Limited to 350 MT	

(Table to be continued on next page)

Table 6-1 **Summary of Site Information** (Cont'd)

ASPECT		JOSE SITE	ANACO SITE	GÜIRIA SITE
AVAILABLE INFRASTRUCTURE	Roads	Very good, including highway	Good national road from Jose and Barcelona	National road to Caripito
	Shipping Facilities	Various, at Condominium	None	Future TAP Terminal
	Intercon. Pipelines	To PLC Refinery	None useful	None
	Other Process Plants	Many, at JIC	San Joaquín NGL Plant	Future LNG Plant
UTILITIES	Electricity Supply	Ample, from EDELCA	Currently limited	Use of on-site generation
	Cost of Electricity	20 mills/KWH	20 mills/kWh (future)	30 mills/kWh (future)
	Water Source	Outsourced (reservoir)	Wells	Use of desalted seawater
	Water Availability	Ample and pre-treated	Very limited, crude	According to design
	Water Cost	0.52 US$/$m^3$	0.70 US$/$m^3$	Desalted water cost
	Cooling System Type	Circulating (cooling tower)	Maximization of air cooling	Seawater once-through
	Liquid Waste Disposal	To the sea	Injected underground	To the sea

(Table to be continued on next page)

Table 6-1 **Summary of Site Information** (Cont'd)

ASPECT		JOSE SITE	ANACO SITE	GÜIRIA SITE
SYNERGY OPPORTUNITIES	Market for Electricity	Yes, at 14 mills/KWH	Yes, at 14 mills/KWH	Yes, at 21 mills/KWH
	Market for Steam	Yes, at 8.00 US$/Ton	No	Yes, at LNG Plant
	Market for Water	Limited, at 0.42US$/$m^3$	Limited, at 0.56 US$/$m^3$	Yes, at LNG Plant
	With Adjacent Plants	Yes, PDVSA Gas, PLC Refineries, METOR and FertiNitro	No	Yes, with TAP Terminal (for marine pier) and LNG Plant
NEW INFRASTRUCTRE	Product Pipelines	Short, inside JIC	New, 110 Km long	Short, to pier
	Marine Pier	Modify existing pier	At Jose	New or shared with LNG
	Other	Minimum, since basic facilities exist at JIC	Water supply wells, treatment, waste injection, pumping	Grassroots, with desalting plant

(Table to be continued on next page)

Table 6-1 **Summary of Site Information** (Cont'd)

ASPECT		JOSE SITE	ANACO SITE	GÜIRIA SITE
EVALUATIONS	AVANTAGES	Existing, well developed infrastructure of roads, harbors, ample water and utilities systems. Seashore location with access to export markets. Highest opportunities for synergy with adjacent process plants at the JIC. Nearby PLC Refineries. Proximity to NGL Plant (Fractionation).	Lowest cost of gas feed.	Stable, "long term" gas supply (non-associated). Seashore location with access to export markets. Ideal synergy opportunity with LNG Plant. A bigger plant could have greater range of products.
	DISADVANTAGES	Limited need for excess water, other than watering green areas in the JIC. Must use circulating cooling tower system.	Very limited synergy opportunities, confined to exporting electricity. Due to inland location, requires new product pipeline(s) to Jose. Limited water supply, sourced from wells. Maximization of air cooling. Limitation in movement of heavy equipment over inland roads.	Project must be vertically integrated, with other costs involved. Highest cost of gas feed. Profitability could be sensitive to LNG Project.

PDVSA

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