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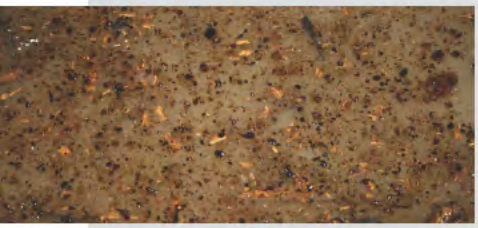

A Supplemental Report Regarding the Environmental Contamination From Texpet's E&P Activities

In the Matter of An Arbitration Under the Rules of the United Nations Commission on International Trade Law

Chevron Corporation and Texaco Petroleum Company vs. the Republic of Ecuador

PCA Case No. 2009-23

PREPARED FOR:
Winston & Strawn, LLP
1700 K. Street NW
Washington, DC 20006-3817

SUBMITTED BY:
The Louis Berger Group, Inc.
412 Mt. Kemble Ave.
Morristown, NJ 07962-1946

November 7, 2014

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Winston & Strawn, LLP
1700 K Street NW
Washington, DC 20006-3817

Prepared by:

Kenneth J. Goldstein, M.A., CGWP
Edward A. Garvey, Ph.D, PG

The Louis Berger Group, Inc.
412 Mount Kemble Avenue
Morristown, NJ 07962-1946

Kenneth J. Goldstein, M.A., CGWP

11/7/14

Date

Elmsford, NY

Location

Edward A. Garvey, Ph.D, PG

11/7/2014

Date

Morristown, NJ

Location

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Executive Summary

The Louis Berger Group, Inc. (LBG) is an international engineering firm with expertise in environmental evaluations and remediation. The firm was retained by Winston & Strawn LLP (Winston) on behalf of Respondent, the Republic of Ecuador (Republic), as technical consultants in *the Matter of An Arbitration Under the Rules of the United Nations on International Trade law; Chevron Corporation and Texaco Petroleum Company v. The Republic of Ecuador*.[1] The Republic asked LBG to provide expert opinions related to evidence of contamination, damage to ecology[2], and human health risks[3] due to contamination in the Oriente region of Ecuador. LBG's scope of work has been limited to the following:

1) Findings and expert opinions related to "The existence of any environmental harm claimed by the Respondent to have been caused by the Claimants" as defined by the Tribunal in Procedural Order 23 ¶ 4.3;[4]
2) A response to the *Claimants' Supplemental Memorial on Track 2 (2014), Chapter IV*[5] (where applicable to technical matters pertaining to item 1) and the opinions of Mr. John A. Connor[6] and Dr. Robert E. Hinchee[7] (where applicable to item 1);
3) Presentation of data and analyses resulting from site reconnaissance and field investigations[8] conducted from April to July 2014, which demonstrate that TexPet's contamination a) is not limited to the immediate vicinity of exploration and production (E&P) facilities, b) has migrated

[1] We reserve the right to amend the findings and opinions in this Report should additional information be presented or reviewed.

[2] Dr. Edwin Theriot has provided separate opinions regarding damage to the flora and fauna caused by TexPet in the Concession Area. This document is not intended to provide opinions covering topics already addressed by Dr. Theriot and to which Claimants have never responded. *A Rejoinder to Chevron's Rebuttal to the Opinion of Edwin Theriot, PhD Addressing Damages to the Flora and Fauna Caused by TexPet in the Concession Area Oritente Region, Ecuador* (hereinafter referred to as Theriot, 2013).

[3] Dr. Harlee Strauss has provided opinions regarding human health risk and health impacts caused by crude oil contamination in the former Petroecuador-Texaco. This document is not intended to provide opinions covering topics elsewhere addressed by Dr. Strauss. (*See generally* Supplemental Opinion of Harlee Strauss, Ph.D Regarding Human Health Risks and Health Impacts Caused by Crude Oil Contamination in the Former Petroecuador-Texaco Conession, Oriente Region, Ecuador (hereinafter Strauss, November 2014)).

[4] Procedural Order 23 ¶ 4.3.

[5] Claimants' Supplemental Memorial on the Merits, 2014 (hereinafter Claimants' Supplemental Memorial, 2014).

[6] Expert Opinion of John A. Connor, P.E., P.G., B.C.E.E. Regarding Remediation Activities and Environmental Conditions in the Former Petroecuador-Texaco Concession, Oriente Region, Ecuador, Response to LBG Reports of December 2013, issued May 7, 2014 (hereinafter Connor, 2014).

[7] Second Expert Report, Robert E. Hinchee, PhD., P.E., 2014 (hereinafter Hinchee, 2014).

[8] We did not perform a complete remedial investigation as recommended in A Rejoinder to Criticisms of the Expert Opinion of Kenneth J. Goldstein, M.A., CGWP and Jeffrey W. Short, Ph.D. Regarding the Environmental Contamination From TexPet's E&P Activities in the Former Napo Concession Area Oriente Region, Ecuador (hereinafter *LBG December 2013 Rejoinder Report*). We did, however, expand upon the five sites investigated in 2013 to gather more information relevant to our analysis of the environmental condition of the Concession Area. *See generally* Annex 1, Appendix A, Site Investigation and Data Summary Report (hereinafter 2014 SI Report).

to locations where residents, their domestic animals, agricultural activities, or groundwater or surface water resources are present. These results further support our opinion that contamination is widespread as previously presented in LBG's expert reports dated February 2013 and December 2013.

Since our involvement began in 2011, we have endeavored to understand and interpret the environmental condition of the former Concession Area in accordance with the scope of our engagement. LBG's February 2013 Expert Report primarily evaluated the available environmental data from the Lago Agrio trial and prior studies, from which we concluded that widespread contamination currently exists in the Concession Area, contrary to Claimants' assertions of limited residual contamination.[9] A summary of our opinions offered in February 2013 is as follows:[10]

- As designated Operator of the Concession, TexPet caused widespread contamination associated with its crude oil exploration, drilling, production, and transport activities. TexPet's operations caused past and persistent environmental injury from exposure to toxic and hazardous chemicals and consequent risk to human health and ecological receptors;
- This contamination is due to the presence and persistence of a large range of hydrocarbon and other related compounds released by TexPet;
- TexPet's limited September 1995 Remedial Action Plan (RAP) failed to identify or address much of the contamination from TexPet's past operations and associated risks to human health and the environment;
- Some of the sites TexPet supposedly remediated in the 1990s continue today to (a) exceed the performance standards contained in the RAP, (b) exceed permissible limits promulgated in Ecuadorian laws and regulations and (c) pose a risk to human health and the environment;
- During the Lago Agrio Litigation Chevron's sampling programs and testing procedures (e.g., composite sampling) were not representative and thus did not adequately characterize the extent of contamination; notwithstanding this limitation, however, Chevron's (and the Plaintiffs') sampling and testing evidenced significant contamination by toxic compounds; and
- The Judgment's assessment of damages was reasonable.

Later in 2013, we conducted a limited field investigation and independently documented the presence of petroleum contamination at Judicial Inspection (JI) sites across the former Concession Area, through both physical observations and chemical analyses.[11] Field staff reported that one simply had to press one's foot into the soil in certain wetland areas and oil seeped from the ground. Based on the results of the field investigation and analyses presented in our December 2013 Report, we confirmed our opinions presented in the February 2013 Report and offered the following additional opinions:

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[9] *Claimants' Supplemental Memorial on Track 2*, 2014 p. 85.

[10] *Expert Opinion of Kenneth J. Goldstein, M.A., CGWP and Jeffrey W. Short, Ph.D. Regarding the Environmental Contamination From TexPet's E&P Activities in the Former Napo Concession Area Oriente Region, Ecuador* (hereinafter *LBG February 2013 Expert Report*).

[11] *LBG December 2013 Rejoinder Report*.

- Claimants' assertion that any groundwater investigation beyond sampling of nearby, hand-dug water wells is unwarranted,[12] is not borne out by field data showing that, where groundwater was found to exist as a resource, it is contaminated.[13]
- Claimants' blanket assumption that impermeable clay occurs everywhere, rendering pit lining unnecessary,[14] is false.
- Chevron's metric for assessing Total Petroleum Hydrocarbon (TPH) contamination (*i.e.,* TPH_{8015}) is inadequate and substantively underrepresents the actual TPH concentration.[15]
- Analysis shows that Chevron's data failed to identify the existence of "clean perimeters" for nearly all JI sites, contrary to Chevron's assertions.[16]
- Our 2013 sampling shows that sediment contamination in streams that flow adjacent to E&P facilities occurs at significant distances from the facility and at locations where people and animals access the streams.[17]
- Our 2013 sampling demonstrates that contamination caused by TexPet's operations is still present and mobile in the environment.[18] Our well site inspections and follow-up investigations documented instances where natural resources (i.e., soils, sediments, surface water, and groundwater) continue to be impacted by TexPet-era E&P activities. Along the streams adjacent to the sites, we observed crude oil bubbling upward when sediment was disturbed. We also observed areas where people use these same impacted water resources.[19]
- This TexPet-originated contamination is not limited to open pits or unremediated oil spills, is not confined to localized areas within the oil facility, and includes chemical impacts to groundwater and surface water.[20]

In 2014, we more than tripled the geographical coverage of our reconnaissance and investigation from 18 to 60 E&P sites. In 2014, our investigations especially targeted non-JI sites operated solely by TexPet;

[12] Expert Opinion of John A. Connor, P.E., P.G., B.C.E.E. Regarding Remediation Activities and Environmental Conditions in the Former Petroecuador-Texaco Concession, Oriente Region, Ecuador, Response to LBG Report of February 2013, issued June 3, 2013 (hereinafter Connor, 2013).

[13] *LBG December 2013 Rejoinder Report* § 2.2, and Appendix B – Site Investigation and Data Summary Report (hereinafter 2013 SI Report)

[14] Connor, 2013, p. 3.

[15] *LBG December 2013 Rejoinder Report,* Appendix C and § 3.3.4.

[16] *LBG December 2013 Rejoinder Report,* Appendix C and § 4.2.1.

[17] 2013 SI Report and *LBG December 2013 Rejoinder Report* § 2.2.

[18] Expert Opinion of Jeffrey W. Short, PhD Regarding Remediation Activities and Environmental Conditions in the Former Petroecuador-Texaco Concession, Oriente Region, Republic of Ecuador, 2013, (hereinafter Short, 2013), p.14-16; 2013 SI Report and *LBG December 2013 Rejoinder Report* § 2.2.

[19] 2013 SI Report and *LBG December 2013 Rejoinder Report* § 2.2.

[20] 2013 SI Report and *LBG December 2013 Rejoinder Report* § 2.2.

and we uncovered yet additional, significant evidence of petroleum contamination.[21] We observed residents in the former Concession Area in daily contact with contaminated environmental media that present potentially complete exposure pathways. The more one investigates E&P sites of the Concession Area, the more crude oil contamination one finds, both as the inventory of sites investigated is increased, and as the level of scrutiny at any given location is increased. These findings reinforce our opinion that the Judgment's assessment of damages was reasonable.[22] It is our opinion that information developed during the JI process, while substantial, just scratches the surface of identifying the environmental condition of the Concession Area.

We also performed forensic analyses and found that despite Claimants' assertions of limited contamination,[23] contamination due to TexPet's E&P activities extends beyond the pits and the immediate vicinity of the E&P facilities to surrounding soils, groundwater, surface water and stream sediments.[24] In each medium, the contamination is present at levels in excess of Ecuadorian standards and the cleanup threshold established in the Judgment.[25] This is significant because it not only confirms and reinforces the full range of chemical data and expert observations available to the Lago Agrio Court, but it also confirms what the Court (as well as the people of the Oriente) could see for itself. As explained in more detail in this report and accompanying annex and appendices:

1) TexPet's waste disposal practices led to environmental harm in the Concession Area.
2) Environmental audits performed in the early 1990s and the data associated with the Remedial Action Program (RAP) in the mid-1990s confirm environmental impacts to soil, groundwater, surface water and sediment by TexPet.
3) Data associated with Chevron's Preliminary Inspections (PIs), JIs, and shadow team sampling show similar impacts, substantiating that contamination resulting from TexPet E&P operations remains and continues to impact environmental media. This was described in LBG's February 2013 Expert Report, was further elaborated in our December 2013 Rejoinder Report , and is supported by the findings presented in this report.
4) Results of LBG's 2013[26] and 2014[27] independent site investigations found crude oil-related contamination due to TexPet's E&P operations.

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[21] For example, former RAP pits with trenches cut through them by local farmers, discharging the contents directly into a stream, open streams undergoing remediation with black oil on the sidewalls and under the streams banks, droplets of oil floating in streams, and the smell of petroleum at many sites.

[22] We did not analyze monetary damages related to the contamination because it is not within the scope of Track 2. (*See generally LBG February 2013 Expert Report*).

[23] *Claimants' Supplemental Memorial on Track 2*, 2014 p. 85.

[24] *See generally* Annex 1*,* Appendix D, Distribution of TPH_{8015} Contamination in Oriente Soils.

[25] *See generally* 2014 SI Report.

[26] 2013 SI Report.

[27] 2014 SI Report.

5) Contaminated environmental media present potentially complete exposure pathways for people living in the former Concession Area and their domestic animals.
6) In selecting JI sampling locations, Chevron preselected at least 20% of its JI samples based on the low concentrations found at those locations during its PI sampling.[28] For example, the surface locations Chevron resampled during the JI had contaminant concentrations lower by an average of 40-fold than those not resampled. These resampled locations did not form clean perimeters around sites[29] but clearly served only to add known low concentration locations to the JI data set. There is no way to know how many JI locations Chevron considered and rejected due to high concentration of contaminants found during the PIs.
7) Our analyses estimate the mass of residual oil contamination remaining in the soils of the Oriente is large by any calculation basis. For the 52 JI sites, we estimate the TPH_{8015} inventory within 200 meters of the pits at 23 million kilograms. Other, more accurate measures of TPH would substantially increase this estimate. In addition to these large inventories, the data also indicate that the vast bulk of the oil contamination lies in the soils beyond the pits, not in the pits themselves.

The above conclusions support our opinion that TexPet's E&P operations caused environmental contamination in the Concession Area that persists today. Specifically, we have found that TexPet's contamination: a) is not limited to the immediate vicinity of E&P facilities, and b) has migrated to locations where residents, their domestic animals, agricultural activities, or groundwater or surface water resources are present. These results further support our opinion that contamination is widespread. Our three reports build on one another. With each new investigation of the Concession Area, we find additional contamination in the soils, groundwater, surface water and sediments not previously identified or documented. Our 2014 site investigation reinforces our prior opinions. Therefore, the Lago Agrio Judgment's assessment of damages regarding environmental harm was reasonable.

This report describes the scientific basis for our opinions, describes how TexPet's E&P operations caused widespread contamination[30] in the Concession Area, and responds to Claimants' 2014 Supplemental Memorial on Track 2. Fuller discussion, supporting data, and extended analysis can be found in Annex 1 and the Appendices submitted with this report.

[28] Annex 1, Appendix B - Supplemental Assessment of the Preliminary Investigation (PI) and Judicial Inspection (JI) Sampling Objectives and Outcomes.

[29] *See* Appendix C of *LBG December 2013 Rejoinder Report*.

[30] Recall that on page ES-2 of our December 2013 Rejoinder Report, "widespread contamination" is defined as, "*a pattern of contamination at multiple E&P facilities across the Concession Area, present in one or more environmental media beyond the immediate confines of the E&P facilities.*"

1 Introduction – Scope of Assignment

In *Claimants' Supplemental Memorial on Track 2* (2014), they assert that "If *anything, LBG's December 2013 report confirms the conclusions reached by Chevron's environmental experts regarding contamination in the Concession Area: (1) it is very limited; (2) it is neither migrating nor threatening human health or the environment; and (3) it is Petroecuador's responsibility under the Settlement Agreement, not TexPet's*."[31] As a preliminary matter, we have offered no view as to the rights and obligations of the parties under the referenced Settlement Agreement. We are not attorneys and offer no such legal analysis. As to Claimants' first two claims above we tested these statements by evaluating: (1) whether contamination is limited, as Claimants' experts assert, and (2) whether contaminants are migrating to locations where residents, their domestic animals, agricultural activities, or groundwater or surface water resources are present. Dr. Harlee Strauss was retained to evaluate exposure pathways and calculate human health risks as a result of these contaminants.[32]

In the LBG February 2013 Expert Report and December 2013 Rejoinder Report, and again in this Supplemental Report, we have considered Claimants' experts' assertions as hypotheses that can be tested using the scientific method. We have relied on both the body of information collected previously and newly gathered information from site inspections and investigations conducted from May through July 2014. This approach is neither designed to describe the full nature and extent of contamination[33] nor to allocate pollution liability between TexPet and Petroecuador.[34] Rather, our approach was designed scientifically to test Claimants' assertions that environmental contamination in the former Concession Area (1) is very limited in extent, and (2) is neither migrating nor threatening human health or the environment.[35]

The scientific method provides the foundational process by which hypotheses are tested. Figure 1.2-1, The Scientific Method, demonstrates the steps we employed in our analysis to test Claimants' assertions as hypotheses.

[31] *Claimants' Supplemental Memorial on Track 2*, 2014 p. 85.

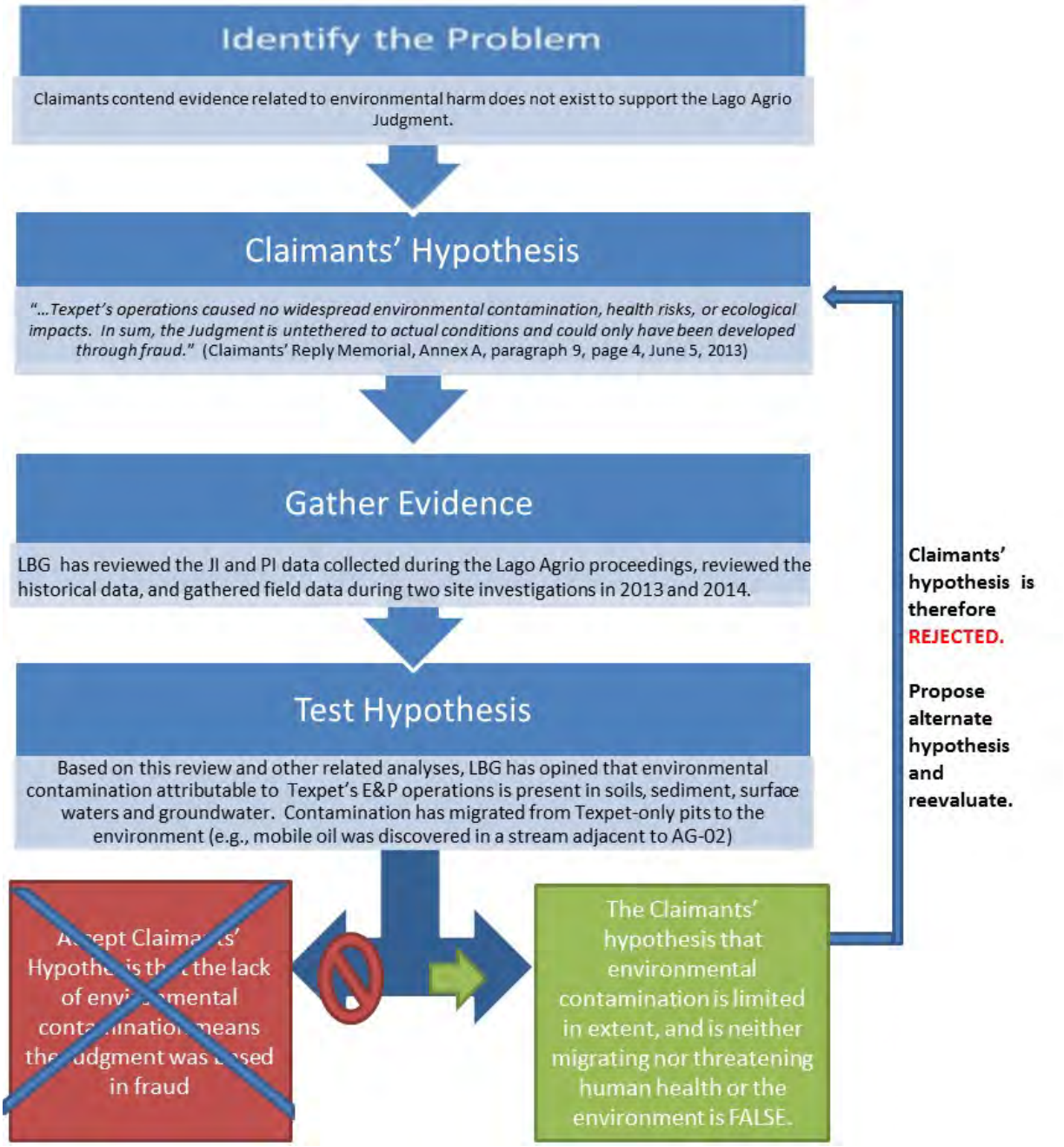
[32] *See generally* Strauss, November 2014.

[33] Identification of the full extent of contamination will require a massive effort and should be the first step in any overall remediation. As is discussed in this section, our goal was to gather enough data to prove or disprove Claimants' assertions.

[34] Allocation of responsibility for contamination is largely a legal question.

[35] *Claimants' Supplemental Memorial*, p. 85; Dr. Harlee Strauss was retained to evaluate exposure pathways and calculate human health risks. Strauss, November 2014.

Figure 1.2-1 Scientific Method as applied to Environmental Contamination from TexPet's E&P Operations in the Former Napo Concession Area, Ecuador



We have considered and explicitly reject Claimants' criticisms of our earlier work:

- Claimants stated that we should have provided an opinion on actual remediation costs using Petroecuador costs as a basis.[36] We understand that an analysis of remediation costs is not within the scope of Track 2, per Procedural Order No. 23 dated February 10, 2014.[37]
- Claimants stated that we should have provided an opinion apportioning liability between Petroecuador and TexPet. As instructed by counsel, we did not include discussion of the allocation of responsibility for the environmental contamination in the Concession Area because it falls outside the scope of Track 2.
- Claimants stated that we should have offered an opinion on *scientific fraud* though they declined to identify what that *scientific fraud* entailed.[38] The Republic's counsel directed that we decline to provide an opinion regarding "fraud" because that is beyond the scope of our assignment and addresses legal issues. But to ensure that our analysis is both independent and untainted, we have relied in all material respects upon only Chevron's own data and those from previous studies commissioned by TexPet or the Consortium.

Our primary Track 2 task is to evaluate Claimants' claim that "*The Judgment is untethered to actual* [environmental] *conditions….*"[39] We understand this to mean that, in Claimants' view, no substantive environmental contamination or impacts to human health exist for which TexPet is responsible,[40] and therefore that a judgment awarding monetary damages against TexPet for environmental harm is logically impossible. This Supplemental Expert Report presents the result of our evaluations of Claimants' assertions, as well as a rebuttal to Claimants' Supplemental Memorial dated May 14, 2014 and accompanying expert reports.

2 Historical Discussion: TexPet Waste Disposal Practices and RAP Findings

From 1964 to 1990, in the course of its petroleum E&P operations, TexPet disposed of numerous wastes either directly into the rainforest[41] or into unlined, earthen pits.[42] The most consequential wastes were the drilling and workover wastes discharged to well site pits and the oily produced water discharged

[36] *Claimants' Supplemental Memorial on Track 2*, 2014, p. 76.

[37] Quantification of damages and remediation costs will be addressed in Track 3. "All extant issues between the Parties regarding determination of quantum…(ii)the quantification of environmental harm claimed by the Respondents to have been caused by Claimants." (Procedural Order No. 23 ¶ 4.3).

[38] *Claimants' Supplemental Memorial on Track 2*, 2014, p. 85.

[39] *Claimants Reply Memorial Track 2, Annex A,* 2013, ¶ 9.

[40] *Claimants' Supplemental Memorial on Track 2*, 2014, ¶ 161.

[41] HBT Agra, 1993, Table 4-3, p. 4-8 ("Excess fluids discharged into forest." – 1984, 85 and 86 column).

[42] TexPet memo from U.V. Henderson et al dated November 14, 1990, Item 2, p. 3 ("The drilling fluids and cuttings are managed in unlined reserve pits.").

from production stations (and some wellsites) directly into wetlands and surface waters. The majority of TexPet's waste pits were not identified and therefore not included in their remediation program.

TexPet created 344[43] well sites in the Oriente. Given that operation of each well site required the creation of at least 4 to 6 pits based on TexPet's documented operations and typical well drilling processes of that era (1 water pit, 1 to 2 mud pits, 1 reserve pit, optionally 1 test pit, and 1 or more workover pits), the number of pits created in the Oriente is estimated at 1,400 to 2,000 pits. However, fewer than 2 pits at each well site were identified and included in the TexPet remediation program[44] (a total of 250 pits at 133 sites[45]). It is therefore easy to see that TexPet's efforts to identify and remediate former pits during the RAP were inadequate.

Figure 2.0-1 Generic Conceptual Site Model, Well Sites in the Concession Area

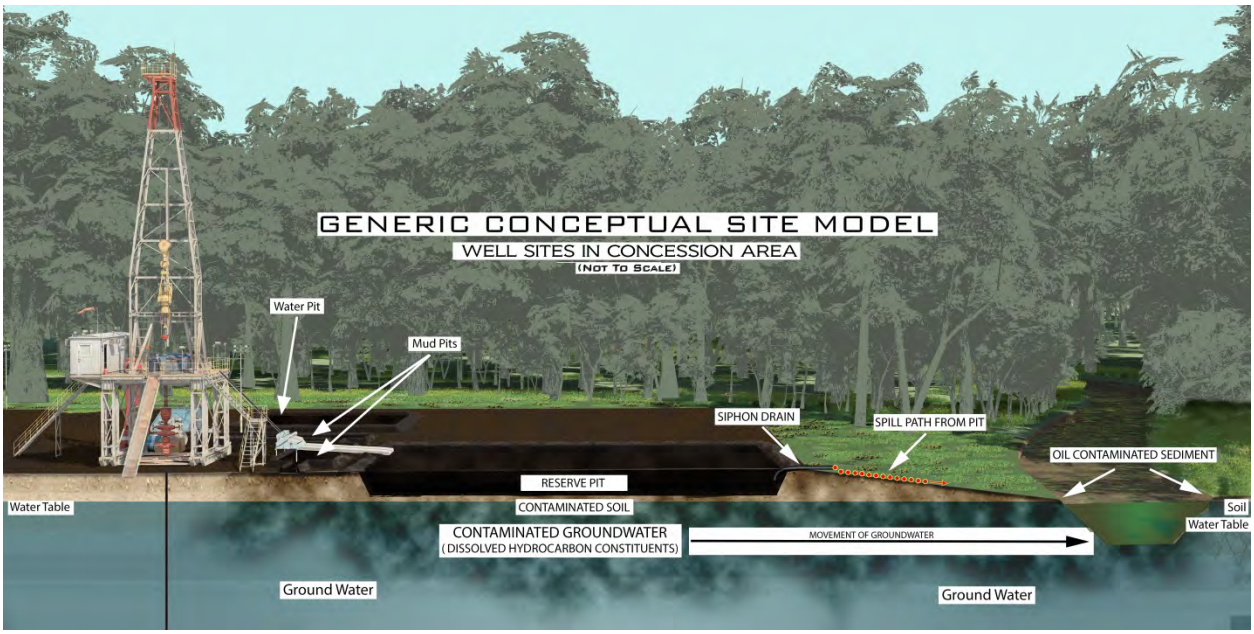


Figure 2.0-1 depicts a generalized oil well site where drilling is nearly completed. The drill rig is still present and the reserve pit is filled with a combination of soil and rock cuttings, spent drilling mud, test oil, other process wastes, and rainwater. TexPet generally installed a siphon drain (also called a "gooseneck" pipe) in the side wall of the reserve pit to, ostensibly, drain water from underneath the oil floating on top of the pit. However, when heavy rainstorms fill the pit quickly, the rising water pushes the floating oil up and causes the oil to overflow the pit. The released oil is free to then spill down into the nearby stream, leading to surface water and sediment contamination in the stream and soil contamination along the drainage pathway to the stream.

[43] Connor, 2010, Figure 1, p. 4.

[44] Connor, 2010, Item 18, p. 18.

[45] Connor, 2010, Table 1A.

The mud pits and reserve pit depicted above are unlined—as were TexPet's pits. As a consequence, contaminants placed in the pits may infiltrate underlying soils. As oil companies had known for decades, unlined pits leaked oil. Our findings show that pits excavated in the Oriente were underlain by a combination of sandy, silty and clayey soils and therefore wastes placed in the pits could migrate through subsurface soils to the groundwater. Once crude oil encounters groundwater, it can be transported as whole oil and/or as dissolved contamination, as confirmed by our field investigations, with the potential to flow to and discharge into downgradient streams or seeps/springs.

Historical documents confirm the narrative above. As various auditors found when they investigated the region, contamination migrated out of these pits by: seeping into surrounding soils;[46] overflowing pit berms,[47] especially during heavy rainfall;[48] leaking through siphons and after berm failure .[49]

A Texaco official described their wellsites in May 16, 1972:

> *"Many of the wellsites have been left in disgraceful condition after the drilling rig has moved off the location…Many wellsites and their adjacent natural drainage are contaminated with crude oil due to inadequate burning and containment during well testing…The pits which are used for mud and well cuttings during the drilling of the well are generally in need of repair and inadequate to contain test oil by the time a well is tested."*[50]

At the end of the drilling process TexPet would test each well's output by letting oil run out of the newly drilled well into an unlined earthen pit.[51] Once these pits were no longer needed, TexPet's practice was to simply fill them in with soil,[52] sometimes leaving little indication that they ever existed. TexPet's wells produced from 500 to more than 1,000 barrels per day.[53] Records for selected wells (AG-02, LA-02, LA-16, SA-54, and SA-65) document that TexPet ran yield tests for 2[54] to 12[55] hours, resulting in disposal of 27.1[56] to 300 barrels[57] of crude oil per test. For example, from October 1970 through February 1971,

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[46] Woodward-Clyde, 2000, § 3.2, p. 3-4 and Figure 3-1.

[47] Fugro, 1992, § 6.3.3, p. 6-10 ("The contamination usually occurred as a result of pit overflow, berm failure or releases through the siphon.")

[48] HBT Agra, 1993, § 2.2, p. 2-1 ("Rainfall in the Oriente is generally heavy, ranging from 2,000 mm to 5,000 mm annually. There is no dry season…")

[49] Fugro, 1992, § 6.3.3, p. 6-10.

[50] TexPet memo from G. Warfield Hobbs dated May 16, 1972, Items 2 and 3, p. 1.

[51] Texaco "Daily Radio Report – Service Rig" dated July 9, 1978 for SA-65, Item 5 ("10 Hrs. Flowing well to burn pit. Checking samples every hour.")

[52] TexPet memo from G. Warfield Hobbs dated May 16, 1972, Items 2 and 3, p. 1.

[53] Canfield, 1991, "Sacha Field – Ecuador Oriente Basin", pp. 285-86.

[54] "Testing and BHP Program #1" for LA-02, Item (e) ("Change to ¼" ck and test until stabilized for at least two hours.")

[55] "Test Data for Drilling Report" form dated October 26, 1970 for LA-16, Item (C).

[56] "Test Data for Drilling Report" form dated August 15, 1970 for AG-02, Item (F).

TexPet conducted extensive flow testing at LA-16, resulting in the disposal of approximately 857 barrels[58] of crude oil to a pit.

Figure 2.0-2 Generic Conceptual Site Model, A Closed Pit at a Well Sites in the Concession Area

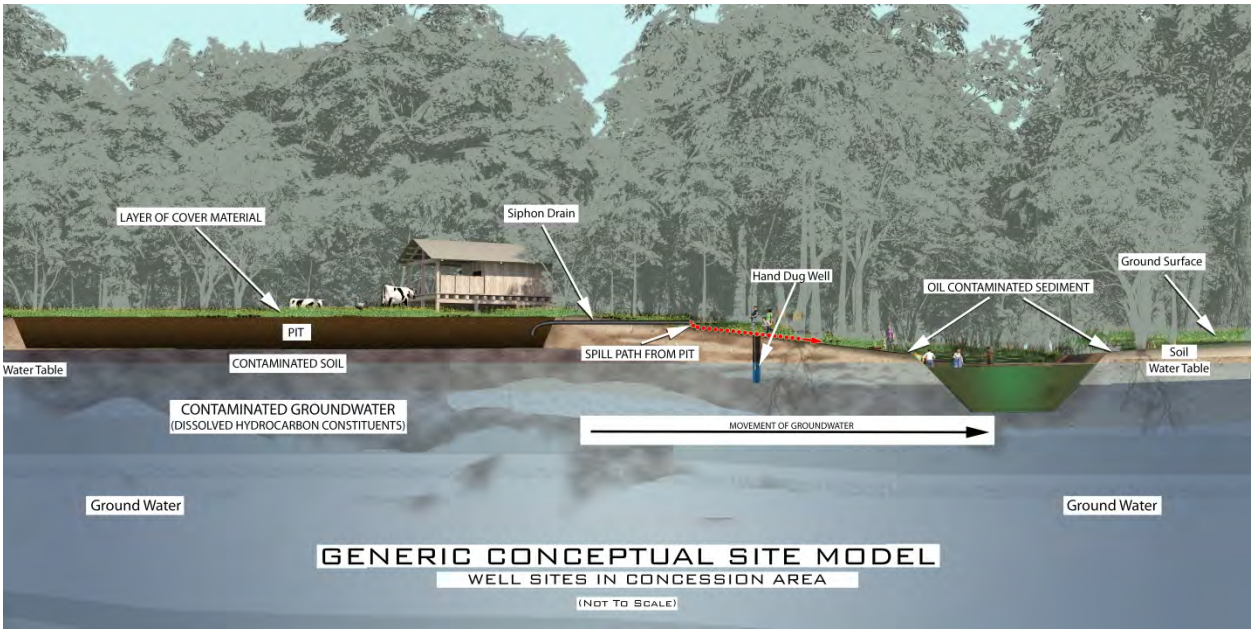

Figure 2.0-2 depicts the same typical well site after the drill rig has been removed, the reserve pit covered, and a nearby residence constructed, as we have observed at many sites. The siphon that TexPet originally installed to drain water from the pit is now buried but still capable of releasing oil from deep in the pit and down the hillside when rainfall saturates the pit contents. Contamination from the pit has seeped into the soils below the pit and reached the groundwater table. Once the oil meets the groundwater, some of the crude oil constituents are dissolved into the water and others migrate with the water. As a result, a nearby hand dug water well has become contaminated. As seasonal shifts in groundwater elevation naturally occur the contamination on the groundwater moves up and down through various layers of the soil, including more porous sands and fractured clays, and pathways created by plant roots. The subsurface transport of contamination from the pit and the surface drainage from the siphon both contaminate the nearby stream's water and sediments. When people or animals disturb the sediments a brilliant sheen forms on the surface as globules of crude oil are released. When the children from the nearby house come back from the stream from cooling off and playing and the adults return from bathing and laundering clothes, they unknowingly track sediment contamination and soil contamination from downslope of the pit siphon back to their house, where it may be found on their toys and on the floors and furnishings.

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[57] "Test Data for Drilling Report" form dated 26 October 1970 for LA-16, Item (F).

[58] "Test Data for Drilling Report" forms individually dated October 7-8, 1970; October 9, 1970; October 22, 1970; October 24 & 25, 1970; October 26, 1970; and February 13, 1971 – refer to Item (F) on each form.

Once pits are covered with soil, contamination continues to spread by: seeping into surrounding and underlying soils;[59] leaking through siphons, or being exposed through slope failure or unwitting site disturbance.[60] The release of contamination into underlying soils was observed by TexPet's contractors — they documented contamination in soils underlying the pits.[61] TexPet's contractors also observed that "in certain instances, roots of some secondary growth located along the perimeter provided avenues for the degraded hydrocarbons to migrate."[62] The RAP did not, however, address impacts from TexPet's waste disposal activities outside pits and only addressed a number of specifically-identified spill areas. For instance, the RAP did not require any groundwater or surface water testing in nearby streams. Moreover, the RAP did not require any evaluation or cleanup of wetland sediments surrounding a majority of sites.

In addition to wellsite wastes discharged to pits, discharge of oily produced water from production stations to surface water bodies and wetlands resulted in the release of petroleum hydrocarbons from TexPet's operations into the environment.[63]

During its period of operations, TexPet discharged 377 million barrels[64] or 59 billion liters[65] of produced water into the environment, primarily to surface waters of the Oriente. Historical sampling and analysis of produced water revealed TPH concentrations ranging up to 139.3 mg/L[66]. Based on the concentration and total volume released, TexPet's discharge of produced water equates to release of up to 1.2 million kg of petroleum[67] into the surface waters of the Oriente.

[59] Woodward-Clyde, 2000, § 3.2, p. 3-4 and Figure 3-1.

[60] Features observed during LBG's 2013 and 2014 site visits.

[61] Woodward-Clyde, 2000, Figure 3-1, (Typical Pit Cross Section).

[62] Woodward-Clyde, 2000, Section 3.3.1, pg. 3-5.

[63] HBT Agra, 1993, § 6.4.1.3, p. 6-20 ("*Crude oil is present in the produced water discharged to these pits…Produced water is being discharged to the environment in all cases. Contamination of soil and water below the discharge pipe was noted in all cases.*").

[64] HBT Agra, 1993, Table A-1.

[65] Using conversion of 1 bbl of oil = 42 gallons = 159 liters; 59 billion liters is enough water to fill more than 20,000 Olympic swimming pools.

[66] Texaco Memo from U.V. Henderson, Subject: Ecuador NRDC Allegations Water Samples (CA1108477 through CA1108485), HBT Agra, 1993, Table 7-2 and Fugro-McClelland, 1992, Tables B-1 through B-19.

[67] *See* Annex 1, Appendix E - TexPet Produced Water Calculations.

3 LBG's Site Investigations and Evaluations Establish that TexPet E&P Operations Caused Widespread Contamination which is Encountered by Residents of the Concession Area and Their Domestic Animals

3.1 Discussion of Analytical Methods Used to Measure Petroleum-related Compounds

In the LBG February 2013 Expert Report,[68] we explained that chemical analyses performed by TexPet under the RAP and by Chevron during the JIs and PIs only quantify a portion of the full set of toxic and hazardous constituents in crude oil released to the environment. We also explained that analyses of environmental samples by USEPA *Method 418.1* detect a larger range of petroleum hydrocarbons than analyses by USEPA *Method 8015*. In the December 2013 Rejoinder Report,[69] LBG examined the limitations and biases of each of these methods in measuring TPH in crude oil contaminated environmental media.

In this Report, LBG further examined the accuracy of Chevron's use of USEPA *Method 8015* as a measure for TPH.[70] Given that Chevron's petroleum hydrocarbon measurements were shown to underestimate TPH concentrations in site soils and sediments, we then needed a consistent analytical metric to be able to compare Chevron measurements with our more accurate measurements. As a result we developed a metric to compare and present the results from the various methods for measuring petroleum hydrocarbons.[71]

3.2 Summary of the 2013 and 2014 Site Investigations

The data and analysis resulting from the site investigations we performed in 2013 and 2014 confirm the presence of widespread contamination due to TexPet's E&P activities. As presented in the following, we have found petroleum-related contaminants in soil, groundwater, sediment, or surface water at every well site investigated for those media.[72] The presence of this contamination in and migrating from facilities or features developed and occupied only by TexPet contradicts Claimants' opinions that contamination due to TexPet's activities is limited in extent and is neither mobile or poses a threat to human health or the environment.[73] We presented the results of our 2013 site investigation in our December 2013 Rejoinder Report and in Appendix B to that report (2013 SI Report). Below we have summarized our 2014 site investigation results. We provide more detailed analysis and discussion in our 2014 SI Report (Annex 1, Appendix A).

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[68] LBG February 2013 Expert Report, § 3.1.1, pp. 34-35.

[69] LBG December 2013 Rejoinder Report, § 3.3.4, pp. 44-49.

[70] Annex 1, Appendix C2, Assessing the Accuracy of Chevron's Method *8015* as a Measure of Total Petroleum Hydrocarbons.

[71] For a fuller discussion see Annex § 3.1.

[72] 2014 SI Report, p. RS-5.

[73] Claimants' Supplemental Memorial on Track 2, 2014, p. 85.

The principal purpose of our 2013 and 2014 site investigations has been to assess the continued presence of crude oil E&P-related contamination in areas where TexPet previously operated in the Oriente. The location of the sites investigated is shown on Figure 3.2-1. The following is a summary of sites studied during the 2013 and 2014 investigation:

Figure 3.2-1: Locations of Sites LBG investigated in 2014

During our 2014 site investigations we observed that: 1) contamination has migrated and continues to migrate away from pits in soils and other media, which further supports our opinion regarding the presence of widespread contamination, 2) stream sediments and surface water are impacted by petroleum-related contaminants, and 3) groundwater is contaminated by petroleum-related contaminants.

The following summaries of site histories, site observations and findings from the 2013 and 2014 site investigation are provided to describe our observations and findings related to the sites we investigated in the Concession Area.[74]

Summary of 2013 and 2014 Site Investigations

Aguarico 02 (AG-02)[75]

LBG detected contaminated sediment adjacent to a groundwater seep/spring located downgradient and west of Pits 2 and 3. LBG also observed this seep visibly discharging oily water to the ground surface in 2013. Contamination from the well site's pits was likely historically transported via direct discharge and/or recurring overflows during rainfall down the slope and drainage paths. The contamination migrated to a stream that is currently used for laundering clothes and bathing. Chevron likewise confirmed contamination at this site during their PI.

Aguarico 04 (AG-04)

The well site consists of a platform and several pits dug into a wetland area that is thickly vegetated. A strong petroleum odor is present around the pits, some of which contain liquid crude oil and thick tar, partially covered by approximately 12 inches of leaf litter. Laboratory analysis established oil contamination several thousand times over the cleanup standard in the Lago Agrio Judgment.

Aguarico 06 (AG-06)

During LBG's investigation, sediment and surface water samples were collected upstream and downstream from the well site platform, demonstrating heavy crude oil contamination. Polycyclic Aromatic Hydrocarbons (PAH) were detected in soil, groundwater, sediment, and surface water samples. Every groundwater and surface water sample analyzed for water-soluble crude oil components showed signs of contamination. The detection of contamination in groundwater and downgradient sediment demonstrates that crude oil has migrated away from the site.

Guanta 06 (GU-06)[76]

LBG detected TPH, PAH, and metals (including barium, an indicator of drilling operations) contamination in the soil at TexPet's former Pit A. Visible oil contamination was encountered in groundwater samples, which were also contaminated with TPH, benzo[g,h,i]perylene, and

[74] 2014 SI Report and 2013 SI Report.

[75] AG-02 was investigated in 2013, but was not part of the 2014 site investigation.

[76] GU-06 was investigated in 2013, but was not part of the 2014 site investigation.

chrysene. LBG also observed visible crude oil contamination in sediments in a stream located downgradient of Pit A; the sediment contamination continues for nearly half a kilometer downstream.

Lago Agrio 02 (LA-02)

In 2013, LBG's investigation found that Pit 3 was a historical source of contamination to the stream; soil, groundwater, surface water, and sediment remain impacted 24 years after TexPet closed the pit. In June 2014, wipe samples were collected inside the residence revealing contamination had spread inside the house. LBG collected soil samples that later analysis proved were contaminated with petroleum compounds.[77] LBG also collected groundwater samples which were contaminated.

Lago Agrio 16 (LA-16)

Three homes are near the platform. The household drinking water source is a hand dug well, which LBG observed had an oil sheen and oil droplets on the water surface during its site visit in April 2014. LBG also detected petroleum contamination in both soil and groundwater samples.

Lago Agrio 35 (LA-35)

During LBG's site investigation the siphon installed in a now abandoned and covered TexPet pit was still discharging oil and water. We found petroleum contamination in sediment samples collected at the siphon and continuing downstream. We also found petroleum contamination in every surface water sample collected.

Shushufindi 13 (SSF-13)

LBG observed petroleum sheen on water standing on top of TexPet's former Pit 3. Cattle grazed within and around the footprint of the pit and were observed drinking the standing water. Pit 3 is one of three TexPet pits identified under the RAP, and was designated No Further Action because it had been closed in 1976 by TexPet.[78] We found petroleum contamination in soil, sediment, groundwater, and surface water samples.

Shushufindi 25 (SSF-25)

Analyses performed during the limited 2013 investigation found that groundwater, soil, sediment, and surface water contamination related to a TexPet-remediated pit (addressed during the RAP) persists in locations where people can encounter it. In 2014, we conducted additional testing and found petroleum contamination in every soil and groundwater sample collected.

[77] One sample was actually a chunk of asphaltic material.

[78] Trip Report for Site Inspections, Douglas M. Mackay, DRAFT, 31 May 2006.

Shushufindi 34 (SSF-34)

LBG found a previously undocumented TexPet pit. Our investigators found free-flowing, liquid crude oil. We detected petroleum contamination in soil and in every groundwater sample collected.

Shushufindi 43 (SSF-43)

To the north of the platform, homes have been constructed on a former pit and a hand-dug well has been dug behind one home. In April 2014 that well exhibited petroleum odor and had a sheen on the surface. The hand-dug water supply well was no longer in use at the time of LBG's initial visit but, according to the residents, they had dug the well more than 20 years ago and had used it until 8 years ago. We detected petroleum contamination in both the groundwater samples collected as well as one of the soil samples.

Shushufindi 55 (SSF-55)

A road currently cuts through the former platform; the abandoned well is on the east side of the road. To the south and downhill of the former pit area is a wetland with visual evidence of petroleum impacts. During sediment sampling, our investigators observed petroleum sheens and odors throughout the wetland. We also found petroleum contamination in the sediment samples at concentrations that exceed Ecuadorian standards.

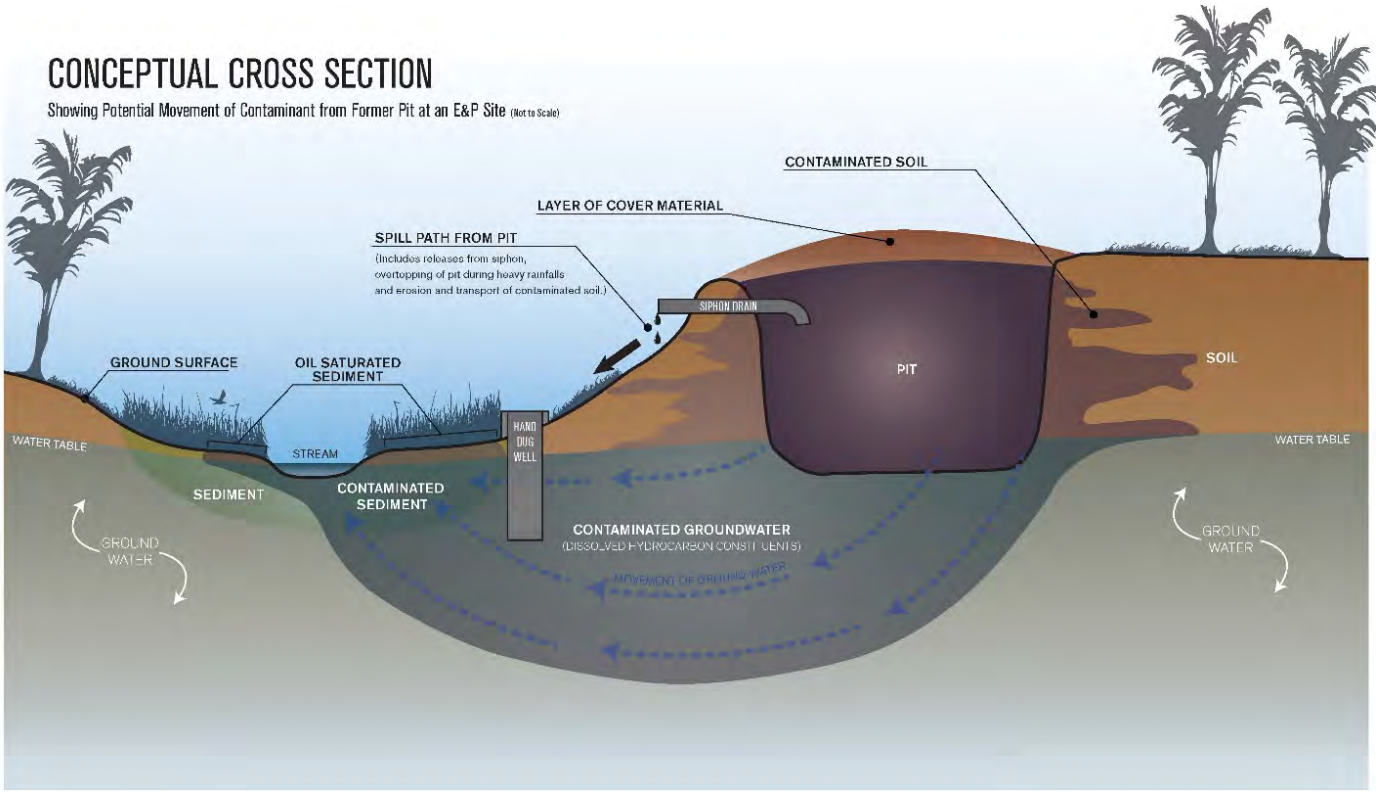
Yuca 02 (YU-02)[79]

Sediment samples collected by LBG from a marshy area located to the north of the wellhead confirmed the presence of petroleum contamination. Chevron's own findings during their PI and JI sampling efforts corroborate LBG's findings. Chevron attributed the detected contamination to a historical spill that occurred during the period of TexPet's operations.

In summary, our site investigations have shown that contamination persist in soils, groundwater, surface water and sediment, and has migrated beyond the immediate vicinity of E&P facilities developed and used by TexPet. See Figure 3.2-2, Fate and Transport Conceptual Model. These findings contradict Claimants' assertions that TexPet's contamination is immobile and limited to the immediate vicinity of the facilities.

[79] YU-02 was investigated in 2013, but was not part of the 2014 site investigation.

Figure 3.2-2 Fate and Transport Conceptual Site Model[80]



3.3 Soil Impacts

3.3.1 Conceptual Site Model

After careful analysis of the historical documentation and of Chevron's own sampling and after conducting our own inspections at 60 sites and environmental data collection at 13 of those sites (soil samples were collected at 11 of those 13 sites),[81] it is our opinion that TexPet's oil E&P operations in the Concession Area caused widespread petroleum-related contamination of soils. Additionally, contaminants persist in soils, as evidenced by the visual observations and analytical data presented herein. Oil that has discharged from pit siphons, seeped through pit walls and bottoms, and spilled has resulted in surface and subsurface soils contaminated by crude oil constituents (see Figure 3.2-2, Fate and Transport Conceptual Site Model).

After soil is contaminated by crude oil releases, there are a variety of physical and chemical mechanisms that spread contaminants from soil to other environmental media. These mechanisms release contaminants and allow for transport of those contaminants to more extensive soil areas, surface water,

[80] This schematic shows a composite of features from a variety of E&P sites for illustration purposes.

[81] A site investigation includes substantial sampling and detailed evaluation of at least one aspect of a site, especially using intrusive methods, whereas a site inspection is a minimally invasive review of a site's history and current conditions.

sediment, and groundwater. Once crude oil is released into the environment, people, as well as plants and animals (including fish and game, home-grown and agricultural produce, and livestock) are exposed to those contaminants. Tracking by people and animals can transport contaminants into homes. These release mechanisms result in complete or potentially complete human exposure pathways, which are discussed in Dr. Strauss' 2014 Report.

The visual observations and analytical data presented herein document that all of these release mechanisms are present and cause continual releases or transport of soil contaminants to other soil areas, groundwater, surface water, and sediment.

3.3.2 Observations of Residents' Encounters with Contaminated Soil

The lifestyles of people in the Concession Area put them in intimate contact with soil; they live, predominantly, off the land.[82] We observed that many residents do not wear protective rubber boots or gloves during their daily activities, as we often did during our observations and sampling activities.

During our time in the Concession Area, we observed current conditions at 60 sites formerly operated by TexPet.

We also observed various land uses and activities consistent with rural lifestyles which place residents and their animals in routine contact with crude oil-related soil contamination (see, for example, Figure 3.3-2).[83]

[82] Strauss, November 2014, § 2.2.

[83] Strauss, November 2014, pp. 7-9.

Figure 3.3-2 Land use at SSF-13 (Pasture – Livestock Grazing on top of Pit 3 berm and next to breach where soil, surface water, and sediment contamination was found)

We observed that local farmers generally take advantage of the surrounding cleared areas that are, in fact, closest to oil production platforms for agicultural use. This is particularly true for abandoned well sites, where local farmers use the cleared land near the platform — land often associated with the pits (including hidden, unidentified pits) — to raise both vegetables and livestock. We observed residents, particularly children, spending much of their time at or close to their residences outdoors.

3.3.3 Current Conditions (LBG Investigations)

During inspection of 60 E&P sites for our 2013 and 2014 site investigations, we found:

- 55 percent of sites had readily apparent petroleum contamination.
- 23 percent of sites had free oil in the pits.
- 37 percent of the sites had visible evidence of drainage or migration beyond the pit.
- 45 percent of sites had a pit area that was accessed by or accessible to local residents.[84]
- 38 percent of sites had evidence of agricultural use near a pit.

At all 11 of the 13 of the well sites at which we collected soil samples, we observed evidence of persistent free-phase oil inside and outside the boundaries of TexPet well sites, pits closed prior to the RAP, and undocumented pits. As discussed in our 2013 and 2014 Site Investigtion Reports and detailed

[84] LBG field staff stated that they were able to access 100% of the areas wearing stout boots and wielding a machete. Dense vegetation and steep terrain make accessibility more difficult but not impossible.

below, at many of these locations we measured crude oil constituent concentrations in excess of Ecuadorian standards.

We collected 104 soil samples for laboratory analysis of petroleum-related contaminants during our investigations of the 13 well sites. Data for some (but not all) petroleum-related contaminants are summarized below:

- Petroleum hydrocarbons were detected in 83 percent of the soil samples. Of these samples, 39 percent demonstrated contamination exceeding the RAOHE standard for agricultural soil and the TULSMA standard for residential soil (2,500 mg/kg), 48 percent were greater than the RAOHE soil standard for sensitive ecosystems (1,000 mg/kg), 55 percent were greater than the TULSMA standard for agricultural soil (500 mg/kg), and 82 percent were greater than the Lago Agrio Judgment criterion (100 mg/kg).
- PAH compounds were found in 100 percent of the soil samples. Total PAH concentrations[85] in soil are greater than the RAOHE and TULSMA standards for agricultural soil (2 mg/kg) in 44 percent of the samples and greater than the RAOHE standard for sensitive ecosystems (1 mg/kg) in 51 percent of the samples.
- Total PAH concentrations in soil range from marginally greater to almost 200 times greater than the sum of the detected 16 PAH compounds[86] often used to characterize PAH contamination.
- Volatile organic compounds were found in 38 percent of the soil samples.
- Barium concentrations greater than the TULSMA standard for for agricultural soil (750 mg/kg) were detected in 12 percent of the soil samples and greater than the TULSMA standard for residential soil (500 mg/kg) were detected in 24 percent of the samples.[87]

We observed and analytically detected oil in concentrations above both RAP and current Ecuadorian standards inside TexPet-remediated pits, pits closed prior to the RAP, or undocumented TexPet pits at 5 of the 11 well sites where we collected soil samples. We also found evidence of petroleum contamination in soil borings adjacent to TexPet-remediated pits or pits closed prior to the RAP at 10 of the 11 sites, and in 63 percent of the borings, where we collected soil samples.

During our investigations, petroleum-related contamination of the soils at the well sites was apparent in pits that were never closed or were never part of the RAP. While asphalt-like deposits were common, we also observed liquid oil or mobile petroleum contamination in soils adjacent to swamps and streams. We observed such mobile petroleum near siphon pipes and in abandoned pits. Even in areas where

[85] Total PAHs = sum of all detected parent PAH compounds and their alkylated derivatives.

[86] The 16 PAHs compounds analyzed by Method 8100 specified in RAOHE (and USEPA Method 8270) include: acenaphthene, acenaphthylene, anthracene, benzo[a]anthracene, benzo[a]pyrene, benzo[b]fluoranthene, benzo[g,h,i]perylene, benzo[k]fluoranthene, chrysene, dibenzo[a]anthracene, fluoranthene, fluorene, indeno[1,2,3-cd]pyrene, naphthalene, phenanthrene, and pyrene.

[87] There are no RAOHE standards for barium in soil.

contamination was not visibly apparent, we detected petroleum using instruments, such as a photoionization detector (PID).[88]

Our investigations at the 11 well sites involving soil sampling have demonstrated that, contrary to Chevron's assertions, soil impacts are not confined to the immediate vicinity of the former oilfield facilities. Rather, they extend onto adjacent properties.[89] Thus, we documented the "footprint" of the soil contamination at many of these locations to be much more expansive than generally acknowledged by Claimants.[90]

3.3.4 Historical Environmental Data

For the most part, Chevron's experts and sampling teams collected surface and subsurface soil samples from outside and "upgradient" of the pits. In several instances, at well sites where cover material was placed on top of so-called "remediated" pits, they collected shallow samples that were not deep enough to penetrate the cleaner cover material. In a number of instances, composited samples were collected from outside the pits, combining soil obtained from different depths before testing.[91] As we explained in 2013,

> "Collection of composite samples within pit boundaries may be appropriate in some cases, but use of composite samples outside of pits should be avoided in most circumstances because it dilutes observed concentrations of toxic compounds and blurs the differences in concentration from place to place which are necessary to understanding contaminant movement (direction and distance) away from the source."[92]

And again,

> "Vertical sample compositing at a location ignores concentration variations with depth and masks the maximum interval concentration. Deeper soil borings have a greater tendency to mask the maximum concentration since more intervals are included in the composite. Additionally, there is a greater likelihood that deeper, uncontaminated segments may be added to the composite, thereby diluting the composite sample and resulting in an artificially low concentration."[93]

Chevron's composite sampling approach can lead to sample results with a wide range of contaminant concentrations from the same contaminated zone. This is illustrated in Figure 3.3-5 below, Hypothetical Vertical Composite Samples Outside Pit.

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[88] 2013 SI Report.

[89] LBG December 2013 Rejoinder Report, p. 25.

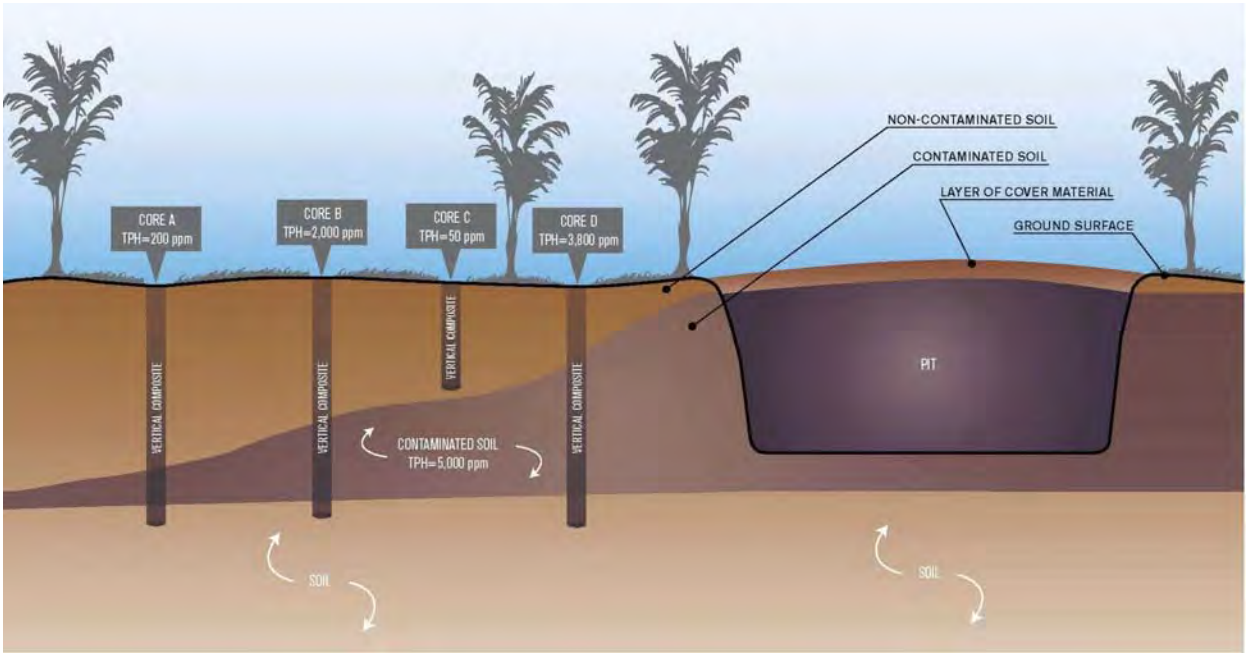
[90] Claimants' Supplemental Memorial on Track 2 2014, p. 85.

[91] LBG February 2013 Expert Report, p. 32.

[92] LBG February 2013 Expert Report, p. 25-26.

[93] LBG December 2013 Rejoinder Report, p. 42.

Figure 3.3-5 Hypothetical Vertical Composite Samples Outside Pit[94]

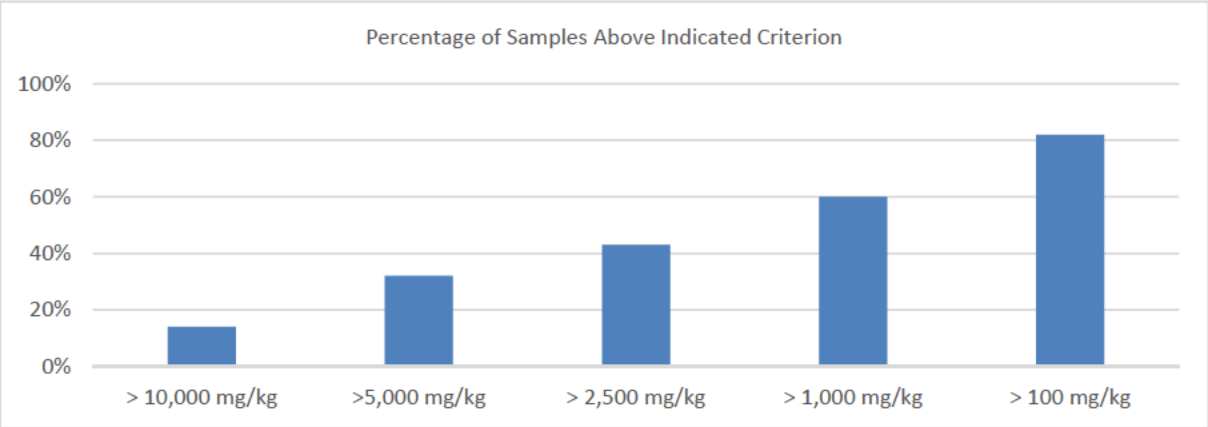


However, Chevron's own data from subsurface samples collected outside of pits (samples that were not composited and came from the subsurface)[95] show that petroleum hydrocarbons are able to escape the pits and contaminate the surrounding soil at depth. Figure 3.3-6 shows that for these samples, 43 percent exceed the RAOHE standard for agricultural soil and TULSMA standard for residential soil (2,500 mg/kg), 60 percent exceed the RAOHE standard for sensitive ecosystems (1,000 mg/kg), and 82 percent are greater than the Lago Agrio Judgement criterion of 100 mg/kg.

[94] This schematic shows a composite of features from a variety of E&P sites for illustration purposes.

[95] From Chevron's August 2013 Access Database, a total of 141 samples were classified as "JI," "PI," or "Rebuttal," "Outside," "subsurface," "Non-RAP soil," but, not classified as "composite", "single boring composite," or "perimeter".

Figure 3.3-6 Comparison of Petroleum Hydrocarbon[96] Concentrations in Subsurface Soil Samples Analyzed by Chevron to Various TPH Criteria



In addition, and as discussed more fully in Appendix B, we performed several additional analyses to examine the relationships among the PI and JI data collection efforts. The results of this analysis show that, during the JI, Chevron resampled at a subset of the PI surface soil locations that were statistically biased towards low concentrations relative to the PI locations Chevron did not resample. PI petroleum hydrocarbon concentrations for the resampled locations were lower than those for PI locations that Chevron did not resample in all cases.[97] This low bias was shown to be highly statistically significant for the set of all surface sample locations and for all surface sample locations excluding the pits. Subsurface sampling locations also appeared to be biased low, but the results were not statistically significant, likely because of an insufficient data set. The inclusion of a subset of low biased sample locations in the JI investigation has the potential to add a low bias to the entire JI data set.[98]

3.4 Groundwater Impacts

Our site investigations in 2013 and 2014 documented groundwater contaminated by crude oil in the Oriente. For the most part, the features and sites we investigated were created by TexPet and are at locations where PetroEcuador did not produce oil, thereby confirming that crude oil released by TexPet continues to affect the environment and living spaces of people 30 to 40 years later.

3.4.1 Conceptual Site Model

Groundwater contamination around the E&P sites in the former Concession Area occurs when oil and other wastes[99] are spilled onto the ground[100] or discharged into unlined pits. The discharged

[96] This presentation is based on samples analyzed by USEPA Method 8015; *see* Annex 1 § 3.1.

[97] This included comparisons with or without the pit samples, and for both surface and subsurface sample locations.

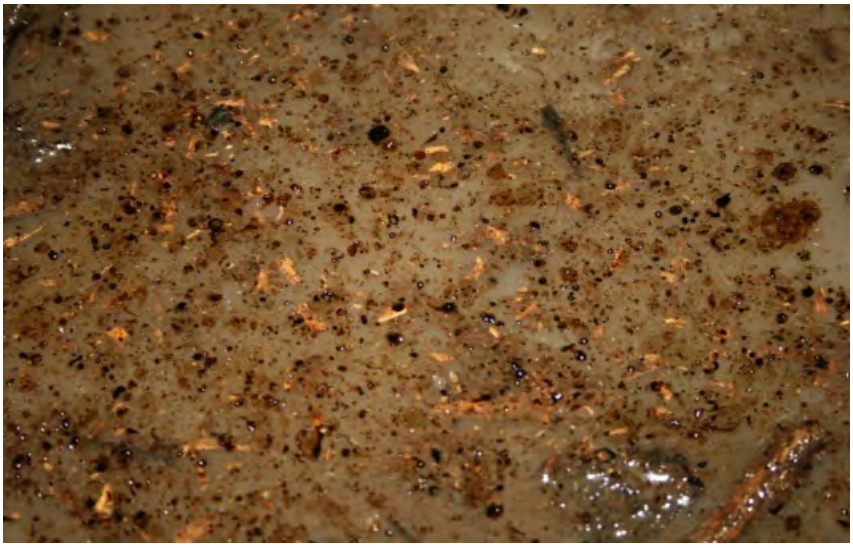
[98] Annex 1, Appendix B, Supplemental Assessment of Chevron's Preliminary Investigation (PI) and Judicial Inspection (JI) Sampling Objectives and Outcomes.

[99] Other contaminants discharged into unlined pits by TexPet include acidic chemicals and solvents used during workovers as well as other wastes. The 1990 Henderson memo under the heading "Workover and Stimulation

contaminants seep into the subsurface through pore spaces between soil particles (e.g., through more porous soil), through fractures in the clayey (less porous) soil, and through root casts created by plant roots.[101]

During our investigations, we observed that shallow groundwater, groundwater springs, and seeps are common. Also, LBG's observations that interlayered sand, silt, and clay exist at most sites contradict Claimants' assertion that the unlined pits were constructed in essentially impermeable clays.[102]. We detected impacts to groundwater at every one of the sites where we sampled groundwater (10 sites spread across the former Concession Area).

Figure 3.4-1 – Photograph of oil droplets in water in wetland at GU-06



Wastes" (Item 3, page 4, U.V. Henderson to W.C. Benton, Nov 14, 1990) states: *"These pits contained oil, produced water, workover brines, spent acid, and treatment solvents. Fluids are not generally recovered from these pits, since in many cases they are inaccessible."*

[100] *Subsurface Persistence of Crude oil Spilled on Land and its Persistence in Groundwater*; J. J. Duffy, M. F. Mohtadi, E. Peake, 1977 IOSC Proceedings, 1977.

[101] *LNAPL in Fine-Grained Soils: Conceptualization of Saturation, Distribution, Recovery, and Their Modeling*; M. Adamski, V. Kremesec, R. Kolhatkar, C. Pearson, and B. Rowan, *Groundwater Monitoring and Remediation*, Winter 2005 pages 100-112 discusses in detail how macropores (fractures and rootcasts) in clay present ways for oil (LNAPL) to be transported in the subsurface. The authors go through a litany of previous studies that also describe the transport of liquid contaminants through clay. LBG observations in the former Concession Area found that areas where "impermeable clay" was the substrate, crude oil migrated as free oil at least 60 meters in fractures in the clay. Ironically, Claimants' arguments rely on naturally occurring clay to stop oil from migrating from pits, when our observations are that oil may migrate farther along fractures in clay than through porous media such as silty sand (Connor 2013 p. 3: "*This fact is particularly relevant to the Oriente region in Ecuador, where the predominately clay soils strongly impede infiltration of crude oil from pits or spills…*".).

[102] Connor, 2013, p. 3.

LBG's findings in the Oriente comport with groundwater findings by the United States Geological Survey ("USGS") at crude oil spills. Our observations in the Oriente are that at some locations groundwater contamination exists like a halo within a few tens of meters around a pit while groundwater contamination elsewhere may extend farther. For example, LBG observed contamination more than 60 meters from the pit at AG-06. Based on our studies to date, groundwater contamination in the Oriente is not expected to occur at distances much greater than 175 to 200 meters from a petroleum source. The distances observed by LBG in the Oriente, over 60 meters, however, are more than sufficient to intersect with surface water bodies and domestic water sources in many locations. Often surface water discharge points and hand-dug domestic wells were observed to be much closer to a pit than even 25 meters.[103]

The LBG investigations confirmed groundwater contamination caused by TexPet operations at 10 well sites: AG-02, AG-06, GU-06, LA-02, LA-16, SSF-13, SSF-25, SSF-34, SSF-43 and YU-02.[104] These represent all of the sites where LBG investigated groundwater contamination (LBG investigated the remaining 3 sites for sediment or soil only).[105]

Critically, residents living near TexPet's former E&P facilities who rely on groundwater often get that water from unlined, unfiltered, shallow, hand-dug water supply wells. Figure 3.4-3 below shows the conditions at hand-dug wells where the walls of the well are exposed aquifer material. This is typical of the hand-dug wells we observed, which are all similarly constructed and do not provide any means of either holding back aquifer material from sloughing into the well, or stopping infiltration of surface water. During our site investigations, we observed that water was often drawn and used by the residents without regard to the amount of suspended solids (turbidity) in the water. This means that any suspended solids in water (along with any dissolved constituents, oil droplets, colloids, or emulsions) from the well are consumed or contacted by the person using the water.

[103] HBT Agra, 1993, p. 8-20.

[104] 2013 SI Report, 2014 SI Report.

[105] *See* LBG February 2013 Expert Report and December 2013 Rejoinder Report for discussions regarding observations of groundwater contamination by others.

Figure 3.4-3 Photograph of hand-dug well at LA-16 (note that nothing separates the aquifer material from the water being used)

LBG's investigation teams, various site auditors (such as HBT Agra), and Claimants' investigation teams all documented crude oil-related contamination in groundwater near former TexPet sites at seeps and springs, in monitoring wells, and in both abandoned[106] and active domestic water supply wells.[107]

The occurrence of groundwater is driven by seasonal variations in precipitation, temperature, and evapotranspiration. These factors cause fluctuations in groundwater levels and influence seasonal changes in a local population's reliance on groundwater. During rainy periods, many residents near TexPet's former E&P facilities use rain water as their primary source of water but, during dry periods, these residents' reliance on groundwater necessarily increases.[108] In addition, the likelihood of contamination increases in the hand-dug wells during dry periods due to the prevalence of groundwater, as opposed to rainy periods when surface water may fill the well.

The effects of seasonality are exemplified by our observations at the hand-dug well at SSF-43, which was first visited for reconnaissance during the dry season in April 2014. At that time the water level in the well was about 6 to 7 feet below the ground surface (see Figure 3.4-4). Water collected from the well

[106] LBG has documented water supply wells abandoned at least two of the sites investigated in 2014, SSF-43 and LA-16 (SI report).

[107] Connor, J.A. and Landazuri, R. 2008. *Response to Statements by Mr. Cabrerra Regarding Alleged Impacts to Water Resources in the Petroecuador-Texaco Concession Area*. August 29, 2008. The authors note that at least some wells contain petroleum contamination, although Connor attributes the contamination to "natural causes" such as "naturally occurring sediment in the sample."

[108] Strauss, December 2013, p. 27.

smelled of crude oil and produced a reading of 6.5 ppm using a photo-ionization detector (PID), which detects volatile organic compound vapors in the air above the water (see Figure 3.4-5).

Figure 3.4-4 Hand dug well at SSF-43 in April 2014 - water level is about 7 feet below ground surface

Figure 3.4-5 Water from hand dug well at SSF-43 - PID reading from water is 6.5 ppm

When we returned to investigate SSF-43 in late June and July 2014 (during the wet season), there was standing water near the well, and the water level in the well was just 1 foot below the ground surface. Furthermore, PID readings from the well did not indicate the presence of volatile organic vapors. On the day we collected a sample from the well, the water level had dropped to 4.5 feet below the ground surface but the PID reading was still at a background level (see Figure 3.4-6).

Figure 3.4-6 Hand-dug well at SSF-43 during sampling on June 28, 2014; water level is at 4.5 feet below ground surface

Analysis of water samples collected from both the hand-dug well and the monitoring well clearly indicate impacts by crude oil. However, because the hand-dug well's concentrations were lower than the concentrations in the monitoring well (despite the fact that they were both drawing water from the same aquifer), it is likely that the water in the hand-dug well was diluted by (less contaminated) surface water runoff. Because of the proximity of the two wells and that they both access the same groundwater, it is likely that the hand-dug well would have had similar concentrations to those detected in the monitoring well had the sample been collected during the dry season.

3.4.2 Residents' Encounters with Contaminated Groundwater

Based on our observations in the Concession Area, residents obtain water from several sources, including:

- Rain water collection
- Hand-dug domestic supply wells
- Machine-drilled water supply wells for individual residences (only observed by LBG in the Sacha wellfield)
- Springs
- Surface water, such as streams and ponds
- Municipal water supplies (such as municipal water wells)
- Water vendors

Of these, hand-dug wells, springs, and machine-drilled water supply wells for individual residences are where residents most likely encounter contamination in groundwater. Some residents use primarily unfiltered groundwater for drinking, cooking, bathing, watering livestock, and cleaning.[109]

3.5 Surface Water and Sediment Impacts

Based on our investigations and evaluations, we observed and conclude the following:

1. TexPet E&P operations, including management of produced water, caused surface water contamination;
2. TexPet discharged contaminated water directly to streams;
3. Site investigations performed by LBG in 2013 and 2014 confirm the existence of contamination in surface water and sediment; and
4. During the 2013 and 2014 site investigations, we observed direct resident exposure and opportunities for exposure to contaminated media.

Based on surface water and sediment contamination detected by Chevron during the JI process, the environmental audits, and our visual observations and sampling results, it is clear that petroleum-related contamination in surface water and sediment at the well sites operated by TexPet is still extensive and persistent in the environment.[110]

3.5.1 Conceptual Site Model

As with soil and groundwater, there is no doubt that surface water and sediment are impacted in the Concession Area. In fact, the presence of contaminated sediment is a point of agreement between Claimants' experts[111] and LBG.

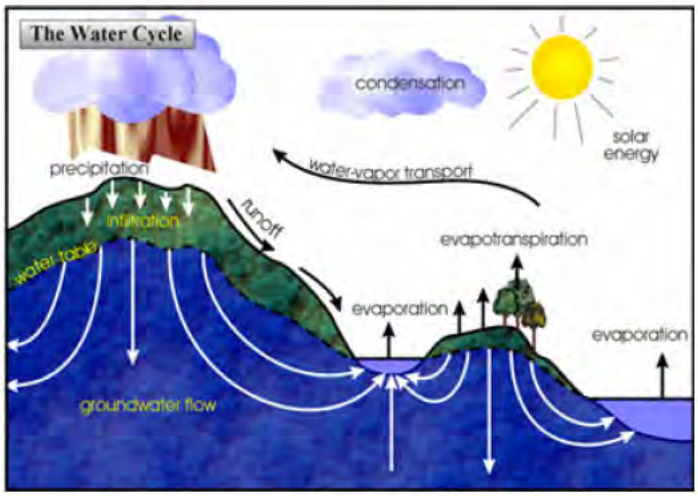
Water moves through the environment in a pattern that follows the hydrologic cycle as depicted in Figure 3.5-1. During TexPet's operational history, TexPet discharged oil into pits, directly to streams and wetlands, and spilled oil directly onto the ground surface. Over time the petroleum components mixed with water and followed the hydrologic cycle and collected in the streams and sediments.

[109] Strauss, November 2014, § 2.2.

[110] LBG February 2013 Report, p. 44.

[111] Connor 2013, p. 4

Figure 3.5-1-Hydrologic Cycle[112]



3.5.2 Residents' Encounters with Contaminated Surface Water and Sediment

People living in the former Concession Area are dependent upon the streams for drinking water, bathing, laundry, fishing, and recreation as depicted in the photographs in Figure 3.5-2. We also observed a trench dug through a former RAP pit at SA-90, exposing its contents (see Figure 3.5-2) thus contradicting again Claimants' contention that any remaining contamination has no possibility of release to the environment.

[112] Adapted from Coastal Carolina University www.coastal.edu.

Figure 3.5-2 Photographic Evidence of Resident Encounters with Contaminated Surface Water and Sediments

Bathing and Laundry at AG-02

REDACTED

Trench dug through RAP pit at SA-90

Oil on stream being remediated by PetroAmazonas at SA-86

3.5.3 Current Conditions in Surface Water and Sediment (LBG Investigations)

During our 2013 and 2014 site investigations, we observed liquid oil or mobile petroleum contamination in soils, sediments, and in the surface waters of adjacent swamps, ponds, and streams. As presented in our 2013 SI Report and as further supported by our 2014 site investigation, analytical data confirm the presence of contamination in the surface water and sediments.

During the 2014 site investigation, we collected surface water samples at 3 well sites and sediment samples at 4 well sites in the Concession area. We analyzed a total of 36 surface water samples and 54 sediment samples and compared the results to Ecuadorian standards.[113]

[113] 2014 SI Report.

In surface water we found:

- Petroleum hydrocarbons in 100 percent of the samples;
- Petroleum hydrocarbon concentrations greater than the TULSMA standard for surface water (0.5 mg/l) in 17 percent of the samples.
- PAHs in 100 percent of the samples;[114]
- Total PAH concentrations greater than the TULSMA standard for surface water (0.0003 mg/l) in 36 percent of the samples.
- 31 percent of samples showed crude oil VOCs — compounds indicative of unweathered oil.
- Barium above background levels in 6 percent of the samples.[115]

In sediments we found:

- Petroleum hydrocarbons in 100 percent of samples;
- Petroleum hydrocarbon concentrations greater than the RAOHE standard for sensitive ecosystems (1,000 mg/kg) in 81 percent of the samples.
- PAHs in 100 percent of the samples;[116]
- Total PAH concentrations greater than the RAOHE standard for sensitive ecosystems (1 mg/kg) in 85 percent of the samples.
- 35 percent of the sediment samples showed crude oil VOCs — compounds indicative of unweathered oil.
- Barium above background levels in 67 percent of the samples.[117]

3.5.4 Historical Environmental Data

During the period 1964-1990, it is estimated that TexPet discharged a total of 377 million barrels of produced water to surface water and the environment in the Oriente. [118] Using historical sampling results of produced water[119] we can estimate the total mass of crude oil discharged to surface water. These estimates are conservative, because none of the historical programs sampled every production station's effluent. Using the TexPet 1990, HBT Agra, and Fugro-McClelland results we can reasonably

[114] PAHs =Polycyclic aromatic hydrocarbons, as sum of all detected PAHs and alkylated derivatives.

[115] There are no RAOHE standards for barium in surface water. Barium is an indicator of contamination from drilling activities. Barium is toxic and mobile in the environment and can be produced when drilling fluids and naturally occurring barium minerals are exposed to acidic maintenance liquids.

[116] PAHs =Polycyclic aromatic hydrocarbons, as sum of all detected PAHs and alkylated derivatives.

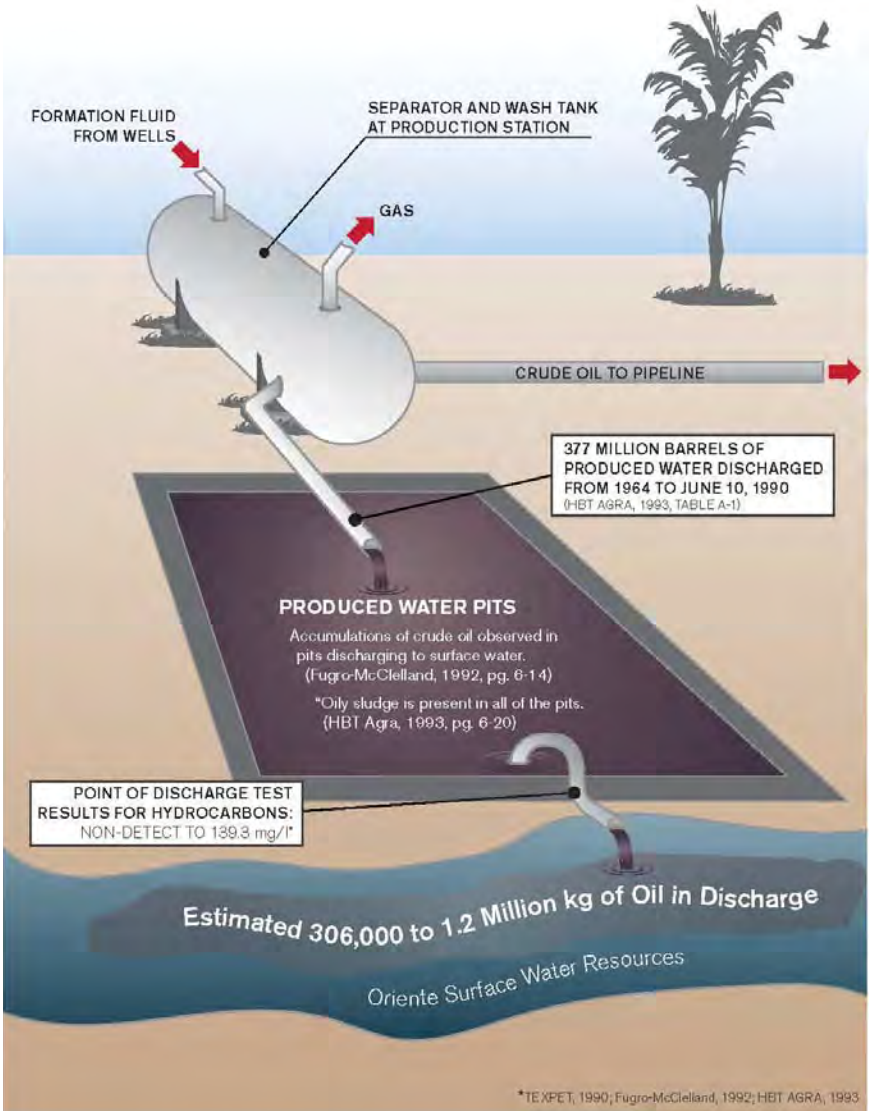
[117] There are no RAOHE standards for barium in sediment.

[118] Annex 1, Appendix E, Produced Water Calculation.

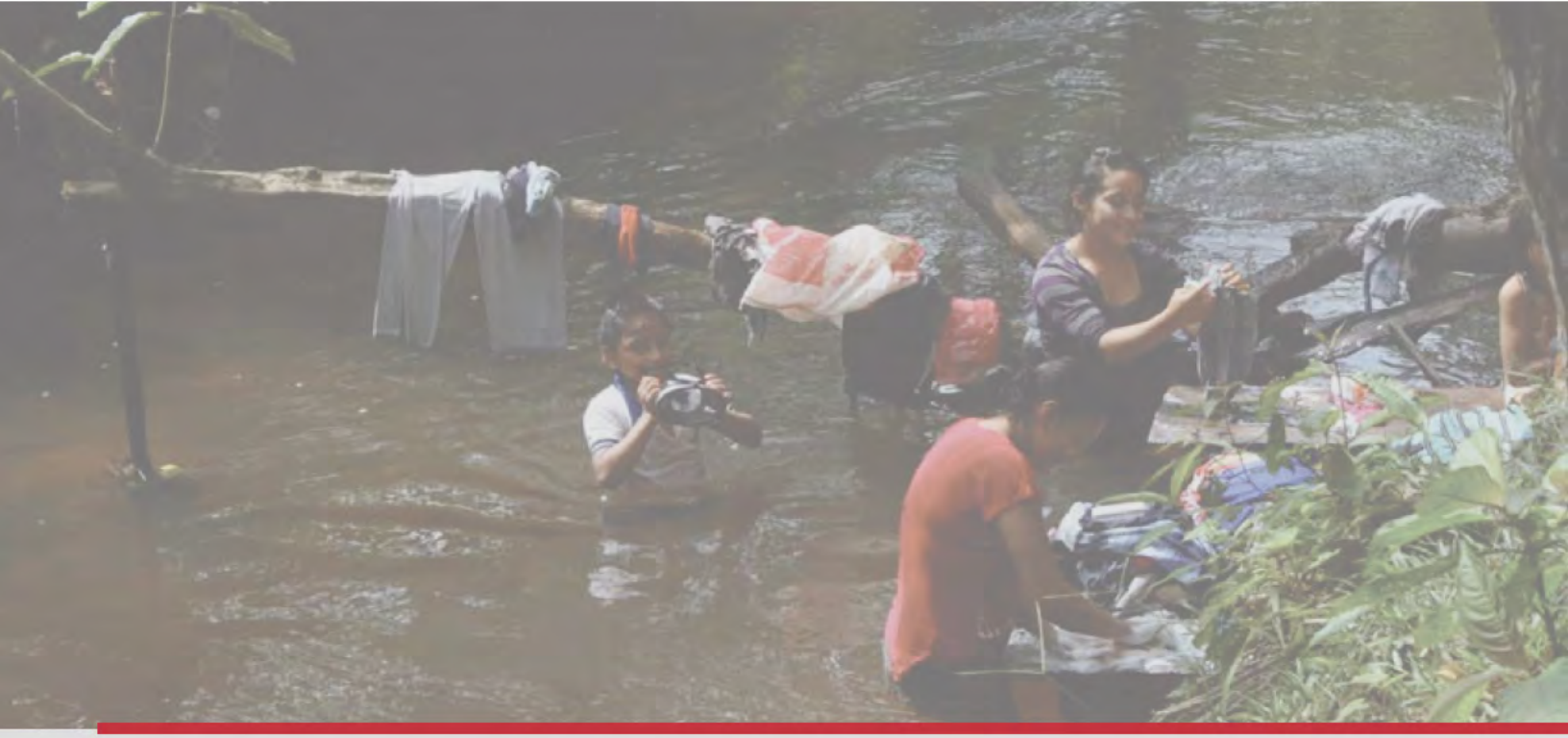
[119] There was sampling by TexPet in 1980 and 1990. Texpet, Water Study of Samples from the Rivers Nearest to Production Stations Upstream and Downstream, Water Study, February 1980, SDNY 04 CIV 8378, pgs. CA1108384 to CA1108410; Texaco Memo from U.V. Henderson to W.C. Benton dated January 15, 1991, SDNY 04 CIV 83 -9678, pgs. CA1108477 to CA1108491. The audits also sampled produced water. HBT Agra, 1993, Table 7-2; Fugro, 1992, Appendix B, Tables B-1 through B-19.

estimate cumulative petroleum hydrocarbon discharge to surface water of 306,000 to 1.2 million kilograms, as illustrated in the figure below.[120]

Figure 3.5-6 Produced Water Discharge



[120] Annex 1, Appendix E, TexPet Produced Water Calculations.



PREPARED FOR:
Winston & Strawn, LLP
1700 K. Street NW
Washington, DC 20006-3817

SUBMITTED BY:
The Louis Berger Group, Inc.
412 Mt. Kemble Ave.
Morristown, NJ 07962-1946

Louis Berger