TECHNICAL SUMMARY REPORT

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EXPERT FOR THE COURT OF NUEVA LOJA

EXPERT OPINION

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1 INTRODUCTION

This report was written by Expert Engineer Richard Stalin Cabrera Vega to provide expert technical assistance to the Superior Court of Justice in Nueva Loja in Case No. 002-2003, filed by Maria Aguinda et al. (hereinafter referred to as *plaintiffs*) against Chevron Corporation (hereinafter referred to as *defendant*). The purpose of this report is to assist the court with technical issues which are important to the case. The President of the Court in Nueva Loja, in the Decision handed down on March 19, 2007, 8.30 a.m., has appointed me as Court Expert, ratified by a Decision issued on May 17, 2007, at 8.30 a.m. Subsequent to this appointment, on June 13 2007, I, Richard Stalin Cabrera Vega, took up my position as Court Expert and undertook to carry out a study on "*all the fields explored by Texaco as operator of the Consortium in which the company [Texpet], Gulf and CEPE, subsequently Petroecuador, held interests*"[1] which, as ordered by the court, addresses the following points:

a. ***Evaluate the environmental damage suffered, if any, by primary resources soil, water, vegetation, fauna and other elements in the surrounding area, detailing their characteristics***

b. Specify, if possible, the origin of such damage, on a causal and chronological basis

[1] This study acknowledges the fact that 100% of Consortium operations were carried out by TEXACO within the period under analysis, and that TEXACO operated said Concession through its subsidiary, the company Texpet, therefore we shall refer to the latter when speaking of operations in the Concession area.

c. Verify the current existence of any substances affecting the environment and which constitute what could be considered a danger to living organisms or a threat to their subsistence and way of life

d. Specify the technical work, activities and measures which must be implemented to reclaim the environment and restore it, as far as technically possible, to its original state before the environmental damage occurred

e. Determine methods for restoration and the appropriate environmental standards or goals, based on the characteristics of each environment.

In addition to the order issued by the Judge, I am also bound to observe and comply with the provisions governing our country and which are related to this expert testimony and expert report.

In this task, I have taken into consideration the fact that this Expert Report has been requested to complement and analyze the information presented previously in Court in the Judicial Inspections that were ordered by the President of the Court and conducted by the experts of both parties.

A substantial amount of information has been presented in court by both parties in the proceedings and by the expert witnesses they have called. This information was carefully considered. Despite the fact that both parties have written and spoken to a great extent in the media regarding these proceedings, I based my work only on the data and information provided by the court and not what has been said and written elsewhere. I have concentrated on the contamination of soil, groundwater, surface water and air that has been caused by Texpet operations, and the effects of this contamination on the health and welfare of people, including indigenous peoples, and on the ecosystem. I believe that my analysis is fair, and it reflects my best recommendations to the Court.

At the end of this report are a series of Annexes, each of which covers a specific issue included in this report. This summary report presents a compilation and summary of the more detailed scientific analyses that are in the Annexes.

This Expert Report required extensive work to address all the charges from the President of the Court. I relied on other experts who carried out some of the technical analyses. These experts are members of my technical team, which includes impartial professionals with reputable credentials, as described in Annex V of this report.

The report contains the following sections:

- Section 2.- Statement of findings.
- Section 3.- A description of the environmental contamination caused by the oil production activities carried out by Texpet in the Concession.[2]

[2] The oil Concession for which Texpet was operator will be referred to in the report as *the Concession*, although I acknowledge that Gulf was also part of the Concession initially and that CEPE has changed its name to Petroecuador.

- Section 4.- Information on damage caused by contamination to persons living in the region.

- Section 5.- An evaluation of ecological damage caused by contamination.

- Section 6.- The measures that need to be taken to improve and reclaim the damaged environment.

- Section 7.- The dollar value of some of the losses that have been suffered by people and the environment.

2 STATEMENT OF FINDINGS

I, expert Richard Cabrera Vega, declare that the following are the findings of the evaluations requested of me by the President of the Superior Court of Justice in Nueva Loja:

1. **Sources of contamination:** The primary sources of contamination in the Concession area are the crude petroleum, drilling muds and other additives, and production waters that were released into the environment beginning in 1967. Contaminants from these sources are present in soil, groundwater, sediment, and surface water in the Concession area and continue to persist in the environment to this day.

2. **Responsibility:** The primary cause of the contamination is the oil exploration and development operations conducted by Texpet. Texpet operated in the Concession area with inadequate environmental protection policies and practices, and Texpet used few, if any, environmental controls in their operations. As a result, their operations have caused most of the contamination in the area (Texpet improperly managed production well wastes, discharged one hundred percent of the produced water in streams and rivers, openly burned gases in the atmosphere, and caused dozens of oil spills) (Annexes E, F, H, I, S and T).

3. **Sufficient and reliable information:** There are sufficient environmental data of sufficient validity to make determinations about environmental contamination in the Concession area. As part of the litigation, thousands of environmental analyses were made by myself and the Experts for the plaintiffs and for the Defendant. The methods used to collect and analyze the samples produced reliable data that support the conclusion that the soil and water are contaminated from petroleum production activities.

4. **Background levels:** The background levels of contaminants are low in soil and water. The areas in the Concession that have not been impacted by oil production activities have low or non-detectable concentrations of hydrocarbons and metals in soils and water.

5. **Contamination in the Concession:** The ecosystem of the Concession is contaminated with petroleum hydrocarbons and other contaminants released from oil operations. The soils at stations and oil production wells contain petroleum hydrocarbons and metals at concentrations that are many times higher than the

environmental cleanup standards in Ecuador and other countries of the world (see Annex D). The groundwater beneath waste pits is contaminated above Ecuadorian standards. When the production water was discharged directly from the stations during Texpet operations, rivers, streams, marshes and soils were highly contaminated with petroleum, metals and salts at concentrations that were much higher than the Ecuadorian standards. The environmental contamination is documented in the data collected by all the parties (myself and the experts of the plaintiffs and of the defendant) and widely corroborated by historical sampling that took place in years prior to the beginning of the lawsuit (Annexes B, C and E).

6. **Damage to people:** The environmental contamination has caused damages to people in the Concession area. People that live in the area of the Concession area suffer from adverse health effects as a result of exposure to oil field contaminants. These effects include cancer, death by cancer, and spontaneous abortions (as documented in Annexes L and P). In addition, settlers who live near wells and stations have suffered moral, social, and economic damages.

7. **Indigenous groups:** The contamination has adversely affected the food gathering and cultural traditions of indigenous groups and displaced indigenous people from their native lands. The groups principally affected are those that traditionally lived in the area of the Concession area.

8. **Damage to the ecosystem:** The environmental contamination has caused damages to the ecosystem in the Concession area. The concentrations of oil-related contaminants in soil and water are much higher than the levels that cause toxicity to plants, animals, birds and other biological resources. Direct observations in the field confirm that plant and animal life have been and continue to be impacted by the contamination.

9. **Previous cleanup activity:** Previous and ongoing remediation has not adequately cleaned up the contamination. The remediation conducted by Texaco between 1995 and 1998 addressed only some of the contaminated sites, and the methods used at those sites left large amounts of contamination behind. Recent sampling of sites remediated by Texaco confirms that petroleum hydrocarbons and other contaminants are still present above background levels, above environmental standards, and even above the standards in the remediation contract. The methods used currently by PetroEcuador/PEPDA for site remediation also will leave large amounts of contamination behind.

10. **Remediation of contaminated soils:** An additional and improved remediation is necessary to clean the existing contamination in the environment. The contaminated soils should be remediated to levels less than 1,000 ppm total petroleum hydrocarbons (TPH), at an approximate cost of $1.7 billion. The proposed remediation is for existing contamination in the soil. Additional clean-up actions are necessary to remedy the contaminated surface water, sediments, groundwater, flora, and fauna. However, there is insufficient information available to determine to what extent these additional remediation actions should be undertaken, and for this reason specific actions (and costs) to clean up these resources are not included in this analysis.

11. **Other reparations:** Other actions besides the soil remediation are necessary to address current environmental contamination and prevent future contamination. There are 4 recommended actions that will partially repair the existing damages caused by the operations of Texpet in the area of the Concession area:

    - Provide potable water to the people who live in and near the Concession area. The approximate cost is FOUR HUNDRED TWENTY-EIGHT MILLION DOLLARS ($428,000,000).
    - Provide a health care system for the people of the region. The approximate cost is FOUR HUNDRED AND EIGHTY MILLION DOLLARS ($480,000,000).
    - Implement a land, food and cultural recovery program for ancestral indigenous groups that have been affected by Texaco operations. The approximate cost is FOUR HUNDRED AND THIRTY MILLION DOLLARS ($430,000,000).
    - Improve the oil production infrastructure to reduce further contamination of the ecosystem. The approximate cost is THREE HUNDRED AND SEVENTY-FIVE MILLION DOLLARS ($375,000,000).

    The approximate total cost for these actions is **THREE BILLION FOUR HUNDRED AND THIRTEEN MILLION DOLLARS ($3,413,000,000).** Providing a potable water supply source and a health care system will repair damages that have not been caused solely by the operations of Texpet. These actions are appropriate because the proposed contaminant cleanup is directed at existing soil contamination and it does not include the remediation of contamination in other natural resources. Improving the oil infrastructure is appropriate because the field operations continue to be plagued by the poor infrastructure and deficient environmental practices left by Texpet.

12. **Compensation for losses:** Past and future contamination impacts to the people and the environment must be compensated:

    a. The appropriate compensation for the excess cancer deaths suffered by the people living in the Concession area area totals **TWO BILLION NINE HUNDRED AND TEN MILLION FOUR HUNDRED THOUSAND DOLLARS ($2,910,400,000).**

    b. The appropriate compensation for loss of the forest ecosystem caused by the impact of oil wells, stations and highways built when Texpet operated in the Ecuadorian Amazon area is between **EIGHT HUNDRED AND SEVENTY-FIVE MILLION DOLLARS ($875,000,000) AND ONE BILLION SIX HUNDRED AND NINETY-SEVEN MILLION DOLLARS ($1,697,000,000).**

13. **The costs do not cover all of the damage caused:** The identified actions and costs to repair the damages and to compensate for the losses are conservative and are not designed to address all the impacts. The cleanup is for remediation, and it will not achieve a total restoration that restores the environment to its condition prior to the oil exploration and production. Furthermore, not all of the losses suffered by the people and the environment have been included.

14. **Texaco's unjust enrichment:** Texaco saved a large amount of money by operating the Concession without the adequate controls that would have protected the ecosystem. Texaco saved money by not managing oil wastes properly, by not reinjecting produced water, by constructing defective waste pits, and by burning gases instead of capturing. As a result of the savings, Texaco unjustly realized gains of approximately $8.31 billion (Annex T). This amount is a wholly separate kind of value that provides a context for the costs to repair the damages and compensations for losses. The Court, if it so chooses, can impose this sum on Chevron because it will help to cover the difference between the cost of the proposed remediation and the full cost of a complete environmental restoration.

15. **Total value of damage considered:** Table 2.1 presents the total sum of the values corresponding to each type of damage and loss that was considered.

Table 2.1 Values corresponding to each type of damage taken into account

Reparation for Damages (est.)	**Estimated Cost**	**Minimum Cost**
Soil remediation	$1,700,000,000	
Health care system	$480,000,000	
Indigenous impacts	$430,000,000	
Drinking water system	$428,000,000	
Infrastructure	$ 375,000,000	
Total Reparations	**$3,413,000,000**	
Compensation for Losses		
Excessive Cancer Deaths	$2,910,400,000	
Ecosystem Losses	$1,697,000,000	$875,000,000
Total Losses	**$4,607,400,000**	**$3,785,400,000**
Total Losses and Damages*	**$8,020,400,000**	**$7,198,400,000**

** Unjust enrichment totals $8,310,000,000. If the court decides that it is appropriate, this amount may be added to the total value for damages and losses, in whole or in part, in order to cover the gap between the incomplete remediation described herein and complete restoration.*

3 ENVIRONMENTAL CONTAMINATION CAUSED BY TEXPET OPERATIONS

3.1 Method

The environmental contamination and the resulting damages to people and the environment were evaluated in two stages. In the first stage, I evaluated the environmental contamination caused by Texpet in the Concession area, which is the subject of this section. In the second stage, I evaluated the damages that the contamination has caused to people (settlers and indigenous peoples) and the ecosystem within the Concession. Section 4 describes the damage caused to people, and section 5 describes the damage caused to the ecosystem.

This section evaluates the environmental contamination caused by Texpet, which operated the consortium. I first describe, in general terms, the sources, migration and fate of the chemicals that were discharged into the environment by Texpet. I then identify the environmental standards used to evaluate whether chemical concentrations in the environment are higher than normal, or sufficiently high to cause damage to people and ecosystems. I carefully review the environmental information on contaminants from the Concession collected by myself and my technical team, as well as information from other phases of the case to guarantee their reliability. I then compare the reliable information collected during the case with current environmental standards to evaluate the level of contamination caused by Texpet activities.

Finally, I analyze the environmental cleanup that was conducted by Texpet between 1995 and 1998. I evaluate the cleanup using the abundant data available from the sampling that I carried out, from the sampling conducted by experts for both parties as part of the Judicial Inspections, and from the sampling conducted by the State Controller General.

3.2 Contaminant sources, transport and exposure

The information presented in this report is taken from various documents presented to the court and provides a general idea of the sources and transport of the contaminants. It also describes how people and ecosystems are exposed to the contaminants. The following sections provide more detailed information based on environmental data that has been collected during the case.

3.2.1 Chemical emissions into the environment

Based on my review of the technical information provided by the experts of both parties for the Judicial Inspections, there are many ways in which the chemicals in crude oil,

drilling muds and other additives, and production waters released by Texpet reached the environment. Contamination begins at the oil wells.

Texpet drilled and operated 356 oil wells in the Concession area, and at each well the wastes generated from drilling and other operations were dumped into waste pits..[3] The wells in the Concession generally had three pits each, although some wells had more. The waste collected in the pits was mainly crude oil, drilling mud and other additives, as well as production water. The pits were constructed as holes or trenches in the ground and were not lined underneath. Initially, all of the waste pits were open, although over time, some of them were covered with dirt (Annex H). Sometimes, the waste pits would overflow, especially during periods of heavy rainfall. Some waste pits were constructed with pipes through their sides which allowed the crude oil and other waste to flow into the adjacent forest. In addition, since the waste pits were not lined, there was constant leakage or the edges of the pits would fall in, which meant that chemicals would travel through the soil and contaminate the groundwater underneath the pits, as can be seen in multiple documents or letters (Annex H). Some pits were also intentionally burned, releasing crude oil chemicals into the air.

Texpet also operated 22 processing stations where the mixtures of crude oil, production water and gases that came out of the production wells were separated. For many years, the crude oil and the production water was separated in pits similar to those that Texpet built at the production wells, though the station pits were typically bigger. These pits were also unlined, therefore crude oil and production water contamination has migrated through the soil. There are no records of Texpet reinjecting the formation water into the subsoil, therefore we can state that Texpet discharged the formation water during the entire period that it handled operations in the area, separating it from crude oil and dumping it directly into streams, rivers or swamps located nearby, without suitable treatment. During Texpet operations in the Concession area, many billions of gallons of production water were dumped into streams, rivers and swamps in the Concession area (Annex F). Furthermore, it extracted 230,464,948 cubic feet of gas, which were burned using the burners installed at the stations, or released into the atmosphere using the venting system at the stations.

The main sources of chemicals discharged by Texpet into the Concession area are crude oil, production water, and chemicals or chemical solutions used during drilling and to maintain the oil wells (for example, drilling mud and drilling fluids). As explained further on in this report, these chemicals can be toxic to people and the environment.

Crude oil contains thousands of individual chemicals. Most of the chemicals are hydrocarbons, meaning that they contain only carbon and hydrogen atoms. The hydrocarbons in crude oil include chemicals that are toxic to people and wildlife, such as benzene, toluene, and polycyclic aromatic hydrocarbons. Crude oil also contains metals, such as nickel, vanadium, and zinc. Samples of crude oil from the Concession that were collected and analyzed during the Judicial Inspections confirm that the crude oil in the Concession contains these chemicals.

Drilling muds, which aid in the drilling of oil wells, contain high concentrations of barium that is added to the drilling muds (Health and Safety Executive, 2000). Other chemicals that are added to drilling muds include potassium chloride and chromium (Health and

[3] Annex H contains details of the operational history of Texpet in the Concession.

Safety Executive, 2000). Other additives used in oil well perforation or reconditioning can include chromium, barium, formaldehyde, and hydrochloric acid (Health and Safety Executive, 2000; Camino Castro, 2004).

Produced waters are waters that occur underground with the crude oil and come up out of the wells along with the crude oil. Chemical analysis of the produced waters from Concession show that they contain high concentrations of salt (in some cases the produced water is saltier than sea water), hydrocarbons such as benzene and toluene, and metals (Fugro-McClelland West, 1992).

3.2.2 Crude oil spills in the Concession area

Texpet operations in the Concession area caused a large number of oil spills over the years. These spills are described in a series of communiqués, memoranda, letters, notices and reports sent and received by Texpet, which have been compiled and analyzed (Annex I).

Due to the long period of time that the company was operating, the precise number of spills is unknown. The documents which have been reviewed only seem to include a portion of the decades during which operations were carried out, which means that the number of spills recorded does not reflect true figures and we can safely say that more spills occurred. However, the data from this analysis allows us to build a model which, although not statistically representative of the total number of spills that took place during the years of operation, clearly reflects the operating conditions on site.

Altogether, the documents analyzed report 276 oil spills which total approximately 26,400 barrels spilt.

The spills were catalogued by cause (force majeure, operating failures, third-party activities) and their effects (contamination, penalties, fires and other damage). With regards to the causes, the majority of spills were caused by operator error (almost 80%). These include normal operating failures, such as instances where spills were caused by manifest negligence. We do not have percentage information on the results of the spills, as in most cases they had more than one consequence.

It is important to point out that the majority of the documents are from Texpet files and it is the company's own employees who accept that the spills were caused by acts and omissions of people related to the company (Annex I).

Petroecuador spills

During my travels and fieldwork I witnessed several crude oil spills from recent months and years. There are many documents that prove that the spills already existed when the company Petroamazonas, currently Petroproducción, operated in the Concession area, as stated by *defendant* in various written submissions and referenced in reports by the *defendant's* experts.

The total number of spills and barrels of oil spilt is based only on available data, which only reflects a portion of the years that Texpet operated in the Ecuadorian Amazon. It is expected that the actual number of spills and barrels spilt is higher.

The fact that most of the spills are linked to Texpet operations suggests that there are serious problems with its Concession station and well operating practices and policies.

3.2.3 Spreading of crude oil on highways

Another source of contamination in the Concession area was the Texpet practice of spreading crude oil on the roads to keep the dust down, as described in various documents and testimony from the local inhabitants. Texpet sprinkled crude oil on all highways and access roads to the wells and along highways connecting oilfields. As the Ecuadorian Amazon is an area of high rainfall, the crude oil spread on the highways ended up in the rivers and estuaries surrounding the area or neighboring the highways (Annex I).

3.2.4 Chemical movement and degradation

The chemicals in the crude oil, produced water, and well additives can move from the place of their original release. The chemicals in produced water and crude oil can be carried downstream in rivers or streams. Chemicals that can dissolve in groundwater can be carried with the groundwater as it flows underground. Chemicals released into the air from gas flares or flare pits can be carried by the wind. In these ways, the chemicals are dispersed to areas that are much greater than the original areas where they were released into the environment.

Some of the hydrocarbons in crude oil can decompose in the environment, and studies carried out by the experts for the *defendant* as part of the Judicial Inspections demonstrate the degradation of some crude oil in the Concession area. Microbial degradation can transform some hydrocarbons into other, less toxic compounds. Microbial degradation tends to be faster in areas with abundant oxygen and water. In areas without oxygen, such as underground, microbial degradation is much slower. Also, microbial degradation tends to act only on certain types of hydrocarbon compounds in crude oil, whereas other types of compounds are not affected. Furthermore, certain crude oil hydrocarbons can evaporate from spills or uncovered pits, whereas others cannot. The metals in crude oil or drilling mud do not decompose in the environment.

3.2.5 Exposure of people and the environment to the chemicals

The people living in the Concession area have been exposed to chemicals from crude oil, production water, gas flaring and well additives in a variety of ways. One of these is inhaling vapor either from crude oil operations or gas flares. For example, when crude oil is spread on highways, people who live nearby breathe in the more volatile compounds as they evaporate, including compounds such as benzene, which can cause cancer. People living near the pits can also inhale vapor from the compounds that evaporate from the pits. Gas flares produce different hydrocarbon compounds, because combustion within the flames is incomplete (Strosher, 1996). Therefore, people living near areas where crude oil is left uncovered or close to gas flares may be exposed to contaminants as they breathe, taking these contaminants into their lungs.

People can also be exposed to the chemicals by drinking contaminated water or eating contaminated food. People who live in the area use groundwater and surface water as drinking sources, and both kinds of water are contaminated (details provided later in this report). In addition, crops and other plants that people eat can accumulate contaminants, as can fish and animals. People can also be exposed to crude oil and metals contaminants by direct exposure to skin.

The ecosystem in the Concession area is exposed to contaminants in the soil, in rivers and streams, in the groundwater and in the air. For example, plants may be exposed to contaminants in the soil where they grow, in the groundwater absorbed by their roots and in the air. In a similar manner to humans, animals are also exposed to the contaminants they breathe, ingest and drink, and by direct exposure through the skin. Animals may also be trapped in the crude oil pits, and crude oil in bird feathers makes it impossible for them to fly, thereby killing them.

3.2.6 Contaminant data considered

In order to reach specific conclusions on environmental contamination in the Concession area, I relied primarily on the data collected by myself and my technical team based on the instructions issued by the Court (Annex A), as well as data collected by the experts or expert witnesses of the *defendant* and *plaintiffs* during the Judicial Inspections. (Annex E)

During the trial, both sides raised concerns about the reliability of the analytical data that has been gathered. Annex B evaluates the quality and reliability of the analytical data from the *plaintiffs* and from the *defendant*, as well as the data that I collected in the fall of 2007. As described in the Annex, there is sufficient documentation on laboratory quality/safety control to conclude that the information generated by all of the laboratory analysis is valid and reliable. However, I place less emphasis on some of the groundwater data collected by the *plaintiffs* because the methods used for some of the groundwater samples probably introduced high levels of suspended soil into the samples, and this material may bias the sample results.

I also considered the data on environmental contamination that was collected by various groups prior to the Judicial Inspections. These data include data collected by Texaco contractors as part of audits (Fugro-McClelland West, 1992; HBT Agra Limited, 1993), data collected by TexPet contractors as part of the remediation that was conducted in the 1990s (Woodward-Clyde International, 2000), and data collected by researchers and published in the scientific literature (Jochnick et al., 1994; San Sebastian et al., 2001, 2002) (Annex C). I did not put as much weight on these data because they were not collected as part of the litigation. Rather, I reviewed them for their consistency with the litigation data and for any information on environmental contamination that is not addressed in the Judicial Inspection data or my data.

3.2.7 Environmental standards

Some of the chemicals produced by Texpet, for example the metals, are naturally present in the environment. Other chemicals, such as the chemicals in crude oil, do not occur naturally in the area's ecosystem, but if present in very low concentrations they will probably not harm people or the environment. Therefore, I have evaluated the damage caused by contamination from Texpet operations by comparing environmental data on contamination with standards and norms established by the Ecuadorian government to protect people and the environment (Annex D).

Table 3.1 lists the important Ecuadorian environmental regulations. These regulations have been established by Ecuadorian law and can be used to evaluate when the soil, surface water or groundwater have been so contaminated as to pose a risk or source of harm to people and the environment. As described in Annex D, when more than one regulation is provided by Ecuadorian law for a specific contaminant, I use the lowest standard available. Annex D, referred to as Review of Environmental Quality Regulations in Ecuador, also compares Ecuadorian regulations with regulations from other countries or international groups, and this comparison shows that the Ecuadorian regulations protecting people and the environment are similar to standards used in other countries. This similarity provides Ecuadorian regulations with additional credibility. Thus, I compare the environmental contamination information with the Ecuadorian standards to determine the locations where contamination is present, even though it probably does not present a risk or danger, and where contamination does present a risk or danger.

Failure to apply these or any regulations would make it impossible to determine the existence of any risks or damage, and without a comparison to these standards this expert investigation would be impossible.

Table 3.1: Relevant Ecuadorian environmental quality standards for surface water and soil. See Annex D for further details.

Parameter	Surface water (ppm)	Soil (ppm)
Cadmium	0.001	< 1
Chrome VI	0.05	0.4
Chrome	0.016	65
Nickel	0.025	< 40
Zinc	0.18	200
Total petroleum hydrocarbons (TPH)	0.325	1,000
Benzene	0.01	0.05
Benzopyrene	0.00001	0.1
Naphthalene	0.035	0.1
Polycyclic aromatic hydrocarbons (PAHs)	0.0003	< 1

Of particular importance are the standards from Decreto No. 1215 for total petroleum hydrocarbons (TPH) in soil. These regulations are the "acceptable limits for identifying and decontaminating contaminated soil in all phases of the hydrocarbon industry." Therefore, these regulations are directly applicable to identify soils in the Concession area exceeding permitted TPH limits and to identify the need to remediate these soils. Decree number 1215 specifies three permissible TPH soil concentrations: 1,000 ppm (or parts per

million, ppm) for sensitive ecosystems; 2,500 ppm for agricultural soils and 4,000 ppm for soils involved in industrial use. The Concession area is in the tropical Amazon forest, which is a sensitive ecosystem. Moreover, the homes of many people living in the area are very close to the oil wells and production stations, or in areas where crude oil has been spilt and therefore people living in the region may easily be exposed to oil contamination.

The information contained in Annex D indicates that the Ecuadorian standard of 1,000 ppm of TPH is higher than many other standards or guidelines. For example, in the United States, oil contamination in soil is regulated by the States. Among states which have recently issued TPH regulations, 10 enacted standards that are lower than 1,000 ppm TPH (Annex D). Therefore, the Ecuadorian standard of 1,000 ppm of TPH is higher than the standard in certain U.S. states, and may be too high. It is certainly higher than the background level for petroleum hydrocarbons in the soil, which is close to zero.[4] However, the value of 1,000 ppm of TPH is used here because it is the standard for Ecuador.

Additionally, PEPDA[5] has established concentrations of TPH and certain metals that reflect different levels of environmental quality. These values are used to assess the efficiency of its cleanup work at contaminated oil pits within the Oriente region. According to PEPDA, the TPH and metal values in the Decree 1215 Ecuadorian standards for sensitive ecosystems (described above) are equivalent to 70% of full environmental quality. PEPDA does not allow environmental quality values below 70%. PEPDA uses a value of <100 ppm TPH to indicate when cleanup achieves 100% environmental quality. Most pits treated by PEPDA and whose information has been reviewed showed environmental quality levels after cleanup of 90 to 100%. This means that the 1,000 ppm TPH standard is conservative when compared not only with international regulations and legislation but also with the criteria for complete cleanup used in the country by Petroecuador.

Based on the relevant Ecuadorian standards and the considerations made in this section, there is a range of TPH standards which can be used to determine the cleanliness of impacted soils and evaluate TPH concentrations in environmental samples from the Concession area. For the purposes of this report, we will use a standard of 1,000 ppm as the relevant standard. Please note that the lowest decontamination values are readily attainable and would be most beneficial for the health of local populations and the ecosystem.

[4] The average background TPH level in soils depends on the analysis used. Using certain methods, background TPH may reach levels of 100 mg/kilogram because of organic material naturally present in soils.

[5] Project to Eliminate Pits in the Amazon District [*Proyecto de Eliminación de Piscinas del Distrito Amazónico*] (PEPDA)

Table 3.2

TABLA Nº 12. VALORACIÓN PORCENTUAL DE LOS INDICADORES DE DESCONTAMINACIÓN

Parámetro	TPH	CADMIO	NÍQUEL	PLOMO	Valoración Porcentual de Calidad Ambiental
Valor Analítico	>5500	>5	>200	>350	0
	5500	5	200	350	10
	5000	4,5	175	300	20
	4500	4	150	250	30
	4000	3,5	125	200	40
	3500	3	100	150	50
	3000	2,5	75	125	60
	2500*	2	50	100	70**
	1500	1,5	25	70	80
	500	1	20	40	90
	<100	<0,6	<10	<12,5	100
Unidad de medida	mg/l	mg/l	mg/l	mg/l	%

*RAOH Decreto 1215: Límites permisibles para la identificación y remediación de suelos contaminados en todas las fases de la industria hidrocarburíferas, incluidas las estaciones de servicio)
**Los valores analíticos que corresponden a un valor porcentual menor que 70, se consideran como no permisibles.

Elaborado por: Equipo Técnico Ambiental- PEPDA

Source: Petroproducción and PEPDA, 2006. Elimination of the SA-14-1 pit. Final Report. Project for the elimination of contaminated pits and cleaning of spillages in the Amazon District. PEPDA. Pg. 22.

The numeric environmental standards in Ecuador were established after Texpet ceased operating in the Concession area. However, while Texpet was operating there were guidelines and accepted practices for handling and disposing of oil exploration and production waste which were not followed by Texpet (e.g., API 1962). Furthermore, current environmental standards are applicable to environmental damage regardless of when the contamination occurred. Even if the contamination was caused many years previously, current standards are applicable as cleanup standards for remediation. This is consistent with environmental conservation laws worldwide, as well as CERCLA (or Superfund) in the USA. These laws establish the standards and requirements for cleaning up existing contamination and are applied regardless of when the contamination occurred. Therefore, the fact that the Ecuadorian environmental regulations were established after Texpet operations had concluded is irrelevant, and these standards should be used to determine adequate levels of contaminant cleanup.

3.2.8 Background concentrations

When comparing contaminant concentrations in environmental samples from the Concession area with the applicable standards, background concentrations must also be taken into account. Metals and certain organic chemicals may be present naturally in the soil and water. This section describes background concentrations that PEPDA considers to be representative of conditions that are not impacted by contamination.

Background concentrations of metal in soils

Certain metals are present in the Concession area contamination sources (e.g., in oil, drilling muds and production water). As these metals also occur naturally in soils, we must take into account background metal concentrations when evaluating the contaminant data.

I and the experts for both parties analyzed soil samples from the Concession area for metals content as part of the Judicial Inspections and the Expert Examination. Data from the *defendant's* experts was selected to evaluate background metal concentrations because they collected a greater number of samples from outside the pits and away from potential contamination sources than the other parties, and furthermore because the vanadium results in the soil samples produced by the *plaintiffs* were considered too low (see Annex B). The following procedures were used to identify background metal concentrations in the soil data provided by *defendant's* experts:

- Use only samples collected outside the pits.

- Use only samples collected outside the stations (there can be widespread contamination at the stations because of spills and the gas flares).

- Use only samples without clear evidence of TPH, BTEX (benzene, toluene, ethylbenzene, or xylenes, which are light compounds in petroleum) or PAHs (polycyclic aromatic hydrocarbons, which are also in petroleum).

There are about 50 to 60 samples that meet these criteria (depending on the metal). However, as the samples were not collected specifically to determine the background levels and as they were collected in and around oil production wells, some of the samples probably contain metals originating from oil production activities. Therefore, I used the 75^{th} percentile of the concentrations to represent the upper limit of background concentrations. The values are shown in Table 3.3 and are compared with the Ecuadorian soil values established by Decree 1215 and Decree 3516. As the selected background levels are lower than the Ecuadorian standards, this means that soils with metal concentrations exceeding Ecuadorian standards are probably contaminated because of oil production activities in the Concession.

Table 3.3 Background distribution of metal concentration (mg/kg, or ppm) in soil samples collected by *defendant* experts for the Judicial Inspections.

Parameter	n	Minimum	Average	75th Percentile (background)	Decree 1215	Decree 3516
Barium	72	30.1	196	399		750
Cadmium	72	0	0.10	0.49	1	2
Copper	72	0	31.7	49.5		63
Chromium	61	0	17.3	26.6		65
Chromium VI	59	0	0.00	0.00		0.4
Mercury	59	0	0.06	0.09		0.8
Nickel	72	0	14.5	26.5	40	50
Lead	61	0	9.00	12.0	80	100
Vanadium	61	0	71.8	108		130
Zinc	72	0	47.1	71.2		200

3.2.9 PEPDA cleanup standards

PEPDA cleanup standards were discussed in section 3.2.7. Cadmium, nickel and lead concentrations representing a 100% improvement in environmental quality (or complete cleanup) are 0.6, 10 and 12.5 ppm , respectively (Table 3.1) These values are similar to the 75th percentile values for background concentrations in table 3.3. Any of these parameters can be used to compare measured contaminant concentrations to background values in this case.

3.2.10 Description of the environmental contamination

Description of the Judicial Inspection studies and my study in late 2007

During the Judicial Inspections, the experts of the *defendant* and *plaintiffs* collected samples from 34 production well and 11 station sites. Moreover, the experts for the *defendant* collected samples from three well sites where the *plaintiffs'* experts did not collect samples, and *plaintiffs*' experts collected samples from another three well sites where *defendant's experts* did not collect samples. The experts for the *defendant* also collected samples from a station where *plaintiffs* did not. In 2007, I collected samples from 48 oil production wells and one station site that were not sampled by either party during the Judicial Inspections (Annexes A and E). This means that altogether samples have been taken from 82 production wells and 12 stations, which constitutes a representative sample of the Concession. *Plaintiffs*, *defendant* and I collected soil samples and, where possible, surface and groundwater samples and conducted chemical concentration analyses at analytical laboratories. Table 3.4 lists the production well and station sites sampled by *plaintiffs* and *defendant* during the Judicial Inspections and by me in 2007. The sampled sites are shown in figure 3.1.

Table 3.4: Number of samples collected by the various parties for the case

	Soil samples	**Water samples**	**Other samples[6]**
Experts of the *defendant* (Judicial Inspection)	948	335	29
Experts of the *plaintiffs* (Judicial Inspection)	355	105	3
Richard Cabrera (2007)	211	119	46

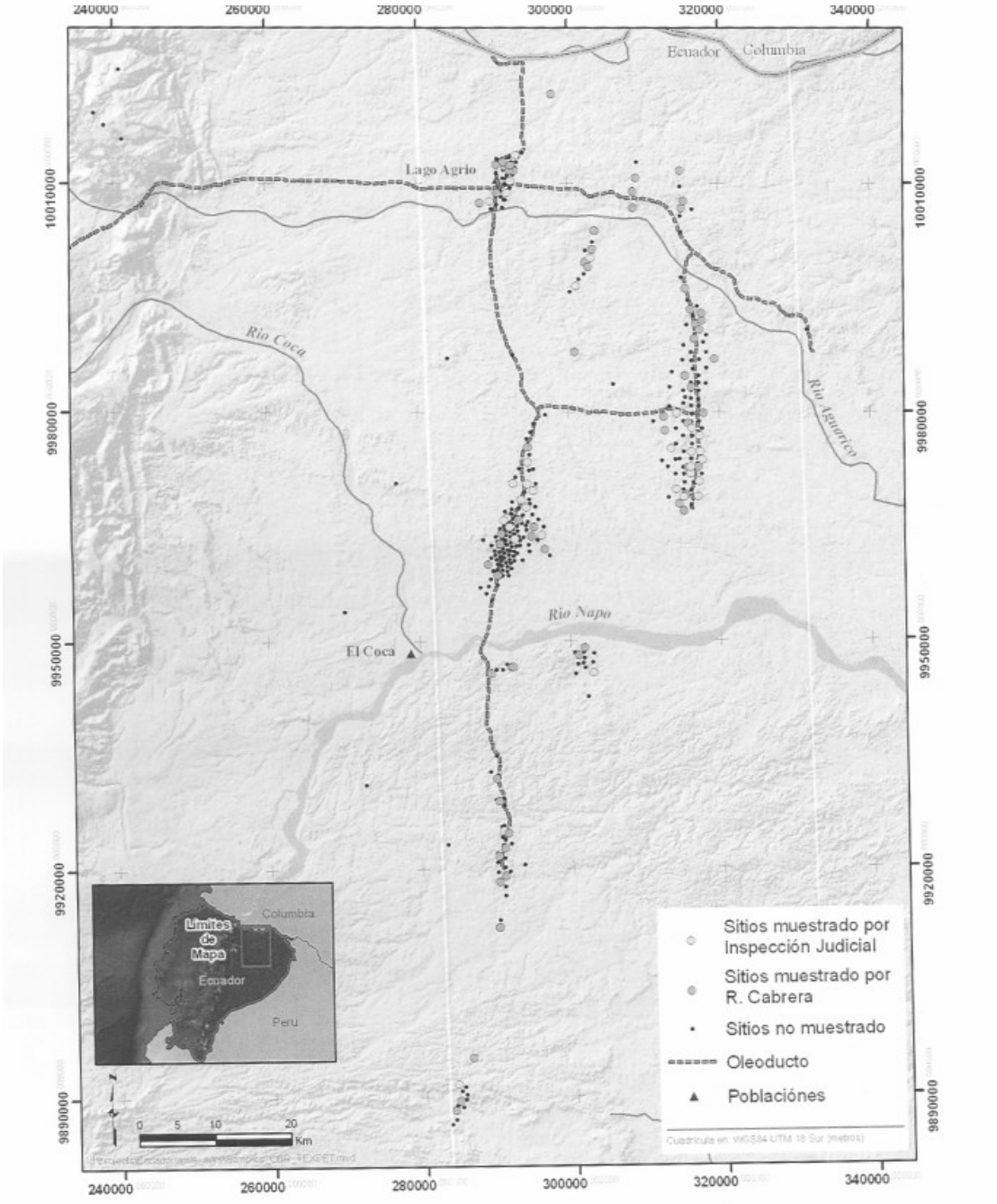
One of the most important chemical measurements in this case is the quantity of TPH in a sample. TPH is the total quantity of petroleum hydrocarbons in a sample. Annex B describes the different methods used by the experts from the *plaintiffs* and *defendant* to measure TPH and how these methods can affect the results. The experts for the *plaintiffs* and I used an analytical method for TPH (method 418.1) which measures all petroleum hydrocarbons, although it tends to overestimate the quantity of TPH in soil samples when TPH concentrations are low (approximately 100 to 200 ppm of TPH). However, as the standard for soil TPH is 1,000 ppm, this tendency to overestimate concentrations when there is little or no TPH present does not present a problem. The experts for the *defendant* used TPH analysis methods which uses separate measurements for different types of petroleum hydrocarbons, and then the separate measurements are added together to obtain a TPH result. However, the method they used does not measure all types of petroleum hydrocarbons, and therefore TPH measurements of the *defendant*'s experts tend to be biased low (that is, they underestimate TPH concentrations) (Annex B). Regardless, the information from both parties is consistent in that samples from both clearly show high levels of petroleum contamination in the soil within the Concession.

I, Richard Cabrera, also conducted a study in 2007 as part of my role as Court Expert in this case. I collected samples from 47 production wells and one station site. My intention was to carry out a study in a similar manner to the studies conducted for the Judicial Inspections. I collected soil, surface water and groundwater from the sites (Annex A). One difference between my study and the Judicial Inspections was the manner in which I collected the samples of groundwater. After building temporary groundwater wells, I let the water in the wells settle for approximately 24 hours. This reduced the amount of soil in suspension when I collected the water, eliminating the problem that occurred with some groundwater samples collected by *plaintiffs* (Annex B).

One last comment on the Judicial Inspections and my 2007 field study is that the studies did not collect samples from every one of the production wells, believing this to be unnecessary and inadequate for this type of study. Annex G indicates that the sampled sites are representative of all of the sites,. The 82 wells that were sampled are 23% of the 356 wells drilled by Texpet in the Concession, and the 12 production stations are 54% of the 22 production stations. Therefore, the conclusions from the subgroup of sites that were sampled are valid for all production stations and wells in the Concession area.

[6] These include crude oil, production water, sediment and asphalt.

Figure 3.1: Location of station and well sites in the Concession with sampled sites highlighted in orange and yellow.



Also, based on the information that various organizations provided me with, I have reconstructed the operating history of Texaco in the Ecuadorian Amazon region (Annex F). Based on the analysis described in Annex F, I conclude that Texaco operations did not vary from one field to the next. This means that the same operating method was put into practice at all fields throughout the years that it was operating in the Concession area for which it was responsible.

Environmental contamination

During my fieldwork in 2007 and during the Judicial Inspection process, thousands of samples were collected from oil wells and stations in the Concession. Annex A contains the details, description, samples and analysis for each of the sites that I sampled. The experts of both parties also presented detailed information on each site that was sampled during the Judicial Inspections, and these reports contain very valuable information and data. In this document, I summarize the data collected during the court proceedings with special emphasis on whether the contaminant concentration measurements are greater than Ecuadorian standards or not.

In Annex E the chemical concentration data for each site are summarized on a single page. TPH concentrations are summarized on the front of each page and data on other contaminants is summarized on the back. Annex E should be reviewed for a more complete description of the environmental contamination at the individual sites that have been sampled.

3.2.11 Petroleum hydrocarbons in the soil

At every production well and station that was sampled, at least one soil sample contained TPH concentrations exceeding 1,000 ppm. This fact indicates that crude oil has been spilled or leaked at every one of these sites and that TPH concentrations exceed the Ecuadorian standard in at least one sample at each site.

A more detailed inspection of the soil TPH data shows that out of all of the waste pit samples, 88% (173 out of 196) have TPH exceeding 1,000 ppm in at least one sample. Many of the pits had multiple samples that exceeded 1,000 ppm, as shown in Annex E. Given the high TPH concentrations in almost every well pit that was sampled, this means that almost every waste pit in the Concession is contaminated with petroleum hydrocarbons over and above Ecuadorian standards. Tables 3.5 summarize the TPH information on all soil samples collected for the court proceedings, separated into samples taken from the pits and from outside of them. Table 3.5.a contains data from my study, and table 3.5.b contains data presented by the experts for the parties to these proceedings.

Table 3.5a: Summary of TPH information from soil samples collected for the case by Richard Cabrera

	Number of samples	Quantity of samples (%) > 1,000 ppm TPH	Average TPH (ppm)	Maximum TPH (ppm)
Pit samples	131	109 (83%)	22,219	414,414
Samples taken outside pits	82	23 (28%)	7,500	175,095

Table 3.5.b: Summary of TPH information from soil samples collected by the experts for the parties to these proceedings

	Number of samples	Quantity of samples (%) > 1,000 ppm TPH	Average TPH (ppm)	Maximum TPH (ppm)
Pit samples	640	344 (54%)	19,586	> 900,000
Samples taken outside pits	844	234 (28%)	5,028	333,262

A higher percentage of individual samples from pits (54% according to the data of the experts representing the parties, and 83% according to my own studies) have TPH concentrations exceeding 1,000 ppm higher than samples from outside the pits (28% according to the data of the experts representing the parties, and 28% according to my own studies). The data shows that the pits are severely contaminated with petroleum hydrocarbons. The data also shows that petroleum contamination is not limited to the pits. The sample information indicates that TPH concentrations in many soil samples taken outside the pits also exceed 1,000 ppm TPH. Contamination outside the wells is caused by spills (Annex I), leaks or see page (Annex H). Annex H and Annex N include additional details on TPH soil contamination.

3.2.12 Metals in soil

Table 3.6 summarizes the data for metals in the soils. Table 3.6.a contains data from my study, and table 3.6.b contains data from the experts of the parties to these proceedings. In my studies, vanadium, barium and cadmium exceed legal standards in 36%, 29% and 14% of the samples, respectively. Copper, barium, vanadium and chromium VI most frequently exceed the standards (14% to 24% of all samples from the experts representing the parties during the Judicial Inspections). Copper and vanadium are present in crude oil, and barium is used in drilling mud. Chromium VI was used as an excavation additive. This information indicates that the soil at the sites contains oil production related metal concentrations exceeding Ecuadorian standards.

Table 3.6.a: Summary of metal data from soil samples collected for the case by Richard Cabrera

Metal (standard, ppm)	**Number of samples**	**Number of samples (%) > limit**	**Average (ppm)**	**Maximum (ppm)**
Barium (750)	28	8 (29%)	595	1,736
Cadmium (1)	7	1 (14%)	0.54	1.4
Copper (63)	0			
Chromium (65)	12	0	6.9	9.2
Chromium VI (0.4)	0			
Mercury (0.8)	0			
Nickel (40)	30	0	7.8	11,9
Lead (80)	8	0	4.4	7.3
Vanadium (130)	22	8 (36%)	99	290
Zinc (200)	0			

Table 3.6.b: Summary of metals data from soil samples collected for the case by the experts for the parties

Metal (standard, ppm)	Number of samples	Number of samples (%) > limit	Average (ppm)	Maximum (ppm)
Barium (750)	1,276	212 (17%)	490	10,100
Cadmium (1)	1,248	147 (12%)	0.69	316
Copper (63)	1,000	239 (24%)	44	130
Chromium (65)	487	31 (6%)	26	233
Chromium VI (0.4)	745	107 (14%)	0.52	87
Mercury (0.8)	457	2 (0,4%)	0.079	1.1
Nickel (40)	1,274	51 (4%)	18	199
Lead (80)	558	4 (1%)	12	294
Vanadium (130)	445	95 (21%)	92	290
Zinc (200)	1,214	16 (1%)	67	1,181

3.2.13 Petroleum hydrocarbons in groundwater

Data on groundwater collected by the experts for the *plaintiffs*, by the experts for the *defendant*, and by myself show a substantial difference in the percentage of samples exceeding the Ecuadorian standard of 0.325 mg/L TPH (Table 3.7). Of the 192 samples collected by the *defendant's* experts, only 2 (or 1%) of the samples contained TPH exceeding the standard, and most of the samples contained no detectable TPH. On the one hand, 59% of the groundwater samples collected by experts for the *plaintiffs* contained TPH levels that exceeded groundwater standards. The difference between the data presented by the parties is probably due to the different places that they collected the samples in the field and the analytical methods used. Also, as shown in Annex B, some of the groundwater samples taken by the *plaintiffs'* experts may tend to be higher in TPH because of the relatively high quantities of soil in the samples. On the other hand, it is possible that the analytical methods used by *defendants* do not measure all of the petroleum hydrocarbons in the samples (see details in Annex B).

Table 3.7: Summary of TPH results in groundwater samples collected for the case

Investigator	Number of groundwater samples analyzed to determine TPH	Number of samples exceeding TPH standard of 0.325 mg/L	Percentage of samples exceeding TPH standard
Experts representing plaintiffs	39	23	59%
Experts representing defendant	192	2	1%
Cabrera (2007)	104	33	32%

The groundwater data that were collected under my direction in 2007 falls between the results from the two litigants. 32% of the samples that I collected contained TPH exceeding the 0.325 mg/L standard. This result is almost identical to the overall average of

the percentage of samples exceeding TPH standards from the *plaintiffs*' and *defendant*'s data, which is 30%, suggesting that my study produced neutral, unbiased results.

Tables 3.8 summarizes the actual TPH concentrations measured in groundwater, separated by whether samples were taken from beneath pits or not. Table 3.8.a contains data from my study, and table 3.8.b contains data from the parties' experts. As expected, a higher percentage of samples collected from underneath the pits exceed the groundwater standard, and the average TPH concentration is higher beneath the pits. This is consistent with the pits being a source of TPH contamination to the underlying groundwater.

Table 3.8.a: Summary of groundwater TPH data for samples collected for the case by Richard Cabrera

	Number of samples	Quantity of samples (%) > 0.325 ppm TPH	Average TPH (ppm)	Maximum TPH (ppm)
samples from beneath pits	64	18 (45%)	6.2	68
Samples from outside of pits	40	15 (23%)	2.5	94

Table 3.8.b: Summary of groundwater TPH data for samples collected by the parties' experts

	Number of samples	Quantity of samples (%) > 0.325 ppm TPH	Average TPH (ppm)	Maximum TPH (ppm)
/samples from beneath pits	94	30 (32%)	3.4	68
Samples taken from outside of pits	241	28 (12%)	1,03	94

Therefore, the groundwater data shows that groundwater at the oil pits and station sites is contaminated with TPH. My study showed that 45% of samples from beneath pits exceed the Ecuadorian standard, whereas approximately 30% of the Judicial Inspection samples contain excessive TPH. The groundwater underneath the pits tends to be more contaminated with TPH than the groundwater away from the pits. In the three studies together, samples of groundwater were taken from approximately 73 different sites, and groundwater TPH concentrations exceeded the TPH standard at 32 (44%) of these sites.

3.2.14 Metals in groundwater

Concentrations of metals in the groundwater exceed Ecuadorian standards in about 10% of the samples. This result shows that the metals represent a small problem in groundwater compared with petroleum hydrocarbons. The metals exceeding standards by the highest percentages are barium and cadmium, both of which exceed the limits in 9% of groundwater samples.

3.2.15 Surface water contamination

At some of sites visited during the Judicial Inspections, the experts representing the *defendant* collected water samples from streams, rivers or swamps located nearby. In general, the samples do not show contamination over and above the standards.

However, the majority of these water samples were collected near production wells, and the potential pathways from contamination sources to places where samples were taken were not always clear. Other studies have shown that there is contamination in rivers and streams within the Concession. The studies are described in the following section. Therefore, despite the fact that most surface water samples taken by *defendant*'s experts show that contamination in many locations within the Concession is small or none, the data does not show that all of the water in the Concession is free of contamination.

Other investigators have collected and analyzed samples from rivers and streams within the Concession. These included TPH studies in rivers used by people for drinking, bathing, or washing clothes, such as Jochnick et al. (1994) and studies carried out by Texaco contractors on the contamination of streams from the discharge of production water from stations (Fugro-McClelland West, 1992). These studies document that petroleum hydrocarbons (TPH), metals and other contaminants from production water have indeed contaminated rivers and streams. For example, TPH has been measured at concentrations much higher than the Ecuadorian standard in production water discharged into rivers; almost all river water samples also contain TPH that exceeds the standard. Chloride concentrations obtained from production water discharges were also much higher in rivers downstream from the stations.

Using data on chloride concentrations in estuaries not suffering impacts and in production water at each production station during the period that Texpet operated the Concession, the impact of production water contamination can be quantified. Production water discharges from stations between 1972 and 1990 contaminated around 2.8 trillion L of surface water above the water quality standards issued by the US EPA (230 mg/L chloride). This volume of water is equivalent to the total volume of water used by residents in Quito over a 12 year period.[7] Put another way, the volume of water contaminated by station discharges between 1972 and 1990 is the same as 80% of the water used by the population in Quito every year.

3.2.16 Timetable of Texpet operations causing contamination

Texpet operated in the Concession area until June 1990, when Petroecuador took over operations via Petroamazonas, currently Petroproducción. Since then Petroecuador has installed additional wells, although these wells are not included at all in this report. While Texpet ran operations in the Concession, it installed and operated approximately 356 oil production wells and 22 oil processing stations. After Petroecuador took over operations, it continued operating most of the wells and all the stations that Texpet had installed. Since June 1990, some Texpet production wells have been abandoned and Petroecuador has installed new production stations and wells. One issue to consider is the relative amounts of contamination caused by Texpet and by Petroecuador since it took over operations.

[7] EMMAP Quito, March 2006, Metropolitan sewage and drinking water company.

Separate environmental audits of Texpet operations have been carried out since the early 1990s, after the company stopped operating the Concession. These audits were carried out by Texaco subcontractors, and both of the audits included environmental sampling from waste pits, soil and water. Despite criticism from a variety of oversight institutions, including the National Congress, the audits showed that Texpet operated using few environmental controls or none at all (Annexes C, F, I). The waste pits were not lined, and many of them were not large enough to hold all of the waste that was dumped into them. During most of the time that Texpet operated the Concession, all production water was discharged directly into rivers and streams and all gases were released into the atmosphere. However, in the last few years of operations, Texpet installed a few gas capture stations, although most of the gases were still openly burned. Crude oil was spread on highways mainly during Texpet's tenure. Furthermore, when Texpet was operating the Concession, hundreds of oil spills were reported totaling many thousands of barrels. The environmental information collected in the Texpet contractor audits confirmed that there was massive contamination of the Concession area during this period. There is therefore overwhelming evidence that a large part of the contamination in the Concession area was caused by Texpet operations.

Petroecuador also contributed to environmental contamination. Petroecuador continues to discharge waste into unlined pits at the oil wells. For several years, Petroecuador continued to discharge production water directly into rivers and streams, although it did make an effort to reinject production water back into the ground. As of 2005 almost 100% of the production water has been reinjected. Petroecuador is still releasing gases despite the fact it has constructed installations to capture more gas and not flare it into the atmosphere. There have also been additional oil spills since Petroecuador took over operations in 1990.

However, it is clear that all of the contaminants that were released into the environment prior to June 1990 are the responsibility solely of Texpet. Data from the Judicial Inspections show that the sites operated exclusively by Texpet are still contaminated, and Texpet contaminants are still present in the environment at all sites operated by Texpet. Conversely, all of the contamination at sites that were constructed by Petroecuador after June 1990 is the responsibility solely of Petroecuador; these sites are not included in this report. The question remains then regarding the contamination that has occurred after June 1990 at sites operated initially by Texpet and then taken over by Petroecuador.

There are two possible ways of establishing liability at sites operated first by Texpet and then by PetroEcuador after June of 1990. One is to determine that Texpet is still responsible for the majority of the contamination at these sites since it established the operating methods of the sites which started the contamination and which are still being used. For example, Texpet built the waste pits that are still being used at these sites. Texpet also established the normal operating procedures for handling waste, such as discharging production water into streams and rivers and releasing gas into the atmosphere. Texpet also created the procedures for activities such as oil pipeline control and maintenance. It is unrealistic to expect that Petroecuador could immediately change all of the Concession operations in order to make them safer. Instead, Petroecuador has had to operate all of the infrastructure in the Concession in the manner in which it was handed over by Texpet, and thus the contamination which has continued since June 1990 at the sites originally operated by Texpet is substantially the responsibility of Texpet. I believe that Texpet failed to install a system that would have considerably reduced the ecological impact for its successor in the operations. This would require deploying technical advances to ensure appropriate and

complete formation water reinjection (Annexes S and T) in order to prevent further environmental contamination.

A second way of looking at the contamination which has occurred and continues to occur after June 1990 is to use the relative quantity of crude oil produced at the sites since June 1990 to represent total liability. However, this quantity would probably underestimate Texaco's relative contribution to total contamination of the sites, as Petroecuador has improved its operations and reduced the volume of environmental contamination. For example, Petroecuador now reinjects almost 100% of production water into underground wells. This means that the second method of calculation would probably attribute too low a percentage of the environmental contamination to Texaco.

3.2.17 Texpet pit remediation

My team and I carried out an in-depth investigation on this issue. We analyzed various aerial photographs from the Military Geographical Institute (IGM), information on the pits that was provided to me by the Ministry for the Environment, as well as several surveys that have been carried out during the audits and other studies included in the proceedings. Having analyzed all of the information collected, I have reached the conclusion that Texpet opened or built 916 pits in the Concession, as explained in Annex H. However, many of these pits have been covered with vegetation or soil and are not included in any of the preceding studies or in Annex A of the claim filed by *plaintiffs* (Annex H).

On May 4, 1995, Texpet entered into an agreement to clean up the pits in the Concession area. Texpet stated that this clean-up would encompass its entire contamination liability in the Concession. Texpet stated that the clean-up represented 37.5% of the contaminated oil well sites in the Concession area, which it accepted as its portion of the liability. Based on this cleanup agreement, the government of Ecuador and Petroecuador signed a document on September 30, 1998 releasing Texaco and all persons or companies related to it from all liability. However, the *plaintiffs* state that the company (Texpet) which operated 100% of the consortium should bear all liability, as the material cause of the damage. They also state that it is irrelevant whether Texaco carried out the clean-up, as the area remains highly contaminated, including the sites where Texpet conducted its cleanup. The Texpet TPH target for soils was less than 5000 ppm in the pits.

According to the information I have collected on this issue, I can state that of the 916 pits included in this analysis, 215 were within the scope of the Texpet RAP, not including the station pits that were remediated. Of the pits selected for remediation, 70 were designated no further action required (NFA), 27 included in the RAP, therefore 156 pits underwent "Complete Cleanup." We can therefore deduce that 77% of the pits constructed by Texpet were not included in the remediation, 16% underwent cleanup, and 7% were considered for cleanup but it was not carried out because the pits had been covered over or were being used by the local community or crops were growing on them.

Rather than focus on the claims about the number of sites that were cleaned up or whether the cleanup actions were appropriate, we can rely on the data on the contamination remaining at the sites where Texpet conducted their cleanup. Annex H provides an analysis of the contamination data collected during the Judicial Inspections or that I collected during late 2007 from the sites that *defendant* claims it has properly cleaned up. During my

fieldwork I collected samples from several pits that have been reported as completely cleanup by Texpet in the RAP; during the Judicial Inspection the expert witnesses representing the parties collected samples from other pits that were reported by Texpet to have been completely cleaned up. Of the 156 pits that Texpet reported as being completely cleaned up, a total of 54 pits have been sampled (34.6%). The analysis in the Annex shows that these waste pits that the *defendant* claims to be decontaminated in fact contain levels of petroleum hydrocarbons above the Ecuadorian standard of 1,000 ppm TPH, and many others also exceed the 5000 ppm limit (which was the limit set for the cleanup). Some pits contain TPH levels of almost 325,000 ppm (Lago Agrio 2). In fact, the level of petroleum contamination in the pits that were cleaned up by Texpet appears to be no lower than the contamination in pits that Texpet did not clean up. Therefore, aside from the claims submitted by both parties, the data shows that Texpet activities did not succeed in remediating the pits in a manner complying with Ecuadorian regulations and the contamination is still present. Furthermore, I have based my recommendations regarding additional cleanup needs on the data collected during the Judicial Inspections and that I collected during 2007. These data show a need for further cleanup actions, regardless of claims by the parties about Texpet's prior cleanup actions.

3.2.18 Comparison with the Judicial Inspection Reports

The expert witnesses for the *defendant* and *plaintiffs* have issued lengthy reports as part of the results of their investigations during the Judicial Inspections. The reports are comprehensive and cover many different issues related to the contamination in the Concession area. In essence, the two parties reached different conclusions in their reports:

- the experts working on behalf of the *defendant* concluded that there are no contamination problems in the Concession area. They concluded that most of the data from their samples reflect low concentrations in the environment and the relevant standards have not been exceeded with sufficient frequency to be considered a problem. They also maintain that the cleanup carried out in the 1990s resolved any contamination they had caused and which had been a problem.

- the experts for the *plaintiffs* concluded that there is soil, water and groundwater contamination in the Concession and that the entire area has been severely contaminated to the point that the people and the environment have been severely affected throughout the Concession.

My analysis of the information concludes that there is in fact contamination from Texpet production and exploration activities. However, the contamination does not affect the entire Concession area. The contamination is focused in areas around the wells, stations and spills. When the production water was discharged from the stations, a substantial number of rivers and streams downstream from the stations were severely contaminated.

In my opinion, the experts representing the *defendant* relied excessively on samples taken from areas outside the contamination in reaching their conclusions. They also used higher limits than the environmental standards required by law in Ecuador and safety levels used by other countries. On the other hand, the data collected by the experts for the *plaintiffs* does not fully reflect the extent of contamination in the Concession area because it concentrates mainly on contamination sources.

I consider it very important that there is an overall consistency among the many different investigations that have been conducted in the Concession area. All of the studies that have been conducted in the Concession, including those conducted for the litigation and those conducted prior to the litigation (Annex C), show that there is serious and widespread (but not ubiquitous) contamination in the Concession area. These multiple investigations corroborate each other, making the data from each individual study more powerful.

It is worth noting that this similarity demonstrates the reliability of the data. Additionally, I should note that the conclusions in the reports issued by expert witnesses representing the *defendant* have not been taken into account as they ignore the presence of contaminants by avoiding any comparison of their results with applicable regulations in Ecuador or other environmental safety thresholds.

3.3 Conclusions

Sources of contamination

The primary sources of contamination in the Concession are crude oil, drilling muds and other additives, and produced water that were released into the environment. Crude oil consists mainly of petroleum hydrocarbons. Drilling muds contain metals, such as barium. Produced water, which was discharged primarily from stations, contains petroleum hydrocarbons, metals, and salts. At sufficient concentrations, these chemicals are harmful to humans and to the environment.

Contamination data

Thousands of environmental samples were taken from the Concession area and analyzed as part of the proceedings. Although samples were not taken from every well and station site, the results of the samples can be used to extrapolate results to the entire Concession area because the samples are sufficiently representative (54% of stations and 22.8% of the wells have been sampled). I have reviewed the samples and the analytical methods and reached the conclusion that the data is reliable and can be used for making decisions on environmental contamination and clean-up.

Environmental contamination

The data show that the environment of the Concession is highly contaminated with petroleum hydrocarbons and other contaminants released from oil operations. Every waste pit contains petroleum at concentrations above the Ecuadorian standard of 1,000 ppm TPH. Soils at wells and stations that are outside of pits are also highly contaminated with petroleum from spills and from leaks from pits. Groundwater at 44% of the sites sampled contain petroleum hydrocarbons in excess of standards, and groundwater from beneath pits tends to be more contaminated with hydrocarbons than groundwater outside of pits. When produced water was discharged to rivers and streams, the rivers and streams in the Concession were highly contaminated.

Remediation actions

At the time that Petroecuador took charge of the operations, it had no choice but to continue the operations that Texpet had commenced. Over time, Petroecuador has implemented improvements, such as reinjecting production water (although its reinjection wells are inadequate and unsafe). Texpet cleanups carried out during the 1990s were insufficient to resolve the contamination: there is still a very high level of contamination in the pits that requires additional cleanup.

4 IMPACT ON HUMAN POPULATIONS

The preceding sections have described environmental contamination in the Concession caused by petroleum production and exploration. Both the contamination and its toxic effects constitute the environmental damage caused by oil production and exploration within the Concession.

This section describes another type of damage caused by oil exploration activities in the Concession: the harm caused to people who live in the Concession territories. As a vital part of the environment, people are also subject to different types of impact from oil exploration and development activities. This section describes other types of harm caused to people in the Concession:

- Adverse effects on human health, including high rates of cancer, spontaneous abortions, high infant mortality rates and birth deformities.

- Human Rights violations suffered at the hands of Texpet employees, such as rape, ethnic violence and discrimination.

- Impact on indigenous communities, including displacement from their ancestral territories and loss of cultural integrity and identity.

This type of harm is described here because it must be carefully considered when evaluating measures needed to completely resolve all of the environmental damage generated by Texpet's petroleum exploration and production in the Concession. The mandate that I received from this court included *"evaluating whether there is any environmental damage suffered by primary resources: the soil, water resources, vegetation, fauna and other elements in the surrounding areas, detailing their characteristics."* It is impossible not to include human beings as a fundamental aspect of the environment and surrounding areas, therefore this report would be remiss if it failed to describe the impacts that the people in the Concession have suffered.

Data presented below are taken from field studies carried out by Beristain, *et al*, These studies included quantitative surveys of 1064 persons from different families, as well as a qualitative surveys using six focus groups selected according to ethnic criteria (Annex L). The surveys and focus groups focused on people living in the area during Texpet operations and their findings are related to this company.

4.1 Legitimacy and validity of the survey methodology

The use of household surveys to gather quantitative and qualitative data is a widely accepted method to gather information about people. The surveys are carefully designed so that the there is a consistency in the survey method across all the people surveyed, which allows for quantitatively comparisons to be made. For example, for decades the World Bank has used household surveys of people to track the living standards and health condition of people across the world, and the results that they obtain are widely accepted as being quantitative, reliable, and directly comparable from one country to another (http://www.worldbank.org/LSMS/; Wang, 2003), including in Ecuador (World Bank 1996). More specifically, we can see in the survey described in Annex L that there is an internal consistency of the results that help confirm that the data collected are valid. For example, there is a strong consistency in the relationship between the distance people live from wells and their health condition, as described in more detail below. This consistency is observed in many different measures of health, not in just a few random measures. Since the survey was conducted in an unbiased manner (as described in Annex L), this shows that there is an internal consistency to the study results, which helps demonstrate the validity and meaningfulness of the study results. Therefore, the household survey described in Annex L is a widely accepted and valid way to gather data about people's past and current conditions and experiences.

Moreover, the results of the survey conducted for this matter is further confirmed by the fact that it's conclusions are the same as other studies that have investigated the relationship between the how close people live to contaminated sites and their health problems. For example, Dayal, *et al* (1995) found that neurological problems occur with much greater frequency in people who live nearby toxic waste dumps, compared with people in the same community living further away from the dumps (the study did not consider cancer rates). Many of the toxic chemicals in the sanitary dumps are the same chemicals found in the Concession, including benzene, benzoanthracene, benzopyrene, chryseme and chromium. Thus, the results of the surveys in the Beristain study are consistent with similar health studies carried out involving people who live near other contaminated sites.

4.2 Adverse effects on human health

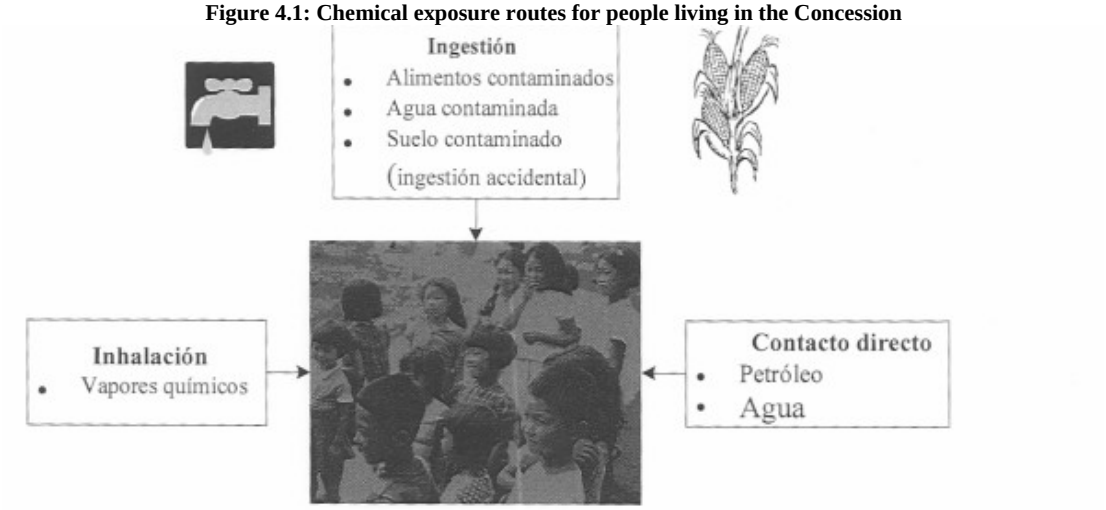
4.2.1 Introduction: Types of human exposure to environmental contamination

The population living in the Concession area is exposed to chemicals from crude oil, production water, drilling mud and additives in a variety of ways (Figure 4.1). People can ingest chemicals when they eat contaminated food, drink contaminated water or accidentally ingest contaminated soil. Volatile contaminants, such as benzene, toluene, ethylbenzene and xylene (BTEX) can be inhaled and can lodge in the lungs. Certain petroleum hydrocarbons can also be absorbed through the skin.

The chemicals found in crude oil, production water and drilling waste in the Concession are toxic to humans. Annex K establishes the toxicity of key compounds to which people were exposed and provides further details on ways in which people can be exposed to these chemicals. The information in the Annex shows that the chemicals in the Concession cause a range of toxic effects which are damaging to health, including cancer, lung damage, liver

damage, central nervous system damage and damage to other organs, low weight at birth and the effects on fetuses as well as effects on the stomach and skin.

Figure 4.1: Chemical exposure routes for people living in the Concession



4.2.2 Cancer

Cancer distribution by type, sex and age

The quantitative study described in Annex L asked several questions about cancer. In 21.33% of the families surveyed, or almost one in every four, we found at least one case of cancer in the family. The total number of cases refers to persons suffering from or who have died of cancer. This incidence of cancer, in almost than one in every four families surveyed, is very high.

For comparison, according to the National Records on tumors, there is a lower frequency of cancers in Quito than in the Beristain study among young people. We note that the exact characteristics of these two studies are different, and therefore we cannot make definitive conclusions from this data. However, the data suggest that there is a higher proportion of people of this age with tumors in the area.

Of the cancer cases reported in the survey, a slight majority occurred in women. In women the most frequent type of cancer was uterine cancer (37.34%), while among men it was stomach cancer (25.7%).

Distribution as a function of distance from the wells

We compared the aforementioned cancer cases with the distance that the survey population lived from the wells. The results are shown in the following table:

Figure 4.2 Distribution of cancer cases as a function of distance from the wells

Distance from an oil well	Cancer cases as a % of the total N = 1064	Number of cancer cases in	Average

		the family	
Less than 250 meters	34.49%	158	1.43
251-500 m	17.57%	43	1.23
501- 2000 m	29.22%	76	1.24
Over 2 km	17.1%	26	1.14
No data	1.59%	3	

Approximately 58.62% of those surveyed that live less than 250 m from a well reported at least one case of cancer, which is numerically significant considering that only 34% of people in the survey live within this radius.

Distribution as a function of ethnic group

The focus groups presented many reports of cancer cases associated with environmental contamination. The most common cases are in the groups of settlers, especially women settlers.

89.65% of those who reported more than one case of cancer in their families, or nearly 9 out of every 10, are of mixed race, and the remainder are indigenous. This data is consistent with the background of these population groups. Mixed race people are more exposed to petroleum contamination than the indigenous population in general, given that they live closer to areas where Texpet conducted operations.

The appearance of cancer can be related to the period of Texpet operations (which is to 1990), and cancer has continued to appear beyond this period. Therefore it could be argued that these later effects are related to later factors such as continued exploration carried out by other companies which has affected people's health. However, there are several reasons why this probably is not true: 1) exposure during the 25 years that Texpet was operating in the area covers an extremely relevant period of time, more so than later periods, 2) the levels of contamination described at that time were not based on guidelines or effective controls, resulting in massive contamination as was shown in previous sections, 3) direct contact with petroleum does not immediately lead to cancer, rather the cancer can appear years later, 4) the survey concentrated specifically on people residing in the region during Texpet operations.

4.2.3. Spontaneous abortions

Of the total number of people surveyed, 71.71% say they became pregnant during the period that Texpet was operating the Concession (1964 to 1990). The number of spontaneous abortions reported was 11.9% of total pregnancies, while 88.1% of pregnancies went to term. Of the total number of families reporting spontaneous abortions, 65.9% of families had a single abortion, 22.8% reported two abortions and 11.3% reported three abortions or more. Although the ratio of abortions to the number of pregnancies is comparatively similar to other regions today, the data reflects greater exposure to contamination resulting in increased frequency of abortions, with a greater number of cases in the family.

4.2.4. Infant deformities

97 cases of infants born with deformities occurred within 79 of the families surveyed. This equates to 10.35% of the families reported children born with deformities. Although definitive conclusions are not reached with these data, other studies demonstrate this effect being caused by petroleum or related chemicals used in the oil industry, such as PAHs (depending on the dosage and level of exposure).

4.2.5 Infant mortality

Among the 97 cases surveyed, in other words 12.71% of those reporting pregnancies, people reported a total of 133 babies dying within the first 30 days of birth. This represents 3.73% of pregnancies that went to term. 103 people surveyed reported a total of 125 infant deaths within the first year, representing 3.51% of the total number of pregnancies taken to term. Overall, 7.24% of infants died during the first year of life.

Of the 77 cases surveyed, in other words 11.53%, 88 infant deaths were reported between the first and fifth years of life. This represents 2.47% of pregnancies taken to term. There is also a relationship between how close someone lives to an oil well and the incidence of these deaths (figure 4.6).

Figure 4.3 Number of child deaths between the ages of one and five years, in relation to the distance from wells.

Distance to wells	Average number of infant deaths below the age of five
Less than 250 m	2.29 (28 cases)
250- 500 m	2.11 (18 cases)
500m – 2 Km	2.05 (21 cases)
Over 2 km	2.00 (6 cases)

4.2.6. Health

Health-related data refers to self-reported information on people's perception of their own health and of their families. The results from the survey are dramatically different than the results for other groups of people surveyed elsewhere. Of the total number of people surveyed in the region, around 60% believe that their health and that of their family is poor or very poor, while similar studies worldwide have established that 65% of people believe their health is good or very good.

It is important to note that people report that their poor health conditions are associated with Texpet presence and operations. 85.2% believe they have been affected "a lot" or "very much" because of oil exploration activities, which shows that these people are fully aware of the damage inflicted on them.

4.3 Human Rights violations at the hands of Texpet workers

4.3.1 Sexual violence

10.1% of people interviewed said that at least one woman in their family has been sexually abused by oil workers. These incidents are especially prevalent in the Durenos and Shushufindi fields, as the Cofanes live in Dureno and the Sionas and Secoyas live in Shushufindi.

One in every five people interviewed believes that the raping of women has had a massive effect on the community, while one in every 20 reports direct knowledge that this abuse was frequent among adult women as well as girls under the age of 18. One in every 10 interviewed has suffered sexual violence within their own family, committed by Texpet employees. These high figures, alongside the fact that a very significant percentage of people know that there are children in their communities born following these forms of abuse by Texpet workers or managers, demonstrate the serious nature of this problem in the Concession area.

4.3.2 Hostile conduct and discrimination

62% of those surveyed reported that the treatment they received from Texpet employees was “poor” or “very poor” and that these employees were disrespectful and unresponsive.

Approximately 50% of those surveyed say they have been victims of hostile conduct from Texpet employees, which took place at times of conflict, for example when complaining of loss or damage to their territories, and at other times when forced to live among the employees.

Indigenous peoples are the most frequent victims of discrimination from Texpet workers. This discrimination comprised misleading conduct, taking advantage of the communities, or ridiculing their cultural ways or dress..

4.4 Impacts on indigenous communities

4.4.1. Land lost as a result of contamination or exploration

We evaluated the impact of Texpet oil exploration or contamination in terms of possible land losses. In terms of land lost, 74.1% of those interviewed said they had lost land as a result of petroleum exploration or contamination. These losses are more common among indigenous communities.

The indigenous communities reported they were affected to a greater extent than settlers in terms of land lost and contamination of their territory, especially water contamination. These differences could also be due to cultural differences as indigenous communities’ relationship with the land is given much greater value. The earth is a fundamental aspect of the survival of each individual as well as the community, and their relationship with the land is part of the collective identity.

4.4.2. Forced displacement

More than one in every five of those interviewed, 22.1%, claimed they were forced to move because of Texpet. Reasons for displacement include, in order of frequency, impacts to land and rivers, noise and contamination, the fact that farming is incompatible with oil exploration, serious illnesses, destruction of property, accidents, violence and legal problems. Once again, we see that indigenous groups were much more frequently displaced than mixed-race groups.

4.4.3. Cultural impact and community cohesion

Texpet activities, including the mere presence of its workers in the area, had a range of impacts on indigenous community culture. First of all, we detected a process of forced cultural change to adopt Western cultural practices and references, such as money, alcohol and the Spanish language.

In many of these cases the cultural change was not a simple result of contact, but rather was part of a systematic policy. Alcohol, for example, caused the death of a Cofán shaman and seriously affected community health and cohesion.

The impacts to personal rights from violence, insecurity, discrimination, hostile conduct, etc, were reported more frequently among indigenous groups.

4.4.4. Hunting and fishing

For indigenous groups, hunting and fishing are more than just a means of procuring food, but rather they are a central part of their life and culture. 94.2% of those interviewed said that they were unable to hunt because the number of animals had dropped following contamination, and 96.1% said that fishing has been adversely affected. This data demonstrates both a loss of the numbers or populations of these species as well as a loss of biodiversity.

4.5 Conclusions

People living in the area have suffered harm as a result of oil exploration and production activities ranging from various types of cancer to rape and discrimination against indigenous people.

Annex L indicates that there is a substantial relationship between these health problems and how closely people live to oil wells.

5 ECOSYSTEM IMPACTS

5.1 Introduction

This section summarizes the ecological impacts caused by the contamination in the Concession. Potential impacts to all components of the ecosystem are considered, including plants, animals, invertebrates, and fish.

The chemicals in crude oil, produced water, and drilling muds and other additives are toxic to all types of living things. However, for toxicity to occur an organism must be exposed to the chemical, such as through ingestion, and that exposure dose must be sufficiently high to cause toxicity. For some chemicals, exposure below a certain dose does not cause any observable adverse effects.

There is a large amount of scientific literature on the doses of chemicals that cause toxicity to living things. There are other factors besides dose that also determine whether a particular chemical exposure will cause toxicity to an organism, such as for how long the dose lasts; whether the organism is exposed to other chemicals at the same time; the

overall health of the organism; the age of the organism; and whether the organism is sensitive to the chemical. Nevertheless, the dose of a chemical exposure is the primary factor that determines whether environmental contamination will cause toxicity to an exposed organism.

To evaluate whether the contamination in the Concession area causes ecological impacts or not, the following steps were used:

1. A conceptual model of how organisms may be exposed to chemicals was developed, and the key chemicals of concern were identified.

2. The toxicity of the key chemicals of concern was researched, and toxicity threshold levels were selected.

3. The contaminant data collected for the litigation were compared against the toxicity thresholds.

4. Surface water data collected prior to the litigation studies were used to evaluate the toxicity in rivers where produced water was discharged.

5. Field ecological studies that were conducted for the litigation were reviewed and compared against the conclusions from the chemical evaluation.

Details are provided in Annex J. A brief summary and description of conclusions are presented here.

5.2 The ecological toxicity of oil and produced water

The contaminants in crude oil that are of primary concern are the petroleum hydrocarbons. Of the thousands of chemicals in crude oil, the ecological toxicity of BTEX and of polycyclic aromatic hydrocarbons have been the most studied. These compounds are toxic to plants, birds, mammals, invertebrates, and fish. At high enough doses these chemicals can cause acute (i.e., immediate) death. At lower doses, they can cause effects that lead to death, such as cancer, as well as effects that can decrease an organism's ability to survive, such as reduced growth or decreased ability to resist disease. Other chemicals in crude oil are also toxic, but they have been studied much less.

Produced water also contains BTEX and petroleum hydrocarbons. It also contains high concentrations of salt, and produced water often is saltier than seawater. Metals concentrations are also high in produced water. These chemicals can kill fish and other aquatic life, or cause changes in the aquatic community so that only the most pollution tolerant organisms can survive.

Organisms can be exposed to these chemicals in several different ways, including:

- Ingestion. Animals can eat prey items that are contaminated, or they can ingest the chemicals that are attached to soil or sediment particles. Many animals inadvertently consume significant amounts of soil or sediment as they feed.
- Direct contact. The hydrocarbon compounds in petroleum can be accumulated across the skin.

- Inhalation. Some of the hydrocarbon compounds are volatile, such as BTEX.
- Plants can take up contaminants through their roots (from contaminated soil), leaves (volatized contaminants or deposition of contaminated rainwater or soot), or across seed membranes.
- Fish are exposed to chemicals in water through uptake across their gills.

In addition, crude oil can also harm organisms through its physical effects. Oil on feathers can affect the ability of birds to fly. Oil also makes fur and feathers less effective at insulating or at repelling water. These types of effects can occur where oil is pooled on the ground or atop the water after a spill, or in pits with floating oil (Annex J).

5.3 Comparison of chemical concentrations in the Concession to toxicity levels

Toxic threshold concentrations in soil and in surface water (streams and rivers) were selected after a careful review of the scientific literature and of government regulations and standards. In many cases, the Ecuadorian standards for the protection of the environment were used, since these standards are designed to protect the environment from toxicity and because the values are consistent with data from the scientific literature. Toxicity thresholds were identified for the following chemicals:

- TPH in soil and water
- Metals in soil and water
- BTEX and polycyclic aromatic hydrocarbons in water
- Chloride in water

Table 5.1 lists the selected toxicity thresholds. In some cases, there is more than one threshold to represent the range of exposure and toxicity that can occur for different types of organisms.

The environmental contamination data from the Concession were compared to the thresholds shown in Table 5.1. For soils, only data from soils at or near the surface (within 1 meter of the surface) were used in the comparison, since ecological exposure is limited to soil contaminants that are beneath the surface.

Table 5.1. Toxic thresholds for key contaminants

Contaminant	Surface water (ug/L)			Soil (mg/Kg)				
	Ecuador standard	U.S. EPA acute	U.S. EPA chronic	Ecuador standard	Plant (U.S.)	Invertebrates (U.S.)	Avian (U.S.)	Mammal (U.S.)
Benzene	–	5,300	262.0	–	–	–	–	–
Toluene	–	17,500	110.3	–	–	–	–	–
Ethyl benzene	–	32,000	1,800	–	–	–	–	–
Xylene	–	–	2,600	–	–	–	–	–
HAPs	0.3	–	–	–	–	–	–	–

TPH	500	–	–	1,000	–	–	–	–
Barium	1,000	–	–	–	–	330.0	–	2,000
Cadmium	1.0	2.0	0.25	–	–	–	–	–
Chromium III	50.0	570.0	74.0	–	–	–	26.0	34.0
Chromium VI	–	16.0	11.0	–	–	–	–	–
Copper		13.0	9.0		70	80	28	49
Lead	–	65.0	2.50	–	–	–	–	–
Nickel	25.0	470.0	52.0	–	–	–	–	–
Zinc	180.0	120.0	120.0	–	160.0	120.0	46.0	79.0
Chloride	–	860,000	230,000	–	–	–	–	–

* = Toxicity modified with respect to water hardness, criteria normalized to a hardness of 100 mg/L.
References: Decreto No. 1215; CEPA, 1993; Rowe et al., 1997; U.S. EPA, 1980a, 1980b, 1985, 1988, 1996, 2005a, 2005b, 2005c, 2007.

The data show that the chemical concentrations in the Concession exceed the toxicity thresholds. For example, Figure 5.1 and Figure 5.2 compare the concentrations of TPH in surface soils taken from inside and outside of pits (respectively) to the threshold of 1,000 mg/kg. The figures plot the data on a logarithmic scale because of the wide range in concentration data. Each horizontal line on the plots represents a ten-fold difference in concentrations. Figure 5.1 shows that many samples from the surfaces of pits have TPH concentrations well above 1,000 mg/kg. Concentrations are up to 1,000 times higher than the threshold (in the Sacha and Lago Agrio campos), which indicates that the soil is very toxic. The surfaces of the pits have these high concentrations despite the fact that many of them have been covered over with soil. Figure 5.2 shows that soils from outside of pits are also expected to be toxic. Both figures show that the high TPH concentrations occur in all of the fields that were sampled.

Figure 5.1: TPH concentrations in surface soils from the pit areas, by field. The red line represents the 1,000 ppm threshold. Note that the data are plotted on a logarithmic scale.

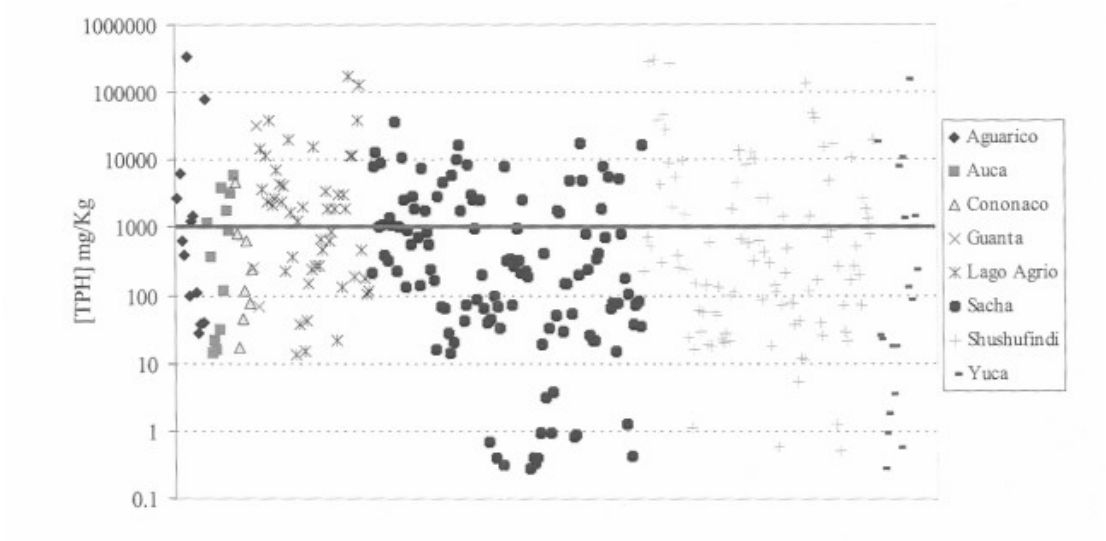
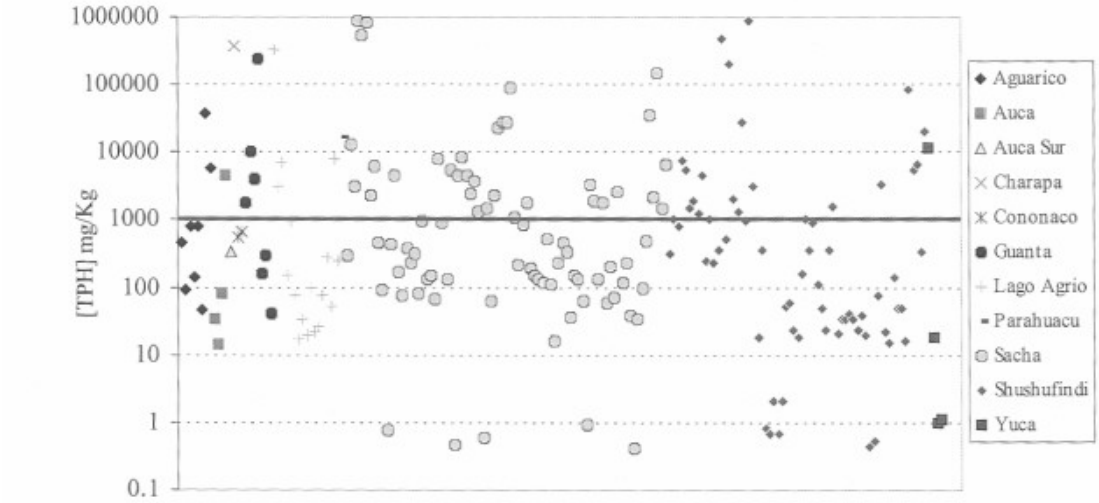


Figure 5.2: TPH concentrations in surface soils outside of pits, by field. The red line represents the 1,000 ppm threshold. Note that the data are plotted on a logarithmic scale.



Concentrations of metals in surface soils also exceed toxicity thresholds. In particular, concentrations of barium, copper, and zinc exceed the thresholds in many of the surface soil samples collected during the litigation (see Annex Q). The TPH and metals data together show that much of the surface soil at the wells and stations within the Concession are contaminated enough to cause toxicity to terrestrial organisms.

Produced water that was discharged into streams and rivers made them unsuitable for aquatic life. The produced waters themselves contain concentrations of BTEX, HAPs, TPH, and chloride that are many times higher than toxicity thresholds. Data from downstream of some stations shows that concentrations are still toxic at 450 meters or 700 meters downstream of the station discharge. The data clearly show that the produced water discharges made the streams and rivers downstream of the stations toxic to aquatic life.

In addition, chemical measurements in fish collected from rivers in the Concession show that they contain metals at concentrations above safe levels for human consumption. In particular, the concentrations of arsenic, cadmium, chromium, mercury, and zinc are routinely higher in fish than safe levels.

5.4 Field observations

The comparison of chemical concentrations in the Concession to toxicity thresholds shows that the contamination is sufficient to cause toxicity to plants and animals. In addition, there are field observations on the effects of oil exploration and production activities on the ecosystem in the Concession.

First, there are the conditions that are visible at the wells. It is common at wells to see areas where there are fewer plants, or the plants are of different types or smaller than in uncontaminated areas. It is also common that plants do not grow as well on the covered pits as they do in nearby uncontaminated areas. In some areas, evidence of old oil spills is still apparent as weathered oil on the ground and reduced ability of plants to grow. Figure 5.3 shows an example of an area like this near well Sacha 56.

Second, there have been studies of the flora and fauna in the Concession and how they compare to areas that are not impacted by oil activities. Martinez (2007) compared the diversity of Concession plant communities to the diversity of Amazon forests in areas not affected by oilfield operations. Their study shows that there are little to no natural species present in the plant communities closest to the well pads. Outside of these heavily disturbed areas there are areas of fragmented forest that lack the biodiversity to fully sustain a healthy forest ecosystem. The study concludes that the biodiversity of flora and fauna in the fragmented forests is much lower than in areas not impacted by oilfield activities.

Gallo (2007) investigated the diversity of Concession fauna through extensive surveys of mammals, birds, amphibians, reptiles, and aquatic invertebrates. The study shows that the diversity of mammals, birds, amphibians, and reptiles is substantially lower than what would naturally occur in similar not affected areas. The fauna that are present are those that are highly tolerant of habitat disturbances. For example, species that are adapted to feeding on cultivated crops such as yucca and fruits were common.

Figure 5.3: Oil spill area near well Sacha 56. The oil spilled from the pipelines to the coffee plants in the background. The photograph shows that the plants in the spill area still have impaired growth decades after the spill occurred.

5.5 Conclusions

Crude oil, produced water, and drilling muds and other additives contain chemicals that are toxic to ecological life. The question of whether toxicity is actually occurring depends primarily on how high the environmental exposures are compared to concentrations that cause toxicity.

Data from the Concession show that concentrations of crude oil and metals in surface soils at wells and stations exceed toxicity thresholds. The thresholds are exceeded in surface soils from both inside and outside of pits. These data show that the environmental contamination is sufficient to cause toxicity to terrestrial biota.

Produced water is highly toxic to aquatic life. Concentrations of petroleum hydrocarbons, metals, and chloride are many times higher than toxic threshold concentrations. Few, if any, aquatic biota could survive for very long in the produced water discharge. When produced water was discharged from stations into rivers, the concentrations of the chemicals in the rivers exceeded toxicity thresholds for at least hundreds of meters downstream of the stations.

In addition to the effects of chemicals, the environment also suffers from habitat degradation brought on by the development of the oil field. Roads, construction, field operations, and other activities have degraded the habitat in the Concession area so that it is much poor habitat quality than before. The forest plants and animals are mostly gone, and only the plants and animals that can withstand disturbance can survive in the area.

6 ACTIONS TO REPAIR THE DAMAGE

This section describes the actions that must be taken to repair damage caused by Texpet to the Concession area environment. First, we summarize the damage caused by Texpet, as described in the preceding sections. Then the approach to repair the harm is described, as well as the specific actions that should be taken. Then each of the actions is described in more detail, including the estimated cost of each proposed action.

6.1 Summary of the damage caused by Texpet

Texpet caused widespread contamination of the environment in the Concession area. The Concession's environment has been polluted with crude oil, produced water, and chemicals from well drilling and flaring of gas. The people and the ecosystem of the Concession have been and are exposed to chemicals in these materials, including BTEX, PAHs, metals, and chloride. There also has been widespread habitat degradation brought about by TexPet's development of the oil fields.

The effects on humans in the area are many. One of the most important effects is on the health of the people in the region. People in the region suffer from higher rates of cancer, death, spontaneous abortions, and infant mortality (Annex Q).

Another effect on human beings is the displacement of indigenous groups that have been forced to abandon their ancestral territories in the Concession area.

There are also effects on the ecosystem. Soils and rivers in the area are toxic to plants, animals, and other organisms. The biodiversity of the area is much lower than in healthy forest ecosystems, and the plants and animals that live in the area are primarily those that are tolerant of habitat degradation and human disturbance.

These impacts have been occurring for many years, and they will continue into the future until the contamination is cleaned up and the harm to the people and the environment is repaired.

6.2 Repairing the damage

The harm caused by Texpet to the people and environment of the Concession area needs to be repaired. The first step in repairing the harm is to clean up the contamination that is left behind. Therefore, a proposal to remediate contaminated soils at wells and stations is included. The remediation approach is focused on cleaning up crude oil and petroleum hydrocarbons from pits and other contaminated soils at wells and stations. Cleaning up contaminated pits and other areas of contaminated soils is a clear and direct way to repair the ongoing harm being caused by the contamination in the Concession area that still remains. An effective cleanup of the areas contaminated with oil by Texpet is urgently required (Annex N).

However, cleaning up contaminated pits and associated soils at wells and stations will not repair the harm to the environment and human health. To mitigate this harm in a comprehensive way, the people in the area need potable drinking water and a reliable health care system. Many people in the region do not have access to clean water for drinking and washing. Many people use water that is contaminated because of oilfield activities or because of poor sanitation mainly because these people do not have access to clean water to drink or wash. This contaminated water is a significant factor in the poor health of people in the area. In addition, health care in the region is limited. A dependable health care system would substantially improve the health of the people by giving them prompt and easy access to the care they need. These two actions, providing potable water and establishing a good health care system, will be the most effective actions to improve the health and well being of the people in the Concession area who are suffering from the effects of the oil field activities.

Oil field operations are not directly responsible for all of the contamination in drinking water or all of the adverse health effects that people suffer. However, the people in the area have suffered from adverse effects that are related to oil operations for so long, and will continue to in the future, that providing potable water and a viable health care system will help stop the ongoing harm to people's health and will help compensate for the health impacts in the past. Therefore, providing potable water and a health care system to the people of the region is a reasonable approach to address the harm caused by Texpet's oil exploration and production activities. Based on these facts and as independent expert and in compliance with court-ordered duties, I recommend that the potable water system (Annex R) and health care system (Annex P) be put in place to prevent additional suffering.

Another action that is necessary to repair the harm is to prevent future environmental contamination from PetroEcuador's ongoing operations. When PetroEcuador took over the operation of the Concession from Texpet, it inherited the infrastructure and operations that had been established by Texpet. While PetroEcuador has made some improvements in the Concession operations, such as using old oil wells to reinject produced water and capturing some of the gas rather than flaring all of it, additional improvements are needed. Specifically, the produced water reinjection system should be overhauled to make it safe, and actions should be taken to capture all of the gas that is currently being flared at stations across the Concession. These actions are necessary to prevent future contamination that would result from the legacy of Texpet's operations in the Concession. The new, modern and reliable produced water reinjection technologies and proper handling of the remaining gas would, I believe, be a major step towards preventing ongoing environmental contamination initially left by Texpet and continued by (Annexes S and T).

Finally, it is of the utmost importance to carry out actions, where possible, to rebuild the life of the indigenous peoples who have been displaced and affected by Texpet operations in the Concession in terms of their territory, food and cultural traditions (Annex M).

6.3 Specific actions to repair damages and their costs

Based on the relevant legal provisions, I have calculated the economic value of the damages and the costs of repairing the damage. I am submitting this information for the consideration of the judge, who is in a better position to approve or reject it, in whole or in part, at his discretion.

6.3.1 Restoring the pits and contaminated soil

The extent of pit and soil remediation that is required is based on the Ecuadorian standard for petroleum contamination in soils of sensitive ecosystems of 1,000 ppm TPH. Annex D show that this standard is consistent with the standards from other countries and international organizations, although some other standards are much less than 1,000 ppm TPH. This concentration is also higher than background levels of TPH in the Concession.[8] Nevertheless, the 1,000 ppm TPH standard is used here to determine how much soil requires remediation. Also, soils in the Concession are contaminated with other chemicals besides crude oil, but TPH is used as the chemical for the remediation target because most of the soil contamination comes from crude oil, and because most of the available soil data in the Concession are for TPH.

The pit and soil remediation should address the contaminated pits and other contaminated soils, such as soils at wells and stations that are contaminated from spills. There are a total of approximately 916 pits at the wells and stations that were operated by Texpet (Annex H). These pits were all installed by Texpet; no pits at wells installed by PetroEcuador are included in this report. Based on the information in Annex H, about 80% of the pits at wells and 100% of the pits at stations require remediation. In addition, an assumption is made that the area of additional soil outside of pits that requires remediation is 50% of the area of the pits that requires remediation. This assumption is based on the sampling data that show high levels of TPH outside of pits, on the numerous crude oil spills that have been documented at wells and stations, and on professional judgment. Table 6.1 shows that there are 947,000 m^2 of pits and soils in the Concession that require remediation. Details are provided in Annex N.

Table 6.1: Surface area of Concession soils requiring remediation (> 1,000 ppm TPH)

Soil surface area	Wells	Stations	Total
Total surface area of pits	691,000 m^2	77,500 m^2	769,000 m^2
Surface area of pits requiring remediation	553,000 m^2 (80% of pit soils)	77,500 m^2 (100% of pit soils)	631,000 m^2
Surface area of soils outside of pits that require remediation (50% of pit soils)			316,000 m^2
Total surface area of soils requiring remediation			**947,000 m^2**

To estimate the cost of the remediation, the depth of contamination must also be known. An analysis of the depth of contamination is in Annex N, and the average depth of contamination is estimated as 4 meters. This gives a total volume of 3,788,000 m^3 of soil that requires remediation.

Annex N discusses several possible options for how to conduct the remediation. It also describes the ongoing remediation being conducted by PEPDA, and why that cleanup is not adequate to remove the contamination from the pits. A more rigorous and complete remediation is necessary to address fully the contamination that exists. To completely remediate the contamination and reduce it to less than 1,000 ppm TPH, it is necessary to dig out soils from the pits and other contaminated areas and use bioremediation to reduce

[8] Background levels of petroleum contamination are at or near zero, but some TPH measurement methods may provide values as high as 100 to 200 ppm TPH because of naturally occurring organic compounds in soils.

the petroleum concentrations. The pits will then be backfilled with clean soil, and restored. The average cost for similar projects that address similar kinds of contamination is $448/m^3 of soil (Annex N). Multiplying this cost by the total volume of soil that must be remediated gives a total cost estimate of **ONE BILLION SEVEN HUNDRED MILLION DOLLARS (**$1,700,000). Therefore, the remediation of the contaminated pits and soils in the Concession will cost approximately $1,700,000 (Annex N).

6.3.2 Potable water supply

Annex R describes a potable water system that would be installed to provide clean drinking water to the people in the Concession. The system would take water from rivers upstream of oil exploration and production areas and distribute the water to the residents of the region. Three regional systems would be installed: one for communities and areas north of Rio Aguarico; one for the communities bounded by Rio Aguarico to the north, Rio Coca to the west, and Rio Napo to the south; and one for communities in Canton Francisco de Orellana to the south of the Napo River.

The costs to supply potable water to the region are described in Annex R. The cost for the three regional systems is estimated at **FOUR HUNDRED AND TWENTY EIGHT MILLION DOLLARS ($428,000,000)** (Annex R)**.**

6.3.3 Healthcare system: Proposed complete healthcare program following oil exploration activities in Sucumbíos and Orellana

Background and justification

The information presented here shows that a comprehensive health plan that is sustainable, effective and all-encompassing is needed to address the health problems of the people in Sucumbíos and Orellana. This plan must address not only immediate health care needs but also prevention, investigation/basic monitoring for cancer and a group of subsidiary programs. The healthcare approach goes beyond merely treating the conditions and illnesses directly and specifically caused by Texpet operations. However, this can be justified because harm has been caused that is not necessarily health-related and which cannot be remedied by the company, for which the local inhabitants must be compensated.

Characteristics of the Complete Healthcare Program

The complete healthcare program described in Annex P relies on a series of administrative agencies which will develop and maintain the program. One component of the program will be a "Monitoring and Response Unit Network", which will be responsible for monitoring the environment and people's health for problems caused by oil exploration, systematizing and analyzing all relevant information, implementing oversight activities, and applying environmental, industrial and collective health and safety regulations. These actions will help ensure that the people will have access to immediate and high-quality attention at any healthcare unit in part of the system.

Today, in the area where Texpet operated, there are several hospitals, dispensaries, clinics and health centers operated by a variety of public and private agencies. The recommended healthcare program includes two central components related to these existing services: 1)

provide these healthcare institutions with the full technical and human resources that they require to improve the well being of the people living in the region; and 2) connect these institutions as part of a complete healthcare network that operates on a coordinated and coherent basis to maximize the effectiveness of the available resources and activities. The current healthcare resources and policies available to the people in the region affected by Texpet oil operations are inadequate, and this negatively impacts the peoples' lives. This is why implementation of the Complete Healthcare Program is essential to improve the quality of life of people in the Sucumbíos and Orellana provinces.

The area contains hospitals and centers dedicated to mitigating and preventing local population health problems. The problem is that they do not have the technical or human resources to fulfill their objectives. The proposed plan will solve the inadequacies of the current system and allow it to work in a coherent and interdependent manner.

The cost of providing adequate health care in the Concession area is **FOUR HUNDRED AND EIGHTY MILLION DOLLARS ($480,000,000).**

6.3.4 Improve the existing oil infrastructure

Two actions are required to improve the infrastructure of existing oil operations so that there will be no or limited ongoing and future environmental contamination: re-engineer the existing produced water reinjection system; and capture all the gas so that none is flared. I believe that the system should be installed by the company operating the Concession at the time petroleum operations began in the Concession area. These costs are required to eliminate the operating practices which Texpet left behind and which are causing ongoing contamination.

Annex S describes the specific actions needed to improve the infrastructure of the current operations. Although all or nearly all of the produced water currently is being reinjected, the reinjection system uses old oil production wells that have been retrofitted for water reinjection. This system is prone to failure and is not a satisfactory long-term approach. Oil production wells are not designed to handle the pressure and conditions of produced water reinjection, and they are not built with the safeguards needed to ensure that the water does not contaminate the shallow groundwater in the area. For example, cracks in the casing of well Shushufindi 45A have resulted in extensive contamination of the groundwater around the well with the toxic produced water, and the produced water is being discharged to the surface in some areas. Other retrofitted oil wells in the Concession have also experienced problems. Therefore, a system for water reinjection that is properly designed and constructed is needed to stop and prevent contamination in the future.

Similarly, because of the original infrastructure left behind by Texpet, most of the gas separated from crude oil and production water at Concession area stations is flared. Gas flaring produces many toxic hydrocarbon chemicals that can be carried for fairly long distances in the air. These chemicals can be inhaled by people or animals, or they can be deposited on plants or soil in rain. The proper management of the gases is to capture them and use the gas as an energy source for oilfield operations. This approach also reduces the amount of diesel and other fuels that need to be transported into the Concession to operate power plants.

Annex S estimates the cost of a properly designed and constructed water reinjection system and a gas capture system. In order to reinject production water, the following system improvements are required at a total cost of $124 million:

- Optimizing current water reinjection systems -- modernizing the current separation and reinjection systems, covering demand for the next 10 years. Estimated cost is $52 million.
- New reinjection facilities to cover unmet demand. Estimated cost is $45 million.
- Drill 2 new reinjectors (SSFRW3 and SSFRW4) in the Shushufindi field to increase injection capacity by 20,000 barrels of water per day. Estimated cost for this item is $12 million.
- Increase the capacity of current reinjection systems by creating mini reinjection stations. Estimated cost for this item is $15 million.

In order to capture and use the gas which is currently flared, the gas must be captured, pumped from the stations to the gas processing plants. The proposed project includes maintenance and operational planning for 10 years. The total estimated cost for these actions is $251 million ($126 million of start-up capital and $25 million for annual operational and maintenance costs for 10 years).

We therefore estimate that the total cost for these Petroecuador improvements is **THREE HUNDRED AND SEVENTY-FIVE MILLION DOLLARS ($375,000,000).**

6.3.5 Provision for reparations to affected indigenous groups

Annex M partially describes the harm caused to indigenous peoples which used to inhabit the Concession area. As indicated in the same Annex, it is extremely difficult to establish the cost based on the harm caused, which is why I will avoid doing so. As stated in Annex M, there are other factors which have been linked to Texpet operations and which have also affected indigenous populations which previously inhabited and continue to inhabit these lands.

Annex M establishes a cost for the actions needed to partially recover, re-establish or improve the lives of the following nationalities: Sionas, Secoyas, Cofanes and Huaorani. According to the study, the cost for these activities is **FOUR HUNDRED AND THIRTY MILLION DOLLARS ($430,000,000).**

6.4 Summary

Texpet's actions in the Concession have caused harm to the people and to the environment that need to be repaired. Table 6.2 provides a summary of the actions that are needed to repair the harms caused by Texpet. Taken together, these actions are necessary to repair the current harm, help prevent future harm, and (in part) compensate for past harms caused by Texpet. The total cost for these actions is **THREE BILLION FOUR HUNDRED AND THIRTEEN MILLION DOLLARS ($3,413,000,000).**

Table 6.2: Summary of actions required to remedy the harm caused by Texpet.

Action	Estimated cost

Remediate contaminated pits and soils at wells and stations	$1,700,000,000
Provide potable water for communities within the Concession area	$ 428,000,000
Establish a complete health care program	$ 480,000,000
Improve existing infrastructure	$ 375,000,000
Provide for displaced and affected indigenous groups	$ 430,000,000
Total	**$ 3,413,000,000**

7 VALUE OF LOSSES SUFFERED BY PEOPLE AND THE ENVIRONMENT

The previous section describes the action that are necessary to repair the harm caused by the actions of Texpet. Those actions will remediate existing environmental contamination, prevent ongoing and future contamination, and provide for potable water, health care, and support for indigenous groups that will improve the health and well being of the affected people. However, the losses suffered by the people and the environment have been occurring for many years, and they will continue to occur until the actions to repair the harm are completed. This section estimates what the value of some of those losses are. The values of the losses are distinct from the costs to repair the harm that are described in the previous section. Both should be included in damages estimates: the harm must be repaired (Section 6), and there must be compensation for the losses that occur until the repairs are completed (this section).

The approach to include both the costs to repair the harm and the value of the losses until the repair is completed is consistent with environmental law and regulations and with concepts of justice and fairness. Consistent with an international approach in this matter, if one party causes harm to another that lasts for many years, simply stopping the harm from occurring is not enough. There must also be some compensation for the losses that have happened over time for the harmed party to be made whole.

This section presents estimates of the values of two kinds of losses: excess deaths from the increased cancer rates for people that live in the area of the Concession; and losses of the ecosystem services provided by the rainforest. This section also includes a calculation of the unjust enrichment gained by Texpet by not spending the money to operate the Concession in an environmentally sound manner.

There are many other losses that the people in the Concession area suffer besides excess deaths from increased cancer rates. These losses are described in Annexes L, P, and M. These losses include other adverse health effects besides death from cancer, human rights violations, displacement of indigenous groups from their native areas, and loss of food resources. However, it is very difficult to place a value on these losses, even though these losses are real and they have been occurring for many years. For this reason, some portion of the actions described in the previous section to provide potable water, establish a health care system, and support indigenous groups is intended to help offset the losses, in addition to preventing ongoing harm.

7.1 The value of cancer deaths

Section 4 and Annex L present the results of a detailed survey of people in the Concession area that demonstrates that people that live near oil wells have a much higher rate of cancer than people who live at least 2 km from a well. Other published studies on the health of people in the Concession area came to the same conclusion, as described in Annex Q. These results are consistent with the fact that crude oil contains chemicals that cause cancer, such as benzene and polycyclic aromatic hydrocarbons.

A higher than normal cancer rate within the Concession area means that there is a higher than normal number of cancer cases. The term *excess cancer cases* refers to the number of cancer cases within the Concession that are above what is expected or normal, if the people in the Concession were not exposed to pollution from oil field activities. Based on the study in Annex L and the studies in the literature, the cancer rate in the Concession is approximately 1.7 times higher than normal. Given the rate of cancer observed in the Concession area and compared to the normal rate, this equates to a total of 638 excess cancer cases among the 30,000 people that suffered a direct impact. The details of this calculation are included in Annex Q. The number of excess cancer cases may be conservative, as many more than 30,000 people live in the area. Furthermore, there are many other population health problems related to oil exploration and production which have not been taken into account in these calculations.

Annex L also reports that the death rate from cancer is approximately 67% in the Concession area. This means that for the 638 excess cancer cases, there were approximately 428 excess deaths. In other words, the increased cancer rate in the Concession caused about 428 more people to die than normal or expected.

There are established approaches and methods in the U.S. and other countries that place a dollar value on what is called a “statistical life.” A statistical life is a concept that is used to assess increases or decreases in the mortality risk to a population of people when the individuals experiencing the risk are not actually identified. The value of a statistical life is frequently used to evaluate the benefits (or costs) of actions that decrease (or increase) the risks of death. For example, the value of statistical life is used by the U.S. government to compare the benefits of proposed regulations that will save lives (such as reducing pollution) against the costs of the regulations. Although this concept may seem to be a crude way of placing value on people’s lives, it has been relied upon in many circumstances and provides one of the few tools we have for valuing the losses that the people in the Concession area have suffered.

The value of a statistical life in the U.S is $6.8 million (Annex Q). The reason why the value of a statistical life from the U.S. is appropriate to use in this case is because by choosing to operate without proper environmental controls, Texpet chose to pollute the environment of the Concession. The people who live there bear the cost in terms of health effects, while the Texpet reaps the financial rewards. Since the rewards were realized in the U.S., it is fair and proper that the real costs of Texpet’s decision to operate without environmental controls also be in terms of U.S. value. Therefore, the U.S. value of a statistical life is the appropriate measure to use to value the excess cancer deaths. Additional details are provided in Annex Q.

Multiplying the 428 excess cancer deaths by $6.8 million results in an amount for excess deaths of **TWO BILLION NINE HUNDRED AND TEN MILLION FOUR HUNDRED THOUSAND DOLLARS ($2,910,400,000).** This value represents the value of the lives lost because of the higher cancer rate in the Concession. In other words, it is the cost of the excess cancer deaths losses suffered by people of the Concession area because of the operational decisions made by Texpet.

7.2 Value of ecosystem losses

The ecosystem losses caused by Texpet include direct losses of rainforest habitat at the oil wells and stations (for example, pits, spills, platforms) and indirect rainforest losses caused by the roads and development that Texpet built as part of its operations.

There are two different methods used here to determine the economic value of the rainforest losses. One method is to determine how much it would cost to restore an amount of rainforest that would, over time, offset the rainforest losses. This restoration would be in addition to remediating and restoring the contaminated areas, such as the pits. By restoring additional rainforest, the ecosystem services that have been lost over time can be compensated for.

The second method is to use the dollar value that people place on rainforest ecosystems. There are literature studies in which researchers have determined how much money people are willing to pay to protect rainforests, which represents how much money rainforests are worth to people. This value can be used to determine the dollar value of the rainforest losses that have occurred over time.

Annex O presents the details of the calculations. Briefly, the amount of rainforest that has been lost at wells and stations is estimated to be 627 hectares. The losses are integrated over time, going back to when the wells and stations were first installed and continuing until a time in the future when the remediation is assumed to be completed. These losses are not offset by restoring other degraded rainforest to a more natural state. Because the losses have occurred over such a long time, and because the benefits of the restoration will occur only in the future, a total of 3,544 hectares of rainforest restoration are required to offset the losses(Annex J) . The cost to restore a hectare of rainforest is estimated to be $29,180. Therefore, the cost to restore enough rainforest to compensate for the losses ranges from between **EIGHT HUNDRED AND SEVENTY-FIVE MILLION DOLLARS ($875,000,000) AND ONE BILLION SIX HUNDRED AND NINETY-SEVEN MILLION DOLLARS ($1,697,000,000)** depending on the calculation method, as explained in Annex O.

Annex O also describes the second approach, which is to use the value that people place on rainforests. Using multiple studies from the literature, the value that people place on the rainforest is expressed in terms of $/hectare/year. The rainforest losses are then calculated for each year, continuing until the remediation occurs. The result is that the value of the rainforest directly lost at wells and stations is from $150 million to $206 million, with a central estimate of $178 million. Annex O contains details of this calculation.

7.3 Unjust enrichment

Unjust enrichment is the financial benefit gained by Texpet from not spending enough money on proper environmental controls during their operation of the Concession. The calculation of unjust enrichment includes two components: (1) an estimate of the cost "savings" gained by Texpet by not using proper environmental controls; and (2) the present-day worth of those savings based on the *defendant's* return on capital investments. The details of the unjust enrichment calculation are provided in Annex T. In some cases around the world, the unjust enrichment is used to determine a punitive damage amount. Although the court may decide to use the unfair enrichment calculation in this manner, the calculation is in fact presented in order to compare it with the value of the losses suffered by people in the Concession area, in order to put those losses into perspective.

The proper and environmentally sound way to operate an oil field includes three distinct actions to manage the wastes that are produced: (1) reinject all produced water; (2) properly handle and dispose of wastes generated at the wells; and (3) capture all gas so that it is not flared into the atmosphere. Since Texpet did not do any of these actions, the costs of these three actions are the amount of money that Texpet "saved" by not using proper environmental controls. Annex T describes these actions in more detail, and their costs. If had Texpet implemented these actions while operating the Concession area, this would have cost approximately EIGHT HUNDRED AND SEVENTY-NINE MILLION EIGHT HUNDRED AND SIX THOUSAND TWO HUNDRED AND NINETY-SIX DOLLARS ($879,806,296). Using accepted methods for converting this cost into a current value, the total Texpet unjust enrichment is **EIGHT BILLION THREE HUNDRED AND TEN MILLION DOLLARS ($ 8,310,000,000).**

7.4 Conclusions

We can calculate some of the losses that people in the Concession area have suffered. We estimate the value of excessive cancer deaths above normal levels to be **TWO BILLION NINE HUNDRED AND TEN MILLION FOUR HUNDRED THOUSAND DOLLARS ($2,910,400,000).** In addition, the value of tropical forest ecosystem losses is estimated to be between **EIGHT HUNDRED AND SEVENTY-FIVE MILLION DOLLARS ($875,000,000)** and **ONE BILLION SIX HUNDRED AND NINETY-SEVEN MILLION DOLLARS ($1,697,000,000)** depending on the calculation used. There are many other losses that people living in the Concession area have suffered for which no value can be estimated, such as the adverse health effects beyond cancer deaths, the displacement of indigenous people from their ancestral lands and an altered perception and attitude toward the environment they live in.

Table 7.5: Summary of quantified losses

Type of Losses	**Estimated damages amount**	**Amount using minimum for ecosystem losses**
Value of ecosystem losses	$ 1,697,000,000	$875,000,000
Value of excess cancer losses	$ 2,910,400,000	$ 2,910,400,000
Total	**$ 4,607,400,000**	**$ 3,785,400,000**

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