SOAH DOCKET NO. 582-08-2186
TCEQ DOCKET NO. 2006-0612-MSW

IN THE MATTER OF THE APPLICATION OF WASTE MANAGEMENT OF TEXAS, INC., FOR A MUNICIPAL SOLID WASTE PERMIT AMENDMENT PERMIT NO. MSW-249D	§ § § § § §	**BEFORE THE STATE OFFICE OF ADMINISTRATIVE HEARINGS**

PREFILED DIRECT TESTIMONY

OF

MATTHEW M. ULIANA, PH.D., P.G.

ON BEHALF OF TJFA, L.P.

FEBRUARY 13, 2009

EXHIBIT TJFA 300

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I. INTRODUCTION AND QUALIFICATIONS

Q. PLEASE STATE YOUR NAME.

A. My name is Matthew M. Uliana.

Q. PLEASE STATE YOUR BUSINESS ADDRESS AND TELEPHONE NUMBER.

A. My business mailing address is Martin Geologic Consulting, P.O. Box 81883, Austin, Texas, 78708. My office address is Martin Geologic Consulting, 505 East Huntland Drive, Suite 250, Austin, Texas, 78752. My telephone number is (512) 791-9076.

Q. WHAT IS YOUR OCCUPATION?

A. I am a geologist specializing in hydrogeology, water resources, and general geology. I provide consulting services in geology and ground water-related projects, including water resource assessments, water quality studies, contamination assessments, and ground water modeling

Q. WHAT IS YOUR EDUCATIONAL BACKGROUND?

A. In 1991, I obtained a Bachelor of Science in Geology/Anthropology from James Madison University in Harrisonburg, Virginia. I obtained a Master of Arts (1995) and a Ph.D. (2000) from the University of Texas at Austin, both in Geological Sciences (Hydrogeology).

Q. HOW ARE YOU CURRENTLY EMPLOYED?

A. I am the owner of Martin Geologic Consulting, a general partnership that I share with my wife.

Q. WHAT IS YOUR POSITION WITH MARTIN GEOLOGIC CONSULTING?

A. I am the owner and principal hydrogeologist of Martin Geologic Consulting.

Q. WHAT KINDS OF WORK DOES MARTIN GEOLOGIC CONSULTING PERFORM?

A. We provide consulting in hydrogeology, geology, and water resources, specializing in ground water-related projects, including resource assessments, water quality studies, contamination assessment, and ground water modeling.

Q. HOW LONG HAVE YOU BEEN IN BUSINESS AS MARTIN GEOLOGIC CONSULTING?

A. Since January 2007.

Q. PLEASE OUTLINE YOUR WORK HISTORY PRIOR TO THE FORMATION OF MARTIN GEOLOGIC CONSULTING?

A. In 1991 and 1992, I worked as a Project Geologist with Geotechnical and Environmental Services in Mt. Sydney, Virginia, where I performed ground water-related field studies. My responsibilities included monitoring well design and installation, ground water sampling, aquifer testing, report preparation, and project management. Our projects were primarily related to assessments of ground water contamination resulting from old underground petroleum storage tanks. From 1995 through 2001, I was a Consulting Hydrogeologist and Staff Scientist with the R. J. Brandes Company, Terra Dynamics, Inc., and Robert S. Kier Consulting, all in Austin, Texas. The three companies shared office space, and I provided technical assistance to each of them in various ground water and surface water related projects that included the preparation, use, and review of computer ground water models; analysis of geochemical data and assessment of ground water quality and ground water contamination; analysis of aquifer testing data and calculation of aquifer parameters; ground water resource evaluations; development of input parameters for surface water resource models; and litigation support related to ground water contamination. From 2002 through 2006, I was an independent consulting professional geologist in Austin, Texas. During that time, I managed or provided technical support for various projects that included the preparation, use, and review of computer ground water models; analysis of geochemical data and assessment of ground water quality and ground water contamination; analysis of aquifer testing data and calculation of aquifer parameters; ground water resource evaluations; and environmental assessments for proposed building sites.

Q. HAVE YOU TAUGHT ANY ACADEMIC COURSES?

A. Yes, I have nine (9) semesters of service as a tenure-track assistant professor. In 2001 and 2002, I was an Assistant Professor in the Department of Geological Sciences at the State University of New York at New Paltz. From 2002 through 2006, I was an Assistant Professor in the Geology Program and Aquatic Resources (Department of Geology) at Texas State University-San Marcos. I taught courses on general geology, applied geology, hydrogeology and water resources, and structural geology. In addition, I have eight (8) semesters of service as a teaching assistant in the Department of Geological Sciences at the University of Texas at Austin. At UT-Austin, I taught laboratory sections for introductory geology courses, hydrogeology courses, and field methods courses.

Q. HAVE YOU AUTHORED ANY PUBLICATIONS?

A. Yes, I have authored or co-authored twelve (12) publications addressing my areas of research. I am the lead or sole author on three peer-reviewed journal articles; I am a junior author on one peer-reviewed publication and three papers in edited monographs; I have authored three entries in the Wiley Encyclopedia of Water; and I have authored two articles for published conference proceedings. All of these publications are related to hydrogeology and ground water chemistry. I have also presented research results and published nineteen (19) abstracts at national and regional science conferences.

Q. DO YOU HAVE A PARTICULAR SPECIALTY?

A. My general specialty is in physical hydrogeology, which is the study and characterization of the movement of fluids in the subsurface. My specific expertise is in analytical calculations and computer modeling related to ground water flow systems, characterization of the movement of contaminants and naturally-occurring chemicals in ground water, computer modeling of geochemical reactions, ground water availability studies, and fluid flow in fractured systems.

Q. DO YOU HOLD ANY LICENSES, REGISTRATIONS, OR CERTIFICATIONS?

A. Yes. I am a licensed Professional Geoscientist (Geology) in the State of Texas, License No. 2506.

Q. ARE YOU A HYDROGEOLOGIST?

A. Yes, that is one of the main specialties or sub-disciplines of geology in which I practice.

Q WHAT IS A HYDROGEOLOGIST?

A. A hydrogeologist is a scientist that studies and characterizes the movement of fluids in the subsurface. A hydrogeologist generally has an academic background in either geology or engineering, and has received additional academic training in mathematics, physics, and chemistry. A hydrogeologist understands the basic physics and mathematics of the movement of fluids through a porous medium, and also understands the various geologic settings in which those fluids occur.

Q. BASED ON YOUR EDUCATION AND RELATED WORK EXPERIENCE, ARE YOU RECOGNIZED AS A "QUALIFIED GROUNDWATER SCIENTIST" AS THAT TERM IS USED IN BOTH FEDERAL AND STATE ENVIRONMENTAL REGULATIONS?

A. Yes. I am recognized as a "qualified groundwater scientist," as that term is used by the U.S. Environmental Protection Agency ("EPA") and the Texas Commission on Environmental Quality ("TCEQ" or the "Commission"), and predecessor agencies. For reference purposes, the term "qualified groundwater scientist" is defined by TCEQ at 30 TEX. ADMIN. CODE § 330.3(120) as:

> a licensed geoscientist or licensed engineer who has received a baccalaureate or post-graduate degree in the natural sciences or engineering and has sufficient training in ground water hydrology and related fields as may be demonstrated by state registration, professional certifications, or completion of accredited university programs that enable the individual to make sound professional judgments regarding ground water monitoring, contaminant fate and transport, and corrective action.

Q. DO YOU HAVE EXPERIENCE EVALUATING MUNICIPAL SOLID WASTE ("MSW") LANDFILL PERMIT APPLICATIONS?

A. Yes.

Q. HOW MANY MSW LANDFILL PERMIT APPLICATIONS HAVE YOU EVALUATED?

A. In addition to the review that I have conducted related to the application that is the subject of this proceeding, I have also reviewed data from the BFI Waste Industries of North America, Inc.'s ("BFI") Sunset Farms Landfill. That review was conducted as part of a challenge of the pending amendment application to expand the BFI Sunset Farms Landfill.

Q. BY WHOM ARE YOU RETAINED FOR YOUR REVIEW AND EVALUATION OF WASTE MANAGEMENT OF TEXAS'S ("WMTX" OR "APPLICANT") AMENDMENT APPLICATION (THE "ACL AMENDMENT APPLICATION") TO EXPAND THE AUSTIN COMMUNITY RECYCLING AND DISPOSAL FACILITY, ALSO KNOWN AS THE AUSTIN COMMUNITY LANDFILL ("ACL"), *i.e.*, THE SUBJECT OF THIS PROCEEDING?

A. I have been retained by TJFA, L.P. ("TJFA"), a protestant in this proceeding, to provide expert opinions with respect to the hydrogeology and ground water chemistry of the ACL.

Q. DO YOU HAVE EXPERIENCE INVOLVING THE GEOLOGIC SETTING IN WHICH THE ACL IS LOCATED OR IN SIMILAR GEOLOGIC SETTINGS?

A. Yes. The ACL is located in the "Taylor Formation, which is commonly referred to as the Taylor Clay, the Taylor Marl, the Ozan Formation or the "lower Taylor Marl," in different parts of Texas. I have reviewed ground water chemistry data obtained from the adjacent BFI Sunset Farms Landfill, and I have reviewed ground water chemistry data obtained from the Applied Materials site, both of which are also located in the Taylor.

Q. WERE ANY OF THESE PROJECTS MSW FACILITIES?

A. Yes. The Sunset Farms Landfill is a MSW landfill facility.

Q. DO YOU HAVE A RÉSUMÉ THAT SUMMARIZES YOUR EDUCATIONAL AND WORK EXPERIENCE?

A. Yes.

Q. IS YOUR RÉSUMÉ A COMPLETE AND UP-TO-DATE SUMMARY OF YOUR EDUCATIONAL AND WORK EXPERIENCE?

A. No, it is current as of September 2007. Furthermore, not all of my experience is identified, but the résumé does provide a good summary of my education, work experience, and professional societies to which I belong.

Q. PLEASE IDENTIFY WHAT HAS BEEN MARKED AS EXHIBIT TJFA 301?

A. Exhibit TJFA 301 is a copy of my résumé, providing a summary of my education, work experience, and membership in professional societies.

Q. IS EXHIBIT TJFA 301 A TRUE AND ACCURATE COPY OF YOUR RÉSUMÉ?

A. Yes.

Q. IS EXHIBIT TJFA 301 AN ACCURATE REFLECTION OF YOUR EDUCATION, PROFESSIONAL HISTORY, AND QUALIFICATIONS?

A. Yes.

[MOVE TO ADMIT EXHIBIT TJFA 301]

II. BACKGROUND AND OVERVIEW OF ACL AMENDMENT APPLICATION

Q. ARE YOU FAMILIAR WITH TCEQ'S RULES CONCERNING THE PERMITTING OF MSW LANDFILLS IN TEXAS—30 TEX. ADMIN. CODE CHAPTER 330—AS SUCH RULES WERE AMENDED AND BECAME EFFECTIVE IN MARCH 2006, i.e., THE "NEW" MSW RULES?

A. Yes, particularly those portions of the rules that address subsurface investigations and ground water monitoring

Q. IS IT YOUR UNDERSTANDING THAT THE "NEW" MSW RULES, THOSE MSW RULES THAT WENT INTO EFFECT IN MARCH 2006, WILL APPLY IN THIS PROCEEDING?

A. Yes.

Q. SO, DO YOU AGREE THAT ANY DISCUSSION OF APPLICABLE TCEQ MSW RULES IN THIS PROCEEDING WILL REFER DIRECTLY TO THE "NEW" MSW RULES THAT WENT INTO EFFECT IN MARCH 2006?

A. Yes.

Q. ARE YOU FAMILIAR WITH THE ACL AMENDMENT APPLICATION?

A. Yes. I have reviewed the version of the ACL Amendment Application identified as WMTX's Exhibit APP-202, a six-volume application identified as "Revision 10 – May 2008." My review focused on Attachments 4 and 5, of Part III of the ACL Amendment Application, the Geology Report and the Groundwater Characterization and Monitoring Report.

Q. DID YOU REVIEW ANY OTHER MATERIALS OR DOCUMENTS IN THE COURSE OF YOUR REVIEW OF THE ACL AMENDMENT APPLICATION?

A. Yes.

Q. PLEASE IDENTIFY AND DESCRIBE ANY ADDITIONAL MATERIALS OR DOCUMENTS YOU REVIEWED IN ADDITION TO THE ACL AMENDMENT APPLICATION IN THE COURSE OF YOUR ANALYSIS.

A. I have reviewed many materials produced by WMTX during the discovery process, and I have also reviewed applicable state and federal rules, technical guidance, and relevant published documents. I have reviewed and evaluated a number of documents available in the public record for the ACL concerning ground water monitoring systems and results, subsurface investigations and reports, and correspondence. In particular, I have evaluated the results of ground water monitoring and the subsurface investigations performed.

III. GROUND WATER CHEMISTRY

Q. PLEASE DESCRIBE THE FOCUS OF YOUR REVIEW AND EVALUATION AS RELATED TO THE ACL AMENDMENT APPLICATION.

A. I reviewed historical ground water data, including water levels and the results of chemical analyses of ground water samples.

Q. TO WHAT ARE YOU REFERRING WHEN YOU SAY THAT YOU HAVE "REVIEWED HISTORICAL GROUND WATER DATA, INCLUDING WATER LEVELS AND THE RESULTS OF CHEMICAL ANALYSES OF GROUND WATER SAMPLES"?

A. First "ground water" refers to water below the surface existing in the pores and cracks in soil, sediment, and rock. Ground water samples are taken from, and water levels are measured in, monitoring wells located at a landfill facility. Taken together, the water levels, as measured in the ground water monitoring wells, are a general indication of the direction of fluid movement below ground, such that water moves from higher levels to lower levels. I reviewed water level data from the ACL facility in order to identify the directions of fluid movement into, around, and out of the ACL. I also reviewed the results of the chemical analyses of ground water samples taken from ground water monitoring wells at the ACL in order to evaluate the water quality at the ACL and to determine if there is evidence of past releases of contamination from the ACL.

Q. WHAT WAS THE SOURCE OF THE DATA YOU REVIEWED?

A. I reviewed publicly-available ground water monitoring data submitted by WMTX to TCEQ or its predecessor agencies pursuant to its MSW landfill permit. The monitoring data is submitted to TCEQ or the predecessor agencies to report the results of required ground water sampling events at the ACL. Most of the data I reviewed was obtained from TCEQ files over time, but some was produced by WMTX during discovery in this proceeding.

Q. FROM WHAT YEARS WERE THE DATA?

A. The data I reviewed were from sampling events from 1985 through 2006.

Q. DID YOU REVIEW DATA FROM ALL OF THE GROUND WATER MONITORING WELLS AT THE ACL FACILITY?

A. Yes. While not all of the ground water monitoring wells were active and/or sampled during every sampling event, I did review all of the ground water monitoring data for the sampling events for which there were publicly available ground water monitoring data/reports.

Q. FROM HOW MANY GROUND WATER MONITORING WELLS DID YOU HAVE DATA?

A. I evaluated data from a total of thirty-four (34) wells. Again, there was not monitoring data from each of those ground water monitoring wells for every sampling event through the years.

Q. WHY IS THAT?

A. Over time, WMTX replaced ground water monitoring wells, stopped using certain ground water monitoring wells, and added new ground water monitoring wells.

Q. DO YOU HAVE A FIGURE OR A MAP THAT SHOWS THE LOCATIONS OF ALL OF THE DIFFERENT GROUND WATER MONITORING WELLS THAT YOU ARE DISCUSSING TODAY?

A Yes. The map that I would like to refer to is from the ACL Amendment Application. Specifically, it is Figure ATT4-9 from Part III, Attachment 4, Geology Report of the ACL Amendment Application. (*See* APP-202 at 1473.) Figure ATT4-9 is included with my testimony, as an Attachment, for convenience.

Q. FOR YOUR PURPOSES, WHAT IS SHOWN ON FIGURE ATT4-9?

A. The information that I am interested in, as shown on Figure ATT4-9, are the locations of the abandoned monitoring wells, the existing monitoring wells, and the existing piezometers.

Q. WHAT ELSE DID YOU DO AS PART OF YOUR EVALUATION?

A. I also reviewed the ion chemistry, which is the concentrations of dissolved elements such as calcium, sodium, chloride, iron, magnesium, manganese, potassium, fluoride, the carbonate and bicarbonate ions, and the sulfate ion. In addition, I reviewed data on trace metal concentrations, including arsenic, barium, cadmium, mercury, selenium, and zinc, and I reviewed data on the concentrations of total organic carbon (TOC), total organic halogens (TOX), and the concentrations of dissolved organic chemicals that may potentially represent contamination from the ACL.

Q. WHY IS AN EVALUATION OF GROUND WATER CHEMISTRY IMPORTANT FOR THE REVIEW OF AN APPLICATION FOR A MSW PERMIT?

A. There are two aspects of ground water chemistry that need to be considered in evaluating an application for a MSW permit. The first aspect of ground water chemistry that needs to be considered, and probably the most obvious, is the ground water chemistry resulting from contamination by human impacts, such as releases of leachate from a landfill. This is important because the goal of interring waste in a landfill is to isolate it from the natural environment and keep any harmful chemicals from impacting natural waters and adversely affecting human health and natural biological systems. This is a particularly relevant review for an amendment application where the applicant seeks to expand an existing landfill. The second aspect of ground water chemistry that needs to be considered is the naturally-occurring ground water chemistry, which includes the dissolved ions and chemicals in the ground water that occur from natural processes.

The two aspects affect each other. The release of contaminants can often result in changes in the concentrations of various ions, such that changes in the ground water chemistry can serve as indicators of contamination. Therefore, the natural ground water chemistry cannot be ignored when investigating ground water contamination.

Q. WHAT ARE "DISSOLVED IONS"?

A. A dissolved ion is an atom of an element or a molecule comprising several different elements that has been dissolved by a solution, such as in water, and in its dissolved state it has either a positive or a negative charge. For example, the mineral halite (rock salt) is an arrangement of sodium (Na) and chlorine (Cl) atoms bonded together into a solid. If a piece of halite is dissolved into water, the Na and Cl atoms separate from the solid mass, and in the process each dissolved atom has either a positive charge (in the case of sodium) or a negative charge (in the case of chloride).

Q. ARE THERE SPECIFIC DISSOLVED IONS THAT YOU EXPECT TO SEE IN A GROUND WATER SAMPLE?

A. Yes, in a typical ground water sample, the overwhelming majority of the dissolved ions, usually 95-98% by weight, will be some combination of calcium, sodium, magnesium, chloride, sulfate, and bicarbonate. These ions are frequently found in concentrations greater than ten (10) milligrams per liter (mg/L). Hydrogeologists and geochemists refer to these ions as the "major ions." The proportions of each of these ions in a ground water sample are controlled by the minerals that the ground water encounters in the subsurface and the solubility of those ions, that is the maximum concentration that can occur at a given temperature, pH (hydrogen ion concentration or degree of acidity) and Eh (also known as the oxidation-reduction potential). Other ions that are common in natural ground water samples, but rarely occur at concentrations greater than a few milligrams per liter, are called “minor ions”. These include iron, potassium, manganese, and fluoride.

Q. WITH REGARD TO MAJOR ION CHEMISTRY IN GROUND WATER SAMPLES, WHAT WOULD YOU EXPECT TO SEE FOR A SITE LIKE THE ACL?

A. Due to the relatively small size of the ACL site and the relatively homogenous nature of the surface and subsurface geology, I would expect to see trends in the natural ground water chemistry in the ground water samples that are consistent with the soils, sediments, and rocks present in the subsurface at the ACL.

Q. WHAT DOES “TRENDS” MEAN, AS YOU USED IT ABOVE?

A. ”Trends” in this case refers to the variations in the concentrations and relative proportions of the various ions in the ground water throughout the ACL site. The concentrations and proportions of the dissolved ions in the ground water should vary from one well to another; however, that variation should not be random and it should fall within a certain expected range, and those variations should be predictable in some way.

Q. WHAT DO YOU MEAN WHEN YOU SAY “HOMOGENOUS NATURE OF THE SURFACE AND SUBSURFACE GEOLOGY”?

A. The soils and the bedrock found throughout the site of the ACL facility do not vary all that much from place to place. The soils are primarily Taylor clay, and the bedrock is very fine-grained rock called marl, which is a rock composed predominantly of calcarious clay.

Q. AND WHAT DO YOU MEAN WHEN YOU SAY "TRENDS IN THE NATURAL GROUND WATER CHEMISTRY . . . THAT ARE CONSISTENT WITH THE SOILS, SEDIMENTS, AND ROCKS PRESENT IN THE SUBSURFACE AT THE ACL"?

A. The natural ground water chemistry is controlled by interactions with the minerals in the soils, sediments, and rock through which the ground water flows. If the soils, sediments, and rock do not vary from one place to another, I would expect to see trends in the concentrations of ions and in the ratios of related ions that are consistent with the soils, sediments, and rocks present in the subsurface and the general directions of fluid movement in the subsurface.

Q. IN YOUR EVALUATION OF THE ACL AMENDMENT APPLICATION AND THE ACL SITE, DID YOU FIND TRENDS IN THE NATURAL GROUND WATER CHEMISTRY THAT ARE CONSISTENT WITH THE SOILS, SEDIMENTS, AND ROCKS PRESENT IN THE SUBSURFACE AT THE ACL SITE?

A. I found trends in the concentrations of several ions in the ground water samples that are <u>not</u> consistent with what I would expect from the types of soils, sediments, and rocks present at the ACL.

Q. SINCE YOU HAVE IDENTIFIED THAT YOU FOUND TRENDS THAT WERE NOT CONSISTENT WITH WHAT YOU WOULD EXPECT TO FIND AT THE ACL. PLEASE EXPLAIN WHAT YOU WOULD EXPECT TO FIND.

A. If the ground water at the ACL is not affected by releases of contamination, I would expect to see chloride/sodium (Cl/Na) ratios that approach one (1) with increasing chloride concentrations. I would also expect to see calcium/sulfate (Ca/SO_4) ratios increasing in a consistent trend with increasing calcium concentrations. In addition, I would expect to see low concentrations of dissolved iron in the ground water, and I would expect to see consistent and relatively low total organic carbon concentrations throughout the site. I would not expect to see any organic halogens dissolved in the ground water.

Q. WHAT TRENDS DID YOU FIND THAT WERE <u>NOT</u> CONSISTENT WITH WHAT YOU WOULD EXPECT TO FIND AT THE ACL?

A. I found trends that were not consistent with what I would expect to find at the ACL related to: (1) chloride and sodium concentrations and ratios; (2) calcium and sulfate concentrations and ratios; (3) iron content; (4) total organic carbon (TOC); and (5) total organic halogen (TOX). Each of these trends will be discussed below.

A. <u>Chloride and Sodium Concentrations and Ratios</u>

Q. WHAT DID YOUR EVALUATION FIND WITH REGARD TO CHLORIDE AND SODIUM CONCENTRATION AND RATIOS?

A. Based on my evaluation, the overall trend throughout the ACL site is that the chloride/sodium (Cl/Na) ratios are increasing with increasing chloride concentrations, such that the Cl/Na ratios are exceeding one (1) at higher chloride concentrations.

Q. PLEASE IDENTIFY WHAT HAS BEEN MARKED AS EXHIBIT TJFA 302.

A. Exhibit TJFA 302 is a graph that illustrates the Cl/Na ratios that I just described.

Q. WHAT DOES EXHIBIT TJFA 302 DEPICT?

A. Exhibit TJFA 302 graphically depicts the conclusions of my review regarding chloride and sodium concentrations and ratios—that the Cl/Na ratios are linearly increasing with increasing chloride concentrations above the Cl/Na ratio of one (1).

Q. DID YOU CREATE EXHIBIT TJFA 302?

A. Yes, I did.

Q. WHAT IS THE SOURCE OF THE INFORMATION DEPICTED ON EXHIBIT TJFA 302?

A. I created Exhibit TJFA 302 based on the ground water data that I have reviewed, as identified above.

Q. DOES EXHIBIT TJFA 302 ACCURATELY SUMMARIZE THE DATA YOU REVIEWED RELATING TO CHLORIDE AND SODIUM CONCENTRATIONS AND RATIOS?

A. Yes, it does.

Q. IS EXHIBIT TJFA 302 USEFUL IN YOUR TESTIMONY TODAY AND/OR IN ASSISTING THE ADMINISTRATIVE LAW JUDGE TO UNDERSTAND YOUR TESTIMONY TODAY, SPECIFICALLY AS IT RELATES TO CHLORIDE AND SODIUM CONCENTRATIONS AND RATIOS?

Q. Yes, it is.

[MOVE TO ADMIT EXHIBIT TJFA 302]

Q. WHAT DO INCREASING CHLORIDE CONCENTRATIONS INDICATE?

A. Increasing chloride concentrations are usually caused by the dissolution of halite (rock salt) or, over long time periods or distances, other minerals. In the area of the ACL site, where the monitoring wells are relatively close to the waste management unit, increasing chloride should be associated with the dissolution of halite crystals and the release of connate (*i.e.*, ancient) seawater trapped in the marine shales (*i.e.*, the Taylor Marl) or leachate from ordinary municipal solid waste ("MSW").

Q. BASED ON YOUR EVALUATION, DOES IT APPEAR THAT THE INCREASING CHLORIDE CONCENTRATIONS AT THE ACL SITE ARE ASSOCIATED WITH THE DISSOLUTION OF HALITE CRYSTALS AND THE RELEASE OF CONNATE SEAWATER OR LEACHATE FROM ORDINARY MSW?

A. No. Halite, which is ordinary table salt or salt used in food preparation, contains an equal number of chloride and sodium atoms; therefore, dissolution of halite would cause the Cl/Na ratios to approach a value of one (1) without exceeding one (1), even as the concentration of chloride ions increases. Most of the chemistry data from the ground water monitoring wells at the ACL follow a linear trend where the Cl/Na ratio exceeds a value of one (1).

Q. PLEASE EXPLAIN.

A. All samples from monitoring well MW06 at the ACL facility, and select samples from monitoring wells MW03, MW01A, MW02A, and MW20 at the ACL facility, have Cl/Na ratios greater than one (1). The linear trend and the samples with Cl/Na ratios exceeding one (1) indicate that some process at the ACL site is adding excess chloride ions to the ground water.

Q. WOULD YOU EXPECT THAT A RELEASE OF LEACHATE FROM THE MSW LANDFILL COULD RESULT IN THIS ADDITION OF EXCESS CHLORIDE IONS TO THE GROUND WATER?

A. No, even if there were a release of leachate from an ordinary MSW landfill in Texas, which regulates industrial waste differently from MSW and from hazardous waste, I would expect to see a chloride/sodium ratio remain near one, simply from the dissolution of salt in the food wastes. I would not expect the small amount of industrial waste routinely collected with MSW or conditionally exempt small quantity generator waste ("CESQGW") accepted at MSW landfills to make much of a difference.

Q. IN YOUR PROFESSIONAL OPINION, WHAT TYPE OF PROCESS AT THE ACL COULD BE ADDING EXCESS CHLORINE IONS TO THE GROUND WATER?

A. The excess chlorine ions could be added to the ground water at the ACL site through a process like degradation of chlorinated solvents (*e.g.*, trichloroethylene (TCE), perchloroethylene (PCE), or vinyl chloride).

Q. WHY DO YOU BELIEVE THAT THE DEGRADATION OF CHLORINATED SOLVENTS IS A PROCESS THAT COULD BE THE SOURCE ADDING EXCESS CHLORINE IONS TO THE GROUND WATER?

A Chlorinated solvents are organic chemicals that contain chloride ions, and the breaking down, or degradation, of these chemicals in the subsurface releases chloride ions to the ground water. This process results in elevated chloride concentrations and Cl/Na ratios in the groundwater.

Q. IS THIS PROCESS INVOLVING THE DEGRADATION OF CHLORINATED SOLVENTS ACCEPTED BY AUTHORITIES IN YOUR FIELD?

A. Yes. The following is a short list of references that deal with the effects of chlorinated solvent degradation on chloride concentrations:

- Bedient, Phillip B.; Rifai, Hanadi S.; and Newell, Charles J.; 1994. *Groundwater Contamination: Transport and Remediation.* New Jersey, Prentice Hall, 541 pp.
- Clement, T.P., Johnson, C.D., Sun, Y., Klecka, G.M., and Bartlett, C., 2000, "Simulation of natural attenuation at a chlorinated solvent contaminated site," *Journal of Contaminant Hydrology*, v. 42, p. 113–140.
- Fetter, C. W., 1993. *Contaminant Hydrogeology.* New York, Macmillan, 458 pp.
- Semprini, L., Kitanidis, P., Kampbell, D., Wilson, J., 1995. "Anaerobic transformation of chlorinated aliphatic hydrocarbons in a sand aquifer based on spatial chemical distribution." *Water Resour. Res.* 31, 1051–1062.
- Sun, Yunwei and Xinjian Lu, 2006. "A chloride transport model for identifying sequential bioreactive systems of chlorinated solvents," *Geosphere*, v. 2, no. 2, p. 83-87.

Q. WHAT EVIDENCE IS THERE THAT THE DEGRADATION OF CHLORINATED SOLVENTS COULD BE THE CAUSE OF THE EXCESS CHLORINE IONS IN THE GROUND WATER AT THE ACL?

A. I believe that degradation of chlorinated solvents must be considered for the ACL site because there is a record of hits for the following chlorinated solvents in monitoring wells MW05, MW06, MW13, MW21, and PZ-26: 1,1-dichloroethane, cis-1,2-dichloroethene, chloroform, methylene chloride, PCE, TCE, and vinyl chloride. Biologic mediated degradation of chlorinated solvents would be consistent with the anaerobic (reducing) conditions that develop in MSW landfills, given the abundance of methane that is commonly produced by decomposition of the waste in the landfill. Furthermore, as Dr. Kier has indicated in his testimony, there is a historical record of the disposal of solvents in bulk form or in drums at the ACL.

Q. DO ALL OF THE MONITORING WELLS AT THE ACL SITE FOLLOW THE SAME LINEAR TREND OF INCREASING Cl/Na RATIOS WITH INCREASING CHLORIDE CONCENTRATIONS?

A. Most ground water monitoring wells at the site of the ACL facility exhibit trends in chloride concentrations and Cl/Na ratios that are similar to the overall trend of a linear increase in Cl/Na ratio with increasing chloride concentration. Monitoring wells MW03 and MW06, the two monitoring wells that were installed nearest to what Dr. Kier has identified as the industrial waste unit ("IWU") at the ACL, do not exhibit the same linear chloride and Cl/Na ratio trend.

Q. HOW DO THE TRENDS IN MONITORING WELLS MW03 AND MW06 DIFFER FROM THE TRENDS IN OTHER WELLS?

A. Monitoring wells MW03 and MW06, which are located closest to the IWU, show a much greater variation in Cl/Na ratios and Cl/Na ratios ≥ 1. As shown on Exhibit TJFA 302, all MW06 samples plot above Cl/Na = 1, indicating that the Cl/Na ratios in samples from MW06 are distinctly different from the other samples at the ACL site.

Q. WHAT ARE YOUR CONCLUSIONS REGARDING CHLORIDE CONCENTRATIONS AND RATIOS?

A. The overall trends in chloride concentrations and Cl/Na ratios indicate that some process is adding excess chloride ions to the ground water. The samples from monitoring wells closest to the IWU at the ACL facility exhibit a large range of Cl/Na ratios, indicating that they are the most affected by this process. A potential source of excess chloride ions in the ground water is the degradation of chlorinated solvents. Chlorinated solvents have been detected in several wells at the ACL site, indicating that they are present at the ACL. In my professional opinion, the overall trend of Cl/Na ratios increasing above one (1) throughout the ACL site indicates that releases of chlorinated solvents from the IWU are affecting the entire site, and it indicates that the industrial and/or hazardous wastes interred in the IWU are not properly contained.

Q. YOU HAVE IDENTIFIED THAT YOU BELIEVE THE SOURCE OF THE CHLORINATED SOLVENTS IS FROM A RELEASE FROM THE IWU. COULD THERE BE OFFSITE SOURCES OF THE CHLORINATED SOLVENTS?

A. Based on my review of the ACL Amendment Application and other sources of information identifying the past and present land uses in the area of the ACL, I do not believe that there are other industrial sources in the vicinity of the ACL that could be the source of the chlorinated solvents.

B. Calcium and Sulfate Concentrations and Ratios

Q. WHAT DID YOUR EVALUATION FIND WITH REGARD TO CALCIUM AND SULFATE CONCENTRATIONS AND RATIOS?

A. The majority of the samples at the ACL site fall on a trend of increasing calcium concentration with a stable calcium/sulfate (Ca/SO_4) ratio. This trend is consistent with the expected geochemical evolution of ground water in contact with the calcareous marl in the Taylor formation in which gypsum, $CaSO_4$ is a common, and highly soluble constituent.

Q. PLEASE IDENTIFY WHAT HAS BEEN MARKED AS EXHIBIT TJFA 303.

A. Exhibit TJFA 303 is a graph that illustrates the trend of increasing calcium concentrations with relatively constant Ca/SO_4 ratio that I just described.

Q. WHAT DOES EXHIBIT TJFA 303 DEPICT?

A. Exhibit TJFA 303 graphically depicts the conclusions of my review regarding calcium and sulfate concentrations and ratios—that there is a trend of increasing calcium concentrations with relatively consistent Ca/SO_4 ratios.

Q. DID YOU CREATE EXHIBIT TJFA 303?

A. Yes, I did.

Q. WHAT IS THE SOURCE OF THE INFORMATION DEPICTED ON EXHIBIT TJFA 303?

A. I created Exhibit TJFA 303 based on the ground water data that I have reviewed, as identified above.

Q. DOES EXHIBIT TJFA 303 ACCURATELY SUMMARIZE THE DATA YOU REVIEWED RELATING TO CALCIUM AND SULFATE CONCENTRATIONS AND RATIOS?

A. Yes, it does.

Q. IS EXHIBIT TJFA 303 USEFUL IN YOUR TESTIMONY TODAY AND/OR IN ASSISTING THE ADMINISTRATIVE LAW JUDGE TO UNDERSTAND YOUR TESTIMONY TODAY, SPECIFICALLY AS IT RELATES TO CALCIUM AND SULFATE CONCENTRATIONS AND RATIOS?

A. Yes, it is.

[MOVE TO ADMIT EXHIBIT TJFA 303]

Q. YOU STATED THAT THE MAJORITY OF THE SAMPLES AT THE ACL SITE FALL ON THE DESCRIBED TREND. DID OTHER SAMPLES DEVIATE FROM THE TREND YOU DESCRIBED?

A. Samples from several wells deviated from this trend. All samples from monitoring wells MW03 and MW06 at the ACL plot in the region of excess calcium, that is with a Ca/SO_4 ratio greater than 1. Some samples from monitoring wells MW11, MW12, MW21, PZ-29, and PZ-32 at the ACL also plot above the trend in the region of excess calcium.

Q. WHAT DO THESE DEVIATIONS INDICATE?

A. These deviations indicate that those monitoring wells at the ACL site (*i.e.*, MW03, MW06, MW11, MW12, MW21, PZ-29, and PZ-32) are influenced by some other geochemical process at the site.

Q. IN YOUR PROFESSIONAL OPINION, WHAT TYPE OF PROCESS AT THE ACL COULD BE CAUSING THESE DEVIATIONS?

A. A potential process that could result in these deviations is the presence of sulfate-reducing bacteria.

Q. WHAT ARE "SULFATE-REDUCING BACTERIA"?

A. Sulfate-reducing bacteria are anaerobic organisms that essentially use sulfate as an electron donor, similar to the way aerobic organisms use oxygen, and reduce the sulfate to sulfide, which then commonly combines with hydrogen to form hydrogen sulfide (H_2S). Sulfate reducing bacteria exist in environments devoid of available oxygen, such as within a landfill or where there is an abundance of organic compounds, and the bacteria are typically involved in the degradation of wastes and chemicals in landfills in addition organic compounds.

Q. WHAT IS THE RESULT OF THE SULFATE-REDUCING BACTERIA PROCESS?

A. The process results in a reduction of sulfate concentrations without a corresponding change in calcium concentrations, and on a graph of calcium versus Ca/SO_4 would "push" the samples into the region of excess calcium.

Q. WHAT ARE YOUR CONCLUSIONS REGARDING CALCIUM AND SULFATE CONCENTRATIONS?

A. Calcium and sulfate concentrations and ratios indicate that sulfate-reducing bacteria at the ACL are consuming sulfate in the ground water and elevating the Ca/SO_4 ratios in many of the ground water samples. The samples from monitoring wells closest to the IWU are the most affected by this process. Samples from other wells near the IWU, including MW11, MW12, and MW21, are also affected. In my professional opinion, this indicates that leachate and/or organic compounds disposed at the IWU at the ACL are affected by sulfate-reducing bacteria and are being released from the ACL.

Q. YOU HAVE IDENTIFIED THAT YOU BELIEVE THE ACL IS THE SOURCE OF THE SULFATE-REDUCING BACTERIA. COULD THERE BE OFFSITE SOURCE OF THE SULFATE-REDUCING BACTERIA?

A. Although sulfate reducing bacteria are fairly common, their abundance is usually limited by a lack of an energy source. Based on my review of the ACL Amendment Application and other sources of information identifying the past and present land uses in the area of the ACL, I do not believe that there are other locations in the vicinity of the ACL that could be the origin of the levels of sulfate-reducing bacteria suggested by the changes in $CaSO_4$ ratios at the ACL. Furthermore, since the monitoring wells closest to the IWU are the most affected, this suggests that releases of leachate and/or organic compounds play a large role in the inferred abundance of sulfate reducing bacteria and the high Ca/SO_4 ratios.

C. <u>Iron Content</u>

Q. WHAT DID YOUR EVALUATION FIND WITH REGARD TO IRON CONTENT?

A. Site-wide at the ACL there are results from 432 analyses for iron concentrations. Three hundred two (302) of these analyses detected dissolved iron in the samples. Most of the results (261 results) are less than 5 mg/L.

Q. ARE THESE TYPES OF RESULTS WHAT YOU WOULD EXPECT TO FIND AT A SITE LIKE THE ACL?

A. Yes. Ground water within eighty (80) feet of the ground surface, as found at the ACL site, generally contains some dissolved oxygen and is known as an "oxidizing environment." In an oxidizing environment, iron is not very soluble; therefore, most iron present in the environment would be in a mineral form rather than a dissolved form, and low concentrations of dissolved iron are expected.

Q. DID ALL OF THE ANALYSES FOR IRON CONCENTRATION FALL INTO THIS GROUP THAT YOU DESCRIBED ABOVE?

A. No, I identified high iron content in monitoring well MW06.

Q. PLEASE DESCRIBE WHAT YOU FOUND IN THE SAMPLES FROM MONITORING WELL MW06.

A. Concentrations in all but one (1) of the forty-one (41) samples from monitoring well MW06 range from 10 mg/L to 90 mg/L, with thirty-five (35) samples greater than 50 mg/L.

Q. WHAT DOES THIS INDICATE WITH REGARD TO MONITORING WELL MW06?

A. In my professional opinion, it is indicative of a reducing environment in the close vicinity of the IWU. I say in the close vicinity of the IWU because monitoring well MW06 is one of the monitoring wells located closest to the IWU.

Q. WHAT DO YOU MEAN BY A "REDUCING ENVIRONMENT"?

A. A reducing environment is essentially the opposite of an oxidizing environment. In the simplest terms, it means that there is no oxygen available and the iron present can be in a reduced state, which is more soluble than in an oxidized state. In a reducing environment, therefore, one would expect to see much more dissolved iron. Reducing conditions are consistent with sulfate reduction and excess calcium, which in turn are consistent with the presence of sulfate reducing bacteria, hydrogen sulfide, and organic compounds.

Q. HAVE YOU IDENTIFIED OTHER ISSUES RELATED TO THE HIGH LEVELS OF IRON CONTENT?

A. Yes. With TCEQ concurrence, WMTX has ceased sampling for major ions and iron in the two ground water monitoring wells nearest the IWU. The last samples from monitoring wells MW03 and MW06 that were analyzed for major ions and iron were taken on September 12, 1995. The last samples from monitoring wells MW03 and MW06 were taken on February 25, 1999; however, these samples were not analyzed for iron or other major ions, including chloride, sodium, calcium, or sulfate. It should also be noted that the February 25, 1999, sampling at monitoring wells MW03 and MW06 was an isolated sampling event. Monitoring wells MW03 and MW06 were last monitored regularly on July 22, 1994.

Q. ARE THERE OTHER MONITORING WELLS IN THE VICINITY OF MONITORING WELLS MW03 AND MW06 AND THE IWU?

A. Yes, piezometer PZ-25 was installed next to MW03 near the IWU in 1994; however, only one sample was taken from PZ-25 (on February 25, 1999), and this sample was not analyzed for iron or other major ions, including chloride, sodium, calcium, or sulfate. Monitoring well MW29A and piezometer PZ-26 were installed near MW06 and the IWU. Between February 25, 1999, and April 19, 2006, monitoring well MW29A was sampled thirteen (13) times, while PZ-26 was sampled fifteen (15) times. None of these samples included analyses for iron or other major ions, including chloride, sodium, calcium, or sulfate.

Q. WHAT ARE YOUR CONCLUSIONS REGARDING IRON CONTENT?

A. High dissolved iron concentrations near the IWU indicate the presence of a reducing environment in the ground water in that area. This is consistent with the presence of sulfate-reducing bacteria and organic contamination, as indicated by the Ca/SO_4 ratios. Ground water near the surface, such as that found at the ACL site, should contain dissolved oxygen and be in oxidizing conditions. In my professional opinion, the presence of a reducing environment at the ACL site indicates that the degradation of wastes and waste constituents at the ACL adversely affects the ground water around the ACL. I believe this is an indication that the ACL is not adequately containing wastes and waste constituents and that releases from the landfill are contaminating the shallow groundwater.

D. Total Organic Carbon

Q. WHAT DID YOUR EVALUATION FIND WITH REGARD TO TOTAL ORGANIC CARBON (TOC)?

A. I identified high TOC concentrations in monitoring wells MW02, MW03, MW06, and PZ-32.

Q. WHAT DO YOU CONSIDER A HIGH TOC CONCENTRATION?

A. High TOC concentrations are those concentrations close to or above 10 mg/L.

Q. PLEASE EXPLAIN YOUR FINDINGS WITH REGARD TO TOC AT THE ACL FACILITY.

A. The following summarizes the concentrations identified in the monitoring wells I enumerate above:

- MW02A – four (4) values between 81 mg/L and 90 mg/L from samples taken in 1992.
- MW03 – values greater than 10 mg/L between April 1987 and November 1988, including a high concentration of 93.2 mg/L in February 1988.
    - PZ-25 was installed in 1994 approximately twenty-five (25) feet from MW03; however, only one sample from PZ-25 (taken in February 1999) was analyzed for TOC.
- MW06 – 15 mg/L in January 1985 with increasing trend in TOC content through September 1995. Very high concentrations (190 mg/L to 200 mg/L) were observed in November 1987, (approximately three (3) months before the high values were recorded in MW03). No later samples were analyzed for TOC.
    - PZ-26 was installed in 1994 approximately 175 feet from MW06; however, only one sample from PZ-26 (taken in February 1999) was analyzed for TOC despite the fact that the well was sampled several times through April 2006.
    - MW29A was installed in 2000 approximately one hundred (100) feet from MW06; however, no samples from this well were

analyzed for TOC despite the fact that it was sampled numerous times between March 2000 and April 2006.

- PZ-32 – Values greater than 15 mg/L were observed on October 1, 2003 (35 mg/L) and May 12, 2006 (16 mg/L). No samples were taken before or between those measurements.

Q. WHY ARE THE OBSERVATIONS OF HIGH CONCENTRATIONS OF TOC IMPORTANT?

A. High TOC concentrations are a potential indicator of releases of organic contaminants from the ACL.

Q. WHAT DO YOU MEAN BY "RELEASES OF ORGANIC CONTAMINANTS"?

A. As previously stated, the purpose of interring waste in a landfill is to isolate the waste from the natural environment so that harmful chemicals, such as chlorinated solvents, cannot affect human health and natural biological systems. When a landfill fails to contain the harmful chemicals within it, scientists refer to that as a "release" of chemicals or contamination. If ground water is affected, the ground water is said to be contaminated

Q. AND WHAT IS A CONSIDERED AN "ORGANIC CONTAMINANT"?

A. Organic compounds are any of those of a large class of compounds where the origin of carbon in the compound was originally thought to be organic, meaning living or formerly living source. According to the U.S. Environmental Protection Agency's ("EPA") glossary of environmental terms, a contaminant is any physical chemical, biological, or radiological substance or matter that has an adverse effect on air, water, or soil. An organic contaminant, therefore, is an organic chemical compound that has an adverse effect on air, water, or soil.

Q. WERE THE HIGH TOC CONCENTRATIONS ADDRESSED BY WMTX?

A. No. The high concentrations of TOC in wells MW02A, MW03, and MW06 have never been addressed, before or after WMTX plugged and abandoned monitoring well MW02A and stopped sampling monitoring wells MW03 and MW06. In addition, the other wells near the IWU (PZ-25, PZ-26, and MW29A) were only sampled for TOC once or, in the case of MW29A, not at all.

Q. WHAT ARE YOUR CONCLUSIONS REGARDING TOC?

A. High TOC concentrations in samples from ground water monitoring wells at the ACL are potential indicators of releases of contamination from the landfill. In my professional opinion, this is consistent with the indications of contamination releases from the Cl/Na ratios, the Ca/SO_4 ratios, and the high iron contents, and is additional evidence that the ACL is not properly containing the wastes that were interred there.

Q. ARE THERE POTENTIAL OFFSITE SOURCES THAT COULD BE CAUSING THE HIGH TOC CONCENTRATIONS?

A. Although the BFI Sunset Farms Landfill could be a potential source in portions of the ACL, it cannot be a source at MW03 and MW06, nor MW02. The only known sources of TOC, the old Diamond Shamrock gas station and the former Leif Johnson body shop along US 290 are down hydraulic gradient from the ACL facility; thus, these facilities cannot possibly be a the source of the elevated TOC concentrations at ACL.

E. <u>Total Organic Halogen</u>

Q. WHAT DID YOUR EVALUATION FIND WITH REGARD TO TOTAL ORGANIC HALOGEN (TOX)?

A. TOX, meaning total organic halogens—halogens being those in column seven of the periodic table, including chloride—was also observed in monitoring wells MW01A, MW02A, MW03, MW05, and MW06. Concentrations as high as 0.3 mg/L were observed in MW06. Concentrations as high as 0.13 mg/L were observed in MW02A.

Q. WHAT IS CONSIDERED A HIGH TOX CONCENTRATION?

A. In that halogenated organic compounds are all man-made, any concentration of TOX is of concern.

Q. WAS TOX ROUTINELY MONITORED AT THE ACL?

A. No. TOX was analyzed only between January 28, 1985, and January 23, 1986. No other TOX values were taken.

Q. WHY ARE THE OBSERVATIONS OF CONCENTRATIONS OF TOX IMPORTANT?

A. TOX is a measure of the total amount of chlorinated organic compounds in the soil and ground water. Finding TOX in ground water samples is most commonly an indication of the presence of chlorinated organic compounds, such as chlorinated solvents, in the ground water. These all are man-made compounds and do not naturally occur in the environment.

Q. WHAT DOES THE PRESENCE OF CHLORINATED ORGANIC COMPOUNDS INDICATE?

A. The most likely source for chlorinated organic compounds in the ground water around the ACL is the IWU. The presence of chlorinated organic compounds, therefore, would indicate contamination of the ground water by a release of those compounds from the IWU. As Dr. Kier testified, though, industrial wastes were accepted at the ACL after the IWU was supposed to be closed, at least as late as 1976. The disposition of those wastes is unknown, but likely they were placed either in what Dr. Kier has identified as the Phase 1 unit or in what is known as the East Hill.

Q. ARE THERE POTENTIAL OFFSITE SOURCES THAT COULD BE CAUSING THE HIGH TOX CONCENTRATIONS?

A. Based on my review of the ACL Amendment Application and the other sources identifying the past and present land uses in the area of the ACL, I do not believe that there are any offsite sources in the vicinity of the ACL that could causing the high TOX concentration.

Q. WHAT ARE YOUR CONCLUSIONS REGARDING TOX?

A. The presence of TOX at the ACL site in monitoring wells near the IWU, including monitoring wells MW03 and MW06, is an indication of releases of chlorinated organic compounds, such as chlorinated solvents, from the IWU. This is consistent with the indications of contamination releases from the Cl/Na ratios, the Ca/SO_4 ratios, the high iron contents, and the high TOC concentrations, and, in my professional opinion, is additional evidence that the ACL is not properly containing the wastes that were interred there.

IV. POTENTIAL MIGRATION OF CONTAMINATED GROUND WATER

Q. DO YOU HAVE REASON TO BELIEVE THAT THE CONTAMINATED GROUND WATER THAT YOU HAVE DISCUSSED ABOVE MAY BE MOVING THROUGH THE ACL SITE?

A. Yes. I believe that contaminated ground water may be moving through the weathered Taylor at the ACL site, primarily in fractures, and thus moving throughout the site and even offsite.

Q. WHAT DO YOU MEAN BY "FRACTURES" AT THE ACL SITE?

A. Fractures, in geological terms, are defined as planar separations or discontinuities in a geologic formation such as rock, sediment, or soil. In other words, they are cracks in rocks, sediments, or soil. Simply put, fractures are any parting of the soil material. At the ACL site, the soils contain numerous fractures that could allow for the movement of ground water and contaminants through the site.

Q. WHY DO YOU BELIEVE THAT THERE ARE SUCH FRACTURES AT THE ACL SITE?

A. Part III, Attachment 4 (Geology Report) of the ACL Amendment Application contains a photograph of the soils at the ACL. (*See* APP-202 at 1400.) The photograph shows intersecting vertical and horizontal fractures in the clay, and is attached to my testimony for your reference. In addition, during my review of documents produced by WMTX during discovery in this proceeding, I found additional photos of clay fractures. This photograph is also included with my testimony as an Attachment for ease of reference.

Q. PLEASE IDENTIFY WHAT HAS BEEN MARKED AS EXHIBIT TJFA 304.

A. Exhibit TJFA 304 includes copies of the photographs that I found in the documents produced by WMTX during discovery in this proceeding.

Q. ARE THE PHOTOGRAPHS IDENTIFIED IN ANY WAY?

A. Yes, WMTX Bates labeled the photographs, and they are labeled Bates numbers WM-GOLD-00028697, WM-GOLD-00028698, and WM-GOLD-00028706.

[MOVE TO ADMIT EXHIBIT TJFA 304]

Q. WHAT DO THE PHOTOGRAPH FROM THE ACL AMENDMENT APPLICATION AND THE PHOTOGRAPHS IN EXHIBIT TJFA 304 SHOW?

A. The photograph from the ACL Amendment Application and the photographs in Exhibit TJFA 304 show a lighter-colored zone in the clay surrounding the fracture. Geologists call this an alteration zone.

Q. WHAT CAUSES AN "ALTERATION ZONE"?

A. Alteration zones are caused by water moving through the fracture and reacting with the sides of the fracture. Reactions include physically removing mineral grains, dissolving soluble minerals, replacing ions in the clay crystals with other ions, precipitation or deposition of minerals, and chemical reactions that change or break down minerals.

Q. WHAT IS THE SIGNIFICANCE OF WHAT IS SHOWN ON THESE PHOTOGRAPHS?

A. The alteration zone indicates that the fractures are zones of active movement of ground water; in other words, water is flowing through the fractures. Further, fractures can affect the direction of fluid flow in the subsurface. Ground water flows parallel to the direction of decreasing hydraulic head (*i.e.*, the gradient); however, if a fracture or set of fractures is not oriented parallel to the gradient, the fractures can affect the direction of ground water flow, which can in turn, affect the direction of the movement of contaminants. The result is that contamination could move in directions that are not predicted by the hydraulic gradient.

Q. DO YOU HAVE OTHER CONCERNS RELATED TO THE PRESENCE OF FRACTURES IN THE CLAY AT THE ACL SITE?

A. Yes. Fractures can drastically increase the rate of flow, which in turn can drastically increase the rate of transport of contaminants. Contaminants could therefore move much farther in a year or a decade than predicted by calculating the flow rates using hydraulic conductivity values and not properly considering or estimating the porosity of the material through which the ground water is actually moving... In addition, if the movement of ground water at the ACL is controlled by fractures, and the monitoring wells do not intersect the fractures, then the contamination could move past the monitoring wells in the fractures without being detected.

Q. DO YOU KNOW THAT THE GROUND WATER IS MOVING THROUGH FRACTURES AT THE ACL?

A. Typically, with respect to the weathered Taylor, ground water flow is considered to occur predominantly in the fractures. The photographs identified above document that there are fractures at the ACL site and certainly raise the probability that ground water movement at the ACL is affected by fractures. In addition, though, Dr. Kier has previously testified as to the affects on clays of pure solvents, strong acids, and saline water.

V. SUMMARY AND CONCLUSIONS

Q. IN SUMMARY, DR. ULIANA, DO YOU HAVE AN OPINION REGARDING WHETHER THE ACL AMENDMENT APPLICATION ADDRESSES THE GEOCHEMICAL EVIDENCE FOR RELEASES OF CONTAMINATION FROM THE IWU THAT YOU HAVE DESCRIBED ABOVE?

A. Yes. It is my opinion that the ACL Amendment Application has failed to address evidence that contaminants have been released from the ACL and that the ground water has been impacted by those releases.

Q. PLEASE EXPLAIN.

A. High TOC concentrations in samples taken near the IWU indicate releases of organic compounds from that area; however, samples have not been taken in those wells since 1999, and have not been taken on a routine basis since 1994. The ACL Amendment Application does not address the existing data nor does it provide any provisions for continued monitoring of TOC near the IWU.

Similarly, the iron concentrations and trends in Ca/SO_4 ratios indicate a reducing environment and the influence of sulfate-reducing bacteria and the presence of organic compounds in the ground water near the IWU, indicating that the anaerobic conditions present in the ACL are affecting ground water. Analyses for iron, calcium, and sulfate concentrations in samples from wells near the IWMU have not been done since 1999 and the ACL Amendment Application does not address these trends in the existing data nor does it provide any provisions for continued monitoring or for investigation of the presence of sulfate-reducing bacteria.

High TOX concentrations near the IWU indicate the presence of chlorinated solvents in the soil and ground water; however, analysis for TOX has not been done since 1986, and the ACL Amendment Application does not include future monitoring of TOX as a means of identifying potential contamination from chlorinated solvents.

Finally, trends in Cl/Na ratios near the IWU, and throughout the ACL site, also indicate the influence of chlorinated solvents on the ground water chemistry; however, samples from the monitoring wells near the IWU have not been analyzed for chloride or sodium since 1999 and the ACL Amendment Application does not address the Cl/Na trends that indicate releases of chlorinated solvents.

Q. HOW DOES THE PRESENCE OF FRACTURES AFFECT YOUR DISCUSSION, ABOVE, REGARDING ION GROUND WATER CHEMISTRY AT THE ACL?

A. The presence of fractures in the clay soils, and the evidence that water is moving through those fractures, mean that contamination from the IWU could be moving faster and farther than expected, and in different directions than expected. At this point, there is not enough information to adequately understand the role that fractures play in the movement of ground water and contaminants at the ACL. Dr. Kier's consideration of the impacts of pure solvents, strong acids, and saline water on the permeability of clays, combined with fracture trends also could govern the movement of contaminated ground water.

Q. DO YOU BELIEVE THAT AS WRITTEN THE ACL AMENDMENT APPLICATION CONTAINS ADEQUATE GROUND WATER MONITORING REQUIREMENTS TO ADDRESS THE CONCERNS THAT YOU HAVE RAISED REGARDING GROUND WATER CONTAMINATION?

A. No, I do not.

Q. BASED ON THAT, DO YOU BELIEVE THAT THE MONITORING REQUIRED IN THE ACL AMENDMENT APPLICATION COULD PROVIDE ADEQUATE PROTECTION FOR HUMAN HEALTH AND THE ENVIRONMENT?

A. No, I do not.

Q. DOES THIS CONCLUDE YOUR DIRECT TESTIMONY?

A. Yes. However, I would like to reserve my rights to supplement or amend my testimony as appropriate and as permitted by the Administrative Law Judge.