



*ASSESSMENT OF ENVIRONMENTAL IMPACT  
AND INDUSTRIAL SAFETY IN  
DEVELOPMENT WELLS  
PALAGUA – CAIPAL FIELD  
PUERTO BOYACA (BOYACA, COLOMBIA)*



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**Bogotá D.C., Colombia – 2010**



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## EXECUTIVE SUMMARY

### A. DESCRIPTION OF THE PROJECT



The project "DEVELOPMENT WELL DRILLING IN PALAGUA-CAIPAL FIELD" is located in the municipality of Puerto Boyacá (Boyacá). The project is framed within the concept of petroleum development extraction in the region, helping to improve the quality of life of the inhabitants of the municipality of Puerto Boyacá, especially the resident population in the area adjacent to the Palagua – Caipal Field.

## A.1 CHARACTERISTICS OF THE PROJECT

### A.1.1 TECHNICAL DESCRIPTION OF THE PROJECT



**Figure 1 Drilling Activities Palagua-Caipal Field**

UT-IJP became the Palagua field operator in 2001. Since then, various activities such as rehabilitation of oil wells, drilling, and the application of production technologies have enhanced the field oil production rates from 2500 barrels of oil per day in 2001 to 5,000 barrels per day in March 2010.

## A.1.2 LOCATION OF THE PROJECT

The Palagua production field is located 30 kilometers away from the municipality of Puerto Boyacá, Boyacá (Department / State), in the basin of the Middle Magdalena Valley, about 7 km east of the Vasconia Station of Empresa Colombiana de Petroleos, ECOPETROL SA, at a height of 137 meters above sea level.



**Figure 2 General Location of Palagua – Caipal Field**

### SPANISH TO ENGLISH TRANSLATION KEY:

|                                |                      |
|--------------------------------|----------------------|
| <u>Top map:</u> Campo Palagua: | Palagua Field        |
| Pto Boyacá:                    | Puerto Boyacá        |
| Dpto. De Boyacá:               | Department of Boyacá |

#### Bottom map:

*\* Left hand side:*

|                    |                     |
|--------------------|---------------------|
| Troncal de la Paz: | Main road de la Paz |
| Estación Vasconia: | Vasconia Station    |
| Campo Teca:        | Teca Field          |
| Campo Cocorná:     | Cocorná Field       |
| Río Magdalena:     | Magdalena River     |

*\* Right hand side:*

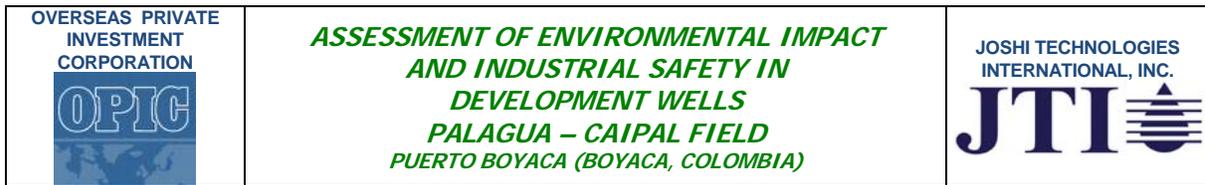
|                          |                         |
|--------------------------|-------------------------|
| Zona Industrial Palagua: | Palagua Industrial Area |
| Est. #:                  | Station #               |
| PIA:                     | Water Injection Plant   |
| Bat. #:                  | Battery #               |
| Ciénaga de Palagua:      | Palagua Marsh           |
| Sendero:                 | Path                    |
| Estación Velázquez 26:   | Velázquez Station 26    |
| Batallón Bárbula:        | Bárbula Battalion       |
| Zona Industrial Omimex:  | Omimex Industrial Area  |
| Aeropuerto:              | Airport                 |

The project involves the drilling of development oil wells of directional type to reach areas of the site that have not been drained by existing wells. The proposed drilling locations of the development wells of the Palagua – Caipal Field are listed below:

**Table 1 Coordinates of new development wells**

| Coordinate System: Gauss-Kruger<br>Bogota<br>Geographix Project: Palagua (N&E)<br>Data: Bogota Observatory |          |         |          |               |       |       |      |
|--|----------|---------|----------|---------------|-------|-------|------|
| #  | Name     | Y       | X        | Drill Site(s) |       |       |      |
| 1  | P-222    | 1165264 | 951999   | P-220         | P-185 |       |      |
| 2  | NWP13    | 1165588 | 952284   | P-104         | P-133 |       |      |
| 3  | C-15     | 1170095 | 954093   | C-9           |       |       |      |
| 4  | C-14     | 1170157 | 953828   | C-9           | C-6   |       |      |
| 5  | C-17     | 1169778 | 953890   | C-6           |       |       |      |
| 6  | NWP17    | 1164504 | 952364   | P-27          | P-115 | P-157 |      |
| 7  | P-223    | 1163920 | 951544   | P-175         |       |       |      |
| 8  | NWP39    | 1167136 | 951798   | P-43          | P-142 | P-46  |      |
| 9  | NWP35    | 1167101 | 952187   | P-142         |       |       |      |
| 10   | NWP12    | 1165748 | 952310   | P-104         |       |       |      |
| 11   | NWP11    | 1165724 | 952485   | P-133         |       |       |      |
| 12   | NWP41    | 1167084 | 951586   | P-43          | P-46  | P-137 | P-40 |
| 13   | N017W010 | 1162637 | 952091.2 | P-10          | P-1   |       |      |
| 14   | N020W116 | 1162687 | 951841   | P-196         | P-18  |       |      |
| 15   | N021W116 | 1162887 | 952041.1 | P-201         | P-18  |       |      |
| 16   | N034W186 | 1163853 | 951309.1 | P-206         | P-140 |       |      |
| 17   | N045W155 | 1165336 | 950991.2 | P-210         | P-31  |       |      |
| 18   | N116W109 | 1167286 | 951840.7 | P-142         | P-46  |       |      |
| 19   | N143W109 | 1166736 | 950691   | P-123         | P-189 |       |      |
| 20   | N149W145 | 1167335 | 950586.3 | P-41          | P-135 |       |      |
| 21   | N153W145 | 1168536 | 950490.9 | P-146         | P-148 |       |      |
| 22   | N155W145 | 1168786 | 950741.2 | P-148         | P-113 |       |      |
| 23   | N197W155 | 1166037 | 951540.6 | P-141         | P-71  |       |      |
| 24   | N202W062 | 1164265 | 952123.4 | P-172         | P-169 |       |      |
| 25   | N203W062 | 1164037 | 952141   | P-169         | P-52  |       |      |
| 26   | N210W116 | 1162387 | 951890.6 | P-138         | P-201 |       |      |
| 27   | N211W116 | 1162237 | 951991.2 | P-138         | P-202 |       |      |
| 28   | N215W010 | 1162137 | 952290.7 | P-139         | P-138 |       |      |
| 29   | N219W155 | 1166137 | 951068.8 | P-32          | P-95  |       |      |
| 30   | N222W155 | 1165986 | 951091.3 | P-32          | P-212 |       |      |
| 31   | N233W155 | 1165436 | 951591.4 | P-30          | P-29  |       |      |
| 32   | N259W155 | 1167407 | 951789.8 | P-142         | P-46  |       |      |
| 33   | N269W116 | 1163428 | 952528.4 | P-106         | P-13  |       |      |
| 34   | N271WCPL | 1170777 | 954180.6 | C-9           | C-14  |       |      |
| 35   | N272WCPL | 1169766 | 953883.7 | C-6           | C-12  |       |      |
| 36   | N275W186 | 1165227 | 952326.4 | P-82          | P-157 |       |      |
| 37   | N284W155 | 1166474 | 952431.2 | P-49          | P-48  |       |      |
| 38   | NWP8     | 1166235 | 951760   | P-53          | P-34  |       |      |
| 39   | NWP31    | 1163077 | 952713   | P-2           | P-203 |       |      |
| 40   | NWP4     | 1166699 | 952346   | P-49          | P-48  |       |      |

(1) Field Data gathered with GPS Garmin map, Origin Coordinates Bogotá



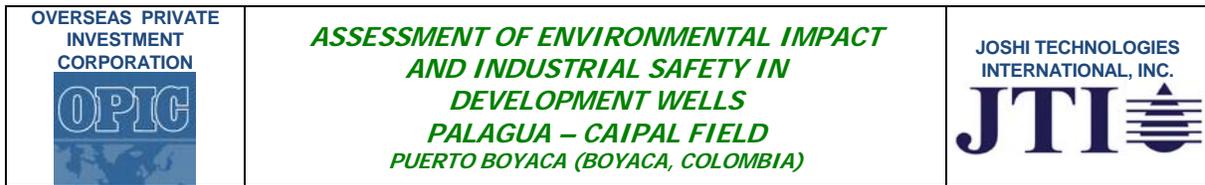
The project involves the drilling of forty (40) (directional) development wells to reach areas of this site that have not been drained yet by the existing production (drilled) wells. The drilling of these development oil wells at the Palagua Field requires a series of activities to be undertaken sequentially in several steps.

The sequential order of activities for the drilling of each one of the wells is as described in the following table:

**Table 2 Activities during drilling**

| ACTIVITY                              | DESCRIPTION  |
|---------------------------------------|--|
| Selection of the project area         | <ul style="list-style-type: none"> <li>• According to oilfield and geologic studies.</li> <li>• Low environmental impact area.</li> <li>• Easy execution of civil work according to topography.</li> </ul>   |
| Environmental Development Plan - EDP  | <ul style="list-style-type: none"> <li>• Drafting of the document and respective management before the Environmental Authorities (CORPOBOYACÁ and MAVDT)</li> </ul>  |
| Road Improvement                      | <ul style="list-style-type: none"> <li>• Improvement of the road to comply with technical specifications using motor graders.</li> <li>• Stabilization and compacting of the road using road rollers and compacters.</li> </ul>  |
| Terraplain building                   | <ul style="list-style-type: none"> <li>• Movement of land to re-level the soil.</li> <li>• Load-bearing capacity tests.</li> </ul>   |
| Equipment transport and installation  | <ul style="list-style-type: none"> <li>• Rig, drilling equipment, control equipment and storage of solids, cementation equipment, electrical recording equipment, electrical generator, mud pumps, pipelines.</li> </ul>   |
| Drilling                              | <ul style="list-style-type: none"> <li>• Drill to the depth where according to the design of the well the surface casing will set.</li> <li>• Take out the drilling pipes.</li> <li>• Cementation of the surface casing.</li> <li>• Continue drilling to the desired depth.</li> <li>• Take electrical records to identify the interval of the productive formation and the inter-phase level.</li> <li>• During the whole drilling period the drilling cutting are treated and dehydrated and the mud residues is treated to recover products and improve the quality of the liquid waste to be sent to the Water Injection Plant.</li> </ul> |
| Equipment dismantling                 | <ul style="list-style-type: none"> <li>• Dismantling of the equipment used in the operation.</li> <li>• Final disposition of the drilling cuttings.</li> <li>• Mud Residue disposal.</li> </ul>  |
| Well completion                       | <ul style="list-style-type: none"> <li>• Cementation of the casing.</li> <li>• Seat the shoe to for securing the casing.</li> <li>• Open by perforating the productive interval.</li> <li>• Install the artificial lifting system (PCP Pumping).</li> <li>• Install pressure control devices.</li> </ul>   |
| Connection to existing infrastructure | <ul style="list-style-type: none"> <li>• Installation and laying of the production lines from the well to the nearest collector.</li> </ul>  |

Source: UT-IJP



- **PRELIMINARY STAGE**

This stage locates the area where the project will be executed based on biotic, geological, social, and stratigraphic criteria. It also includes the development of the Environmental Mitigation Plan provided in the Environmental Management Report, submitted to the Competent Environmental Authorities of the Colombian Government.

- **IMPROVEMENT ACTIVITIES**

This stage of the project includes the improvement of the existing roads for the transportation of machinery and other equipment required for drilling. It specifies to build well locations strong enough to bear the load of drilling rig equipment. It also includes construction of perimeter channels to handle storm water.

- **INSTALLATION OF DRILLING EQUIPMENT**

At this stage the drilling rig and other equipment are erected and installed, along with installation of tanks for solid waste management and production tests.

- **OPERATION, CLOSURE, AND ABANDONMENT STAGE**

This stage involves the drilling activities from the start of the operation to reaching the desired drilling depth. Then, it is followed by dismantling of the drilling rig to continue the task of completing the well, connecting the production tubing from the well to the existing infrastructure, treatment of mud and drill cuttings outside the location, and finally the recovery of the area.

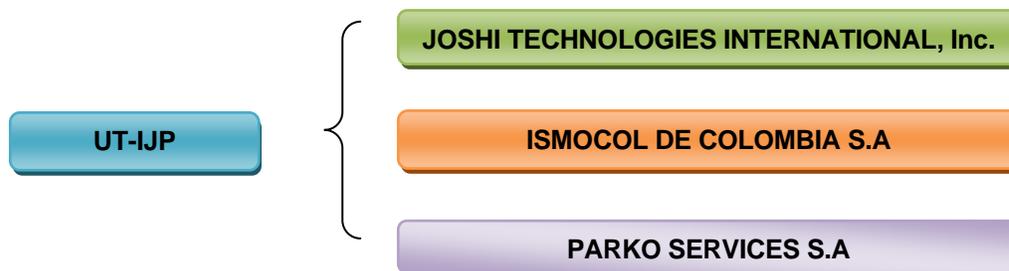
**- CONCLUSIONS**

*According to the field visit, the areas selected for the drilling of the development wells do not require large movements of earth or forestry management (cutting or removal of species - forestry), or water sources involving a complex environmental management.*

*The Oil Field Palagua - Caipal has an extensive road infrastructure both internally and externally. Regular maintenance is carried out to facilitate access to selected areas. Therefore, the area does not require construction of new roads since development wells will be drilled from the existing locations with good access roads.*

## B. IDENTIFICATION OF THE HOSTS, OPERATORS, AND CONTRACTORS

The Union Temporal (UT-IJP) consists of the following companies:



The companies that are members of the Union Temporal (UT-IJP) will make the following contributions:

- a) **JOSHI TECHNOLOGIES INTERNATIONAL, Inc.:** Will provide the technology, the knowledge and the design of the well stimulation, the Work-over, the design and completion of wells, the geological and oilfield studies, will take part in the management of oil and gas production activities of the field, will assist with the management of the project, the engineering, the operation and the supply and management of purchases, will act as co-operator, will also provide training services, supplies and R&D (research and development) functions.
- b) **ISMOCOL DE COLOMBIA S.A.:** Will provide logistic and the necessary infrastructure support for the execution and compliance with the CONTRACT, management of the project, engineering, operation of the field, the supply and management of purchases, the building, the services, the relationship with customers and other agencies. Ismocol has the following ISO certificates:

| Standard  | Valid even                     | Certification              |
|---|--------------------------------|----------------------------|
| ISO 9001:2000   | November 14 <sup>th</sup> 2010 | CO231235 by Bureau Veritas |
| ISO 14001:2004  | November 17 <sup>th</sup> 2012 | CO231236 by Bureau Veritas |
| OHSAS 18001:2007  | October 13 <sup>th</sup> 2011  | CO230762 by Bureau Veritas |
| <b>Ismocol Activities:</b><br>CONSTRUCTION, OPERATION AND MAINTENANCE OF OIL PIPE LINES AND GAS |                                |                            |

|  |   |   |
|--|---|---|
| <p>OVERSEAS PRIVATE<br/>INVESTMENT<br/>CORPORATION</p>  | <p><b>ASSESSMENT OF ENVIRONMENTAL IMPACT<br/>AND INDUSTRIAL SAFETY IN<br/>DEVELOPMENT WELLS<br/>PALAGUA – CAIPAL FIELD<br/>PUERTO BOYACA (BOYACA, COLOMBIA)</b></p> | <p>JOSHI TECHNOLOGIES<br/>INTERNATIONAL, INC.</p>  |
|--|---|---|

PIPELINES, COLLECTING LINES AND CONDUCTION IN GENERAL; CONSTRUCTION OF CIVIL WORKS, ELECTROMECHANICAL, INSTRUMENTATION SET-UPS AND IN GENERAL ALL THE WORKS OF INFRASTRUCTURE FOR THE AREA OF HYDROCARBONS AND BESIDES INDUSTRY'S SECTORS; CONSTRUCTION, OPERATION AND MAINTENANCE OF: OIL FACILITIES, INDUSTRIAL PLANTS, PETROCHEMICAL PLANTS, REFINERIES AND FACILITIES OF PRODUCTION; CONSTRUCTION OF TANKS; DRILLING EQUIPMENT SUPPLY OF OIL, GAS AND WATER WELLS AND SERVICE TO WELLS; ADMINISTRATION, OPERATION AND MAINTENANCE OF OIL FIELDS.

- c) **PARKO SERVICES S.A:** Will provide technical assistance and purchase management support necessary for the execution and compliance with CONTRACT.

In consideration of clause 4.19 of the CONTRACT UT-IJP is the project operator.

**Contractors:**

**HALLIBURTON**

An American company specialized in drilling, cementing, logging and other oil services.

**SCHLUMBERGER**

An American company specialized in electrical logging and gravel packing.

**ISMOCOL DE COLOMBIA**

A Colombian company specialized in construction, operation and maintenance of oil pipelines and gas pipelines and drilling equipment for the supply of oil and gas.

## C. ENVIRONMENTAL CONDITIONS BASE LINE

The project is located in the Rural Area Palagua, municipality of Puerto Boyacá, Boyacá Department, at 137 meters above sea level. The Palagua - Caipal oil field is approximately 7 km east of the Vasconia Station of the Empresa Colombiana de Petroleos, **ECOPETROL SA**.

### C.1 CLIMATIC ASPECTS

At the Palagua – Caipal oil field the annual average temperature ranges between 26 ° C and 31° C. Rainfall since 1989 holds an average of 2589 mm; the relative humidity in the area of influence of the wells under study varies throughout the year between 61% and 86%, and cloud presents an average value of 3 octas.

### C.2 SOIL, GEOLOGY, GEOMORPHOLOGY AND GEOTECHNICS



**Figures 1 and 2 Rocky outcrops**

The ground soils in the area have developed from clay and sandy material. The soil is characterized as shallow with fluctuating underground water level. In the Palagua – Caipal oil field, the organic layer is shallow and steep in some areas.

The hydro - geological behavior in the Palagua - Caipal Field is determined by the geomorphology of the terrain and its lithological composition, which determine the mechanical, physical, and hydraulic properties of the rock.

In the Palagua – Caipal oil field, there is an outcrop of sedimentary rocks of the Tertiary age to recent deposits, while in the underground the age of formations ranges from the Tertiary to Triassic – Jurassic periods.

The production area of the Palagua – Caipal oil field is located in the basin of the Middle Magdalena River Valley (VMM), in the foothills of the Eastern Cordillera. It is bound on the east by the faults of the Foothills of the Eastern Cordillera, and to the West by the faults of the Central Cordillera. The tectonic depression is molded throughout the area, mainly because of the tertiary period rocks, which present some over-thrusting with vertical dips in the high part, but in depth they are leaning toward the eastern side.

The project’s area is characterized by having the following geological faults:

- Mesa Formation (Tsm)
- Real Formation (Tmr)
- Colorado Formation (Toc)
- Mugrosa Formation (Tom)
- Esmeralda Formation
- La Paz Formation

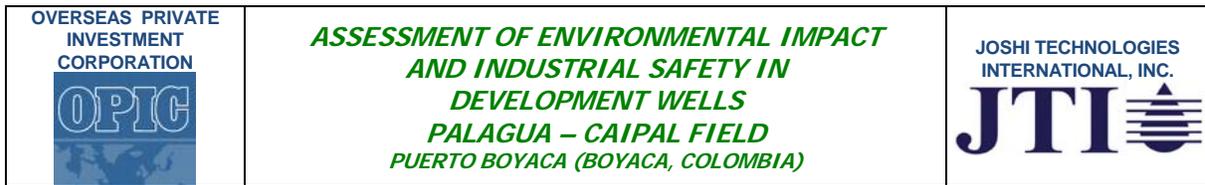
### C.3 VEGETATION



**Figure 3 Overview of existing vegetation in the Project area**



**Figure 4 Overview of existing vegetation in the Project area**



The population of flora is made up of trees and bushes arranged in narrow strips. It should be noted that the project's influence on this vegetation is low, because the direct involvement in the development of the activities does not impact the area. The area involved has no woody vegetation; it is an area with a covering of weed species and low stubble, or underbrush.

In the area of flooding lowlands (valleys), the vegetation is characterized by strips of fixed and floating macrophytes, reeds, and some shrub and woody species around the drains. Some associated species are: *Azolla polyrrhiza*, *Pistia sp.*, *Typha sp.*, *Bidens sp.*, *Eleocharis sp.* However, drilling locations are in the hilltop areas and not in valleys or lowlands.

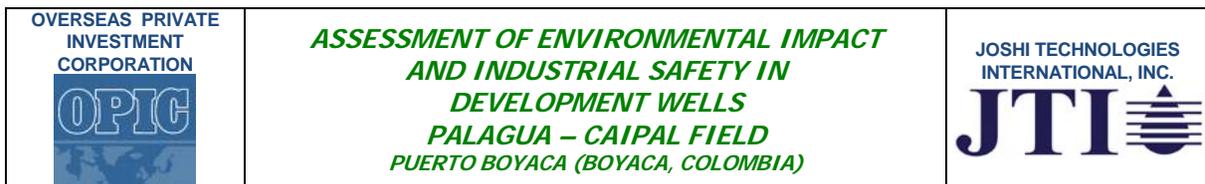
#### **C.4 USE, DEVELOPMENT AND ALLOCATION OF NATURAL RESOURCES**

During the execution of this work, the materials used are the soil resource, land covering material and water resource.

- **Water Resource:** All the water required for domestic use and industrial use shall be taken from PW-1 underground, 85 meter deep water well, located within the administrative area. The granting of groundwater was established by CORPOBOYACA by Resolution 463 of June 8, 2005. The estimated average consumption is of 0.3 liters per second.
- **Construction Material:** The material required for improving drilling locations will be acquired through commercial agencies located in Puerto Boyacá that have the corresponding environmental permit granted by the Regional Autonomous Corporation - CORPOBOYACÁ. Part of the material used will come from the area of former Station No. 3.
- **Forest Resource:** During the construction of locations, forest resources will not be affected, since the drilling of new wells will only use existing well locations.
- **Dumping:** During construction work, debris or refuse will not be generated; therefore, permit for the disposal of construction materials will not be required.

The wells will be drilled in previously existing locations and there will be no cafeteria for the employees at the location, hence, additional involvement of natural resources will be minimal.

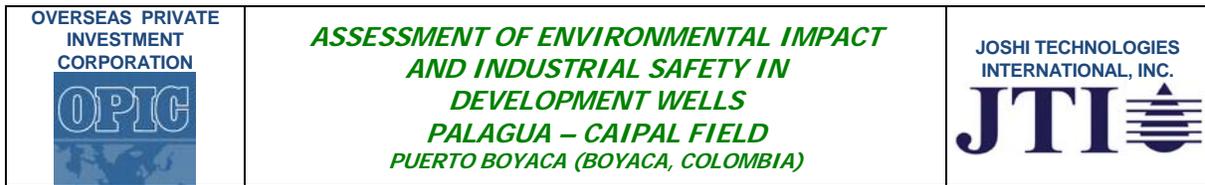
- **Liquid Industrial and Domestic Wastes:** These are formed mainly by runoff water (contaminated and uncontaminated), domestic wastewaters, industrial waters, and oily residues. Following is a description of each.
  - **Runoff water.** For the management of rainwater at the locations we have perimeter channels with sediment recollection and drainage structures in order to channel the



waters into the surrounding environment without affecting the current hydrodynamics. The rainwater that collects in the channels within the location will be lead to the oil trap and then to the Industrial Waste Water Treatment Plant (PIA) of the field.

- **Domestic Waters.** Water used in human activity such as bathrooms, kitchens and sinks is treated in a septic system which includes several tanks and filters. Approximately 150 gallons of domestic waste water is generated daily. This represents a minimum amount in comparison with the 11,000 barrels per day of produced water for oil wells in the Palagua-Caipal field.
- **Industrial Waters.** It is the liquid that comes from the residual mud and water from separation of cutting and drilling fluids. These waters are directed into the tanks where coagulant chemicals, flocculants and clarifiers are injected enhancing water separation. Then water is pumped to a sedimentation tank from where it is collected with the vacuum truck and then disposed of in the Waste Water Treatment Plant (API) of the field. The waste water plant injects all the produced water back into the formation from which it came at a depth of about 4000 ft.
- **Residual Waste Oils:** They are composed mainly of oil burned in the various engines of the equipment; these will be stored on location in fifty-five (55) gallon drums, and then they will be transported to the dump site of the Palagua battery.
- **Dumping:** All domestic and industrial liquid waste shall be subjected to primary treatment at the location to subsequently be taken to the separation system at Battery No.1, and then taken to the Water Treatment plant of the Palagua Field. Therefore, no dumping permit is required for the drilling of development wells.
- **Domestic Solid Waste:** It is that produced in the project's offices as personal hygiene, and food waste, among others. These wastes are composed of cardboard, glass, food waste, paper and aluminum. Household waste is taken to the temporary storage site in the Industrial Area of the Palagua Field, and subsequently collected by Public Companies of Puerto Boyacá.
- **Industrial Solid Waste:** It is considered waste such as cuttings from the separation of the solids control equipment, and also waste or surplus product of the cementing, scrap metal, wood, filters, packaging and others from the maintenance of machinery and equipment.

Drilling cuttings and waste mud will be removed from the location to be stabilized with lime for dehydration and will be finally stabilized in the land farming area. The scrap metal will be taken to the storage yard for such types of waste located at the Palagua Battery. The contaminated soils will be transported for bioremediation in the land farming area. Oil-infused waste is stored in the existing collection area (dump site) in the Industrial Area of Palagua Field for subsequent shipping and incineration in the kilns of Holcim at Nobsa, Boyacá.



## **D. APPLICABLE ENVIRONMENTAL STANDARDS**

With respect to the Environmental Quality standards and guidelines at a national and international level (Environmental Health and Safety Guidelines from the World Bank for Onshore Operations), these are environmental management instruments that consist of parameters and obligations that aim to regulate and protect the public health and environmental quality. In the Palagua field, UT-IJP performs monitoring activities to measure the quality of the air, water and soil, to ensure that the company activities have not caused a health risk for the people that work in the company, or to the community near the project and the environmental impacts have been mitigated.

### **D.1 AIR QUALITY**

The results obtained in the Palagua-Caipal field were compared with Resolution 601 of April, 2006, (601/2006) fulfilling the standards established by the Ministry of Environment and Territorial Development (M.A.V.D.T in Spanish) and the Environmental, Health, and Safety (EHS) Guidelines of the World Bank – used by the International Finance Corporation (IFC).

The conclusions are:

- Out of the four monitoring stations, all of them comply with the annual local air quality standard and most of the levels reported in the Palagua field are low.
- We comply with Colombian regulations and IFC standards for nitrous oxide, sulphur dioxide, particulate material higher than 10 microns (PM 10), and ozone levels in the air.
- In general, air quality in the Palagua-Caipal field is good.

## D.2 WATER QUALITY

### D.2.1 DRINKING WATER

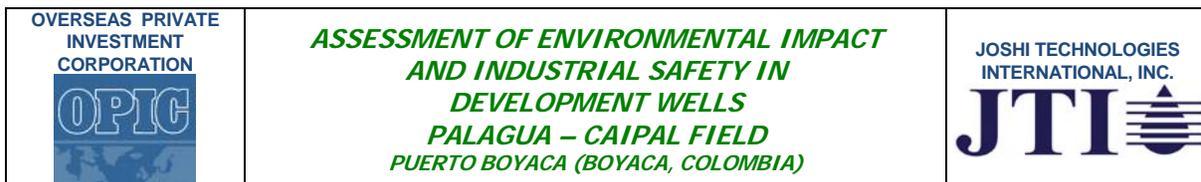
Samples of water used for domestic and industrial consumption were taken from the water wellhead PW-1 and storage tank outlet and tested by the laboratory ASINAL LTDA.

The following table show the results of the analysis.

Table 3 Physical – Chemical Analysis of water from water well PW-1 (88.5 meter depth)

| PARAMETERS                   | UNITS                     | TECHNIQUE OF ANALYSIS AND/OR EQUIPMENT USED | RESULTS AT THE TOP OF THE WELL | RESULTS AT THE POINT OF CONSUMPTION | MAXIMUM LIMITS Decree 475/98 |
|------------------------------|---------------------------|---|--------------------------------|-------------------------------------|------------------------------|
| pH                           | Units                     | pH meter                                    | 8.8                            | 8.7                                 | 6.5 – 9                      |
| Conductivity                 | µS/cm                     | Conductivity meter                          | 212                            | 211                                 | 50 - 1000                    |
| Total Alkalinity             | mg CaCO <sub>3</sub> / L  | Metric Title                                | 88                             | 79                                  | 100                          |
| Total Hardness               | mg CaCO <sub>3</sub> / L  | Metric Title                                | 16                             | 10                                  | 150                          |
| Turbidity                    | NTU                       | Nephelometric                               | 1                              | 1.1                                 | < 5                          |
| Total Solids                 | Mg / L                    | Gravimetric                                 | 114                            | 109                                 | < 500                        |
| Total Dissolved Solids – TDS | mg/L                      | Electrometric                               | 111                            | 109                                 | Not Rated                    |
| Total Suspended Solids       | Mg/L                      | Dried Filtration at 105 °c                  | 3                              | <1                                  | Not Rated                    |
| Real Colour, Hazen Units     | Hazen Units (Pt-Co)       | Colorimeter                                 | 5                              | 5                                   | < 15                         |
| Chlorides                    | Mg Cl - / L               | Conductivity meter                          | 5                              | 7                                   | 250                          |
| Nitrites                     | Mg NO <sub>2</sub> - / L  | Spectrometer UV                             | < 0.01                         | < 0.01                              | 0.03                         |
| Phosphates                   | Mg PO <sub>4</sub> -3 / L | Spectrometer UV                             | 0.02                           | 0.04                                | Not Rated                    |
| Sulphates                    | mg SO <sub>4</sub> -2/ L  | Spectrometer UV                             | 1                              | 1                                   | 250                          |
| Total Iron                   | mg Fe +++/ L              | 3500- B S. M. 21 ST Editions                | 0.28                           | < 0.01                              | 0.3                          |
| Total Coli forms             | UFC/100 cm <sup>3</sup>   | Filtration through membrane                 | 0                              | 0                                   | 0                            |
| Escherichia coli.            | UFC/100 cm <sup>3</sup>   | Filtration through membrane                 | 0                              | 0                                   | 0                            |

As the table shows, the well water meets all the environmental guidelines as issued in the Decree 475 from the Health Ministry on March 10, 1998, as well as those for the International Finance Corporation (IFC) and the World Health Organization (WHO) Guidelines for Drinking-Water Quality.



## **D.2.2 SURFACE WATER IN PALAGUA LAKE**

In July 2001, the National Oil Company ECOPETROL handed over the Palagua and Caipal oil fields to UT-IJP for their operation under an incremental production contract. The field was operated by Texaco from 1957 onwards. Thus, Ecopetrol and Texaco operated the Palagua Caipal field from 1957 till 2000.

Prior to taking over the field, UT-IJP conducted an environmental base study. One of the important conclusions of 2000 Environmental Base line study was that Lake Palagua was polluted and lacked oxygen in water. To this effect, Ecopetrol took over the responsibility of correcting the situation. As per the agreement between Ecopetrol and UT-IJP, it is Ecopetrol's responsibility to pay for and arrange to remedy environmental damage, if any, prior to the year 2000. The lack of oxygen in the lake water was due to the presence of a plant called "Tarulla." Since 2004 and onward, Ecopetrol removes these plants from the lake. This has resulted in an increase in oxygen in the lake water and fish have returned to the Lake.

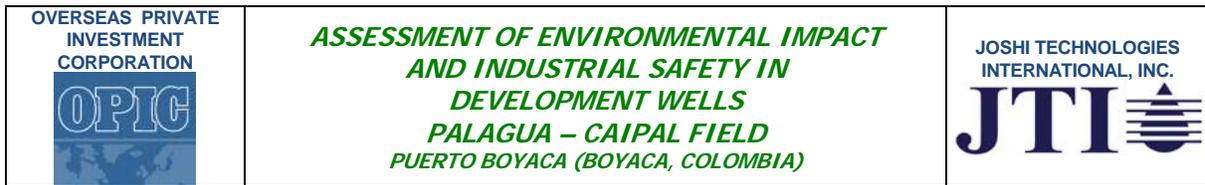
Thus, there is a significant improvement in the quality of lake water from the year 2001 to 2010. Additionally, the Palagua Lake water will not be affected by drilling of the proposed additional 40 wells.

## **D.2.3 UNDERGROUND WATER**

In the year 2000, prior to UT-IJP (Ismocol, Joshi, Parko) taking over the field, Colombian Environmental Ministry asked Ecopetrol to install ground water monitoring stations and correct the ground water problems, if any. To comply with the order, Ecopetrol has installed 19 monitoring shallow wells (3 to 4 meters deep) to monitor ground water. Some of the problems found have been fixed by Ecopetrol over time. In the last 10 years there is a significant improvement in the ground water quality.

Most of the ground water problems were found near battery No 1, where there was a spill and a fire in 1996. There are ground water monitoring stations in the Battery No1. Two stations out of three stations now are free of any hydrocarbons.

Additionally, most of the measurement stations show no damage due to BTEX (benzene, toluene, ethylbenzene, xylenes) or phenols. In general, due to Ecopetrol's efforts, the quality of the underground water has improved significantly in the last 10 years. Additionally, drilling of the proposed development wells would have no effect on this underground water.



### **D.3 SOIL QUALITY**

Due to previous hydrocarbon operations in the field, the Colombian Petroleum Institute (ICP from Ecopetrol) provides the technical advice for the land farming of this field. ICP performed a physic-chemical characterization of the soil.

The soil in the Palagua Field was evaluated according to the legislation in the Louisiana Administrative Code, Natural Resources, Subsection 1, state-wide Order No. 29b. This norm contains the requisites for in-situ storage, treatment, and disposal of non-hazardous residues.

The conductivity and concentrations of grease, oil, and metals (silver, arsenic, barium, cadmium, lead, selenium, zinc and mercury) in the monitored soil in Campo Palagua are below the permitted limits in the Louisiana norm.

The pH levels in the site samples are slightly outside the range as per the Louisiana norms. In general, the soil in the area is of an alkaline nature.

### **D.4 NOISE**

The monitoring of environmental noise in the Production Area of PALAGUA FIELD corresponding to possible noise emission sources during production and operation show:

- Readings from all location points monitored during the daytime measurements in a work day and during a holiday comply with the maximum limit established in Resolution 627/06 article 17 SECTOR C: restricted medium noise. Only at the water treatment plant, the value is slightly higher when compared with the IFC guidelines.
- At some of the location points monitored, during the night time noise measurements, values that exceed the maximum limit established in resolution 627/06 article 17 SECTOR C: (restricted medium noise) and the IFC guidelines are shown. However, this enhanced noise level is due to the presence of animals in the area.

## E. PROPOSED MITIGATION MEASURES

- The measures aimed at prevention, control, mitigation, recovery, and compensation of impacts that occur during project activities are presented in a series of components and programs that make up the Proposed Mitigation Actions (PMA). These components and programs are the result of the analysis of the impact assessment. Accordingly, the Environmental Management Plan is developed.

### E.1 GUIDELINES FOR THE EVALUATION AND MANAGEMENT RISK FOR OIL AND GAS DEVELOPMENT

The following table contains a summary of the the guidelines of the Environmental, Health and Safety Program that have been developed.

**Table 5 Summary of the Guidelines of the Environmental, Health and Safety Program**

| PROGRAM   | DOCUMENT REFERENCE NUMBER                    | ENVIRONMENTAL, HEALTH AND SAFETY MANAGEMENT GUIDELINES                            |   |
|---|--|---|---|
| COMPREHENSIVE PROGRAM OF EVALUATION AND MANAGEMENT OF RISKS AND SPECIFIC POTENTIAL IMPACTS OF THE PROJECT | 6.5.1  | Assessment and management of risk and potential impacts of emissions into the air |   |
|   | 6.5.2  | Wastewater discharge management – Effluents                                       |   |
|   | 6.5.3  | 6.5.3.1   | Solid waste management  |
|   |  | 6.5.3.2   | Liquid waste management   |
|   | 6.5.4  | Assessment and management of risk and potential impacts from noise generation     |   |
|   | 6.5.5  | 6.5.5.1   | Conformation and stabilization of slopes at the locations       |
|   |  | 6.5.5.2   | Environmental revegetation and recovery of the surrounding area |
|   | 6.5.6  | 6.5.6.1   | Environmental management of production testing                  |
|   |  | 6.5.6.2   | Waste management and pollution control                          |
|   | 6.5.7  | Assessment And Management Risk For Blow Out (Well Control Policy)                 |   |
| 6.5.8   | Measures for energy saving and efficient use |   |   |
| 6.5.9   | Water consumption measures                   |   |   |
| 6.5.10  | Water quality                                |   |   |

## E.2 GENERAL GUIDELINES ON ENVIROMENTAL HEALTH AND SAFETY

The table below contains a summary of the the guidelines of the Environmental Management Program.

**Table 6 Summary of Guidelines of the Environmental Management**

| SECTION                            | Number in the document | GUIDELINE OF ENVIROMENTAL MANAGEMENT  |
|------------------------------------|------------------------|---|
| SOCIAL MANAGEMENT                  | 6.4.1                  | 6.4.1.1 Information and communication guideline   |
|                                    |                        | 6.4.1.2 Guideline for hiring local work force   |
|                                    |                        | 6.4.1.3 Guidelines for education and training of staff of the work staff                            |
|                                    |                        | 6.4.1.4 Archeological information guideline   |
| ENVIROMENTAL                       | 6.4.2                  | 6.4.2.1 Guideline on environmental management of production testing                                 |
|                                    |                        | 6.4.2.2 Pipeline (flow line) management guideline   |
|                                    |                        | 6.4.2.3 Guideline of monitoring and tracking to disposition of industrial water and drilling solids |
|                                    |                        | 6.4.2.4 Guidelines on waste management  |
| HEALTH AND OCCUPATIONAL SAFETY     | 6.4.3                  | 6.4.3.1 Signposting guideline (access road, location, flow line)                                    |
|                                    |                        | 6.4.3.2 Guideline of handling and storage of chemical products                                      |
| HEALTH AND SAFETY OF THE COMMUNITY | 6.4.4                  | 6.4.4.2 Guideline of control and monitoring to the social management program                        |
|                                    |                        | 6.4.4.3 Guideline of dump areas, land removal and land-fills management at the locations            |
|                                    |                        | 6.4.4.4 Guideline of drainage management of access roads and locations                              |
| CONSTRUCTION AND DECOMMISSIONING   | 6.4.5                  | 6.4.5.1 Environmental alternatives guideline (abandonment stage)                                    |
|                                    |                        | 6.4.5.2 Liquid waste management guideline (stage of abandonment)                                    |

## E.3 EMERGENCY AND CONTINGENCY PLAN - GENERAL

This section establishes the mechanisms and response actions to attend in a timely and effective manner any partial or total disruption of activities of the project "**DEVELOPMENT WELL DRILLING IN PALAGUA-CAIPAL FIELD.**" It also seeks to reduce the environmental impact caused to the affected area. Appropriate measures and equipment are in place in the field to handle emergencies such as fire and blow out of the wells.

## F. NET ENVIRONMENTAL IMPACT

According to the assessment of the different environmental aspects involving the drilling of development wells, comparing them with the present baseline, **these activities do not change or alter significantly the current environmental conditions of the region.**



## **F.1 PHYSICAL-BIOTIC COMPONENT**

The current operation of the Palagua – Caipal oil field does not significantly affect the regional environmental status; as it is expected that the drilling of development wells does not alter this situation, which, according to different studies, remains constant or tends to decline. It is considered that the machinery, equipment, and vehicles used in the area will not generate emissions in quantities that exceed the values laid down in the regulations.

The noise impact is considered tolerable, and its effects are restricted to the areas of operation. The duration of the noise is short and the reversibility and recoverability of the initial conditions of the environment is high.

The effect of drilling activities on bodies of water is insignificant. Although the project includes drilling of additional wells, the new wells use the existing well locations. Hence, there is no effect on bodies of water in the area.

The current situation shows that the conditions for the geospheric component of the area will not be affected significantly, since there are already internal and external access roads that allow access to the wells.

Additionally, the current tree population will not be affected by the installation of equipment, or by operation of the development wells.

## **F.2 SOCIO-ECONOMIC AND CULTURAL COMPONENT**

The study area of this project includes the Palagua – Caipal oil field, a rural area of the municipality of Puerto Boyacá. The proposed development drilling program will not change the socioeconomic conditions significantly. Only minor change will be generated in the behavior of the population. The project will improve the general institutional infrastructure of the Palagua – Caipal area.

## **F.3 RISK ANALYSIS**

The results of the analysis indicate that the risks are not highly significant for the environmental components. The most important risks to be managed are the management of equipment, possible gas leaks, product spills, and fire and well bow out.