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Phytoremediation Interim Measure
Monitoring and Maintenance Plan
Former Unocal Chemical Distribution Facility

Prepared for
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Acronyms and Abbreviations

%	percent
θ	water use multiplier for a tree
bgs	below ground surface
BTEX	benzene, toluene, ethylbenzene, and xylene
CAD	Corrective Action Decision
cm	centimeter
cm^2	square centimeter
cm^3	cubic centimeter
COC	chemical of concern
cVOC	chlorinated volatile organic compound
DCE	dichloroethene
EMC	Environmental Management Company
ft	foot, feet
ft^3	cubic feet
hr	hour(s)
IM	Interim Measure
KDHE	Kansas Department of Health and Environment
L	liter
LAI	leaf area index
mg	milligram
M&M	Monitoring and Maintenance
MSDS	Material Safety Data Sheet
mV	millivolt
NM	Not measured
ORP	oxidation-reduction potential
PCE	tetrachloroethene
PID	photoionization detector
ppm	parts per million
RSK	Risk-Based Standards for Kansas
sec	second
$\triangle T$	temperature difference
TCE	trichloroethene
TDP	thermal dissipation probe
Unocal	Unocal Chemical Distribution Facility
URS	URS Corporation
V_T	rate of transpiration

1.0 Introduction and Background

This Phytoremediation Interim Measure (IM) Monitoring and Maintenance (M&M) Plan describes the recent and future M&M activities associated with the phytoremediation systems installed by the Chevron Environmental Management Company (EMC) at the former Unocal Chemical Distribution Facility (Unocal) in Wichita, Kansas. In April 2010, Chevron EMC installed two stands of deep-rooted willow trees on the site (Plots B and C) as an IM.

The objectives of the Phytoremediation IM are to:

- Reduce the potential for off-site migration of contaminants from Plumelets B and C by creating two groundwater hydraulic barriers with stands of deep-rooted willow trees; and
- Lower chlorinated solvent concentrations to below Kansas Department of Health and Environment (KDHE) Tier 2 Residential Risk-Based Standards for Kansas (RSK) via phytoremedial processes (rhizodegradation and phytovolatilization) and natural attenuation.

Phytoremedial tree stands were installed at historical Plumelets B and C where the bedrock surface is relatively shallow (approximately 20 feet below ground surface [ft bgs]). The potential for off-site contaminant migration will be reduced, as the tree stands will alter the water balance and serve as a hydraulic impediment for contaminant migration. Dissolved-phase contaminants will be removed by various phytoremediation processes, including degradation by microbes in the root-zone of the trees *(rhizodegradation)* and plant uptake followed by volatilization (*phytovolatilization*). Rhizodegradation occurs for benzene, toluene, ethylbenzene, and xylene (BTEX) and chlorinated volatile organic compounds (cVOCs), although some percentage of the cVOCs will also be phytovolatilized and photo-degraded in the atmosphere.

Historically, several other remedial actions have been performed at the site, including soil vapor extraction, excavation, and active groundwater extraction and treatment. Phytoremediation can be considered the last step in a treatment train approach for these areas of the site. All previous response actions were documented in the ***Final Revision 1 Feasibility Study Report*** (URS Corporation [URS], June 2009) (hereafter referred to as the ***Feasibility Study Report***). The ***Feasibility Study Report*** also presented a conceptual approach for implementing phytoremediation.

The ***Phytoremediation Interim Measure Workplan*** (URS, March 2010) was submitted to KDHE on March 3, 2010. On March 24, 2010, KDHE issued a letter with comments regarding the plan. Chevron EMC prepared a response letter (submitted to KDHE on March 30, 2010) providing

responses to comments regarding phytoremediation system installation; however, Chevron EMC proposed that comments associated with monitoring, maintenance, and contingencies be addressed at a later date. KDHE approved the phytoremediation installation activities in a letter dated April 2, 2010, with the condition that previous comments regarding maintenance, monitoring, and contingencies be addressed later. These comments are addressed in this M&M plan.

This IM was performed in conjunction with other IMs and corrective actions, each of which will be documented in the Corrective Action Decision (CAD) document currently being prepared by the KDHE. The CAD will document all corrective actions to date, the IM injection work that was performed in December 2009, and this Phytoremediation IM.

This work plan is organized as follows:

Section 1.0	Introduction and Background
Section 2.0	Implementation Overview
Section 3.0	Monitoring Plan
Section 4.0	Maintenance Plan
Section 5.0	Contingency Plan
Section 6.0	References

2.0 Implementation Overview

A Phytoremediation IM installation summary was discussed in the ***Documentation of Phytoremediation Interim Measure Activities*** letter that was submitted to KDHE on September 6, 2010 (URS, September 2010). This section provides an overview of the IM installation activities that were performed.

2.1 Implementation Summary

Phytoremediation system implementation activities were conducted in April 2010 (the optimal hardwood planting time in Kansas) in accordance with the ***Phytoremediation IM Workplan*** (URS, March 2010). To establish the IM, two plots (B and C) of specially cultivated willow trees (*Salix alba*) were planted in fully-penetrating boreholes and allowed to grow over the summer of 2010. Plot B was installed over a 0.07 acre area within historical Plumelet B and Plot C was installed over a 0.15 acre area that lies within and adjacent to historical Plumelet C. In both of these areas, the bedrock surface is relatively shallow.

Locating and staking of borehole locations for tree planting was conducted at Plots B and C prior to subcontractor mobilization (Remington Technologies of Loveland, Colorado).

Once all personnel were on site, the ***Phytoremediation IM Workplan*** was reviewed prior to conducting the following activities at each location where a willow was to be planted:

- Drilled a fully penetrating borehole using a 3-inch diameter solid auger. The total depth of each borehole is provided in Table 1. These boreholes were drilled to a refusal point.
- Backfilled the fully-penetrating 3-inch borehole with coarse sand from the bedrock surface to land surface.
- Overdrilled in the same location using an 8-inch diameter solid steel auger to the water table (~9 ft bgs).
- Backfilled the 8-inch borehole with a compost, sand, and nutrient mixture (rooting matrix) to stimulate root growth. The rooting matrix was soaked with water and tamped until it was well settled in the borehole.

After completing the above steps for all of the boreholes, the subcontractor performed localized grading to address low spots within the plots in order to reduce surface flow from higher elevations toward the planted areas. Top soil was trucked to the site and spread with a front-end loader to level the plot areas. This was performed over the entire west side of Plot B and in the

southeast corner of Plot C. Additionally, the gravel driveway was expanded to provide space for parking and turnaround. The subcontractor demobilized from the site after the grading was complete.

Long hardwood willow cuttings (*Salix alba*) (8-foot long "poles") were delivered and stored in a shady, cool area. In preparation for planting, the cuttings were soaked for several days in water held in clean 55-gallon drums. A long dibble rod was used to make a planting hole in the rooting matrix backfill where the hydrated poles were installed. The willow pole cuttings were planted approximately 7.5 feet deep in the rooting matrix, leaving roughly six inches above grade.

At Plot B, the rows of trees were spaced 10 feet apart and trees within the rows were planted on 10-foot centers (depicted on Figure 1). At Plot C, the tree spacing in the north-south direction was 12 feet and the tree spacing in the east-west direction was approximately 10 feet (Figure 2).

2.2 Summary of First Season Growth

After installation, the phytoremedial plots were monitored to evaluate the growth and health of the willows. On a monthly basis, each tree is measured and observed; these measurements and observations are recorded on an inspection form. Each tree's height was measured during 2010; each tree's height and diameter at the base were measured in April 2011 and will continue to be measured in the future. Observations made during 2010 and beyond include the condition of the leaves (whether they are green, brown, or curled), soil condition surrounding the tree, the presence of weeds or pests, and any damage to the tree structure.

Table 2 provides a synopsis of growth (height only) and tree condition through December 2010. The average height of all of the trees in June 2010 was 2.23 feet, while the average height of all the trees in December 2010 was 4.25 feet. Ten trees (four in Plot B: B-4, B-18, B-27, and B-33 and six in Plot C: C-8, C-16, C-21, C-37, C-46, and C-58) showed limited to no growth during 2010 and were replaced in April 2011. As a rule of thumb for phytoremedial installations, 10 percent (%) mortality is commonly expected. All 100 trees appear to be healthy at this time (June 2011).

In June 2010, it was noted that undesirable insects were present on the willow trees. Two insects were present: centipedes and bagworms. In a letter dated July 15, 2010, Chevron EMC proposed that a natural organic insecticide, Spinosad, be used to address the insects (URS, July 2010). KDHE approved this approach on July 15, 2010. The Spinosad was mixed with water inside a spraying rig, and each tree was sprayed individually in July 2010. The Material Safety Data Sheet (MSDS) for Spinosad is presented in Appendix A. The August inspection revealed that the insect population was drastically reduced (only the "bags" from the bagworms remained, and these were picked off the trees according to instructions provided with the product).

Between September and October 2010 damage occurred at nine of the trees, including claw marks and broken limbs. It was initially speculated that armadillos may have caused the damage; a local nurseryman indicated that armadillos had been a problem during that time. Recent information indicates that rabbits may have been the problem, as they are attracted to the high sugar content in the willow plant matrix. A granular animal repellent, Bonide Shot-Gun Repels All Animal Repellent Concentrate, was spread around both Plots B and C in October 2010 (MSDS provided in Appendix A). Additionally, 2-foot tall metal cages were placed around each tree to prevent animals from accessing the trees. In subsequent monthly inspections, evidence of further animal damage was not observed.

3.0 Monitoring Plan

The monitoring plan for the groundwater phytoremediation systems in Plots B and C involves four components:

- Groundwater quality monitoring;
- Monitoring for hydraulic effects of the phytoremediation systems;
- Monitoring tree growth and health;
- Measuring transpiration rates of the tree stands; and
- Measuring phytovolatilization rates for cVOCs.

Monitoring for the phytoremedial systems will consist of annual groundwater quality monitoring for chemical parameters until the trees are established (anticipated in 2012 or 2013). After tree establishment, hydraulic monitoring will be used in conjunction with the annual groundwater quality modeling to estimate the effectiveness of the Phytoremediation IM. In response to KDHE's comments in a letter dated March 24, 2010 (KDHE, March 2010), Chevron EMC installed four additional monitor wells and eleven peizometers in the vicinity of historical Plumelets B and C, as described in the ***December 2010 Field Activities Implementation Report*** submitted to KDHE on February 21, 2010 (URS, February 2010). The eleven peizometers were installed for use as part of the phytoremedial hydraulic monitoring system, while the monitor wells will be used to monitor groundwater quality.

3.1 Groundwater Quality

Groundwater quality monitoring will be performed to determine contaminant concentrations within and/or adjacent to the tree stands using the existing monitoring well network. As part of the 2011 Annual Groundwater Monitoring Event (June 2011), Chevron EMC collected samples from the following monitor wells to determine the baseline concentrations for historical Plumelets B and C:

- R-1 (a "core" well for the former Unocal site);
- MW-17S;
- MW-2;
- MW-26;
- MW-27;
- MW-28;
- MW-4;
- P-17S;

- P-17D;
- P-18; and
- P-19.

The locations of the proposed wells for annual monitoring for Plumelet C and the onsite portion of Plumelet B are shown on Figure 3. The groundwater samples were analyzed by Lancaster Laboratories, a KDHE-certified laboratory, for cVOCs by U.S. Environmental Protection Agency (EPA) Method SW8260B. This list of wells may be revised for future annual groundwater monitoring events once the baseline results are reviewed. Once the trees are established, Chevron EMC may propose to modify the groundwater monitoring program as conditions warrant, as suggested by KDHE in a letter dated March 24, 2010 (KDHE, March 2010).

3.2 Hydraulic Effects

When fully mature, the willow trees that were installed in April 2010 will "pump" groundwater from the entire saturated thickness of the aquifer. The water table will be evaluated periodically as the trees mature. The potentiometric surface will be determined during the 2011 Annual Event and again during September 2011, when the hydraulic effect will be most pronounced (it is unclear to the extent that measurable effects will be detectable during the 2011 growing season).

The water balance presented in ***Phytoremediation IM Workplan*** (URS, March 2010) suggests that the maximum rates of transpiration for the mature stands will exceed the pre-stressed Darcy flux of groundwater within the footprints of the tree stands. Transpiration is predicted to exceed the Darcy flux by 6.4 times for Plot C and by 24.6 times for Plot B. This condition should create a substantial decrease in water table elevation within the vicinity of the Phytoremedial Plots.

To supplement the monitoring well system for hydraulic evaluation, 11 piezometers were installed within and near Plots B and C. Figure 3 shows the location of the existing piezometers relative to Plots B and C, respectively. Water level measurements will be collected periodically until the stands attain canopy closure (anticipated in 2013). Hydraulic monitoring may occur more frequently during the 2013 through 2015 growing seasons, after the trees begin to remove significant volumes of groundwater. Hydraulic data from the monitoring wells and/or piezometers outside of the tree stands will provide a means to account for seasonal changes in water table elevation and evaluate the breadth of the capture zone. Additionally, transpiration rates will be determined once the trees are established, as described in Section 3.4. The transpiration data, along with the hydraulic data, will be evaluated to determine if the pre-stressed Darcy flux of groundwater is being exceeded.

3.3 Tree Growth and Health

As described in Section 2.2, tree growth and health were monitored on a monthly basis in 2010. During the monthly inspections, tree height, the condition of the leaves, ground/soil conditions, presence of weeds, and other observations (including the presence of pests) were recorded. Photographs were also taken from set locations on a monthly basis. Ten trees exhibited limited or no growth by December 2010 and were replaced in April 2011 with new willows using the same techniques outlined in the ***Phytoremediation IM Workplan*** (URS, 2010) and described in Section 2.1 of this Plan.

For 2011, inspections will be performed monthly during the growing season (April through October) to evaluate the growth and health of the trees. The inspections will monitor the same parameters as in 2010; however, the diameter (width) at the base of the trees will also be recorded. Once the trees are established (anticipated in 2012 or 2013), the radius of each tree's canopy will be measured semiannually, at a minimum.

3.4 Transpiration

Thermal dissipation probes (TDPs) will be installed when the majority of trees have sufficient trunk diameter (> 1.5-inch, anticipated by the early summer of 2012). TDPs will be used to estimate transpiration rates for a subset of trees in Plots B and C. TDPs measure sap velocity based on thermal dissipation over a set distance, converting the measurement into a velocity of centimeters per hour (cm/hr), for individual trees. This is the rate at which a particle of sap flows upward through the xylem (sapwood) of the tree. TDPs are two needle-like sensors that are inserted into holes drilled into the stem, one above the other and about two inches apart. The upper needle is heated, and the temperature difference ($\triangle T$) between the two needles is measured. When sap velocity is high, heat in the upper needle is dissipated, and the $\triangle T$ is reduced. Values for $\triangle T$ and sap velocity are empirically related. The product of sap velocity in centimeters per second (cm/sec) and the cross sectional area of the sapwood at the point at which the TDPs are inserted in square centimeters (cm^2), yields sap flow in cubic centimeters per hour (cm^3/hr), or gallons per day.

The electrical leads from the TDPs will be routed to nearby data loggers via electrical conduit. One data logger will be required for each of the two Plots (Plumelets B and C). Rainfall totals will be obtained from the nearest airport weather station.

Obtaining transpiration data for the tree stands will be useful to assess the following factors:

- Effectiveness of the planting methods;
- Extent of chemical phytotoxicity; and

- Rate of cVOC phytovolatilization using transpiration data in conjunction with xylem sap analysis.

Planting method effectiveness. As presented in the ***Phytoremediation IM Workplan*** (URS, 2010), the pre-stressed Darcy fluxes of groundwater were estimated to be 209 cubic feet (ft^3) per month and 1,633 ft^3 per month for Plots B and C, respectively. If planting is effective in allowing the mature tree stands to take up water from the entire thickness of the aquifer, then the theoretical rate of groundwater uptake would be at least three times the pre-stressed Darcy flux. The total volume of water theoretically available for the stand transpiration would be three times the Darcy flux plus the infiltrating precipitation (data from an on-site rain bucket). Therefore, measuring the transpiration rates by the tree stands would be an indication of the effectiveness of planting.

Assessing potential for phytotoxicity. Concentrations of cVOCs greater than about 50 milligrams per liter (mg/L) can inhibit root growth (Newman et al., 1997). The footprint of Plot C is located near MW-26, which had a concentration of total cVOCs in groundwater of 28.5 mg/L. Therefore, there is only a slight potential for phytotoxicity to the willow trees. As of June 2011, all willow trees in the vicinity of MW-26 are quite healthy. The extent to which the phytotoxic conditions may exist in different portions of the tree stands could be assessed using TDPs. Any adverse conditions (e.g., phytotoxic chemical-stress, water-stress, over-crowding, diseases) can reduce both water use multiplier for a tree (θ) and leaf area index (LAI) and thereby reduce rate of transpiration (V_T) (see Section 3.3.2 of the ***Phytoremediation IM Workplan*** [URS, March 2010]).

3.5 Phytovolatilization of cVOCs

Tree core analysis for cVOCs will occur once the majority of trees attain sufficient growth (stem diameter > 1.5-inch, anticipated by early summer of 2012). The xylem sap from tree core samples of select trees in each plot will be assayed for the presence of cVOCs. These analytical results will be used in conjunction with TDP data to estimate rates of phytovolatilization. This approach is based on the results of investigations showing that cVOCs can be taken up and transported from subsurface to above surface by trees (Ma and Burken, 2002; Vroblesky *et al.*, 1999). These compounds can enter the trees either by advective uptake into the roots via the transpiration water or by diffusive uptake into the roots from groundwater or the soil vapor phase.

Following uptake, the cVOCs may undergo sorption to wood, degradation (by plant enzymes), transport to leaves via the xylem, and diffusion to the atmosphere from stem and leaves (phytovolatilization). Most of the data in the literature regarding the fate of cVOCs in planted systems is for trichloroethene (TCE) in hybrid poplars. Accumulation in poplar tissue reportedly

accounts for < 1% of the TCE that is taken up, while TCE volatilization was shown to be the major fate mechanism (Ma and Burken, 2002). It is expected that the Salix species, being in the same family as poplars (Salicaceae), would behave similarly in regard to accumulation of TCE and other cVOCs.

Tree core samples will likely be collected during the 2012 growing season (April through September). The method for collection will be determined prior to implementation based on site conditions and desired sensitivity.

4.0 Maintenance Plan

Maintenance for the mature phytoremediation tree stands is expected to be minimal. The following sections describe maintenace activities associated with the phytoremedial activities.

4.1 Tree Replacement

After the first growing season (i.e., 2010), 10 of the 100 trees did not exhibit significant growth and had no leaves. These trees were replaced in April 2011 using the following procedure:

1) Removed the cage, mulch, weed barrier, and dead tree from the borehole.

2) Moistened the borehole with water until saturated.

3) Planted long hardwood willow cuttings (8-foot long "poles") 7.5 feet deep in the backfill. A long dibble was used to make a planting hole in the backfill. This planting method, called "pole planting," is further described in the ***Phytoremediation IM Workplan*** (URS, March 2010).

4) Re-installed weed barrier and placed new mulch around the tree base.

5) Re-installed cage around the tree.

Additionally, tree handling is important to ensure that the trees are healthy when planted. Once on-site, the replacement trees were stored under the tree that lies south of the field trailer, completely out of the sun throughout the day. Two to four days prior to planting, the trees were soaked in water held in a clean polyvinyl chloride container.

If there are additional stressed trees in the future, they will be replaced using the above procedure.

4.2 Fertilization Application

Fertilization of the trees was performed during the initial implementation, during the April 2011 tree maintenance event, and will be performed annually until the trees are established. Tree fertilizer spikes (http://www.gemplers.com/product/G42701/Tree-Shrub-Fertilizer-Spikes) were installed in April 2011. One spike per tree was placed at the edge of the weed barrier. After the 2011 growing season, further evaluation of the fertilizer application procedures may be performed. It is anticipated that the fertilization application will be reduced, if not stopped, after the trees have become established.

4.3 Insect Management

The natural organic insecticide, Spinosad, was applied in July 2010 and will be reapplied as needed if centipedes and bagworms are observed on the trees. The MSDS for Spinosad is presented in Appendix A. In July 2010, the Spinosad was mixed with water inside a spraying rig, and each tree was sprayed individually. Due to the late emergence of the bagworms (roughly at dusk), spraying began late in the afternoon so that the bagworms would encounter the product before it dissipated. The method was effective, so it will continue to be used in the future. The use of the natural organic insecticide during future growing seasons will occur if centipedes and bagworms are observed during the growing season.

4.4 Animal Management

To prevent animals from damaging the trees in the future, the cages will be kept in place around the trees. Additionally, the same granular animal repellent, Bonide Shot-Gun Repels All Animal Repellent Concentrate applied in October 2010 will be reapplied at least semiannually (i.e., in April and August). For 2011, the first application of animal repellent was performed in May 2011. The MSDS for Bonide Shot-Gun Repels All Animal Repellent Concentrate is presented in Appendix A. Once the trees have become established, the cages will be removed so as to not impede future growth, although the use of animal repellent may be continued.

4.5 Weed Management

During 2010, a weed barrier (4 ft x 4 ft) was placed around each tree during planting and mulch was placed on top of the barriers. However, over time, weeds were observed to be growing within the mulch. These weeds were removed by hand during the 2010 season. During April 2011, additional mulch was added around each tree to limit the amount of weeds present at the beginning of the growing season. The existing weed barriers were kept in place under the mulch. Additionally, a post-emergent organic herbicide, called Avenger® Weed Killer Concentrate, will be applied as needed until the trees are established (anticipated in 2012 or 2013). The MSDS for Avenger® Weed Killer Concentrate is presented in Appendix A. After the 2011 growing season, further evaluation of weed management procedures may be performed. It is anticipated that weed management will be reduced, if not stopped, after the trees have become established. However, the site will continue to be mowed in order to reduce the presence of pests that could be harbored in the tall grass.

4.6 Management of Plant and Organic Waste

Since pruning of the trees is not necessary, the leaf is the only part of the tree that will be displaced on a regular basis as the willows are deciduous. While the leaves quickly transpire

cVOCs to the atmosphere, the constituents do not accumulate in the leaf tissue. Therefore, cVOCs will not be present in the leaves when they fall to the ground.

Other organic wastes that may be generated at the site include tree poles that have not shown significant growth and old mulch. These organic wastes will be managed as typical plant waste and will be spread around the site.

4.7 Tree Watering

Since the bottom of the trees were planted within the boreholes drilled to the saturated zone, supplemental watering or irrigation is not required. The trees will obtain water directly from groundwater. During the monthly inspections, the trees will be monitored for any apparent signs that a water deficit exists. During installation, a trailer-mounted tank was deployed to the site for the initial saturation of the borehole media. Such tanks can be readily obtained if supplemental watering is desired.

5.0 Contingency Plan

The monitoring plan described in Section 3.0 will be used to assess the effectiveness of the Phytoremediation IM. Depending on the monitoring results, amendments to the phytoremediation plan, such as the addition of trees, the installation of an irrigation system, and/or the thinning of Plots B and/or C, may be proposed at a later time. Prior to implementation, an amendment to this workplan outlining the details of the activities would be provided to KDHE for review.

If Plots B and C prove to be ineffective for the hydraulic control of Plumelets B and C, the following contingency plans would be implemented (Sections 5.1 and 5.2). This plan is based on Alternative 3 in the ***Feasibility Study Report*** (URS, June 2009), but has been modified to incorporate the 2009 and 2010 analytical results from the previously installed wells in historical Plumelets B and C.

5.1 Plumelet B

If Plot B proves to be ineffective for control of Plumelet B, a bio enhancement barrier would be installed along the Site's southern fence line (URS, June 2009; Figure 5-4). The design would be similar to the bio-barrier proposed in Alternative 3 of the ***Feasibility Study Report***. The presence of both electron donors (BTEX) and degraded chlorinated constituents indicates a highly reduced environment in this area. In the southern portion of Plumelet B, the primary chlorinated constituents tetrachloroethene (PCE) and TCE have degraded to *cis*-1,2-dichloroethene (DCE) and vinyl chloride. If it is decided that a contingency plan is necessary, substrates or other amendments will be selected on the basis of the distribution of contaminants at that time.

A workplan outlining the details of the injection would be provided to KDHE for review prior to implementation. This workplan also would include a groundwater monitoring plan. Current monitor wells MW-2, MW-4, MW-17S, P-17S, P-17D, and P-18 are used to monitor the effectiveness of the barrier.

5.2 Plumelet C

If Plot C proves to be ineffective for control of Plumelet C, injections would be carried out from 6 to 18 ft bgs along the southern and western extents of Plumelet C (URS, June 2009; Figure 5-5). This Plumelet exhibits high concentrations of both electron donors (BTEX) and chlorinated constituents, including the primary contaminants PCE and TCE. If it is determined that a contingency plan is necessary for Plumelet C, substrates will be selected on the basis of their ability to reduce concentrations of the chemicals of concern (COCs).

Prior to implementation, a workplan outlining the details of the injection and a proposed monitoring plan would be provided to KDHE for review. Current monitor wells MW-28, P-19, USD-1, USD-2, USD-3, and PMW-7 would be used to monitor these bio-barriers.

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Tables

Table 1. Data Collected During Phytoremediation Installation

Boring	Total Depth (ft bgs)	PID in Hole (ppm)	Water Level (ft bgs)	ORP (mV)
Plot B				
B-1	32	0.3	7.25	-95
B-2	32	23.5	7.23	-255
B-3	37	19.0	7.20	-295
B-4	36	6.0	7.02	-241
B-5	36	23.6	6.75	-167
B-6	37	5.1	6.90	-169
B-7	37	2.7	7.21	-191
B-8	37	12.9	7.43	-174
B-9	37	1.2	7.45	38
B-10	35	1.2	7.07	-8
B-11	37	3.5	7.22	-309
B-12	33	3.6	6.89	-318
B-13	37	17.7	NM	NM
B-14	35	0.6	6.95	166
B-15	35	0.9	7.12	-188
B-16	40	24	7.23	-174
B-17	37	2.4	7.48	-222
B-18	36.5	1.6	7.72	0
B-19	34	2.2	7.34	-196
B-20	35	3.4	6.98	-305
B-21	35	1.4	6.86	-338
B-22	36	0.6	7.33	-275
B-23	36	0.3	7.02	-296
B-24	40	1.7	7.42	-198
B-25	37	0.3	7.40	-337
B-26	38	0.6	7.47	-342
B-27	35	0.7	7.62	-229
B-28	37	0.6	7.43	-259
B-29	35	2.7	7.21	-298
B-30	34	4.2	7.64	-289
B-31	35	3.2	7.45	-225
B-32	34	5.8	7.48	-279
B-33	40	2.6	7.53	-253
B-34	40	5.9	7.62	-223
B-35	40	3.1	7.54	-392
B-36	35	14.7	7.62	-167
Plot C				
C-1	31	0.0	6.4	307
C-2	32	0.0	7.32	315
C-3	33	0.0	7.07	313
C-4	30	0.0	8.4	317
C-5	31	1.4	9.25	311
C-6	45	0.0	1.95	295
C-7	31	0.0	1.88	311
C-8	31	0.0	9.11	305
C-9	32	0.0	3.15	-10

Table 1. Data Collected During Phytoremediation Installation (Continued)

Boring	Total Depth (ft bgs)	PID in Hole (ppm)	Water Level (ft bgs)	ORP (mV)
Plot C (Continued)				
C-10	32	0.0	9.75	224
C-11	30.5	0.0	8.7	NM
C-12	35	0.2	5.9	280
C-13	35	2.6	7.22	220
C-14	35	7.5	8.61	160
C-15	32	2.1	7.22	225
C-16	32	0.0	9.2	220
C-17	33	0.0	1.71	-350
C-18	35	0.0	9.44	262
C-19	35	0.0	12.26	246
C-20	30.5	0.0	10	265
C-21	30.5	0.0	NM	NM
C-22	25	0.0	8.2	302
C-23	25	1.4	6.94	285
C-24	25	16	12.42	287
C-25	25	37	8.94	186
C-26	25	0.1	1.74	193
C-27	25	0.0	1.8	237
C-28	25	0.2	1.9	301
C-29	25	0.0	14.96	302
C-30	25	0.0	15.12	305
C-31	25	0.0	10.19	294
C-32	25	0.2	NM	NM
C-33	25	2.0	NM	NM
C-34	25	52	1.81	253
C-35	25	50	1.62	292
C-36	25	3.2	1.73	301
C-37	25	0.0	9.72	311
C-38	25	0.0	5.2	330
C-39	25	0.0	10.27	322
C-40	25	0.0	14	326
C-41	25	0.0	NM	NM
C-42	25	0.4	NM	NM
C-43	25	0.0	2.05	200
C-44	25	2.0	1.59	109
C-45	25	0.0	NM	NM
C-46	25	0.0	13.95	309
C-47	25	0.5	11.32	304
C-48	25	1.0	NM	NM
C-49	25	1.0	NM	NM
C-50	25	10.9	NM	NM
C-51	25	3.3	NM	NM
C-52	25	20.7	NM	NM
C-53	25	6.2	8.75	275
C-54	25	6.2	10.15	167
C-55	25	16.4	NM	NM

Table 1. Data Collected During Phytoremediation Installation (Continued)

Boring	Total Depth (ft bgs)	PID in Hole (ppm)	Water Level (ft bgs)	ORP (mV)
Plot C (Continued)				
C-56	25	2.0	NM	NM
C-57	25	63.1	16.15	230
C-58	25	172	NM	-491
C-59	25	2.2	9.25	71
C-60	25	9.8	12.3	91
C-61	25	1.3	16.2	211
C-62	25	2.6	15.7	131
C-63	25	23	7.2	111
C-64	30	24.8	7.05	140

ft bgs - Feet below ground surface.
mV - Millivolt.
NM - Not measured due to borehole collapse.
ORP - Oxidation-reduction potential.
PID - Photoionization detector.
ppm - Parts per million.

Table 2. Phytoremediation Growth Summary through December 2010

Tree	2010 Monthly Height (ft)							Total Height Change in 2010 (ft)	Notes	Replaced in April 2011?
	Jun	Jul	Aug	Sep	Oct	Nov	Dec	June to December		
Plot B										
B-1	2.7	3.9	4.5	5.5	5.9	5.7	5.7	3		N
B-2	1.6	2.8	3.7	4.6	4.8	5.0	5.0	3.4		N
B-3	1.7	2.3	3.2	3.9	4.2	4.0	4.0	2.3		N
B-4	2.4	2.6	2.5	2.4	2.4	2.4	0.0	-2.4	Tree had Died and Fallen	Y
B-5	1.65	2.8	3.9	4.9	5.0	5.1	5.1	3.45		N
B-6	1.5	2.2	3.6	3.6	2.2	2.4	2.2	0.7		N
B-7	1.4	1.7	1.5	1.7	1.2	1.3	1.1	-0.3	Small Tree, Leaves Present	N
B-8	4.6	4.8	5.4	5.9	5.9	5.5	5.5	0.9		N
B-9	3.8	3.9	4.5	5.0	5.0	5.2	5.2	1.4		N
B-10	1.9	1.9	2.4	2.6	2.8	3.0	3.0	1.1		N
B-11	4.2	5.2	6	6.8	6.9	7.0	7.0	2.8		N
B-12	1.9	2.4	3.1	4.0	4.3	4.4	4.2	2.3		N
B-13	1.9	2.5	3.7	4.4	4.8	4.5	4.6	2.7		N
B-14	1.4	2.3	3.7	4.0	4.2	4.0	4.1	2.7		N
B-15	3.8	4.2	4.9	5.3	5.4	5.4	5.4	1.6		N
B-16	2.8	3.4	4.3	4.3	4.6	4.6	4.6	1.8		N
B-17	2.3	3	3.9	4.1	4.3	4.2	4.2	1.9		N
B-18	1.4	1.4	0	0	0	0.0	0.0	-1.4	Tree had Died and Fallen	Y
B-19	3	3.9	4.6	5.5	6.3	5.6	5.6	2.6		N
B-20	5	5.5	6	6.7	6.7	6.7	6.7	1.7		N
B-21	3.8	4.3	5	5.3	5.3	5.3	5.3	1.5		N
B-22	3.4	3.9	4.5	5.3	5.0	5.2	5.2	1.8		N
B-23	3.95	4.2	5.2	5.7	5.7	5.7	5.7	1.75		N
B-24	4	4.4	4.7	5.7	5.7	5.8	5.8	1.8		N
B-25	1.3	2.3	3.8	4.9	3.9	3.9	3.9	2.6		N
B-26	2.8	3.5	4.3	4.5	4.0	4.6	4.6	1.8		N
B-27	1.7	1.9	2.2	2.2	1.7	1.9	1.9	0.2	No Leaves	Y
B-28	3.2	4	5	5.6	5.9	5.8	5.8	2.6		N

Table 2. Phytoremediation Growth Summary through December 2010 (Continued)

Tree	2010 Monthly Height (ft)							Total Height Change in 2010 (ft)	Notes	Replaced in April 2011?
	Jun	Jul	Aug	Sep	Oct	Nov	Dec	June to December		
B-29	1.6	1.9	2.7	3.7	4.3	4.4	4.4	2.8		N
B-30	4.7	5.1	5.3	5.9	5.5	5.9	5.9	1.2		N
B-31	1.8	3	3.3	4.3	4.3	4.2	4.2	2.4		N
B-32	3.1	4.1	5.3	5.5	5.5	5.7	5.7	2.6		N
B-33	2	2.1	2.6	2.6	2.6	2.6	2.6	0.6	No Leaves	Y
B-34	2.2	3.1	4.2	4.4	4.4	4.6	4.6	2.4		N
B-35	1.7	2.9	3.5	3.9	3.9	4.0	4.0	2.3		N
B-36	1.5	2	2.6	2.9	1.3	1.5	1.5	0		N
Plot C										
C-1	1.7	2.5	4.1	4.8	5.0	5.1	5.1	3.4		N
C-2	4.2	4.9	5.8	6.3	6.3	6.5	6.5	2.3		N
C-3	1.5	2.8	4	1.8	2.8	2.8	2.8	1.3		N
C-4	0.7	2	4	4.6	4.5	4.5	4.5	3.8		N
C-5	1.9	3.3	4.6	5.4	5.4	5.4	5.2	3.3		N
C-6	1.9	3.2	5	6.0	6.8	6.9	6.9	5		N
C-7	2.8	3.2	4.1	5.0	5.1	5.1	5.1	2.3		N
C-8	0.7	0.5	0.7	0.0	0.0	0.0	0.0	-0.7	Tree had Died and Fallen	Y
C-9	1.5	0.7	1.7	2.1	0.9	0.8	1.0	-0.5	Tree damaged by animal between Sept. and Oct.	N
C-10	2.4	3.4	4.3	4.8	1.3	1.3	1.3	-1.1	Tree damaged by animal between Sept. and Oct.	N
C-11	1.3	2.1	3.1	3.2	0.0	0.3	0.3	-1	Tree damaged by animal between Sept. and Oct.	N
C-12	3.5	4.7	6	6.3	6.4	6.5	6.5	3		N
C-13	2	3.3	4.6	5.0	5.2	5.3	5.3	3.3		N
C-14	2.7	2.6	4.5	5.1	5.1	5.2	5.2	2.5		N
C-15	1.7	3	4.7	5.1	5.1	5.3	5.3	3.6		N
C-16	1.7	2.2	3.1	3.5	1.3	1.3	1.3	-0.4	Tree damaged by animal between Sept. and Oct.	Y
C-17	1.3	2.9	4.3	5.1	6.1	6.2	6.2	4.9		N

Table 2. Phytoremediation Growth Summary through December 2010 (Continued)

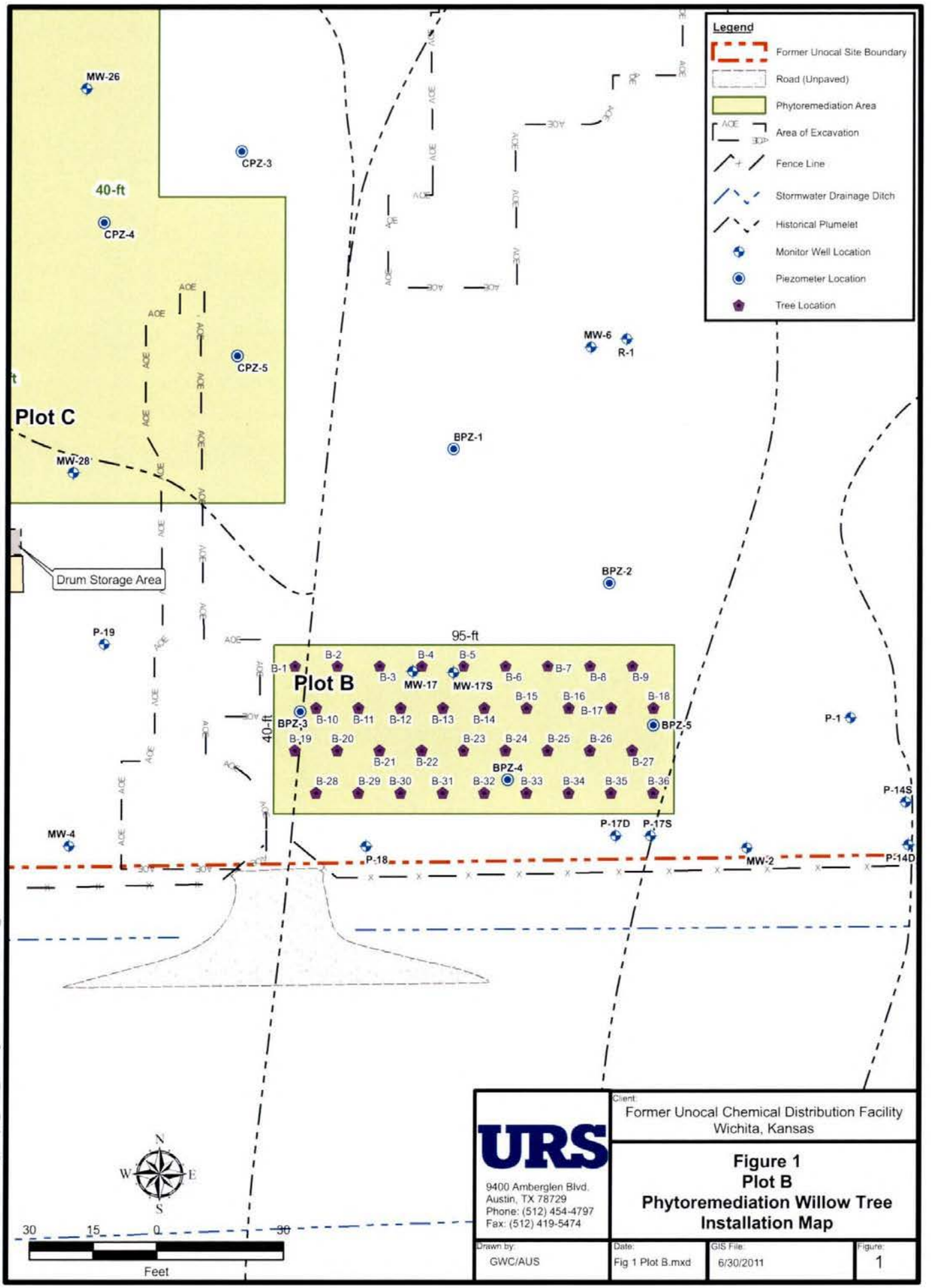
Tree	2010 Monthly Height (ft)							Total Height Change in 2010 (ft)	Notes	Replaced in April 2011?
	Jun	Jul	Aug	Sep	Oct	Nov	Dec	June to December		
C-18	2	2.6	3.9	3.8	1.7	1.7	1.7	-0.3	Tree damaged by animal between Sept. and Oct.	N
C-19	3.1	4.2	5.4	4.8	5.0	5.1	5.1	2		N
C-20	1.7	2.6	4	4.7	4.7	2.3	2.3	0.6		N
C-21	1.3	1.3	0	0	0.0	0.0	0.0	-1.3	Tree had Died and Fallen	Y
C-22	2.9	4	5.3	6.1	6.3	6.2	6.4	3.5		N
C-23	2	3.8	5.3	5.6	5.8	5.8	5.8	3.8		N
C-24	1.9	3.6	4.4	4.9	5.0	5.0	5.0	3.1		N
C-25	1.8	3.3	4.7	4.9	4.9	4.8	4.8	3		N
C-26	2.5	3.2	4.4	4.9	4.9	5.0	5.0	2.5		N
C-27	2	2.9	4.5	5.3	5.4	5.4	5.4	3.4		N
C-28	2.1	2.8	4.4	5.3	5.6	5.7	5.7	3.6		N
C-29	1.3	1.6	3.1	3.9	5.0	5.0	5.0	3.7		N
C-30	3.1	3.9	4.8	5.5	5.6	5.7	5.7	2.6		N
C-31	1.6	2.8	3.5	3.9	3.9	2.9	2.9	1.3		N
C-32	2.8	3.9	5.8	5.7	2.0	2.1	2.1	-0.7	Tree damaged by animal between September and October	N
C-33	1.3	2.4	4.1	4.6	4.9	4.9	4.9	3.6		N
C-34	2.8	4	4.8	5.1	5.1	5.2	5.2	2.4		N
C-35	2.9	3.1	4	4.6	4.7	4.8	4.8	1.9		N
C-36	1.4	2.9	4.7	5.3	4.5	4.5	4.5	3.1		N
C-37	2.3	2.5	2.4	2.5	2.3	2.3	2.3	0	No Leaves of Growth	Y
C-38	2.3	3.1	3.4	4.4	4.7	4.6	4.6	2.3		N
C-39	2.3	3.2	4.5	5.1	5.2	5.0	5.1	2.8		N
C-40	2	3.2	5	6.0	6.4	6.5	6.5	4.5		N
C-41	1.5	2.3	3.8	4.0	1.2	1.4	1.4	-0.1	Tree damaged by animal between September and October	N
C-42	1.2	2.6	3.3	3.8	1.1	0.9	1.0	-0.2	Tree damaged by animal between September and October	N
C-43	2	3.1	4.7	5.2	5.3	4.8	4.8	2.8		N

Table 2. Phytoremediation Growth Summary through December 2010 (Continued)

Tree	2010 Monthly Height (ft)							Total Height Change in 2010 (ft)	Notes	Replaced in April 2011?
	Jun	Jul	Aug	Sep	Oct	Nov	Dec	June to December		
C-44	1.5	2.8	4.8	5.5	5.5	4.7	4.7	3.2		N
C-45	1.8	3	4.5	5.2	5.2	5.5	5.5	3.7		N
C-46	1.7	0.5	0.3	0.5	0.5	0.5	0.5	-1.2	Tree had Died and Fallen	Y
C-47	1.5	2.7	4.1	4.6	4.6	4.6	4.6	3.1		N
C-48	0.9	2.3	3.7	3.9	1.3	1.4	1.4	0.5	Tree damaged by animal between September and October	N
C-49	2.1	2.8	4.3	4.9	4.9	5.0	5.0	2.9		N
C-50	2.8	3.9	4.9	5.2	5.3	5.3	5.3	2.5		N
C-51	2.7	3	4.4	5.2	5.4	5.3	5.3	2.6		N
C-52	2.5	3.7	4.9	5.3	5.3	5.2	5.3	2.8		N
C-53	1.7	2.9	4.5	5.2	5.3	5.2	5.2	3.5		N
C-54	3	4	5.2	5.8	5.7	6.0	6.0	3		N
C-55	2.3	3.7	4.9	6.0	7.3	+7.4	+7.5	5.2		N
C-56	1.9	3.1	4.6	5.2	5.3	5.9	5.9	4		N
C-57	1.7	2.9	4.7	5.6	5.6	5.7	5.7	4		N
C-58	1.3	1.7	1.2	1.3	0.8	0.0	0.0	-1.3	Tree had Died and Fallen	Y
C-59	1.6	2.3	4.1	4.7	5.0	4.7	4.7	3.1		N
C-60	1.7	2.5	3.7	1.8	1.1	1.0	1.2	-0.5	Small Tree	N
C-61	2.3	2.9	4.2	5.4	6.3	5.8	5.9	3.6		N
C-62	2.5	3.2	3.9	4.5	4.5	4.6	4.6	2.1		N
C-63	2.1	2.9	3.9	4.8	5.0	4.9	4.9	2.8		N
C-64	1.9	2.8	3.5	4.7	5.1	5.1	5.1	3.2		N
Average	**2.23**	**3.01**	**4.01**	**4.47**	**4.29**	**4.27**	**4.25**	**2.02**		

Shading indicates the trees that did not survive the first year growing season.
ft – Feet.
N – No.
Y – Yes.

Figures



URS

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Phone: (512) 454-4797
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Client:
Former Unocal Chemical Distribution Facility
Wichita, Kansas

Figure 1
Plot B
Phytoremediation Willow Tree Installation Map

Drawn by:	Date:	GIS File:	Figure:
GWC/AUS	Fig 1 Plot B.mxd	6/30/2011	1

Q:\Unocal-Wichita\Drawings\Phyto_M&M_Plan\Fig 1 Plot B.mxd 6/30/2011 @ 11:41:53 AM

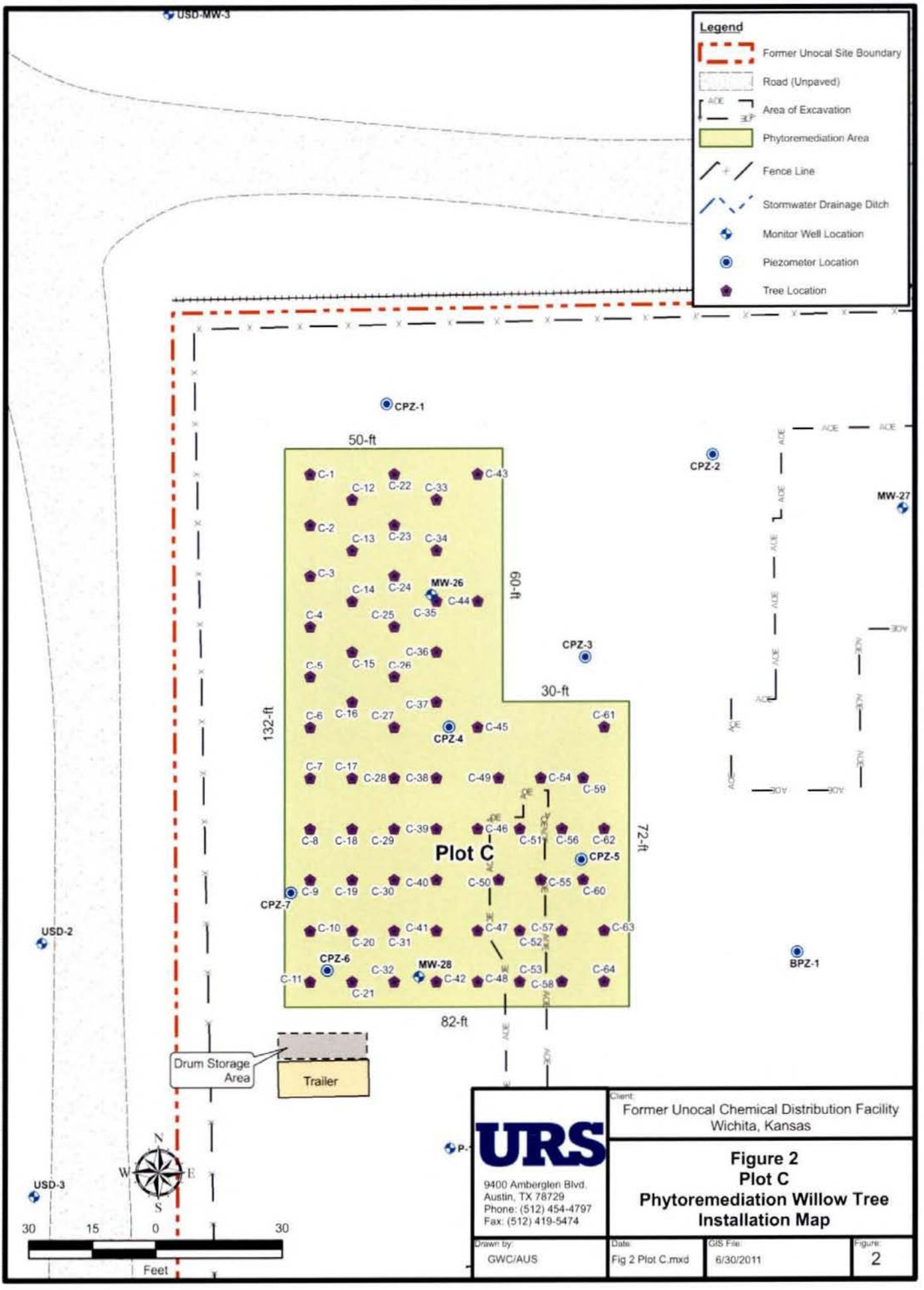
Legend
Former Unocal Site Boundary
Road (Unpaved)
Area of Excavation
Phytoremediation Area
Fence Line
Stormwater Drainage Ditch
Monitor Well Location
Piezometer Location
Tree Location
USD-MW-3
CPZ-1
CPZ-2
MW-27
CPZ-3
CPZ-4
CPZ-5
CPZ-6
CPZ-7
MW-26
MW-28
USD-2
USD-3
BPZ-1
50-ft
60-ft
30-ft
72-ft
82-ft
132-ft
Plot C
Drum Storage Area
Trailer
Feet
30 15 0 30
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Figure 2
Plot C
Phytoremediation Willow Tree
Installation Map
Drawn by: GWC/AUS
Date: Fig 2 Plot C.mxd
GIS File: 6/30/2011
Figure: 2
Q:\Unocal-Wichita\Drawings\Phyto_M&M_Plan\Fig 2 Plot C.mxd 6/30/2011 @ 12:04:18 PM

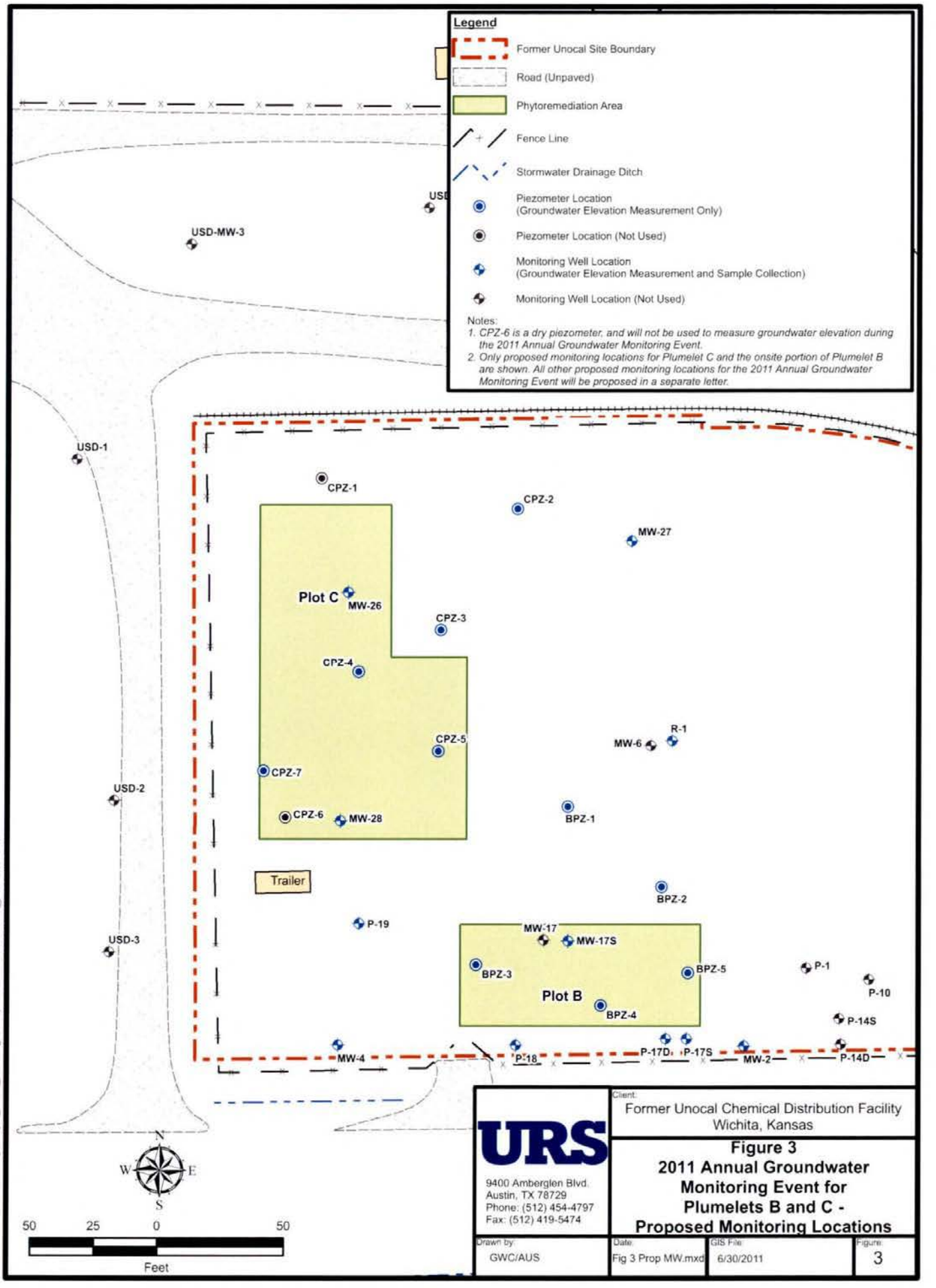

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Figure 3
2011 Annual Groundwater Monitoring Event for Plumelets B and C - Proposed Monitoring Locations

Drawn by:	Date:	GIS File:	Figure:
GWC/AUS	Fig 3 Prop MW.mxd	6/30/2011	3

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Appendix A

Material Safety Data Sheets

Avenger® Weed Killer Concentrate

Cutting Edge Formulations, Inc.
3057 Summer Oak Place
Buford, GA 30518
August, 2006

MATERIAL SAFETY DATA SHEET

For Avenger® Weed Killer Concentrate
(EPA Reg. No. 82052 – 1)

Emergency Phone Numbers:
Cutting Edge Formulations: (678) 546-5009
CHEMTREC 24 Hour Number (800) 424-9300

Section 1 – IDENTIFICATION

Product Name: Avenger® Weed Killer Concentrate

Section 2 – INGREDIENT INFORMATION

Avenger Weed Killer Concentrate consists of:
d-Limonene (technical grade): 74 to 78% (CAS Number: 5989-27-5)
Castor Oil: 1 to 4%
Emulsifiers: 18 to 23%

Section 3 –HEALTH HAZARDS IDENTIFICATION

Health Hazards: Harmful if absorbed through skin. Causes moderate eye irritation. Avoid contact with skin, eyes, or clothing.
Signs and Symptoms of Exposure: Product may be irritating to the skin, eyes, nose and throat.
Medical Conditions Generally Aggravated by Exposure: Persons with allergies or pre-existing skin conditions should avoid contact with this product.

Emergency & First Aid Procedures :
Eyes: Remove contact lenses at once. Flush with water for at least 15 minutes.
Skin: Wash affected area with copious amounts of soap and water. If irritation develops, seek medical attention.
Ingestion: Seek medical attention immediately. Do not induce vomiting. Rinse mouth with water, then drink one glass of water. Do not leave victim unattended. Never give anything by mouth if victim is unconscious, is rapidly losing consciousness, or is convulsing.
Inhalation: If symptoms of overexposure are experienced, evacuate to fresh air.
If any symptoms persist, seek medical attention.

The toxicity parameters of the primary ingredient, d-Limonene, are as follows:
It is not acutely toxic.
Oral: LD50 >5 g/kg, rabbit
Dermal: LD50 >5 g/kg, rabbit
Skin: The skin irritancy of limonene in guinea pigs and rabbits is considered moderate and low, respectively.
Inhalation: LC50 >1000 ppm

Hazardous Materials Identification System - HMIS:

1 Health Hazard - Mild skin irritant
2 Flammability - Flashpoint 122° F (50°C), as determined by TAG Closed Cup
0 Reactivity - Stable
G Protection - Safety glasses, gloves

This substance contains no materials subject to the reporting requirements of SARA TITLE III SECTION 313.

Chronic Toxicity: Not listed as a carcinogen (OSHA, NTP, IARC, or ACGIH)
Ecotoxicological Information: Product may be toxic to aquatic organisms.

Section 4 –PHYSICAL DATA

Appearance: Clear, colorless liquid
Odor: Orange or lemon-lime aroma
Specific Gravity: 0.854 g/ml (53.3 lb/ cu. ft.) at 68°F (20°C)
Flashpoint: 122°F (50°C), as determined by TAG Closed Cup
pH: aqueous mixture containing 1% v/v of Concentrate has a pH of 4.8 at 73°F (23°C)
Viscosity: 1.50 at 23°C

Section 5 – FIRE AND EXPLOSION HAZARD DATA

Flash Point: 126°F (52°C)
Extinguishing Media: Carbon dioxide, foam or dry chemical
Special Fire Fighting Procedures: SCBA recommended. Smother to exclude air. Do not use water. Handle as an oil fire.
Unusual Fire and Explosive Hazards: Combustible liquid. Keep away from heat, sparks, and open flame.
Hazardous Decomposition Materials: Smoke may be acrid and the fumes may be irritating. Burning generates CO, CO_2, and smoke.
Conditions to Avoid for Stability: Avoid temperatures over 122° F (50°C)

Section 6 – SPILL OR LEAK PROCEDURES

Steps to be Taken if Material is Released or Spilled: Use protective gloves to avoid skin contact. Small spills can be wiped up. Large spills should be absorbed by dirt, sand, or other suitable absorbents for disposal.

Section 7 –SPECIAL PROTECTION INFORMATION

Eye Protection: Safety goggles or glasses suggested.
Skin Protection: Oil resistant gloves.
Appropriate Hygienic Practices: Wash thoroughly after handling. Launder contaminated clothing before re-use.

Section 8 – SPECIAL PRECAUTIONS

Precautions to be Taken in Handling and Storing: Usual precautions for combustible liquids.

Section 9 – REGULATORY INFORMATION

Registration for use as a herbicide has been approved at the U.S. Environmental Protection Agency (EPA). EPA Registration No. 82052 – 1

Section 10 – TRANSPORTATION INFORMATION

TDG Status: Hazardous DOT Label/Placard [exemption § 173.150(f) applies:
IMO Status: Hazardous Highway/Rail: per requirements for Combustible Liquids
IATA Status: Hazardous Air/Ship: per requirements for Flammable Liquids

SHIPPING CLASSIFICATION:
Proper Shipping Name: TERPENE HYDROCARBONS, N.O.S.
Hazard Class: 3
Identification No.: UN2319
Packing Group: III
The listed Transportation Classification does not address regulatory variations due to changes in package size, mode of shipment or other regulatory descriptors.

Section 11 – ADDITIONAL INFORMATION

National Fire Protection Association Hazard Ratings - NFPA(R):
1 Health Hazard - Slight
2 Flammability - Moderate
0 Reactivity - Minimal

Key Legend Information:
ACGIH American Conference of Governmental Industrial Hygienists
OSHA Occupational Safety and Health Administration
NTP National Toxicology Program
IARC International Agency for Research on Cancer 4

The information contained herein is based on current knowledge and experience: no responsibility is accepted that the information is sufficient or correct in all cases. Users should consider these data only as a supplement to other information obtained by the user. No warranty is expressed or implied regarding the accuracy of this data, the results to be obtained from the use thereof, or that any such use will not infringe any patent. Users should make independent determinations of suitability and completeness of information from all sources to assure proper use and disposal of these materials, the safety and health of employees and customers, and the protection of the environment. This information is furnished upon the condition the person receiving it shall determine the suitability for the particular purpose. This MSDS is to be used as a guideline for safe work practices and emergency response.

Cutting Edge Formulations, Inc.
3057 Summer Oak Place
Buford, GA 30518
August, 2006

Bonide Shot-Gun Repels All Animal Repellent Concentrate

Material Safety Data Sheet
May be used to comply with
OSHA's Hazard Communication Standard,
29 CFR 1910.1200. Standard must be consulted
for specific requirements.

U.S Department of Labor
Occupational Safety and Health Administration
(Non-Mandatory Form)
Form Approved
OMB No. 1218-0072

IDENTITY (As Used on Label and List)

Bonide Shot-Gun Repels All Animal Repellent Concentrate **ID No. 237-25b**

Date: March 13, 2008

Section I

Bonide Products, Inc.
6301 Sutliff Road
Oriskany, NY 13424

(800) 424-9300
(315) 736-8231

Section II - Ingredients/Identity

Hazardous Components (Specific Chemical Identity: Common Name(s)	OSHA PEL	ACGIH TLV	Other Limits	% (Optional)
Dried Blood	N/A			0.016%
Putrescent whole egg solids	N/A			0.016%
Garlic Oil	N/A			0.003%

Section III - Physical/Chemical Ingredients

BOILING POINT: >212 degrees F
VAPOR DENSITY (Air=1): NA
SPECIFIC GRAVITY (H2O=1): 1.01
MELTING POINT: NA
SOLUBILITY IN WATER: YES
EVAPORATION RATE (Butyl Acetate=1): NA
APPEARANCE AND ODOR: Light Brown liquid with Vinegar like odor

Section IV - Fire and Explosion Data

FLASHPOINT: > 325 degrees F
FLAMMABLE LIMITS: NA
EXTINGUISHING MEDIA: Carbon Dioxide, Dry Chemical, Foam or Water
FIRE FIGHTING COMMENTS: As in any fire, wear self-contained breathing apparatus pressure-demand and full protective gear.

Section V - Reactivity Data

STABILITY: Stable
CONDITIONS TO AVOID: NA
INCOMPATIBILITY (Materials to Avoid): NA
HAZARDOUS POLYMERIZATION: Will not occur
HAZARDOUS DECOMPOSITION OR BYPRODUCTS: NA

Section VI - Health Hazard Information

ROUTES OF ENTRY: Inhalation: NA Skin: Yes Ingestion: Yes Eyes: Yes
SIGNS AND SYMPTOMS OF EXPOSURE: Product can cause moderate eye irritation. For certain individuals, skin irritation may occur. In case of eye contact, flush with plenty of water. In case of skin irritation, wash area thoroughly with soap and water. Seek medical attention if irritation persists. Do no use this product if you are allergic to eggs.

Section VII - Safe Handling/Use

HANDLING AND STORAGE: Store in a cool, dry place away from heat or flame. Avoid freezing. Keep out of reach of children. After use, wash hands and other exposed skin surfaces prior to smoking or consuming food or beverages.

Section VIII - Environmental and Disposal Information

SPILL OR LEAK PROCEDURES: Contain and absorb spilled material with a solid absorbent such as sand, cat litter, commercial clay or other suitable absorbent.
WASTE DISPOSAL METHOD: Because acceptable methods of disposal may vary by location and because regulatory requirements may change, the appropriate regulatory agencies should be contacted prior to disposal.

KEEP OUT OF REACH OF CHILDREN

ABBREVIATION KEY

N/A: NOT AVAILABLE OR APPLICABLE	N/E: NOT ESTABLISHED	ND: Not Determined
TLV: THRESHOLD LIMIT VALUE	TWA: TIME WEIGHTED AVG./8 HOUR WORKDAY	
STEL: SHORT TERM EXPOSURE LIMIT	D.O.T.: DEPARTMENT OF TRANSPORTATION	

DISCLAIMER OF EXPRESSED AND IMPLIED WARRANTIES

Buyer assumes all risks of use, storage and handling of this material not in strict accordance with directions given herewith.

Natural Guard® Spinosad

MATERIAL SAFETY DATA SHEET

For Chemical Emergency, Spill, Leaf, Fire, Exposure, or Accident, Call CHEMTREC Day or Night: 1-800-424-9300
For Medical Emergencies Only, Call: 1-877-325-1840

Voluntary Purchasing Groups, Inc.
230 FM 87
Bonham, Texas 75418

Natural Guard® Spinosad

Effective Date: December 12, 2008

1. PRODUCT AND COMPANY IDENTIFICATION:

PRODUCT: Natural Guard Spinosad
EPA No.: 62719-314-7401

COMPANY IDENTIFICATION:
Voluntary Purchasing Groups, Inc.
230 FM 87
Bonham, Texas 75418

2. HAZARDOUS IDENTIFICATIONS:

EMERGENCY OVERVIEW
Off-White to tan liquid suspension with low odor. May cause slight eye irritation. Material is slightly toxic to aquatic organisms.
EMERGENCY PHONE NUMBER: 800-424-9300

3. COMPOSITION/INFORMATION ON INGREDIENTS:

COMPONENT	CAS NUMBER	W/W%
Spinosad: Spinosyn A	131929-60-7	0.5%
Spinosyn D	131929-63-0	2.0
Balance, Total, Including: Propylene glycol (1,2-Propanediol)	000057-55-6	99.5%

4. FIRST AID:

EYE: Hold eyes open and rinse slowly and gently with water for 15-20 minutes. Remove contact lenses, if present, after the first 5 minutes, and then continue rinsing eyes. Call a poison control center or doctor for treatment advice.

SKIN: Take off contaminated clothing. Rinse skin immediately with plenty of water for 15-20 minutes. Call a poison control center or doctor for treatment advice.

INGESTION: Call a poison control center or doctor immediately for treatment advice. Have person sip a glass of water if able to swallow. Do not induce vomiting unless told to do so by the poison control center or doctor. Never give anything by mouth to an unconscious person.

INHALATION: Move person to fresh air. If person is not breathing, call 911 or ambulance, and then give artificial respiration, preferably by mouth to mouth. Gall a poison control center or doctor for further treatment advice.

NOTE TO PHYSICIAN: No specific antidote. Treatment of exposure should be directed at the control of symptoms and the clinical condition of the patient.

5. FIRE FIGHTING MEASURES:

FLASH POINT: Not determined (aqueous suspension)
METHOD USED: Not applicable

FLAMMABLE LIMITS:
LFL: Not determined (water-based product)
UFL: Not determined (water-based product)

EXTINGUISHING MEDIA: To extinguish combustible residues of this product use water fog, carbon dioxide, dry chemical or foam.

FIRE AND EXPLOSION HAZARDS: Keep people away. Isolate fire and deny unnecessary entry. Under fire conditions some components of this produce may decompose. The smoke may contain unidentified toxic and/or irritating compounds.

FIRE-FIGHTING EQUIPMENT: Wear positive-pressure, self-contained breathing apparatus (SCBA) and protective fire-fighting clothing (includes fire-fighting helmet, coat, pants, boots and gloves). If protective equipment is not available or not used, fight fire from a protected location or safe distance.

6. ACCIDENTAL RELEASE MEASURES:

ACTION TO TAKE FOR SPILLS: Use non-reactive absorbent to absorb small spills and collect for disposal. Report large spills to CHEMTREC 800-424-9300

7. HANDLING AND STORAGE:

PRECAUTIONS TO BE TAKEN IN HANDLING AND STORAGE: Keep out of reach of children. Avoid eye contact. Do not take internally. Wash thoroughly after handling and before eating, drinking, or smoking. Store product in original container. See product label for additional instructions.

8. EXPOSURE CONTROLS/PERSONAL PROTECTION:

These precautions are suggested for conditions where the potential for exposure exists. Emergency conditions may require additional precautions.

EXPOSURE GUIDELINES: Propylene glycol: AIHA WEEL is 10 mg/ M^3 for total vapor and aerosol.
Spinosad: Voluntary Purchasing Groups Industrial Hygiene Guide is 0.3 mg/ M^3, TWA.

ENGINEERING CONTROLS: Provide general and/or local exhaust ventilation to control airborne levels below the exposure guidelines.

RECOMMENDAITONS FOR MANUFACTURING, COMMERCIAL BLENDING, AND PACKAGING WORKERS:

EYE/FACE PROTECTION: Use of safety glasses is recommend

SKIN PROTECTION: Use gloves chemically resistant to this material when prolonged or frequently repeated contact could occur.

RESPIRATORY PROTECTION: Atmospheric levels should be maintained below the exposure guideline.

APPLICATORS AND ALL OTHER HANDLERS: Refer to the product label for personal protective clothing and equipment.

9. PHYSICAL AND CHEMICAL PROPERTIES:

APPEARANCE: Off-white to light tan
ODOR: Low odor
BOILING POINT: 100°C C (212F) water
PHYSICAL STATE: Liquid suspension

VAPOR PRESSURE: similar to water
SOLUBILITY IN WATER: Dispersible
DENSITY: 1.09 g/ml

10. STABILITY AND REACTIVITY:

STABILITY: (CONDITIONS TO AVOID) Thermally stable at typical use temperatures. Some components of this product can decompose at elevated temperatures.
INCOMPATIBILITY: (SPECIFIC MATERIALS TO AVOID) None known.

HAZARDOUS DECOMPOSITION PRODUCTS: Hazardous decomposition products depend upon temperature, air supply and the presence of other materials.

HAZARDOUS POLYMERIZATION: Not known to occur.

11. TOXICOLOGICAL INFORMATION:

POTENTIAL HEALTH EFFECTS: This section includes possible adverse effects, which could occur if this material is not handled in the recommended manner.

EYE: May cause slight eye irritation. Corneal injury is unlikely. May cause pain disproportionate to the level of irritation to eye tissues.

SKIN: Prolonged contact may cause slight skin irritation with local redness. The LD50 for skin absorption in rabbits is >5,000 mg/kg. Prolonged skin contact is unlikely to result in absorption of harmful amounts. Did not cause allergic skin irritation or reactions when tested in guinea pigs.

INGESTION: Very low toxicity if swallowed. Harmful effects not anticipated from swallowing small amounts. The oral LD_{50} for rats is >5,000 mg/kg.

INHALATION: No adverse effects are anticipated for single exposure to mist. The aerosol LC_{50} for rats is >.50 mg/L for 4 hours (limit test).

SYSTEMIC (OTHER TARGET ORGAN) EFFECTS: Repeated exposure did not produce systemic toxicity when applied to the skin of rabbits.

CANCER INFORMATION: Did not cause cancer in laboratory animals.

TERATOLOGY (BIRTH DEFECTS): Spinosad did not cause birth defects in laboratory animals.

REPRODUCTIVE EFFECTS: Spinosad, in laboratory animal studies, effects on reproduction have been seen only at doses that produced significant toxicity to the parent animals.
Mutagenicity: For spinosad, in-vitro and animal mutagenicity studies were negative.

12. ECOLOGICAL INFORMATION:

ENVIRONMENTAL FATE::

MOVEMENT & PARTITIONING:
Based largely or completely on information for spinosad.
Bioconcentration potential is low (BCF >100 or Log Pow >3). Based on information for spinosyn A.
Bioconcentration factor (BCF) in fish is 33.

DEGRADATION AND PERSISTENCE:
Based largely or completely on information for spinosad.
Based on information for spinosyn A.
The photolysis half-life in pH7 buffer is 0.96 days.
Under aerobic soil conditions the half-life is 9.4 and 17.3 days.
Based on information for spinosyn D.
The photolysis half-life in soil is 9.44 days.
The photolysis half-life in pH7 buffer is 0.84 days.

ECOTOXICOLOGY:
Material is slightly toxic to aquatic organisms on an acute basis (LC50/EC50 between 10 and 100 mg/L in most sensitive species.
Acute immobilization EC50 in water flea (Daphnia magna) is 16.9 mg/L.
Acute LC50 in water flea (Daphnia magna) is >90.9 mg/L.
Acute LC50 in zebra fish (Brachydanio rerio) is >120 mg/L.
Acute LC50 in common carp (Cyprinus carpio) is >100mg/L.
The LC50 in earthworm (Eisenia foetida) is >2000 mg/kg.
Growth inhibition EC50 in diatom (Navicula sp.) is 0.667 mg/L.
Growth inhibition EC50 in green alga (Selenastrum capricornutum) is >100 mg/L.
Acute contact LC50 in honeybee (Apis mellifera) is 0.12 ug/bee.
Acute oral LD50 in honeybee (Apis mellifera) is .011 ug/bee.

13 DISPOSAL CONSIDERATIONS:

DISPOSAL METHOD: If wastes and/or containers cannot be disposed of according to the product label directions, disposal of this material must be in accordance with your local or area regulatory authorities. This information presented below only applies to the material as supplied. The identification based on characteristics(s) or listing may not apply if the material has been used or otherwise contaminated. It is the responsibility of the waste generator to determine the toxicity and physical properties of the material generated to determine the proper waste identification and disposal methods in compliance with applicable regulations. F the material as supplied becomes a waste, follow all applicable regional, national and local laws and regulations.

14. TRANSPORT INFORMATION:

U.S. DEPARTMENT OF TRANSPORTATION (DOT) INFORMATION:

For all package sizes and modes of transportation:
This material is not regulated for transport.

15. REGULATORY INFORMATION:

NOTICE: The information herein is presented in good faith and believed to be accurate as of the effective date shown above. However, no warranty, express or implied, is given. Regulatory requirements are subject to change and may differ from one location to another; it is the buyer's responsibility to ensure that its activities comply with federal, state or provincial, and local laws. The following specific information is made for the purpose of complying with numerous federal, state or provincial, and local laws and regulations.

U.S. REGULATIONS

SARA 313 INFORMATION: To the best of our knowledge, this product contains no chemical subject to SARA Title III Section 313 supplier notification requirements.

MATERIAL SAFETY DATA SHEET

For Chemical Emergency, Spill, Leaf, Fire, Exposure, or Accident, Call CHEMTREC Day or Night: 1-800-424-9300
For Medical Emergencies Only, Call: 1-877-325-1840

Voluntary Purchasing Groups, Inc.
230 FM 87
Bonham, Texas 75418

Natural Guard® Spinosad

Effective Date: December 12, 2008

SARA HAZARD CATEGORY: This product has been reviewed according to the EPA "Hazard Categories" promulgated under Sections 311 and 312 of the Superfund Amendment and Reauthorization Act of 1986 (SARA Title III) and is considered, under applicable definitions, to meet the following categories:

An immediate health hazard

TOXIC SUBSTANCES CONTROL ACT (TSCA): All ingredients are on the TSCA inventory or are not required to be listed on the TSCA inventory.

STATE RIGHT-TO-KNOW: The following product components are cited on certain state lists as mentioned. Non-listed components may be shown in the composition section of the MSDS.

CHEMICAL NAME	CASE NUMBER	LIST
1,2-Propanediol	000057-55-6	PA1

PA1=Pennsylvania Hazardous Substance (present at >or = to 1.0%.

OSHA HAZARD COMMUNICATION STANDARD: This product is a "Hazardous Chemical" as defined by the OSHA Hazard Communication Standard, 29 CFR 1910.1200.

COMPREHENSIVE ENVIRONMENTAL RESPONSE COMPENSATION AND LIABILITY ACT (CERCLA,OR SUPERFUND): To the best of our knowledge, this product contains no chemical subject to reporting under CERCLA.