Evaluation of Chevron's Sampling and Analysis Methods

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August 28, 2006

Introduction

This report has been developed specifically to provide a technical and scientific evaluation of issues raised in the report of Ann Maest, Mark Quarles, and Bill Powers dated March 8, 2006 (for simplicity, this will be referred to as the Maest 3/06 report). The Maest 3/06 report is primarily a critique of the sampling and analysis approach used by Chevron in the current Judicial Inspection process evaluating the efficacy of remediation efforts conducted by Texaco Petroleum Company (TEXPET) in the 1990s for sites in the Oriente Region of Ecuador. We find that the Maest 3/06 report raises serious allegations without providing evidence to support them. Working as a team, we have undertaken an independent review of the Judicial Inspection process, including the issues raised in the Maest 3/06 report, and have arrived at the opinions expressed herein. In the course of this effort, members of our team have been present at two Judicial Inspections, visited six other sites at which Judicial Inspections have already occurred, and interviewed experts nominated by Chevron and appointed by the Court to conduct Judicial Inspections (these experts will be referred to as Chevron's experts in this report; similarly the Plaintiffs have court-appointed experts). In addition, we have reviewed a considerable amount of written material and database queries relevant to the Judicial Inspections and the situation in general. Neither Chevron nor its consultants have provided direction as to the scope of the effort or the information that we should review.

The sampling and analysis program in question is a part of the Judicial Inspections and done only with close supervision by the court and in the presence of the Plaintiffs. It is our understanding that the goals of the sampling and analysis program that Chevron's experts are conducting for the ongoing Judicial Inspections are to:

1. Determine whether TEXPET complied with its remedial obligations, including pit closure, as specified in the Remedial Action Plan agreed to by the Government of Ecuador and TEXPET on 9/8/1995.

2. Determine whether residents living in the vicinity of these sites are, at the time of the Judicial Inspections, being exposed to harmful concentrations of contaminants in soil or water due to oil field operations.

The Government of Ecuador's oil company, PETROECUADOR, currently operates, and for some time, has operated these oil fields. As the oil company is a part of the Government of Ecuador, in this report, we have chosen to use the term "Government of Ecuador" when referring to any part of the Ecuadorian government including PETROECUADOR.

Summary of Opinions

We find that the Judicial Inspection assessment program, as originally planned and now being implemented, is appropriate to address the above goals (i.e., assess remediation compliance and risks to human health at the time of the Judicial Inspection). Furthermore, we find that the sample selection, collection, and analysis methods used are appropriate and are consistent with common practices and standards used by governments, companies, and consultants involved in the environmental remediation business worldwide.

We believe there is no foundation for the serious allegations in the Maest 3/06 report, including the allegation that the sampling program that Chevron's experts are conducting deliberately hides or minimizes the existing contamination and associated risks. Those allegations are not supported by factual information contained in the Maest 3/06 report; by any published information we have reviewed to date; or by any actions or circumstances that we have witnessed first-hand during sampling efforts for the Judicial Inspections of the Shushufindi SW production station (October 2004) and the Sacha Norte 1 production station (April 2006), or during our own site inspections in May 2006 of Shushufindi-004, Shushufindi-013, Sacha-06, Sacha-51, Sacha-53, and Sacha-Central (four of these sites were alluded to in the Maest 3/06 report). To our knowledge, prior to issuing their report, Maest and co-authors did not attend any Judicial Inspections, observe the decision-making process used during the Judicial Inspections to establish the sampling locations, or observe the sampling efforts used by the court-appointed experts.

It is also apparent that Maest and co-authors either did not review or did not understand Chevron's Judicial Inspection expert reports, including their extensive appendices; the latter describe in detail many of the Chevron efforts that Maest and co- authors asserted were lacking (e.g. consideration of background metals concentrations in soils; consideration of oil saturation and mobility in soils; evaluation of international standards for oil field pit closures; calculation of site-specific risk-based criteria for selected parameters; general considerations regarding weathering of crude oil in the environment; lab studies of degradation of crude oil in soil samples from various sites; BTEX, PAHs, and metals content of Ecuadorian crude oils; effects of crude oil on livestock; consideration of bioavailability of weathered crude oil in soils, etc.). Further, the Plaintiffs for whom the Maest team worked were present for all of the Judicial Inspection sampling and were free to suggest alternate sampling locations during the Judicial Inspection process. Most of the sampling locations requested by the Plaintiffs during the Judicial Inspections have also been sampled by Chevron's Judicial Inspection experts. In fact, in the first 37 Judicial Inspections, Chevron's experts collected and analyzed over 700 soil and over 250 water samples; in contrast, the Plaintiff's experts analyzed fewer than half that number. Sample collection was conducted under mutual oversight of court-appointed experts nominated by the two opposing parties, and, thus, it is clear that the sampling program during each Judicial Inspection was as much the product of the Plaintiffs as of Chevron.

In developing the opinions in the Maest 3/06 report, it is possible that the Maest team:

(a) May not have understood the scope and purpose of the Judicial Inspection sampling efforts.

(b) May not have completed a systematic evaluation of the enormous compilation of documents that describe the sampling and analysis agreements, the procedures to be used, and the results of the Judicial Inspection efforts (the vast majority of which were written in Spanish).

(c) May have been misinformed about the mutual oversight provided by court-appointed experts during the Judicial Inspections.

(d) May be unaware that the contract agreed upon by the Government of Ecuador and TEXPET in 1995 concluded that only certain specified sites were within TEXPET's scope and that many other areas in the Oriente Region were not within TEXPET's scope (e.g., sites and pits that were not included in the Remedial Action Plan, pits still in use by the Government of Ecuador, oil spills that occurred after 1990, etc.).

We believe that forming a well-founded and unbiased opinion as to the adequacy of the Chevron Sampling and Analysis Program requires both a clear understanding of the objectives and purpose of that program and considerable time and effort to adequately review the compiled documents, pertinent agreements, sample selection and collection procedures, and analytical results. We have determined the scope of such an effort and have undertaken that effort.

Qualifications

The authors of this report have extensive experience characterizing and remediating sites contaminated by petroleum or other chemical substances. We worked collaboratively as a team, each member with his own expertise reviewing available information and conducting independent and collaborative analysis. All of the opinions expressed in this report are opinions jointly held by all three authors.

Dr. Pedro J.J. Alvarez is the George R. Brown Professor and Chair of Civil and Environmental Engineering at Rice University. He received a bachelor of engineering (B. Eng.) degree in Civil Engineering from McGill University and Master of Science (M.S.) and doctor of philosophy (Ph.D.) degrees in Environmental Engineering from the University of Michigan. Dr. Alvarez has over 15 years experience in applied and fundamental research associated with the fate and transport of environmental pollutants and the cleanup of contaminated sites. He co-authored with Dr. Walter A. Illman the textbook, *Bioremediation and Natural Attenuation of Groundwater Contaminants: Process Fundamentals and Mathematical Models*, published by John Wiley & Sons. Dr. Alvarez is a Diplomate of the American Academy of Environmental Engineers and a Fellow of the American Society of Civil Engineers. His honors include the Cleanup Project of the Year Award from SERDP (2002); the Button of the City of Valencia (2000); the Collegiate Excellence in Teaching Award from the University of Iowa (1997); the Alejo Zuloaga Medal from the Universidad de Carabobo, Venezuela (1996); a Career Award

from the National Science Foundation (1995); the Outstanding Achievement Award in Environmental Engineering from the University of Michigan (1991); and several best paper awards. He currently serves on the editorial boards of *Biodegradation;* the *European Journal of Soil Biology;* and the *Journal of Environmental Engineering.* He also serves as adjunct professor at UFSC in Florianopolis, Brazil and UNAM in Mexico City and as President of the Association of Environmental Engineering and Science Professors (AEESP).

Dr. Douglas Mackay is Adjunct Professor in the Department of Land, Air & Water Resources at the University of California at Davis and Consulting Professor in the Department of Civil and Environmental Engineering at Stanford University. He has B.S., M.S., and Ph.D. degrees from Stanford University, the latter two in Environmental Engineering. For over 20 years, his research has focused on controlled field experiments on contaminant transport, transformation, and remediation in groundwater, as well as laboratory studies of processes controlling field behavior. Research has addressed chlorinated hydrocarbon transport and bioattenuation, flushing of chlorinated hydrocarbons from geologic media during pump-and-treat remediation, non-linearity and spatial variability of sorption processes, *in situ* aerobic bioremediation of methyl tertiary-butyl ether (MtBE), anaerobic biotransformation of MtBE, evaluation of methods for estimation of contaminant mass discharge, and impacts of ethanol on natural attenuation of other fuel components. The field research has required special focus on application of standard and innovative methods for characterization of contaminated sites. He served on two National Research Council committees culminating in two reports: *Alternatives to Groundwater Cleanup* (NRC, 1994) and *Natural Attenuation for Groundwater Remediation* (NRC, 2000). He serves as an associate editor for the *Journal of Contaminant Hydrology* and *Ground Water Monitoring and Remediation* and has served as peer reviewer for a number of other journals.

Dr. Robert Hinchee is an environmental engineer with a Ph.D. in Civil and Environmental Engineering from Utah State University. He has worked in the petroleum contamination and remediation industry for over 30 years and has been involved in characterization and remediation of over 1000 sites worldwide. For example, he served as the Technical Director overseeing characterization and remediation of the Trecate oil well blowout near Milan, Italy. This 15.000-cubic-meter blowout contaminated approximately 7 square kilometers of farm land with oil more than 1 meter deep in places. The remediation was the largest soil cleanup in European history and has resulted in complete restoration of the land to agricultural use. Dr. Hinchee has also worked in Saudi Arabia and Kuwait characterizing and developing remedial approaches for dealing with the hundreds of square kilometers of land and shoreline contaminated with oil as a result of Iraqi actions in the 1991 Gulf War, the largest oil spill in history. In this role, Dr. Hinchee has testified to the United Nations and provided technical support to the United Nations. In addition, he has authored, co-authored, edited, and co-edited numerous publications including more than 25 books, examples of which include *Hydrocarbon Bioremediation* and *Cost-Effective Remediation and Closure of Petroleum-contaminated Sites*. He was the founding editor of the *Journal of Bioremediation.*

Review Process

In order to perform an independent review and to address the issues raised in the Maest 3/06 report, the authors have designed the following process to ensure an independent and complete review. Each of the issues raised by Maest has been considered and opinions developed. In each case, the issues have been judged by our understanding of the objectives of Chevron's Sampling and Analysis Program during each Judicial Inspection:

1. To determine whether TEXPET complied with its remedial obligations, including pit closure, as specified in the Remedial Action Plan agreed to by the Government of Ecuador and TEXPET on 9/8/1995.

2. To determine whether residents living in the vicinity of these sites were being exposed to harmful concentrations of contaminants in soil or water associated with oil field operations at the time of the Judicial Inspection (i.e., when sampling was conducted). Regarding the second objective, potential subsurface exposure pathways and natural attenuation processes at selected Judicial Inspection sites were also considered in the formulation of our opinion.

The 122 sites in this lawsuit include old oil well sites and production stations. Based on our review of a number of documents cited at the end of this report, we have developed the following understanding. The sites in the lawsuit were all jointly developed by the Government of Ecuador and TEXPET. TEXPET was never the majority owner of the oil field operations. In 1964, a consortium (50 percent owned by TEXPET and 50 percent owned by Gulf Ecuatoriana) entered into a concession agreement with the Government of Ecuador for exploration and development of the oil field. At that time, the Government of Ecuador owned all of the land and mineral rights in the area. The consortium was never given ownership of the land. Oil production began in 1972. In 1974, Ecuador's oil company, Corporación Estatal Petrolera Ecuatoriana (CEPE), acquired 25 percent ownership of the consortium. In 1977, CEPE acquired Gulf Ecuatoriana's shares to become a 62.5 percent owner of the consortium. In 1989, CEPE became known as PETROECUADOR. In 1992, the Government of Ecuador acquired 100 percent ownership of the oil field and TEXPET's concession expired. Neither TEXPET, nor Chevron now, has any operations in the area and the Government of Ecuador continues to operate the oil field.

In 1995, the Government of Ecuador and TEXPET reached an agreement dividing the responsibility and detailing procedures for clean up of these sites (Memorandum of Understanding Scope of Environmental Work and the Remedial Action Plan). Based on these documents, it was agreed that TEXPET would take lead responsibility for a variety of remedial actions including cleanup of numerous sites and provision of various equipment such as reinjection pumps. By agreement with the Government of Ecuador, certain pits originally included in the Remedial Action Plan were later designated as "No Further Action" pits because it was discovered that some of them were closed prior to remediation or otherwise did not warrant cleanup actions, while certain other pits were designated as "Change of Condition" pits and excluded from the work program because they were still being used by the Government of Ecuador. TEXPET cleaned up the sites within its scope between 1995 and 1998; during this time, TEXPET remediated 250 pits and 7 spill areas at 133 well sites. After reviewing and

accepting TEXPET's work on each of these sites, the Government of Ecuador signed the Final Release of Claims in 1998 (Acta, 1998). In our report, pits for which TEXPET has remediation responsibility are referred to as "in scope" and pits for which TEXPET has no remediation responsibility are termed "out of scope."

To understand Chevron's sampling program, the context under which it is being conducted is important. Beginning in 2004, Chevron undertook sampling and analysis of soil and water as part of the Judicial Inspection process. The program's objective is to evaluate the remedial work done in the 1990s by TEXPET, and to determine as required by the Judicial Inspection process, if any of the TEXPET-remediated sites present unacceptable risk to human health or the environment at the time of the Judicial Inspection. Chevron developed this Sampling and Analysis Program working in cooperation with the Plaintiff's technical consultant, Mr. David Russell (personal communication from Sara McMillen, Chevron Energy Technology Company). Field and laboratory protocols were documented in the "Sampling Plan" and "Analysis Plan" documents issued in August 2004 and accepted for use by both parties per the Terms of Reference issued by the court and signed by both parties. At every Judicial Inspection, the Plaintiffs are free to accompany Chevron and to split samples with Chevron and vice versa, and, in some cases, both parties have done so. During the Judicial Inspections completed and available at the time of this writing, Chevron's experts collected and analyzed over 700 soil and over 250 water samples; in contrast, the Plaintiff's experts analyzed fewer than half that number. It is this Sampling and Analysis Program, as applied to date, that is the subject of this report and, according to our understanding, was the subject of the Maest 3/06 report.

This lawsuit involves a large number of sites and an enormous quantity of data and documentation has been generated for the investigations conducted to date. Therefore, we decided to start our review with a representative subset of the data and, thus, selected seven sites for more focused analysis. These seven representative sites were chosen by our independent review team, not by Chevron or its consultants. The reviewed sites are listed below.

Site Name	Site Type	In Scope?	Rationale for Selection
Shushufindi-13	Well	Yes	Cited in Maest 3/06 report
Shushufindi-4	Well	No	To review a site that was not part of the Scope of Work or Remediation Action Plan.
Shushufindi Southwest	Production station	Yes	The Judicial Inspection was attended by Dr. Pedro Alvarez as an independent contractor
Sacha 6	Well	Yes	Cited in Maest 3/06 report
Sacha 51	Well	Yes	Cited in Maest 3/06 report
Sacha 53	Well	Yes	The Peritos Dirimentes' report was available
Sacha Central	Production station	Yes	Large important production station; Judicial Inspection report quoted in Maest 3/06 report

Each of these sites was visited by at least one of the authors and a request was made to Chevron for all relevant documents and information relating to each of these sites. This information was reviewed and the Chevron consultants who conducted the actual sampling and analysis work were interviewed. We also reviewed Plaintiff's expert reports for several sites and the Settling Experts' Report for Sacha-53. A complete list of the materials reviewed and persons interviewed

is attached. We believe this information to be representative of the program as a whole, and, to that extent, our review and opinions apply to the program as a whole.

Adequacy of Chevron's Selection of Soil Sample Locations

We find that Chevron's sampling locations were appropriate and designed to achieve the objectives as defined. In general, soil samples were collected at Remedial Action Plan sites within the stipulated pits (by vertical augering or coring from surface and then first collecting samples of the clean soil covers and, below that, samples of the pit contents) and also at perimeter locations around pits or sites at one to four locations. Where Plaintiffs' experts sampled during the Judicial Inspection, generally Chevron's experts did also. At non-Remedial Action Plan sites (out-of-scope sites), Chevron experts normally collected perimeter samples and, according to the information available to us for the sites at which Judicial Inspections had occurred by the time of the writing of this report, also sampled nearly all of the locations where the Plaintiffs' experts sampled. These locations were chosen around the areas of concern, typically pits or spills. In the course of the Judicial Inspections completed and available to us at the time of this writing, Chevron's experts collected and analyzed a total of over 700 soil samples; many more soil samples will be collected before all Judicial Inspections are complete. Our opinion about the adequacy of Chevron's soil sampling locations is largely based upon our detailed reviews of the seven selected sites; these include review of the cited documents, visits to these sites, and interviews with the Chevron sampling teams.

Maest et al. appear not to have understood the Judicial Inspection sampling process or the purpose of the Chevron Sampling and Analysis Program. Furthermore, it appears that they did not fully consider all of the data presented by Chevron. Chevron's Sampling Program is adequate to achieve its stated objectives and certainly would meet a relevant U.S. standard, Environmental Protection Agency (EPA) or otherwise. Perhaps more significantly, the Plaintiffs for whom Maest et al. worked were involved in the development of the sampling and analysis plans that Chevron followed and had their own representatives present at the Judicial Inspection sampling events. Chevron met with Mr. David Russell, the Plaintiffs' expert, to jointly develop an approach to sampling and analysis at these sites. As a result of that collaboration, the Sampling Plan (2004) and Analysis Plan (2004) were developed and submitted to the court prior to the first Judicial Inspection. Additionally, the Plaintiffs are always present at the Judicial Inspections and have the same rights and obligations to choose sampling locations as Chevron's experts. Nearly every sampling location selected by the Plaintiffs' experts was co-sampled by the experts nominated by Chevron. In fact, as previously discussed, Chevron collected and analyzed many more samples than did the Plaintiffs. Thus, the overall approach to sampling and analysis was as much a product of the Plaintiffs' direction as Chevron's, and these activities were conducted under mutual oversight. This fact makes Maest's criticisms particularly puzzling.

An example of Maest et al's lack of understanding of the sampling program is their criticism that Chevron's experts generally collected samples only at superficial depths that often did not penetrate the layer of "clean" soil that TEXPET had added during the remediation. This statement is incorrect. For the sites we reviewed, which included those specifically cited by Maest et al. in their report, Chevron analyzed core samples from both the clean cap and the underlying remediated materials. This is a very common sampling approach used to verify that a

cap was originally placed and is still in place and that the deeper material was properly remediated. In fact, in one location (Pit 4 at Shushufindi-48), an exceedance of the TPH criteria was found at depth. The pit appeared to have been properly remediated by stabilization and the oil was stabilized and did not appear to represent a problem, however, the treated material exceeded the agreed cleanup criteria. This is only one exceedance in one pit of the many pits TEXPET remediated and that Chevron has sampled to date. Had Maest et al. read Chevron's Judicial Inspection reports carefully, they would have been aware of this deeper sampling.

In another example of confusion in the Maest 3/06 report (page 3), Maest et al. state that, in regard to Sacha-51, "Texaco claimed to have remediated the pit to below 5000 ppm, but when tested by plaintiffs during trial, the site revealed no less than 29.657 ppm of TPH." Maest et al. appear to have confused the locations of two separate pits at this well site, since the sample they refer to as having been collected by their experts from Pit 2 appears to have, in fact, been taken by their experts from Pit 5, a pit which was out of scope. TEXPET was not required to remediate Pit 5 and did not claim to have remediated this pit to below 5000 parts per million (ppm) or any other level. (Note that 1 ppm in soil is equivalent to 1 mg/kg. While Maest et al. appear to use these terms interchangeably, for consistency, we use mg/kg except when specifically addressing or quoting a Maest et al. statement using ppm.)

Referring to Sushufindi-013, Maest et al. reports seeing "petroleum hydrocarbon contamination … in a stream downhill from the pit." However, they did not specify the location. In our visit to Sushufindi-013 in May 2006, we observed what appeared to be petroleum-derived materials in shallow auger samples in a small, iron-stained portion (several square meters) of the drainage, approximately 30 meters north of Pit 2 (it is possible this was the same material Maest et al. described). This suggests that both they and we observed something similar in the area north of Pit 2 in 2006, long after the Judicial Inspection had been conducted at that site. However, the presence of some oily materials in that section of the drainage had also been noted during the Judicial Inspection at Sushufindi-013, and sampling downstream had indicated no exceedance of criteria. Thus, despite our agreement with Maest et al. regarding the observation of a small area of oily materials in the drainage just mentioned, we do not agree with the general and serious allegations in the Maest 3/06 report about the intent and performance of Chevron's investigations.

Chevron has routinely collected both groundwater and surface water samples. Groundwater samples were collected from any drinking water wells identified at or near the site. No effort was made to single out wells based on the direction of groundwater flow. This is a common and accepted approach to assess impact on human health, as it is not always possible to be certain of the direction of groundwater flow, which can change seasonally in response to changes in rainfall, river stage, or groundwater extraction. Thus, collection of samples from all surrounding wells ensures that, if contamination is present at one or more wells, it will be found. Surface water samples were collected from locations both up and downstream of potential sources of contamination. This is a common approach. Should surface water contamination be found, it helps determine the contribution of the source being investigated. Furthermore, upgradient samples are needed to assess the validity of Plaintiff claims that some drinking water sources are contaminated upstream of potential source zones.

Although Chevron's groundwater and surface water sampling approach was based on common and accepted methods, Maest et al. are critical of Chevron by stating, "Chevron's sampling approach almost never includes taking downgradient samples; to the contrary, Chevron's technical experts take samples upgradient of the sources – an approach that will always fail to find pathways for transport of contaminants….." This statement by Maest et al. is untrue and appears to reflect a failure on their part to review all of Chevron's sampling data. Furthermore, it is not clear if Maest et al. were referring to groundwater or surface water. For groundwater, as stated above, all nearby water wells were sampled since the actual hydraulic gradient was generally unknown. In the case of surface water, our review suggests that, where feasible, Chevron collected downstream or downgradient samples, and, in most cases, upgradient or upstream samples as well. Again, the sampling was done based on the jointly developed Sampling and Analysis Plans during the Judicial Inspections. The Plaintiffs and their experts were present for the sampling and free to request sampling wherever they believed appropriate.

Chevron worked with the Plaintiffs to develop a sampling program that would specifically address the two questions: 1) was the remediation carried out by TEXPET as agreed in 1995? and 2) at the time of the Judicial Inspections, were there unsafe human exposures to contaminants related to the oil field operations? The plan and its implementation appear appropriate to achieve these objectives. However, Maest et al. are critical of Chevron by stating, "Standard site investigation practices for soil, surface water and groundwater investigation require that a company take a variety of steps to determine the horizontal and vertical extent of the contamination, and sample from the areas that are expected to contain the highest concentrations of contaminants. Chevron met none of these basic requirements." Maest et al. then cite a U.S. EPA guidance document in support of their allegations. It appears that Maest et al. did not understand the objectives of the Judicial Inspection sampling programs; these were not Superfund site characterization efforts as described in the U.S. EPA document that they referred to; these efforts were designed to determine if TEXPET's remediation efforts had achieved the specific objectives that had been previously defined and agreed upon by the Government of Ecuador and TEXPET. For those objectives Chevron's program was adequate and reasonable.

In its Judicial Inspection reports, Chevron provides some interpretation of site data and presents what appear to us to be reasonable conclusions regarding the sites. Maest et al., however, present apparently unfounded accusations. One example is found on page 5 of their report: "In Chevron's conceptual model, for example, contaminants and groundwater are apparently capable of defying gravity and flowing uphill to the locations where Chevron ultimately decides to take its samples." Maest et al. do not provide any specific support for this serious claim. Indeed, this Maest et al. claim is not supportable based on our review. Thus, we can only conclude that Maest et al. were misinformed concerning Chevron's reports, or they failed to understand the reports, or they have chosen to include unsupportable statements.

Chevron composited some of its soil samples and were forthright in documenting that approach. Compositing is a well-accepted sampling technique, which we understand is authorized by Ecuadorian regulation, and it appears it has been appropriately used by Chevron. In fact, since composite sampling was done under the original Remedial Action Plan, it was only reasonable to use compositing in Chevron's Sampling and Analysis Plan to determine if the objectives of the

remediation carried out by TEXPET (as agreed upon in the 1995 Remedial Action Plan) had been met. Chevron has used compositing for a specific purpose: to obtain separate but representative samples of cap and remediated material. Additionally, some vertical compositing was done of samples collected from 1) pits and locations that TEXPET was not required to remediate and 2) delineation points. The compositing performed by Chevron is clearly described in the Sampling Plans and Judicial Inspection reports. The Plaintiffs' experts also composited soil samples. Nonetheless, Maest et al. are highly critical of Chevron's use of compositing and accuse Chevron of mixing "clean topsoil and lesser contaminated soil with underlying contaminated soil in the "remediated pits." Maest et al. do not cite any evidence of this mixing of clean and contaminated soil and do not say on which site(s) this supposedly happened. Based on our review, we could find no evidence to support this claim. It appears to us that Chevron used appropriate compositing techniques and that Maest et al.'s accusations are inaccurate.

Adequacy of Laboratory Tests Used by Chevron for Remediated Soils

We find that the laboratory testing that Chevron has done is appropriate and the methods have been correctly selected to meet the stated objectives. Chevron is analyzing soil samples using a number of different laboratory techniques to generate analytical results for total petroleum hydrocarbons (TPH); individual aromatic hydrocarbons, namely benzene, toluene, ethylbenzene, and xylene isomers (BTEX); polyaromatic hydrocarbons (PAHs); various metals; and the U.S. EPA's Toxicity Characterization Leaching Procedure (TCLP). It is our understanding that these analyses had been agreed to by Plaintiff's expert Mr. Dave Russell (personal communication from Sara McMillen) and Chevron, and are detailed in the Analytical Plan and the Terms of Reference. This is a comprehensive set of analyses for assessment of petroleum-contaminated soils and well within the industry practice for this purpose.

Petroleum is a naturally occurring material consisting of a wide variety of petroleum hydrocarbons. There are literally thousands of individual compounds in crude oil, most of which are not toxic and not of environmental concern. Because of this complex composition, there is no single ideal laboratory technique for crude oil analysis. TPH analysis is a technique for measuring the total petroleum in soils; however, not all crude oil fractions are identified in any one analysis and often naturally occurring, non-petroleum compounds are incorrectly identified as TPH. TPH analysis is by its nature a gross measurement and not directly indicative of toxicity or environmental impact. For example, asphalt pavement is as much as 50 percent (or 500.000 mg/kg) TPH and of no toxic concern. In fact asphalt is used and desired by citizens throughout the world. The compounds found in crude petroleum that are of toxic concerns are BTEX and PAHs. The concentrations of these compounds vary but never make up the majority of crude. The BTEX fraction is highly volatile and biodegradable and tends to weather from the oil relatively quickly, and, thus, it is frequently found in significant concentrations in fresh crude but at much lower concentrations or not at all in weathered crude. Some of the PAHs are of toxic concern; however, their concentration in fresh crude is usually much less than BTEX and low in most crude oils.

Chevron has correctly analyzed all soil samples for TPH, BTEX, and PAH. Review of the resultant analytical data provides a good understanding of both the presence or absence of crude oil contamination and the potential for toxic concerns from that oil. Chevron has also

appropriately analyzed soil samples for heavy metals, which can be present in oils and drilling fluids. The data show that the metals contents of Ecuadorian crude oils are relatively low and the soil sampling did not show any metal concentrations above the evaluation criteria in TEXPET remediated pits.

The TCLP test was specified in the original Remedial Action Plan as a measure of remedial performance and Chevron is appropriately using this test to determine remedial performance as required. The TCLP is a leaching test in which soil is mixed with water and the water is then analyzed. Crude oil can enter water either in a dissolved form, as a free liquid, or as an emulsion. The closure standard of 1000 milligrams per liter (mg/L) when applied to the TCLP would be indicative of the mobility of any residual oil in the soils. If oil was present at high enough levels to be mobile as a separate liquid phase or emulsion, then the 1000 mg/L would likely have been exceeded. In this context, the TCLP test and 1000-mg/L TPH criterion is an appropriate measure of remedial success. The TCLP test is less sensitive to potential dissolved petroleum hydrocarbon impacts, but we have seen no evidence Chevron used the test in this way. While BTEX analysis was not required in the Remedial Action Plan, for the Judicial Inspections Chevron is appropriately having chemical-specific analysis for BTEX performed. The analytical results are demonstrating that BTEX constituents are rarely detected in soils or waters outside the remediated materials; this may be in large part be due to their susceptibility to rapid biodegradation in soils and sediments, as documented in many studies in the U.S. and elsewhere (Alvarez and Illman, 2005).

Despite the fact that the TCLP test was required by the Government of Ecuador (see the Remedial Action Plan), and, as we understand it, authorized by current Ecuadorian regulations, Maest et al. are highly critical of Chevron's use of the TCLP and state, "The more appropriate test, ignored by Chevron, used by most experts and by experts for the affected communities, bypasses all of TCLP's inherent problems by directly measuring the total amount of TPH in the soil." It appears that Maest et al. were not aware of the analyses being done by Chevron. In fact, Chevron did analyze all soils during the Judicial Inspections using exactly the total TPH technique Maest et al. recommended. Had Maest et al. read Chevron's Judicial Inspection expert reports carefully, they would have been aware of this. It appears that Maest et al.'s criticism on this point disregards the facts.

The Appropriate Role of Institutional Controls at These Sites

We find that Chevron likely could not have implemented institutional controls at these sites. Institutional controls are restrictions on future land use that are usually imposed either by the landowner or by a government entity. Examples of institutional controls include deed restrictions, zoning regulation, and legal restrictions on land use such as banning groundwater use in an area. Institutional controls are widely used in the U.S. at Superfund sites. However, in the U.S., institutional controls are rarely used at oil and gas sites, in part because oil companies rarely own the land and exposure risks are much less than at Superfund sites. Institutional controls are for the most part a U.S. legal concept; their value and applicability outside of the U.S. and in Ecuador in particular, is questionable. If institutional controls were to be needed at these sites, those controls could only be put in place by the landowner and governmental authorities; as we understand it, this would be the Government of Ecuador.

Maest et al. criticize Chevron for the lack of institutional controls by TEXPET and state, "decisions for proper pit closure must always include structural and institutional controls to limit human exposure to the waste that remains and to protect the environment." In fact, TEXPET did use structural controls for this purpose: for example the clean soil placed on top of the closed pits is a structural control. As stated previously, it would not have been possible for TEXPET to place institutional controls on these sites, nor for Chevron to have enforced them. Maest et al. appear not to understand industry practice in the rest of the world where institutional controls rather than "always" being used are, in fact, rarely used at oil field sites.

Adequacy of Chevron's Use of U.S. EPA Guidance and Related Standards and Norms

We find that the evaluation criteria used by Chevron are reasonable and well within the range typically applied at oil-contaminated sites worldwide. Chevron has used two types of criteria for different purposes: 1) cleanup criteria agreed upon with the Government of Ecuador in the 1990s and used to evaluate the effectiveness of remediation and 2) criteria to assess potential human health impacts based on current exposure. The cleanup criteria for TCLP and soil TPH are the same standards to which the Government of Ecuador and TEXPET agreed in the 1990s, and, in the Judicial Inspection process, Chevron is using these criteria to evaluate the remediated sites and determine if the originally agreed upon standards were met. These standards are less than 1000 mg/L of TPH by TCLP before March 1997 and both the TPH by TCLP and less than 5000 mg/kg for TPH after March 1997. Maest et al. state that the Ecuadorian TPH standard in soil is 1000 mg/kg, but this was not true at the time of the TEXPET remediation work in 1995 to 1998 when Ecuador had no numerical standards for soil remediation or pit closures. The 1000-mg/kg standard was not adopted until publication of Decreto 1215 in February 2001, long after the remediation was complete, and, even now, this limit only applies to sensitive ecosystems, not to agricultural land or industrial operations, as are commonly encountered at the oil field sites included in this Judicial Inspection process. The standards employed by TEXPET are reasonable standards and are within the range of TPH standards set elsewhere in the world in 1995 and even today. For example, as recently as 2003 and 2004, when reviewing Kuwaiti and Saudi claims for remediation of oil released during the 1991 Iraqi invasion of Kuwait, the United Nations Compensation Commission concluded that oil contamination at concentrations well above 10.000 mg/kg could appropriately be left in place. Much of the Kuwaiti and Saudi contamination was surficial, not capped like the material in the remediated pits investigated in the Ecuadorian Judicial Inspection process (UNCC, 2003 and 2004).

For the purpose of the Judicial Inspection process, Chevron has identified *evaluation criteria* either based on prevailing regulations or if regulatory values were not available on possible risk to human health. These criteria were based on the standard of practice in the mid-1990s, the time of the remediation and the time when TEXPET had its last involvement with operations in this oil field. Criteria were set for the compounds of toxic concern found in petroleum (i.e., BTEX and PAH as well as for a variety of metals). Evaluation criteria were used for water and soil. Drinking water criteria were based on the most stringent of Ecuador Decree 2144, U.S. EPA or World Health Organization (WHO) drinking water standards. Soil criteria were based on a review of published Ecuadorian, Latin American, U.S., and international organization standards specifically applicable to oil field remediation. For specific compounds such as

BTEX, PAH, and inorganics, criteria were developed using worst-case assumptions and the U.S. EPA Soil Screening Guidance approach (U.S. EPA, 1996a and b). It is our opinion that this is a reasonable approach to set the evaluation criteria and, further, that the criteria Chevron used are reasonable and within the standard of practice for cleanup of such sites worldwide.

Maest et al. are critical of Chevron's approach and accuse Chevron of inventing norms and misapplying U.S. EPA guidance. Maest et al. offer little evidence and we found nothing to support these allegations.

Much of Maest et al.'s detailed criticism of Chevron on this topic focuses on barium; in fact, this is the only compound Maest et al. specifically cites in regard to this criticism. It appears that Maest et al. do not understand how barium is used in the petroleum business. Apart from naturally occurring barium commonly found in clay soils, the only source of man-made barium contamination at these sites would be the barium sulfate used to increase density of drilling muds. Barium sulfate, also called barite, is a non-toxic, naturally occurring mineral. According to the U.S. Center for Disease Control, barium sulfate is extremely insoluble and considered non-toxic (ATSDR, 2005). In 1994, the U.S. EPA identified barium sulfate as non-hazardous and not subject to toxic release reporting requirements (40 CFR 372). The lack of human health concerns about barium sulfate is illustrated well by the fact that barium sulfate is frequently ingested by or injected into human patients in standard medical practice to serve as a radio contrast agent for X-ray imaging of internal organs and other diagnostic procedures. The lower barium criterion recommended by Maest et al. is the U.S. EPA generic soil screening level for protection of groundwater from soluble forms of barium, which is not relevant to barium sulfate and not relevant to the form of barium found here or at oil field sites in general. In fact, the 82 mg/kg suggested by Maest et al. as the "correctly-applied U.S. EPA standard for barium" makes no sense. It is below natural barium levels in soils (see ORNL 2006); such a criterion would result in most soil on earth being considered dangerous.

Conclusions

Based on our review of Chevron's Sampling and Analysis Program, we have found it to be well designed and executed to meet the stated goals (i.e., assess remediation compliance and risks to human health at the time of the Judicial Inspection) and certainly consistent with international practice. Additionally, we have found that the program is one that was jointly developed and carried out with full involvement by the Plaintiffs and mutual oversight. Our review of Maest et al.'s criticism of Chevron's sampling and analysis has found that their serious allegations are baseless. Thus, Chevron's Sampling and Analysis Program appears adequate for the agreed-upon purposes of the Judicial Inspection process. It appears Maest et al. did not do a complete review of the program and that they were apparently not fully aware of international practices and standards as applied to oil field cleanup.

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The **Chevron Environmental Database** was provided to us. It is our understanding that all available analytical data from the Judicial Inspections, generated both by Chevron and Plaintiffs', is included in this database.