

FINAL

**Work Plan for the
Phytostabilization of Chlorinated Solvents from
Groundwater at Site 2
Altus Air Force Base Oklahoma**



Altus Air Force Base, Oklahoma

Prepared For

**Air Force Center for Environmental Excellence
Technology Transfer Division
Brooks Air Force Base**

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FINAL

**WORK PLAN FOR THE DEMONSTRATION OF
PHYTOSTABILIZATION AT SITE 2
ALTUS AIR FORCE BASE, OKLAHOMA**

MAY 1999

PREPARED FOR:

**AIR FORCE CENTER FOR ENVIRONMENTAL EXCELLENCE
TECHNOLOGY TRANSFER DIVISION
BROOKS AIR FORCE BASE, TEXAS**

AND

**97TH CES/CEV
ALTUS AIR FORCE BASE, OKLAHOMA**

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LIST OF ACRONYMS AND ABBREVIATIONS

$\mu\text{g/L}$	micrograms per liter
1,2-DCE	1,2-dichloroethene
AFB	Air Force Base
AFCEE	Air Force Center for Environmental Excellence
atm	atmospheres
bgs	below ground surface
CAH	chlorinated aliphatic hydrocarbons
CO_2	carbon dioxide
DOC	dissolved organic carbon
ft/d	foot per day
ft/ft	foot per foot
ft^2	square foot
gal/d	gallons per day
$\text{L/m}^2\text{-d}$	liters per square meter per day
$\text{L/m}^2\text{-yr}$	liters per square meter per year
$\log K_{ow}$	octanol-water partition coefficient
m^2	square meters
mm/yr	millimeters per year
OM&M	operations, maintenance, and monitoring
Parsons ES	Parsons Engineering Science, Inc.
PCE	tetrachloroethene
POC	particulate organic carbon
QA	quality assurance
SCAPS	Site Characterization and Analysis Penetrometer System
SWL	static water level
TCE	trichloroethene
TOC	total organic carbon
US	United States
USEPA	US Environmental Protection Agency
VC	vinyl chloride

SECTION 1

INTRODUCTION

This work plan was prepared by Parsons Engineering Science, Inc. (Parsons ES) for the Air Force Center for Environmental Excellence (AFCEE) as part of an overall demonstration of engineered tree plantings to hydraulically control (phytostabilize) groundwater contaminated with chlorinated aliphatic hydrocarbons (CAHs). The activities outlined in this work plan will be performed at Altus Air Force Base (AFB), Oklahoma.

Two primary objectives exist for this project:

1. Demonstrate the ability or inability of engineered tree plantings to hydraulically control groundwater through field measurements; and
2. Utilizing the field measurements, refine and calibrate a water balance model to be used as a screening and evaluation tool for phytostabilization at other Air Force sites (to be completed by others).

These two objectives provide the basis for the activities outlined in this work plan.

1.1 PHYSTOSTABILIZATION OVERVIEW

The extensive use of CAHs, such as trichloroethene (TCE), as cleaning solvents has resulted in their inappropriate disposal and subsequent soil and groundwater contamination. Highly engineered systems (i.e., pump and treat, zero-valent metal barrier walls) currently used for control and treatment of groundwater contaminated with CAHs are expensive to install and operate. Phytoremediation is a potentially more efficient and/or less costly alternative for shallow groundwater remediation.

Phytoremediation is defined as the use of plants to remove, degrade, or sequester pollutants in contaminated soil or groundwater. One application of phytoremediation is phytostabilization. Phytostabilization can be defined as the use of plants to hydraulically control the migration of a contaminant plume through transpiration and to aid in the remediation of the dissolved phase contaminants through the rhizosphere degradation or gradual volatilization. Plants have profound effects on physical, chemical, and biological processes in soils, and can significantly impact the environmental fate of organic chemicals in soil systems. Plants increase microbial and chemical activity on and around their root surfaces, thereby potentially accelerating the microbial degradation of organic contaminants. Root exudates may act as electron donors for organic contaminants that are biodegraded through reductive dechlorination.

Uptake, transpiration, and/or metabolism of organic chemicals may be important in some cases. These processes are accelerated by the mass flow of solution to the root surface induced by the transpiration flux of water from plant leaves.

If the water being used by the vegetation for transpiration is being supplied by the groundwater, plants may have the ability to control the migration of contaminant plumes and possibly enhance transfer of contaminated groundwater into the microbially rich rhizosphere (Davis *et al.*, 1996). The relative impact of vegetation on groundwater is dependent on many factors including groundwater aquifer depth and soil conditions. In low permeability areas where the recharge is low, groundwater use by plants may depress the groundwater table significantly. Where the recharge rate is high, such as sandy soil conditions near a surface water, the impact may not be as great. An annotated bibliography for watersheds in the western U.S. indicates that annual water use by cattails, cottonwoods, rushes, reeds, sedges, and tamarix can exceed 60 inches of water. A 10-ft by 50-ft planted strip of this vegetation could remove over 18,700 gallons per year from the subsurface.

In certain cases, plant uptake and metabolism of CAHs also may be important. Plant membranes are composed of a lipid bi-layer that prevents the uptake of almost all highly water-soluble compounds except plant nutrients, which are actively absorbed via specific ion pumps. The plant uptake of organic compounds tends to increase with the lipid solubility of the compounds up to a log of their octanol-water partition coefficient ($\log K_{ow}$) of about 2 (Briggs *et al.*, 1982). Highly lipophilic compounds ($\log K_{ow}$ greater than 3) are thought to cross plant membranes more slowly than compounds of intermediate lipophilicity ($\log K_{ow}$ 1 to 3) because highly lipophilic compounds are tightly bound to the lipid membranes and are insoluble in the aqueous cytoplasm inside the cell. Translocation from roots to shoots also is optimal for chemicals with intermediate lipophilicity, and translocation appears to increase with transpiration (Ryan *et al.*, 1988). TCE is considered to be a compound of intermediate lipophilicity having a $\log K_{ow}$ of 2.5. However, while TCE uptake into plants has been observed, the quantitative relationship between groundwater concentration and the overall plant removal rate has not been established (Anderson and Walton, 1992; Newman *et al.*, 1997; Schnable *et al.*, 1996). Metabolism of TCE in plant tissue has also been described, with chlorinated alcohols and aliphatic acids being reported as byproducts (Newman *et al.*, 1997; Edwards *et al.*, 1997).

Microbial degradation of CAHs occurs under both anaerobic and aerobic environmental conditions. Anaerobic micro-sites are commonly found throughout aerobic rhizosphere (root-zone) regions. Saturated soil conditions can increase the likelihood of anaerobic sites because oxygen diffusion is reduced when soil pores are filled with water.

Under aerobic conditions, a variety of bacteria, including methane and propane oxidizers, ammonia oxidizers, and toluene (aromatic) oxidizers, have been shown to oxidize CAHs cometabolically. Although optimal conditions are uncommon, comparisons of TCE mineralization in planted versus unplanted soil suggest that vegetation may accelerate TCE degradation (Walton and Anderson, 1990).

The plant rhizosphere contains an abundance of organic compounds, originating from both plant deposition and microbial metabolism. Anaerobic conditions in the rhizosphere may therefore favor reductive dechlorination of CAHs. Under anaerobic conditions, TCE undergoes reductive dechlorination to 1,2-dichloroethene (1,2-DCE), and then to vinyl chloride (VC). Although the breakdown of TCE to VC is an undesirable process, many studies have indicated that VC can be further dechlorinated to ethene and then mineralized to carbon dioxide (CO₂). A metabolic process has been proposed linking reductive dechlorination to methanogenesis, which requires an electron-donating substrate. VC is also very volatile and is rapidly oxidized aerobically as it passes through the upper levels of the soil column.

In summary, phytostabilization has the potential to aid in the remediation or hydraulic control of CAH contaminant plumes by the following mechanisms:

1. Groundwater removal via transpiration could act to hydraulically control the migration of contaminants similar to groundwater extraction wells;
2. Contaminants in the groundwater that are removed via transpiration could be metabolized within the plant or translocated to the atmosphere; and
3. The rhizosphere could enhance the biodegradation of contaminants by altering the subsurface through the production of aerobic/anaerobic micro-sites, the natural production of low molecular weight carbon sources by plants could enhance aerobic/cometabolic degradation or reductive dechlorination.

SECTION 2

SITE CHARACTERISTICS

A detailed report regarding the characteristics at Site 2 can be found in the *Revised Description of Current Conditions RCRA Facility Investigation, Altus Air Force Base, Oklahoma* (URS, 1997). The following sections provide a summary of information found in that report in addition to a description of recent investigative activities (November 1998) performed by the United States (US) Army Corps of Engineers; details of which can be found in Appendix A.

2.1 GENERAL DESCRIPTION AND TEST SITE LOCATION

Altus AFB is located in southwestern Oklahoma, just east of the city of Altus in Jackson County. Oklahoma City is approximately 140 miles to the northeast. Altus AFB encompasses approximately 5,900 acres. The Base is organized around a primary north-south runway with the support facilities to the west. Additional runways and taxiways have been constructed to the east of the primary runway. The primary mission of Altus AFB is to conduct training for strategic airlift and air refueling crews. In addition, Altus AFB maintains a worldwide air refueling capability to support the Air Forces's mission of providing global reach and power. Altus AFB provides instruction to the Air Force Reserve, National Guard, US Navy, Marines, Coast Guard, and Air Forces of allied nations.

A preliminary screening of the site and the field investigation indicated contaminant locations, site restrictions, and underground utilities limit the area available for the tree planting. Based on the screening, the proposed planting area is an area bounded by a paved road to the east, Buildings 507 and 508 to the west, and two east/west access roads to Facilities 507 and 508 to the north and south. Underground fuel and water lines run parallel to the paved road to the east, overhead electrical line runs at a diagonal to the west of the planting area running northwest to southeast, and the tree planting straddles an underground sewer line which runs parallel to the paved road. Descriptions of soil and groundwater conditions is limited to that information pertaining to this demonstration project.

2.2 PRECIPITATION

As summarized in Table 2.1, rainfall in the vicinity of Altus AFB occurs primarily in the spring with May being the wettest month. Annual precipitation averages approximately 25 inches (657 mm) per year.

TABLE 2.1
PRECIPITATION DATA (mm) FOR ALTUS, OKLAHOMA

**PHYTOSTABILIZATION DEMONSTRATION
WORK PLAN
SITE 2
ALTUS AFB, OKLAHOMA**

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sept	Oct	Nov	Dec	Annual
1993	NR ^{a/}	55.8	63.5	86.1	199.9	55.6	43.9	118.9	83.6	23.9	25.9	30.0	787.2
1994	4.8	29.7	53.6	103.1	63.0	30.0	41.9	15.5	39.4	46.5	130.3	6.9	564.6
1995	16.0	3.3	31.0	88.4	132.6	235.2	110.0	184.2	158.2	14.5	4.3	22.9	1000.5
1996	0.5	0.8	24.4	0.8	NR	103.6	189.8	170.9	118.6	46.5	36.1	1.2	697.5
1997	6.4	115.3	0.5	187.4	95.5	133.4	74.4	140.5	155.7	NR	14.5	NR	923.5
Avg. ^{b/}	20.8	23.7	37.5	63.0	106.7	93.5	46.6	64.0	73.1	70.5	32.3	24.6	657.4

^{a/} NR = not reported.

^{b/} Average precipitation compiled from 66 years of data between 1914 and 1995.

Source: Altus Irrigation Reservoir NCDC Station, Jackson County, Oklahoma (www.worldclimate.com).

2.3 TOPOGRAPHY

The land surface at Altus AFB is nearly level to gently sloping and generally lacks distinct features. Local relief is mostly the result of stream erosion. Surface elevations range from 1,330 feet to the south of the Base and 1,390 feet to the north end of the Base (separated by approximately 3 miles).

2.4 SUBSURFACE CONDITIONS

2.4.1 Soil Conditions

Surface soils near the proposed planting area consist generally of the Tillman and Hollister series. These series are characterized by clay soils with Permian red parent material.

Two primary geologic units are present below the site:

- Fill soils; and
- Hennessey shale (and its residual mantle).

The fill soils consist mainly of silty clay and sandy clay. The thickness of the fill is variable but averages about 5 to 8 feet. Thicker fills (10 to 15 feet) are found adjacent to subsurface structures such as the utility trenches that are present to the east and west of the planting area. Underlying the fill soils is the Hennessey shale and associated residual soil cover. The uppermost 5 to 20 feet of the unit generally consists of dark red clay/silty clay. Deposits below 10 to 20 feet in depth are generally described as red shale or silty shale. The shale contains various sized carbonate concretions and thin seams of gypsum.

These descriptions are consistent with the lithological data collected by the US Army Corps of Engineers during investigative activities in support of this demonstration (Appendix A). Soil classification based on cone penetrometer readings to a depth of 13 feet below ground surface (bgs) in the middle of the proposed planting area is described as red silty clay. The top of the weathered shale appears to be approximately 18 feet bgs.

No residual soil contamination has been identified near the planting area.

2.4.2 Groundwater Conditions

Two water bearing zones have been identified below the planting area, which correlate to the residual clay and shale of the Hennessey Group. The "upper water-bearing zone" consists of the geologic material between 0 and 20-feet bgs and the "lower water-bearing zone" consists of material encountered below 20-feet bgs. Based on similar hydrogeologic characteristics identified in previous investigations, it is not believed that these two units are distinct, but are part of the larger regional hydrogeological unit.

Groundwater is generally less than 10 feet bgs under the planting area. Groundwater flow is to the south-southeast at a horizontal gradient of approximately 0.0009 to 0.003 foot per foot (ft/ft). Both upward and downward vertical gradients have been identified between the upper and lower water-bearing material.

Aquifer tests performed during previous investigations resulted in hydraulic conductivity values of 3 to 5 feet per day (ft/d) for the upper zone and 1 to 2 ft/d for the lower zone. Using a hydraulic gradient of 0.002 ft/ft, a hydraulic conductivity of 3 ft/d and an effective porosity of 35 percent, the velocity of groundwater flow is expected to be approximately 6 feet per year.

Recent investigations performed by the US Army Corps of Engineers using a Site Characterization and Analysis Penetrometer System (SCAPS) in support of this demonstration indicate that dissolved phase TCE concentrations within the proposed planting area range from 4.3 to 4,800 micrograms per liter ($\mu\text{g/L}$) (Figure 2.1, Table 2.2, and Appendix A). The highest concentrations were detected to the north of the east/west access road leading to Building 508 (05HSPSD). Tetrachloroethene also was found in numerous monitoring points within the proposed planting area. Based on previous investigations, the contaminant source in this location is most likely the AGE Washrack Pond to the north and the storm sewer line which runs parallel to the paved road to the east of the proposed planting area (URS, 1997).

2.5 CANDIDATE PLANT SPECIES

The selection of plant species for phytostabilization at Altus AFB should be assessed using several criteria, including:

1. Potential for deep roots and potential to utilize groundwater;
2. Potential for phreatophytic, freely transpiring leaves;
3. Potential for transpiration during winter months (evergreen species);
4. Tolerance of anaerobic root-zone environments;
5. Rapid growth rates to maximize interception of solar radiation;
6. Reduced potential to spread and become problem weed species; and
7. Reduced attractiveness to birds.

The local species with the greatest potential for accelerating the attenuation of TCE-contaminated groundwater at Altus AFB are those with a capacity to access and utilize groundwater on a year-round basis. The use of groundwater by vegetation is primarily determined by the environment rather than by the type of plant. Atmospheric factors that can lead to groundwater utilization include a period of low rainfall during a period of high evaporative demand. Therefore, the meteorological conditions during the summer months at Altus AFB (Section 2.2) are very favorable for groundwater utilization. Equally important are the soil characteristics. A coarse-textured, permeable soil that facilitates oxygen transfer is critical to good root growth in lower

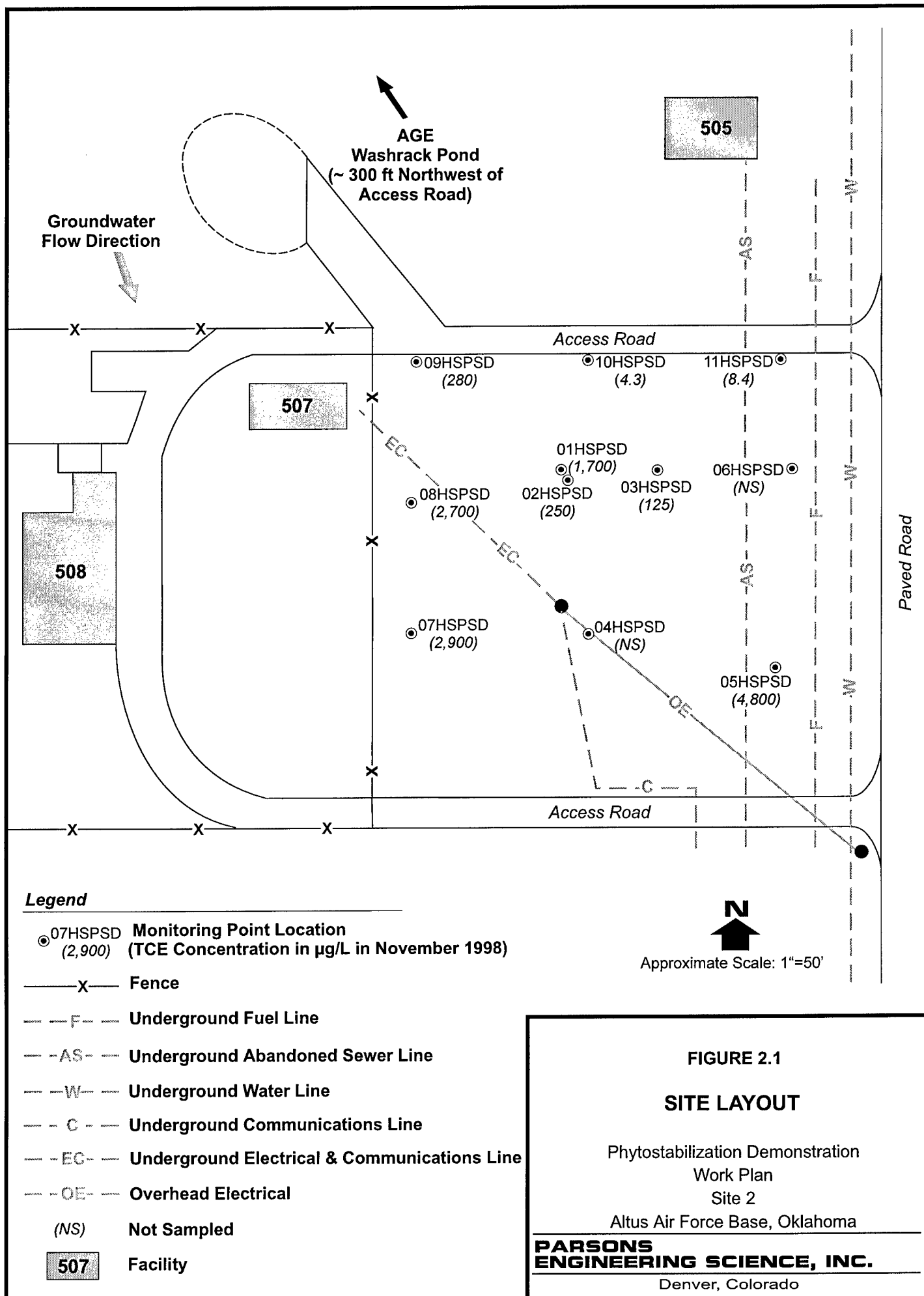


TABLE 2.2
MONITORING POINT DATA

PHYTOSTABILIZATION DEMONSTRATION
WORK PLAN
SITE 2
ALTUS AFB, OKLAHOMA

Location	Depth (ft bgs) ^{a/}	Static Water Level (ft bgs) ^{b/}	TCE (µg/L) ^{c/}	DCE (µg/L) ^{c/}	PCE (µg/L) ^{c/}
01HSPSD	16.8-19.8	8.0	1,700	350	510
02HSPSD	9-12	8.0	250	200	190
03HSPSD	9-12	7.9	125	79	87
04HSPSD	9-12	8.0	not sampled (dry at time of sampling)		
05HSPSD	7-12	8.2	4,800	2,200	4,800
06HSPSD	9-12	9.7	not sampled (dry at time of sampling)		
07HSPSD	9-12	8.3	2,900	1,900	2,000
08HSPSD	8-11	8.5	2,700	1,700	5,500
09HSPSD	7.9-17.5	8.4	280	70	110
10HSPSD	9-18.6	8.4	4.3	<5	2.4
11HSPSD	9-18.3	8.0	8.4	<5	2.0

a/ ft bgs = feet below ground surface.

b/ Static water level on November 10, 1998.

c/ Sampled in November 1998 by the US Army Corps of Engineers (Appendix A); µg/L = micrograms per liter.

soil layers. In low permeability soils, passive air vents can be used to create aerobic conditions.

Because there is little information on differences among plant species for the uptake of organic compounds, the selection of species for phytoremediation should be based primarily on maximizing the uptake of groundwater. Phreatophytic species (also called phreatophytes) are defined as those species that are freely transpiring. This means that the stomates (pores in the leaves that exchange water vapor and CO₂ with the atmosphere) are open in a wide range of environmental conditions. Most plant species partly close their stomates during hot dry periods so that the plant can conserve water. In order for phreatophyte species to be freely transpiring they must also have the ability to access significant amounts of water through their root systems. This means that they have vigorous root systems. These root systems can grow laterally for great distances or have deep roots, which can proliferate in the capillary fringe above the groundwater. Selection of phreatophyte species should potentially increase the utilization of groundwater when environmental factors (periods of drought) place stress on the plant.

Several plant species are known to grow well in areas that have shallow groundwater and these species are generally considered to be phreatophytes. These species include many species in the Saliceae (willow) family, particularly plants in the *Populus* genus (cottonwood and poplar) and the *Salix* genus (willows). These species commonly grow along streams and are thought to access water in low-oxygen root-zone environments. Unfortunately, all of these species are deciduous (drop their leaves in the winter) and would not use groundwater in the winter months. Because of their year-round water uptake, evergreen species are often better choices than deciduous species for phytoremediation. However, transpiration rates in evergreen species would be significantly lower in the winter, because of the dormant state of the trees.

Although we have a limited understanding of the ability of specific types of trees to access groundwater, there is some information available on the ability of species to tolerate the anaerobic conditions associated with flooding. If deep rooting of these species can be encouraged, they should have the potential for root growth into the anaerobic groundwater region. Flood tolerance implies that the plants can survive in flooded (i.e., low oxygen) environments. The rooting pattern of the plants will be dependent on environmental conditions (i.e., soil type, rainfall patterns). The roots will be found in both anaerobic and aerobic zones. Roots in the anaerobic zone will be depleted of oxygen and become stressed. Roots in the aerobic zones would be able to supply oxygen to the root cells only as necessary for growth and survival. Oxygen for the remaining portions of the plant is obtained primarily above grade. Broad-leaf trees generally tolerate flooding better than most conifers, but there are exceptions.

Transpiration rates are largely determined by interception of solar radiation by the surface of leaves. Radiation falling on the ground does not cause transpiration and does little to increase surface evaporation because the soil surface usually quickly dries out. Thus species with rapid growth rates in the semi-arid environment at Altus AFB are crucial to maximizing the use of groundwater. Rapidly growing trees have fragile branches, but they form new leaves quickly. This leads to rapid interception of solar radiation, which leads to high transpiration rates. Many tree species have rapid growth rates. The growth rates and proliferation of some of these species are so rapid that they

are considered to be problem weed species in most states. These species include tamarisk (*Tamarix chinensis*) and siberian elm (*Ulmus pumila*). These species are not recommended because of the potential to spread beyond the planted area and become problem weeds.

Other deciduous species with fairly rapid growth rates that are adapted to various soil conditions (e.g., moist or dry) and would probably utilize groundwater are Eastern cottonwood (*Populus deltoides*), silver maple (*Acer saccharinum*), river birch (*Betula nigra*), and sandbar willow (*Salix exigua*). Evergreen species that prefer or are adaptable to moist and poorly drained soils include loblolly pine (*Pinus taeda*) and Austrian pine (*Pinus nigra*).

Based on the preceding discussion, the following attributes should be considered in selecting the type of vegetation to be used in a phytoremediation system:

- Trees that are considered phreatophytic or freely transpiring (e.g., willows, cottonwoods, poplars);
- Trees that can maximize transpiration throughout the year (e.g., evergreens as opposed to deciduous trees that drop their leaves);
- Trees that are considered flood and drought tolerant;
- Trees that are rapidly growing;
- Trees that are tolerant of high salinity conditions that could exist in soil and groundwater; and
- Trees that are native or adapted to the climate and soils of the region.

It is apparent that there are many contributing factors to selecting possible types of vegetation to be used. As stated earlier, little information on differences among species for the uptake of organic compounds is available. Therefore, a rapidly growing tree, which is adapted to the region, should be used. Keeping this in mind it is recommended that the Eastern cottonwood (or one of its hybrids) be used. Characteristics of these species are detailed below.

Eastern cottonwood or one of its hybrids would be a good choice to use at Altus AFB; however, a seedless (i.e., cottonless) cultivar should be chosen to eliminate problems with flying cotton on the runways. Some hybrid crosses, such as Eastern cottonwood and black cottonwood (*Populus trichocarpa*) produced leaves that are four times larger than the parent plants, increasing transpiration rates. Advantages of using Eastern cottonwood include: 1) grows quickly, 4 to 5 feet per year; 2) has high transpiration rates; 3) extends taproots and lateral root systems quickly; 4) tolerates pollutants and high salinity in soil and groundwater, which occur with frequent irrigation; and 5) degrades organics, such as TCE, by enzymes in plant membranes. One disadvantage of using cottonwoods is that transpiration will cease during the winter months.

Eastern cottonwoods grow to an average height of 60 to 100 feet (18 to 30 meters) and an average width of 40 to 75 feet (12 to 23 meters). The tree form is upright spreading with an oval to rounded crown. It is a short-lived species and trees over 70 years old deteriorate rapidly. A fast growth rate of 4 to 5 feet (1.2 to 1.5 meters) per year in rich, moist soil is not uncommon for the Eastern cottonwood, and two-year-old trees may attain heights of 30 feet (9 meters). Male cottonwood (i.e., cottonless) cultivars grow slower; between 2 to 4 feet (0.6 to 1.2 meters) per year. With optimal conditions, 35-year-old Eastern cottonwood trees may average 20 inches (51 centimeters) in caliper and 130 feet (40 meters) in height. Eastern cottonwood prefers growing in moist, well-drained soil. However, it tolerates a wide range of soils. The groundwater in the region typically contains significant amounts of total salts, and the salinity of the soil and groundwater at the site may increase due to irrigation or as the trees remove groundwater. The cottonwood cultivar will tolerate these increasing saline conditions.

Cottonwoods are prone to disease and insects, so locally-grown native trees should be used. Cottonless cottonwood varieties that are available from nurseries in Oklahoma include the cultivars 'Siouxland,' 'Robusta,' and 'Noreaster.' All of these cultivars are seedless and grow quickly. Many Oklahoma nurseries carry 5-gallon container stock (6- to 8-foot tall trees); however, 1.25- to 3-inch caliper trees (e.g., 10- and 15-gallon container, ball and burlap) may be available. Planting is usually done from November to March. Young cottonwood trees are highly susceptible to deer browsing, so appropriate precautions should be taken to limit damage. Based on current availability from local nurseries, the 'Noreaster' will be specified for use during this project.

SECTION 3

PROPOSED PLANTING

3.1 BASIS OF DESIGN

The field objective of this demonstration project is to establish whether engineered tree plantings can hydraulically control the movement of contaminated groundwater. Therefore, the basis of design for the tree plantings needs to be developed with the intent of providing a system conducive to deep root penetration and the use of contaminated groundwater for transpiration. The following sections provide additional detail with respect to the rationale used to design and configure the plantings with these objectives in mind.

3.1.1 Groundwater Interception

3.1.1.1 Simplified Transpiration Model

Transpiration is fundamentally driven by the input of solar radiation. Transpiration is a physical process that follows the first law of thermodynamics: energy use equals energy output. A reasonable estimate of the maximum potential transpiration rate can be made for Altus AFB by assuming that 100 percent of the solar energy per plant (leaf) unit area is used to evaporate water.

Thus:

$$\text{TRANSPIRATION} = (\text{Daily incident solar radiation in Megajoules [MJ] per square meter of leaf surface per day [25 MJ/m}^2\text{-d]}) / (\text{The latent heat of vaporization of water [2.45 MJ/L]})$$

Substituting typical values for solar radiation in the Altus region indicates a potential transpiration rate of about 10 liters per square meter per day (L/m²-d) (3,650 liters per square meter per year [L/m²-yr]) during the summer months (Oklahoma Climatological Survey, 1998). This decreases to about 4 L/m²-d in the spring and fall (1,460 L/m²-yr), and to about 2 L/m²-d (730 L/m²-yr) in the winter (for non-dormant species only).

Evapotranspiration rates for the Altus region range from 600 L/m²-yr (dry land) to 1,950 L/m²-yr (potential evapotranspiration) (Hauser, 1998). This high transpiration rate would be achieved only when vegetation covers more than about 95 percent of the soil surface. With a dense planting of young, fast-growing trees, this 95-percent interception of incoming radiation might be achieved in about 3 years. With a less dense planting of trees, good radiation interception would take 4 to 5 years.

Vegetation with ready access to water in the top 1 foot of soil would typically reach these potential transpiration rates. However, forcing the vegetation to utilize groundwater means that the plants would have a lower water potential and may not achieve this high potential transpiration rate. This is true even with the freely transpiring phreatophytic vegetation, because the stomates would close to prevent water loss from exceeding the rate at which water can be taken up by the roots. The transpiration rate could be reduced by 40 to 50 percent if the plants must draw water from capillary fringe above the groundwater table. This would result in a transpiration rate of about 1,000 L/m²-yr. With annual precipitation averaging around 660 millimeters per year (mm/yr) (equivalent to 660 L/m²-yr) (Table 2.1), the amount of groundwater transpired would equal approximately 340 L/m²-yr (groundwater utilization rate = transpiration - precipitation).

3.1.1.2 Groundwater Flow Estimates

In order to estimate the volume of contaminated groundwater that must be intercepted by a strip of trees planted perpendicular to the plume flow line at Site 2 the plume geometry was assumed to have a width of 300 feet (see Section 2.4.2). A depth of 10 feet was assumed to be the maximum depth to which vegetation may influence the system below the current groundwater table. Actual influence may be higher or lower than this value. This demonstration project will attempt to elucidate this value. With this geometry, the volume of contaminated groundwater passing through the aquifer cross-section at the location of the planted strip can be estimated using Darcy's Law to estimate groundwater velocity at the site. Input for the calculation of groundwater velocity includes hydraulic gradients (i) of 0.0009 to 0.004 ft/ft, aquifer conductivity (K) of 1 to 5 ft/d, and aquifer effective porosity (n) of 0.35 (URS, 1997). With these input values, a range of groundwater velocities can be estimated for the measured K values that apply to the silty clays present below the site. Using these calculated groundwater velocities, the volumetric groundwater flow rate passing through the plume cross-section, assumed to be 300 feet wide and 10 feet thick, can be estimated as the product of the groundwater velocity and the 3,000-square-foot (ft²) cross-sectional area. Table 3.1 summarizes the results of groundwater velocity and flow rate estimates using a range of hydraulic gradients and hydraulic conductivities.

Using these groundwater flow rate estimates and the estimated groundwater utilization rate of trees at Altus AFB of 340 L/m²-yr, the planting area required to intercept this groundwater flow can then be calculated. These calculations are summarized in Table 3.2. It should be noted that during the winter months, transpiration rates will decrease significantly or stop entirely, depending on the dormancy of the vegetation. Thus, hydraulic control of the contaminant plume may not be as effective during the winter months.

From these planting area estimates, a planting configuration footprint can be estimated. These calculations are summarized in Table 3.3. The "Width of Planting Area" values were calculated assuming that plantings would occur across the entire 300-foot width of the plume. The "Number of Trees Required" values were calculated assuming that plantings would occur on 10-foot centers (used for number of trees per row [i.e., 30 trees]) and have a 20-foot-diameter coverage (used for row numbers)

TABLE 3.1
ESTIMATED GROUNDWATER VOLUMETRIC FLOW RATES

**PHYTOSTABILIZATION DEMONSTRATION
WORK PLAN
SITE 2
ALTUS AFB, OKLAHOMA**

Average Groundwater Gradient (ft/ft) ^{a/}	Hydraulic Conductivity (ft/d) ^{b/}	Effective Aquifer Porosity	Total Plume Cross- Section (ft ²) ^{c/}	Effective Plume Cross- Section (ft ²)	Groundwater Velocity (ft/d)	Volumetric Groundwater Flow Rate (gal/d) ^{d/}
Low Estimate						
0.0009	1	0.35	3,000	1,050	0.003	24
Average						
0.002	3	0.35	3,000	1,050	0.02	160
High Estimate						
0.004	5	0.35	3,000	1,050	0.06	470

a/ ft/ft = foot per foot.

b/ ft/d = feet per day.

c/ ft² = square feet.

d/ gal/d = gallons per day.

TABLE 3.2
ESTIMATED PLANTING AREA REQUIRED TO
INTERCEPT VOLUMETRIC FLOW

PHYTOSTABILIZATION DEMONSTRATION
WORK PLAN
SITE 2
ALTUS AFB, OKLAHOMA

Groundwater Flow Rate (gal/d) ^{a/}	Groundwater Flow Rate (L/yr) ^{b/}	Plant Transpiration Rate (L/m ² -yr) ^{c/}	Required Plant Area (m ²) ^{d/}	Required Plant Area (ft ²) ^{e/}
Low Estimate				
24	33,000	340	97	1,000
Average				
160	220,000	340	650	7,000
High Estimate				
470	650,000	340	1,900	20,000

a/ gal/d = gallons per day.

b/ L/yr = liters per year.

c/ Average rate; plant transpiration rates will decrease significantly or stop entirely during the winter months.
L/m²-yr = liters per square meter per year.

d/ m² = square meters.

e/ ft² = square feet.

TABLE 3.3
CONFIGURATION OF PLANTING AREAS AND CORRESPONDING NUMBER
OF TREES REQUIRED TO INTERCEPT VOLUMETRIC FLOW

PHYTOSTABILIZATION DEMONSTRATION
 WORK PLAN
 SITE 2
 ALTUS AFB, OKLAHOMA

Required Plant Area (ft ²) ^{a/}	Width of Planting Area (feet)	Number of Tree Rows	Number of Trees
Low Estimate			
1,000	3	1	30
Average			
7,000	23	1-2	30-60
High Estimate			
20,000	67	3-4	90-120

^{a/} ft² = square feet.

area when mature. Once established, the number of trees could be thinned if unhealthy overcrowding was evident.

As can be seen from the calculations in Table 3.3, a range of planting requirements with up to 4 rows of trees, 300 feet long (or a total plant coverage area of 20,000 ft²), would be required to intercept the contaminated groundwater flowing below the site (using a transpiration rate of 340 L/m²-yr and a groundwater flow volume as high as 650,000 L/yr (470 gal/d). Based on the preliminary screening, the final configuration of the planting area is limited by contamination location and site restrictions.

3.2 PLANT SPECIES

Based on the discussion presented in Section 2.5, a cottonwood hybrid (specifically the cultivar 'Noreaster') will be used.

3.3 LAYOUT AND PLANTING PIT DESIGN

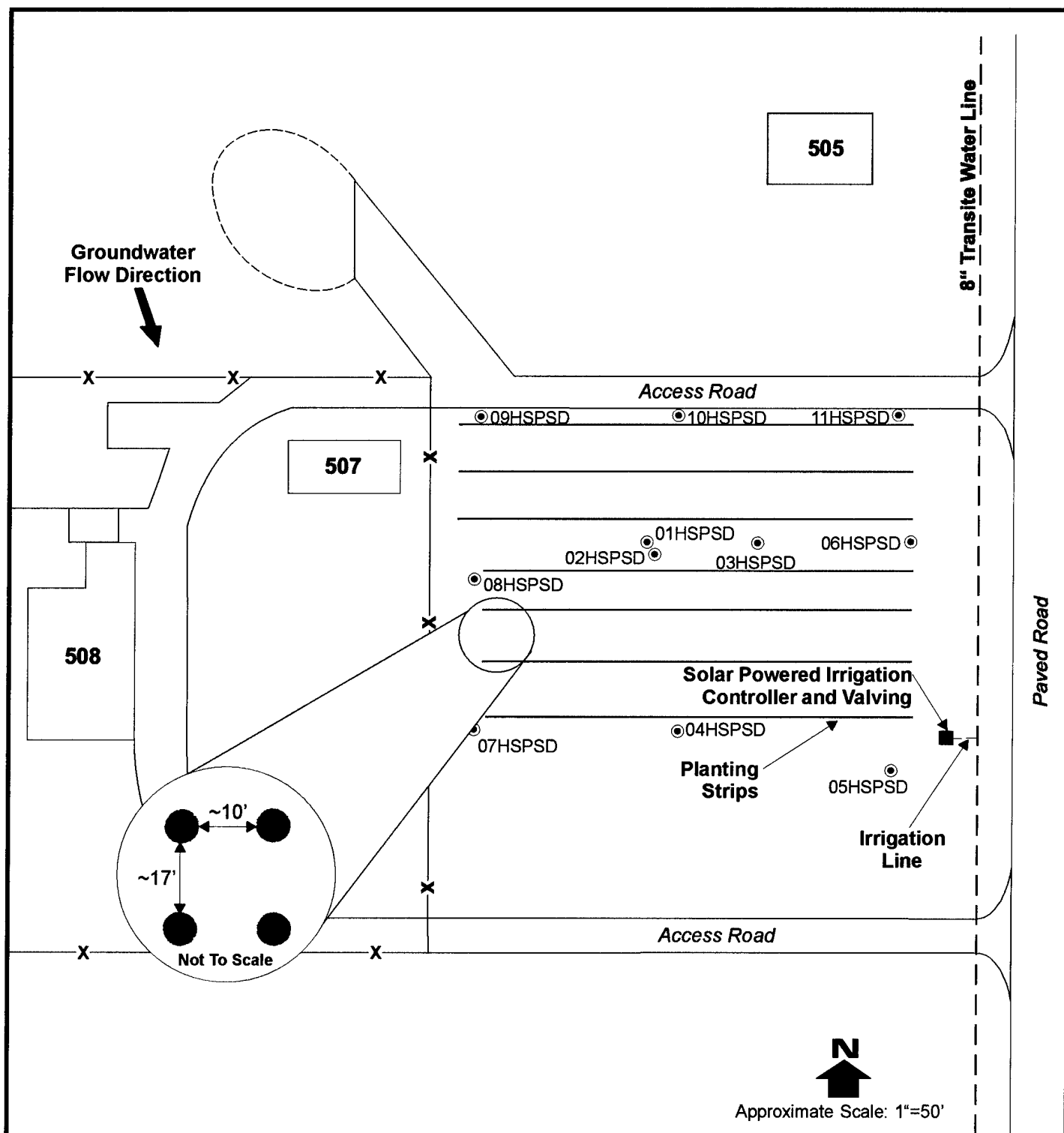
The ability of plants to directly utilize groundwater depends mainly on environmental conditions (e.g., a period of low rainfall during a period of high evaporative demand). A permeable soil that facilitates oxygen transfer also is critical for good root growth in deeper soil layers.

Section 3.1.1.2 and Figure 3.1 provide a detailed description of the proposed layout of the engineered plantings. Site restrictions due to underground and above ground utilities requires a non-uniform planting be established. The following configuration is illustrated on Figure 3.1 (each tree on approximately 10-foot centers with rows spaced approximately 17-feet apart):

- Row 1 (R1) - 16 Trees (T1 - T16)
- Row 2 (R2) - 16 Trees (T1 - T16)
- Row 3 (R3) - 16 Trees (T1 - T16)
- Row 4 (R4) - 15 Trees (T1 - T15)
- Row 5 (R5) - 15 Trees (T1 - T15)
- Row 6 (R6) - 15 Trees (T1 - T15)
- Row 7 (R7) - 15 Trees (T1 - T15)

This planting configuration maximizes the use of available space and is placed as closely as possible to the storm sewer to the east of the site presumed to be a preferential conduit for the transport of contamination. A total of 108 trees will be planted which will result in coverage of approximately 20,000 ft².

This will also provided added distance (100 feet from first row to last row) to intercept groundwater which has migrated during periods of low transpiration (approximately 4 to 6 months during the winter). Groundwater will move approximately 30 to 40 feet during this time period without treatment. Designing the planting width at a total of 100 feet (seven rows separated by 17 feet each), allows for the possibility of groundwater interception and treatment after the period of low transpiration (winter season).



Legend

- 07HSPSD Monitoring Point Location
- x— Fence
- Road
- 507** Facility

FIGURE 3.1

MONITORING POINTS AND PLANTING STRIP LOCATIONS

Phytostabilization Demonstration

Work Plan

Site 2

Altus Air Force Base, Oklahoma

**PARSONS
ENGINEERING SCIENCE, INC.**

Denver, Colorado

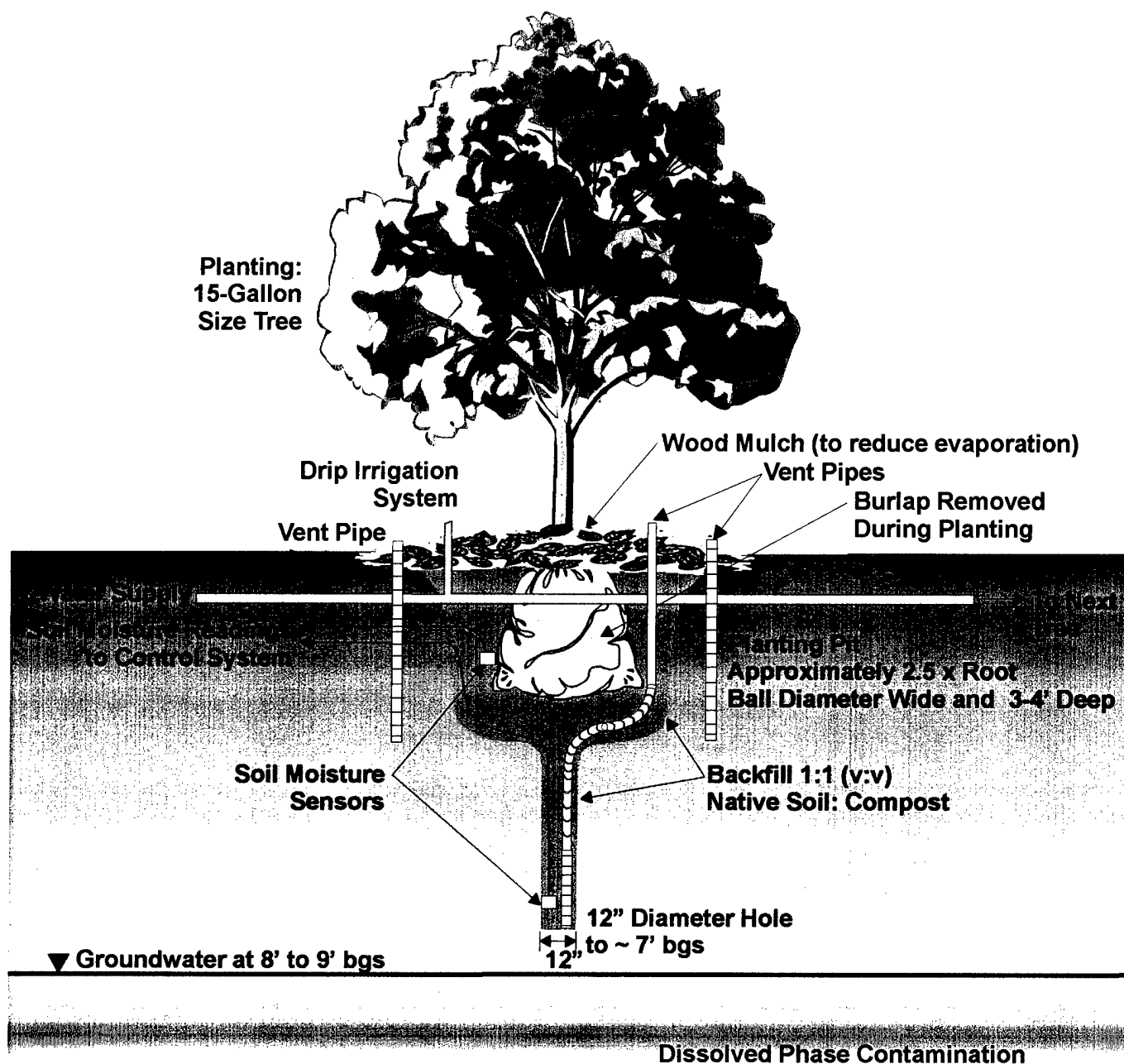
To increase the potential use of groundwater by planted trees, an engineered approach is to be used to modify the planting pit for 83 of the 108 (approximately 75 percent) trees in the planting strip. A planting pit approximately 2.5 times the diameter of the root ball will be excavated to a depth of approximately 3 to 4 feet bgs. This will be the main hole for tree planting. To enhance the vertical migration of roots, a 12-inch diameter hole will be augured to a depth of approximately 7 feet bgs (approximately 1 foot above the water table) starting at the base of the main planting pit. The entire planting pit will be backfilled with a equal volume of native soil and compost which is suitable for good plant growth and will increase the permeability of the planting pit compared to the surrounding area. Passive air inlet wells (3-inch diameter) will be placed in each planting pit with perforations from 3 to 8 feet bgs to provide oxygen to the subsurface directly below the trees. Additional aeration holes will be placed 3 feet to the west and east of each planting pit to a depth of 5 feet bgs. Passive air inlet wells (3-inch diameter perforated pipe) will be placed in each hole to provide oxygen to the subsurface to promote lateral and vertical root growth. An illustration of this design has been provided as Figure 3.2. The 25 remaining pits will be constructed without the 8-foot 12-inch diameter hole containing the central vent pipe. The progress of each type of planting pit will be monitored during the demonstration. Additional details can be found in Appendix B.

3.4 IRRIGATION SYSTEM

An irrigation system will be required for a minimum of three years after the initial planting to supply water to the growing trees. It is anticipated that the amount of water added to the system will decrease with increasing age of the tree to enhance the migration of the roots to the groundwater table. It is necessary that this system supplies sufficient water to ensure the health of the trees during the first three years while minimizing the amount of water added to the groundwater system to avoid displacement/dilution of the dissolved contaminants.

Initially, it is estimated that each tree will required approximately 1 to 1.5 gallons of water per day for irrigation (100 to 150 gallons of water per day for 100 trees) (Hauser, 1998). The water will be provided by tapping into a potable water line approximately 30 feet to the east of the tree plantings (see Appendices B and C and Figure 3.1). Based on conversations with local service providers, the most efficient means of irrigation water delivery to individual plants is through drip irrigation with multiple emitters on or near the surface of each tree basin. The design of the planting pits is such to increase the vertical flow of irrigation water applied at the surface to the deeper regions below the root ball. The tree plantings will be divided into four zones for more discrete control of watering (see Appendix C).

The application of water will be controlled by a programmable solar powered controller (Appendix C). The amount of irrigation water applied to the trees will be dependent on physical inspection of the trees by a local service provider. Current and anticipated weather conditions will be taken into account when scheduling the irrigation frequencies. It is anticipated that the amount of irrigation water applied to the plantings will be substantially reduced in years 2 and 3 of the project to facilitate the trees use of groundwater.



Not To Scale

FIGURE 3.2

PLANTING DESIGN

Phytostabilization Demonstration
Work Plan
Site 2
Altus Air Force Base, Oklahoma

**PARSONS
ENGINEERING SCIENCE, INC.**

Denver, Colorado

3.5 MAINTENANCE ACTIVITIES

Maintenance activities for the tree plantings will be provided by a local service provider. Details regarding the maintenance activities to be performed can be found in Appendices B and C. Watering of the trees will be completed automatically as described in Section 3.4. The schedule of maintenance activities is required to be submitted by the local provider prior to beginning field activities. This will be distributed to AFCEE and Base upon receipt. In summary, maintenance activities will consist of the following activities:

- Periodic walk throughs observing the general condition of the plant material and irrigation system noting any concerns;
- Pruning of the trees as necessary
- Inspections of the stakes and guys;
- Weed control within the tree basins; and
- Insect and disease control.

Replacement of any dead trees will be provided on an as need basis by the local service provider.

SECTION 4

MONITORING ACTIVITIES

Numerous activities will be occurring over the first three years of operations, maintenance, and monitoring (OM&M). A large portion of the monitoring activities will be automated using a data acquisition system integrated with the irrigation controller. A smaller portion of the monitoring will take place annually during schedule site visits. A summary of these monitoring activities is provided in Table 4.1 with the data collected being used as described in Section 5.1. The following sections briefly describe these activities. Additional detail regarding monitoring locations can be found in Appendix C. All activities will be conducted under the guidelines of the project *Health and Safety Plan* found in Appendix D. In addition, all automated monitoring activities are described in more detail in Appendix E.

4.1 SOIL

4.1.1 Soil Moisture

Plant growth, soil temperature, chemical transport, and groundwater recharge are all dependent on the state of water in the soil. The best measure of the state of water in the soil for irrigation purposes is the soil's water potential. The water potential is an expression of the energy state of the water in the soil and the ease with which plants can utilize such water. Free water or gravitational water will drain from a soil until the soil water potential reaches approximately -0.3 atmospheres (atm). This is called the field capacity. As the soil continues to dry (i.e., used by plants), more and more energy is needed by the plants to remove the water. The wilting point is the water potential at which a plant can no longer remove water and usually occurs around -15 atm. Thus, the water potential in the soil is an important variable in understanding the plant-soil-groundwater relationship.

Soil moisture will be measured with granular matrix sensors, which use electrical conductance as an indirect measure of water potential. Soil moisture will be monitored at two depths (10 inches [mid-point of root ball depth] and 6 feet bgs) within each of four pits at the site. Soil moisture readings will be measured and recorded at a frequency of once per hour for three years after the initial planting.

4.1.2 Root Distribution

Roots typically take up more water per unit surface area from shallow roots than from deep roots (Thornley and Johnson, 1990). However, during periods of drought the surface water is depleted more rapidly than the deep water and water uptake per

TABLE 4.1
SUMMARY OF MONITORING ACTIVITIES
PHYTOSTABILIZATION DEMONSTRATION
WORK PLAN
SITE 2
ALTUS AFB, OKLAHOMA

Medium	Type	Number	Frequency
Soil	Soil Moisture	4 locations at 2 depths each	1/hr ^{a/} in OM&M ^{b/} Years 1, 2, and 3
	Root Distribution	2 locations	1/Year in OM&M Years 2 and 3
	pH	6 locations at 2 depths each	1/Year in OM&M Year 3
	TOC ^{c/}	6 locations at 2 depths each	1/Year in OM&M Year 3
	Chloride	6 locations at 2 depths each	1/Year in OM&M Year 3
	Moisture Content	6 locations at 2 depths each	1/Year in OM&M Year 3
Groundwater	SWL ^{d/}	2 locations	1/hr in OM&M Years 1, 2, and 3
	SWL	10 locations	1/Year in OM&M Years 1, 2, and 3
	CAHs ^{e/}	10 locations	1/Year in OM&M Years 2 and 3
Tree	Growth	10 locations	1/Year in OM&M years 1, 2, and 3
	Sap Flow	2 locations	1/Week in March, July, and September in OM&M Years 2 and 3

^{a/} 1/hr = once per hour.

^{b/} OM&M = operation, maintenance, and monitoring.

^{c/} TOC = total organic carbon.

^{d/} SWL = static water level.

^{e/} CAHs = chlorinated aliphatic hydrocarbons.

unit surface area from deep roots can be greater than from shallow roots (Thornley and Johnson, 1990). The relative advantage of shallow roots (per unit surface area) may not be as great in regions with prolonged droughts. Conversely, in drought conditions, the deep roots typically allow the plant to maintain only a minimum hydration state rather than supply a significant amount of water for transpiration. Even if the water uptake of the deep roots was double that of the surface roots on a surface area basis, they would still contribute only a small portion of the annual plant water supply. During periods of increased rainfall, the surface roots typically contribute a disproportionately large fraction of the plant water supply because it requires less energy to draw water from shallow soil than from deep soil layers. This could limit the interaction of the vegetation with the contaminate media.

To evaluate the root distribution in the subsurface during this demonstration, a limited intrusive survey will be conducted in years 2 and 3 of OM&M. The limited intrusive survey will be completed by hand coring or augering through two planting pits to qualitatively evaluate the total depth and density of the roots. Field logs will be maintained at each borehole describing the general density of roots with depth and will record the characteristics of the roots (e.g., size, color, etc.).

4.1.3 Soil Quality

The most important process for the natural biodegradation of the more highly chlorinated solvents is reductive dechlorination. During this process, the CAHs are used as electron acceptors, not as a source of carbon, and a chlorine atom is removed and replaced with a hydrogen atom. This results in chloride concentrations in the system which are elevated relative to background concentrations. As was indicated in the overview, microbial degradation of TCE occurs under both anaerobic and aerobic environmental conditions. The plant rhizosphere contains an abundance of organic compounds, originating from both plant deposition and microbial metabolism. Anaerobic micro-sites are commonly found throughout aerobic rhizosphere (root-zone) regions. Although optimal conditions are uncommon, comparisons of TCE mineralization in planted versus unplanted soil suggest that vegetation may accelerate TCE degradation (Walton and Anderson, 1990). Conditions in the rhizosphere may therefore favor reductive dechlorination of TCE using natural organic matter deposited by the vegetation as electron donors. Thus, the conditions in the rhizosphere may result in elevated degradation of CAHs compared to non-vegetated areas which would cause localized, elevated regions of chloride concentrations. Newman *et al.* (1998) observed this phenomenon in pilot-scale systems planted with hybrid poplar, native western poplar, and black locust.

Because the CAH is used as an electron acceptor, an electron donor is needed. This can be anthropogenic compounds (e.g., landfill leachate, fuel hydrocarbons) or it can be from natural sources (e.g., vegetation). As subsurface biomass of the vegetation degrades or the vegetation exudes low molecular weight organic compounds, the dissolved or particulate organic carbon (DOC [$< 0.45 \mu\text{m}$] or POC [$> 0.45 \mu\text{m}$]) is transported to the groundwater adding natural carbon to system. In systems where the conditions for reductive dechlorination are favorable, this carbon addition may act to locally increase the biodegradation of the contaminants. A stand of trees may serve as a large enough source of organic carbon to impact the migration of contaminants

through mineralization. Lee *et al.* (1998) observed this below a mature cottonwood tree in Texas. In this study it was concluded that a microbially mediated iron-reducing environment capable of degrading TCE had developed from the natural organic carbon being released from the rhizosphere.

Soil quality measured as chloride content and total organic carbon (TOC) content will be collected in year 3 of OM&M to evaluate the potential effect of the rhizosphere on the system. Six samples will be collected within (three locations at two depths each) the planted area and six samples (three locations at two depths each) outside the planted area for comparison purposes. Samples will be collected via hand coring or augering techniques and analyzed in a commercial laboratory.

4.2 GROUNDWATER

4.2.1 Water Level Measurements

The most direct evidence of a plant use of groundwater and potential effectiveness at controlling the migration of a contaminant plume is a localized depression of the groundwater table. As in pump-and-treat remediation schemes, the cone of depression developed by groundwater extraction wells serve to locally reverse the hydraulic gradient of the groundwater thereby stopping or minimizing the downgradient migration of contaminants in that area. This is the ultimate goal of this phytostabilization project.

To assess the impact of the tree plantings on the groundwater table, static water level (SWL) of the groundwater will be measured continually utilizing pressure transducers within two monitoring points at the site. These two monitoring points are intended to establish whether localized depressions exist due to the trees transpiration of groundwater and whether the trees create daily cycles of groundwater elevation change. One location will be within the planted area (02HSPSD) and one location will be outside the planting area (11HSPSD). Measurements will be collected at a frequency of once per hour for the first three years after the initial planting via the data acquisition system. These measurements will be stored in a data logger location in the field and downloaded in computer compatible form at least four times per year.

Once each year, water levels will be measured in all available wells surrounding the trees to assess groundwater depression on a larger scale, flow direction, and rate in the portion of the plume beneath the tree planting.

4.2.2 Ground Water Quality

Groundwater quality changes due to the presence of vegetation is important aspect when evaluating the effectiveness of phytostabilization. These changes can be measured by collecting samples upgradient and downgradient of the planting area and comparing the results. To this end, groundwater samples will be collected upgradient (09, 10, 11HSPSD), within (01, 02, 03, 06, 08HSPSD), and downgradient (04, 05, and 07HSPSD) of the planting area. Groundwater samples will be analyzed for chlorinated hydrocarbons utilizing US Environmental Protection Agency (USEPA) Method 8260 in a commercial laboratory. Groundwater samples will be collected in years 2 and 3 of OM&M.

4.3 TREES

4.3.1 Growth Characteristics

The foundation of success of any engineered tree plantings will be the health and growth characteristic of the vegetation planted. These growth characteristics provide an indication of the effectiveness in establishing the trees in the area and their ability to survive over the long term. In addition, parameters such as canopy diameter can be used to refine and calibrate a water balance model with an aboveground biomass component. Tree growth characteristics including tree height, tree diameter, and canopy diameter will be recorded on an annual basis from at least 10 trees at the site. In addition, photo documentation will be maintained for a number of the trees (Appendix C).

4.3.2 Transpiration Stream

Direct measurement of transpiration allows for the determination of how much water the tree is actually transpiring. These values can be compared versus potential transpiration rates and can be used to further refine water balance models. In addition, if the water being transpired can be proportioned between surface water sources (precipitation and/or irrigation) and subsurface source (groundwater) direct measures of transpiration can be used to quantify the amount of groundwater being removed by a planting system. This can be used in groundwater and contaminant transport models to predict the effectiveness of engineered phytostabilization systems. Additionally, the direct measurement of transpiration during periods of low rainfall or drought will provide an indication of alternative sources available to the plant (i.e., if transpiration is still occurring at a relatively high rate during periods of drought, groundwater may be satisfying the plant's needs).

Direct measurements of transpiration are usually performed on individual trees. Transpiration can be determined by measuring the rate of water movement through the stem of trees. The most common methods use a heat balance as the estimating tool. Four common methods include:

1. Stem Heat Balance Method;
2. Trunk Sector Heat Balance Method;
3. Heat-Pulse Method; and
4. Thermal Dissipation Method.

These four methods have been reported to be accurate to within 10-percent (Smith and Allen, 1996). Common sampling apparatus produced by Dynamax (Houston, Texas) make use of the Stem Heat Balance Method which is summarized below:

1. The stem is heated electrically via a thin flexible heater that encircles the stem.

2. At steady state, this heat input is balanced by heat fluxes out of the stem which consist of:
 - Conduction up the stem;
 - Conduction down the stem;
 - Conduction radially out of the stem; and
 - Convection in the moving transpiration stream.
3. The heat balance is solved for the amount of heat taken up by the water moving up the stem, which is then used to calculate the mass flow of water being transpired (Smith and Allen, 1996; Baker and Nieber, 1989).

Commercial instruments are available in multiple sizes which allow any number of trees to be measured at one time for any period of time. The data is stored electronically and then downloaded to calculate transpiration rates. Once transpiration measurements are made it is often necessary to extrapolate the small sample set to an entire stand (e.g., a rows of trees planted for phytostabilization). To do this, it is often most convenient to convert the transpiration flow measurements (per tree) to transpiration per unit area of land covered by a canopy (e.g., $L/d\cdot m^2$). In uniform stands of monoculture vegetation and closed canopies, the transpiration is not likely to vary significantly among members. The measurement of a few trees can be used to estimate total stand transpiration by plant density (Smith and Allen, 1996). The trees planted at the site are a single species, therefore measurements made on two trees may be extrapolated to the entire stand.

Sap flow will be measured on two trees at the Site in OM&M years 2 and 3 utilizing the Stem Heat Balance Method or equal procedure. Readings will be taken at a frequency of 1 per hour by a modified SapFlow2[®] system produced by Dynamax (Houston, Texas) or equivalent equipment. Minimum measurements will include data collection for one week during March, July, and September (years 2 and 3 only).

SECTION 5

DATA ANALYSIS AND REPORT PREPARATION

5.1 DATA ANALYSIS

As stated in Section 1, the two primary objectives for this project are as follows:

1. Demonstrate the ability or inability of engineered tree plantings to hydraulically control groundwater through field measurements; and
2. Utilizing the field measurements, refine and calibrate a water balance model to be used as a screening and evaluation tool for phytostabilization at other Air Force sites (to be completed by others).

The data gathered during this demonstration will be used to qualitatively and quantitatively assess the trees ability to hydraulically control groundwater. The data will be compiled and assessed to determine phytostabilization effectiveness. Section 4 provides detail regarding the usefulness of each of the variables measured for these purposes. When possible, quantitative estimates of phytostabilization effectiveness will be made.

In addition, the data collected will be utilized by the Air Force to refine and calibrate a water balance model. Tree growth data, sap flow data, and meteorological data will be used to calibrate the water balance model. Once calibrated, the water balance model will be used to predict phytostabilization effectiveness at the site in the future. In addition, the ability of the model to predict phytostabilization effectiveness at other sites will be assessed.

5.1.1 Data Validation

All data will be validated for their quality and for their acceptability for their intended use. When applicable, measures of data quality and the criteria for determining their acceptability for the data quality objectives are described in the *Analytical Quality Assurance Project Plan for Remedial Design/Remedial Action, Long-Term Monitoring, and Long-Term Operations Programs* (Radian, 1996) (Adapted from Travis AFB, California). The goal of the data validation/quality assurance (QA) program is to provide data of sufficient quality that they can be used to make a quantitative assessment of the potential effectiveness of phytostabilization. The raw data and QA checks on the raw data will be organized to permit analysis of their

precision and probable accuracy, so that they may be used to draw defensible and definitive conclusions.

5.2 FINAL REPORT PREPARATION

Upon completion of field data collection and analysis, a draft, draft final, and final technical report will be prepared summarizing the effectiveness of phytostabilization at the site. The report will summarize all field activities completed and provide a summary of all data collected. Plant growth observations, irrigation requirements, transpiration measurements, groundwater impact, and future impact of the engineered tree plantings at the site will be detailed.

The proposed outline for the report is provide in Table 5.1.

TABLE 5.1
PROPOSED TECHNICAL REPORT OUTLINE

PHYTOSTABILIZATION DEMONSTRATION
WORK PLAN
SITE 2
ALTUS AFB, OKLAHOMA

Outline

INTRODUCTION

Phytostabilization Overview

SITE CHARACTERISTICS

General Description and Location

Meteorological Conditions

Topography

Subsurface Conditions

Soil

Groundwater

SAMPLE COLLECTION AND ANALYSIS PROCEDURES

Soil

Groundwater

Trees

RESULTS

Plant Growth Observations

Plant Moisture Requirements

Transpiration Measurements

Impact on Soil Quality

Impact on Groundwater Table Elevation

Impact on Groundwater Quality

Future Impact of Tree Rows (Water Balance Model)

Lessons Learned

CONCLUSIONS AND RECOMMENDATIONS

REFERENCES CITED

SECTION 6

SUPPORT REQUIREMENTS

The following support is required of the Air Force:

- The Air Force (Base coordinators) will arrange for personal identification badges, vehicle passes, and/or entry permits for the initial planting and any subsequent maintenance or monitoring activities.
- Altus AFB personnel will be responsible for identifying the location of all utility lines, fuel lines, or any other underground infrastructure prior to any sampling or planting activities.
- Altus AFB will supply potable water to be used for irrigation purposes.

SECTION 7

SCHEDULE

The following schedule has been established for completion of key tasks. The initial Work Plan submittal is designed to meet the accelerated schedule for tree planting. Thus, only those sections necessary to complete the tree planting are included.

Task	Completion Date
Draft Work Plan to AFCEE	23 December 1998
Initial Tree Planting	February-March 1999
Final Work Plan to AFCEE	01 March 1999 ^{a/}
Operations, Maintenance and Monitoring	February 1999 through March 2001
Draft Technical Report to AFCEE	9 April 2001
Draft Final Report to AFCEE	23 May 2001
Final Report to AFCEE	22 June 2001

^{a/} Dependent on regulatory agency review.

SECTION 8

REFERENCES

- Anderson, T.A. and B.T. Walton. 1992. *Comparative Plant Uptake and Microbial Degradation of Trichloroethylene in the Rhizospheres of Five Plant Species: Implication for Bioremediation of Contaminated Surface Soils*. ORNL/TM-12017. Oak Ridge National Laboratory. Oak Ridge, Tennessee.
- Baker, J.M. and J.L. Nieber. 1989. An analysis of the steady-state heat balance Method for measuring sap flow in plants. *Agricultural and Forest Meteorology*. 48:93-109.
- Briggs, G.G., R.H. Bromilow, and A.V. Evans. 1982. Relationships between lipophilicity and root uptake and translocation of non-ionized chemicals by barley. *Pest. Sci.* 13:495-504.
- Davis, L.C., M.K. Banks, A.P. Schwab, M. Narayanan, L.E. Erickson, and J.C. Tracey. 1996. Plant-Based Bioremediation. *Bioremediation: Principles and Practice*. S.K. Sikdar and R.L. Irvine (Eds). Technomics, Lancaster, Pennsylvania.
- Edwards, R., S. Taffinder, and W. Plaehn. 1997. Phytostabilization of Trichloroethene: Results of a Mature Tree Study for the Remediation of Groundwater. *Fourth International Petroleum Environmental Conference*. San Antonio, Texas. September 9.
- Hauser, V. 1998. Personnel Communication. Mitretek Systems.
- Lee, R.W., S.A. Jones, E.L. Kuniansky, G.J. Harvey, and S.M. Eberts. 1998. Phreatophyte Influence on Reductive Dechlorination in a Shallow Aquifer Containing TCE. *Battelle Conference on the Remediation of Chlorinated and Recalcitrant Compounds*. May.
- Newman, L.A., S.E. Strand, and M.P. Gordon. 1997. Uptake and biotransformation of trichloroethylene by hybrid poplars. *Enviro. Sci. & Technology*. 31(4): 1062.
- Newman, L.A., S.E. Strand, J. Dufy, C. Bod, I. Muiznieks, S. Stanley, X. Wang, P. Heilman, and M.P. Gordon. 1998. Pilot-Scale Testing of Phytoremediation of Trichloroethylene and Carbon Tetrachloride. *Battelle Conference on the Remediation of Chlorinated and Recalcitrant Compounds*. May.
- Oklahoma Climatological Survey. 1998. Mesonet Climatological Data Summary (ALTU) Altus.

- Radian International LLC. 1996. *Analytical Quality Assurance Project Plan for Remedial Design/Remedial Action, Long-Term Monitoring, and Long-Term Operations Programs, Travis Air Force Base, California.*
- Ryan, J.A., R. M. Bell, J.M. Davidson, and G.A. O'Connor. 1988. Plant uptake of non-ionic organic chemicals from soils. *Chemosphere*. 17:2299-2323.
- Schnable, W.E., A.C. Dietz, J.G. Burken, J.L., Schnoor, and P.J. Alvarez. 1996. Uptake and transformation of trichloroethylene by edible garden plants. *Wat.Res.* 4:816-824.
- Smith, D. M. and S.J. Allen. 1996. Measurement of sap flow in plant stems. *Journal of Experimental Botany*. 47:1833-1844.
- Thornley, J. and I. Johnson. 1990. *Plant and Crop Modeling: A Mathematical Approach to Plant and Crop Physiology*. Chapter 14: Transpiration by a Crop Canopy. Oxford Press, Oxford. pp. 339 to 423.
- URS Greiner Woodward-Clyde (URS). 1997. *Revised Description of Current Conditions RCRA Facility Investigation, Altus Air Force Base, Oklahoma.*
- Walton, B. and T. Anderson. 1990. Microbial degradation of trichloroethylene in the rhizosphere: Potential application to biological remediation of waste sites. *Applied and Environ.* 56:1012-1016.

APPENDIX A

PHYTOSTABILIZATION INVESTIGATION RESULTS



DEPARTMENT OF THE ARMY
KANSAS CITY DISTRICT, CORPS OF ENGINEERS
700 FEDERAL BUILDING
KANSAS CITY, MISSOURI 64106-2896

REPLY TO
ATTENTION OF:

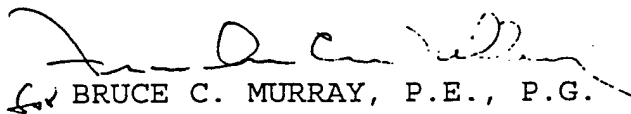
CENWK-PE-GG (200-1C)

19 Nov 98

MEMORANDUM FOR Mr. Sam Taffinder, AFCEE/ERT
3207 North Road Brooks AFB, Texas 78235-5363

SUBJECT: Summary of SCAPS Work at Phytostabilization
Demonstration Site, Altus AFB, Oklahoma

1. Enclosed is a summary of the Kansas City District's SCAPS work at Altus AFB. The summary includes results of direct sample ion trap mass spectrometer provided by Oak Ridge National Laboratory.
2. Eleven well points were installed. Only two well points contained enough water to sample on the same day they were installed. Seven well points contained enough water to sample after 24 hours. Two well points did not contain water after 24 hours and were not sampled. Depending upon sample requirements, well points which are purged dry during future sampling events, especially 04HSPSD and 06HSPSD, may not recover sufficiently in 24 hours to allow sample collection.
3. One hundred and sixty seven holes were drilled to promote root growth of trees which are to be planted at later date. A five foot length of perforated flexible tubing was placed in each hole and a three inch diameter plastic grate was placed inside the top of each piece of tubing. The grates were difficult to place in the tubing because the top of some of the tubing was out of round. Grates would fit more securely if they fit over the top instead of inside.
4. Thank you for the opportunity to assist you with this effort. Please contact Kathleen Older or James Campbell with any questions (816-983-3985).


for BRUCE C. MURRAY, P.E., P.G.
Chief, Planning and
Engineering Division

Summary of SCAPS Work at Altus AFB, 3 - 10 November, 1998

The Kansas City District SCAPS crew arrived at Altus AFB about 0830 on 3 November and met with Mr. Dan Staton, Chief of Environmental; Mr. Tom Dragoo, Parsons Engineering; Mr. Billy Allday, Fire Department; Lt Lange, Biomedical Office; Capt Wise, Security Office; and Tom Swackhamer, Groundskeeper. The purpose of the meeting was to go over standard Altus AFB requirements for conducting site work and the scope of the field work associated with the AFCEE phytostabilization demonstration. Field work included installing direct push small diameter well points to monitor the water table, sampling the well points with hydrosparge and ion trap mass spectrometer, augering five foot deep holes and installing perforated flexible tubing into the augered holes. Figure 1 is a schematic of the site.

Site utilities had been cleared and marked. Mr. Dragoo was laying out a grid for the auger holes, and also had located the first two well point locations. He waited to locate remaining well points until first two were sampled.

All well points were PowerPunch installations. Figure 2 diagrams a typical PowerPunch installation. A one inch outer diameter 0.010 slotted three foot long schedule 40 PVC screen was placed through the PowerPunch sealing body and into a sacrificial drive point. This screen assembly was inserted into the lead push rod and pushed to terminal depth. Threaded 5 foot long sections of PVC riser were attached together as they were placed into the push rods. The entire length of riser was threaded onto the screen section. The push rods were retracted 3 feet to expose the screen and an electronic water level indicator was used to determine water entry. The string of push rods was turned with pipe wrenches in order to set the sealing body in place. The sealing body isolates the screened interval from overlying material.

Soil classification was obtained at the location of the first well point (figure 3), the sensor probe could not be advanced below 13 feet. The material to about 13 feet consists of red silty clay. Based on push resistance, the top of weathered rock appears to be approximately 18 feet below ground. The first well point (01HSPSD) was installed using the sensor probe hole. Refusal was at 19.8 feet. The well screen was opened three feet but no water entered. A second well point (02HSPSD) was installed next to the first. This well point was screened from 9 to 12 feet below ground surface and water did enter the screen. Since water entered the screen between 9 and 12 feet, subsequent well points were planned to be set at the same interval.

Mr. Rob Smith (ORNL) arrived on site about 1230 and the crew loaded his equipment into the SCAPS vehicle. Mr. Smith set up the direct sample ion trap mass spectrometer (DSITMS) and associated equipment, made standard solutions and calibrated the instrument. After these preparations were made, 02HSPSD (9-12) was sampled and tested using the downhole hydrosparge and the DSITMS. A schematic of the hydrosparge device inside a well point is in figure 4. TCE, DCE, and PCE were identified in 02HSPSD (9-12). Based on this sample result, remaining well points were located as planned.

Well point 03HSPSD was installed to 12 feet below ground surface but no water entered.

On the following morning, 4 November, 01HSPSD (16.8-19.8) contained about 2 feet of water but 03HSPSD only contained about 0.2 feet. The hydrosparge device needs approximately one

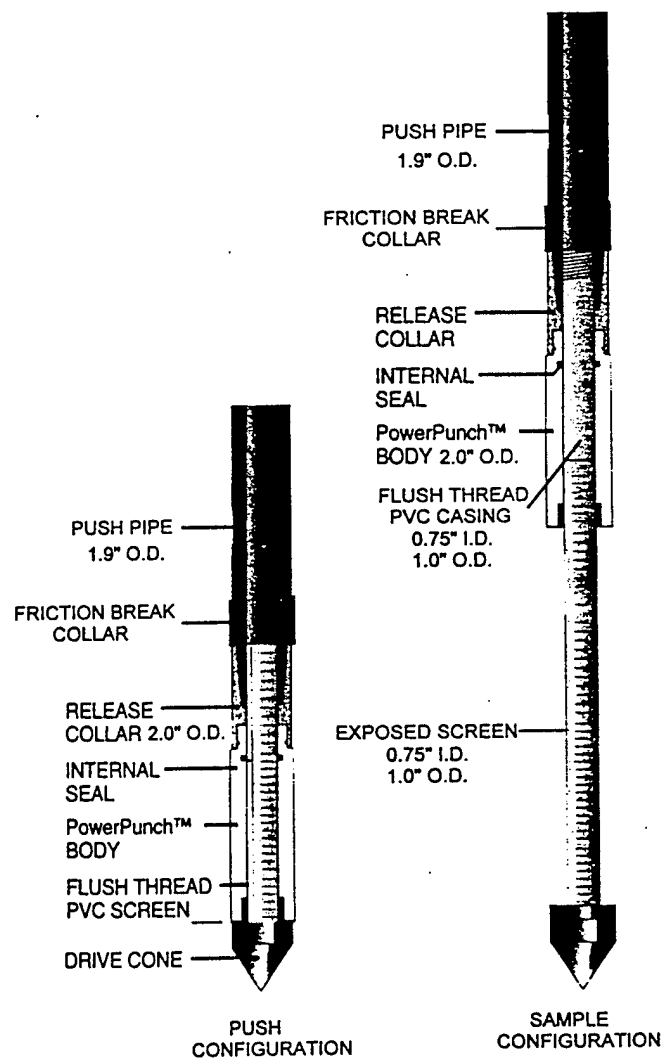


Figure 2

CPT based SOIL
CLASSIFICATION

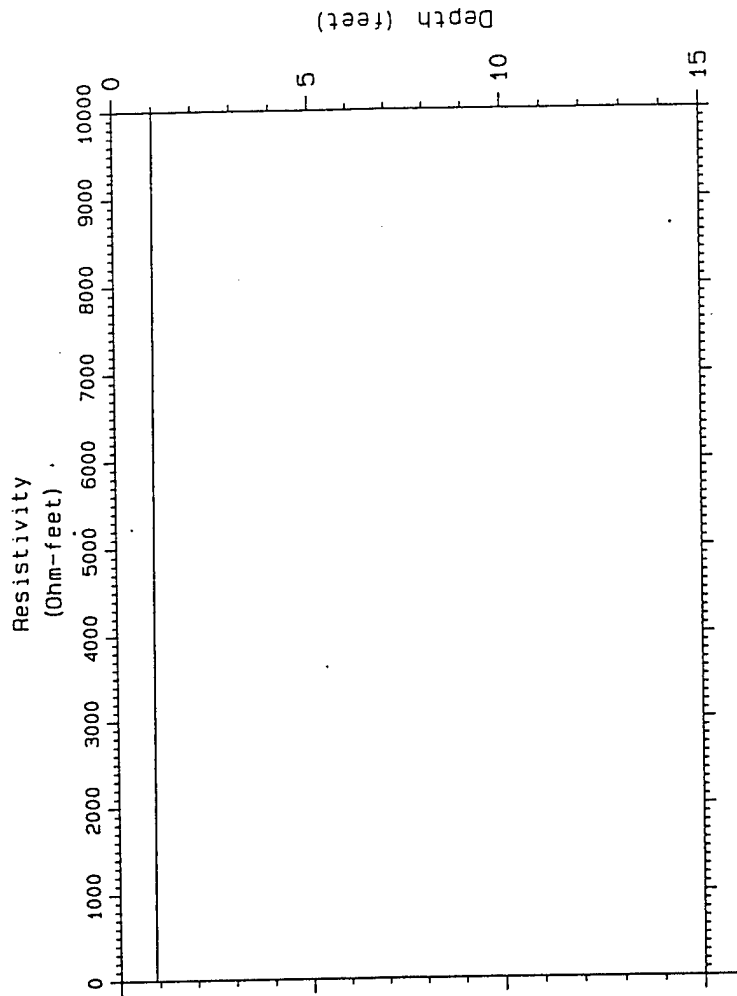
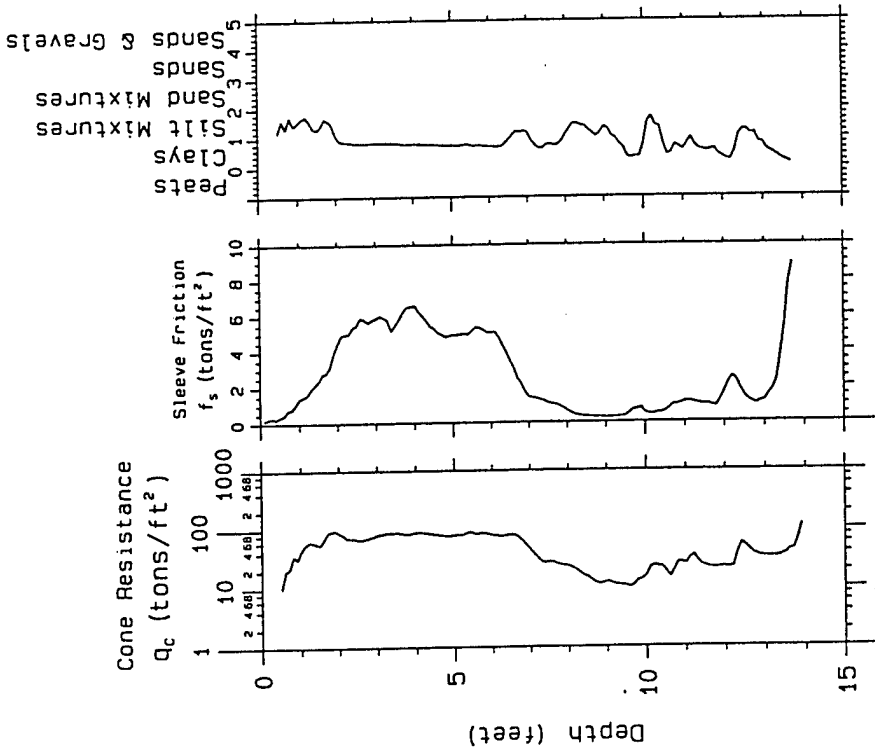


figure 3

Prattville, Alabama
MRK
SCAPS

U.S. Army
Engineer
District
Kansas City
Geotechnical Branch

Probing date: 11-03-1998

Prattville phytostabilization <NEW>
Probe Depth: 14.02
Pre-Push Depth: 0

Site
Characterization
and Analysis
Penetrometer System

CPT; 01PSDAFB

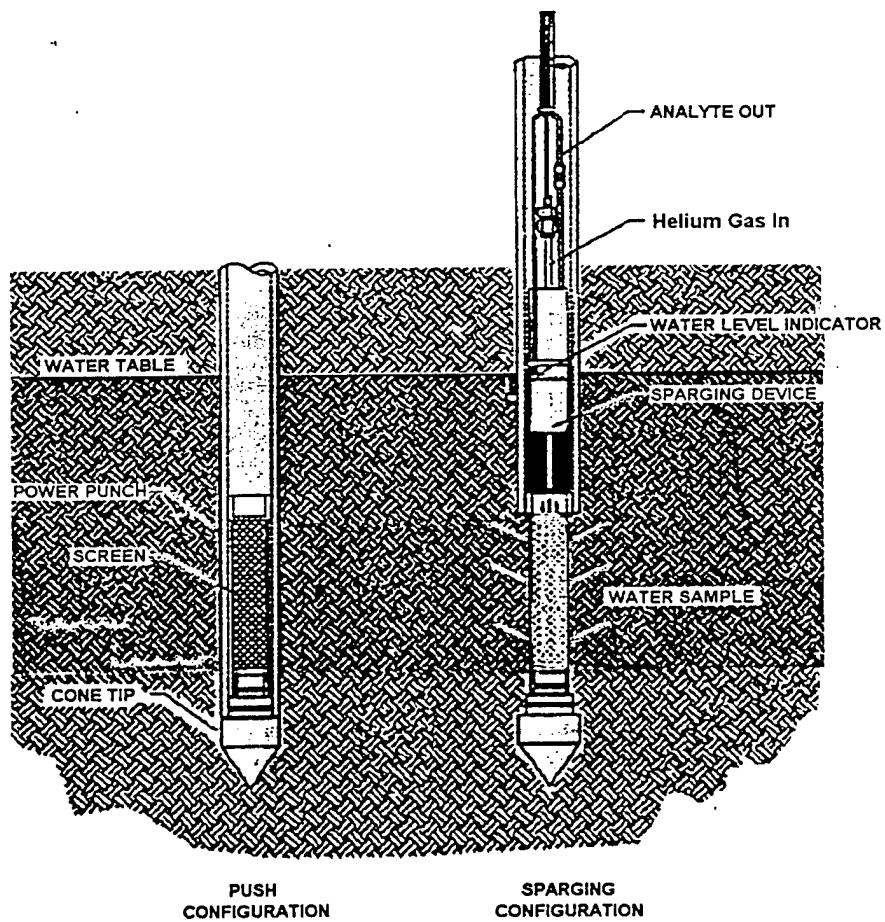


Figure 4

foot of water to function so 03HSPSD could not be sampled. Five more well points were installed to approximately 12 feet. Mr. Sam Taffinder from AFCEE arrived on site mid-morning. Mr. Taffinder and Mr. Dragoo checked two existing monitor wells and determined that they were about 26 feet deep instead of 12 or 15 feet deep. Based on this information, the last three well points were installed to refusal which was about 18 feet below ground surface. Nine feet of screen were set approximately 9-18 feet below ground surface in these last three well points. Three attempts were made to set well point 09HSPSD. The point was broken off at refusal and the PVC came up as the push rods were retracted in the first two attempts. The third attempt stopped short of refusal and was successful, however the sealing body did not remain in place and came out with the push rods.

Only one well point, 08HSPSD (8-11 feet), installed on 4 November contained water. 01HSPSD, which was pushed previous day, and 08HSPSD (8-11) were sampled and tested. Both well points contained volatile compounds.

Fifty-four 5 foot deep, 5 1/2 inch diameter holes were augered with the Earthprobe at locations marked by Parsons representative. The purpose of these holes is to provide pathways for tree roots to follow to water. The trees will be planted at a later date. Flexible, 3 inch diameter, perforated black plastic tubing was cut and capped and placed into each augered hole so that about 3 to 5 inches extended above ground surface. The annular space was backfilled with cuttings from the hole. Spaces for well box covers were dug around 01HSPSD and 02HSPSD.

On the third morning, 5 November, water levels were obtained from all well points which had not been tested. 04HSPSD only contained 0.2 feet of water and 06HSPSD was dry. The remaining holes were sampled for volatiles. Volatiles were found in 05HSPSD (7-12), 07HSPSD (9-12), and 09HSPSD (7.9-17.5). Small amounts of volatiles were found in 10HSPSD (9-18.6) and 11HSPSD (9-18.3). 10HSPSD and 11HSPSD also contained a small amount of aromatic hydrocarbons. Chemical results are in table 1. Seventy auger holes were completed with perforated tubing. Caps or duct tape were temporarily placed over all the flexible tube openings so debris could not blow in. The extra two holes at 09HSPSD were grouted to the surface with portland cement and water, spaces around 4 well points were dug out for covers. Mr. Smith's equipment was removed from the SCAPS vehicle and loaded into his van.

Work resumed on Monday, 9 November. The SCAPS crew arrived at Altus about 1315. Eighteen of the auger holes were drilled and completed with tubing. Spaces for two well box covers were dug and four spaces were squared off.

Work was completed on Tuesday, 10 November. Twenty remaining auger holes were completed. All temporary caps and duct tape were removed from tubing. Plastic grates which were supposed to sit inside the end of the flexible tubing were installed. Some of these did not fit very well because the tubing was often out of round. Remaining spaces for well covers were dug out and all well covers were set in place with Quicrete. Extra tubing, end caps and grates were taken to Building 502 at the direction of Environmental Office. Water levels were collected from all well points. Table 2 summarizes water levels. Well points and the beginning and end of each tree row were surveyed in for relative position. Mr. Dan Staton inspected the site prior to SCAPS departure.

Table 1 : DSITMS RESULTS (3-5 November 1998) Results are in ppb

Well Point ID	TCE	DCE	PCE	CHCl3	CCl4	Aromatic
01HSPSD (16.8-19.8)	1,700	350	510	ND	ND	ND
02HSPSD (9-12)	250	200	190	ND	ND	ND
03HSPSD (9-12)	125	79	87	ND	ND	ND
04HSPSD (9-12)	NS	NS	NS	NS	NS	NS
05HSPSD (7-12)	4,800	2,200	4,800	880	ND	ND
06HSPSD (9-12)	NS	NS	NS	NS	NS	NS
07HSPSD (9-12)	2,900	1,900	2,000	460	26	ND
08HSPSD (8-11)	2,700	1,700	5,500	1,100	ND	ND
09HSPSD (9.7-17.5)	280	70	110	39	ND	ND
10HSPSD (9-18.6)	4.3	ND	2.4	ND	ND	67
11HSPSD (9-18.3)	8.4	ND	2.0	ND	ND	78

ND non detect at instrument detection levels

NS not sampled due to lack of water

TCE trichlorethene

DCE dichloroethene

PCE tetrachloroethene

CHCl3 chloroform

CCl4 carbon tetrachloride

Table 2: Well Point Water Levels, Altus AFB Phytostabilization Demonstration, Nov 1998

Well Point ID	screened interval below ground surface	water level in feet below ground surface			Final water level
		3 NOV	4 NOV	5 NOV	
01HSPSD	16.8-19.8	Dry	16.5	9.5	8.0
02HSPSD	9-12	8.0	Not recorded	not recorded	8.0
03HSPSD	9-12	Dry	11.8	10.3	7.9
04HSPSD	9-12 not sampled		Dry	11.8	8.0
05HSPSD	7-12		Dry	8.3	8.2
06HSPSD	9-12 not sampled		Dry	dry	9.7
07HSPSD	9-12		Dry	8.5	8.3
08HSPSD	8-11		9.6		8.5
09HSPSD	7.9-17.5		Dry	8.5	8.4
10HSPSD	9-18.3		Dry	8.5	8.4
11HSPSD	9-18.3		Dry	16.6	8.0

OAK RIDGE NATIONAL LABORATORY
MANAGED BY LOCKHEED MARTIN ENERGY RESEARCH CORPORATION
FOR THE U.S. DEPARTMENT OF ENERGY

POST OFFICE BOX 2008
OAK RIDGE, TN 37831-6120

PHONE: (423) 574-4861
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INTERNET: SMITHRR1@ORNL.GOV

November 11, 1998

Ms. Kathleen Older
Kansas City Corps of Engineers
USACE EP-GG
Federal Building 601 East 12th St
Kansas City, MO 64106

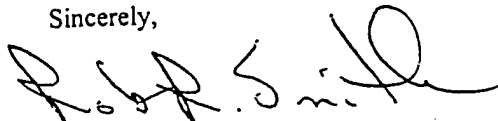
Kathy,

This is the data packet for the Altus AFB job from November 3 through November 5, 1998. The data is in the usual format including two electronic files on the 3.5" floppy diskette.

I changed a few of the results from what I originally reported in the field. The first being the wells number 8 and 1. The results reported here are substantially less than I reported in the field. The reason for this difference is that my high standard was space charging much worse than I originally thought. Therefore, I felt it would be more accurate to use the next lower standards and extrapolate them out to obtain the well concentrations. I also retracted reporting trichloroethane. Upon reviewing the spectra there just was not enough evidence to factually report its presence.

As always, it's been a pleasure serving the Corps in this regard. Should I be of further assistance then please don't hesitate to ask.

Sincerely,



Rob R. Smith

DSITMS Analysis

Altus AFB

November 3 through November 5, 1998

(results in ppb)

01HSPSD(16.8-19.8)

02HSPSD (9-12.0)

03HSPSD(9.0-12.0)

05HSPSD(7.0-12.0)

07HSPSD(9.0-12.0)

08HSPSD(8.0-11.0)

09HSPSD(9.7-17.5)

10HSPSD(9.0-18.6)

11HSPSD(9.0-18.3)

SAMPLE_ID	DATESAMP	TESTNAME	CONC	QUAL	UNITS
01HSPSD(16.8-19.8)	11/04/98	Trichloroethylene	1700 U		ug/L
01HSPSD(16.8-19.8)	11/04/98	1,2-Dichloroethene (Total)	350 U		ug/L
01HSPSD(16.8-19.8)	11/04/98	Tetrachloroethene	510 U		ug/L
01HSPSD(16.8-19.8)	11/04/98	Chloroform	5 J		ug/L
01HSPSD(16.8-19.8)	11/04/98	Carbon Tetrachloride	5 J		ug/L
02HSPSD	11/03/98	Trichloroethylene	250 U		ug/L
02HSPSD	11/03/98	1,2-Dichloroethene (Total)	200 U		ug/L
02HSPSD	11/03/98	Tetrachloroethene	190 U		ug/L
02HSPSD	11/03/98	Chloroform	5 J		ug/L
02HSPSD	11/03/98	Carbon Tetrachloride	5 J		ug/L
03HSPSD(9.0-12.0)	11/05/98	Trichloroethylene	125 U		ug/L
03HSPSD(9.0-12.0)	11/05/98	1,2-Dichloroethene (Total)	79 U		ug/L
03HSPSD(9.0-12.0)	11/05/98	Tetrachloroethene	87 U		ug/L
03HSPSD(9.0-12.0)	11/05/98	Chloroform	5 J		ug/L
03HSPSD(9.0-12.0)	11/05/98	Carbon Tetrachloride	5 J		ug/L
05HSPSD(7.0-12.0)	11/05/98	Trichloroethylene	4800 U		ug/L
05HSPSD(7.0-12.0)	11/05/98	1,2-Dichloroethene (Total)	2200 U		ug/L
05HSPSD(7.0-12.0)	11/05/98	Tetrachloroethene	4800 U		ug/L
05HSPSD(7.0-12.0)	11/05/98	Chloroform	880 U		ug/L
05HSPSD(7.0-12.0)	11/05/98	Carbon Tetrachloride	5 J		ug/L
07HSPSD(9.0-12.0)	11/05/98	Trichloroethylene	2900 U		ug/L
07HSPSD(9.0-12.0)	11/05/98	1,2-Dichloroethene (Total)	1900 U		ug/L
07HSPSD(9.0-12.0)	11/05/98	Tetrachloroethene	2000 U		ug/L
07HSPSD(9.0-12.0)	11/05/98	Chloroform	460 U		ug/L
07HSPSD(9.0-12.0)	11/05/98	Carbon Tetrachloride	26 U		ug/L
08HSPSD(8.0-11.0)	11/04/98	Trichloroethylene	2700 U		ug/L
08HSPSD(8.0-11.0)	11/04/98	1,2-Dichloroethene (Total)	1700 U		ug/L
08HSPSD(8.0-11.0)	11/04/98	Tetrachloroethene	5500 U		ug/L
08HSPSD(8.0-11.0)	11/04/98	Chloroform	1100 U		ug/L
08HSPSD(8.0-11.0)	11/04/98	Carbon Tetrachloride	5 J		ug/L
09HSPSD(9.7-17.5)	11/05/98	Trichloroethylene	280 U		ug/L
09HSPSD(9.7-17.5)	11/05/98	1,2-Dichloroethene (Total)	70 U		ug/L
09HSPSD(9.7-17.5)	11/05/98	Tetrachloroethene	110 U		ug/L
09HSPSD(9.7-17.5)	11/05/98	Chloroform	39 U		ug/L
09HSPSD(9.7-17.5)	11/05/98	Carbon Tetrachloride	5 J		ug/L
10HSPSD(9.0-18.6)	11/05/98	Trichloroethylene	4.3 U		ug/L
10HSPSD(9.0-18.6)	11/05/98	1,2-Dichloroethene (Total)	5 J		ug/L
10HSPSD(9.0-18.6)	11/05/98	Tetrachloroethene	2.4 U		ug/L
10HSPSD(9.0-18.6)	11/05/98	Chloroform	5 J		ug/L
10HSPSD(9.0-18.6)	11/05/98	Aromatic	67 U		ug/L
11HSPSD(9.0-18.3)	11/05/98	Trichloroethylene	8.4 U		ug/L
11HSPSD(9.0-18.3)	11/05/98	1,2-Dichloroethene (Total)	5 J		ug/L
11HSPSD(9.0-18.3)	11/05/98	Tetrachloroethene	2.0 U		ug/L
11HSPSD(9.0-18.3)	11/05/98	Chloroform	5 J		ug/L
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11049801

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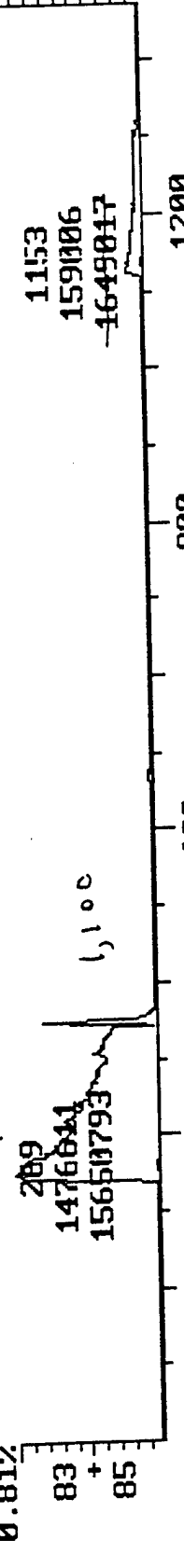
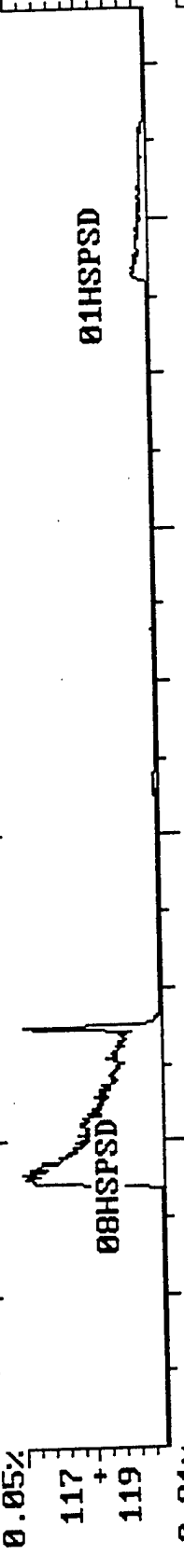
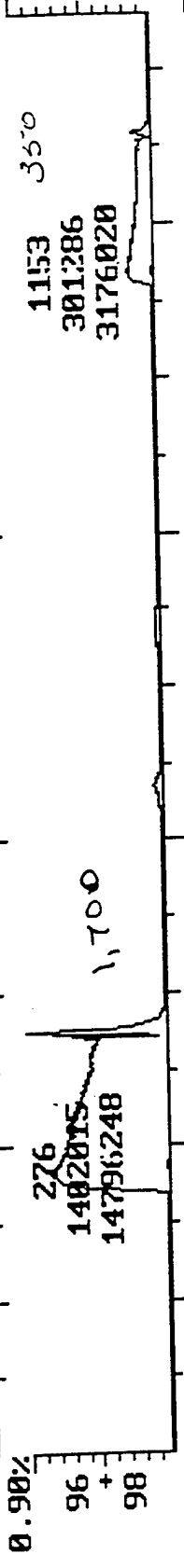
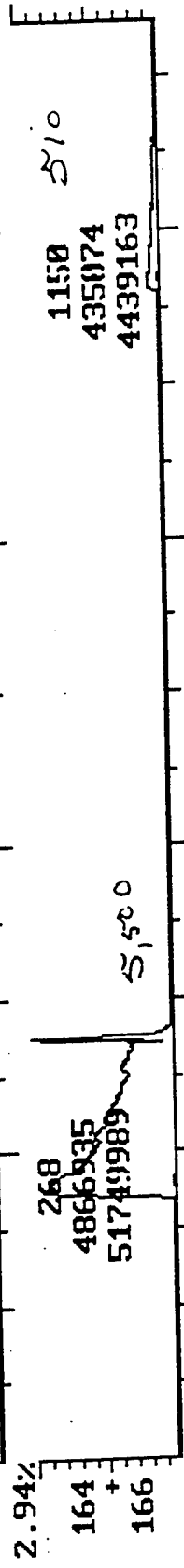
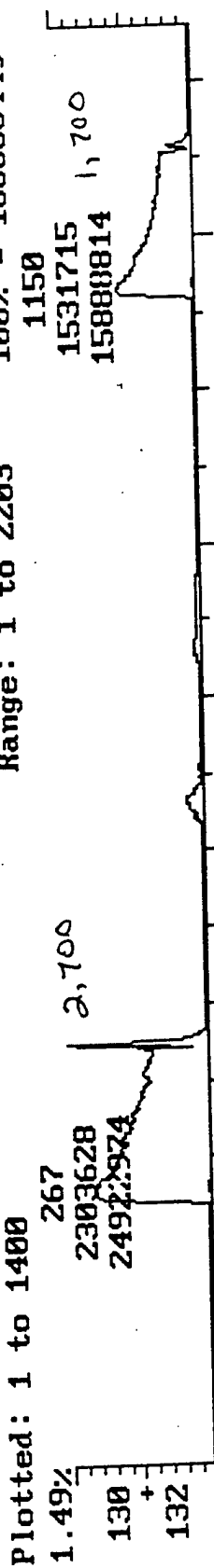
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Chromatogram Plot

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Plotted: 1 to 1400 Range: 1 to 2203 100% = 186838449



11047801

Date: 11/04/98 10:35:20

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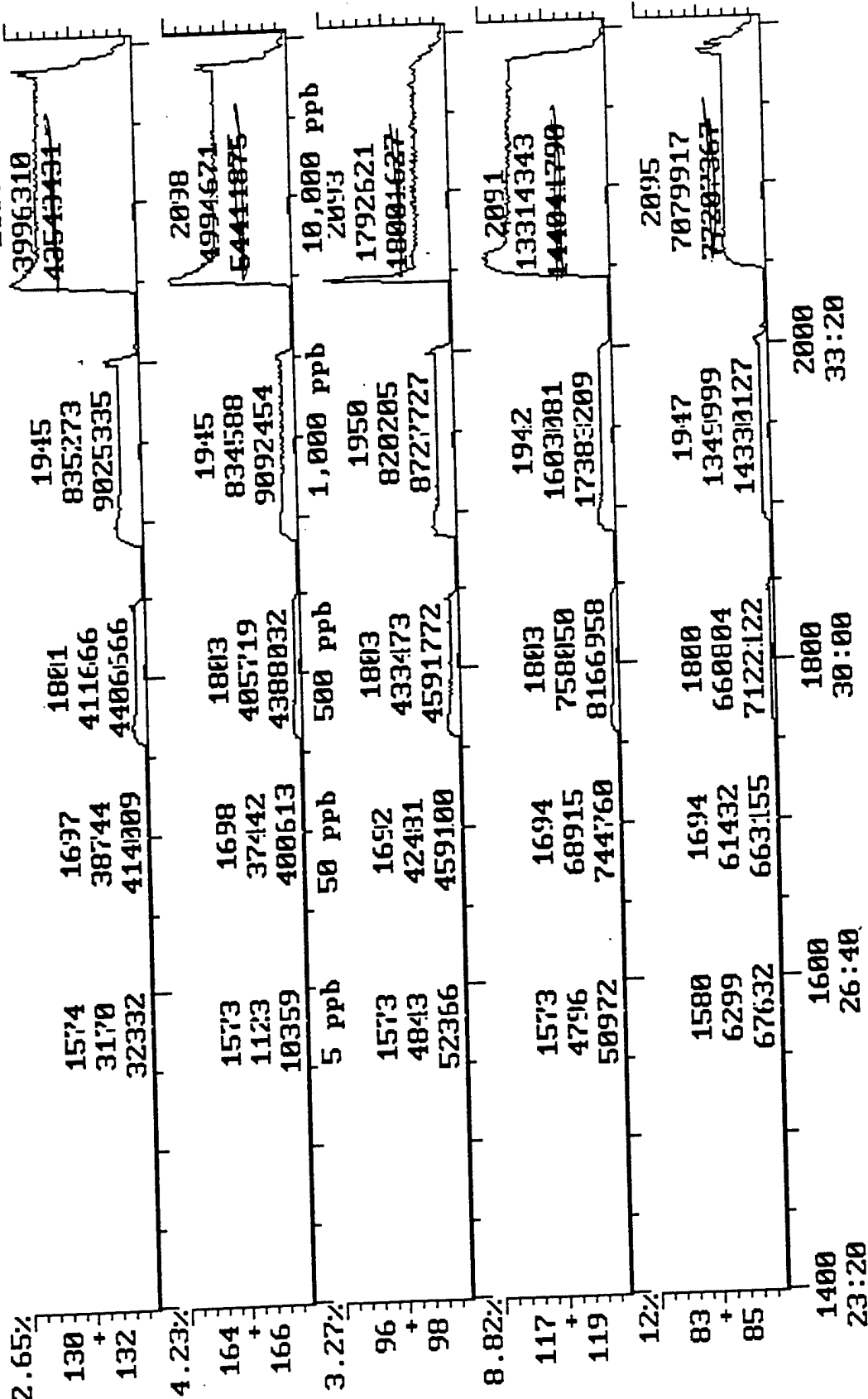
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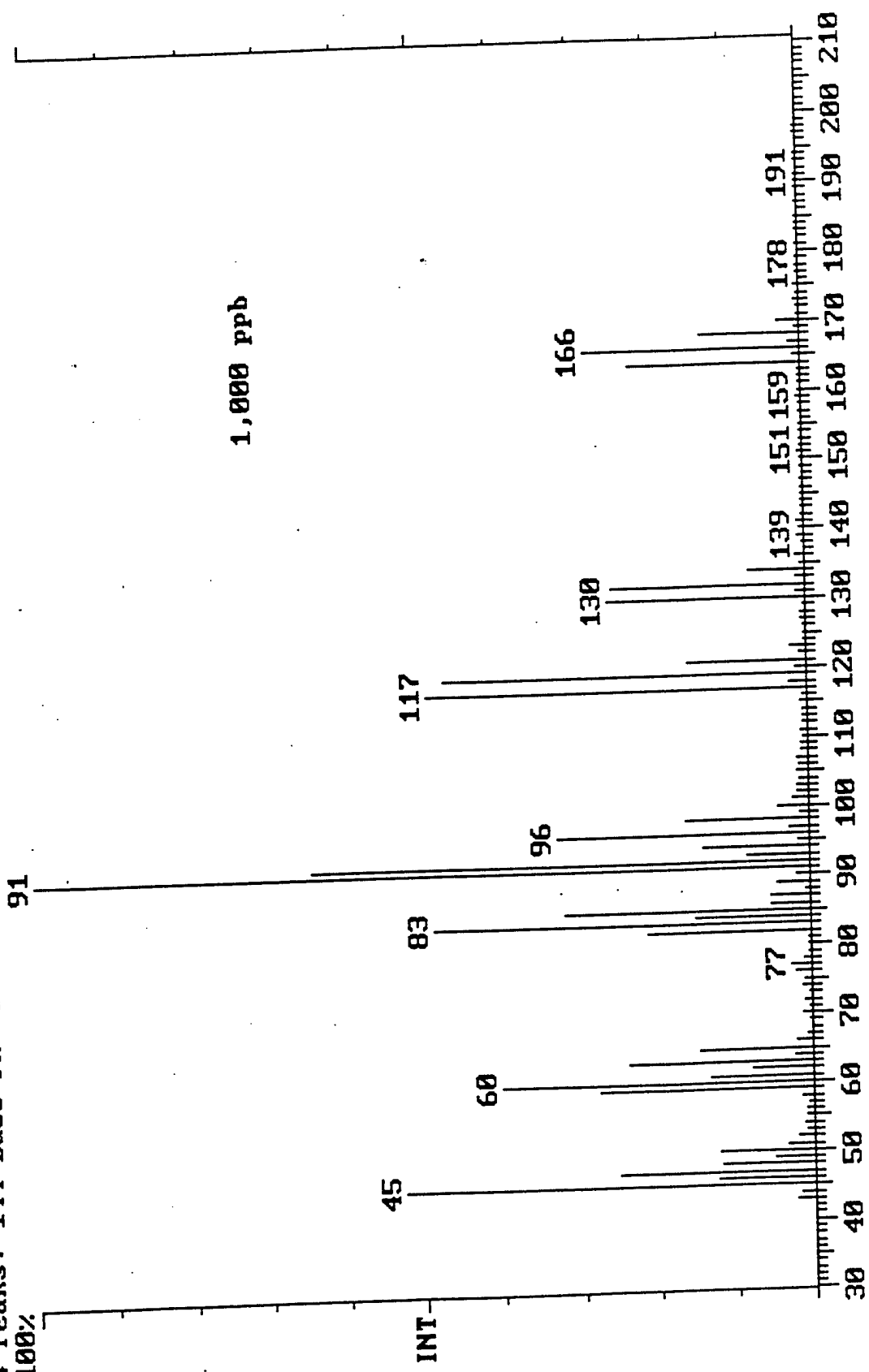
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Plotted: 1400 to 2203 Range: 1 to 2203 100% = 186838449

2097



1649801
Spectrum Plot
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Date: 11/04/98 10:35:20
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Scan No: 1945 Retention Time: 32:25 RIC: 15054732 Mass Range: 43 - 198
Peaks: 144 Base Pk: 91 Ioniz: 73 us Int: 1643150 100.00% = 1643150
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11049801

Date: 11/04/98 10:35:20

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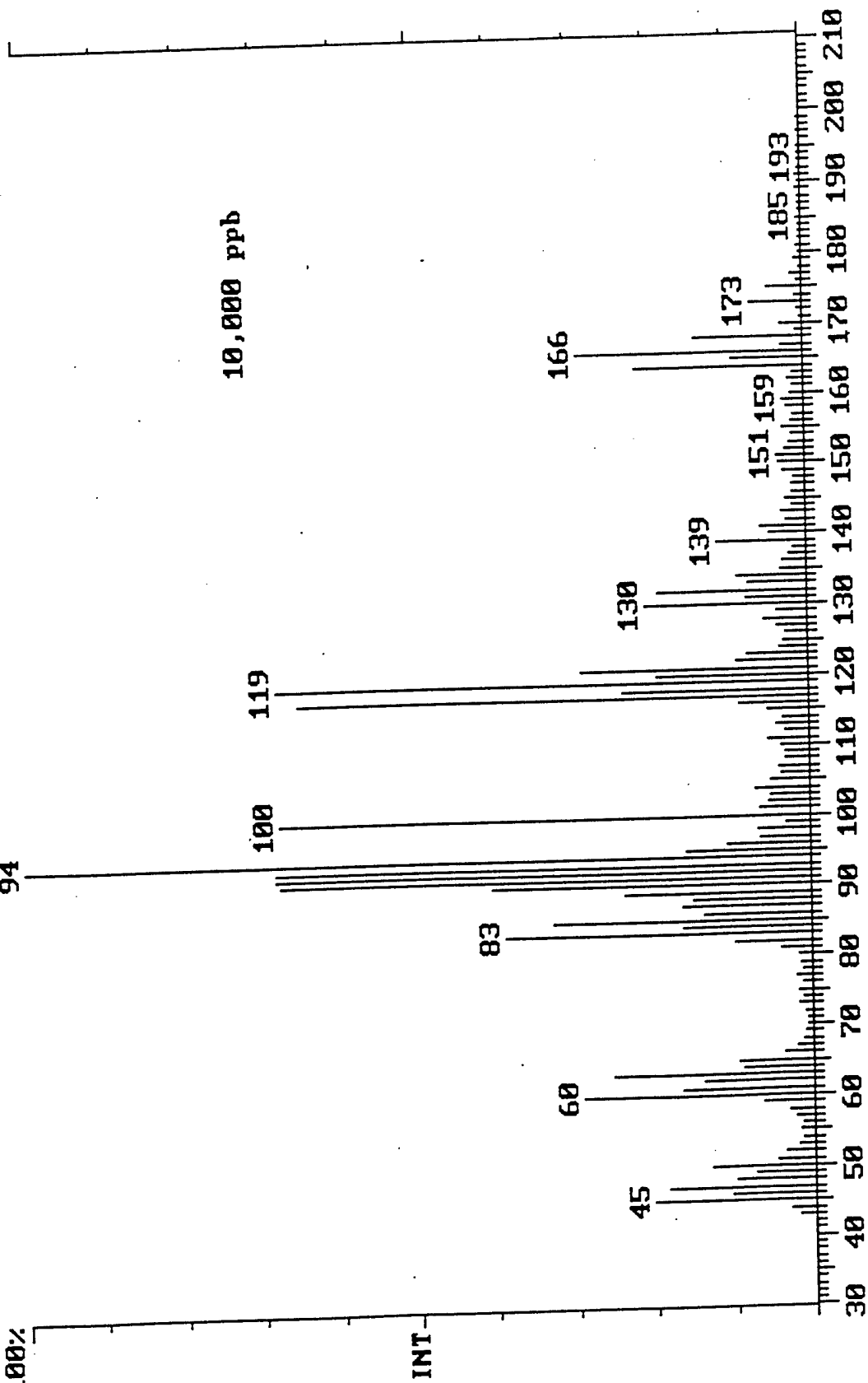
Spectrum Plot

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100%

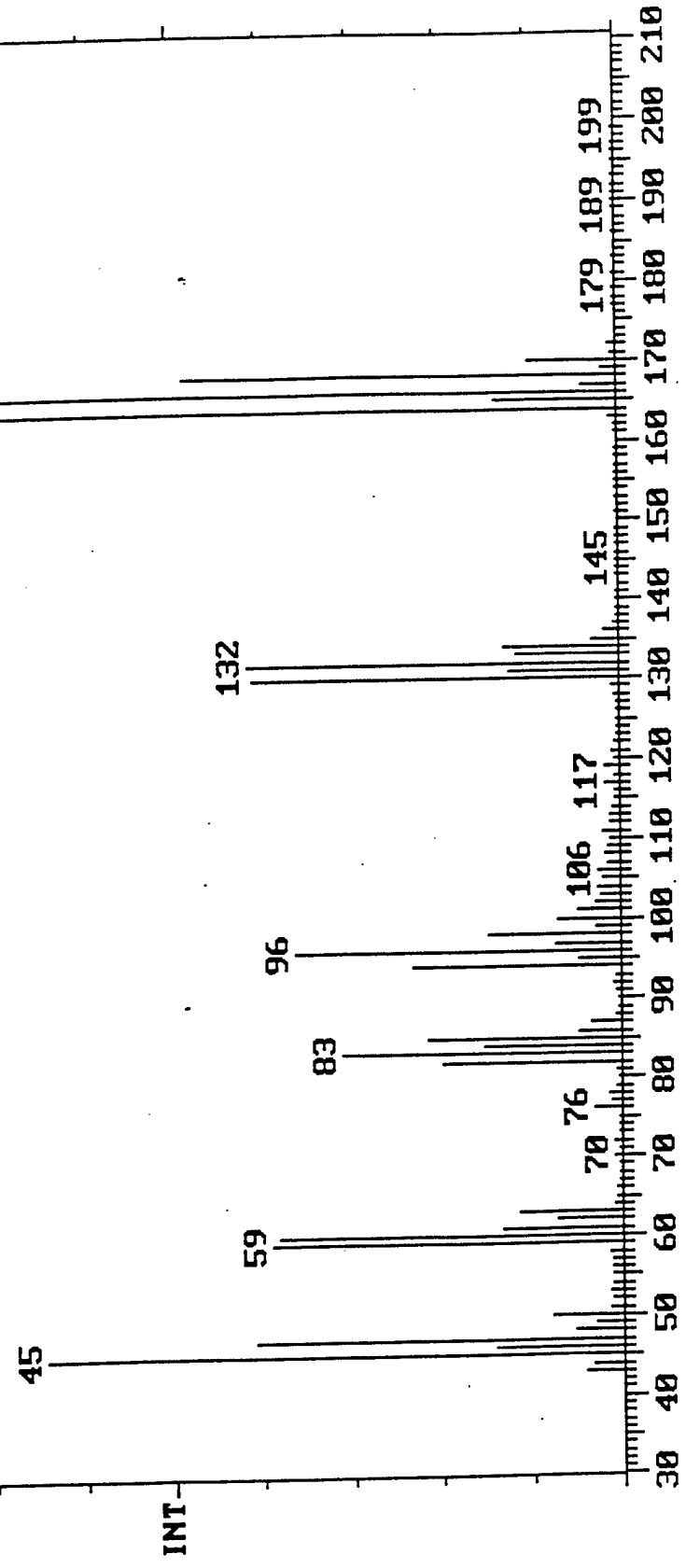


110A17801

Spectrum Plot C:\MAGNUM\DATA\11039801 Date: 11/04/98 10:35:20

Comment: 08HSPSD(8.0-11.0) & 01HSPSD(16.8-19.8)
Scan No: 271 Retention Time: 4:31 RIC: 23933806 Mass Range: 43 - 199
Peaks: 141 Base Pk: 166 Ioniz: 62 us Int: 2746370 100.00% = 2746370
100% 166

08HSPSD(8.0-11.0)



V1049800

Date: 11/04/98 10:35:20

Spectrum Plot

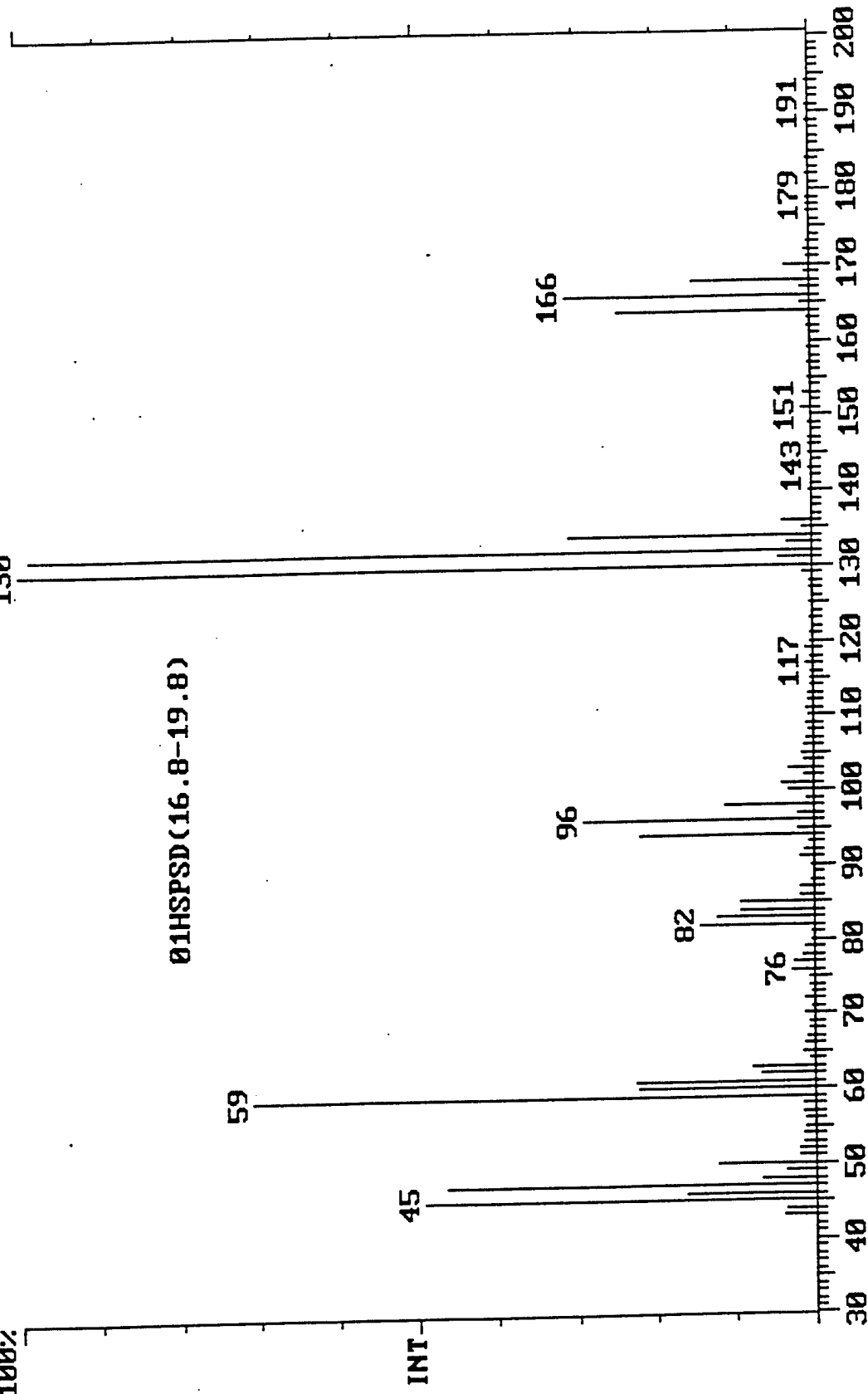
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Scan No: 1153 Retention Time: 19:13 RIC: 5700493 Mass Range: 43 - 194

Peaks: 121 Base Pk: 130 Ioniz: 136 us Int: 756066 100.00% = 756066

100%

01HSPSD(16.8-19.8)



C:\MAGNUM\DATA\11039801 Date: 11/03/98 15:08:42

Chromatogram Plot

Comment: 02HSPSD(9.0-12.0)

Scan No: 1

Retention Time: 0:01

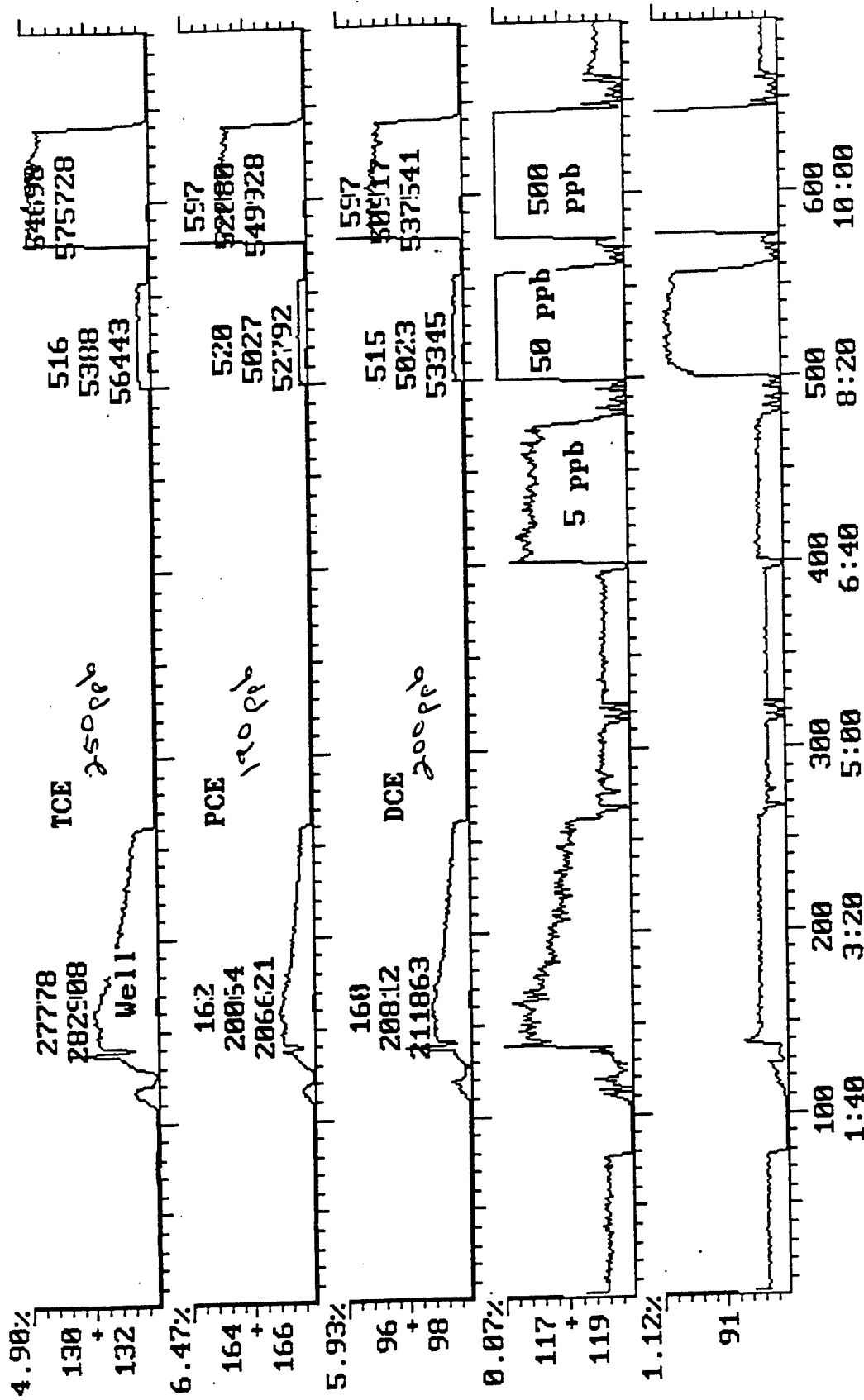
RIC: 0

Mass Range: 0 - 0

Plotted: 1 to 690

Range: 1 to 690

100% = 1115334



Date: 11/03/98 15:08:42

C:\MAGNUM\DATA\11039801

Spectrum Plot

Comment: 02HSPSD(9.0-12.0)

Scan No: 65

Peaks: 152 Base Pk: 91

Retention Time: 1:05

Ioniz: 23839 us

RIC: 20147

Int: 1895

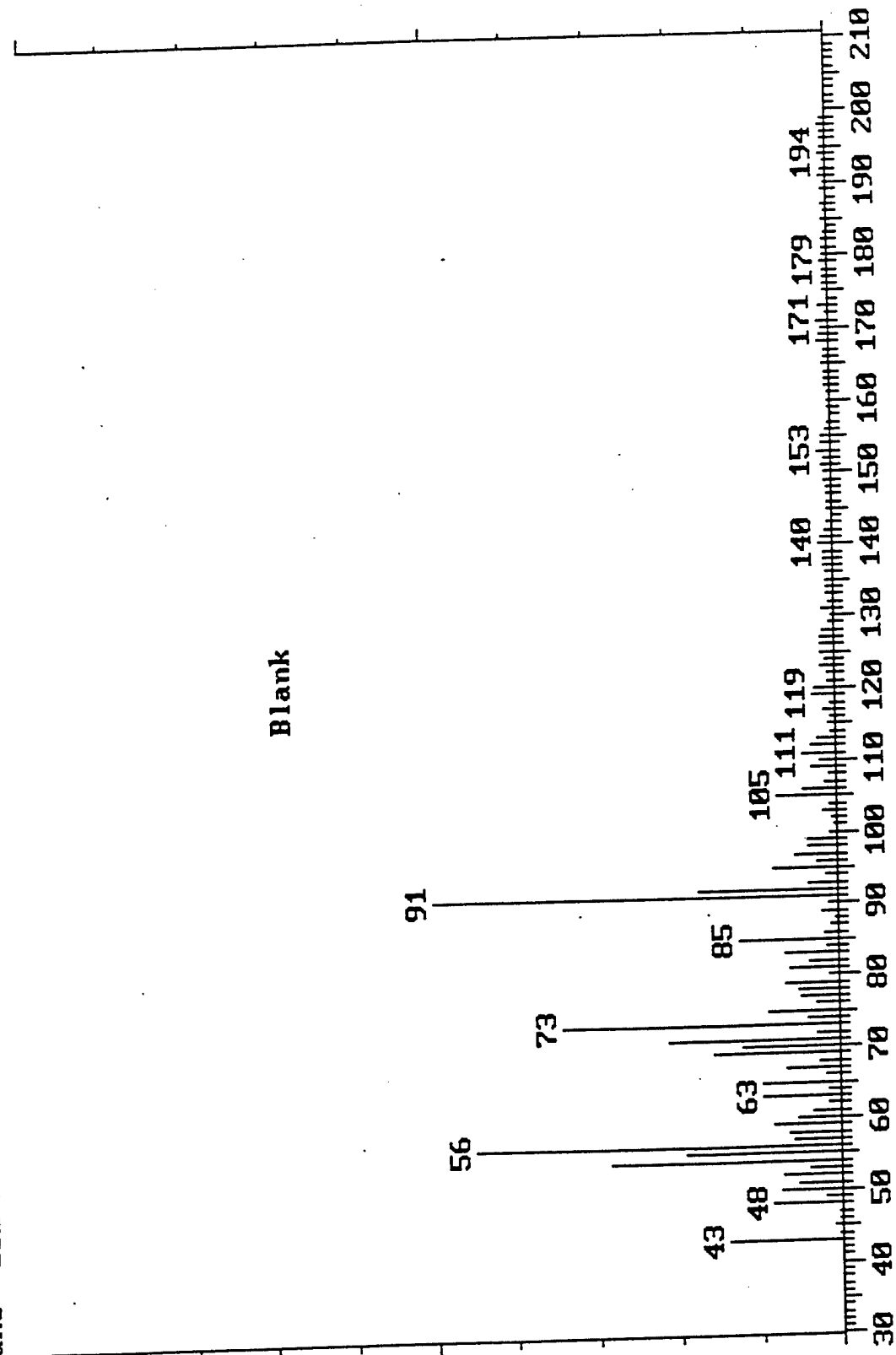
Mass Range: 43 - 199

200.00% = 3790

200%

Blank

INT



Date: 11/03/98 15:08:42

C:\MAGNUM\DATA\11039801

Spectrum Plot

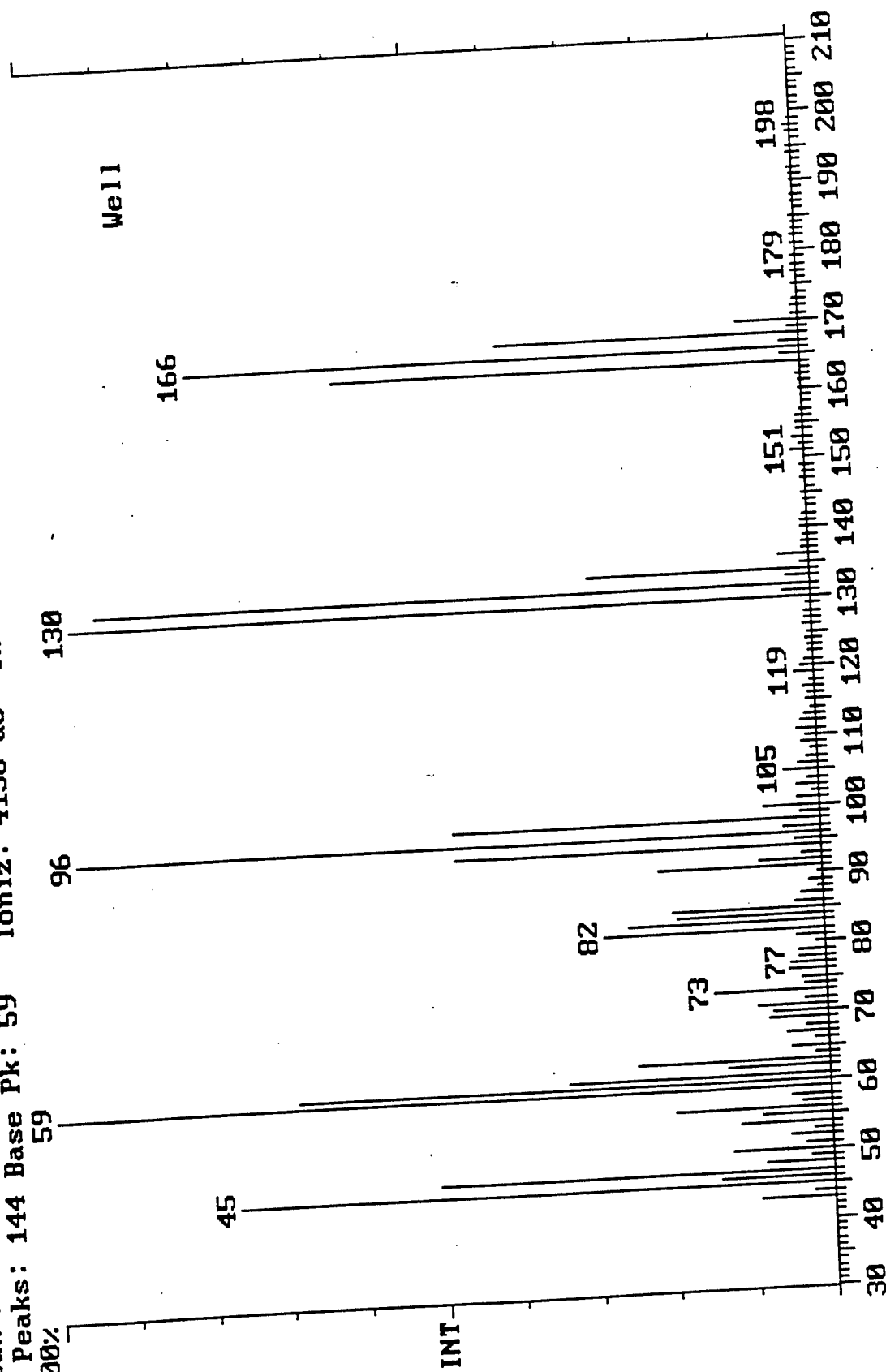
Comment: 02HSPSD(9.0-12.0)

Scan No: 164 Retention Time: 2:44

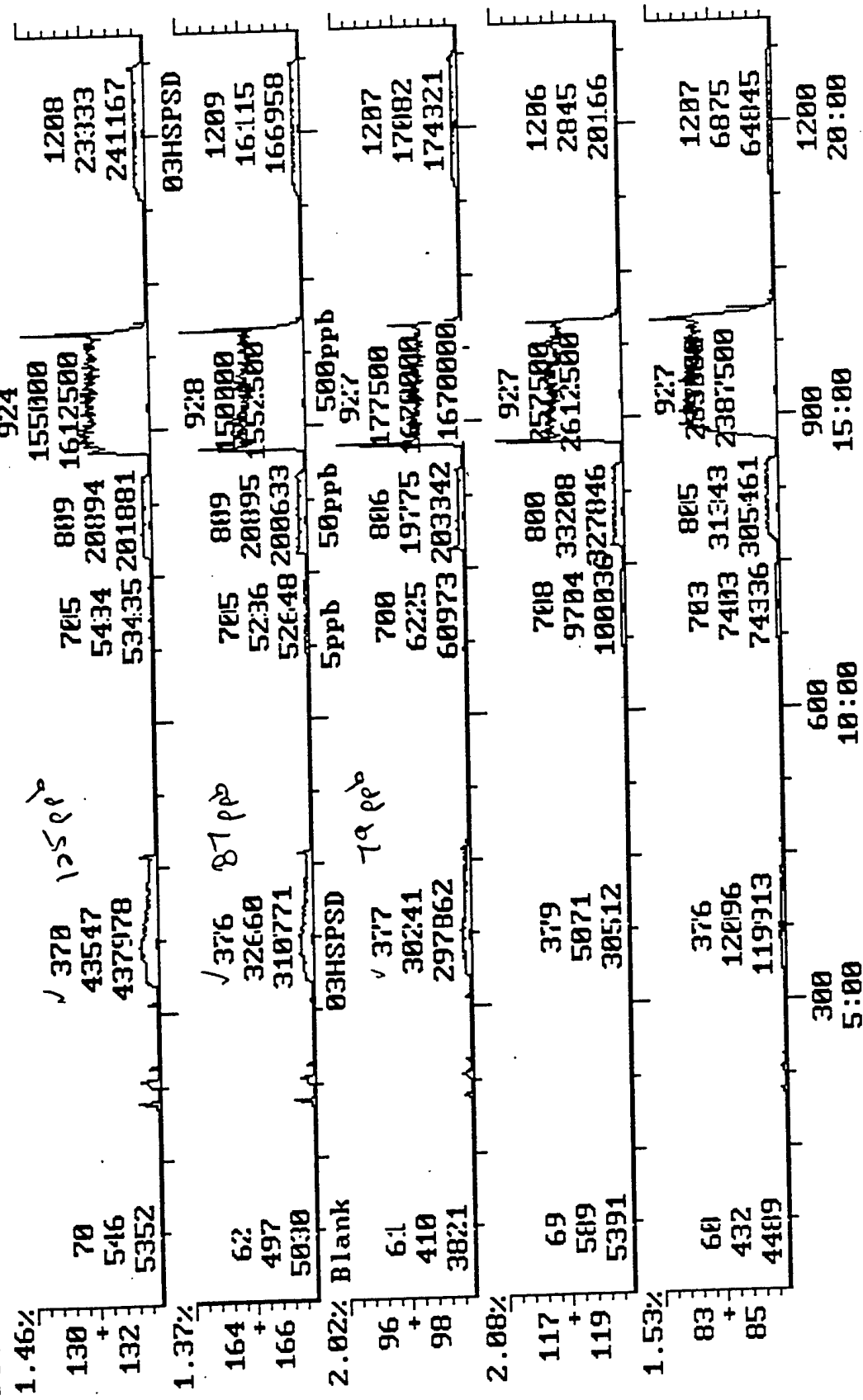
Peaks: 144 Base Pk: 59

RIC: 184175
Int: 13430

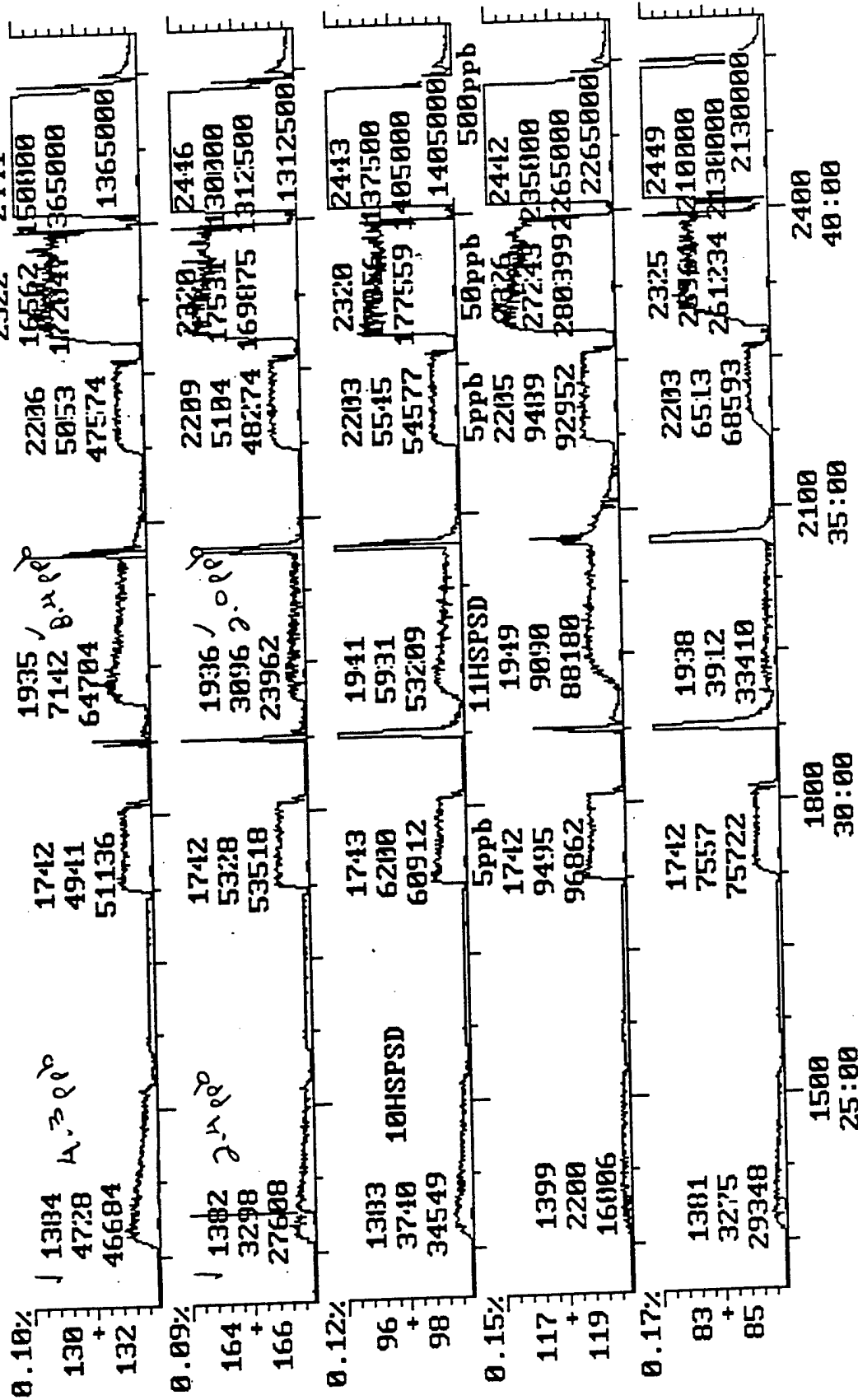
Mass Range: 43 - 199
100.00% = 13430



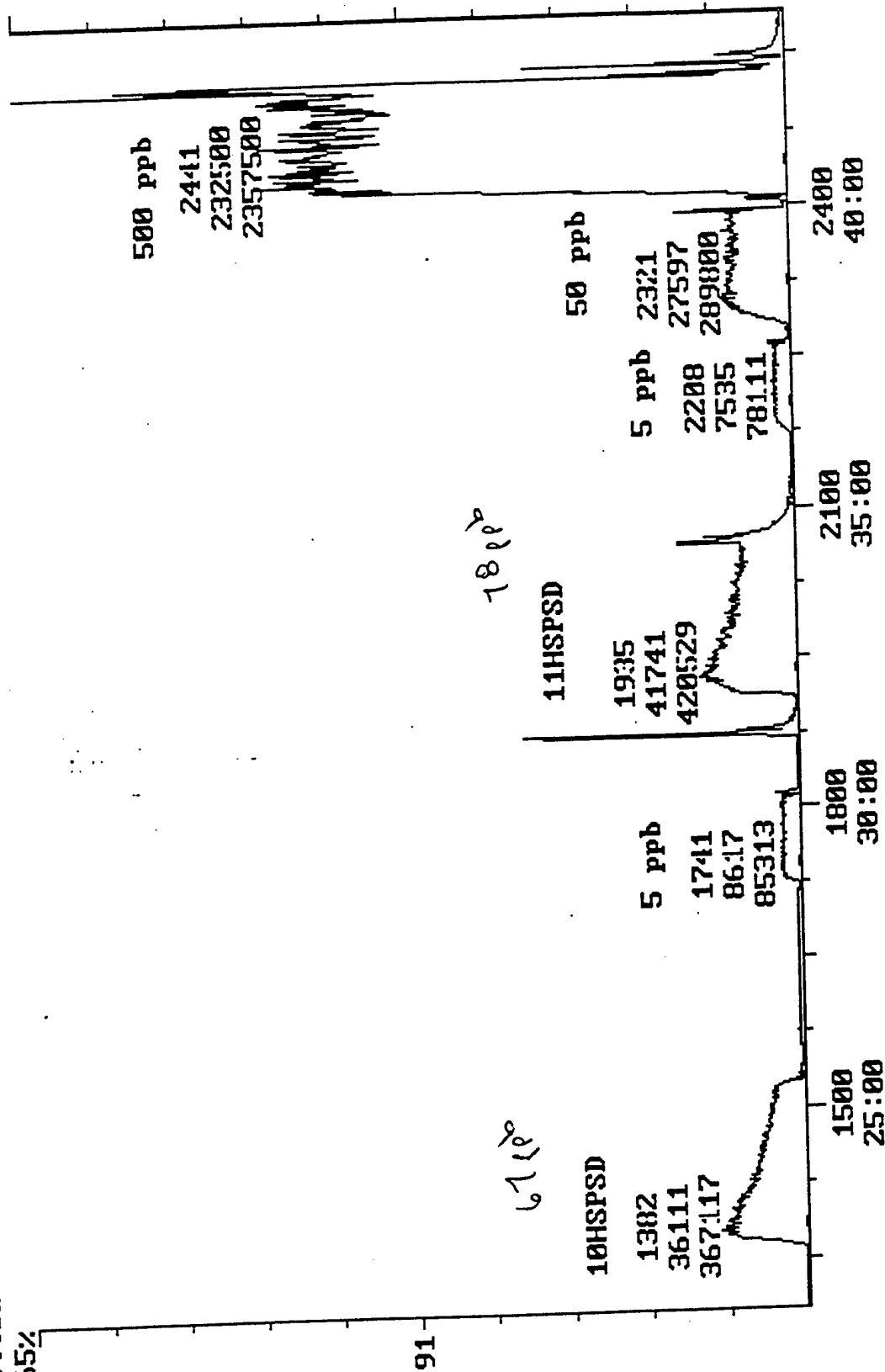
Chromatogram Plot
 Comment: 03HSPSD(9.0-12.0); 10HSPSD(9.0-18.6); 11HSPSD(9.0-18.3)
 Scan No: 1 Retention Time: 0:01 RIC: 0 Mass Range: 0 - 0
 Plotted: 1 to 1300 Range: 1 to 2589 100% = 21035000
 C:\...NALTUS\11_05_98\11059805 11/05/98 11:15:20



Chromatogram Plot C:\... \ALTUS\11_05_98\11059805 11/05/98 11:15:20
 Comment: 03HSPSD(9.0-12.0); 10HSPSD(9.0-18.6); 11HSPSD(9.0-18.3)
 Scan No: 1380 Retention Time: 23:00 RIC: 190645 Mass Range: 44 - 197
 Plotted: 1300 to 2589 Range: 1 to 2589 100% = 21035000



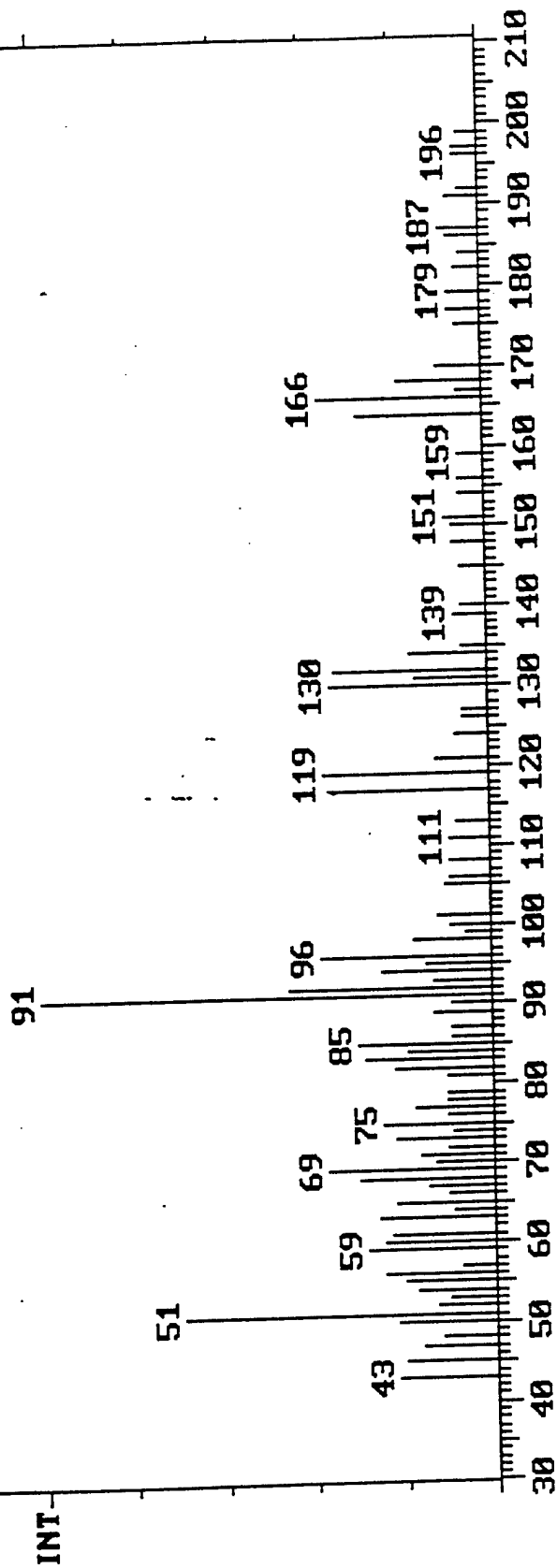
Chromatogram Plot
 C:\...ALTUS\11_05_98\11059805 11/05/98 11:15:20
 Comment: 03HSPSD(9.0-12.0); 10HSPSD(9.0-18.6); 11HSPSD(9.0-18.3)
 Scan No: 2589 Retention Time: 43:09 RIC: 19726 Mass Range: 43 - 198
 Plotted: 1300 to 2589 Range: 1 to 2589 100% = 21035000
 1.65%



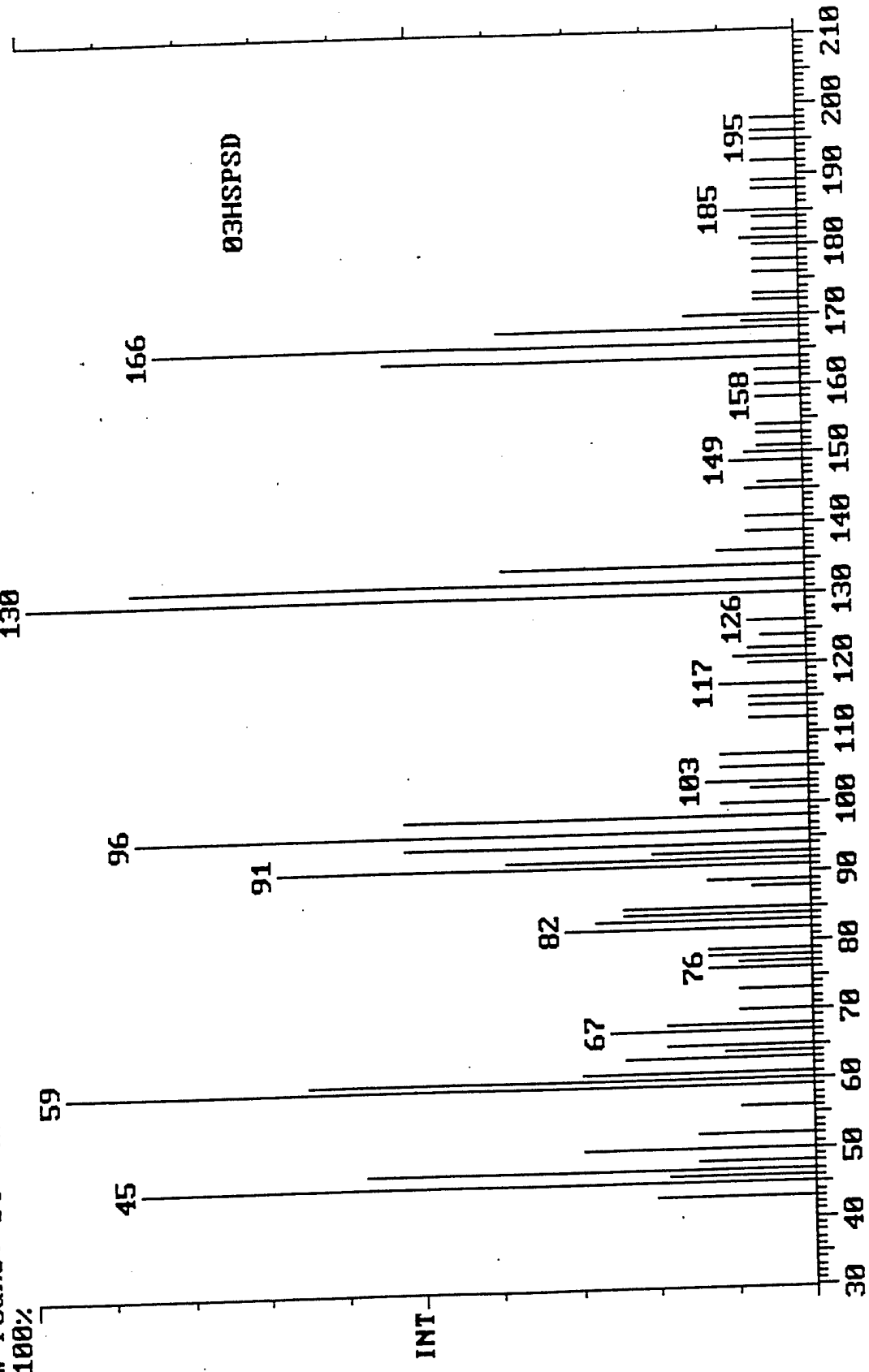
Spectrum Plot
Comment: 03HSPSD(9.0-12.0); 10HSPSD(9.0-18.6); 11HSPSD(9.0-18.3)
Scan No: 64 Retention Time: 1:04 RIC: 11155 Mass Range: 43 - 199
Peaks: 93 Base Pk: 91 Ioniz: 2382 us Int: 745 200.00% = 1490

C:\...\ALTUS\11_05_98\11059805 11/05/98 11:15:20

Blank



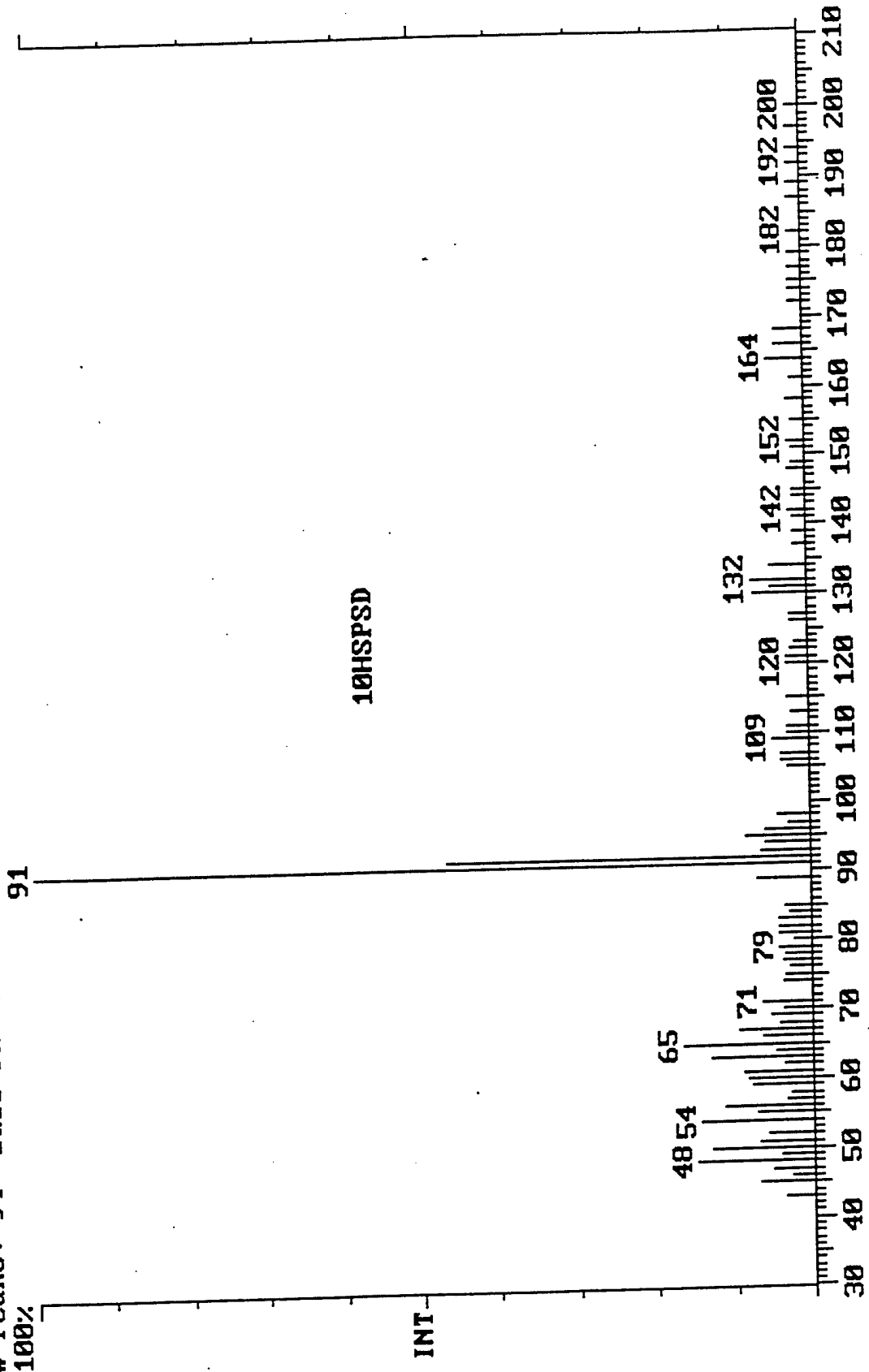
Spectrum Plot
C:\...NALTUS\11_05_98\11059805 11/05/98 11:15:20
Comment: 03HSPSD(9.0-12.0); 10HSPSD(9.0-18.6); 11HSPSD(9.0-18.3)
Scan No: 367 Retention Time: 6:07 RIC: 375348 Mass Range: 43 - 198
Peaks: 84 Base Pk: 130 Ioniz: 64 us Int: 21093 100.00% = 21093



C:\... \ALTUS\11_05_98\11059805 11/05/98 11:15:20

Spectrum Plot

Comment: 03HSPSD(9.0-12.0); 10HSPSD(9.0-18.6); 11HSPSD(9.0-18.3)
Scan No: 1385 Retention Time: 23:05 RIC: 179960 Mass Range: 43 - 200
Peaks: 94 Base Pk: 91 Ioniz: 145 us Int: 33793 100.00% = 33793



C:\... \ALTUS\11_05_98\11059805 11/05/98 11:15:20

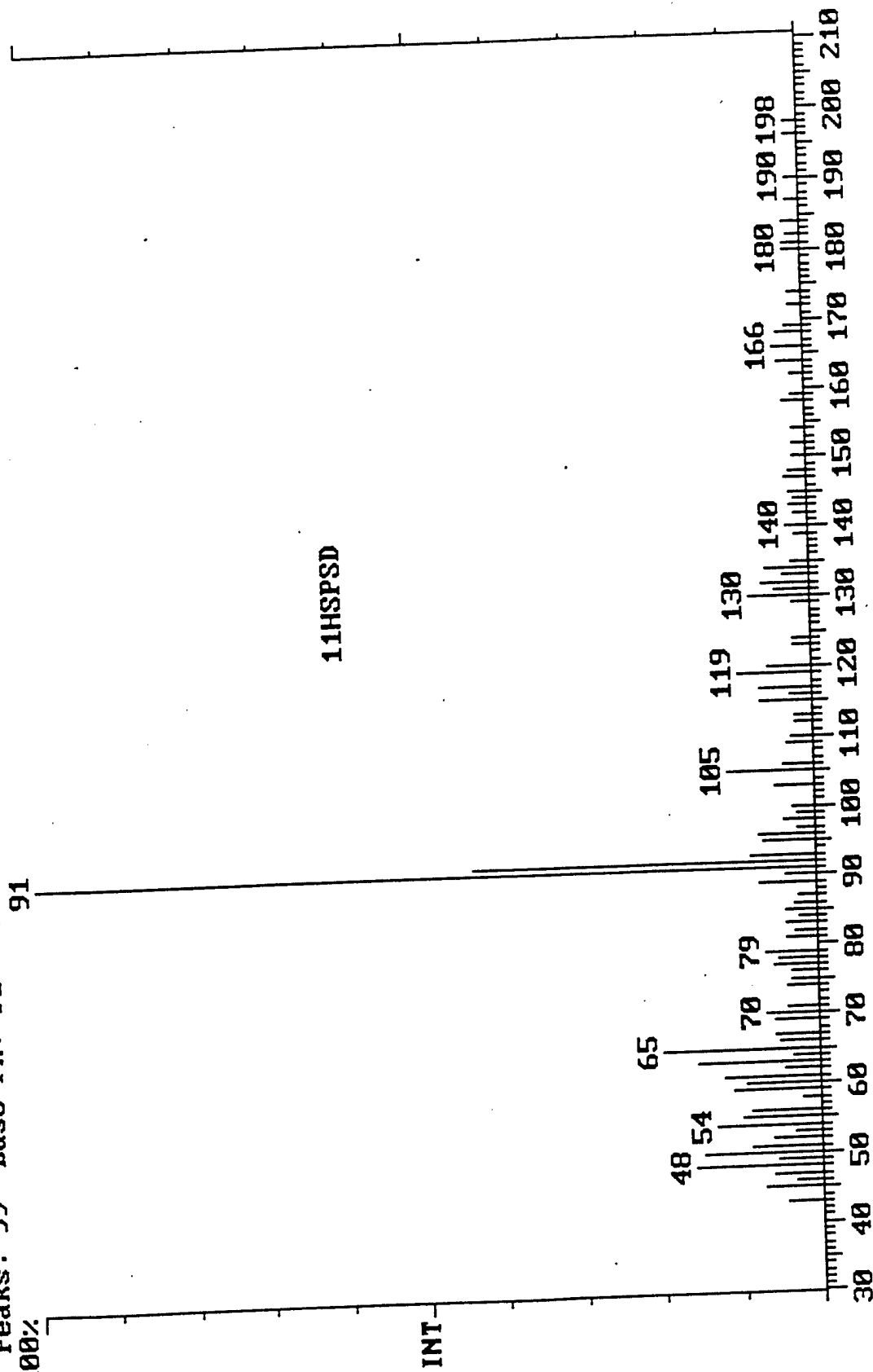
Spectrum Plot

Comment: 03HSPSD(9.0-12.0); 10HSPSD(9.0-18.6); 11HSPSD(9.0-18.3)

Scan No: 1939 Retention Time: 32:19 RIC: 236816 Mass Range: 43 - 198

Peaks: 99 Base Pk: 91 Ioniz: 116 us Int: 39439 100.00% = 39439

100%



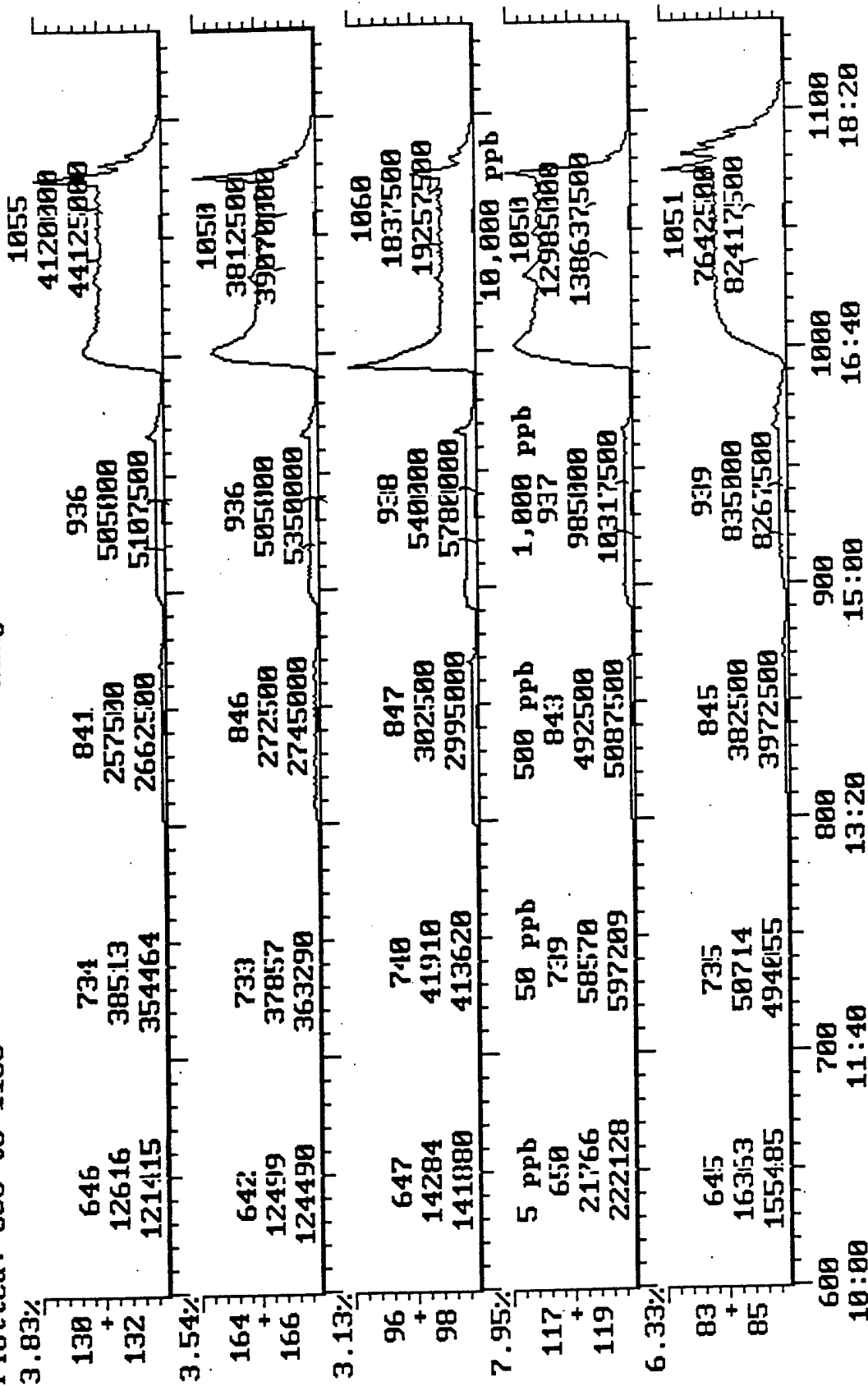
C:\MAGNUM\DATA\11059801 Date: 11/05/98 07:45:30

Chromatogram Plot

Comment: 05HSPSD(7.0-12.0)

Scan No: 1136 Retention Time: 18:56 RIC: 377301 0 ass Range: 44 - 197

Plotted: 600 to 1136 Range: 1 to 1136 100% = 208935000



Chromatogram Plot

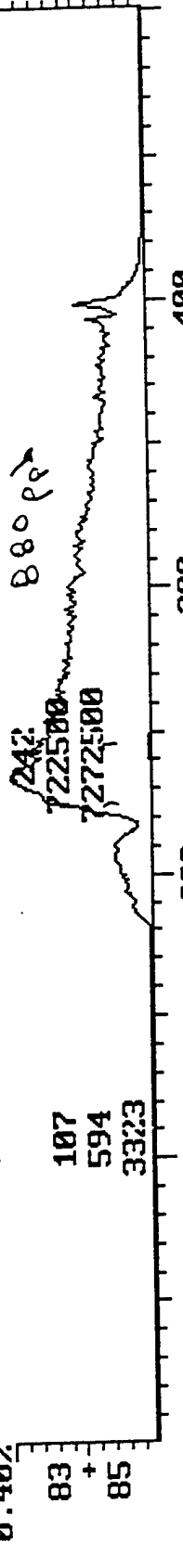
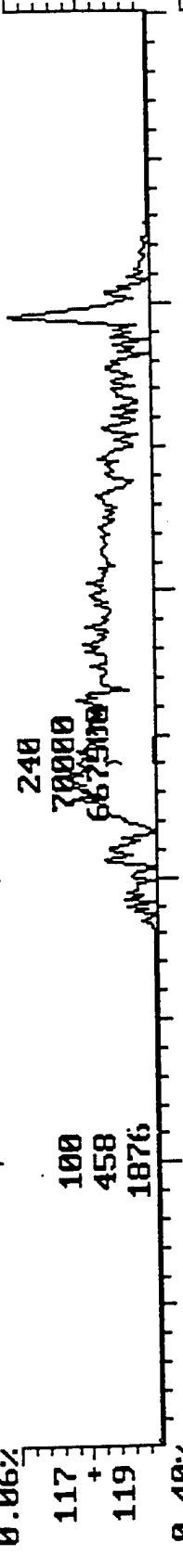
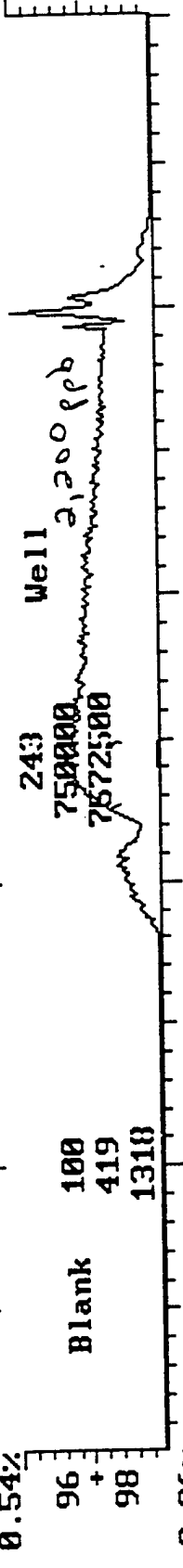
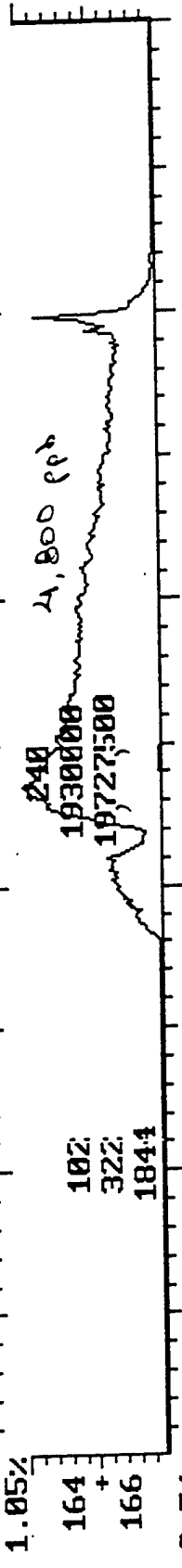
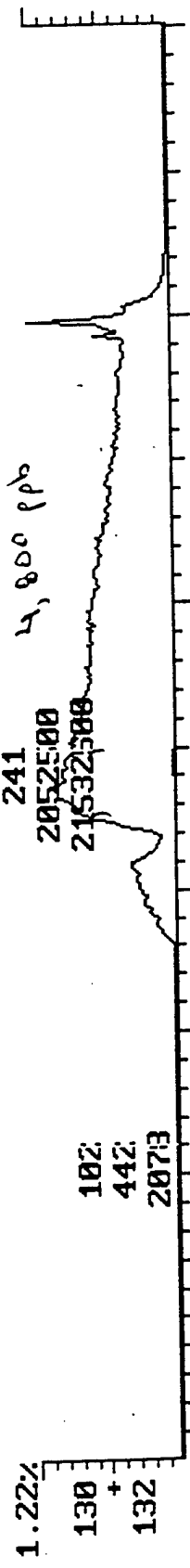
Comment: 05HSPSD(7.0-12.0)

Scan No: 500 Retention Time: 8:20 RIC: 34255 Mass Range: 43 - 199

Plotted: 1 to 500 Range: 1 to 1136 100% = 208935000

C:\MAGNUM\DATA\11059801

Date: 11/05/98 07:45:30



100 1:40 200 3:20 300 5:00 400 6:40

Date: 11/05/98 07:45:30

C:\MAGNUM\DATA\11059801

Spectrum Plot

Comment: 05HSPSD(7.0-12.0)

Scan No: 111

Retention Time: 1:51

Mass Range: 43 - 197

Peaks: 72 Base Pk: 43

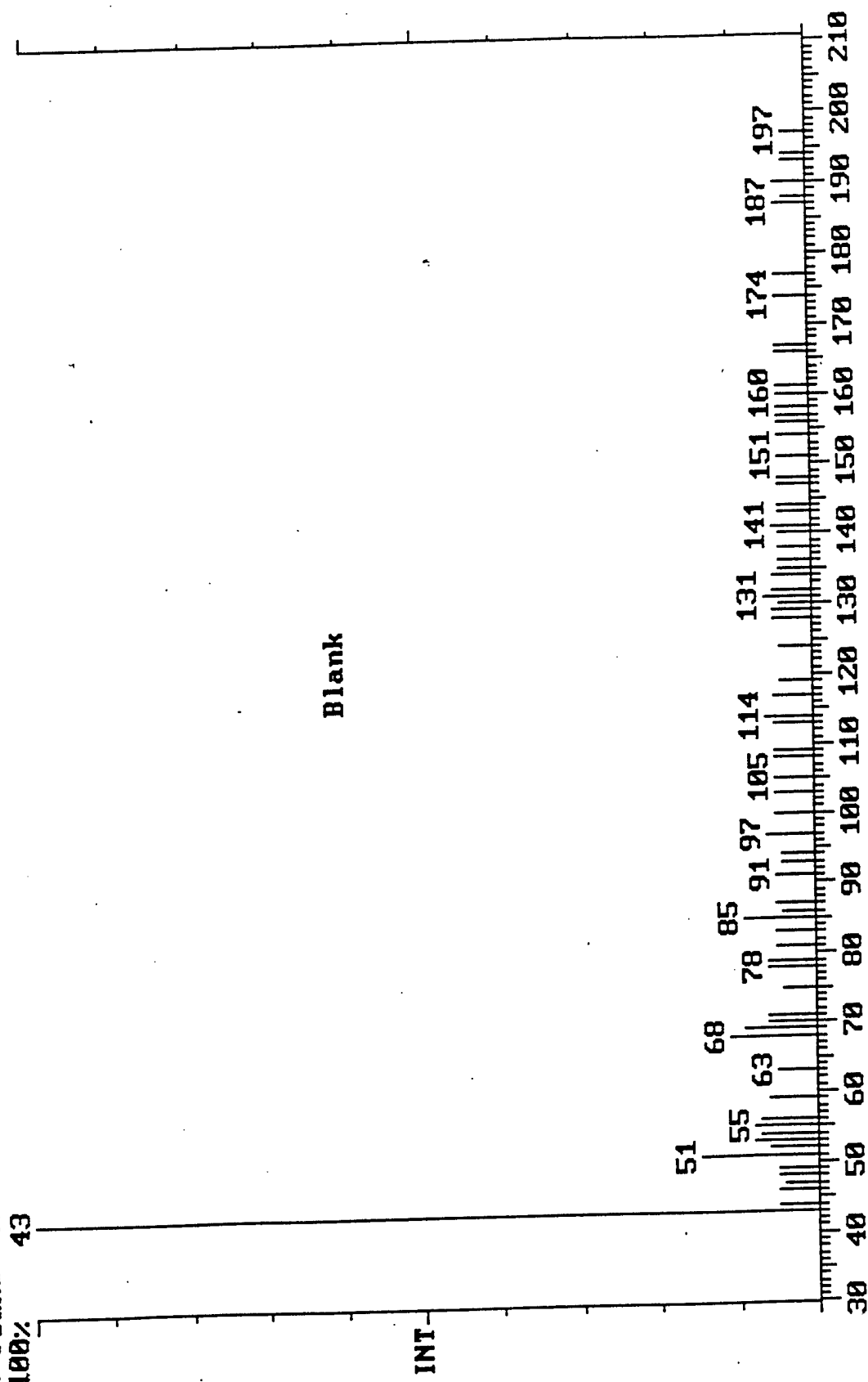
RIC: 15720

100.00% = 3444

Ioniz: 733 us

Int: 3444

100%



Blank

INT

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Spectrum Plot

Comment: 05HSPSD(7.0-12.0)

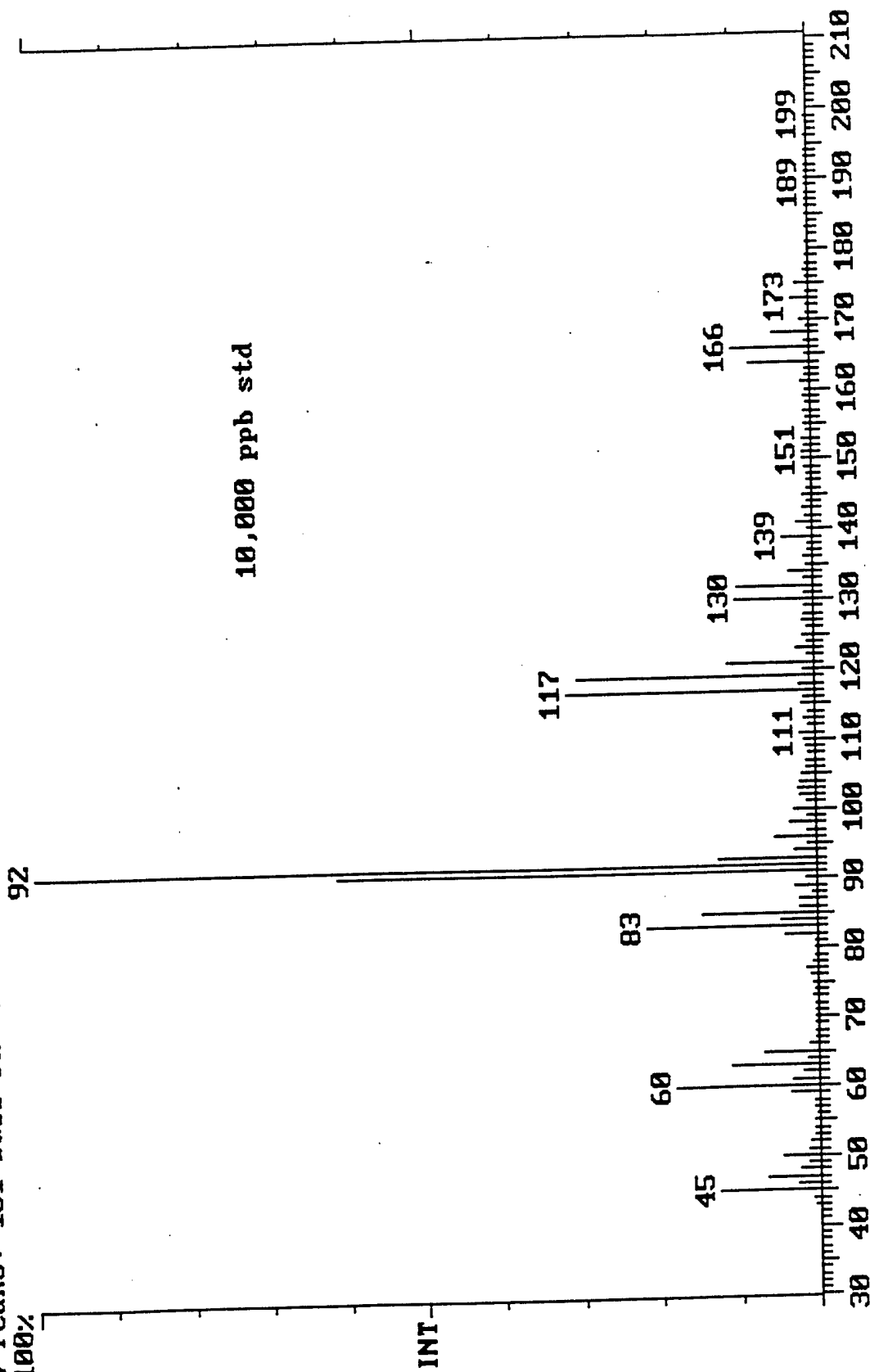
Scan No: 1025 Retention Time: 17:05

Peaks: 151 Base Pk: 92 Ioniz: 10 us

RIC: 104532500 ass Range: 43 - 199

Int: 20470000 100.00% = 20470000

100%



C:\MAGNUM\DATA\11059801 Date: 11/05/98 07:45:30

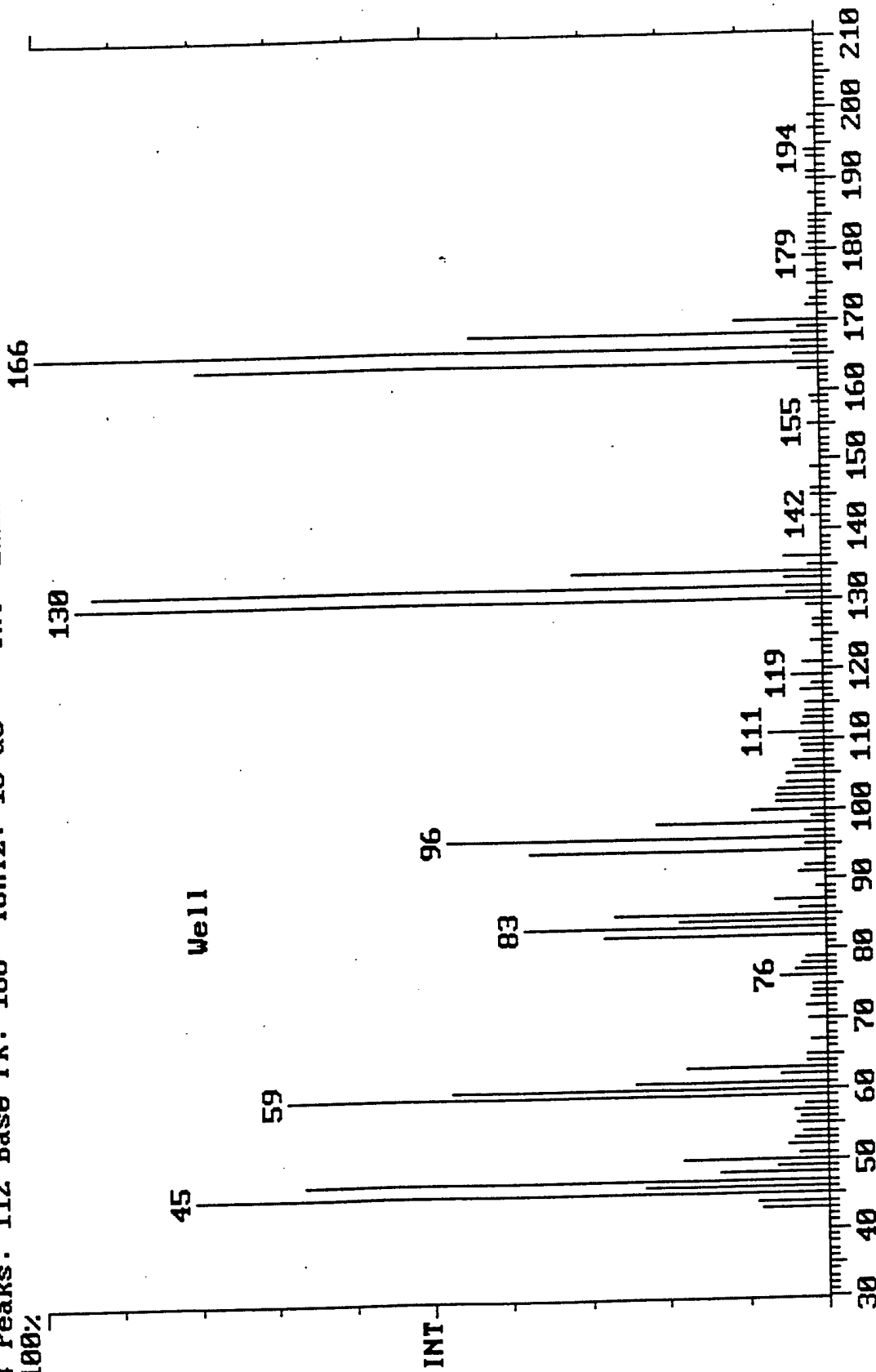
Spectrum Plot

Comment: 05HSPSD(7.0-12.0)

Scan No: 244 Retention Time: 4:04 RIC: 12950000 Mass Range: 43 - 199

Peaks: 112 Base Pk: 166 Ioniz: 10 us Int: 1020000 100.00% = 1020000

100%



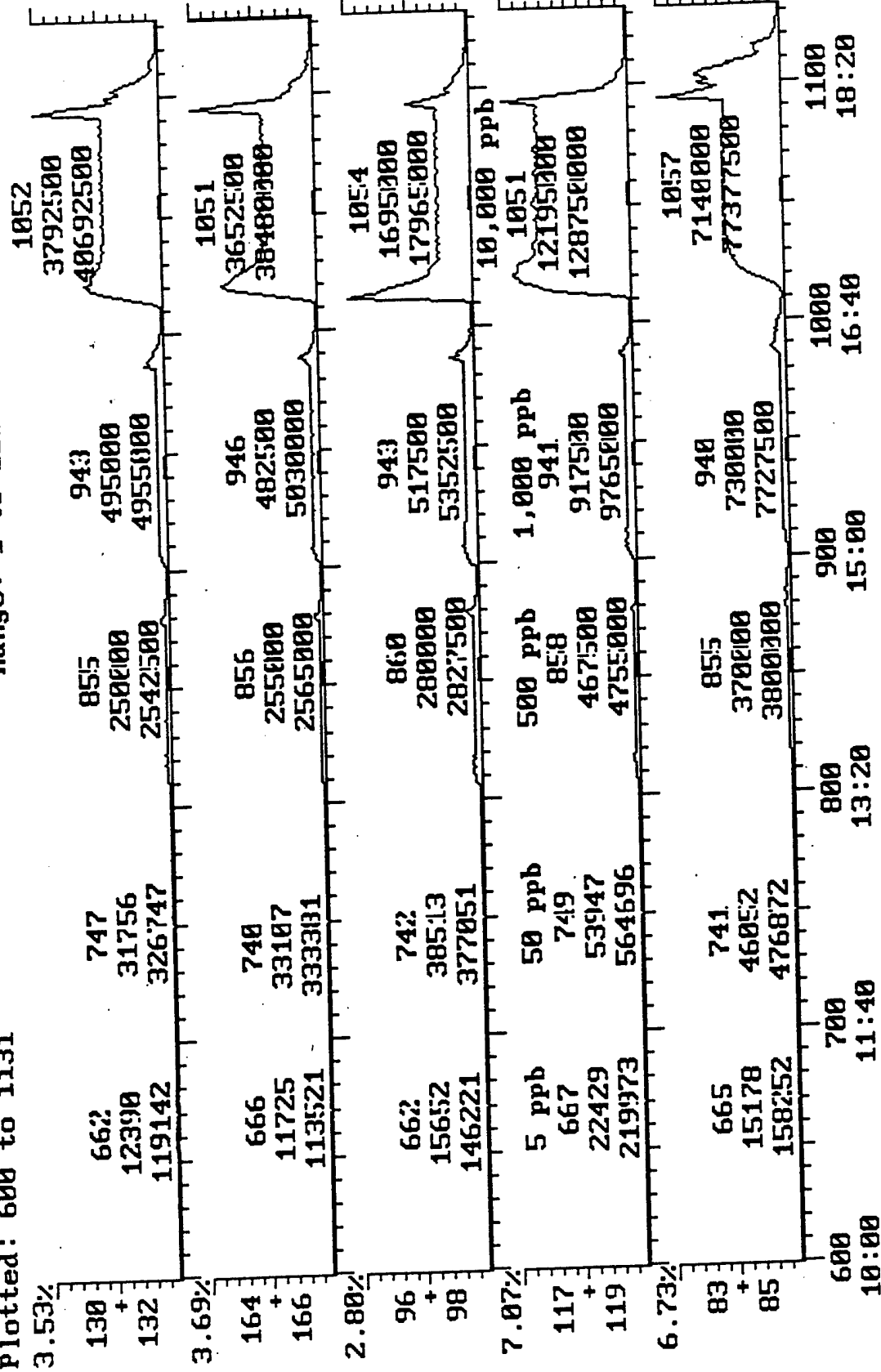
C:\MAGNUM\DATA\11059802 Date: 11/05/98 08:09:53

Chromatogram Plot

Comment: 07HSPSD(9.0-12.0)

Scan No: 1131 Retention Time: 18:51 RIC: 1247335 Mass Range: 43 - 198

Plotted: 600 to 1131 Range: 1 to 1131 100% = 221987500



C:\MAGNUM\DATA\11059802 Date: 11/05/98 08:09:53

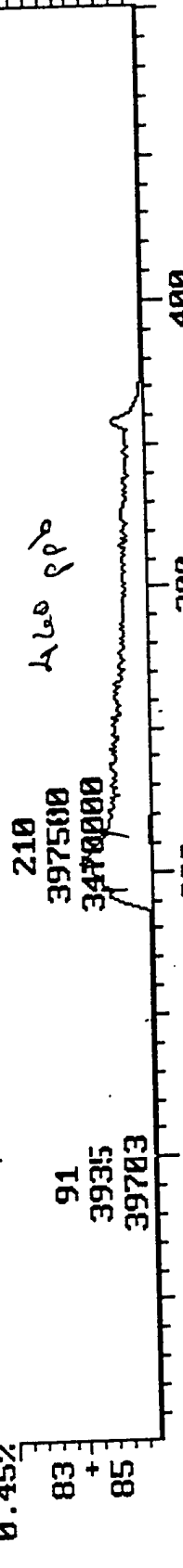
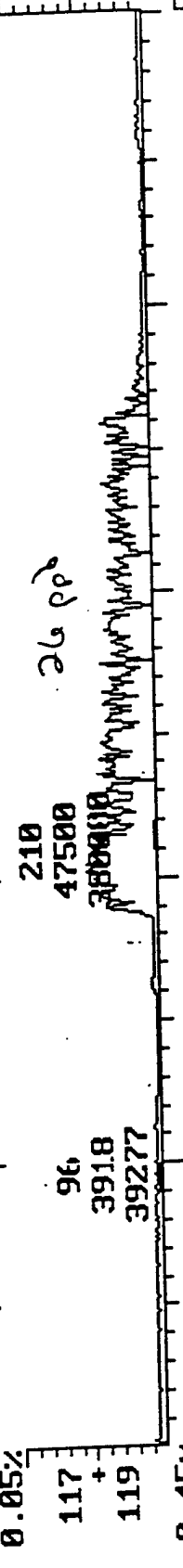
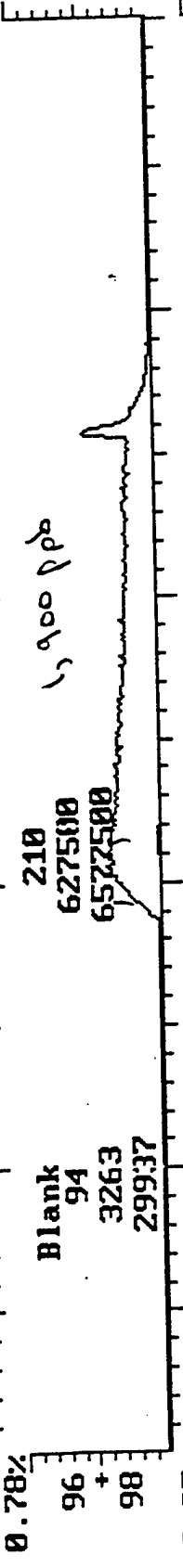
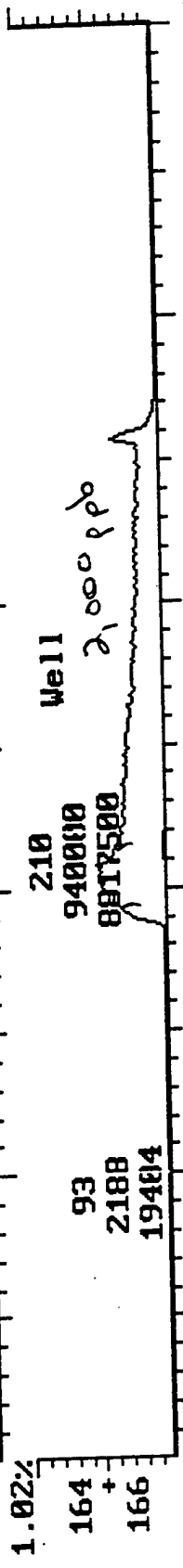
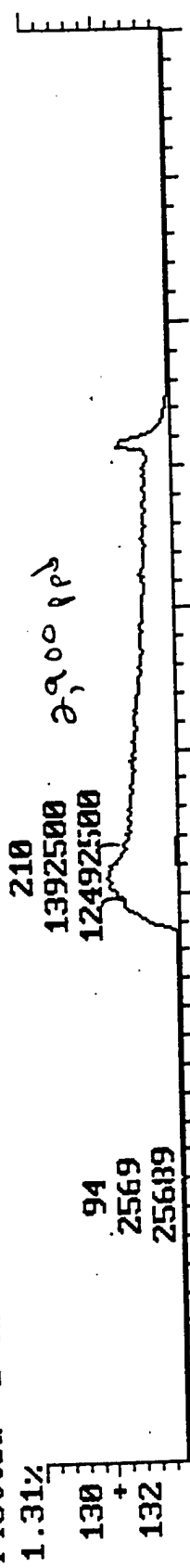
Chromatogram Plot

Comment: 07HSPSD(9.0-12.0)

Scan No: 500 Retention Time: 8:20

Plotted: 1 to 500

RIC: 54214 Mass Range: 43 - 197
Range: 1 to 1131 100% = 221987500



100 1:40 200 3:20 300 5:00 400 6:40

Date: 11/05/98 08:09:53

C:\MAGNUM\DATA\11059802

Spectrum Plot

Comment: 07HSPSD(9.0-12.0)

Scan No: 91

Retention Time: 1:31

RIC: 65264

Mass Range: 43 - 199

Peaks: 88

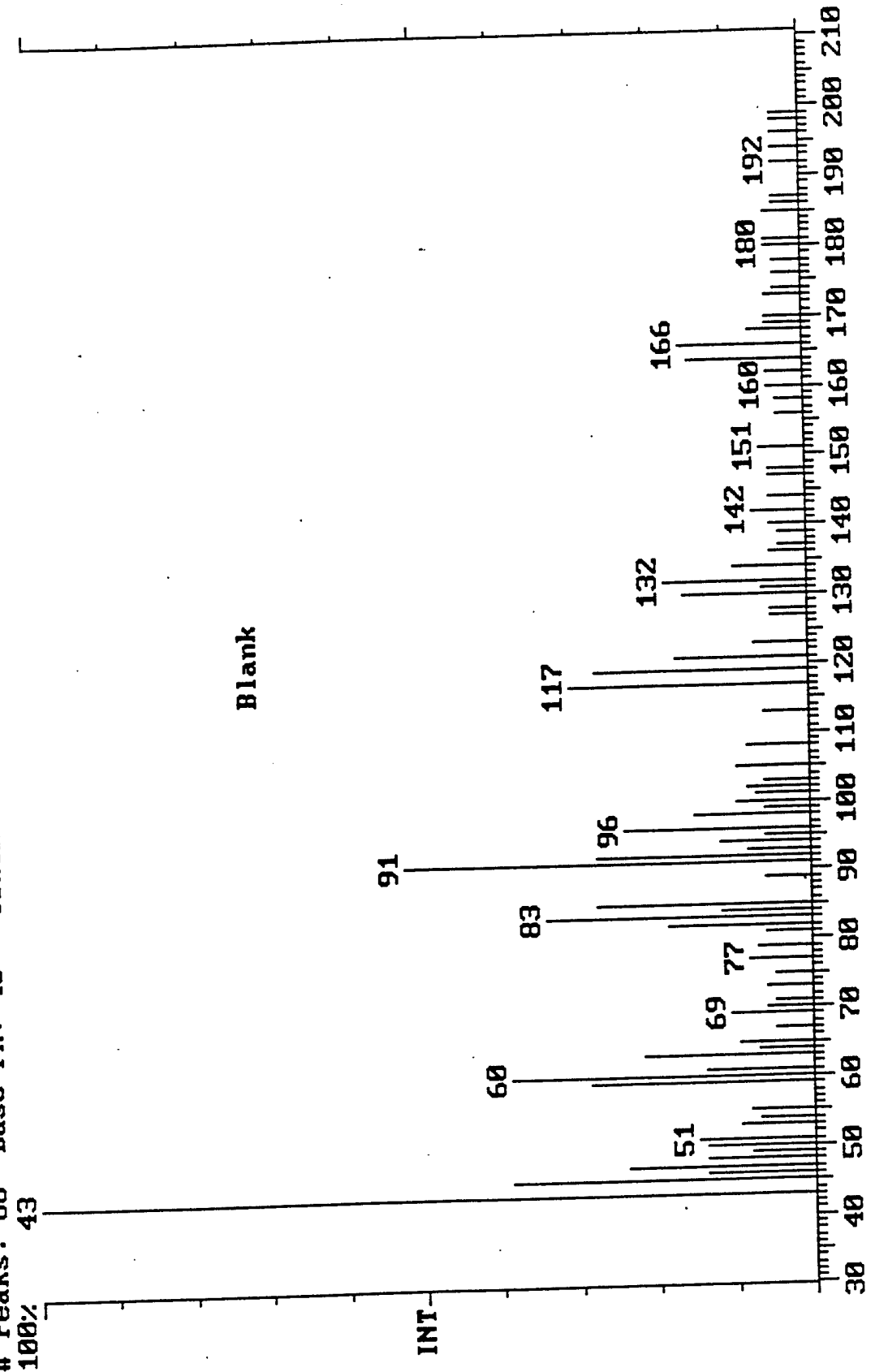
Base Pk: 43

Ioniz: 343 us

Int: 6413

100.00% = 6413

100%



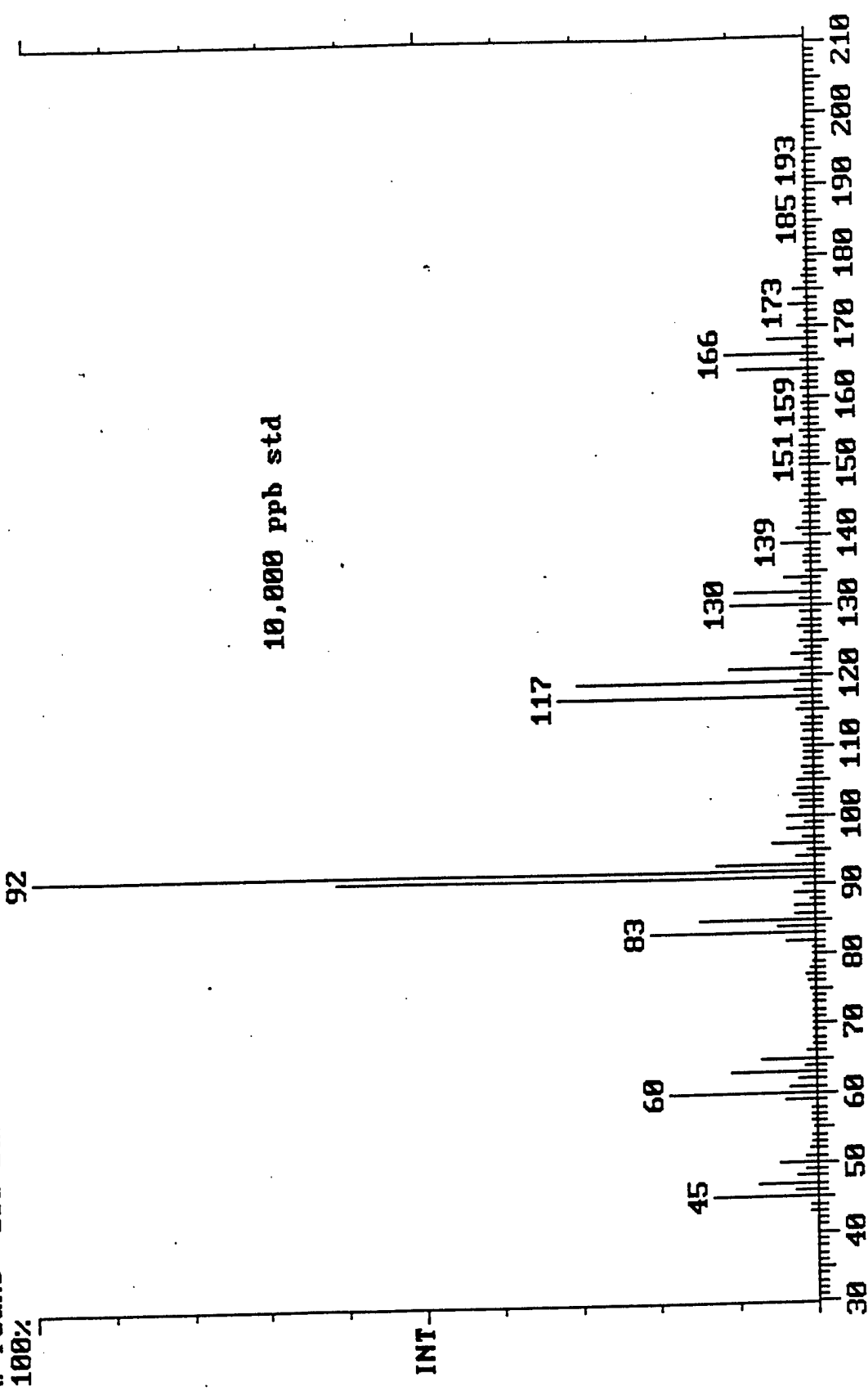
C:\N...\ALTUS\11_05_98\11059802 11/05/98 08:09:53

Spectrum Plot

Comment: 07HSPSD(9.0-12.0)

Scan No: 1033 Retention Time: 17:13 RIC: 100630000 ass Range: 43 - 198

Peaks: 150 Base Pk: 92 Ioniz: 10 us Int: 19547500 100.00% = 19547500



C:\MAGNUM\DATA\11059802 Date: 11/05/98 08:09:53

Spectrum Plot

Comment: 07HSPSD(9.0-12.0)

Scan No: 216

Retention Time: 3:36

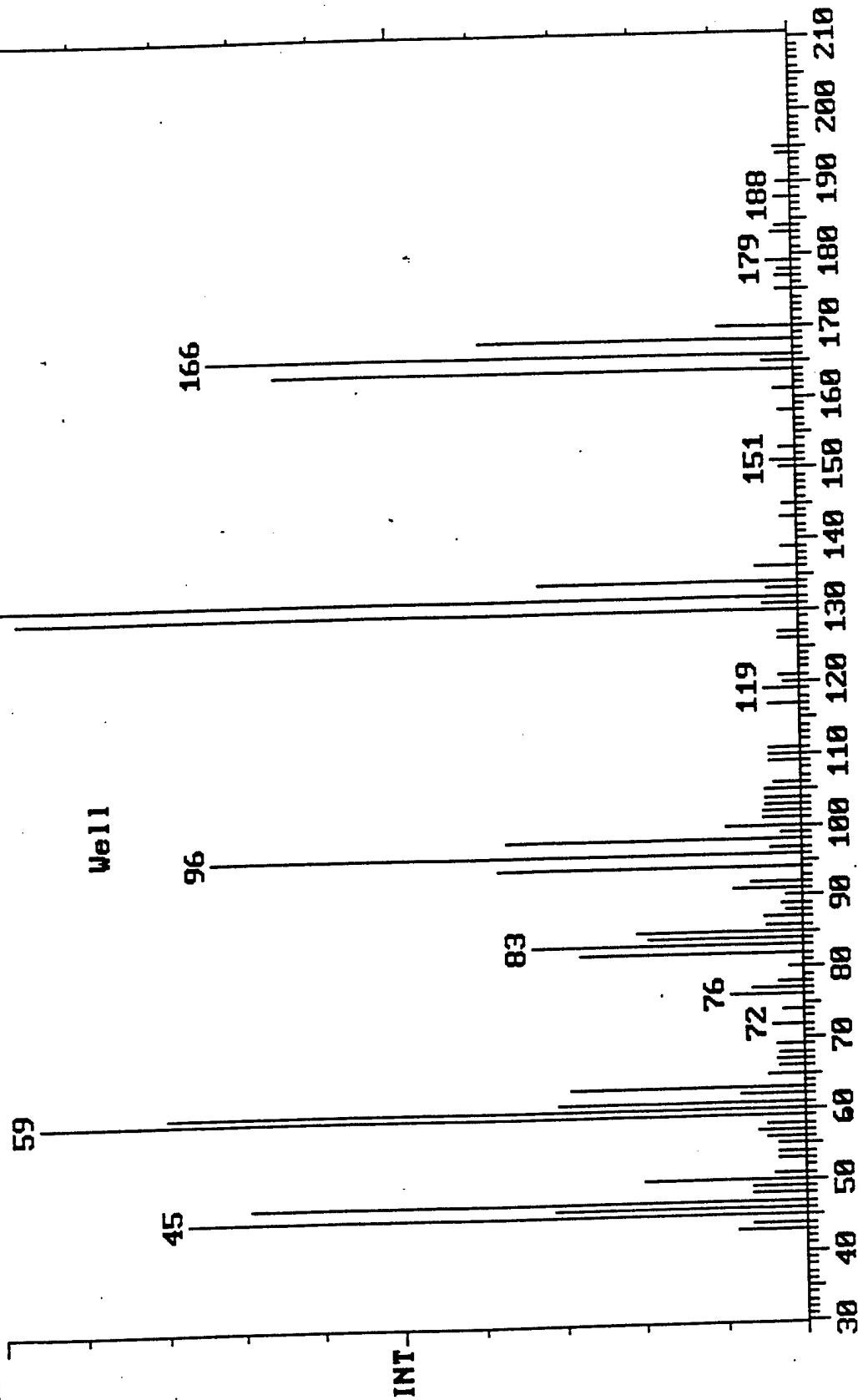
RIC: 7252500 Mass Range: 43 - 195

Int: 535000

100.00% = 535000

Peaks: 92 Base Pk: 132 Ioniz: 10 us

100%

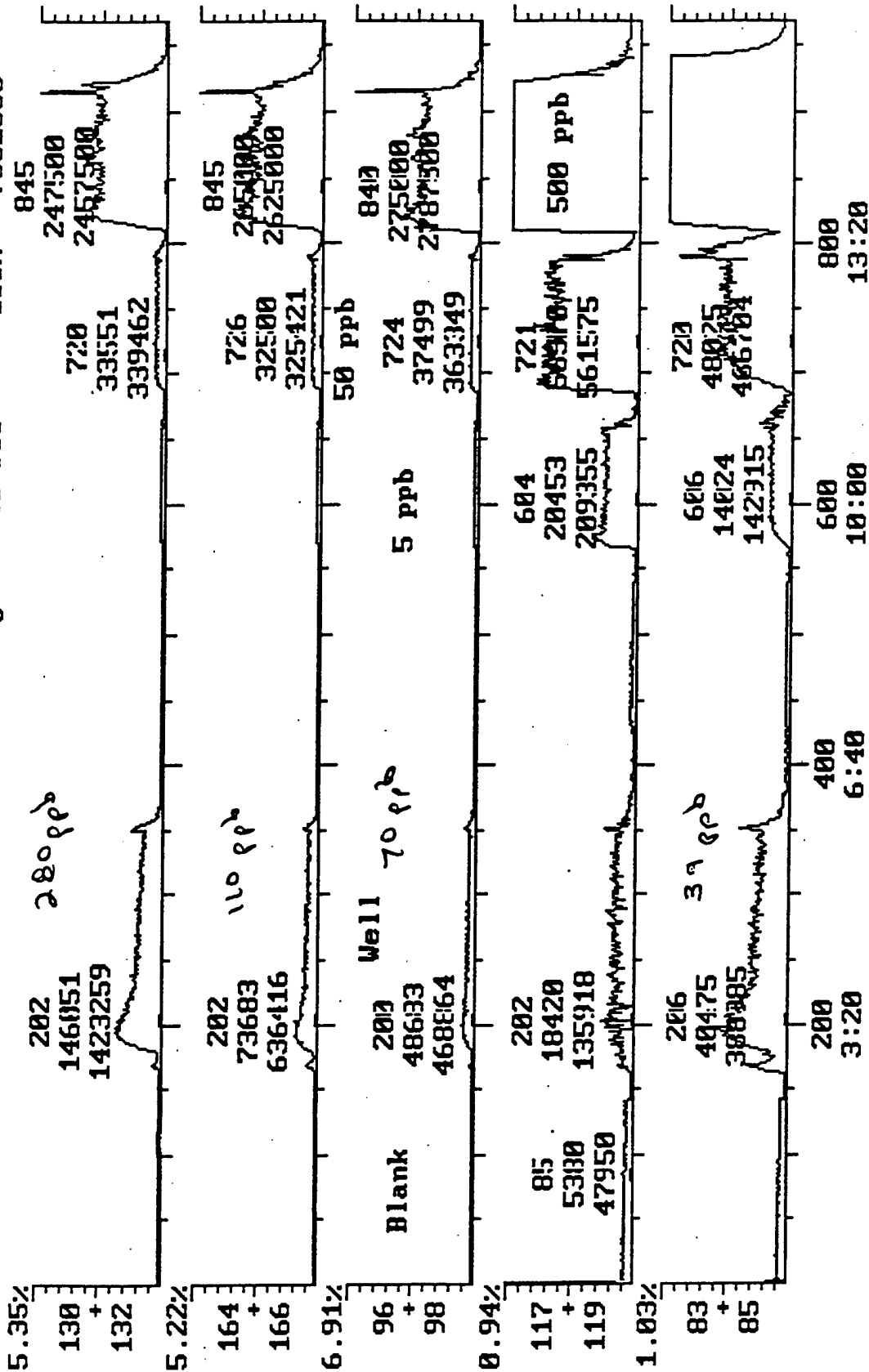


C:\MAGNUM\DATA\11059803 Date: 11/05/98 08:34:30

Scan No: 1 Retention Time: 0:01 RIC: 0 Mass Range: 0 - 0
Plotted: 1 to 966 Range: 1 to 966 100% = 7852500

Scan No: 1 Retention Time: 0:01 RIC: 0 Mass Range: 0 - 0

Range: 1 to 966 100% = 7852500



Spectrum Plot

Comment: 09HSPSD(9.7-17.5)

Scan No: 82

Peaks: 84

Base Pk: 91

Retention Time: 1:22

RIC: 65257

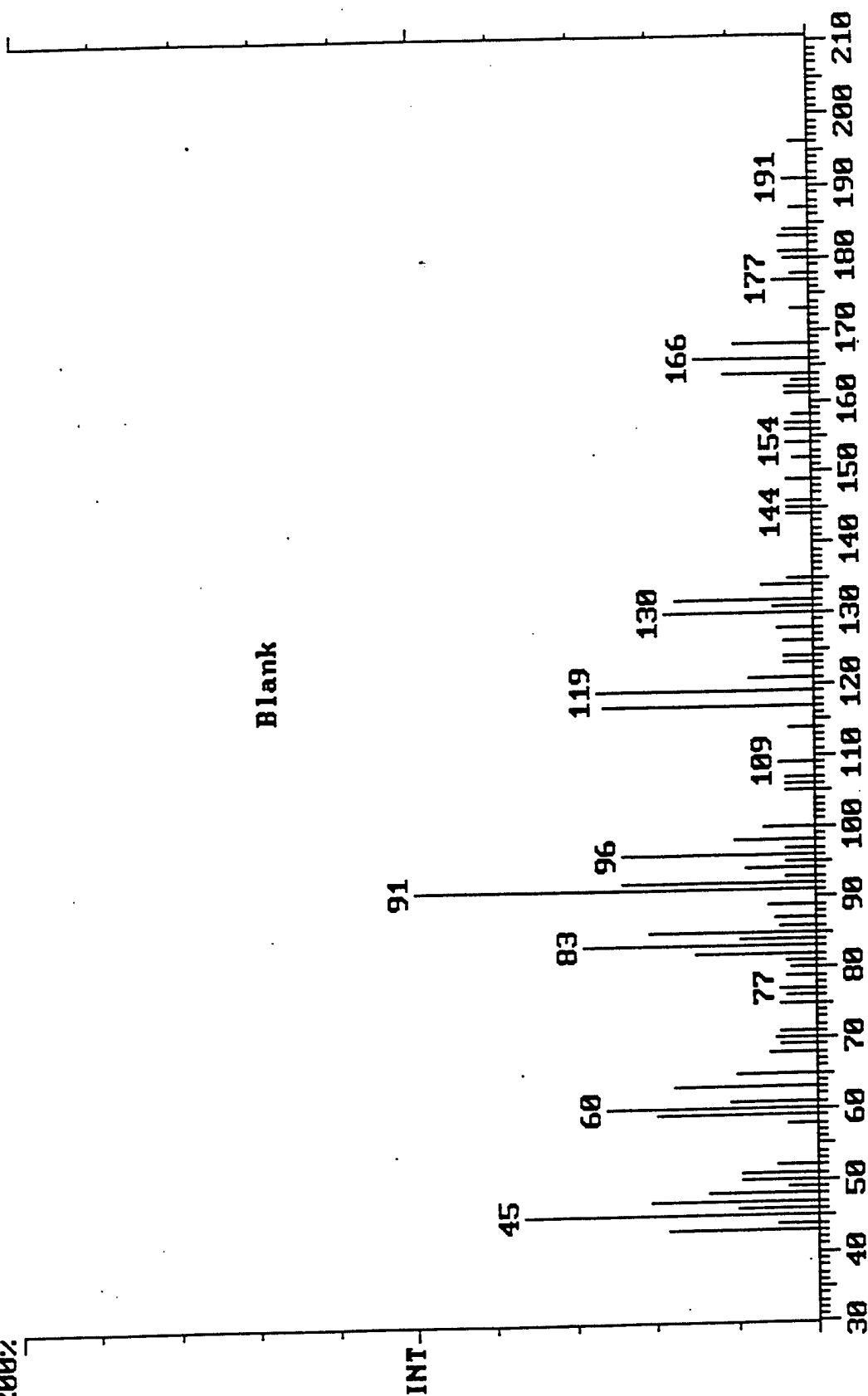
Ioniz: 389 us

Int: 4562

Mass Range: 43 - 196

200.00% = 9124

200%



Spectrum Plot

Comment: 09HSPSD(9.7-17.5)

Scan No: 208

Peaks: 76 Base Pk: 91

100%

Retention Time: 3:28

Ioniz: 23 us

91

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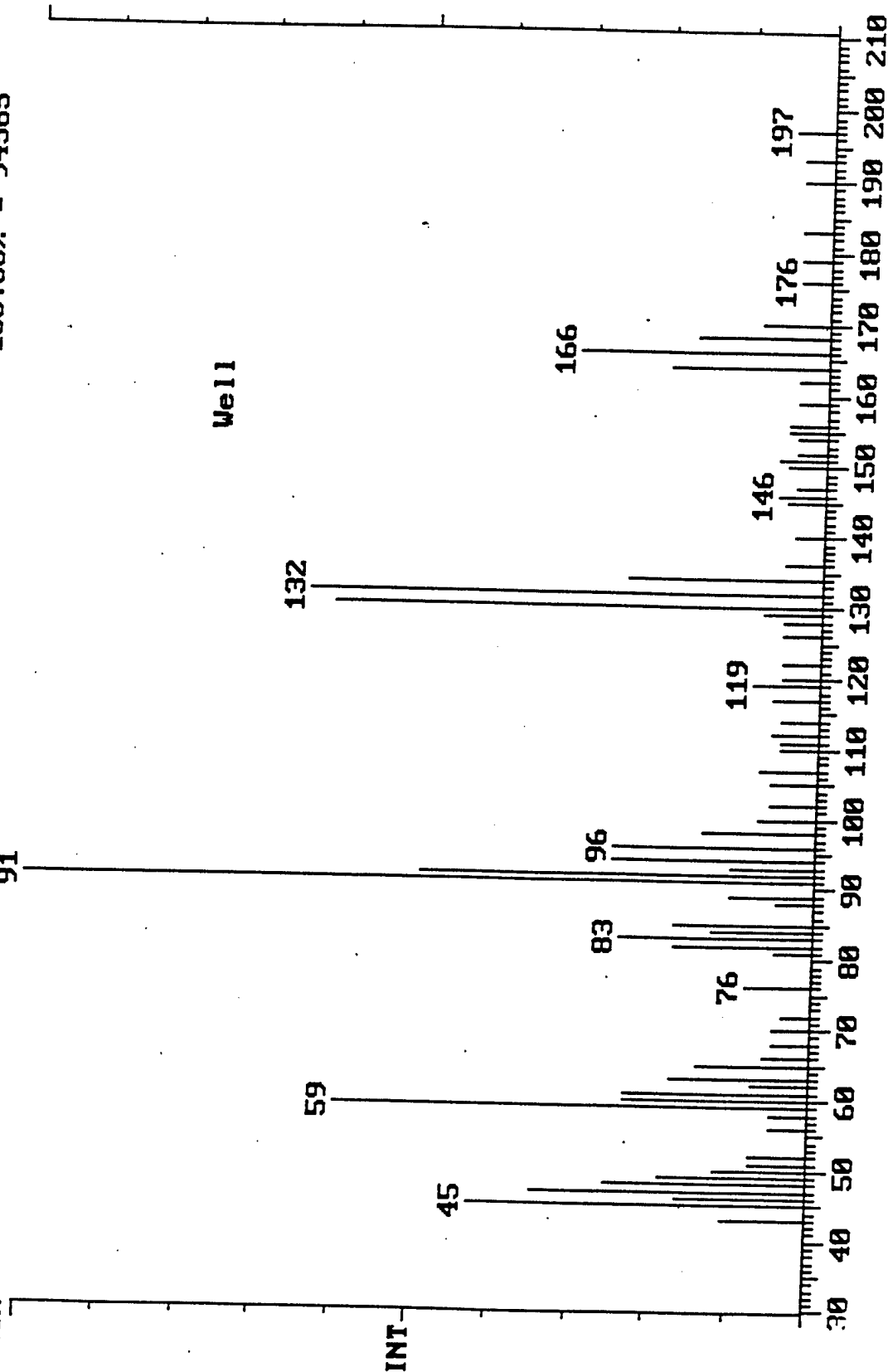
Date: 11/05/98 08:34:30

RIC: 994516

Int: 94565

Mass Range: 43 - 197

100.00% = 94565



APPENDIX B
SPECIFICATIONS

SECTION 02950

TREES

SECTION 02950 - TREES

PART I - GENERAL

1.1 SCOPE

- A. Furnish all labor, materials, supplies, tools, and transportation; and perform all operations in connection with and reasonably incidental to the complete installation of the trees and warranty as specified herein. The work shall include but is not necessarily limited to the following:
 - 1. Excavate planting pits.
 - 2. Provide and install backfill amendments.
 - 3. Planting trees.
 - 4. Clean-up, inspection and approval.
 - 5. Warranty of all plantings.

1.2 QUALITY ASSURANCE

- A. Supplier or grower should have not less than five years experience in growing specified plants.
- B. Installation contractor to have not less than five years of experience in successful installation of plant material.

1.3 SUBMITTALS

- A. *Certificates:* Submit certificates of inspection as required by governmental authorities.
- B. SUBCONTRACTOR shall provide proof within 3 days from notice to proceed, that plant material has been ordered from a nursery with estimated delivery date.

1.4 DELIVERY, STORAGE, AND HANDLING

- A. *Packaged Materials:* Deliver packaged materials in containers showing weight, analysis, and name of manufacturer. Protect materials from deterioration during deliver, and while stored at site.
- B. *Trees:* Do not prune prior to delivery unless otherwise approved by the CONTRACTOR. Do not bend or bind-tie trees or shrubs in such manner as to damage bark, break branches or destroy natural shape. Plants shall be dug and prepared for shipment in a manner that will not cause damage to branches, shape and future development after planting. Trunks shall be wrapped for added protection. Wounds, scars or damage shall be grounds for rejection. Provide protective covering during delivery. Do not drop balled and burlapped stock during delivery. If in full leaf, spray with anti-desiccant such as Wilt-proof or equal.
- C. *Transportation:*
 - 1. Plants to be transported to the project in open vehicles shall be covered with tarpaulins or other suitable covers securely fastened to the vehicle to prevent injury to the plants. Closed vehicles shall be adequately ventilated to prevent overheating of the plants.

SECTION 02950 - TREES

2. Plants shall be kept moist, fresh and protected at all times. Such protection shall encompass the entire period during which the plants are in transit, being handled, or are in temporary storage.
3. Do not unload ball and burlap trees by rolling. Ball and burlap trees shall be unloaded using hooks on wire baskets. Do not drop plants.

D. *Storage:*

1. Unless specific authorization is obtained by the CONTRACTOR, plants shall not remain on the site of the work longer than 3 days prior to planting. Deliver trees and shrubs after preparations for planting have been completed and plant immediately. If planting is delayed more than 6 hours after delivery, set trees and shrubs in shade, protect from weather and mechanical damage, and keep roots moist by covering with mulch, burlap or other acceptable means of retaining moisture. Keep all roots moist before, during and after planting. Duration and method of storage are subject to CONTRACTOR's approval.
2. Do not move balled and burlapped trees while in storage by rolling. Use hooks in wire baskets. Do not drop plants.

E. *Handling:* SUBCONTRACTOR shall exercise care in the handling of plant materials to avoid damage or stress.

1.5 REJECTION OF MATERIALS

- A. Evidence of inadequate protection after digging, in transit, or improper handling or storage, shall be cause for rejection.
- B. Upon arrival at the temporary storage location or the site of the work, plants shall be inspected for proper shipping procedures. Should the roots be dried out, large branches be broken, balls or earth broken, or loosened, or areas of bark be torn, the CONTRACTOR will reject the injured plant.
- C. When a plant has been so rejected, the SUBCONTRACTOR shall at once remove it from the area of the work and replace it.

1.6 PROJECT CONDITIONS

- A. *Work Scheduling:* Proceed with and complete landscape work as required by the *Description of the Work*.
- B. *Utilities:* Determine location of underground utilities and perform work in manner which will avoid possible damage. Hand excavate, as required. Maintain grade stakes set by others until removal is mutually agreed upon by parties concerned.
- C. *Excavation:* When conditions detrimental to plant growth are encountered, such as rubble fill, adverse drainage conditions, or obstructions, notify the CONTRACTOR before planting.

SECTION 02950 - TREES

1.7 INSPECTIONS

Work will be subject to inspection at all times by the CONTRACTOR, who reserves the right to engage an independent testing agency to analyze and test materials used in the construction of the work.

Costs of tests and material analyses made by the testing agency will be borne by the CONTRACTOR when tests indicate compliance and by the SUBCONTRACTOR when tests indicate non-compliance.

- A. *Planting Inspection:* CONTRACTOR shall inspect the staked locations of all trees and container plants before digging shall occur. Stake with flags. The SUBCONTRACTOR shall give the CONTRACTOR 48 hours notice to request inspection of staked locations.

1.8 WARRANTY AND REPLACEMENT

- A. One year warranty period beginning at completion of planting.

1.9 PLANTING TIME AND COMPLETION

Plants shall be planted only when weather and soil conditions permit and in accordance with locally accepted practice, as accepted by the CONTRACTOR, and within the requirements of the schedule.

PART II - PRODUCTS

2.0 SOIL AMENDMENTS

- A. *Bone Meal:* Commercial, raw, finely ground; 4% nitrogen and 20% phosphoric acid.
B. *Organic Matter:*

1. Cow or sheep manure must be composted for 70 to 90 days at 140°F.
2. Minimum acceptable nitrogen/phosphorous/potassium ratio if 1:1:1 (N-P-K).
3. Carbon to nitrogen ratios shall be in the range of 20:1 to 15:1.
4. Trace elements of iron and zinc should be present at a minimum rate of 15 mg/kg.
5. No solid particle greater than 0.5-inch diameter.
6. Acceptable pH range after composting is between 5.5 and 7.7.
7. Moisture content on a dry basis should range between 50 to 60 percent.

- C. *Fertilizer:* Simplot Best-Tabs 20-10-5 or approved equal.

2.1 WOOD MULCH

Shredded, not chipped, bark mulch, free from deleterious materials and suitable for top dressing of trees. Mulch shall be of a long fibrous natural capable of matting together and interlocking when moistened and settled. Shredded cedar bark or equivalent.

2.2 WATER

SUBCONTRACTOR is responsible for coordination of his water needs for irrigation water with the CONTRACTOR.

SECTION 02950 - TREES

2.3 TREES

- A. *General:* Plant materials furnished shall be healthy and vigorous, well-branched, and well-proportioned in respect to height and width relationships, free from disease, injury, insects and their eggs, larvae and weed roots. Plants shall have a well developed fibrous root system. Plant material furnished shall be well branched and proportioned in respect to height and width relationships, and characteristic of the exact type specified.
1. All plants shall meet the requirements the reference standards for size, branching, condition, ball size, number of canes and all other conditions particular to each species.
 2. Plants shall meet the type and sizes specified in the *Description of Work*.
- B. Plants shall be free of physical damage such as scrapes, broken or split branches, scars, bark abrasions, sun scalds, fresh limb cuts, disfiguring knots, or other defects.
- C. *Balled and Burlapped Plants:* Shall be nursery grown stock adequately balled with firm, natural balls of soil in sizes and ratios specified in this reference standards. Balls shall be firmly wrapped with non-treated burlap, secured with wire or jute. Broken balls will not be accepted.

2.4 MISCELLANEOUS LANDSCAPE MATERIALS

The SUBCONTRACTOR shall supply the following in accordance with local practices: Tree Stakes, Staking Wire, Tree Collar, Wrapping Material, Turnbuckles, and Tree Guys.

2.5 VENT PIPE

The SUBCONTRACTOR shall supply a 3-inch diameter perforated pipe to be installed within each planting pit from 2 to 7-feet bgs. The end of the pipe should be finished with a flexdrain snap end cap. The pipe should extend to a least 3-inches above surface grade and be capped with a 3-inch diameter drain grate.

PART III - EXECUTION

3.0 SITE PREPARATION

- A. All areas within the limits of planting shall be planted with trees as specified.
- B. To the extent practical, the existing surface vegetation should be maintained during installation .
- C. Planting may not begin until completion of an operational irrigation system .

3.1 LAYOUT

Layout individual tree locations and areas for multiple plantings. Stake locations and outline areas and secure CONTRACTOR's approval before start of planting work. The configuration for the tree plantings is as described in the *Description of Work*.

3.2 SEQUENCING

SECTION 02950 - TREES

Begin planting after the installation of an operable irrigation system.

3.3 PREPARING SOIL MIX AND BACKFILLING FOR TREE PLANTINGS

- A. Before mixing, clean soil from pit of roots, plants, sods, stones, clay lumps, asphaltic material, concrete, metal and wire fragments and other extraneous materials harmful or toxic to plant growth.
- B. Thoroughly mix equal portions (by volume) of excavated soil and organic matter.
- C. Properly compact soil to avoid air pockets in planting holes. Use remaining excavated soil for plant basin.
- D. Place bone meal in each planting pit in accordance with local practices.
- E. Place fertilizer (at least 3 tabs) in each planting pit.

3.4 PLANTING PITS

- A. Auger or hand dig planting pits vertically for plant material. Angled planting is not acceptable.
- B. SUBCONTRACTOR shall auger a 12" diameter x 7'-0" deep hole, and fill with equal portions of excavated soil and organic matter below each planted tree.
- C. SUBCONTRACTOR shall install a 3" diameter vent pipe of PVC or HDPE construction in each planting pit to provide oxygen to the subsurface. The vent pipe shall be installed so that the screened portion of the pipe is placed at 2 to 7' bgs.
- D. Control any adverse compaction in the soil conditions. Scarify the sides of the planting pit with shovel.
- E. *Planting Pit Widths:* The planting pit shall be minimum of two times the root ball width, and shall be the height of the rootball.
- F. It is not anticipated that the planting shall be done where the depth of soil over underground construction obstructions, or rock, is insufficient to accommodate the roots or where pockets in rock or impervious soil will require drainage. If such conditions are encountered in excavation of planting areas, remove rocks or other underground obstruction.

3.5 STAKING

- A. Secure all trees with two stakes, guying cords and connectors.

3.6 MULCHING

- A. Immediately after planting and compaction, spread a layer of wood mulch material on finished grade within basin of plants to the depth of three inches.

3.7 WRAPPING

SECTION 02950 - TREES

- A. For fall plantings in accordance with local practices, immediately after planting, wrap the trunk and main branches of all deciduous trees.
- B. Wrap spirally, starting at the highest point moving down the trunk.
- C. Overlap wrap two inches on each spiral.

3.8 MAINTENANCE

- A. Begin maintenance immediately after planting.
- B. See Section 02999 for maintenance requirements.

3.9 CLEAN-UP

Keep pavements clean and work area in an orderly conditions. Protect landscape work and materials from damage due to landscape operations, operations by other contractors and trades and trespassers. Maintain protection during installation until final acceptance. Treat, repair or replace damaged landscape work as directed.

END OF SECTION 02950

SECTION 02810

IRRIGATION

SECTION 02810 - IRRIGATION

PART I - GENERAL

1.1 SCOPE

- A. Furnish all labor materials, supplies, equipment, tools, and transportation, and perform all operations in connection with and reasonably incidental to the complete installation of the irrigation system as specified herein. Items of work specifically included are:
1. Procurement of all applicable licenses, permits, and fees, including any permits associated with the installation of the taps.
 2. Excavation, installation, and backfill of tap into potable water line.
 3. Excavation, installation, and backfill of water meter and vault.
 4. Excavation, installation, and backfill for piping and controls for irrigation system including all incidental items (e.g., valve boxes).

1.2 SUBMITTALS

- A. Deliver four (3) copies of all submittals to the CONTRACTOR within 10 days from the date of *Notice to Proceed*.
- B. *Materials List*: Include pipe, fittings, mainline components, water emission components, control system components. Quantities of materials need not be included.
- C. *Manufacturer's Data*: Submit manufacturers; catalog cuts, specifications, and operating instructions for equipment shown on the materials list.

1.3 QUALITY ASSURANCE

- A. *Installer Qualifications*: Installer shall have had considerable experience and demonstrate ability in the installation of irrigation systems of specific types in a neat, orderly, and responsible manner in accordance with recognized standards of workmanship.
- B. *Special Requirements*:
1. Working involving substantial plumbing for installation of copper piping, backflow prevention devices, and related work must be executed by licensed and bonded Plumber(s).
 2. Replacement of Paving and Curbs - Where trenches and lines cross existing roadways, paths, curbing, etc., damage to these must be kept to a minimum and must be restored to original condition.
 3. Damage to Other Improvements - SUBCONTRACTOR must replace or repair damage to grading, soil preparation, seeding, sodding, or planting done under other Sections during Work associated with installation of irrigation system at no additional cost to CONTRACTOR.

1.4 RULES AND REGULATIONS

- A. Work and materials shall be in accordance with the latest edition of the National Electric Code, and Uniform Plumbing Code as published by the Western Plumbing Officials Association, and applicable laws and regulations of the governing authorities. Backflow assembly installation will be performed by a licensed and bonded plumber.

SECTION 02810 - IRRIGATION

1.5 TESTING:

- A. Notify the CONTRACTOR three days in advance of testing.
- B. Pipelines jointed with rubber gaskets or threaded connections may be subjected to a pressure test at any time after partial completion of backfill. Pipelines jointed with solvent welded PVC joints shall be allowed to cure at least 24 hours before testing.
- C. Subsections of mainline pipe may be tested independently, subject to the review of the CONTRACTOR.
- D. Furnish clean, clear water, pumps, labor, fittings, and equipment necessary to conduct tests or retests.
- E. *Hydrostatic Pressure Test:*
 - 1. Subject mainline pipe to a hydrostatic pressure of 85 PSI for a minimum of two hours. Test with mainline components installed.
 - 2. Backfill to prevent pipe from moving under pressure. Expose couplings and fittings.
 - 3. Leakage will be detected by visual inspection. Replace defective pipe, fitting, joint, valve, or appurtenance. Repeat the test until the pipe passes test.
 - 4. Cement or caulking to seal leaks is prohibited.
- F. *Operational Test:*
 - 1. Activate each remote control valve in sequence from controller. The CONTRACTOR will visually observe operation, water application patterns, and leakage.
 - 2. Replace defective remote control valve, solenoid, wiring, or appurtenance to correct operational deficiencies.
 - 3. Replace, adjust, or move water emission devices to correct operational or coverage deficiencies.
 - 4. Replace defective pipe, fitting, joint, valve, sprinkler, or appurtenance to correct leakage problems. Cement or caulking to seal leaks is prohibited.
 - 5. Repeat test(s) until each lateral passes all tests. Repeat tests, replace components, and correct deficiencies at no additional cost to the CONTRACTOR.
- G. *Control System Grounding:*
 - 1. Test for proper grounding of control system per manufacturer's recommendations. Test results must meet or exceed manufacturer's guidelines for acceptance.
 - 2. Replace defective wire, grounding rod, or appurtenances. Repeat the test until the manufacturer's guidelines are met.
- H. *Test Report:*

SECTION 02810 - IRRIGATION

1. Within 5 calendar (5) days of completion of testing, the SUBCONTRACTOR shall provide a letter report to the CONTRACTOR certifying the tests (with the exception of the operational test) were completed and all deficiencies were corrected.

1.6 GUARANTEE/WARRANTY AND REPLACEMENT:

The purpose of this guarantee/warranty is to insure that the CONTRACTOR receives irrigation materials of prime quality, installed and maintained in a thorough and careful manner.

- A. For a period of one year from commencement of the formal maintenance period, guarantee/warranty irrigation materials, equipment, and workmanship against defects. Fill and repair depressions. Restore landscape or structural features damaged by the settlement of irrigation trenches or excavations. Repair damage to the premises caused by a defective item. Make repairs within seven calendar days of notification from the CONTRACTOR.
- B. Contract documents govern replacements identically as with new work. Make replacements at no additional cost to the contract price.
- C. Guarantee/warranty applies to originally installed materials and equipment and replacements made during the guarantee/warranty period.

PART II - PRODUCTS

2.1 QUALITY

Use materials which are new and without flaws or defects of any type, and which are the best of their class and kind.

2.2 SUBSTITUTIONS

Substitutions shall be approved by the CONTRACTOR.

2.3 WATER TAP

A. *Water Tap:*

1. Provide materials required by local codes for installation of the municipal water tap, vault and associated piping.

2.4 SLEEVING

- A. Install separate sleeve beneath paved areas to route each run of irrigation pipe or wiring bundle.
- B. Sleeving material beneath pedestrian pavements shall be PVC Class 200 pipe with solvent welded joints.
- C. Sleeving beneath drives and streets shall be PVC Class 200 pipe with solvent welded joints.
- D. Sleeving diameter equal to twice that of the pipe or wiring bundle.

2.5 PIPE AND FITTINGS

A. *Mainline Pipe and Fittings:*

SECTION 02810 - IRRIGATION

1. Use rigid, unplasticized polyvinyl chloride (PVC) 1120, 1220 National Sanitation Foundation (NSF) approved pipe, extruded from material meeting the requirements of Cell Classification 12454-A or 12454-B, ASTM Standard D1784, with an integral belled end.
2. Use solvent weld pipe for mainline pipe with a nominal diameter less than 3-inches or where a pipe connection occurs in a sleeve. Use Schedule 40, Type 1, PVC solvent weld fittings conforming to ASTM Standards D2466 and D1784. Use primer approved by the pipe manufacturer. Solvent cement to conform to ASTM Standard D2564. I

B. *Lateral Pipe and Fittings:*

1. Use rigid, unplasticized polyvinyl chloride (PVC) 1120, 1220 National Sanitation Foundation (NSF) approved pipe, extruded from material meeting the requirements of Cell Classification 12454-A or 12454-B, ASTM Standard D1784, with an integral belled end suitable for solvent welding.
2. Use Class 160, SDR-26, rated at 160 PSI, conforming to the dimensions and tolerances established by ASTM Standard D2241. Use solvent weld pipe for lateral pipe. Use Schedule 40, Type 1, PVC solvent weld fittings conforming to ASTM Standards D2466 and D1784 for PVC pipe. Use primer approved by the pipe manufacturer. Solvent cement to conform to ASTM Standard D2564, of a type approved by the pipe manufacturer.

C. *Specialized Pipe and Fittings:*

1. *Copper pipe:* Use Type "K" rigid conforming to ASTM Standard B88. Use wrought copper or cast bronze fittings, soldered or threaded. Use a 95% tin and 5% antimony solder.
2. *Ductile iron pipe:* Use Class 50 conforming to ANSI A21.51 (AWWA C151). Use a minimum of Class 53 thickness pipe for flanged piping. Use mechanical joints conforming to ANSI A 21.10 (AWWA C110) and ANSI A21. 11 (AWWA C111) or flanged fittings conforming to ANSI/AWWA C1 10 and ANSI B16.1 (125#).
3. Use a dielectric union wherever a copper-based metal (copper, brass, bronze) is joined to an iron-based metal (iron, galvanized steel, stainless steel).
4. *Low Density Polyethylene Hose:*
 - a. Use pipe specifically intended for use as a flexible swing joint.
 - b. Use spiral barb fittings supplied by the same manufacturer as the hose.
5. Assemblies calling for threaded pipe connections shall utilize PVC Schedule 80 nipples and PVC Schedule 80 threaded fittings.
6. *Joint sealant:* Use only teflon-type tape or teflon based paste pipe joint sealant on plastic threads. Use nor hardening, nontoxic pipe joint sealant formulated for use on water-carrying pipes on metal threaded connections.

2.6 MAINLINE COMPONENTS

SECTION 02810 - IRRIGATION

- A. *Main System Shutoff Valve*: as per local practice and in compliance with local code.
- B. *Backflow Prevention Assembly*: reduced pressure type as per local practice and in compliance with local code.
- C. *Isolation Gate Valve Assembly*: as per local practice and in compliance with local code.
- D. *Quick Coupling Valve Assembly (water access valve)*: as per local practice and in compliance with local code.
- D. *Water Meter*: totalizing type installed in valve box in main line near irrigation control system.

2.7 IRRIGATION COMPONENTS

- A. *Remote Control Valve (RCV) Assembly for Sprinkler System*:
 - 1. DV Control Valve X CZ-075 (Rain Bird) or approved equal. CONTRACTOR to install as required by the control system manufacturer. Use wire connectors and waterproofing sealant to join control wires to solenoid valves. Use standard Christy I.D. tags with hot-stamped black letters on a yellow background. Install a separate valve box over a 6-inch depth of 3/4-inch gravel for each assembly.
- B. *Sprinkler Components*:
 - 1. Drip system. Netafim Techline dripper line with an application rate of 1 GPH or approved equal.

2.8 CONTROL SYSTEM COMPONENTS

- A. *Irrigation Controller Unit*: LEIT 40000 Irrigat5ion Control Unit (Altec Irrigation, Sand Diego, California) or approved equal.
- B. *Soil Moisture Sensors*: Sensors and control wire material provided by others. CONTRACTOR to install sensors with assistance by CONTRACTOR.
 - 1. *Conduit*: PVC Schedule 40.
- C. *Control Wire*:
 - 1. *Wire*: Use American Wire Gauge (AWG) No. 14 solid copper, Type UF or PE cable, UL approved for direct underground burial from the satellite control unit to each remote control valve.
 - 2. *Conduit*: PVC Schedule 40.
 - 3. *Splices*: Use wire connector with waterproof sealant. Wire connector to be of plastic construction consisting of two (2) pieces, one piece which snap locks into the other. A copper crimp sleeve to be provided with connector.
 - 4. *Warning tape*: Inert plastic film highly resistant to alkalis, acids, or other destructive chemical components likely to be encountered in soils. Three inches wide, colored yellow, and imprinted with "CAUTION: BURIED ELECTRIC LINE BELOW."

2.10 OTHER COMPONENTS

SECTION 02810 - IRRIGATION

- A. *Other Materials*: Provide other materials which are part of the irrigation system, even though such items may not have been referenced in these specifications.
- B. *Bollards*: 3-inch diameter concrete filled galvanized steel pipe painted yellow. To be installed around irrigation control system.

PART III: EXECUTION

3.1 INSPECTIONS AND REVIEWS

- A. *Site Inspections*:
 - 1. Verify construction site conditions and note irregularities affecting work of this section. Report irregularities to the CONTRACTOR prior to beginning work.
 - 2. Beginning work of this section implies acceptance of existing conditions.
- B. *Utility Locates ("Call Before You Dig")*:
 - 1. Arrange for and coordinate with CONTRACTOR to ensure all utilities are cleared prior to beginning the work.
- C. *Irrigation System Layout Review*: Irrigation system layout review will occur after the staking has been completed. Notify the CONTRACTOR three (3) days in advance of review. Modifications will be identified by the CONTRACTOR at this review.

3.2 LAYOUT OF WORK

- A. Stake out the irrigation system. Items staked include: pipe, isolation valves, quick coupling valves, remote control valves, sprinklers, and controller.
- B. Install all mainline pipe and mainline components inside of project right of way lines.

3.3 EXCAVATION, TRENCHING, AND BACKFILLING

- A. Excavate to permit the pipes to be laid at the intended elevations and to permit work space for installing connections and fittings.
- B. *Minimum cover* (distance from top of pipe or control wire to finish grade):
 - 1. 18-inch over mainline pipe and sleeving.
 - 2. 18-inch over lateral pipe to sprinklers
 - 4. 20-inch over control wire.
- C. PVC lateral pipes may be pulled into the soil utilizing a vibratory plow device specifically manufactured for pipe pulling. Minimum burial depths equals minimum cover listed above.
- D. Backfill only after lines have been reviewed and tested.
- E. Excavated material is generally satisfactory for backfill. Backfill shall be free from rubbish, vegetable matter, frozen materials, and stones larger than 2-inches in maximum dimension. Remove material not suitable for backfill. Backfill placed next to pipe shall be free of sharp

SECTION 02810 - IRRIGATION

objects which may damage the pipe.

F. Backfill unsleeved pipe in either of the following manners:

1. Backfill and puddle the lower half of the trench. Allow to dry 24 hours. Backfill the remainder of the trench in 6-inch layers. Compact to density of surrounding soil.
2. Backfill the trench by depositing the backfill material equally on both sides of the pipe in 6-inch layers and compacting to the density of surrounding soil.

G. Enclose pipe and wiring beneath roadways, walks, curbs, etc., in sleeves. Minimum compaction of backfill for sleeves shall be 95% Standard Proctor Density, ASTM D69878. Conduct one compaction test for each sleeved crossing less than 50 feet long. Conduct two compaction tests for each sleeved crossing greater than 50 feet long. Costs for such testing and any necessary retesting shall be borne by the SUBCONTRACTOR. Use of water for compaction around sleeves, "puddling", will not be permitted.

H. Dress backfilled areas to original grade. Incorporate excess backfill into existing site grades.

I. Where utilities conflict with irrigation trenching and pipe work, contact the CONTRACTOR for trench depth adjustments.

3.4 WATER TAP

A. Install the hot-tap and associated piping materials in conformance with local regulations. Coordinate with CONTRACTOR to ensure installation is in conformance with Base specifications.

B. Install all components of the water tap in conformance with local regulations.

3.5 SLEEVING AND BORING

A. Install sleeving at a depth which permits the encased pipe or wiring to remain at the specified burial depth.

B. Extend sleeve ends six inches beyond the edge of the paved surface. Cover pipe ends and mark with stakes.

C. Bore for sleeves under obstructions which cannot be removed. Employ equipment and methods designed for horizontal boring.

A. *General:*

1. Keep pipe free from dirt and pipe scale. Cut pipe ends square and debur. Clean pipe ends.
2. Keep ends of assembled pipe capped. Remove caps only when necessary to continue assembly. .
3. Trenches may be curved to change direction or avoid obstructions within the limits of the curvature of the pipe. Minimum radii of curvature is 25 feet for 2-inch diameter pipe, 100 feet for 3-inch diameter pipe. All curvature results from the bending of the pipe lengths. No deflection will be allowed at a pipe joint.

SECTION 02810 - IRRIGATION

B. *Mainline Pipe and Fittings:*

1. Use only strap-type friction wrenches for threaded plastic pipe.
2. *PVC Solvent Weld Pipe:*
 - a. Use primer and solvent cement. Join pipe in a manner recommended by the manufacturer and in accordance with accepted industry practices.
 - b. Cure for 30 minutes before handling and 24 hours before allowing water in pipe.
 - c. Snake pipe from side to side within the trench.

C. *Lateral Pipe and Fittings:*

1. Use only strap-type friction wrenches for threaded plastic pipe.
2. *PVC Solvent Weld Pipe:*
 - a. Use primer and solvent cement. Join pipe in the manner recommended by the manufacturer and in accordance with accepted industry practices.
 - b. Cure for 30 minutes before handling and 24 hours before allowing water in the pipe.
 - c. Snake pipe from side to side within the trench.

D. *Specialized Pipe and Fittings:*

1. *Copper Pipe:*
 - a. Buff surfaces to be joined to a bright finish. Coat with solder flux.
 - b. Solder so that a continuous bead shows around the joint circumference.
2. *Ductile Iron Pipe:*
 - a. Join pipe in the manner recommended by manufacturer and in accordance with accepted industry practices.
3. Insert a dielectric union wherever a copper-based metal (copper, brass, bronze) and an iron-based metal (iron, galvanized steel, stainless steel) are joined.
4. *Low Density Polyethylene Hose:* Install per manufacturer's recommendations.
5. *PVC Threaded Connections:*
 - a. Use only factory-formed threads. Field-cut threads are not permitted.
 - b. Use only Teflon-type tape or teflon based paste.
 - c. When connection is plastic-to-metal, the plastic component shall have male threads and the metal component shall have female threads.
6. Make metal-to-metal, threaded connections with Teflon-type tape or pipe joint compound applied to the male threads only.

SECTION 02810 - IRRIGATION

3.7 INSTALLATION OF MAINLINE COMPONENTS

- A. *Main System Shut Off Valve:* Install conforming to local practices and codes and shall be installed in a valve box to allow for access.
- B. *Backflow Prevention Assembly:* Install conforming to local practices and codes. Install assembly so that its elevation, orientation, access, and drainage conform to the manufacturer's recommendations and applicable health codes.
- C. *Isolation Gate Valve Assembly:*
 - 1. Install conforming to local practices and codes.
 - 2. Locate at least 12-inches from and align with adjacent walls or edges of paved areas.
- D. *Water Meter:* In the main header near the controller system prior to any lateral connections, a water meter (totalizing type) shall be installed in a valve box to allow for periodic readings. An additional isolation valve shall be installed just downstream of the water meter in the same valve box.
- E. *Quick Coupling Valve:* A quick coupling valve for water access shall be installed downstream of the controller system within a valve box.

3.8 INSTALLATION OF SPRINKLER COMPONENTS

- A. *Remote Control Valve (RCV) Assembly for Sprinkler Laterals:*
 - 1. A total of four zones (25 trees each) should be used to irrigate the plantings.
 - 2. Flush mainline before installation of RCV assembly.
 - 3. Install conforming to local practices and as required by the design and layout of the irrigation system. Wire connectors and waterproof sealant shall be used to connect control wires to remote control valve wires. Install connectors and sealant per the manufacturer's recommendations.
 - 4. Install only one RCV to a valve box. Locate valve box at least 12-inches from and align with nearby walls or edges of paved areas. Group RCV assemblies together where practical. Arrange grouped valve boxes in rectangular patterns. Allow at least 12-inches between valve boxes.
 - 5. Adjust RCV to regulate the downstream operating pressure.
 - 6. Attach ID tag with controller station number to control wiring.
- B. *Sprinkler Assembly:*
 - 1. Flush lateral pipe before installing sprinkler assembly.
 - 2. Install per the manufacturer's instructions.
 - 3. Install two (2) rings of drip system around each tree. An outer ring with dimensions of 4-feet by 4-feet and an inner ring of 2-feet by 2 feet.

SECTION 02810 - IRRIGATION

3.9 INSTALLATION OF CONTROL SYSTEM COMPONENTS

A. *Irrigation Controller Unit:*

1. The location of the controller unit will be dependent on the layout of the sprinkler system. This location will be mutually agreed upon between the SUBCONTRACTOR and CONTRACTOR.
2. Install one valve output surge protection arrestor on each control wire and one for the common wire.
3. Attach wire markers top the ends of control wires inside the controller unit housing. Label wires with the identification number of the RCV to which the control wire is connected.
4. Connect control wires to the corresponding controller terminal.

B. *Soil Moisture Sensors:*

1. Install two soil moisture sensors in individual planting pits for each control zone (estimated to be 8 total). Soil moisture sensor and control wire material to be provided by CONTRACTOR.
2. Install the two sensors in one planting pit for each zone. Install the first sensor near the mid-point of the root ball. Install the second sensor at approximately 6' bgs.
3. Run control wire through conduit back to a central location near the control system. Terminate all control wires in a valve box.
4. Attach wire markers to the ends of control wires inside the valve box. Label wires with the identification number of the soil moisture sensor to which the control wire is connected.

C. *Control Wire:*

1. Bundle control wires where two or more are in the same trench. Bundle with pipe wrapping tape spaced at 10-foot intervals.
2. Control wiring may be chiseled into the soil utilizing a vibratory plow device specifically manufactured for pipe pulling and wire installation. Appropriate chisel must be used so that wire is fed into a chute on the chisel, and wire is not subject to pulling tension. Minimum burial depth must equal minimum cover previously listed.
3. Provide a 24-inch excess length of wire in an 8-inch diameter loop at each 90 degree change of direction, at both ends of sleeves, and at 100-foot intervals along continuous runs of wiring. Do not tie wiring loop. Coil 24-inch length of wire within each remote control valve box.
4. Install common ground wire and one control wire for each remote control valve. Multiple valves on a single control wire are not permitted.
5. If a control wire must be spliced, make splice with wire connectors and waterproof sealant, installed per the manufacturer's instructions. Locate splice in a valve box which contains an irrigation valve assembly, or in a separate 6-inch round valve

SECTION 02810 - IRRIGATION

box. Use same procedure for connection to valves as for in-line splices.

6. Unless noted on plans, install wire parallel with and below mainline pipe.
7. Protect wire not installed with PVC mainline pipe with a continuous run of warning tape placed in the backfill six inches above the wiring.

3.10 INSTALLATION OF OTHER COMPONENTS:

- A. *Tools and Spare Parts:* Prior to the Review at completion of construction, supply to the CONTRACTOR operating keys, servicing tools, spare parts, and any other items as necessary.
- B. *Other Materials:* Install other materials or equipment details which are part of the irrigation system, even though such items may not have been referenced in these specifications.
- C. *Bollards:* Install a minimum of four (4) bollards in a rectangular pattern around control system and valve box assemblies. Install bollards with a minimum above ground height of 4-feet and below ground depth of 2-feet. Secure bollards with concrete in a hole at least 18-inches in diameter and 3-feet in depth.

3.11 PROJECT RECORD (AS-BUILT) DRAWINGS

- A. At completion of project, submit as-built drawings (can be hand drawn) showing dimensions from two permanent points of reference (building comers, sidewalk, road intersections or permanent structures), location of following items:
 1. Connection to existing water lines.
 2. Routing of sprinkler pressure lines.
 3. Remote Control Valve Assembly.
 4. Quick Coupling Valve Assembly
 5. Drain Valves.
 6. Control wiring routing if not with mainline pipe.
 7. Gate Valve Assembly.

3.12 OPERATION INSTRUCTIONS

- A. Submit three written operating instructions including winterization procedures and start-up, with cut sheets of products, and coordinate controller/watering operation instruction with CONTRACTOR.

3.13 MAINTENANCE

- A. Upon completion of construction and Review by the CONTRACTOR, maintain irrigation system according to Specification 02999.

3.14 CLEANUP

- A. Upon completion of work, remove from the site all machinery, tools, excess materials, and rubbish.

END OF SECTION 02810

SECTION 02999

PLANTING AND IRRIGATION MAINTENANCE - YEAR 1

SECTION 02999

PLANTING AND IRRIGATION MAINTENANCE - YEAR 1

SECTION 02999 - PLANTING AND IRRIGATION MAINTENANCE - YEAR 1

PART I - GENERAL

1.0 SUMMARY

Furnish all supervision, labor, material, equipment and transportation required to maintain all landscape areas called for under this Contract, in an attractive, healthy, operable condition for a period of one year from the date of final acceptance and coordination with the CONTRACTOR. SUBCONTRACTOR shall be responsible for all maintenance and shall provide winter watering as needed to insure healthy, vigorous plant growth.

1.1 QUALITY ASSURANCE

- A. *Work Force:* SUBCONTRACTOR's representative shall have at least 5 years experience in the maintenance and repair of all types of plantings and irrigation systems which are part of this Contract.
- B. *Materials:* All materials used in maintenance and repair shall conform to these Specifications or shall be otherwise accepted by the CONTRACTOR.

1.2 SUBMITTALS

- A. Submit 10 business days prior to commencement of warranty period, an irrigation and plant maintenance schedule outlining tasks and responsibilities by month for a one year period.
- B. Maintain a record of maintenance activities, including all records of all materials, color provided and the area, rate and amount of herbicide or pesticide used, irrigation schedules, and total water used for irrigation.
 - 1. Submit to CONTRACTOR on a monthly basis.

PART II - MATERIALS

None

PART III - EXECUTION

3.0 GENERAL

- A. Walk project a minimum of once per week during the growing season and once every month during off season and record in writing using a standard format:
 - 1. General condition or status of plant materials.
 - 2. Stressed, dead or dying plant materials.
 - 3. Broken tree stakes, guy wires, missing tree ties.

SECTION 02999 - PLANTING AND IRRIGATION MAINTENANCE - YEAR 1

4. Water retention basins needing repair.
5. Weed control needed.
6. Status of irrigation systems noting:
 - a. Any line breaks or leaks.
 - b. Broken or missing heads.
 - c. Any leaks at valves.
 - d. Receive status report from controller.

Inspection may be accomplished during regular maintenance visits.

3.1 TREES

A. *General:*

1. The SUBCONTRACTOR shall warranty all such plant materials against defects due to any cause except vandalism and acts of God for a period of one year from the date of acceptance.
2. The SUBCONTRACTOR shall make replacements within seven days of notification by the CONTRACTOR's Representative. Replacement planting for trees shall be done in the spring planting season only, except as otherwise approved. Remove dead plants within 7 days of notification.
3. Replacement plants shall be of the same kind, condition, size, and quality and shall closely match adjacent specimens of the same species. Replacements shall also be subject to all requirements stated in this specification. All expenses incurred in the replacements shall be borne by the SUBCONTRACTOR.
4. Plants shall be healthy, and in flourishing condition at the end of the warranty period. Plants shall be free of dying branches and branch tips, and shall bear foliage of normal density, size and color.
5. Two weeks prior to completion of warranty period, SUBCONTRACTOR shall remove all tree stakes, tree guys, straps, wire and tree wrap, unless otherwise directed by the CONTRACTOR's Representative.

B. *Watering:* Automate the irrigation system to supply the necessary water for the health of the tree plantings over the course of the year including the winter, early spring and fall, and the growing season.

C. *Pruning:* None required except at time of planting and as needed to correct damage.

D. *Stakes and Guys:* Inspect regularly to prevent girdling of trunks or branches and to prevent rubbing which might cause bark wounds. Remove and replace damaged stakes and guys as directed by the CONTRACTOR's Representative.

SECTION 02999 - PLANTING AND IRRIGATION MAINTENANCE - YEAR 1

- E. *Weed Control:* Tree basins shall be kept free of weeds and grasses on a monthly basis. Frequent soil cultivation which might destroy shallow roots will not be allowed. Use of mulches to prevent seed germination will be allowed.
- F. *Insects and Disease Control:* Control insects and disease as necessary to prevent damage to the health or appearance of plants, using only approved materials and methods.
- G. *Tree Protection:* Remove and/or apply tree wrap to all trees at the following times when they occur during the maintenance period: remove at the beginning of the growing season, and wrap trees again in late fall, starting wrap from the bottom up to the first branch.
- H. *Emergency Repairs:* SUBCONTRACTOR shall be available to the CONTRACTOR at any time during the maintenance period to perform emergency repairs that may be necessary. Costs will be negotiated by the CONTRACTOR and the SUBCONTRACTOR at the time based on SUBCONTRACTOR's submitted hourly rates.

3.2 IRRIGATION SYSTEM

- A. *General:*
 - 1. SUBCONTRACTOR shall check all systems for proper operation after each mowing, and all repairs shall be made before the next watering cycle. Any damage caused to the system by SUBCONTRACTOR's operations shall be repaired at no cost to the CONTRACTOR.
 - 2. SUBCONTRACTOR shall be responsible for programming the irrigation controller including schedule, cycles, amount of water, etc. SUBCONTRACTOR shall review watering schedule with the CONTRACTOR.
 - 3. SUBCONTRACTOR shall repair all damages to the irrigation system at his own cost. Repairs shall be made within one watering period.
- B. Correct all problems which develop in the system due to faulty materials or workmanship during the warranty period.
- C. Repair or replace such work as directed by the CONTRACTOR's Representative.
- D. Make repairs and replacement promptly when notified.
- E. Provide a written warranty for each segment of the project stating date of completion and guarantee period.
- F. The CONTRACTOR reserves the right to make temporary repairs during the warranty period as necessary to keep systems in operating condition without voiding the contractor's warranty, nor relieving the contractor of his responsibility.
- G. *Winterization:* Under the warranty period, the SUBCONTRACTOR shall be responsible for

SECTION 02999 - PLANTING AND IRRIGATION MAINTENANCE - YEAR 1

draining the system in preparation for the first and second winters after construction. SUBCONTRACTOR shall remove all water from the system using compressed air.

- H. *Spring Start-Up:* Under the warranty period, SUBCONTRACTOR shall be responsible for starting up the irrigation system in the first spring following construction only. SUBCONTRACTOR shall fully activate the system and demonstrate that it is in full working order. Any repairs needed as a result of improper winterization or negligence due to the SUBCONTRACTOR shall be corrected by the SUBCONTRACTOR at no additional cost to the CONTRACTOR.

3.3 LICENSES AND TAXES

- A. *Licenses:* SUBCONTRACTOR agrees to obtain and pay for all licenses required by city, county, state and federal governments that are necessary for the legal conduct of his business.

END OF SECTION -02999

APPENDIX C

OPERATION AND MAINTENANCE MANUAL (TO BE PROVIDED BY LOCAL SERVICE PROVIDER)

APPENDIX C

ADDITIONAL PLANTING DETAILS

LOCATION AND SPACING OF TREES

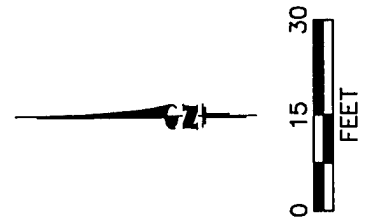
Phytostabilization Demonstration Site 2

Altus Air Force Base, Oklahoma

PARSONS

PARSONS ENGINEERING SCIENCE, INC.

Denver, Colorado



LEGEND

- TREES WITH CENTRAL PILOT HOLES
- TREES WITHOUT CENTRAL PILOT HOLES
- ST ✕ TREES WITH SOIL MOISTURE SENSORS
- MW6 ▲ MONITORING WELL
- ▣ LOCATION OF PRESSURE TRANSDUCERS FOR GROUNDWATER ELEVATION MEASUREMENTS
- -- LOCATION OF UNDERGROUND SENSOR CONDUITS

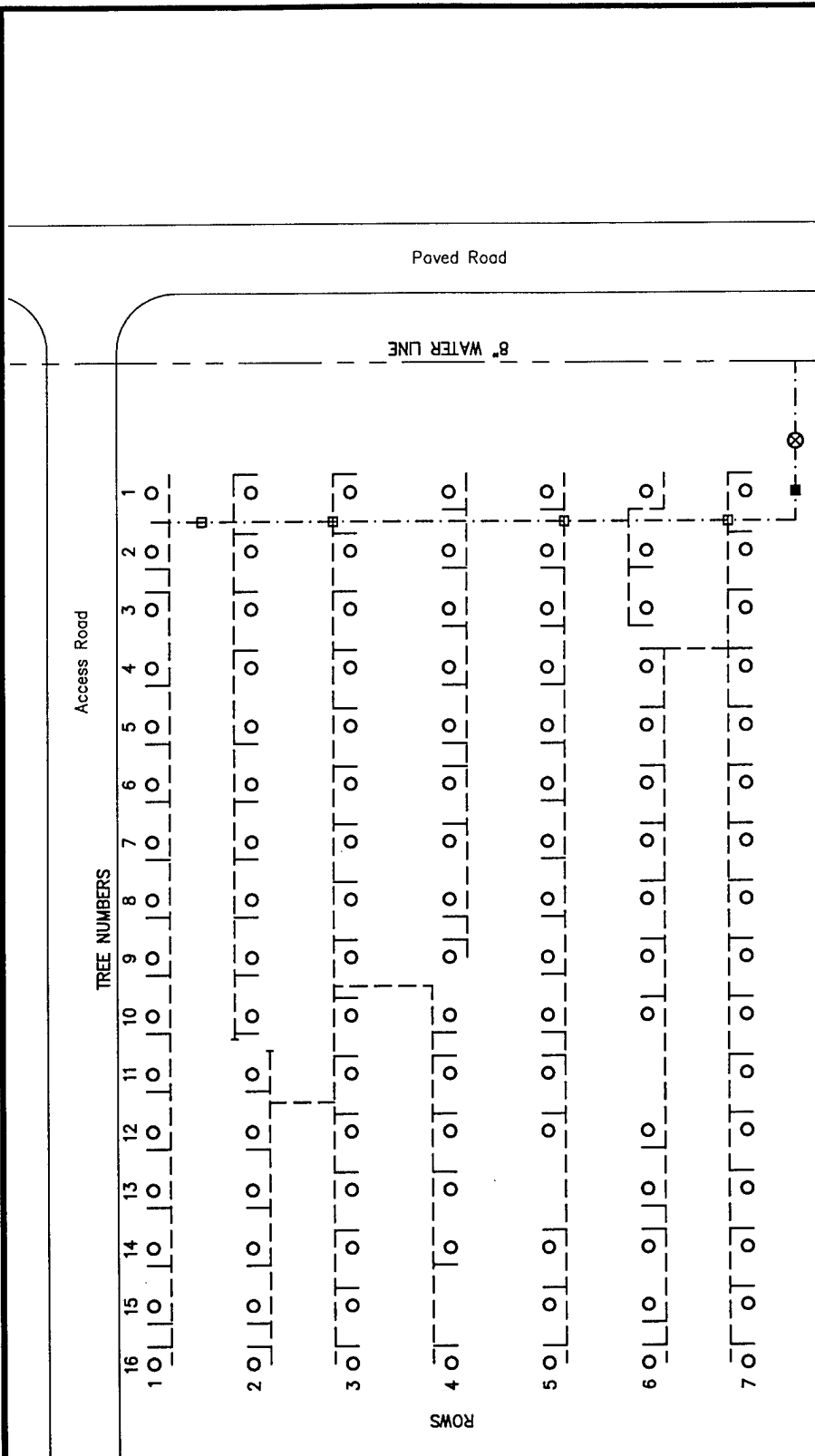
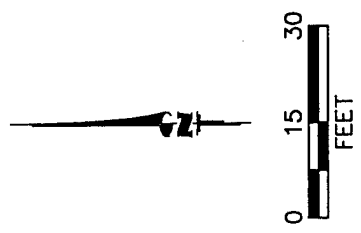


FIGURE 2

IRRIGATION
SYSTEM

Phytostabilization Demonstration
Site 2
Altus Air Force Base, Oklahoma

PARSONS
ENGINEERING SCIENCE, INC.
Denver, Colorado



LEGEND

- TREES
- LATERAL IRRIGATION LINE AND DRIP HOSES
- .-.- MAIN IRRIGATION WATER LINE
- IRRIGATION VALVE
- IRRIGATION CONTROLLER
- ⊗ BACKFLOW PREVENTION DEVICE

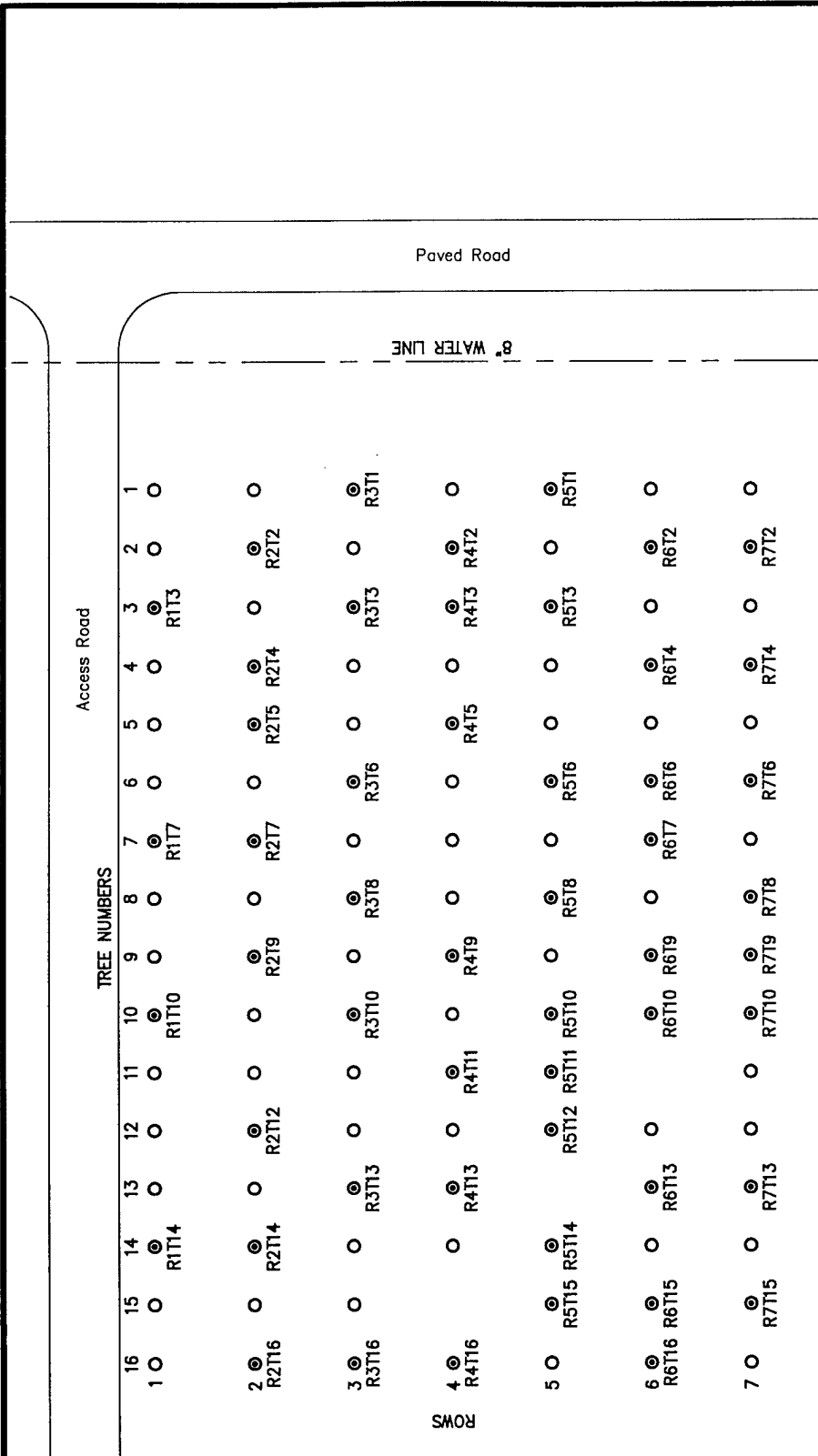
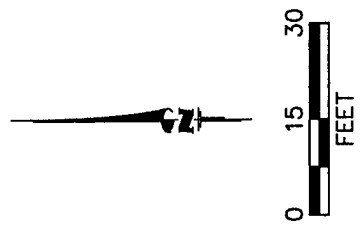


FIGURE 3

TREE PHOTO DOCUMENTATION AND MEASUREMENTS

Phytostabilization Demonstration
Site 2
Altus Air Force Base, Oklahoma

PARSONS
ENGINEERING SCIENCE, INC.
Denver, Colorado



LEGEND

- TREE
- ⊙ TREE IDENTIFICATION (Row 6, Tree 2) FOR PHOTO DOCUMENTATION AND MEASUREMENT

Populus deltoides Marsh.

Eastern Cottonwood

Salicaceae or Willow Family

Hardiness Zone 3

Native to the eastern U. S.

SIZE: 80-100 ft. tree with 40-60 ft. spread. Rapid grower.

FORM: Ovate-crowned large tree.

TEXTURE: Medium.

EXPOSURE: Sun.

LEAVES: Simple, alternate, 3 to 6 in. long, 3 to 4 in. wide and more or less triangular with a bluntly toothed margin. Deep dark green above, shiny, rather pale green below. Petiole is long and flattened allowing the leaves to flutter in any breeze. Fall color is bright yellow.

STEM: Young twigs are moderately stout, light brown or tan, with large, bold, more or less football-shaped terminal buds during the dormant period. As stems get larger, bark becomes a greenish yellow to gray-green eventually thickening and deeply furrowing on old trees to become a gray to silvery gray.

FLOWERS: Male and female on separate trees, not showy.

FRUIT: Long cluster of capsules, containing many seeds in a cottony mass, thus the common name cottonwood.

COLOR: Foliage is deep green above, bright yellow in the fall.

PROPAGATION: Seed, cuttings, or transplanting of trees from streambanks and other disturbed locations where they develop naturally.

CULTURE: Native to bottomlands along rivers and streams, generally in rich moist soils. Does not tolerate poor dry soils, however, it will tolerate a dry climate in areas where soils are moderately good and moisture is present for at least a portion of the year such as along small streams or rivers. Under these conditions it does well throughout most of the Great Plains. Very rapid grower and relatively short-lived. An old tree is one 50-70 years. Wood is soft and decays rapidly when tree becomes mature or when broken limbs allow decay organisms to enter.

PESTS: Borers may attack an old or weakened tree. Wind damage may allow entry of decay organisms that could substantially weaken the tree.

NOTES: A most useful tree in areas where a tree of enormous stature is desired in a short period of time. In many areas of the lower midwest and southern Great Plains where few trees are well adapted, the eastern cottonwood or other closely related species serve a real need in providing shade and attractive specimens in the landscape. Tends to naturalize along streambanks, disturbed areas, abandoned field, and other locations. A good tree where species are limited. Must be criticized for its extremely rapid growth on a good site and weak wood. A desirable feature is the rustling of leaves with any slight breeze, lending a sound feature to the landscape which is not normally provided by plants. Profuse root development may plug drains, etc. Very bad about developing massive fibrous roots in golf greens or other areas of intensive turf culture or flower beds. Cotton from female trees may plug radiators of autos and air conditioners and become matted on window screens. Many cities have ordinances against planting cottonwood because of the weak wood, large size, and voracious root system.

CULTIVARS: Male trees are commonly propagated as cottonless cottonwoods. These are generally not superior except that the seed and "cotton" do not develop and create problems as is sometimes the case with female trees. Other extremely fast growing cultivars are being developed for pulpwood production but have no place in landscaping.

Light Energized Irrigation Technology

Battery operated controllers need constant attention. Their batteries are subject to failure at any time, often with valves latched open. Why risk it? Without batteries or AC power to complicate matters, the *LEIT* system operates reliably around the clock in any weather, anywhere in the world. What's more, the 4-station *LEIT* 4000 is less expensive than many comparable battery operated models. Isn't it time you stopped worrying about batteries...and looked towards the *LEIT*.

LEIT® 4000: HIGH TECH SIMPLICITY

- Operates up to four stations and a master valve.
- Cuts maintenance time and cost because there are no batteries to replace **EVER!**
- Installs like a conventional controller, but with **NO AC** power connections, permits or hassles!

LEMA/LESA Actuators

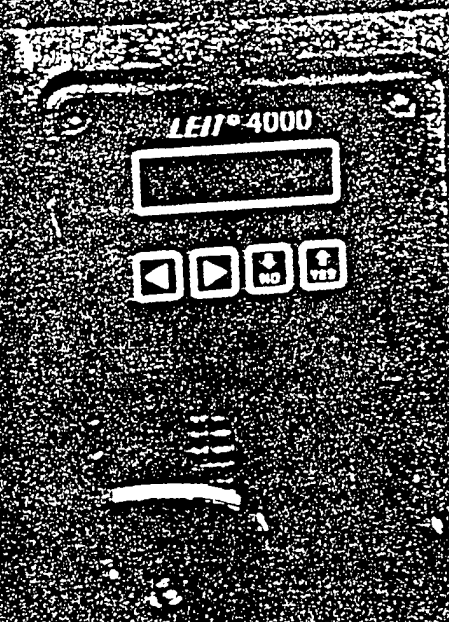
Altec's exclusive Light Energized Micropower Actuators (LEMA) are compatible with most sizes, brands and styles of valves. They switch on and off by way of a tiny digital pulse of energy sent by the controller, eliminating the need for constant 24 volts of AC required by standard power-hungry solenoids. The Light Energized Sensor Actuator (LESA) also accommodates the installation of a sensor.

Why settle for the hassle of battery operated controllers that need to be monitored continuously? Maintenance is time, and time is money.

The *LEIT* 4000 is a light-energized controller with a long-life capacitor that stores all the power you'll ever need for round-the-clock operation — even in overcast weather. Each valve, fitted with Altec's exclusive Light Energized Micropower Actuator (LEMA or LESA)* in place of a conventional solenoid, operates independently with up to four programs.

Programming is quick and easy and includes automatic rain delay, water budgeting and more.

Easy-access wire connector accommodates standard irrigation wire up to 12 gauge. Connections are secured using a standard flathead screwdriver. No special tools required!



SPECIFICATION SHEET:

LEMA & LESA Light Energized Micropower Actuators

LEMA and LESA micropower actuators replace conventional solenoids on most popular sizes and styles of valves, thus enabling LEIT® 4000 and 8000 series of irrigation controllers to operate valves without AC power, batteries or any other external source of power. Once the original solenoid is removed, the actuator is simply screwed into the solenoid's receptacle.

The actuator converts low current pulses generated by a LEIT controller into a high current pulse required to latch the plunger open or closed.

In addition, LESA series actuators provide an interface between LEIT controllers and switch-type sensors for sensing moisture, rain, freezing conditions, etc.

FEATURES:

- Adaptable to a wide range of valves
- Waterproof construction
- Can be used in an explosive environment
- Surge protected

ELECTRICAL:

- DC latching solenoid
- Low voltage DC bipolar pulse

MECHANICAL:

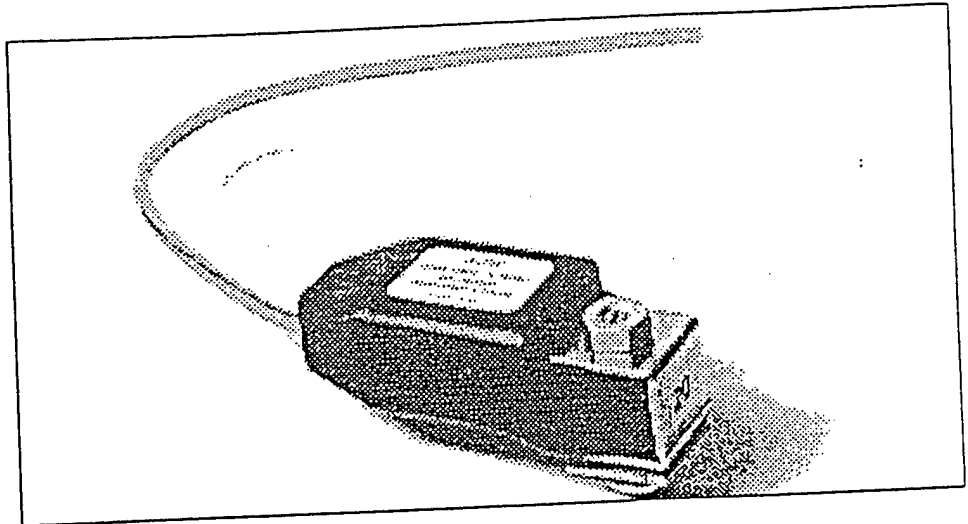
- Length: approx. 3.25 inches
- Width: approx. 3 inches
- Height: approx. 2 inches
- Weight: approx. 1 lb. without stem.

MODELS:

- LEMA 1500 series (specify valve type, size and model)
- LESA 1600 series (designed for sensor hookup)

PARTS INCLUDED:

- Actuator with approximately one foot of cable or wire
- Complete stem assembly



MAXIMUM WIRE RUNS*

*WIRE GAUGE	*MAXIMUM RUN
16 AWG	2,000 feet
14 AWG	3,000 feet
12 AWG	4,800 feet

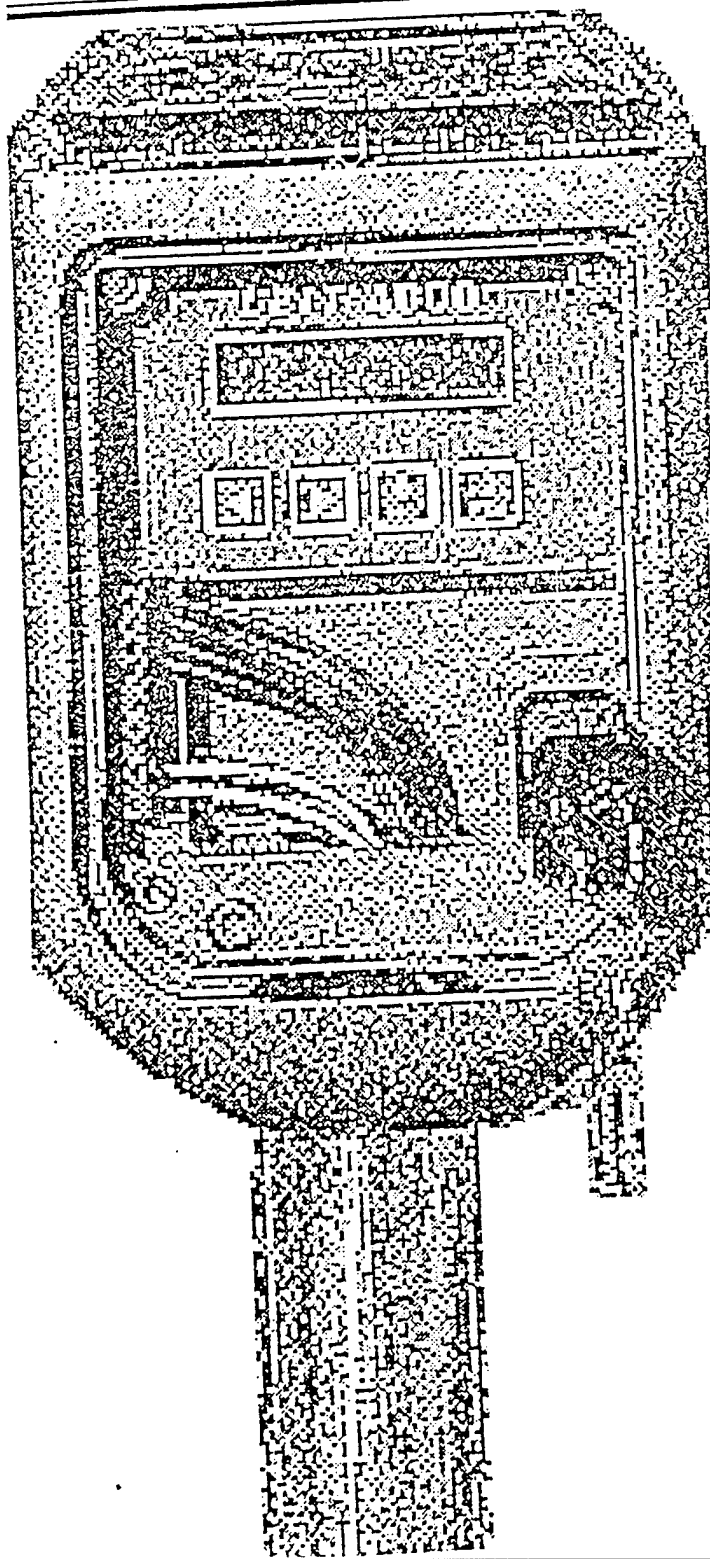
*Maximum wire run is calculated by adding the total length of the common wire *plus* the length of the longest hot wire.

ALTEC IRRIGATION

4698-A Alvarado Canyon Road • San Diego, CA 92120 • (VOICE) 619 / 229-3750 • (FAX) 619 / 229-37

4 Easy Steps

Installing the LEIT[®] 4000



Basic tools
& supplies
you will need:

- Flathead screwdriver (1/8-inch)
- Wire stripper
- Two 60-pound sacks of ready-mix concrete

QUESTIONS?

Call Altec Customer
Service at:

619 / 229-3750

ALTEC
IRRIGATION, INC.

4698 ALVARADO CANYON ROAD, SUITE A
SAN DIEGO, CA 92120
619 / 229-3750 FAX: 619 / 229-3760

INSTALLING THE LEIT® 4000 IN 4 Easy Steps

1.

PREPARE SITE

The LEIT 4000 is installed just like any other irrigation controller with one *BIG* exception:

The LEIT 4000 requires no AC hookup, so you can locate the controller virtually anywhere you want. Consider the following when choosing a location:

- You can minimize wire runs by locating the controller close to the stations or midway between groups of stations
- Direct sunlight is not required. The LEIT 4000 works as well in shaded locations such as beneath trees, under overhangs, etc., as it does in full sun.

2.

INSTALL MOUNTING COLUMN

Set the curved bottom of the MCOL 4000 J-tube mounting column in a 12x12x12-inch hole. Secure in place with concrete (about two 60 lb. sacks), making sure the J-tube is vertical and the opening in the bottom end of the J-tube is clear of debris. All wires will enter the controller through the bottom of this tube.

3.

REPLACE SOLENOIDS

At the valves, remove the conventional solenoids and replace them with the appropriate LEMA 1500-4 or LESA 1600-4 series actuator. Altec actuators are made to fit most brands of valves, but it's important for you to order the right model for the type of valve you have installed. For assistance, contact your distributor or call Altec Customer Service at 619 / 229-3750.

NOTE: LEMA-4 and LESA-4 actuators are identical with one exception: The LESA-4 has two extra wires to accommodate sensor hookups. LESA-4 actuators are required only when you're installing rain, moisture, freeze or other sensors.

4.

CONNECT WIRES

Route individual *hot* wires from the controller to each valve station. Route a single looped common wire from the controller to each valve station. You will find it useful to differentiate between the hot and common wires by using wires with different color jackets (for instance, red for hot and white for common).

CONNECT WIRES (continued)

IMPORTANT: Be careful not to exceed maximum wire runs. Note that the wire run is calculated by adding the total length of the common return wire to the length of the longest hot wire (running from the controller to the station). If using two common wires, each should be calculated independently of the other.

WIRE GAUGE	MAXIMUM RUN (Length of common wire + length of longest hot wire)
16 AWG	2,000 feet
14 AWG	3,000 feet
12 AWG	4,800 feet

AT THE CONTROLLER

- After the concrete has set, bundle the hot and common wires at the base of the J-Tube and insert into the bottom opening. Push the wire all the way up through the tube until a minimum of 12 inches protrudes from the top of the J-tube.
- Unlock the door of the *LEIT* 4000, remove the front lid and slide the controller over the protruding wires and onto the J-tube. Rotate the controller in the desired position and lock in place by tightening the large Allen bolt on the lower left corner of the *LEIT* 4000 (an Allen wrench is provided.)
- If you have installed a master valve or pump, select that hot wire, cut it to length and strip a half-inch of insulation from the tip. Insert the wire into the TOP connector position (labeled *master / pump*). Secure by tightening the connector screw.
- Follow the same procedure for stations one through four, inserting the hot wires into the appropriate connector positions (labeled 1-4).
- The *LEIT* 4000 valve connector provides two commons for your convenience. One or both can be used for common wire hookup. Strip the common wire(s) and insert them into either or both of the bottom two connector positions (labeled *common*).

AT THE STATIONS

- For stations not requiring sensors, the LEMA 1500-4 series actuator should be installed on the valve.
- Strip the ends of the red and white wires leading out of the actuator. Connect the red actuator wire to the station wire (hot) using a waterproof wire nut (not provided).
- Connect the white actuator wire to the looped station common wire using another waterproof wire nut.
- Follow the same procedure for the remaining valves.

IF YOU ARE CONNECTING SENSORS

IMPORTANT: By using an SKIT 8821 Sensor Adaptor Kit, The *LEIT* 4000 is compatible with the following sensors:

All Irometer® series RA and TGA sensors
The Mini-Clik® model 401 freeze sensor
The Mini-Clik® model 502 rain sensor
The Toro® Rainswitch model 850-74.

- Make sure you have installed a LESA 1600-4 series actuator on any valve requiring a sensor. (Locate the sensor as close to the actuator / valve as possible.) On the LESA 1600-4 series actuator, select one of the two red wires and connect it to the station wire (hot), using a waterproof wire nut. Next, select one of the two white actuator wires and connect it to the looped station common wire using another waterproof wire nut.
- Strip the ends of the remaining red and white wires leading from the LESA 1600-4 series actuator and connect them to the red and white wires on an SKIT 8821-4 Switch-type Sensor Adaptor using waterproof wire nuts. Join red wire to red wire and white wire to white wire.

NOTE: If you want to extend the distance of the sensor location from the valve, simply splice appropriate lengths of red and white wire as required.

- Strip a half-inch of insulation from the tips of the two black wires protruding from the other side of the SKIT. Connect these wires to the the sensor wires using the two orange waterproof wire nuts provided with the SKIT.

NOTE: Sensors may be connected directly to the controller using an SKIT 8821 Sensor Adaptor Kit. Simply install the SKIT like an actuator, connecting the hot and common wires from the controller to the red and white wires of the SKIT respectively using waterproof wire nuts.

CONTROLLING A PUMP, A LIGHTING SYSTEM, ETC

You may use the *LEIT* 4000 as a timer that can control the on-off operation of a pump, lighting system or any other electrically powered appliance. Please note that the *LEIT* 4000 won't power the system, only switch it on and off per your schedule using an RKIT 8800-4 Series Relay Interface Module Kit.

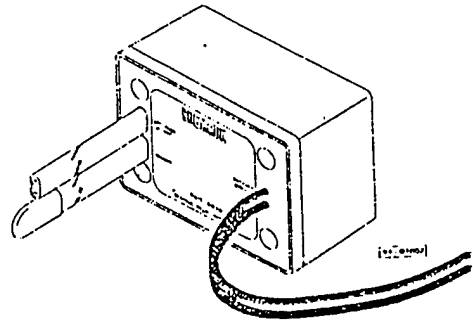
Select the RKIT module appropriate for the power source in use. There are three models:

- RKIT 8810-4 (for 24 VAC control)
- RKIT 8811-4 (for 120 VAC control)
- RKIT 8812-4 (for 240 VAC control)

Connect to appliance:

- Locate the RKIT as close to the appliance as possible so it can be easily spliced into the power line.

- Cut the neutral power line leading to the equipment to be switched. Connect the two black wires protruding from the RKIT, one wire to each end of the cut neutral power line, using the orange water-proof wire nuts provided.



Connect to controller:

- Strip a half-inch of insulation from the end of one of the two red wires protruding from the RKIT.

NOTE: The RKIT has an additional red and white wire pair designated for a sensor hookup. This is used only to install a sensor. Follow the sensor hookup procedure for the LESA 1600-4 series of actuators detailed above using an SKIT 8821-4 Sensor Adaptor Kit.

- Using a waterproof wire nut (not provided), connect this red wire to one of the station wires (hot), from the LEIT 4000. Select and strip on of the two white wires protruding from the RKIT and connect this wire to the looped station common wire, again using a waterproof wire nut.

That's all folks!
You are now ready to program the LEIT 4000.

CONDITIONS OF SALES AND WARRANTY

SALES POLICY: Altec Irrigation, Inc., products are sold through approved irrigation distributors. Prices and specifications are subject to change without notice. Minimum order \$200 net. Subminimum orders invoiced at reduced distributor discount.

TERMS: Net 30 Days (pre-approved accounts only); 2% discount on payment within 10 days. All accounts past 30 days from date of invoice are subject to a 2% per month service charge and conversion of account to C.O.D. terms. Extended terms subject to reduced distributor discount.

FREIGHT: FOB San Diego, California. Carrier selection must be specified with order. Altec absorbs normal shipping charges on all orders of \$7,500 or more.

DISTRIBUTOR STOCK RETURNS: Merchandise in new and saleable condition in original packaging may, only with prior approval from Altec, be returned on a Freight Prepaid and Insured basis for credit. Such merchandise must be clearly marked with a Return Goods Authorization Number (RGA #), issued by Altec, Inc. Customer Service and is subject to inspection and acceptance at our plant. A 20% rehandling charge and any original allowances (if applicable) will be deducted from the credit. Returned merchandise must be identified by invoice number covering original sale. (See "Warranty" information below for return of defective merchandise.)

WARRANTY

Altec, Inc. warrants to its customers who have purchased products from an authorized Altec distributor that such products will be free from original defects in material and workmanship for two (2) years from the date of manufacture.

This warranty applies only to Altec products which are installed as specified and used for irrigation purposes. This warranty applies only to products which have not been altered, damaged, misused or misapplied. This warranty does not cover products adversely affected by the system into which the products are incorporated, including improperly designed, installed, operated, or maintained systems. This warranty does not apply to blockage of solenoids due to use of water containing corrosive chemicals, electrolytes, sand, dirt, silt, rust, scale, algae, bacterial slime, or other organic contaminants. Altec's liability is limited to the repair or replacement, at Altec's sole discretion, of products which are returned prepaid to the factory and found by Altec to be defective, but in no event shall Altec's liability exceed the selling price of the product. Altec is not liable for consequential, incidental, indirect, or special damages, including but not limited to labor to inspect, remove, or replace products, vegetation loss, loss of energy or water, costs of substitute equipment or services, property damage, loss of use, or loss of profits; nor is Altec liable for economic losses, lost profits, consequential damages, or damage to property arising out of Altec's negligence or based on strict liability in tort. The user and/or trade customer agrees to the limitations and exclusion of liability of this warranty by purchase or use of Altec products. Some states do not permit the exclusion or limitation of incidental or consequential damages or of implied warranties. Therefore, some of the above exclusions or limitations may not apply to you.

Altec makes no other warranties, expressed or implied. No representative, agent, or distributor or other person has the authority to waive, alter, or add to the printed provisions of this warranty, or to make any representation of warranty not contained herein.

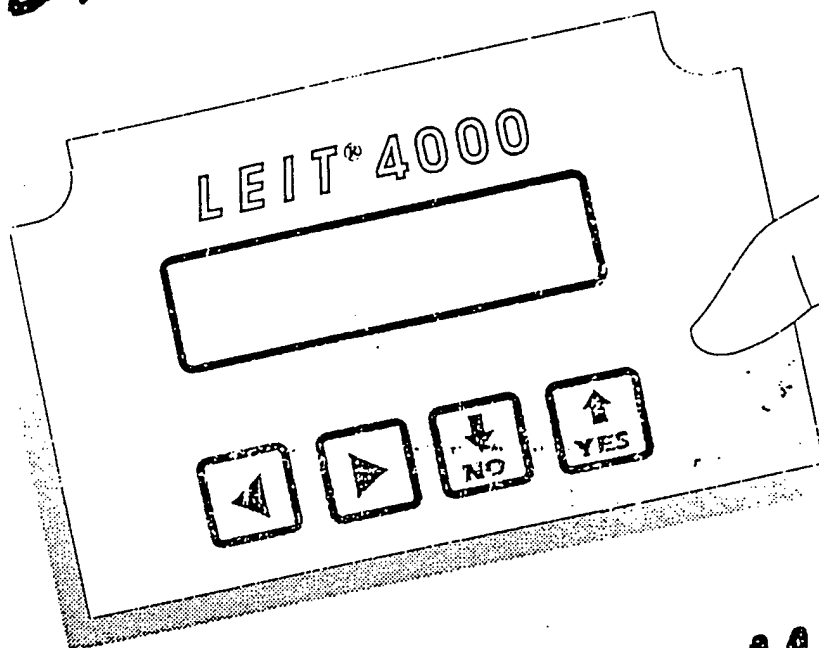
CUSTOMER SERVICE PROCEDURE:

If an apparent defect arises in a Altec product within the warranty period, promptly contact Customer Service at Altec, Inc. to request a Return Goods Authorization Number. Returned goods must be securely packaged and clearly marked with the RGA # on the outside of each carton. Shipment must be Freight prepaid and Insured. For defects determined by Altec to be the responsibility of the manufacturer, Altec will send equivalent replacement equipment within 24 hours of receiving the defective merchandise. The replacement product is covered for the remainder of the warranty period dating from the original purchase. If it is determined by Altec that the merchandise is no longer under warranty - or that the defect is caused by misuse, vandalism, or by any other unwarrantable action or event - Altec will provide the customer with an immediate quotation for the cost of factory-remanufactured, full-warranty replacement equipment. This quotation will be FAXed to the customer within 24 hours of merchandise receipt. Such replacement equipment will be shipped via next-day air within 24 hours following receipt of customer's purchase order for replacement. Alternatively, the customer may choose Custom Repair Service in which case please allow 2 weeks for the completion of repairs to customer's equipment following receipt of the customer's purchase order for service.

U.S. and foreign patents are issued and pending. "Altec", "Light-Energized Irrigation Technology", "LEIT", "Micropower Actuator", "Light-Energized", "LEIT-LINK", "MultiCentral Management", "MULTI-PRO", "PRO-MASTER" and "MULTI-MASTER" are registered trademarks of Altec Irrigation, Inc. Prices and Specifications subject to change without notice. All orders subject to Altec Conditions of Sale and Warranty in effect at time of purchase.

Altec Irrigation, Inc. 4698-A Alvarado Canyon Road San Diego, CA 92020 (VOICE): 619/229-3750 (FAX): 619/229-3760

*Programming the
LEIT[®] 4000*



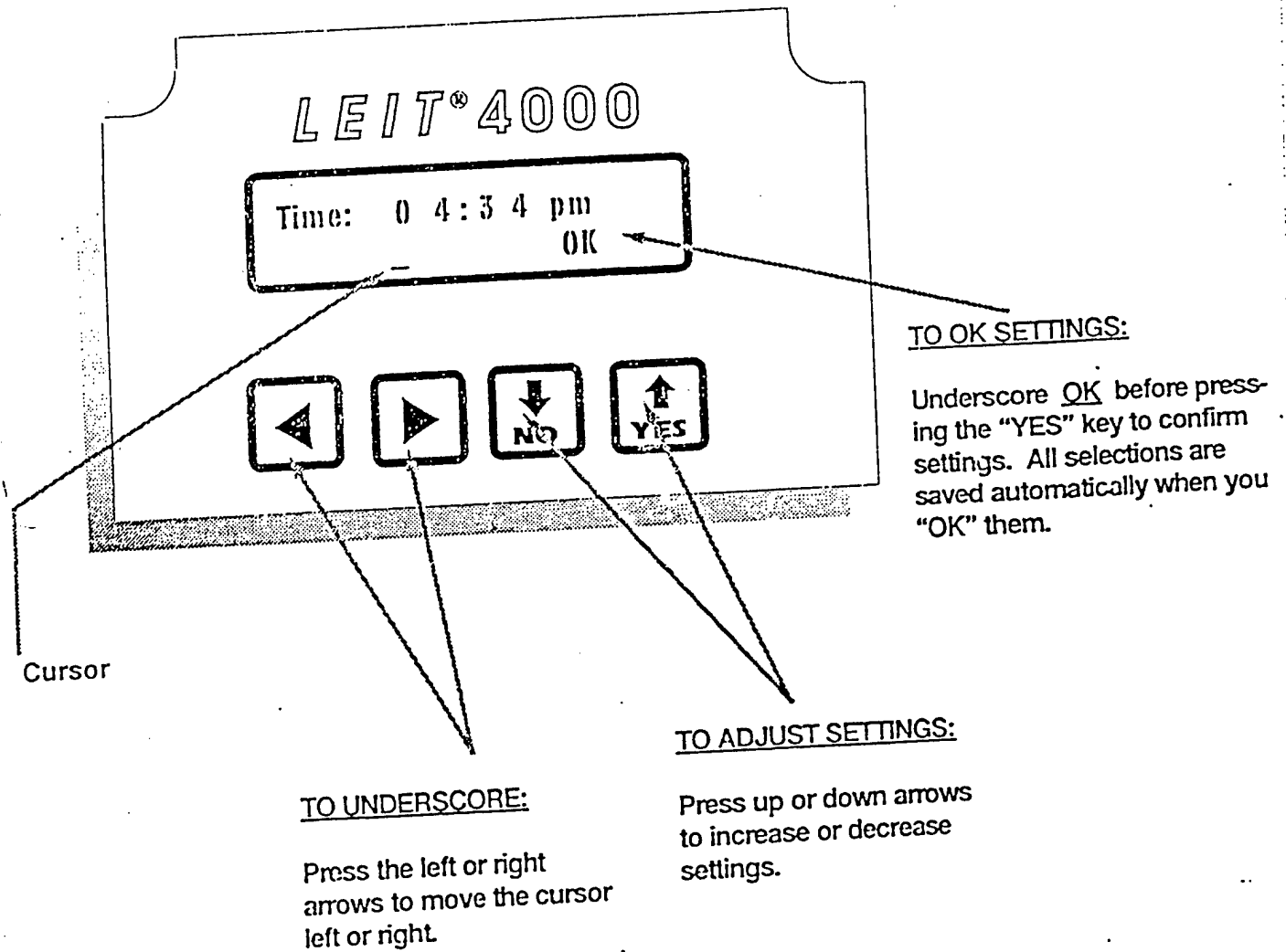
*Do it all
with just 4 buttons!*

ALTEC
IRRIGATION, INC.

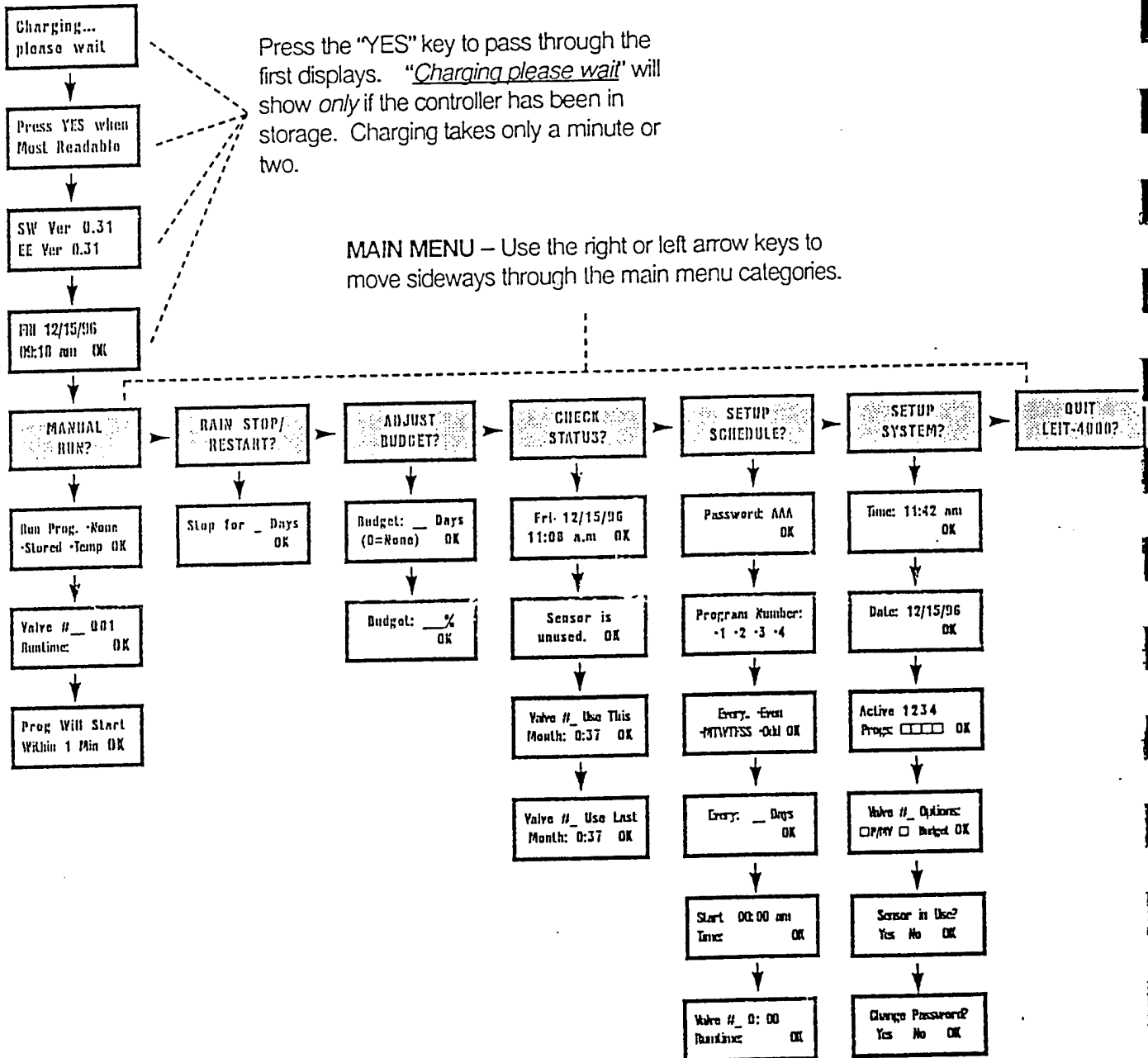
4698-A Alvarado Canyon Road San Diego, CA 92120 (VOICE) 619 / 229-3750 (FAX) 619 / 229-3760

Using the keypad

All programming is accomplished using just four keys. Just remember to underscore your selection using the left or right arrows, adjust settings using the up or down arrows, then underscore OK before pressing the YES key to set your selection.



The LEIT 4000 Program Map



Insert *LEIT* Key.

Charging...
please wait

The above screen will appear only if the *LEIT* 4000 controller has been in storage (as when just pulled from its packaging).

Press YES when
Most Readable

Press YES key when readability is best.

SW Ver 0.31
EE Ver 0.31 OK

This screen identifies the software and rom chip versions that are installed in your *LEIT* 4000. Press YES key.

FRI 12/15/96
09:18 am

The *LEIT* 4000 should display the correct time and date (Pacific Standard Time). If the wrong date and/or time is displayed, don't worry. You can reset later under the *Setup System* menu. Press the Yes key for now.

MANUAL RUN

Using this feature, you can run valves and other stations outside of any automatically scheduled programming. Manual Run is useful for checking the operation of your stations and for applying additional water as required.

MANUAL
RUN?

Press Yes to select Manual Run.

Run Prog. •None
•Stored •Temp OK

Newly installed controllers won't have any programming so the circle beside *None* will be darkened. To set a temporary manual run program, underscore *Temp* and press Yes. Then underscore OK and press YES again.

Valve #_ 001
Runtime: OK

Use the left or right arrow keys to underscore the hour and minute digits, then press the up or down arrow key to adjust the runtime. When finished, underscore OK and press Yes. Follow the same procedure for valves 2, 3 and 4. To skip any valve, simply set the runtime to 0.

Prog Will Start
Within 1 Min OK

Press YES, replace and lock the *LEIT* 4000 door and, if you're within the spray area, move! To stop the manual run prematurely, re-insert the *LEIT* Key and press YES until you see the Manual Run display.

Stop Manual Run?
Yes No OK

Press YES to stop Manual Run.

Prog will stop
within 1 min. OK

Press YES. Manual run will stop within 60 seconds. The screen will return to the Manual Run menu.

Press the right arrow key to enter
Rain Stop / Restart?

RAIN STOP

During rainy weather, you can stop regularly scheduled programs for periods of from 1 to 7 days using the RAIN STOP feature. At the end of the designated period, regularly scheduled programming will resume automatically.

RAIN STOP/
RESTART?

At the above display, press Yes.

Stop for _ Days
OK

Underscore the number of days required for rain delay and use the up or down arrows to select a rainstop setting of from 1 to 7 days. Underscore the OK and press YES. RAIN STOP will cancel itself automatically after the number of days you have selected.

You can manually cancel the RAIN STOP anytime by re-entering the RAIN STOP display. Once there, just press YES to reach the following display:

Cancel Rain Stop?
Yes No OK

Make sure Yes is selected, then press YES. Underscore OK and press YES again. This will bring you back to the RAIN STOP / IRESTART screen.

Press the right arrow key to enter
Adjust Budget?

ADJUST BUDGET

Instead of changing durations for each program, you can use the Adjust Budget feature to temporarily increase or decrease the amount of water used during seasonally dry or wet periods up to 99 days in length. The LEIT 4000 automatically reverts to the standard budget at the conclusion of the budgeted period.

ADJUST
BUDGET?

Press Yes.

Budget: _ Days
(0+None) OK

Use side arrow to underscore "00" digits, then press up or down arrows to adjust the number of budget days (from 1 to 99 days). Underscore OK and press Yes.

Budget: _ %
OK

Underscore the percentage digits and use up or down arrows to select what percentage of the normal water budget you want to supply during the period designated in the previous screen. The LEIT 4000 enables you to adjust your budget from 10 to 200 percent of what you have normally scheduled. When finished, underscore OK and press YES. This will bring you back to the ADJUST BUDGET screen.

NOTE: The water budget will automatically resume to normal after the period of time you've designated. You can also discontinue the water budget in the Setup System menu (outlined on page 7).

Press the right arrow key to enter
Check Status?

CHECK STATUS

This feature allows you to review the operation of your irrigation system for the current month as well as the month immediately preceding.

CHECK
STATUS?

Press YES.

Fri 12/15/96
11:08 a.m OK

Reports on current date and time of day.

Sensor is
unused. OK

Reports on sensors currently in use, if any.

Valve #_ Use This
Month: 0:37 OK

Reports how much time was logged on your valves (1 through 4) during the current month. Press YES to review the individual log for each valve.

Valve #_ Use Last
Month: 0:37 OK

Reports how much time was logged on each valve during the previous month. Press YES to review the individual log for each valve. Press YES after the last valve report to return to the CHECK STATUS screen.

Press the right arrow key to enter
Setup Schedule?

SETUP SCHEDULE

This feature allows you to design up to four separate programs for your irrigation system.

SETUP
SCHEDULE?

Press Yes.

Password: AAA
OK

Underscore OK and press the YES key.

Program Number:
•1 •2 •3 •4

Underscore program • 1 and press Yes, then underscore OK and press Yes again.

•Every.. •Even
•MTWTFSS •Odd OK

Options include:

- **Every** – lets you operate stations from *once a* to *once every 39 days*.
- **Even** – every even-numbered day
- **Odd** – every odd-numbered day
- **MTWTFSS** – lets you select the precise day(s) the week you desire to irrigate

Underscore the preferred option, then press Yes. Underscore OK and press YES again. If you select "EVERY", you'll get the following screen:

Every: _ Days
OK

You can set the controller to operate from 1 to 39 days.

Start 00:00 am
Time: OK

Underscore the appropriate digit to set the start time (including *am* or *pm*). Then underscore OK and press Yes.

Valve #_ 0 : 00
Runtime: OK

Underscore the appropriate digits to set the runtime (from 1 minute to 5 hours and 59 minutes. When finished, underscore the OK and press YES. Follow the same procedure for the remaining valves.

Once you have completed program 1, you'll find yourself back in the **Setup Schedule** display. Press YES if you want to repeat the the setup procedure. The *LEIT* 4000 will let you enter up to three additional programs.

Press the right arrow key to enter
Setup System?

SETUP SYSTEM

SETUP
SYSTEM?

This part of the menu enables you to set the cor time and date, activate or deactivate programs, change passwords, etc. Press YES to enter.

Password: AAA
OK

The above screen will not be displayed if you ha already entered the password in the Setup Sche menu.

Time: 11:42 am
OK

To reset the time, underscore the appropriate dig and use the up or down arrow to change setting When finished, underscore OK and press YES.

Date: 12/15/96
OK

To reset the date, underscore the appropriate dig and use the up or down arrows to change settin Underscore OK and press YES when finished.

Active 1 2 3 4
Progs: ☐ ☐ ☐ ☐ OK

Activate or deactivate programs 1 through 4 by underscoring the appropriate box(es) and press YES (a darkened box indicates an active progr Then underscore OK and press YES again. Scheduled programs will not run unless activate this screen.

Valve #_ Options:
☐ P/W ☐ Bkgt 0

If you want valve #1 to activate a pump or master valve (if either has been installed), underscore P/MV and press YES to darken the box. If you want valve #1 to be regulated by any budget settings you may have programmed, underscore Budget and press yes to darken the box. Underscore OK and press YES again. Follow the same procedure for the remaining valves.

Sensor in Use?
Yes No OK

Indicate whether or not you are using a sensor by underscoring YES or NO as appropriate. (NOTE: Sensors may be installed independently or using a LESA-series actuator. See installation instructions for details.) Underscore OK and press YES. If you are using a sensor, you'll see the following screen:

Sensor on: P/MV
1 2 3 4 OK

Those using a sensor must indicate where the sensor is installed. Underscore the appropriate selection and press YES. Then underscore OK and press YES again.

Sensor 1 2 3 4
Governes: ☐ ☐ ☐ ☐ OK

Any or all of the valves may be governed by a single sensor. Darken the box(es) as appropriate, then underscore OK and press YES.

Change Password?
Yes No OK

You may change the company-provided password (AAA) to any three-digit combination of letters or numbers. Just underscore Yes, then OK your selection.

Enter NEW A A A
Password OK

Underscore the digits you want to change and use the up or down arrow keys to change the password. When finished, OK the new password. This will bring you back to the SETUP SYSTEM screen.

Press the right arrow key to enter
QUIT?

QUIT

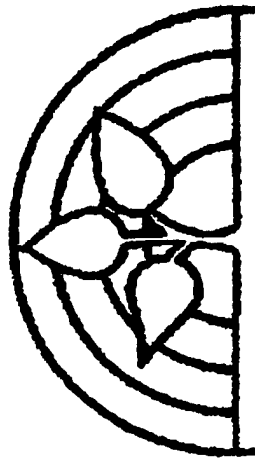
QUIT
LEIT 4000

If you're ready to quit programming, press the YES key.

REMOVE
LEIT KEY!

Remove the LEIT Key and you're finished programming the LEIT 4000. (All selections are saved as you enter the program).

That's all folks!
Your program is saved automatically as you enter your selections.



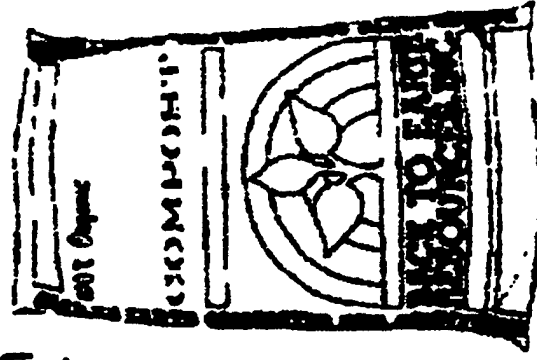
**BACK TO EARTH
RESOURCES, INC.**

THE ORGANICS COMPANY

COTTON BURR COMPOST

100% aerobically com-
posted cotton burrs

from non-defoliated cotton
grown on the high plains of
Texas. Does not contain
chemicals. Its nutrients are
released as soil bacteria act
to decompose the product.
Will not burn, leach or evap-
orate.



CYPRESS MULCH

3 CUBIC FT. (85 L)

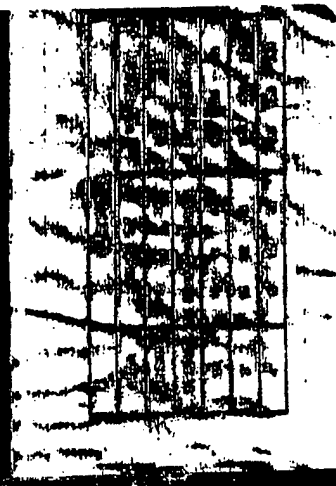


**Consolidated
Forest Products**

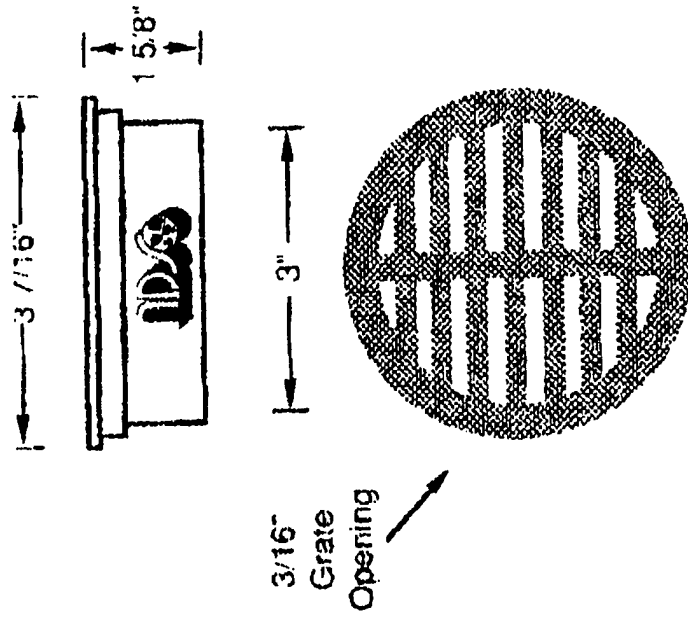
P.O. Box 1209 • Perry, FL 32348

• Phone (850) 584-8422

- Retains Moisture
- Protects Root System
- Regulates Soil Temperature
- Helps to Retard Weed Growth



3" ROUND GRATE



Specification: NDS #14, #15, #16 or #16S, 3" Round Structural Foam Polyethylene Grate with UV inhibitor. Open Surface Area 2.6 sq. in.

Root Stimulator

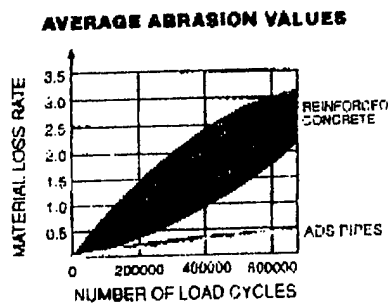


Analysis: 5-12-3

A plant nutrient liquid product especially formulated to stimulate early, strong root formation, reduce transplant shock and promote vigorous greener growth on all newly planted shrubs, roses, vegetables, trees, flowers and bedding plants.

Application Rate: 6 tablespoons per gallon

material loss rate of HDPE is only 15% to 25% that of reinforced concrete under controlled experi-



ments. And decades of in-situ testing and real-world installations have demonstrated polyethylene's interior toughness. It is used successfully with harsh mining and dredging slurries, and is virtually immune to damage from

even the most aggressive sewer cleaning tools.

- 3. Light weight.** Polyethylene weighs 50 to 75% less than comparable steel pipe, and is about one-tenth the weight of concrete. This translates into easier handling, smaller work crews, reduced heavy equipment requirements, and improved safety.
- 4. Chemically inert.** HDPE is highly resistant to corrosion, and is immune to galvanic and electro-

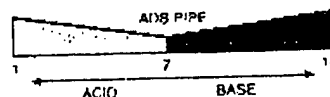
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Additional information available from ADS:

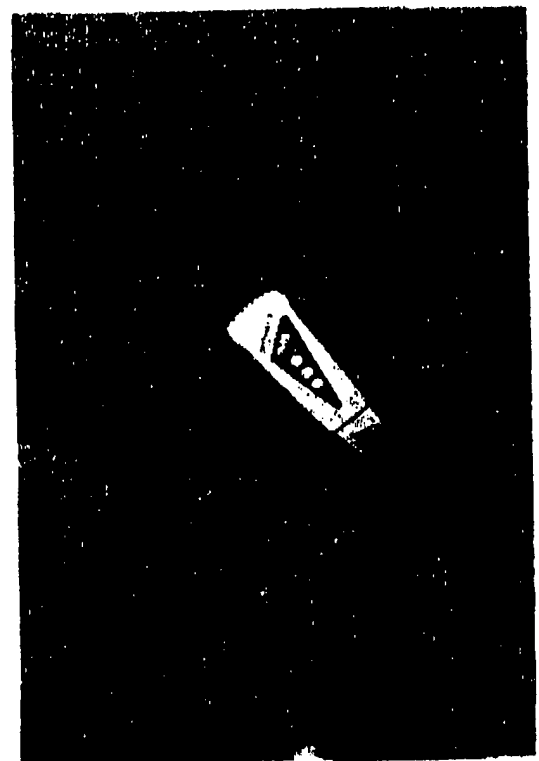
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RECOMMENDED USE pH RANGE

A pH range from 1.0 to 14



HDPE pipe's durability is dramatically demonstrated by this highway cross drain installed in 1981 near an abandoned strip mine. The metal pipe used prior to this time had to be replaced every few years due to the highly acidic and abrasive run-off from the mine. Today, after more than fifteen years, the polyethylene cross drain shows no sign of needing replacement.



High Density Polyethylene: The preferred pipe material

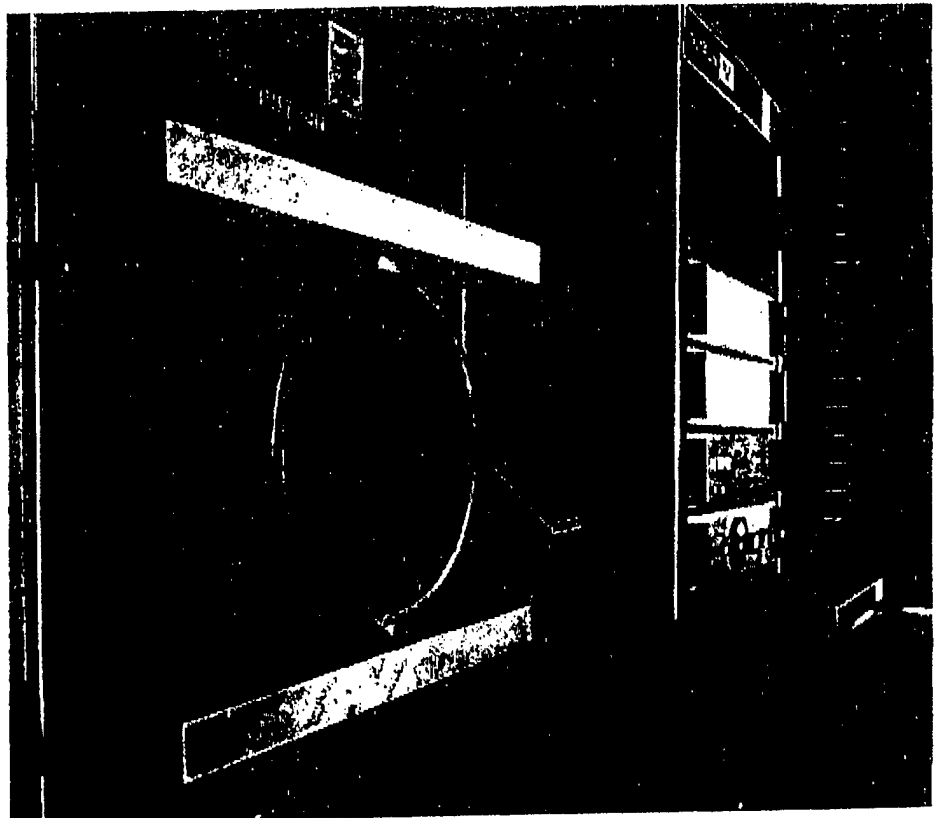


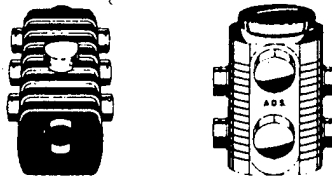
Pipe is generally divided into two categories: rigid and flexible. A pipe is rigid when it will not accept any deflection without structural distress. Examples are concrete, clay, and cast iron. Flexible pipe will accept at least 2 percent deflection without structural distress. Steel, aluminum, and thermoplastics fall into this category. We can further divide flexible pipe into elastic materials, which are the metal pipes, and viscoelastic, represented by thermoplastic materials.

While rigid pipe can be traced back to the Roman Empire, high density polyethylene drainage pipe has only been in use since the 1950s. In this relatively brief period, HDPE has been the subject of exhaustive laboratory tests and field experiments. In real-world installations, the product has built an impressively successful record of trouble-free performance.

Today, we see an accelerating trend among construction engineers to replace steel and concrete piping with polyethylene because of its superior mechanical and chemical properties and cost-effective handling characteristics.

1. **Structural strength.** HDPE's toughness and flexibility enable it to withstand fill heights of 100 feet or more, even under shifting soil conditions. Tests at Utah State University show that heavy soil loads will fracture the wall of rigid pipe, but under identical conditions, will produce only moderate deflection in flexible polyethylene pipe. HDPE will not crack or break during proper installation, and maintains its impact strength at sub-zero temperatures.
2. **Abrasion resistance.** The following chart indicates that the



SPLIT COUPLING  3"-311 10"-1011 4"-411 12"-1211 5"-511 15"-1585 6"-611 18"-1865 8"-811 24"-2413	SNAP COUPLING  3"-312 6"-612 4"-412 8"-812 5"-512 10"-1012	INTERNAL COUPLER  4"-415 5"-515 6"-615 8"-815	INTERNAL REDUCING COUPLER  5" - 4"-425 6" - 5"-526	REDUCING COUPLER  4"x3"-314 8"x 6"- 816 5"x4"-514 10"x 8"-1018 6"x4"-614 12"x10"-1210 6"x5"-516 15"x12"-1512
SNAP TEE  3"-321 5"-525 4"-421 6"-626	SADDLE TEE  4"-443 6"-646 5"-545 8"-843	REDUCING SADDLE TEE  543-5" to 3" 643-6" to 4" 547-5" to 4" 647-6" to 5"	BLIND TEE  3"-341 5"-541 4"-441 6"-641	REDUCING TEE (Single)  523-5" to 3" 624-6" to 4" 524-5" to 4" 625-6" to 5"
SNAP END CAP  3"-332 4"-432	SPLIT END CAP  3"-331 8"- 831 4"-431 10"-1031 5"-531 12"-1231 6"-631 15"-1531	END PLUGS  Perforated Non-Perforated 4"-434 3"-333 4"-433 5"-533 6"-633	45° "Y"  3"-322 5"-522 4"-422 6"-622	REDUCING TEE (Multiple)  644- 6" to 6"/6" to 5" 6" to 4"/6" to 3" 844- 8" to 8"/8" to 6" 8" to 5"/8" to 4" 1044-10" to 10"/10" to 8" 10" to 6" 1244-12" to 12"/12" to 10" 12" to 8" 1544-15" to 15"/15" to 12" 15" to 10"
90° ELL  4"-445 3"-390 4"-490	DOWNSPOUT ADAPTER  3"-364 (3 1/4 x 2 1/4) 4"-464 (3 1/4 x 2 1/4) 4"-465 (3 x 4 1/4)	SNAP ADAPTER  3"-362 5"-562 4"-462 6"-662 8"-862	SEPTIC TANK ADAPTER  4"-463	SEPTIC TEES AND ELLS  No. 494 No. 494*—For smooth wall No. 495—Cast Iron No. 496—Clay No. 497—Vented Ell *4" straight end fits ADS adapter 463 for ADS Plastic Tubing
SUMP LINERS & LIDS FOR BASEMENT  1536 Regular Lid 1537 Heavy Duty Lid  1530 30" Liner 1524 24" Liner	DISTRIBUTION BOXES  1369—Regular 1370—Hillside		OFFSET CONNECTOR  8"- 840 w/o Gasket 10"-1040 8"- 839 10"-1039	



Perforated Tubing

3"- 301-300' Coils
 4"- 401-250' Coils
 5"- 501-165' Coils
 6"- 601-100' Coils
 8"- 801-20' Lengths
 10"-1001-20' Lengths
 12"-1201-20' Lengths
 15"-1501-20' Lengths
 18"-1801-20' Lengths
 24"-2401-20' Lengths
 (301 and 401 also available in bundles of ten - 10' lengths)

Non-Perforated Tubing

3"- 351-300' Coils
 4"- 451-250' Coils
 5"- 551-165' Coils
 6"- 651-100' Coils
 8"- 851-20' Lengths
 10"-1051-20' Lengths
 12"-1251-20' Lengths
 15"-1551-20' Lengths
 18"-1851-20' Lengths
 24"-2451-20' Lengths
 (351 and 451 also available in bundles of ten - 10' lengths)

Septic/Leach Field Tubing

4"-402-10' Lengths
 With Bell End
 (also available in coils)
 (1/2" to 3/4" dia. hole)
 (Perforated to comply with state, county and municipal sanitation codes)

Protective Wrap (Drain Guard® Protective Wrap Guard®)

D/G	Socket
3"- 372	373-300' Coils
4"- 472	473-250' Coils
5"- 572	573-165' Coils
6"- 672	673-100' Coils
8"- 872	873-20' Lengths
10"-1072	1073-20' Lengths
12"-1272	1273-20' Lengths
15"-1572	1573-20' Lengths

Heavy Duty Perforated and Non-Perforated Tubing

Perf.	Non-Perf.
8"- 801	851-20' Lengths
10"-1001	1051-20' Lengths
12"-1201	1251-20' Lengths
15"-1501	1551-20' Lengths
18"-1801	1851-20' Lengths
24"-2401	2451-20' Lengths

SB2® Leach Field Tubing

Filter Wrap (Drain Guard®)
 (1/2" holes)
 8"- 871-20' Lengths
 10"-1071-20' Lengths

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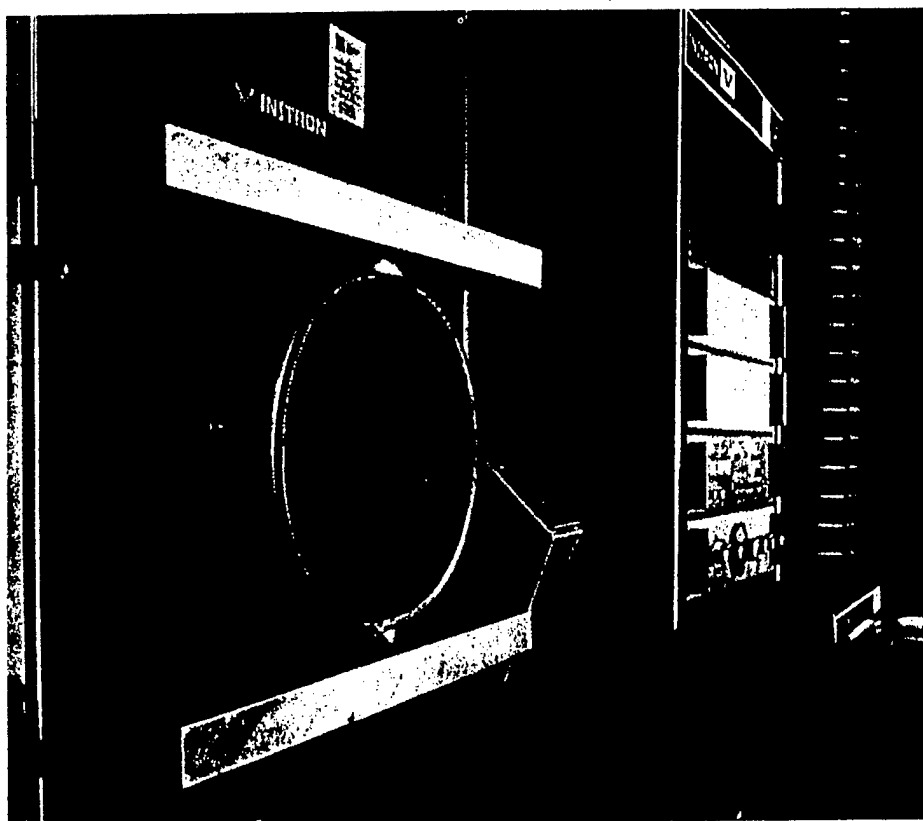


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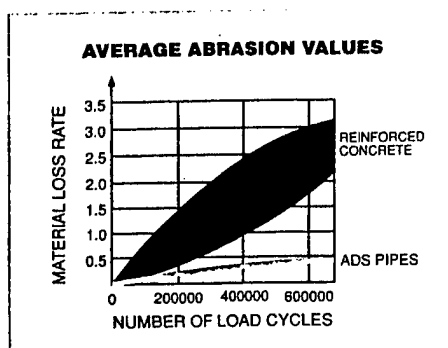
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2. **Abrasion resistance.** The following chart indicates that the



material loss rate of HDPE is only 15% to 25% that of reinforced concrete under controlled experi-

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mechanical reaction. As seen in the diagram, polyethylene can safely be used with soils or effluents with a pH range of 1 to 14.



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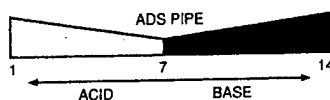
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RECOMMENDED USE pH RANGE

A pH range from 1.0 to 14.



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CATCH BASINS, GRATES & ACCESSORIES

Use with our 7 1/2" Square, 6" Round or 6" Atrium grates.

A single Universal Adapter allows easy connection to 3" or 4" S/D Pipe, 3" or 4" Corrugated, or 4" SDR35 and 4" DWV pipe.

Add 6" SDR pipe to extend to any desired height.

Remove Universal Outlet when using 4" Corrugated pipe.

Universal Outlet Adapter Included with catch basin allows versatile system configurations.

Single or double outlet Catch Basin fits all standard accessories.

6" Catch Basins

	COLOR	STOCK NO	UNITS PER CARTON
 SINGLE AND DOUBLE OUTLETS WILL FIT 3" & 4" S/D PIPE, 3" & 4" CORRUGATED, SDR 35 AND 4" DWV PIPE Universal Outlet Adapter Included 6" SINGLE OUTLET—Black 6" DOUBLE OUTLET—Black UNIVERSAL OUTLET ADAPTER—Black			
		NP-101	10
		NP-201	10
		NP-243	20

Round Grates

APPLICATION: LAWN AREAS, WALKWAYS, PATIOS, POOL AREAS. THESE GRATES FIT DIRECTLY INTO SEWER AND DRAIN FITTINGS, CORRUGATED AND S/D PIPE WITHOUT THE USE OF COUPLING

 3" ROUND GRATE 3" FITS 3" S/D PIPE FITTINGS, 3" BELLEND, 3" CORRUGATED 1 5/8" x 3" x 37/16"	GREEN BLACK GRAY	NP-113 NP-114 NP-115	40 40 40
 4" ROUND GRATE 4" FITS 4" S/D PIPE FITTINGS, 4" BELLEND, 4" CORRUGATED 1 1/2" x 4" x 4 1/2"	GREEN BLACK GRAY	NP-116 NP-117 NP-118	20 20 20
 6" ROUND GRATE 6" FITS 6" S/D PIPE FITTINGS, 6" BELLEND, 6" CORRUGATED, 6" CATCH BASINS 2 3/8" x 6 3/4" x 5 3/4"	GREEN BLACK GRAY	NP-119 NP-120 NP-121	20 20 20
 8" ROUND GRATE 8" FITS 6" S/D PIPE FITTINGS, 6" BELLEND, 6" CORRUGATED, 6" CATCH BASINS 2 1/2" x 7 3/4" x 5 3/4"	GREEN BLACK GRAY	NP-122 NP-123 NP-124	10 10 10

LEIT® 4000

The LEIT® 4000 Irrigation Control Unit operates up to four stations and a master valve or pump start without AC hookups, batteries or cumbersome solar panels. Its compact, time-tested photo-voltaic module harnesses the energy of ambient light to power the unit day and night in any kind of weather, anywhere in the world. Standard irrigation wire is used to connect the LEIT 4000 to standard irrigation valves equipped with Altec's micropower actuators in place of conventional solenoids.

FEATURES:

- Requires no AC power hookup, batteries or conventional solar panels.
- Functions day and night in any weather and most outdoor locations.
- All power is provided by an internal, ultrahigh efficiency photovoltaic module and microelectronic energy management system fueled by ambient light. Requires daily exposure to light levels no higher than the equivalent of 25% of the ambient light level at 55 degrees latitude under 10-year worst-case weather conditions (worst day measured in 10-year-period).
- No direct sunlight is required.
- Controls 4 stations plus one master valve or pump start.
- Compatible with most brands, styles and sizes of valves (refer to LEMA 1500-4 series specification sheet)
- Installs using standard irrigation wire up to 12 gauge.
- Each station operates independently with up to four programs per valve. Set durations from one minute to six hours.

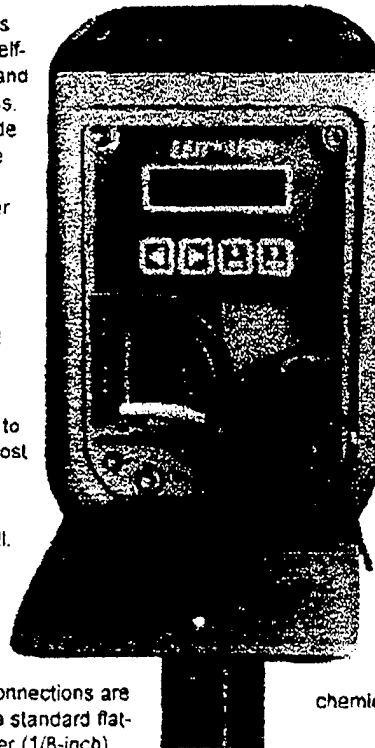
- Programming is easy using a self-guiding menu and just four buttons. Features include pro-grammable rain delay, automatic water budget-ing, password protection, multiple water scheduling and many others.
- Liquid crystal display is easy to read under almost any light-ing conditions
- Simple to install. Easy-access wire connector accommodates standard irrigation wire up to 12 gauge. Connections are secured using a standard flat-head screwdriver (1/8-inch). No special tools are required.
- Two-year full replacement warranty – the best deal in the business!

SECURITY:

- The LEIT Key, powered by a 9-volt battery, prevents unauthorized access to the controller's schedule and programs.
- Unit mounts securely onto a rugged galvanized steel mounting tube using stainless steel lock bolts.
- Stainless steel lock secures weather-resistant exterior panel to the LEIT 4000 after programming and installation are complete

ELECTRICAL:

- All power for the LEIT 4000 is provided by the control unit's internal photovoltaic module and exclusive microelectronic energy management system – without batteries of any kind.
- Power output to micropower valve actuators (light-energized systems) and two-way data communication is delivered via digital control pulses @ 3.5 volts DC.



- All circuitry is fully protected from electrostatic discharge to 27,000 volts.
- Programming mode is activated by a LEIT Key (which uses a 9V battery) to energize the two-line liquid crystal display.

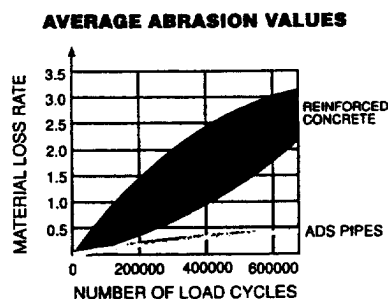
MECHANICAL:

- Protected by a vandal-resistant, waterproof enclosure fashioned from space-age composite material made to endure extreme environments, however hot, cold, wet or dry..
- Super-tough LEXAN™ lens protects the photovoltaic module from moisture, dust chemicals and impact damage.

- Height: 9.4 inches (23,9 cm)
- Width: 5.7 inches (14,5 cm)
- Depth: 3.2 inches (8 cm)
- Weight: 2.6 lbs. (1,2 kg)
- Operational temperature: 14°F to 140°F (-10°C to 60°C)
- Storage temperatures range: -40°F to 194°F (-40°C to 90°C)

Specification Sheet

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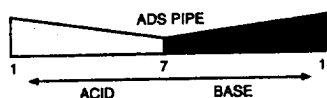
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LASCO®

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LASCO®
FLUID DISTRIBUTION PRODUCTS

Headquarters

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Brownsville, TN 38012
901/772-3180
800/776-2756
FAX 901/772-0835

Limited Warranty

LASCO Fluid Distribution Products are made from 100% virgin materials and are warranted to be free from manufacturing defects in materials and workmanship. They are warranted against rot, rust and electrolytic corrosion for a period of 3 years from date of installation. If LASCO products prove defective due to manufacturing defects in material or workmanship during that period, the manufacturer will provide new replacement units of the same type and size. No remedy will be granted under this warranty if LASCO products are not used strictly in accordance with LASCO's directions with respect to use and storage or if the products have been modified in any way. THE MANUFACTURER'S LIABILITY UNDER EXPRESSED OR IMPLIED WARRANTY OR FOR ANY REASON IS LIMITED TO FURNISHING REPLACEMENT UNITS OR GRANTING A CREDIT FOR DEFECTIVE UNITS. NO LABOR EXPENSE OR CONSEQUENTIAL DAMAGES WILL BE PAID BY LASCO. THIS WARRANTY IS IN LIEU OF ALL OTHER GUARANTEES AND WARRANTIES, EXPRESSED OR IMPLIED, INCLUDING BUT NOT LIMITED TO, WARRANTIES OF MERCHANTABILITY AND FITNESS FOR PURPOSE, EXCEPT FOR ANY WARRANTIES IMPLIED BY LAW FOR NONCOMMERCIAL CONSUMERS. ANY SUCH WARRANTIES ARE LIMITED TO THE DURATION OF THIS WRITTEN WARRANTY.

- DO NOT USE LASCO FITTINGS FOR COMPRESSED AIR OR GASES.
- DO NOT TEST PVC PIPING SYSTEMS WITH COMPRESSED AIR OR GASES.
- DO NOT USE FITTINGS WITH LIQUIDS NOT RECOMMENDED BY LASCO.
- MODIFICATIONS OF FITTINGS VOIDS THE WARRANTY.

STANDARDS AND SPECIFICATIONS — Schedule 40

ASTM D-1784 — Rigid Poly (Vinyl Chloride) (PVC) Compounds and Chlorinated Poly (Vinyl Chloride) (CPVC) Compounds.

ASTM D-2464 — Threaded Poly (Vinyl Chloride) (PVC) Plastic Pipe Fittings, Schedule 40.

ASTM D-2466 — Poly (Vinyl Chloride) (PVC) Schedule 40.

Socket Type Pipe Fittings

MATERIAL — LASCO Schedule 40 Fittings are produced from PVC Type 1, Cell Classification 12454-B.

LISTINGS — NSF (National Sanitation Foundation) for potable water services.

Standard Terms and conditions of sale

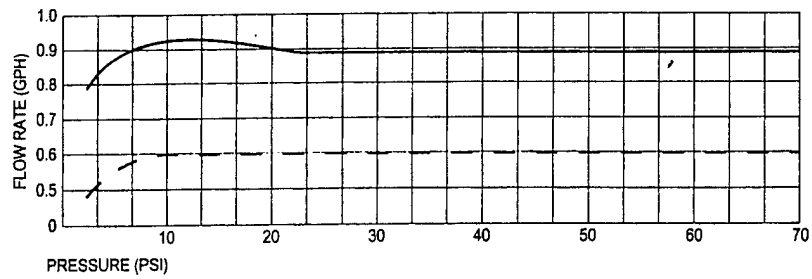
1. **Terms:** 2% 10th prox. Net 30th.
2. **Freight:** FOB LASCO warehouses. Prepaid on orders for products only totaling \$1000 net for one shipment to single destination within the contiguous United States.
3. **Minimum Order:** \$50 net. Smaller orders billed at this minimum charge.
4. **Claims for shipping errors** must be made within 15 days to LASCO. Claims for damage or shortages should be directed promptly to the common carrier by the consignee.
5. **Returns** will be accepted only by prior authorization and if shipped freight prepaid. Returned merchandise subject to a 20% handling/restocking charge.
6. **Pricing** is subject to change without prior notice. However, prior notification will be given in the event of price changes in the period between order placement and scheduled shipment.
7. **Offer to sell** is not implied by possession of this or other LASCO price lists.



Flow per 100 Feet

Dripper Spacing	Dripper Flow			
	0.61		0.92	
	GPH	GPM	GPH	GPM
12"	61	1.02	92	1.53
18"	41	0.88	61	1.02
24"	31	0.51	46	0.77

Dripper discharge rate vs. pressure

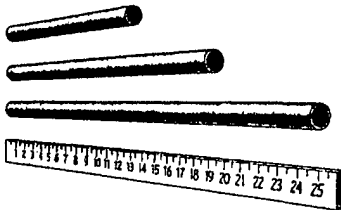


Manufacturing Variation Factor CV = 0.03

Maximum Length of Laterals

PSI	12"		18"		24"	
	0.6	0.9	0.6	0.9	0.6	0.9
15	243	186	342	262	435	330
25	320	244	450	344	572	437
35	371	282	524	400	664	506
45	412	312	582	443	737	560

Calculations based on 7 PSI End Pressure and 0% Slope

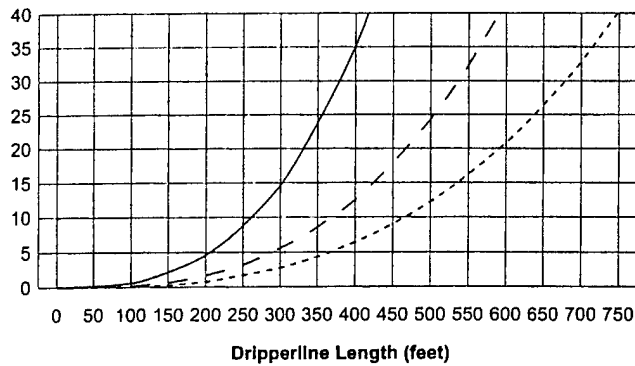


Techline dripperline tubing is available with 12", 18" and 24" dripper spacings.

Techline Dripperline
I.D. 0.57"
Technical Dripper Flow: 0.61 gph

PSI Loss vs. Dripperline Length

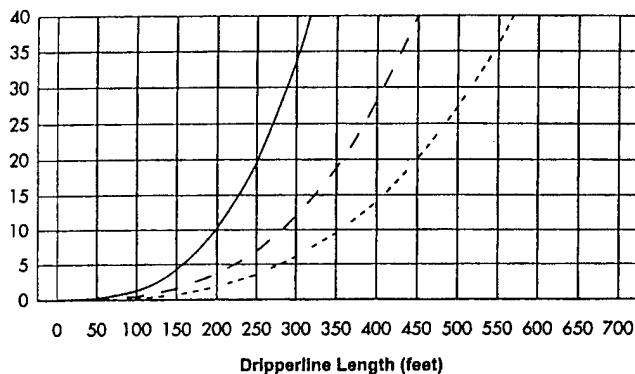
Pressure Loss (psi)



Techline Dripperline
I.D. 0.57"
Technical Dripper Flow: 0.92 gph

PSI Loss vs. Dripperline Length

Pressure Loss (psi)



PVC PRESSURE PIPE – SOLVENT BELL

Sheet No. SW-100190-3

Schedule 40

NSF Listed
20' Standard Lengths
Belled End

Conforms to: ASTM D-1785, D-1784 Cell Class 12454-B, D-2672 Bell End.

PART NUMBER	SIZE	NOM O.D.	MIN I.D.	MAX I.D.	MIN WALL	APPROX WT/FT	MAX PRESSURE RATING AT 73°	FEET PER PACK
A46AE42	1/2	.840	.578	.626	.109	.162	600	6000
A46AG42	3/4	1.050	.780	.828	.113	.216	480	8800
A46BA42	1	1.315	1.004	1.054	.133	.321	450	5400
A46BC42	1-1/4	1.660	1.335	1.385	.140	.435	370	4000
A46BE42	1-1/2	1.900	1.564	1.616	.145	.520	330	3600
A46CA42	2	2.375	2.021	2.073	.154	.700	280	2460
A46CE42	2-1/2	2.875	2.414	2.476	.203	1.110	300	1800
A46DA42	3	3.500	3.008	3.076	.216	1.453	260	1200
A46EA42	4	4.500	3.985	4.035	.237	2.071	220	1080
A46FA42	5	5.563	5.023	5.057	.258	2.807	190	760
A46GA42	6	6.625	6.036	6.076	.280	3.646	180	480
A46JA42	8	8.625	7.888	7.996	.322	5.489	155	360
A46KA42	10	10.750	9.917	10.035	.365	7.787	140	220
A46LA42	12	12.750	11.825	11.953	.406	10.297	130	60

Schedule 80

NSF Listed
20' Standard Lengths
Plain End – Gray

Conforms to: ASTM D-1785, D-1784 Cell Class 12454-B, D-2672 Bell End.

PART NUMBER	SIZE	NOM O.D.	MIN I.D.	MAX I.D.	MIN WALL	APPROX WT/FT	MAX PRESSURE RATING AT 73°	FEET PER PACK
A48AE41	1/2	.840	.502	.550	.147	.207	850	6000
A48AG41	3/4	1.050	.698	.746	.154	.281	690	4400
A48BA41	1	1.315	.910	.962	.179	.414	630	2600
A48BC41	1-1/4	1.660	1.227	1.283	.191	.572	520	2000
A48BE41	1-1/2	1.900	1.446	1.506	.200	.694	470	1800
A48CA41	2	2.375	1.881	1.945	.218	.960	400	1060
A48CE41	2-1/2	2.875	2.250	2.330	.276	1.463	420	1800
A48DA41	3	3.500	2.820	2.908	.300	1.963	370	1200
A48EA41	4	4.500	3.737	3.835	.337	2.871	320	1080
A48FA41	5	5.563	4.713	4.823	.375	3.984	290	760
A48GA41	6	6.625	5.646	5.772	.432	5.482	280	480
A48JA42	8*	8.625	7.490	7.640	.500	8.301	250	360
A48KA42	10*	10.750	9.407	9.579	.593	12.356	230	220
A48LA42	12*	12.750	11.197	11.391	.687	16.950	230	60

*Belled end product.

CANTEX

P.O. Box 340 Mineral Wells, Texas 76067 (817) 325-3344 FAX (817) 325-4644



AMETEK

TURF IRRIGATION VALVE BOXES



BLACKWOLF RUN, KOHLER, WI

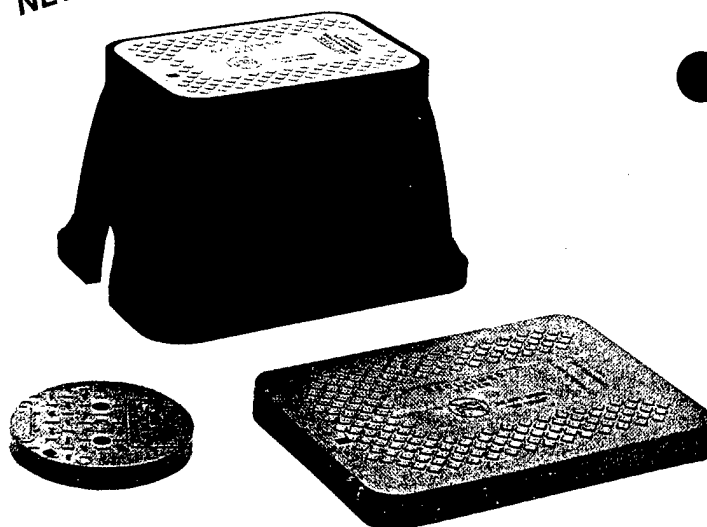
AMETEK

PLYMOUTH PRODUCTS DIVISION



"RECLAIMED WATER"

NEW

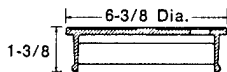
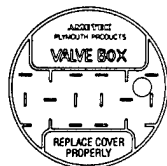


TYPICAL INSTALLATION

AMETEK's Turf Irrigation Valve Boxes are ideal for use in golf course fairways, cemeteries, residential and any commercial lawn where valves or meters are buried. Their molded-in green color blends in with, rather than sticks out of, your turf. Black covers are available for landscaping needs. Purple covers are available for "reclaimed water" (shown above).

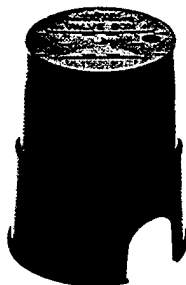
AMETEK's boxes are lighter in weight, easier to handle and less brittle than concrete or cast iron boxes. All boxes nest for simplified storage. And, they are made of a strong, tough thermoplastic material especially suitable for underground use.

AMETEK also offers the standard 12 inch valve box with a black electric cover.

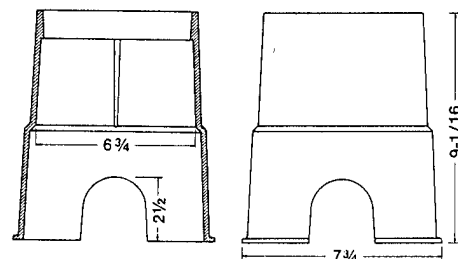


DESCRIPTION	PART #	WEIGHT	SKID
Assembly w/Green Cover (Crated-216)	182101	1 $\frac{1}{10}$ Lbs.	216
Assembly w/Green Cover (Boxed-20)	182103	1 $\frac{1}{10}$ Lbs.	320
Box Only	182001	1 $\frac{1}{4}$ Lbs.	216
Cover Only - Green	182002	$\frac{1}{2}$ Lb.	936
Cover Only - Black	182005	$\frac{1}{2}$ Lb.	936

ECONOMY TURF BOX



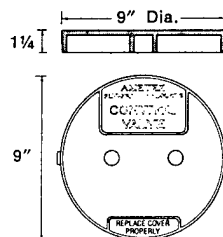
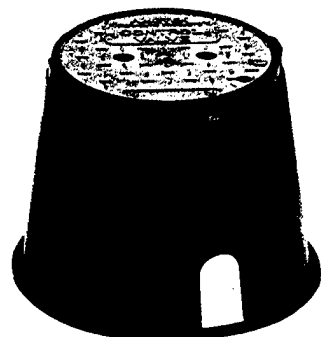
COVER ALSO AVAILABLE
MARKED "CATV"



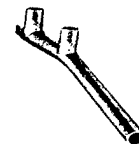
Ametek's ECONOMY TURF BOX has a Snap fit cover and is designed to nest with cover installed during shipment and storage.

DESCRIPTION	PART #	WEIGHT	SKID
10" Ass'y - w/Green C.V. Cover	181104	4 $\frac{3}{4}$ Lbs.	135
10" Ass'y. - w/Black C.V. Cover	181108	4 $\frac{3}{4}$ Lbs.	135
10" Box Only	181014	3 $\frac{1}{2}$ Lbs.	135
10" Cover Only-Green Control Valve	181015	1 $\frac{1}{2}$ Lbs.	650
10" Cover Only - Black Control Valve	181018	1 $\frac{1}{2}$ Lbs.	650
10" Cover Only - Black Electric	181021	1 $\frac{1}{2}$ Lbs.	650
10" Cover Only - Purple "Reclaimed Water"	181022	1 $\frac{1}{2}$ Lbs.	650

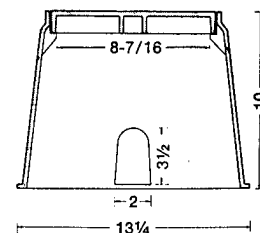
10" CIRCULAR BOX



COVER
LIFTING TOOL
144046



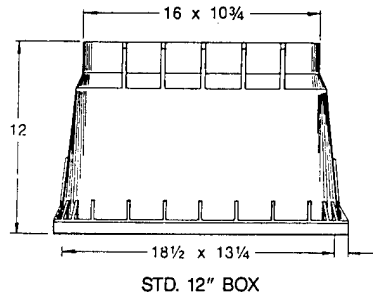
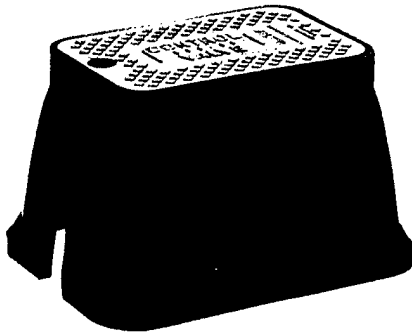
AMETEK'S 10" CIRCULAR BOX combines these features:
TWIST LOCK COVER WITH FLUSH FIT
GREATER WORKING AREA
LESS STORAGE SPACE NEEDED
(Covers are shipped installed)



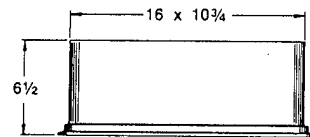
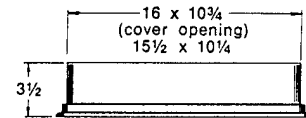
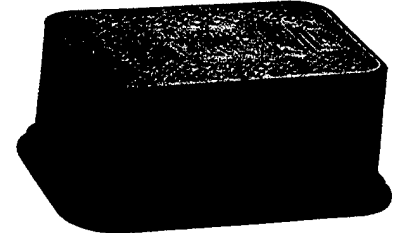
COVERS ALSO AVAILABLE MARKED "CATV", "SEWER" and "ELECTRIC"

STANDARD TURF BOXES, COVERS AND EXTENSIONS

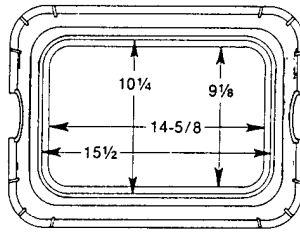
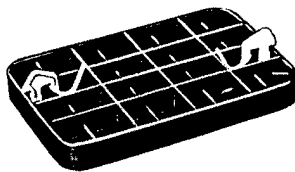
12" METER BOX



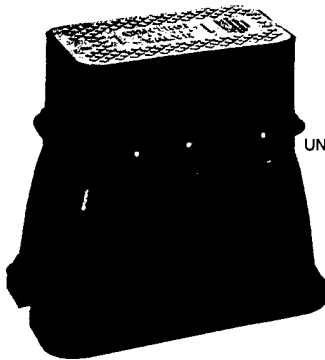
EXTENSIONS



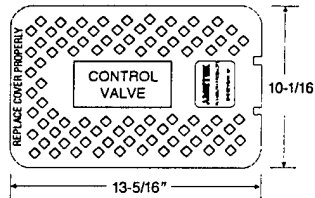
COVER



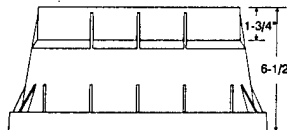
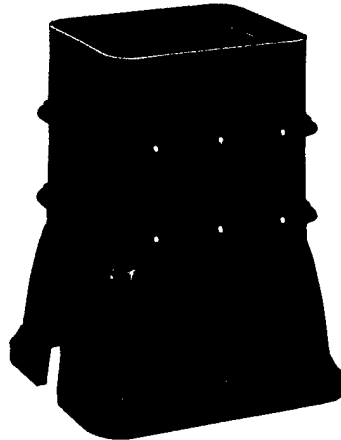
18" METER BOX



SNAP LOCK UNLOCKING TOOL 144022

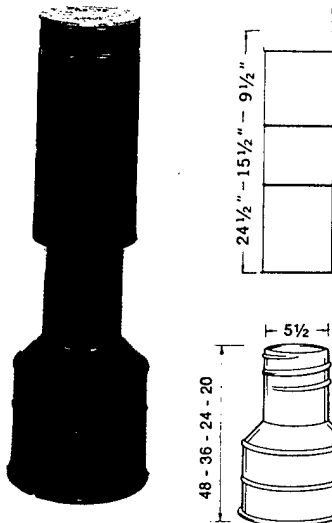


24" METER BOX



DESCRIPTION	PART #	WEIGHT	SKID
12" Black C.V. Cover	171117	3 1/2 Lbs.	225
12" Std. Box w/Green C.V. Cover	170106	11 Lbs.	72
12" Std. Box Only	170101	7 3/4 Lbs.	72
Std. Green C.V. Cover Only	173134	3 1/2 Lbs.	225
Black Elec. Cover Only	171115	3 1/2 Lbs.	225
12" Std. Box w/Pent Lock	170128	7 3/4 Lbs.	72
Green C.V. Cover w/Pent Lock	173142	3 1/2 Lbs.	225
Std. Purple Reclaimed Cover	173143	3 1/2 Lbs.	225
18" Box Only	170124	12 1/4 Lbs.	48
24" Box Only	170125	16 3/4 Lbs.	30
3" Extension Only	170102	2 1/4 Lbs.	126
6" Extension Only	170103	4 1/2 Lbs.	63
6" Flared Box w/Green Cover	170130	8 1/2 Lbs.	78
6" Flared Box Only	170129	47 1/8 Lbs.	90

5 1/4" POLYIRON® VALVE BOX

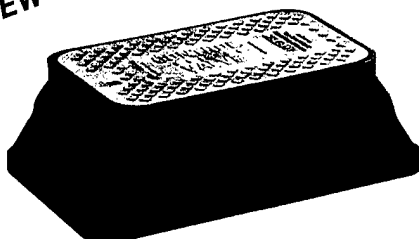


Top sections are made of POLYIRON® magnetically locatable material.

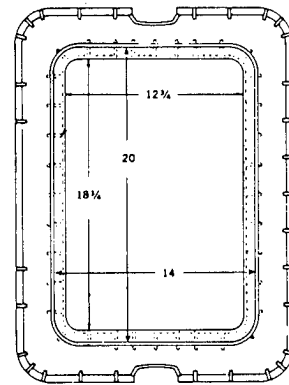
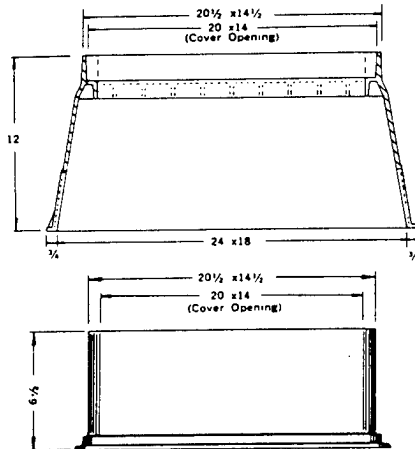
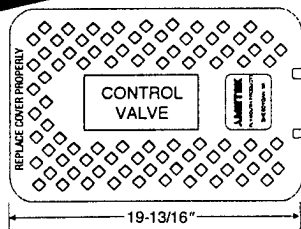
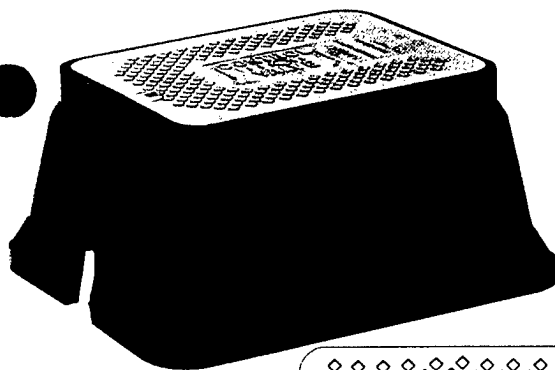
DESCRIPTION	PART #	WEIGHT
9 1/2" Top	111036	2 1/2 Lbs.
15 1/2" Top	111037	4 Lbs.
24 1/2" Top	111038	6 3/4 Lbs.
20" Bottom	111048	4 Lbs.
24" Bottom	111049	4 3/4 Lbs.
36" Bottom	111050	6 3/4 Lbs.
48" Bottom	111051	8 Lbs.
5 1/4" Black Drop Cover	111030	1 1/8 Lbs.
5 1/4" Green Drop Cover	111031	1 7/8 Lbs.

NEW

6" FLARED BOX



JUMBO BOX AND 6" EXTENSION

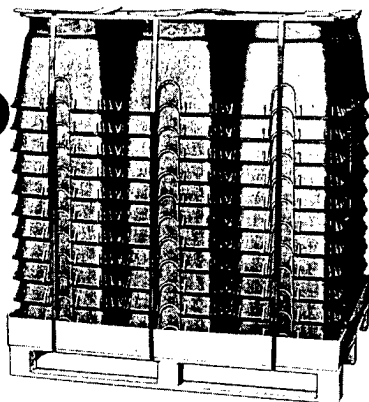


6" JUMBO EXTENSION — 6 Lbs.
3" JUMBO NOT AVAILABLE

LARGE AND EXTRA LARGE UTILITY BOX SPECIFICATION
SHEETS ARE ALSO AVAILABLE

DESCRIPTION	PART #	WEIGHT	SKID
Jumbo Box w/Green C.V. Cover	190106	18 1/4 Lbs.	48
Jumbo Box Only	190101	11 1/4 Lbs.	48
Jumbo Green C.V. Cover Only	192101	6 1/4 Lbs.	132
6" Ext. w/Green C.V. Cover	190115	13 1/4 Lbs.	32
6" Ext. Only	190110	6 1/4 Lbs.	40
Jumbo Box w/Gr C.V. Pent. Lock Cover	190121	19 Lbs.	48
Pentagon Green C.V. Cover Only	192109	6 1/4 Lbs.	132
Jumbo Purple "Reclaimed" Cover Only	192110	6 1/4 Lbs.	132

SPECIFICATIONS, ORDERING INFORMATION



(PALLET SHOWN IS
STANDARD BOX)
48 skids per truck load

PLYMOUTH SUPERFLEXON® BOXES AND COVERS

A rigid combination of polyolefin and fibrous inorganic components. SUPERFLEXON plastic material is chemically inert and normally unaffected by moisture, corrosion and the effects of temperature changes. Superflexon also has a relatively high tensile strength with light weight because it is a solid (not foamed) structural material. Physical properties by ASTM testing method are as follow:

Physical Properties of Plymouth Superflexon Products

	ASTM Test Method	Minimum Test Value
Tensile Strength (2.0"/min.)	D-638-82a	3,400 psi
Flexural Modulus	D-790-81	191,000 psi
Compressive Strength (.05"/min.)	D-695-80	3,350 psi
Impact Strength, Izod.	D-256-81	.6 ft. lb./in.
Durometer Hardness, Type D	D-2240-81	60
Deflection Temp.		
@ 66 psi Stress	D-648-82	230°F
Specific Gravity	D-792-66 (1979)	1.15

PACKAGING INFORMATION

ITEM	UNITS skd./ctr.	CTR. T/L	CTR. WGT.
Std. Box - No Cover	72/skd.	48	593 Lbs.
Std. Box - w/Cover	72/skd.	48	827 Lbs.
Jumbo Box - No Cover	48/skd.	44	604 Lbs.
Jumbo Box - w/Cover	48/skd.	44	904 Lbs.
Std. Covers Shipped Separately	225/ctr.	48	809 Lbs.
Jumbo Covers Shipped Separately	132/ctr.	48	885 Lbs.
Std. 6" Extensions	63/skd.	48	319 Lbs.
Std. 3" Extensions	126/skd.	48	319 Lbs.
Jumbo 6" Extensions	40/skd.	44	280 Lbs.

ITEM	UNITS skd./ctr.	CTR. T/L	CTR. WGT.
Econo Box w/Cover Crate	216	48	401 Lbs.
Econo Box w/Cover Boxed	320	24	541 Lbs.
10" Box w/Cover	135	48	643 Lbs.
LUB 1324-15"	30	24	730 Lbs.
XLUB 1730-15"	22	24	766 Lbs.
XLUB 1730-18"	18	24	688 Lbs.
6" Flared Box w/Cover	78	48	703 Lbs.
6" Flared Box Only	90	48	468 Lbs.

Superflexon covers are NOT traffic covers and should not be used in roadways, etc. ALL ECONOMY, 10" AND 5-1/4" BOXES ARE PACKED IN CRATES AND NOT SKIDDED.



Products Manufactured
From Recycled Plastics

WE RESERVE THE RIGHT TO CHANGE DESIGN, SPECIFICATIONS, OR PRICE WITHOUT NOTIFICATION



Bulletin T-19U 2/97 5M
Printed in U.S.A.



PLYMOUTH PRODUCTS DIVISION
502 INDIANA AVENUE - P.O. BOX 1047
SHEBOYGAN, WISCONSIN 53082-1047, U.S.A.
TELEPHONE: (414) 457-9435 TLX: 6718348 FAX: (414) 457-6652

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Call toll free 1-800-645-5427

The Right Choice in Valves



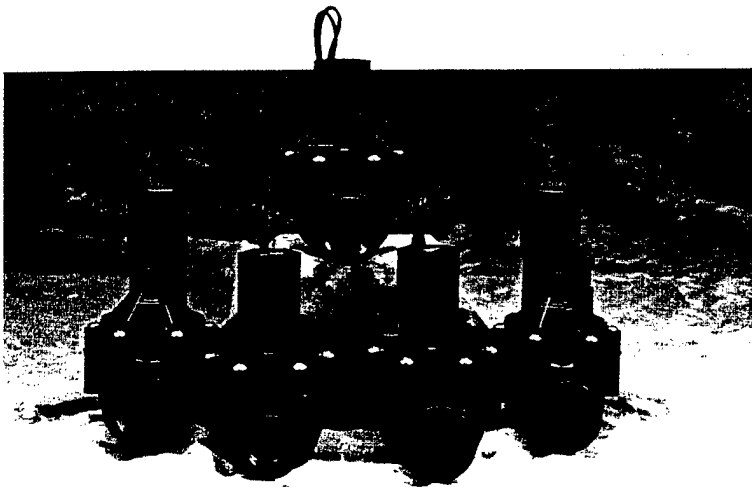
Designed for the utmost in efficiency, Rain Bird's DV Series valves eliminate your landscape worries. Their innovative design allows these dependable valves to operate reliably even in harsh soil or water conditions — opening and closing right on schedule. With Rain Bird's DV valves, you'll know your lawn is getting the water it needs.

DV SERIES VALVES



RAIN BIRD

DV SERIES VALVES



Trouble-free Performance Time After Time

Opening and closing at your controller's command is the job of the DV valve. And it's a job these valves take seriously. Whether in harsh soil or dirty water, DV valves are designed to effectively control the water flowing to your sprinklers.

Outstanding Features:

- Reliable, non-clogging design ensures consistent performance for a healthy, lush landscape.
- Unique balanced-pressure design and contoured flow path provide efficient operation for a long life.
- Spray-free internal bleed offers convenience and water savings.
- Heavy-duty construction protects against temperature extremes and high water pressure.
- Available in globe or angle configuration.



For customer information,
call 1-800-247-3782.



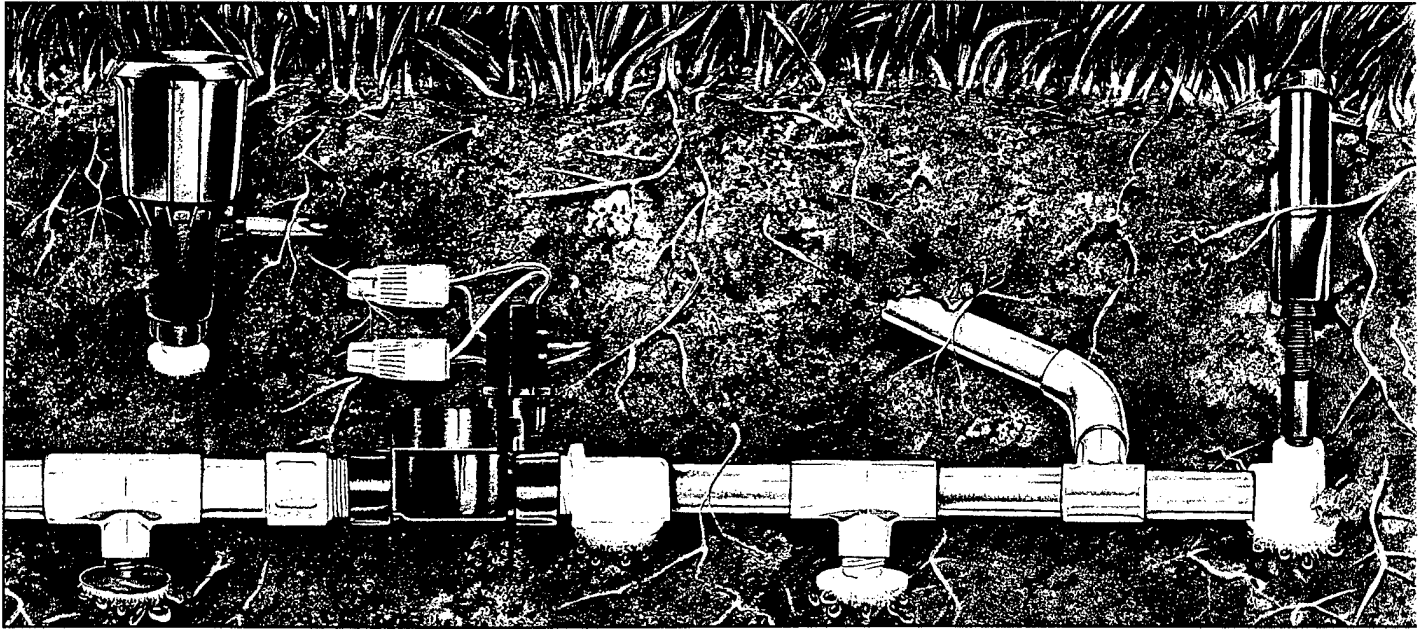
Rain Bird. Conserving More Than Water.
® Registered Trademark of Rain Bird Sprinkler Mfg. Corp.
© 1996 Rain Bird Sprinkler Mfg. Corp. 3/96

RAIN BIRD®

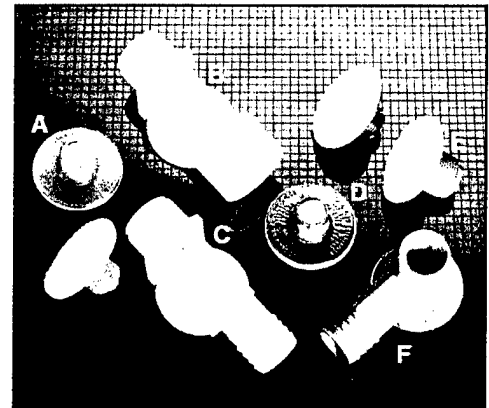
Rain Bird Sales, Inc.
970 West Sierra Madre Avenue • Azusa, CA 91702

FREEZE KING™ Automatic Drain System

Total Freeze Protection For Valves, Sprinkler Heads and Fittings



- Protects all makes of valves, sprinkler heads, pipes and fittings from costly freeze damage
- Highest pressure ratings of all automatic drain valve systems
- All plastic durable construction never corrodes
- Disperses water slowly at root level
- Patented screen keeps dirt in lines from clogging valve
- Unconditionally guaranteed for the life of your system
- Eliminates the potential for freeze damage
- Patented backflow check keeps ground water from re-entering system

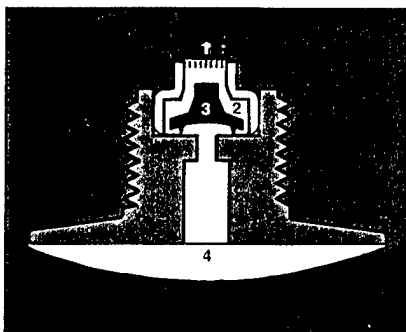


FREEZE KING™ AUTOMATIC DRAIN SYSTEM

FREEZE KING™ AUTOMATIC DRAIN VALVE

- ① Exclusive raised dirt arrestor screen prevents grit and sediment from clogging drain valves from within, while conserving water.
- ② Patented backflow check keeps water flowing out. No ground water can re-enter to cause freeze damage.
- ③ Patented pressure sensitive valve seals line when pressure exceeds 10 psi and opens when pressure is turned off to release water at root level.
- ④ Trademarked broad dispersing pad keeps roots from penetrating drain valve, keeps soil out and virtually eliminates the need for sumps.

- ⑤ Main Line Drains are rated 2,500/1,000 psi for fail-safe operation where pressure is highest.
- ⑥ & ⑦ Valve protectors are engineered for installation adjacent to sensitive solenoid valves to prevent costly freeze cracking in the housing.
- ⑧ Lateral line drain components are placed at bends and low points to protect narrower lines from damage.
- ⑨ & ⑩ Fittings mount under sprinkler heads preventing freeze damage.

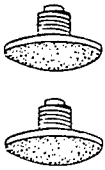
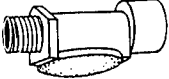


Patent #4890640
U.S. & Foreign Patents Pending

KING®
D R A I N S



FREEZE KING™ Automatic Drain System

DESCRIPTION	PRODUCT #	SIZE	QUANTITIES
 Tan Lateral Line Drains Max. PSI 1000 Open/ Close 9-11 PSI Max. PSI 450	GF 22-163 GF 23-167	1/2" MIPT 3/4" MIPT	B 25 / MC 1000 B 25 / MC 800
 Red Main Line Drain Max. PSI 2500 Open/Close 9-11 PSI	GF 24-181	1/2" MIPT	B 25 / MC 1000
 Blue Low Pressure Drain Max. PSI 450 Open/Close 1-2 PSI Flush Drain for Drip Systems	GF 25-190	1/2" MIPT	B 25 / MC 1000
 Reducing Elbows (Ins. X FIPT) Max. PSI 450 Open/Close 9-11 PSI	IF 15-140 IF 16-142 IF 17-145	3/4" X 1/2" 1" X 1/2" 1" X 3/4"	B 10 / MC 300 B 10 / MC 250 B 10 / MC 240
 Valve Protector, Male Adapter (MIPT X Insert) Max. PSI 450 Open/Close 9-11 PSI	IF 21-155	1"	B 5 / MC 200
 Valve Protector, Male Adapter (MIPT X Slip) Max. PSI 450 Open/Close 9-11 PSI	SF 98-1220	1"	B 5 / MC 200

B = Bag

GF = General Fitting

IF = Insert Fitting

MC = Master Carton

SF = Slip Fitting

LIMITED WARRANTY

King Drains® are unconditionally guaranteed to function for the life of the system, when properly installed. All King Connectors™ carry a limited Lifetime Parts Replacement Guarantee against corrosion-caused failures.

All other King Products are guaranteed against faulty materials or workmanship for a period of one year from the date of purchase. Any part returned to us within this warranty period showing defects in material or workmanship will be renewed or replaced F.O.B. factory without charge. The liability of the Company is limited solely to the repair or replacement of the defective parts. In no case will the Company be liable for incidental damage or loss incurred because of interruption of service or for consequential damages, labor or expense required to repair or replace defective units. This warranty, which is given expressly and in lieu of all other warranties, expressed or implied, of merchantability and fitness for particular purpose, constitutes the only warranty made by the Company.

KING
D R A I N S

KING SAFETY PRODUCTS

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APPENDIX D

HEALTH AND SAFETY PLAN

HEALTH AND SAFETY PLAN
FOR AFCEE PHYTOSTABILIZATION
AT
TRAVIS AIR FORCE BASE, CALIFORNIA
AND
ALTUS AIR FORCE BASE, OKLAHOMA

Prepared for:

AIR FORCE CENTER FOR ENVIRONMENTAL EXCELLENCE (AFCEE)

AND

AIR MOBILITY COMMAND (AMC)

AMC CONTRACT F11623-94-0024

August 1998

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9.16.98

9/16/98

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SECTION 1

PURPOSE AND POLICY

The purpose of this health and safety plan is to establish personnel protection standards and mandatory safety practices for all Parsons Engineering Science, Inc. (Parsons ES) and subcontractor personnel involved in the phytostabilization demonstrations at Travis Air Force Base (AFB) California, and Altus AFB, Oklahoma. This plan provides guidance for general operations on phytostabilization demonstration sites and provides for contingencies that may arise during field operations. All Parsons ES field team members and subcontractors are responsible for reading and conforming to this plan and the associated addenda. No employee will perform a project activity that he or she believes may endanger his or her health and safety or the health and safety of others. All personnel will strive for a record of zero accidents on this project. To the greatest extent possible, work tasks will be designed and conducted to minimize or eliminate hazards to personnel.

A project description and scope of work summary for the project are provided in Section 2. Section 3 presents the project team organization, personnel responsibilities, and lines of authority. Training and medical monitoring requirements are contained in Section 4. Section 5 presents a safety and health risk analysis. Section 6 contains the program emergency response plan. Program requirements for levels of protection are included in Section 7, and air monitoring procedures are provided in Section 8. Site control measures, including designation of site work zones, are contained in Section 9, and Section 10 provides decontamination procedures. Section 11 contains information on the use and calibration of air monitoring equipment. Appendix A contains a Plan Acceptance Form, Site-Specific Training Record Form, Field Experience Documentation Form, Air Monitoring Data Forms, Accident Report Form, Near-Miss Incident Form, Shipping Paper, Daily Vehicle Inspection Report, and Respirator Use Forms.

SECTION 2

PROJECT DESCRIPTION AND SCOPE OF WORK

2.1 PROJECT DESCRIPTION

Under this contract, Parsons ES will provide services to the Air Force Center for Environmental Excellence (AFCEE) and Air Mobility Command (AMC) that will demonstrate the application of engineered tree plantings to hydraulically control shallow groundwater contaminated with chlorinated solvents at two sites located on Travis AFB and Altus AFB.

Engineered tree plantings will be designed, installed, and monitored for a three year duration. Data collected by Parsons will be used to assist AFCEE with the refinement and calibration of a water balance model for each site.

2.1 SITE HISTORY AND DESCRIPTION

Phytostabilization demonstrations will be conducted at Travis AFB in Solano County, California and at Altus AFB in Altus, Oklahoma.

At Travis AFB, field activities will be performed in the area at Building 755, currently the Battery and Electric Shop and formerly a site where rocket engines were tested. Additional site information and maps are located in the work plan entitled *Work Plan for the Demonstration of Phytostabilization of Chlorinated Solvents from Groundwater at Building 755, Travis Air Force Base, California* (Parsons Engineering Science, Inc., 1998).

At Altus AFB, field activities will be conducted at Site 17, an area used as a holding pond for solvents in the southern portion of the base. Additional site information and maps are located in the work plan entitled *Work Plan for the Demonstration of Phytostabilization of Chlorinated Solvents from Groundwater at Site 17, Altus Air Force Base, Oklahoma* (Parsons Engineering Science, Inc., 1998)

2.3 SCOPE OF WORK

Field activities in support of the phytostabilization demonstrations may include excavating; auger and Geoprobe® drilling; monitoring well installation; and soil, soil column moisture, transpiration gas, and groundwater sampling.

SECTION 3

PROGRAM TEAM ORGANIZATION

The Parsons ES team assigned to the phytostabilization demonstrations, their responsibilities, and lines of authority are outlined below.

<u>Name</u>	<u>Task Assigned</u>
Mr. John Stewart	Program Manager
Mr. Doug Downey	Technical Director
Mr. Bill Plaehn	Project Manager
Mr. Timothy Mustard	Program Health and Safety Manager
Mr. Bill Plaehn	Site Manager - Travis AFB
Mr. Bill Plaehn	Site Health and Safety Officer - Travis AFB
Mr. Tom Dragoo	Site Manager - Altus AFB
Mr. Tom Dragoo	Site Health and Safety Officer - Altus AFB
Mr. Sam Taffinder	AFCEE/ERT Point of Contact (POC)

The program manager, Mr. John Stewart, will be the Parsons ES POC for program matters, and will interface with the contracting officer, Base representatives, and the AMC and AFCEE project technical representatives

The technical director, Mr. Doug Downey, is responsible for conduct and review of all technical work on this project to ensure technical accuracy and adequacy. He will provide advice to the project manager and project personnel on technical issues. He will also be responsible for peer review of all deliverables prior to submission.

The project manager, Mr. Bill Plaehn, is directly responsible for the execution of all phases of this project. He is responsible for planning, staffing, assuring adequate planning for health and safety and quality assurance/quality control (QA/QC), execution of each phase, coordination with AFCEE, and interpretation of data and reporting. The project manager will also coordinate with the site manager to obtain permission for site access, coordination of activities with appropriate officials, and serve as the liaison with public officials. The project manager will also ensure that quality work is accomplished on schedule.

The program health and safety manager, Mr. Timothy Mustard, will ensure that all field activities are performed with strict adherence to OSHA requirements and the program health and safety plan. He will be responsible for updating and revising the

program health and safety plan, as needed, and for ensuring that all field team members meet health and safety training and medical monitoring requirements.

The site health and safety officer (SHSO) along with the project manager is responsible for ensuring that day-to-day project activities are performed in strict conformance with the program health and safety plan. The SHSO, project manager, and program health and safety manager have the authority to stop work if actions or conditions are judged to be unsafe or not in conformance with the program health and safety plan. The SHSO will also be responsible for ensuring that field personnel are in compliance with Occupational Safety and Health Administration (OSHA) requirements for training and medical monitoring prior to and for the duration of the field activities.

The site manager will support the project manager for the specific work the team will accomplish at each site and will be responsible for scheduling and coordinating the testing activities at the respective sites. The site manager will assist the project manager in the day-to-day organization and execution of the various project tasks.

SECTION 4

SITE-SPECIFIC EMPLOYEE TRAINING AND MEDICAL MONITORING REQUIREMENTS

The Parsons ES corporate health and safety manual, incorporated by reference, presents general requirements for Parsons ES employee training and medical monitoring. All field team members will have completed the 40-hour basic health and safety training as specified by OSHA in Title 29, Code of Federal Regulations, Part 1910.120, paragraph (e) (29 CFR 1910.120[e]) and the 8-hour annual refresher training thereafter. All supervisory personnel onsite will be required to have completed an 8-hour supervisor course as required in 29 CFR 1910.120(e).

In addition to the 40-hour course, all field employees will be required to have completed a minimum of 3 days onsite training under the supervision of a trained and experienced supervisor, not necessarily at one of the phytostabilization demonstration sites. If this training is received during a phytostabilization demonstration, the training will be documented on the Field Experience Documentation Form provided in Appendix A. Employees will not participate in field activities until they have been trained to the level required by their job function and responsibility. In addition, at least one person on every Parsons ES field crew will have completed Red Cross or equivalent first-aid and cardiopulmonary resuscitation (CPR) courses. All training documentation for Parsons ES personnel will be verified by the SHSO and maintained by the health and safety manager.

All Parsons ES field team members will be on current medical monitoring programs in accordance with federal OSHA requirements (29 CFR 1910.120) and Parsons ES corporate policies. Listed below are additional health and safety training and medical monitoring requirements for this project.

4.1 ADDITIONAL SAFETY TRAINING REQUIREMENTS

If Level B (self-contained breathing apparatus [SCBA]) respiratory protection is used, additional training may be required for those personnel involved. This training will be conducted onsite as necessary by a qualified, Level B-experienced supervisor. Employees will also be trained in use, care, maintenance, limitations, and disposal of personal protective equipment (PPE) in accordance with 29 CFR 1910.132. All field team members must have site-specific training as discussed in the following subsection.

4.1.1 Site-Specific Safety Briefings

Site-specific safety and health briefings will be conducted by the Parsons ES site manager or SHSO for all personnel who will engage in any phytostabilization demonstration activities. Site-specific safety briefings will address the activities, procedures, monitoring, and equipment applicable to the site operations, as well as site or facility layout, potential hazards, and emergency response services at the site. Additional topics that will be addressed at the safety briefings will include:

- Names of responsible health and safety personnel;
- Identification of site hazards;
- Site contingencies and emergency procedures;
- Exposure risk;
- Symptoms of exposure and exposure treatment for chemical contaminants;
- Use, care, maintenance, and limitations of PPE;
- Decontamination procedures to be followed;
- Location of safety equipment;
- Review of planned activities;
- Defined safety procedures to be followed during field activities; and
- Emergency and evacuation procedures.

Safety briefings will be conducted daily prior to commencement of field activities. Documentation of training and briefings, including agenda and signatures of attending personnel, will be maintained onsite. Site-specific training forms are provided in Appendix A.

4.2 MEDICAL MONITORING REQUIREMENTS

Prior to being assigned to the field activities, each Parsons ES employee will receive a preassignment or baseline physical examination. Preassignment screening has two major functions: 1) determination of an individual's fitness for duty, including the ability to perform work while wearing PPE; and 2) provision of baseline data for comparison with future medical data. Medical qualification/certification documentation will be maintained by the program health and safety manager. All medical examinations and procedures will be performed by or under the supervision of a licensed physician, preferably an occupational physician. The examination content will be determined by the examining physician in accordance with 29 CFR 1910.120(f).

SECTION 5

SAFETY AND HEALTH RISK ANALYSIS

5.1 CHEMICAL HAZARDS

The chemicals of primary concern occurring at the Travis and Altus AFB sites include chlorinated solvents; semi-volatiles; and the petroleum hydrocarbon constituents benzene, toluene, ethylbenzene, and xylenes (BTEX).

Tables 5.1.1 and 5.1.2 summarize the health hazards and properties of the aforementioned and additional compounds. If other compounds are discovered at these sites, the pertinent information about these compounds will be provided in Table 5.1.1 (Travis AFB) and Table 5.1.2 (Altus AFB). The health hazards or other physical/chemical hazards (e.g., corrosiveness, flammability) of the compounds will then be communicated to the onsite employees.

Hazardous substances of primary concern identified are those potentially occurring in contaminated groundwater, soils, sediment, surface water, air, buildings, or abandoned structures.

5.2 PHYSICAL HAZARDS

In addition to the hazardous substances potentially present at the Travis and Altus AFB sites, other physical hazards or hazardous conditions may be expected at the sites during the course of performing phytostabilization demonstration activities. These hazards include possible risks from injury while working around motor vehicles including the auger drilling rig and the Geoprobe® unit; stationary or moving equipment; fire or explosion hazards; slip, trip, and fall hazards; electrical hazards; and excessive noise conditions. Additional physical hazards include heat stress and cold-related exposures.

The guidelines presented in this section are applicable to all types of equipment that may be used during phytostabilization demonstration activities at Travis and Altus AFB. Individual equipment types or certain specialized equipment may require additional safety considerations or specialized training prior to its use. Should any specialized equipment be required during the performance of a task, the program health and safety manager will ensure that operators receive appropriate training. The program health and safety manager is also responsible for ensuring that all equipment is routinely inspected and that any piece of equipment considered unsafe is not used until the unsafe conditions are corrected or repaired.

TABLE 5.1.1 HEALTH HAZARD QUALITIES OF HAZARDOUS SUBSTANCES OF CONCERN - TRAVIS AFB

Compound	PEL ^a (ppm)	TLV ^b (ppm)	IDLH ^c (ppm)	Odor Threshold ^d (ppm)	Ionization Potential ^e (eV)	Physical Description/Health Effects/Symptoms
Acetone	750	500	2,500 (10% LEL) ^f	100	9.69	Colorless liquid with mint-like odor. Irritates nose, eyes, and throat. Causes headaches, dizziness, central nervous system (CNS) depression, and dermatitis.
Anthracene	0.2 mg/m ³ ^{a,b}	0.2 mg/m ³ ^b	80 mg/m ³ ^b	NA ^f	7.23	Colorless to yellow crystals with blue fluorescence. Irritates eyes, skin, and respiratory tract. Causes dermatitis, bronchitis, and lung, skin, and kidney cancer. Mutagen and carcinogen.
Antimony	0.5 mg/m ³	0.5 mg/m ³	50 mg/m ³	NA	NA	Silver-white, lustrous, hard, brittle metal, scale-like crystals or dark-gray, lustrous powder. Irritates skin, eyes, nose, throat, and mouth. Causes coughing, dizziness, headaches, nausea, vomiting, diarrhea, stomach cramps, insomnia, anorexia, and inability to properly smell.
Benzene 5 2	1 (29 CFR 1910.1028) ^f	0.5 (skin) ^b	500	4.7	9.24	Colorless to light-yellow liquid (solid < 42°F) with an aromatic odor. Eye, nose, skin, and respiratory system irritant. Causes giddiness, headaches, nausea, staggered gait, fatigue, anorexia, exhaustion, dermatitis, bone marrow depression, and leukemia. Mutagen, experimental teratogen, and carcinogen.
Benzo(a)anthracene	0.2 mg/m ³ ^b	0.2 mg/m ³ ^b	80 mg/m ³ ^b	NA	7.53	Colorless, crystalline solid with greenish-yellow fluorescence. Irritates eyes, respiratory tract, and skin. Causes dermatitis, bronchitis, and lung, kidney, and skin cancer. Carcinogen.
Benzo(b)fluoranthene	0.2 mg/m ³ ^b	0.2 mg/m ³ ^b	80 mg/m ³ ^b	NA	NA	Colorless, needle-like crystals. Irritates eyes, respiratory tract, and skin. Causes dermatitis, bronchitis, and lung, kidney, and skin cancer. Carcinogen.
Benzoic Acid	NA	NA	NA	NA	NA	White crystalline or flaky powder or light tan chips with a faint pleasant odor to odorless and a bitter taste. Irritates skin. Inhaled vapors are highly toxic.

TABLE 5.1.1 HEALTH HAZARD QUALITIES OF HAZARDOUS SUBSTANCES OF CONCERN - TRAVIS AFB

Compound	PEL ^v (ppm)	TLV ^v (ppm)	IDLH ^v (ppm)	Odor Threshold ^v (ppm)	Ionization Potential ^v (eV)	Physical Description/Health Effects/Symptoms
Benzo(k)fluoranthene	0.2 mg/m ³ ^v	0.2 mg/m ³ ^v	80 mg/m ³ ^v	NA	NA	Pale-yellow, needle-like crystals. Irritates eyes, respiratory tract, and skin. Causes dermatitis, bronchitis, and lung, kidney, and skin cancer. Carcinogen.
Benzo(g,h,i)perylene	0.2 mg/m ³ ^v	0.2 mg/m ³ ^v	80 mg/m ³ ^v	NA	NA	Large, pale yellow-green, plate-like crystals. Irritates eyes, respiratory tract, and skin. Causes dermatitis, bronchitis, and lung, kidney, and skin cancer. Carcinogen and possible mutagen.
Benzyl Butyl Phthalate	NA	NA	NA	NA	NA	Clear, oily liquid with a slight characteristic odor. Irritates eyes, nose, throat, and skin. Cause CNS depression, nervous system degeneration, dizziness, light-headedness, leukemia, and damage to the testes.
Beryllium	0.002 mg/m ³	0.002 mg/m ³	4 mg/m ³	NA	NA	Hard, brittle, gray-white, metallic solid. Irritates lungs, skin, eyes, and mucous membranes. Causes berylliosis, anorexia, low-weight, weakness, chest pain, coughing, blue skin, clubbed fingers, pulmonary insufficiency, dermatitis, and lung cancer. Mutagen and carcinogen.
Bromodichloromethane	NA	NA	NA	1,680 mg/m ³	10.88	Nonflammable liquid. Carcinogen.
Cadmium (dust)	0.005 mg/m ³ ^v (29 CFR 1910.1027) ^y	0.01 mg/m ³ ^v 0.002 mg/m ³ ^v	9 mg/m ³	NA	NA	Silver-white, blue-tinged, lustrous, odorless, metallic solid. Causes pulmonary edema, shortness of breath, coughing, chest tightness/pain, loss of sense of smell, chills, muscle aches, headaches, nausea, vomiting, diarrhea, mild anemia, and prostatic and lung cancer. Also attacks kidneys. Mutagen, experimental teratogen, and carcinogen.
Carbon Disulfide	4 (skin)	10 (skin)	500	0.0011-7.7	10.08	Colorless to faint-yellow liquid with sweet ether or foul (reagent grade) odor. Irritating to eyes, skin, and mucous membranes on contact. Causes dizziness, headaches, poor sleep, fatigue, nervousness, low-weight, psychosis, nervous system degeneration, Parkinson-like syndrome, ocular changes, heart disease, gastritis, dermatitis, eye and skin burns, liver and kidney damage, and reproductive effects. Mutagen and experimental teratogen.
Carbon Tetrachloride	2	5 (skin)	200	21.4-200	11.47	Colorless liquid with characteristic, ether-like odor. Irritates eyes and skin. Causes CNS depression, nausea, vomiting, liver/kidney damage, drowsiness, dizziness, and incoordination. In animals, causes liver cancer. Mutagen, experimental teratogen, and carcinogen.
Chloroform (Trichloromethane)	2	10	500	205 ^v	11.42	Colorless, heavy liquid with pleasant odor. Irritates eyes and skin. Anaesthetic. Causes dizziness, mental dullness, nausea, confusion.

TABLE 5.1.1 HEALTH HAZARD QUALITIES OF HAZARDOUS SUBSTANCES OF CONCERN - TRAVIS AFB

Compound	PEL ^a (ppm)	TLV ^b (ppm)	IDLH ^c (ppm)	Odor Threshold ^d (ppm)	Ionization Potential ^e (eV)	Physical Description/Health Effects/Symptoms
4-Chloro-3-methylphenol	NA	NA	NA	0.1 mg/kg	NA	headache, fatigue, anesthesia, and enlarged liver. Also attacks kidneys and heart. In animals, causes liver and kidney cancer. Mutagen, experimental teratogen, and carcinogen.
Chrysene	0.2 mg/m ³ ^f	0.2 mg/m ³ ^f	80 mg/m ³ ^f	NA	7.75	White or slightly pink crystals, odorless when pure, but usually with a phenolic odor. Irritates skin.
Cobalt metal (dust and fumes)	0.05 mg/m ³	0.02 mg/m ³	20 mg/m ³	> 1 mg/m ³ ^f	NA	Colorless, crystalline solid with blue to red fluorescence. Irritates eyes, skin, and respiratory tract. Causes burns to skin and eyes, dermatitis, bronchitis and lung, skin, and kidney cancer. Mutagen and carcinogen.
1,1-Dichloroethane (DCA)	100	100	3,000	120	11.06	Odorless, silver-gray to black, magnetic, somewhat malleable, hard, solid metal. Causes coughing, shortness of breath, wheezing, decreased pulmonary function, dermatitis, low-weight, fibrosis, asthma, and respiratory hypersensitivity. Fumes cause metal fume fever. Suspected carcinogen.
1,2-Dichloroethane (DCA) (Ethylene Dichloride, EDC)	1	10	50	100	11.05	Colorless, oily liquid with chloroform-like odor and hot saccharine taste. Irritates skin. Causes CNS depression and kidney, lung, and liver damage. Experimental teratogen and questionable carcinogen.
1,1-Dichloroethene (DCE) (Vinylidene Chloride)	1	5	NA	NA	10.00	Colorless liquid with a pleasant, chloroform-like odor. Strong narcotic. Irritates eyes. Causes corneal opaqueness, nausea, CNS depression, vomiting, dermatitis, and damage to liver, kidneys, and cardiovascular system. In animals, causes cancer of the forestomach, mammary gland, and circulatory system. Mutagen, experimental teratogen, and carcinogen.
1,2-Dichloroethene (DCE) (cis- and trans-isomers)	200	200	1,000	0.085-500	9.65	Colorless liquid or gas (> 89°F) with a mild, sweet, chloroform-like odor. Irritates eyes, skin, and throat. Causes dizziness, headaches, nausea, shortness of breath, liver and kidney dysfunctions, and lung inflammation. Mutagen and carcinogen.
Di-n-butylphthalate (Dibutylphthalate)	5 mg/m ³	5 mg/m ³	4,000 mg/m ³	0.26	NA	Colorless liquid (usually a mixture of cis- and trans- isomers), with a slightly acrid, chloroform-like odor. Irritates eyes and respiratory system. CNS depressant. Cis- isomer is a mutagen.

TABLE 5.1.1 HEALTH HAZARD QUALITIES OF HAZARDOUS SUBSTANCES OF CONCERN - TRAVIS AFB

Compound	PEL ^v (ppm)	TLV ^v (ppm)	IDLH ^v (ppm)	Odor Threshold ^v (ppm)	Ionization Potential ^v (eV)	Physical Description/Health Effects/Symptoms
Dinitrotoluene (DNT)	1.5 mg/m ³ (skin)	0.15 mg/m ³ (skin)	50 mg/m ³	NA	NA	Orange-yellow, crystalline solid with a characteristic odor. Causes permanent tissue damage due to oxygen deficiency, blue skin, anemia, jaundice, and reproductive effects. In animals, causes liver, skin, and kidney tumors. Mutagen, experimental teratogen, and carcinogen.
Di-n-octylphthalate	NA	NA	NA	NA	NA	Colorless to light-colored, oily liquid with slight odor. Causes eye, skin, mucous membrane or respiratory irritation.
Ethylbenzene	100	100	800 (10% LEL)	0.25-200	8.76	Colorless liquid with an aromatic odor. Irritates eyes, skin, and mucous membranes. Causes dermatitis, headaches, narcosis, and coma. Mutagen and experimental teratogen.
Bis(2-Ethylhexyl)Phthalate (Di-sec Octyl Phthalate)	5 mg/m ³	5 mg/m ³	5,000 mg/m ³	NA	NA	Colorless to light-colored, oily liquid with slight odor. Irritates eyes and mucous membranes. Also affects respiratory system, CNS, and gastrointestinal tract. In animals, causes liver damage, liver tumors, and teratogenic effects. Carcinogen.
5-Fluoranthene	0.2 mg/m ³ ^v	0.2 mg/m ³ ^v	80 mg/m ³ ^v	NA	NA	Pale-yellow, crystalline solid. Causes burns to skin and eyes. Causes nausea, tachycardia, arrhythmia, liver injury, pulmonary edema, and respiratory arrest. ^v Mutagen and carcinogen.
Fluoride	2.5 mg/m ³	2.5 mg/m ³	500 mg/m ³	5.0 mg/m ³	NA	Odorless, white powder or crystals or colorless to dark solid. [Pesticide grade is often dyed blue.] Irritates eyes and respiratory system. Affects CNS, skeleton, kidneys, skin. Causes nausea, abdominal pain, diarrhea, excessive salivation, thirst sweating, stiff spine, dermatitis, convulsions, and calcification of the ligaments of the ribs and pelvis. Mutagen.
2-Hexanone (Methyl n-butyl ketone)	5	5 (skin)	1,600	3.0	9.34	Colorless liquid with an acetone-like odor. Irritates eyes, nose, and skin. Causes nervous system degeneration, weakness, tingling skin, dermatitis, headaches, and drowsiness. Experimental teratogen.
Indeno(1,2,3-cd)pyrene	0.2 mg/m ³ ^v	0.2 mg/m ³ ^v	80 mg/m ³ ^v	NA	NA	Yellow, crystalline solid. Solutions show greenish-yellow fluorescence. Irritates eyes, respiratory tract, and skin. Causes dermatitis, bronchitis, and lung, kidney, and skin cancer. Mutagen and carcinogen.
Lead	0.05 mg/m ³ (29 CFR 1910.1025) ^v	0.05 mg/m ³	100 mg/m ³	NA	NA	Heavy, ductile, bluish-gray, soft metal. Irritates eyes. Causes weakness, exhaustion, insomnia, facial pallor, anorexia, low-weight, malnutrition.

TABLE 5.1.1 HEALTH HAZARD QUALITIES OF HAZARDOUS SUBSTANCES OF CONCERN - TRAVIS AFB

Compound	PEL ^{a/} (ppm)	TLV ^{b/} (ppm)	IDLH ^{c/} (ppm)	Odor Threshold ^{d/} (ppm)	Ionization Potential ^{e/} (eV)	Physical Description/Health Effects/Symptoms
Manganese (compounds and fume, as Mn)	5 mg/m ³ (ceiling) ^{f/} 1 mg/m ³ ^{g/}	0.2 mg/m ³ ^{h/} 1 mg/m ³ ^{i/}	500 mg/m ³	NA	NA	Lustrous, brittle, silvery, solid metal. Irritates eyes and skin. Causes Parkinson's disease, loss of strength, insomnia, confusion, dry throat, coughing, rales, shortness of breath, tight chest, flu-like fever, lower back pain, vomiting, vague discomfort, fatigue, and kidney damage. Fumes cause metal fume fever. Mutagen, experimental teratogen, and questionable carcinogen.
Methylene Chloride (Dichloromethane, Methylene Dichloride)	25	50	2,300	25-320	11.32	Colorless liquid (gas > 104°F) with a sweet, chloroform-like odor (not noticeable at dangerous concentrations). Irritates eyes and skin. Causes nausea, vomiting, fatigue, weakness, unnatural drowsiness, light-headedness, numbness, tingling limbs, and nausea. In animals, causes lung, liver, salivary and mammary gland tumors. Mutagen, experimental teratogen, and carcinogen.
Methyl Ethyl Ketone (2-Butanone)	200	200	3,000	4.8-25	9.54	Colorless liquid with a moderately sharp, fragrant mint- or acetone-like odor. Irritates eyes, nose, and skin. Causes headaches, dizziness, vomiting, and dermatitis. Experimental teratogen.
Methyl Isobutyl Ketone (MIBK, Hexone)	50	50	500	0.28-8	9.30	Colorless liquid with a fruity, ethereal odor. Irritates eyes, skin, and mucous membranes. Causes dermatitis, headaches, narcosis, and coma. In animals, causes liver and kidney damage. Experimental teratogen.
Nickel (soluble) (insoluble or metal)	0.1 mg/m ³ 1 mg/m ³	0.1 mg/m ³ 1 mg/m ³	10 mg/m ³ 10 mg/m ³	NA NA	NA NA	Lustrous, silvery, odorless, hard, malleable, ductile, metallic solid. Causes nausea, vomiting, diarrhea, conjunctivitis, sensitization dermatitis, allergic asthma, pneumonitis, and lung and nasal cancer. Mutagen, experimental teratogen, and carcinogen.

TABLE 5.1.1 HEALTH HAZARD QUALITIES OF HAZARDOUS SUBSTANCES OF CONCERN - TRAVIS AFB

Compound	Odor				Ionization		Physical Description/Health Effects/Symptoms
	PEL ^a (ppm)	TLV ^b (ppm)	IDLH ^c (ppm)	Threshold ^d (ppm)	Potential ^e (eV)		
Perchloroethylene (Tetrachloroethene or PCE)	25 ^f	25	150	5-50	9.32		Colorless liquid with a mild chloroform odor. Eye, nose, skin and throat irritant. Causes nausea, flushed face and neck, vertigo, dizziness, headaches, hallucinations, incoordination, drowsiness, coma, pulmonary changes, and skin redness. Cumulative liver, kidney, and CNS damage. In animals, causes liver tumors. Mutagen, experimental teratogen, and carcinogen.
Pyrene	0.2 mg/m ³ s ^f	0.2 mg/m ³ s ^f	80 mg/m ³ s ^f	NA	7.72		Colorless to pale-yellow, crystalline solid. Solutions slightly bluish with blue fluorescence. Irritates eyes, skin, and respiratory tract. Causes dermatitis, bronchitis, and lung, skin, and kidney cancer. Mutagen and carcinogen.
Silver (soluble compounds and metal)	0.01 mg/m ³	0.01 mg/m ³ (soluble) 0.1mg/m ³ (metal)	10 mg/m ³	NA	NA		White, lustrous, soft, ductile, malleable, solid metal. Causes irritability, skin ulceration, gastrointestinal disturbances, pulmonary edema, hemorrhaging, and localized death of bone marrow, liver, and kidney tissue. Also causes permanent grayish pigmentation of the eyes, skin, throat, and mucous membranes. Questionable carcinogen.
5-7 Tetrachloroethene (PCE) (Perchloroethylene)	25 ^f	25	150	5-50	9.32		Colorless liquid with a mild chloroform odor. Eye, nose, skin and throat irritant. Causes nausea, flushed face and neck, vertigo, dizziness, headaches, hallucinations, incoordination, drowsiness, coma, pulmonary changes, and skin redness. Cumulative liver, kidney, and CNS damage. In animals, causes liver tumors. Mutagen, experimental teratogen, and carcinogen.
Toluene	100	50 (skin)	500	0.2-40 ^g	8.82		Colorless liquid with sweet, pungent, benzene-like odor. Irritates eyes and nose. Causes fatigue, weakness, dizziness, headaches, hallucinations or distorted perceptions, confusion, euphoria, dilated pupils, nervousness, tearing, muscle fatigue, insomnia, skin tingling, dermatitis, bone marrow changes, and liver and kidney damage. Mutagen and experimental teratogen.
1,1,1-Trichloroethane (TCA) (Methyl Chloroform)	350	350	700	20-500	11.00		Colorless liquid with a mild chloroform-like odor. Irritates eyes and skin. Causes headaches, exhaustion, CNS depression, poor equilibrium, dermatitis, liver damage, cardiac arrhythmia, hallucinations or distorted

TABLE 5.1.1 HEALTH HAZARD QUALITIES OF HAZARDOUS SUBSTANCES OF CONCERN - TRAVIS AFB

Compound	PEL ^{a/} (ppm)	TLV ^{b/} (ppm)	IDLH ^{c/} (ppm)	Odor Threshold ^{d/} (ppm)	Ionization Potential ^{e/} (eV)	Physical Description/Health Effects/Symptoms
1,1,2-Trichloroethane (TCA)	10 (skin)	10 (skin)	100	NA	11.00	Colorless liquid with a sweet, chloroform-like odor. Irritates eyes, skin, lungs, and nose. Causes dermatitis, liver and kidney damage, and CNS depression. In animals, causes liver cancer. Mutagen and carcinogen.
Trichloroethene (TCE)	50	50	1,000	21.4-400	9.45	Clear, colorless or blue liquid with chloroform-like odor. Irritates skin and eyes. Causes fatigue, giddiness, headaches, vertigo, visual disturbances, tremors, nausea, vomiting, drowsiness, dermatitis, skin tingling, cardiac arrhythmia, and liver injury. In animals, causes liver and kidney cancer. Mutagen, experimental teratogen, and carcinogen.
Vanadium (as vanadium pentoxide dust)	0.05 mg/m ³ ^{a/} (ceiling)	0.05 mg/m ³ ^{a/}	35 mg/m ³	0.5-2.2 mg/m ³	NA	Yellow-orange powder or dark gray, odorless flakes dispersed in air. Irritates eyes, skin, and throat. Causes green tongue, metallic taste, coughing, runny nose, wheezing, bronchitis, rales, shortness of breath, conjunctivitis, eczema, anemia, loss of appetite, pallor, emaciation, albumin and blood in the urine, and disorders of the gastrointestinal tract, kidneys, blood or CNS.
Vinyl Chloride 50	1 (29 CFR 1910.1017) ^{b/}	5	NA	260	9.99	Colorless gas (liquid <7°F) with a pleasant odor at high concentrations. Severe irritant to skin, eyes, and mucous membranes. Causes weakness, abdominal pain, gastrointestinal bleeding, enlarged liver, pallor or blue skin on the extremities, liver cancer, and frostbite (liquid). Also attacks lymphatic system. Mutagen, experimental teratogen, and carcinogen.
Vinylidene Chloride [1,1-Dichloroethene (DCE)]	1	5	NA	NA	10.00	Colorless liquid or gas (>89°F) with a mild, sweet, chloroform-like odor. Irritates eyes, skin, and throat. Causes dizziness, headaches, nausea, shortness of breath, liver and kidney dysfunctions, and lung inflammation. Mutagen and carcinogen.
Xylene (o-, m-, and p-isomers)	100	100	900	0.05-200 ^{a/}	8.56 8.44 (p)	Colorless liquid with aromatic odor. P-isomer is a solid <56°F. Irritates eyes, skin, nose, and throat. Causes dizziness, drowsiness, staggered gait, incoordination, irritability, excitement, corneal irregularities, conjunctivitis, dermatitis, anorexia, nausea, vomiting, abdominal pain, and olfactory and pulmonary changes. Also targets blood, liver, and

TABLE 5.1.1 HEALTH HAZARD QUALITIES OF HAZARDOUS SUBSTANCES OF CONCERN - TRAVIS AFB

Compound	PEL ^{a/} (ppm)	TLV ^{b/} (ppm)	IDLH ^{c/} (ppm)	Odor Threshold ^{d/} (ppm)	Ionization Potential ^{e/} (eV)	Physical Description/Health Effects/Symptoms
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kidneys. Mutagen and experimental teratogen.

- a/ PEL = Permissible Exposure Limit. OSHA-enforced average air concentration to which a worker may be exposed for an 8-hour workday without harm. Expressed as parts per million (ppm) unless noted otherwise. PELs are published in the *NIOSH Pocket Guide to Chemical Hazards*, 1997. Some states (such as California) may have more restrictive PELs. Check state regulations.
- b/ TLV = Threshold Limit Value - Time-Weighted Average. Average air concentration (same definition as PEL, above) recommended by the American Conference of Governmental Industrial Hygienists (ACGIH), 1997 *TVLs[®] and BEIs[®]*.
- c/ IDLH = Immediately Dangerous to Life or Health. Air concentration at which an unprotected worker can escape without debilitating injury or health effects. Expressed as ppm unless noted otherwise. IDLH values are published in the *NIOSH Pocket Guide to Chemical Hazards*, 1997.
- d/ When a range is given, use the highest concentration.
- e/ Ionization Potential, measured in electron volts (eV), used to determine if field air monitoring equipment can detect substance. Values are published in the *NIOSH Pocket Guide to Chemical Hazards*, June 1997.
- f/ Indicates that the IDLH value was based on 10% of the lower explosive limit for safety considerations, even though relevant toxicological data indicated that irreversible health effects or impairment of escape existed only at higher concentrations (*NIOSH Pocket Guide to Chemical Hazards*, 1997).
- g/ Based on coal tar pitch volatiles.
- h/ mg/m³ = milligrams per cubic meter.
- i/ NA = Not available.
- j/ Refer to expanded rules for this compound.
- k/ (skin) = Refers to the potential contribution to the overall exposure by the cutaneous route.
- l/ NIOSH recommends reducing exposure to the lowest feasible concentration, and limiting the number of workers exposed.
- m/ Total dust.
- n/ Respirable fraction.
- o/ Olfactory fatigue has been reported for the compound and odor may not serve as an adequate warning property.
- p/ Irritation threshold.
- q/ (ceiling) = Ceiling concentration which should not be exceeded at any time.
- r/ Based on analogy to phenol.
- s/ Based on fume.
- t/ Based on dust.

TABLE 5.1.2 HEALTH HAZARD QUALITIES OF HAZARDOUS SUBSTANCES OF CONCERN - ALTUS AFB

Compound	PEL ^v (ppm)	TLV ^v (ppm)	IDLH ^v (ppm)	Odor Threshold ^v (ppm)	Ionization Potential ^v (eV)	Physical Description/Health Effects/Symptoms
Benzene	1 (29 CFR 1910.1028) ^v	0.5 (skin) ^v	500	4.7	9.24	Colorless to light-yellow liquid (solid < 42°F) with an aromatic odor. Eye, nose, skin, and respiratory system irritant. Causes giddiness, headaches, nausea, staggered gait, fatigue, anorexia, exhaustion, dermatitis, bone marrow depression, and leukemia. Mutagen, experimental teratogen, and carcinogen.
2-Butanone (Methyl Ethyl Ketone, MEK)	200	200	3,000	4.8-25	9.54	Colorless liquid with a moderately sharp, fragrant, mint- or acetone-like odor. Irritates eyes, nose, and skin. Causes headaches, dizziness, vomiting, and dermatitis. Experimental teratogen.
Carbon Disulfide	4 (skin)	10 (skin)	500	0.0011-7.7	10.08	Colorless to faint-yellow liquid with sweet ether or foul (reagent grade) odor. Irritating to eyes, skin, and mucous membranes on contact. Causes dizziness, headaches, poor sleep, fatigue, nervousness, low-weight, psychosis, nervous system degeneration, Parkinson-like syndrome, ocular changes, heart disease, gastritis, dermatitis, eye and skin burns, liver and kidney damage, and reproductive effects. Mutagen and experimental teratogen.
Carbon Tetrachloride	2	5 (skin)	200	21.4-200	11.47	Colorless liquid with characteristic, ether-like odor. Irritates eyes and skin. Causes CNS depression, nausea, vomiting, liver/kidney damage, drowsiness, dizziness, and incoordination. In animals, causes liver cancer. Mutagen, experimental teratogen, and carcinogen.
Chlorobenzene	75	10	1,000	0.21-60	9.07	Colorless, liquid narcotic with an almond-like odor. Irritates eyes, nose, and skin. Causes drowsiness, incoordination, and CNS depression. In animals, causes lung and kidney injury. Mutagen and experimental teratogen.
Chloroform (Trichloromethane)	2	10	500	205 ^v	11.42	Colorless, heavy liquid with pleasant odor. Irritates eyes and skin. Anaesthetic. Causes dizziness, mental dullness, nausea, confusion, headache, fatigue, anesthesia, and enlarged liver. Also attacks kidneys and heart. In animals, causes liver and kidney cancer. Mutagen, experimental teratogen, and carcinogen.
Chloromethane	50	50	2,000	10-100	11.28	Colorless gas with a sweet taste and a faint, sweet odor not noticeable at

TABLE 5.1.2 HEALTH HAZARD QUALITIES OF HAZARDOUS SUBSTANCES OF CONCERN - ALTUS AFB

Compound	PEL ^v (ppm)	TLV ^v (ppm)	IDLH ^v (ppm)	Odor Threshold ^v (ppm)	Ionization Potential ^v (eV)	Physical Description/Health Effects/Symptoms
(Methyl Chloride)		(skin)				dangerous concentrations. Causes dizziness, nausea, vomiting, visual disturbances, staggering, slurred speech, convulsions, coma, frostbite (liquid), reproductive and teratogenic effects, and CNS, liver, and kidney damage. In animals, causes lung, kidney, and forestomach tumors. Mutagen, experimental teratogen, and carcinogen.
Dibutylphthalate (Di-n-butylphthalate)	5 mg/m ³ ^v	5 mg/m ³	4,000 mg/m ³	0.26	NA ^v	Colorless to faint-yellow, oily liquid with a slight, aromatic odor and strong, bitter taste. Irritates eyes, upper respiratory system, and stomach. Causes hallucinations, distorted perceptions, nausea or vomiting, and kidney, urethra or bladder changes. Mutagen and experimental teratogen.
1,2-Dichloroethane (DCA) (Ethylene Dichloride, EDC)	1	10	50	100	11.05	Colorless liquid with a pleasant, chloroform-like odor. Strong narcotic. Irritates eyes. Causes corneal opaqueness, nausea, CNS depression, vomiting, dermatitis, and damage to liver, kidneys, and cardiovascular system. In animals, causes cancer of the forestomach, mammary gland, and circulatory system. Mutagen, experimental teratogen, and carcinogen.
1,1-Dichloroethene (DCE) (Vinylidene Chloride)	1	5	NA	NA	10.00	Colorless liquid or gas (> 89°F) with a mild, sweet, chloroform-like odor. Irritates eyes, skin, and throat. Causes dizziness, headaches, nausea, shortness of breath, liver and kidney dysfunctions, and lung inflammation. Mutagen and carcinogen.
1,2-Dichloroethene (DCE) (cis- and trans-isomers)	200	200	1,000	0.085-500	9.65	Colorless liquid (usually a mixture of cis- and trans- isomers), with a slightly acid, chloroform-like odor. Irritates eyes and respiratory system. CNS depressant. Cis- isomer is a mutagen.
Ethylbenzene	100	100	800 (10% LEL) ^v	0.25-200	8.76	Colorless liquid with an aromatic odor. Irritates eyes, skin, and mucous membranes. Causes dermatitis, headaches, narcosis, and coma. Mutagen and experimental teratogen.
Bis(2-Ethylhexyl)Phthalate (Di-sec Octyl Phthalate)	5 mg/m ³	5 mg/m ³	5,000 mg/m ³	NA	NA	Colorless to light-colored, oily liquid with slight odor. Irritates eyes and mucous membranes. Also affects respiratory system, CNS, and gastrointestinal tract. In animals, causes liver damage, liver tumors, and teratogenic effects. Carcinogen.
Methylene Chloride (Dichloromethane, Methylene Dichloride)	25	50	2,300	25-320	11.32	Colorless liquid (gas > 104°F) with a sweet, chloroform-like odor (not noticeable at dangerous concentrations). Irritates eyes and skin. Causes nausea, vomiting, fatigue, weakness, unnatural drowsiness, light-headedness, numbness, tingling limbs, and nausea. In animals, causes lung, liver, salivary and mammary gland tumors. Mutagen, experimental

TABLE 5.1.2 HEALTH HAZARD QUALITIES OF HAZARDOUS SUBSTANCES OF CONCERN - ALTUS AFB

Compound	PEL ^v (ppm)	TLV ^w (ppm)	IDLH ^w (ppm)	Odor Threshold ^d (ppm)	Ionization Potential ^e (eV)	Physical
						Description/Health Effects/Symptoms
teratogen, and carcinogen.						
Tetrachloroethene (PCE) (Perchloroethylene)	25 ^v	25	150	5-50	9.32	Colorless liquid with a mild chloroform odor. Eye, nose, skin and throat irritant. Causes nausea, flushed face and neck, vertigo, dizziness, headaches, hallucinations, incoordination, drowsiness, coma, pulmonary changes, and skin redness. Cumulative liver, kidney, and CNS damage. In animals, causes liver tumors. Mutagen, experimental teratogen, and carcinogen.
Toluene	100	50 (skin)	500	0.2-40 ^w	8.82	Colorless liquid with sweet, pungent, benzene-like odor. Irritates eyes and nose. Causes fatigue, weakness, dizziness, headaches, hallucinations or distorted perceptions, confusion, euphoria, dilated pupils, nervousness, tearing, muscle fatigue, insomnia, skin tingling, dermatitis, bone marrow changes, and liver and kidney damage. Mutagen and experimental teratogen.
1,1,1-Trichloroethane (TCA) (Methyl Chloroform)	350	350	700	20-500	11.00	Colorless liquid with a mild chloroform-like odor. Irritates eyes and skin. Causes headaches, exhaustion, CNS depression, poor equilibrium, dermatitis, liver damage, cardiac arrhythmia, hallucinations or distorted perceptions, motor activity changes, aggression, diarrhea, and nausea or vomiting. Mutagen, experimental teratogen, and questionable carcinogen.
Trichloroethene (TCE)	50	50	1,000	21.4-400	9.45	Clear, colorless or blue liquid with chloroform-like odor. Irritates skin and eyes. Causes fatigue, giddiness, headaches, vertigo, visual disturbances, tremors, nausea, vomiting, drowsiness, dermatitis, skin tingling, cardiac arrhythmia, and liver injury. In animals, causes liver and kidney cancer. Mutagen, experimental teratogen, and carcinogen.
Vinyl Chloride (29 CFR 1910.1017) ^v	1	5	NA	260	9.99	Colorless gas (liquid < 7°F) with a pleasant odor at high concentrations. Severe irritant to skin, eyes, and mucous membranes. Causes weakness, abdominal pain, gastrointestinal bleeding, enlarged liver, pallor or blue skin on the extremities, liver cancer, and frostbite (liquid). Also attacks lymphatic system. Mutagen, experimental teratogen, and carcinogen.
Xylene	100	100	900	0.05-200 ^w	8.56	Colorless liquid with aromatic odor. P-isomer is a solid <56°F. Irritates

TABLE 5.1.2 HEALTH HAZARD QUALITIES OF HAZARDOUS SUBSTANCES OF CONCERN - ALTUS AFB

Compound	PEL ^{a/} (ppm)	TLV ^{b/} (ppm)	IDLH ^{c/} (ppm)	Odor Threshold ^{d/} (ppm)	Ionization Potential ^{e/} (eV)	Physical Description/Health Effects/Symptoms
(o-, m-, and p-isomers)					8.44 (p)	eyes, skin, nose, and throat. Causes dizziness, drowsiness, staggered gait, incoordination, irritability, excitement, corneal irregularities, conjunctivitis, dermatitis, anorexia, nausea, vomiting, abdominal pain, and olfactory and pulmonary changes. Also targets blood, liver, and kidneys. Mutagen and experimental teratogen.

a/ PEL = Permissible Exposure Limit. OSHA-enforced average air concentration to which a worker may be exposed for an 8-hour workday without harm. Expressed as parts per million (ppm) unless noted otherwise. PELs are published in the *NIOSH Pocket Guide to Chemical Hazards*, 1997. Some states (such as California) may have more restrictive PELs. Check state regulations.

b/ TLV = Threshold Limit Value - Time-Weighted Average. Average air concentration (same definition as PEL, above) recommended by the American Conference of Governmental Industrial Hygienists (ACGIH), 1997 TLVs[®] and BEIs[®].

c/ IDLH = Immediately Dangerous to Life or Health. Air concentration at which an unprotected worker can escape without debilitating injury or health effects. Expressed as ppm unless noted otherwise. IDLH values are published in the *NIOSH Pocket Guide to Chemical Hazards*, 1997.

d/ When a range is given, use the highest concentration.

e/ Ionization Potential, measured in electron volts (eV), used to determine if field air monitoring equipment can detect substance. Values are published in the *NIOSH Pocket Guide to Chemical Hazards*, June 1997.

f/ Refer to expanded rules for this compound.

g/ (skin) = Refers to the potential contribution to the overall exposure by the cutaneous route.

h/ Olfactory fatigue has been reported for the compound and odor may not serve as an adequate warning property.

i/ mg/m³ = milligrams per cubic meter.

j/ NA = Not available.

k/ Indicates that the IDLH value was based on 10% of the lower explosive limit for safety considerations, even though relevant toxicological data indicated that irreversible health effects or impairment of escape existed only at higher concentrations (*NIOSH Pocket Guide to Chemical Hazards*, 1997).

l/ NIOSH recommends reducing exposure to the lowest feasible concentration, and limiting the number of workers exposed.

5.2.1 General Vehicle Operations

The following safety procedures will be followed when operating a motor vehicle within a USAF installation:

- Seat belts will be worn at all times.
- Obey all traffic and speed limit signs.
- Park in designated areas.
- Be aware of construction equipment and other vehicles operating in the area.
- Be aware of pedestrian traffic.
- Acquire eye contact and permission from the vehicle/equipment operator to enter an area around operating vehicles.
- Never crouch down in front of or behind a vehicle.
- Drivers must visually check around the vehicle before moving it.
- Vehicles will never be loaded beyond the designed passenger capacity or beyond the rated load capacity.
- Vehicles will never be loaded in a manner that obscure the driver's front or side views.

The daily vehicle maintenance report located in Appendix A must be completed by the vehicle drivers for all field vehicles (including rented vehicles) upon initial receipt of the vehicle and every morning thereafter, prior to use, that the vehicle is used on a Parsons ES project.

5.2.2 Large Motor Vehicles including Drilling Rigs

Working with large motor vehicles could be a major hazard at these sites. Injuries can result from equipment dislodging and striking unsuspecting personnel, and impacts from flying objects or overturning of vehicles. Vehicles and heavy equipment design and operation will be in accordance with 29 CFR, Subpart O, 1926.600 through 1926.602. In particular, the following precautions will be used to help prevent injuries and accidents:

- Do not back up large motor vehicles unless the vehicle has backup warning lights and a reverse signal alarm audible above the surrounding noise level, or an observer signals it is safe to do so.
- Motor vehicle cabs will be kept free of all nonessential items and all loose items will be secured.

- Drilling rig masts will be lowered to the ground and parking brakes will be set before shutting off the vehicle.
- Drilling rig brakes, cables, kill switches, hydraulic lines, light signals, fire extinguishers, fluid levels, steering, tires, horn, and other safety devices will be inspected daily.
- All personnel working at and around the drilling rig must be informed of the locations of the kill switches.
- Only qualified operators will be allowed to operate the drilling rig or other heavy equipment.
- When working near a backhoe, field personnel will maintain sight contact with the operator.
- The limits of the swing radius of the backhoe must be marked on the ground with cones or boundary tape. Personnel will not enter this bounded area until the backhoe has been shut down, and the operator signals that it is acceptable to enter. Backhoe operations will resume only after personnel have left the area within the swing radius.

5.2.3 Hazards Associated with the Geoprobe® Unit

The Geoprobe® unit consists of a hydraulically-driven press mounted on the bed of a pick-up truck, with power supplied to the cylinder via a power-take-off on the truck. A list of safety instructions provided by the Geoprobe® manufacturer is provided below, and will be followed by all Parsons ES and subcontractor personnel.

- Never operate the controls without proper training.
- Always take the vehicle out of gear and set the emergency brake before engaging the remote ignition.
- If the vehicle is parked on a loose or soft surface, do not fully raise the rear of the vehicle with the probe foot, as the vehicle may fall or move, causing injury.
- Always extend the probe unit out from the vehicle, and deploy the foot to clear the vehicle roof line before folding the probe unit out.
- Operators must wear OSHA-approved steel-toed shoes, and keep feet clear of the probe foot.
- Only one person should operate the probe machine and assemble/disassemble the probe rods and accessories.
- Never place hands on top of a rod while it is under the machine.
- Turn off the hydraulic system while changing rods, inserting the hammer anvil or attaching accessories.

- While operating the controls, the operator must stand to the control side of the probe machine, clear of the probe foot and mast.
- Wear safety glasses at all times during the operation of this machine.
- Never exert down pressure on the probe rod so as to lift the machine base over six inches off the ground.

5.2.4 Subsurface Hazards

Before intrusive field activities are performed, efforts must be made to determine if underground installations (i.e., sewers, and telephone, water, fuel, and electrical lines) will be encountered and if so, where such underground installations are located. The site manager will ensure that all underground installations have been identified prior to any intrusive operations.

5.2.5 Electrical Hazards

Some of the equipment used during the phytostabilization demonstrations is powered by electricity. Maintenance and daily activities require personnel to use, handle, and control this equipment. Safe work practices must be strictly observed to avoid serious injury and death.

According to 29 CFR 1910.269(l), only qualified employees may work on or with exposed energized lines or parts of equipment, or in areas containing unguarded, uninsulated, energized lines or parts of equipment operating at 50 volts (V) or more. Qualified employees must be trained in accordance with 29 CFR 1910.269(a) and certified as such by the employer.

Ordinary 120 V electricity may be fatal. Extensive studies have shown that currents as low as 10 to 15 milliamps (mA) can cause loss of muscle control and that 12 V may, on good contact, cause injury. Therefore, all voltages should be considered dangerous.

Electricity can paralyze the nervous system and stop muscular action. Frequently, electricity may affect the breathing center at the base of the brain and interrupt the transmission of the nerve impulses to the muscles responsible for breathing. In other cases, the electrical current directly affects the heart, causing it to cease pumping blood. Death follows due to a lack of oxygen in the body. Therefore, a victim must be freed from the live conductor promptly by use of a nonconducting implement, such as a piece of wood, or by turning off the electricity to at least this point of contact. Bare hands should never be used to remove a live wire from a victim or a victim from an electrical source. Artificial respiration or CPR should be applied immediately and continuously until breathing is restored, or until a physician or emergency medical technician arrives.

General rules for recognizing electrical safety are provided below.

- Only authorized and qualified personnel will perform electrical installations or repairs.

- All electrical wires and circuits will be assumed to be "live," unless it can be positively determined they are not.
- Appropriate protective clothing will be worn by personnel performing electrical work.
- All electrical equipment will be properly grounded and class-approved for the location.
- Ground fault circuit interrupter receptacles and circuit breakers will be installed where required by the National Electric Code and 29 CFR 1926.404.
- Electrical control panels will not be opened unless necessary.
- No safety device will be made inoperative by removing guards, using oversized fuses, or by blocking or bypassing protective devices, unless it is absolutely essential to the repair or maintenance activity, and then only after alerting operating personnel and the maintenance supervisor.
- All power tools will have insulated handles, be electrically grounded, or be double insulated.
- Fuse pullers will be used to change fuses.
- Metal ladders, metal tape measures, and other metal tools will not be used around electrical equipment or overhead electrical lines.
- Wires and extension cords will be placed or arranged so as to not pose a tripping hazard.

5.2.6 Slip, Trip, and Fall Hazards

Existing site conditions may pose a number of slip, trip, and fall hazards, such as:

- Open excavations, pits, or trenches;
- Slippery surfaces;
- Steep or uneven grades;
- Surface obstructions; and
- Construction materials or debris.

The extension cords connecting pumps to power supplies also provide a trip and fall hazard. Caution must be exercised and unnecessary personnel should avoid the area of the cord.

All field team members will be instructed to be cognizant of potential safety hazards and immediately inform the SHSO or the site manager about any new hazards. If the

hazard cannot be immediately removed, actions must be taken to warn site workers about the hazard. The site will be kept in a neat, organized, and orderly fashion. Rubbish, trash, or debris generated by the project team shall be picked up and properly disposed of on a daily basis. Items such as tools, equipment, and hoses will be properly stored when not in use.

5.2.7 Noise-Induced Hearing Loss

Work onsite may involve the use of equipment such as drilling rigs, pumps, and generators. The exposure of unprotected site workers to this noise or to aircraft noise during site activities can result in noise-induced hearing loss. Heavy equipment can emit noise levels exceeding the federal OSHA time-weighted average (TWA) limit of 85 decibels (dB). Noise levels in the area of the drilling rig and Geoprobe® unit will be presumed in exceedance of the OSHA TWA, and hearing protection will be required. Foam ear plugs will generally provide adequate protection. The SHSO will ensure that either ear muffs or disposable foam earplugs are made available to, and are used by, all personnel in the vicinity of the operation of equipment, aircraft noise or other sources of high intensity noise.

5.2.8 Fire or Explosion Hazards

Fuels and solvents have been released into the soils at Travis and Altus AFBs and vapors from these fuels may be flammable or explosive. In addition, drilling or other intrinsic activities may be performed in former or existing landfill areas. Therefore, precautions will be taken when performing phytostabilization demonstration activities to ensure that combustible or explosive vapors have not accumulated, or that an ignition source is not introduced into a flammable atmosphere.

OSHA standards for fire protection and prevention are included in 29 CFR Subpart F, 1926.150 through 1926.154. Of particular concern on these sites are:

- Proper storage of flammables;
- Adequate numbers and types of fire extinguishers;
- Use of intrinsically safe (explosion-proof) equipment where appropriate; and
- Monitoring for development of an explosive atmosphere.

The SHSO will ensure that the above concerns are adequately mitigated.

5.2.9 Electric Power Line Clearance and Thunderstorms

Extra precautions will be exercised when drilling near overhead electrical lines. As stated in 29 CFR 1926.550, the minimum clearance between overhead electrical lines of 50 kilovolts (kV) or less and the drill rig is 10 feet. For lines rated over 50 kV, the minimum clearance between the lines and any part of the rig is 10 feet plus 0.4 inches for each kV over 50 kV. Drilling operations must cease during thunderstorms.

The SHSO will provide onsite surveillance of the drilling subcontractor to ensure that personnel meet these requirements. If deficiencies are noted, work will be stopped and corrective actions implemented. Reports of health and safety deficiencies and the corrective actions taken will be forwarded to the installation manager by the SHSO.

5.2.10 Effects and Prevention of Heat Stress

Adverse weather conditions are important considerations in planning and conducting site operations. Hot or cold weather can cause physical discomfort, loss of efficiency, and personal injury. These conditions are discussed further below.

If the body's physiological processes fail to maintain a normal body temperature because of excessive heat, a number of physical reactions can occur. They can range from mild symptoms such as fatigue; irritability; anxiety; and decreased concentration, dexterity, or movement; to death. Medical help must be obtained for the more serious cases of heat stress. One or more of the following actions will help reduce heat stress:

- Provide plenty of liquids. To replace body fluids (water and electrolytes) lost due to perspiration, each employee must drink 1 to 1.5 gallons of water or commercial electrolyte mix per day. Workers are encouraged to frequently drink small amounts, i.e. one cup every 15-20 minutes.
- Field personnel are cautioned to minimize alcohol intake during off-duty hours.
- Provide cooling devices (e.g., water jackets or ice vests) to aid natural body ventilation. These devices, however, add weight, and their use should be balanced against worker mobility.
- Wear long cotton underwear, which acts as a wick to help absorb moisture and protect the skin from direct contact with heat-absorbing protective clothing.
- Install portable emergency showers and/or hose-down facilities to reduce body temperature and to cool protective clothing.
- In extremely hot weather, conduct non-emergency response operations in the early morning or evening.
- Ensure that adequate shelter is available to protect personnel against sun, heat, or other adverse weather conditions which decrease physical efficiency and increase the probability of accidents.
- In hot weather, rotate workers wearing protective clothing.
- Maintain good hygienic standards by frequent changing of clothing and daily showering. Clothing should be permitted to dry during rest periods. Workers who notice skin problems should immediately consult the SHSO.

5.2.10.1 Heat-Related Problems

- Heat rash: Caused by continuous exposure to heat and humid air, and aggravated by chafing clothes. Decreases ability to tolerate heat and is a nuisance.
- Heat cramps: Caused by profuse perspiration with inadequate fluid intake and chemical replacement, especially salts. Signs include muscle spasms and pain in the extremities and abdomen.
- Heat exhaustion: Caused by increased stress on various organs to meet increased demands to cool the body. Signs include shortness of breath; increased pulse rate (120-200 beats per minute); pale, cool, moist skin; profuse sweating; and dizziness and exhaustion.
- Heat stroke: The most severe form of heat stress. Body must be cooled immediately to prevent severe injury and/or death. Signs include red, hot, dry skin; no perspiration; nausea; dizziness and confusion; strong, rapid pulse; and possibly coma. Medical help must be obtained immediately.

5.2.10.2 Heat-Stress Monitoring

Monitoring of personnel wearing impermeable clothing will begin when the ambient temperature is 70°F (21°C) or above. Table 5.2 presents the suggested frequency for such monitoring. Monitoring frequency will increase as the ambient temperature increases or as slow recovery rates are observed. Heat-stress monitoring will be performed by a person with current first-aid certification who is trained to recognize heat-stress symptoms. For monitoring the body's recuperative capabilities in response to excess heat, one or more of the techniques listed below will be used. Other methods of heat-stress monitoring may also be used, such as the wet-bulb globe temperature index from the American Conference of Governmental Industrial Hygienists (ACGIH) (1997) TLV and BEI booklet.

To monitor the worker, measure:

- Heart rate: Count the radial pulse during a 30-second period as early as possible during the rest period.
 - If the heart rate exceeds 110 beats per minute at the beginning of the rest period, the next work cycle will be shortened by one-third and the rest period will remain the same.
 - If the heart rate still exceeds 110 beats per minute at the next rest period, the following work cycle will be reduced by one-third.
- Oral temperature: Use a clinical thermometer (3 minutes under the tongue) or similar device to measure the oral temperature at the end of the work period (before drinking).
 - If oral temperature exceeds 99.6° (37.6°C), the next work cycle will be reduced by one-third without changing the rest period.

TABLE 5.2
SUGGESTED FREQUENCY OF PHYSIOLOGICAL MONITORING FOR FIT
AND ACCLIMATIZED WORKERS^{a/}

Adjusted Temperature ^{b/}	Normal Work Ensemble ^{c/}	Impermeable Ensemble ^{d/}
90°F (32.2°C) or above	After each 45 minutes of work	After each 15 minutes of work
87.5° - 90°F (30.8° - 32.2° C)	After each 60 minutes of work	After each 30 minutes of work
82.5° - 87.5° F (28.1° - 30.8° C)	After each 90 minutes of work	After each 60 minutes of work
77.5° - 82.5° F (25.3° - 28.1° C)	After each 120 minutes of work	After each 90 minutes of work
72.5° - 77.5° F (22.5° - 25.3° C)	After each 150 minutes of work	After each 120 minutes of work

a/ For work levels of 250 kilocalories/per hour.

b/ Calculate the adjusted air temperature (ta adj) by using this equation: $ta\ adj = ta\ ^\circ F + (13 \times \text{sunshine multiplier [i.e., 50 percent sunshine equals a .5 multiplier]})$. Measure air temperature (ta) with a standard mercury-in-glass thermometer, with the bulb shielded from radiant heat. Estimate the sunshine multiplier by judging what percent of time the sun is not covered by clouds that are thick enough to produce a shadow (100 percent sunshine - no cloud cover and a sharp, distinct shadow; 0 percent sunshine = no shadows).

c/ A normal work ensemble consists of cotton coveralls or other cotton clothing with long sleeves and trousers.

d/ Saranex[®], Poly-Coated Tyvek[®], Etc.

- If oral temperature still exceeds 99.6°F (37.6°C) at the beginning of the next rest period, the following work cycle will be reduced by one-third.
- No worker will be permitted to wear a semipermeable or impermeable garment when oral temperature exceeds 100.6°F (38.1°C).

5.2.11 Cold Exposure

It is possible that work on this project may be conducted during the winter months; therefore, injury due to cold exposure may become a problem for field personnel. Cold exposure symptoms, including hypothermia and frostbite, will be monitored when personnel are exposed to low temperatures for extended periods of time.

Persons working outdoors in temperatures at or below freezing may suffer from cold exposure. During prolonged outdoor periods with inadequate clothing, effects of cold exposure may even occur at temperatures well above freezing. Cold exposure may cause severe injury by freezing exposed body surfaces (frostbite), or may result in profound generalized cooling (hypothermia), possibly causing death. Areas of the body which have high surface area-to-volume ratios such as fingers, toes, and ears are the most susceptible to frostbite.

Two factors influence the development of a cold injury: ambient temperature and wind velocity. Wind chill is used to describe the chilling effect of moving air in combination with low temperature. For example, 14°F with a wind speed of 15 miles per hour (mph) is equivalent in chilling effect to still air at -18°F. Cold exposure is particularly a threat to site workers if the body cools suddenly when chemical-protective equipment is removed, and the clothing underneath is perspiration-soaked. The presence of wind greatly increases the rate of cooling.

Local injury resulting from cold is included in the generic term frostbite. There are several degrees of damage. Frostbite of the extremities can be categorized into:

- Frost nip or incipient frostbite: characterized by suddenly blanching or whitening of skin.
- Superficial frostbite: skin has a waxy or white appearance and is firm to the touch, but tissue beneath is resilient.
- Deep frostbite: tissues are cold, pale, and solid; an extremely serious injury.

Systemic hypothermia, or lowering of the core body temperature, is caused by exposure to freezing or rapidly dropping temperatures. Symptoms are usually exhibited in five stages:

- Shivering and uncoordination;
- Apathy, listlessness, sleepiness, and (sometimes) rapid cooling of the body to less than 95°F (35°C);
- Unconsciousness, glassy stare, slow pulse, and slow respiratory rate;

- Freezing of the extremities; and
- Death.

5.2.11.1 Evaluation and Control

TLVs recommended for properly clothed workers for periods of work at temperatures below freezing are shown in Table 5.3. For exposed skin, continuous exposure should not be permitted when the air speed and temperature results in an equivalent chill temperature of -32°C (-25.6°F). Superficial or deep local tissue freezing will occur only at temperatures below -1°C (30.3°F) regardless of wind speed.

Special protection of the hands is required to maintain manual dexterity for the prevention of accidents. If fine work is to be performed with bare hands for more than 10 to 20 minutes in an environment below 16°C (60.8°F), special provisions should be established for keeping the workers' hands warm. For this purpose, warm air jets, radiant heaters (fuel burner or electric radiator), or contact warm plates may be used. At temperatures below -1°C (30.2°F), metal handles of tools and control bars should be covered by thermal insulating material.

To prevent contact frostbite, workers should wear gloves. When cold surfaces below -7°C (19.4°F) are within reach, a warning will be given to the workers by the supervisor or SHSO to prevent inadvertent contact with bare skin. If the air temperature is -17.5°C (0°F) or less, the hands should be protected by mittens. Machine controls and tools for use in cold conditions should be designed so that they can be handled without removing the mittens.

Provisions for additional total body protection are required if work is performed in an environment at or below 4°C (39.2°F). The workers will wear cold protective clothing appropriate for the level of cold and physical activity. If the air velocity at the job site is increased by wind, draft, or artificial ventilating equipment, the cooling effect of the wind should be reduced by shielding the work area or by wearing an easily removable windbreak garment. If the available clothing does not give adequate protection to prevent hypothermia or frostbite, work will be modified or suspended until adequate clothing is made available or until weather conditions improve.

5.2.11.2 Work-Warming Regimen

If work is performed continuously in the cold at an equivalent chill temperature (ECT) below -7°C (19.4°F), heated warming shelters (tents, cabins, rest rooms) will be made available nearby. The workers will be encouraged to use these shelters at regular intervals, the frequency depending on the severity of the environmental exposure. The onset of heavy shivering, frostnip, the feeling of excessive fatigue, drowsiness, irritability, or euphoria are indications for immediate return to the shelter. When entering the heated shelter, the outer layer of clothing should be removed and the remainder of the clothing loosened to permit sweat evaporation, or a change of dry work clothing should be provided. A change of dry work clothing may be necessary to prevent workers from returning to work with wet clothing. Dehydration, or the loss of body fluids, occurs insidiously in the cold environment and may increase the susceptibility of the worker to cold injury due to a significant change in blood flow to

TABLE 5.3
**THRESHOLD LIMIT VALUES WORK/
WARM-UP SCHEDULE FOR FOUR-HOUR SHIFT**

Air Temperature-Sunny Sky		No Noticeable Wind		5 mph Wind		10 mph Wind		15 mph Wind		20 mph Wind	
°C(approx.)	°F (approx.)	Max. Work Period	No. of Breaks	Max. Work Period	No. of Breaks	Max. Work Period	No. of Breaks	Max. Work Period	No. of Breaks	Max. Work Period	No. of Breaks
-26° to -28°	-15° to -19°	(Norm Breaks)	1	(Norm Breaks)	2	75 min	2	55 min	3	40 min	4
-29° to -31°	-20° to -24°	(Norm Breaks)	1	75 min	2	55 min	3	40 min	4	30 min	5
-32° to -34°	-25° to -29°	75 min	2	55 min	3	40 min	4	30 min	5	Non-emergency work should cease	
-35° to -37°	-30° to -34°	55 min	3	40 min	4	30 min	5	Non-emergency work should cease			
-38° to -39°	-35° to -39°	40 min	4	30 min	5	Non-emergency work should cease					
-40° to -42°	-40° to -44°	30 min	5	Non-emergency work should cease							
-43° & below	-45° & below	Non-emergency work should cease									

Notes for Tables 5.3

- Schedule applies to any 4-hour work period with moderate to heavy work activity, with warm-up periods in a warm location and with an extended break (e.g., lunch) at the end of the 4-hour work period in a warm location. For light-to-moderate (limited physical movement): apply the schedule one step lower. For example, at -35°C (-30°F) with no noticeable wind (Step 4), a worker at a job with little physical movement should have a maximum work period of 40 minutes with 4 breaks in a 4-hour period (Step 5)
- The following is suggested as a guide for estimating wind velocity if accurate information is not available: 5 mph: light flag moves; 10 mph: light flag fully extended; 15 mph: raises newspaper sheet; 20 mph: blowing and drifting snow.
- In general the warm-up schedule provided above slightly under-compensates for the wind at the warmer temperatures, assuming acclimatization and clothing appropriate for winter work. On the other hand, the chart slightly over-compensates for the actual temperatures in the colder ranges, since windy conditions rarely prevail at extremely low temperatures.
- TLVs apply only for workers in dry clothing.

the extremities. Warm sweet drinks and soups should be provided at the work site to provide caloric intake and fluid volume. The intake of coffee should be limited because of the diuretic and circulatory effects.

For work practices at or below -12°C (10.4°F) ECT, the following should apply:

- The workers will be under constant protective observation (buddy system or supervision).
- The work rate should not be so high as to cause heavy sweating that will result in wet clothing; if heavy work must be done, rest periods will be taken in unheated shelters, and the opportunity for changing into dry clothing should be provided.
- New employees should not be required to work full-time in the cold during the first days of employment until they become accustomed to the working conditions and required protective clothing.
- The weight and bulkiness of clothing should be included in estimating the required work performances and weights to be lifted by the worker.
- The work should be arranged in such a way that sitting still or standing still for long periods is minimized. Unprotected metal chair seats will not be used. The worker should be protected from drafts to the greatest extent possible.
- The workers will be instructed in safety and health procedures relative to cold exposures.

5.3 BIOLOGICAL HAZARDS

Various biological hazards may be encountered at Travis and Altus AFBs. These hazards include pathogenic organisms or diseases such as Bubonic Plague, Equine Encephalitis, and Lyme Disease. Other biological hazards include insects, snakes, spiders, and cactuses.

Bubonic plague is a bacterial disease which is spread to humans by fleas that have bitten an infected animal. Bubonic plague displays symptoms rapidly. Chills and fever are soon accompanied by swelling of the lymph nodes, usually on one side of the body. These painful swellings are usually dark blue to black, hence the other common name for this disease, black death. The disease is treatable with antibiotics. Field personnel must wear Tyvek® suits with leg seams taped to boots or boot covers to minimize contact with fleas while working in prairie dog towns.

Equine encephalitis, an inflammation of the brain, can be carried by mosquitoes. Field personnel must wear long-sleeved clothing and/or use insect repellents if they are working in areas of mosquito infestations.

Bites from wood ticks may result in the transmission of Lyme disease - a serious and often fatal bacterial disease. The *Borrelia burgdorferi* bacteria infects wood ticks,

which can bite humans and transfer the bacteria into the bloodstream. Transmission of Lyme disease is most likely in late spring, summer, and early fall.

There are three stages of Lyme disease, although not everyone will proceed through all the stages or experience all the symptoms. The initial symptoms may include a red rash that is circular and blotchy and expands around the tick bite, and flu-like symptoms such as fatigue, headaches, fever, swollen glands, and stiffness and pain in muscles and joints. The next stage can occur from a few days to a few weeks after the initial stage. Symptoms of this phase may include irregular heartbeat, facial paralysis, joint pain, irritability, headaches, dizziness, poor coordination, weakness, severe fatigue, and memory loss. The third stage may occur weeks to years after the second stage. Arthritis, often in the knees, is the most common symptom of this stage. The arthritis may disappear and recur many times, and chronic arthritis may develop.

Prompt medical treatment with antibiotics is usually successful in preventing further complications from this disease. Lyme disease becomes more difficult to treat the longer treatment is delayed. Long-sleeved shirts with snug collar and cuffs, pants tucked into socks, and personal protective equipment will offer some protection. However, the use of tick repellent may also be warranted. Personnel should perform self-checks for ticks at the end of each work day.

The potential exists for contact with snakes or insects which may cause injury or disease when performing phytostabilization demonstration activities at Travis and Altus AFBs. There are plants which may be injurious (i.e., thorns) as well. Sturdy work clothes and shoes will be worn by field personnel to help prevent injuries. Personnel should be aware that rattlesnakes, water moccasins or alligators may be present in an area and should therefore exercise caution, especially when working in previously undisturbed areas and locations around animal dens and wetland habitats.

An abundance of red fire ants may be observed at Travis and Altus AFBs, especially in the vicinity of the existing monitoring wells. Do not stand on, place equipment on or otherwise disturb the ant hills. It is also advisable to place a four foot square piece of plywood where personnel need to stand. An insect repellent may be used if it does not interfere with the desired groundwater sampling analyses. Latex booties taped at the top or Tyvek® suits may also be used. Frequent self-checks for crawling ants should also be performed.

Poison ivy, poison oak, and poison sumac can be encountered at Travis and Altus AFBs. Poison ivy is a woody vine leaves are divided into three leaflets. Poison oak is a low branching shrub with leaflets also in threes. Poison sumac is a shrub or small tree occurring in swamps. Poison sumac have 7 to 13 leaflets which resemble those of green ash trees. All of these species are poisonous and can cause contact dermatitis. Personnel must wear Tyvek® suits or other protective clothing when working in areas containing these plant species.

Black widow spiders and scorpions may also be present onsite. The black widow spider has a shiny black body about the size of a pea, with a red or yellow hourglass-shaped mark on its abdomen. It weaves shapeless diffuse webs in undisturbed areas. A bite may result in severe pain, illness, and possible death from complications, but

usually not from the bite itself. There are several types of scorpions native to the United States. Scorpions may be brown to yellowish in color, and range from 1/2 inch to 8 inches in length. Their bodies are divided into two parts: a short, thick upper body, and a long abdomen with a six-segment tail. A scorpion has six pairs of jointed appendages: one pair of small pincers, one pair of large claws, and four pairs of jointed legs. They are most active at night. A scorpion sting is very painful, but usually will not result in death.

In addition to spiders and scorpions, bees and wasps may be nuisances to field personnel. Properly trained personnel will administer first aid should a bee or wasp sting occur.

SECTION 6

EMERGENCY RESPONSE PLAN

All hazardous waste site activities will present a degree of risk to onsite personnel. During routine operations, risk is minimized by establishing good work practices, staying alert, and using proper PPE. Unpredictable events such as physical injury, chemical exposure, or fire may occur and must be anticipated. The sections below establish procedures and guidelines for emergencies.

6.1 GUIDELINES FOR PRE-EMERGENCY PLANNING AND TRAINING

Employees must read this health and safety plan and the appropriate site-specific addendum to this plan, and familiarize themselves with the information provided. Prior to project initiation, the SHSO will conduct a meeting with the field team members to review the provisions of this health and safety plan and to review the emergency response plan. Employees are required to have a copy of the emergency contacts and telephone numbers immediately accessible onsite and know the route to the nearest emergency medical services.

6.2 EMERGENCY RECOGNITION AND PREVENTION

Emergency conditions are considered to exist if:

- Any member of the field crew is involved in an accident or experiences any adverse effects or symptoms of exposure while onsite.
- A condition is discovered that suggests the existence of a situation more hazardous than anticipated (e.g. flammable atmospheres).
- Concentrations of combustible vapors reach or exceed 10 percent of the lower explosive limit (LEL).
- A fire or explosion hazard exists.
- Concentrations of organic vapors measured in the worker breathing zone by a photoionization detector (PID) are above background air concentrations greater than an amount equal to the lowest permissible exposure limit (PEL) of a contaminant of concern onsite.
- A vehicle accident occurs.

Preventive measures are listed below.

- Site workers must maintain visual contact and should remain close together to assist each other during emergencies. (Use the buddy system.)
- During continual operations, onsite workers act as safety backup to each other. Offsite personnel provide emergency assistance.
- All field crew members should make use of all of their senses to alert themselves to potentially dangerous situations to avoid (e.g., presence of strong and irritating or nauseating odors).
- Personnel will practice unfamiliar operations prior to performing them in the field.
- Field crew members will be familiar with the physical characteristics of investigations and field demonstrations, including:
 - Wind direction in relation to contamination zones;
 - Accessibility to co-workers, equipment, vehicles and communication devices;
 - Communication signals and devices;
 - Hot zone locations (areas of known or suspected contamination);
 - Site access; and
 - Nearest water sources.
- Personnel and equipment in the designated work area should be minimized, consistent with effective site operations.

The discovery of any condition that would suggest the existence of a situation more hazardous than anticipated, will result in the reevaluation of the hazard and the level of protection required, and may result in a temporary evacuation of the field team from the immediate work area. Such conditions may include an adverse effect or symptom of exposure experienced by a field team member, or the exceedance of the action levels for organic vapors and/or combustible vapors. If the action levels for organic vapors and/or combustibles are exceeded, procedures will be followed as stated in Section 7 of this health and safety plan.

In the event of an accident, the SHSO or site manager will complete the Accident Report Form provided in Appendix A. Copies of the completed forms will be maintained by the program health and safety manager in the health and safety file of the affected employee. Follow-up action should be taken to correct the situation that caused the accident.

Near-miss incidents will also be documented using the form provided in Appendix A, and filed with the onsite health and safety records, as well as with the program

health and safety manager. Near-miss incidents are defined as any incident which could have led to injury or property damage, but for whatever reason, did not. The assessment of near-miss incidents provides a better measure of safety program effectiveness than simply tracking accidents, since near-misses tend to occur at much higher frequencies than actual accidents.

6.3 PERSONNEL ROLES, LINES OF AUTHORITY, AND COMMUNICATION PROCEDURES DURING AN EMERGENCY

When an emergency occurs, decisive action is required. Rapidly made choices may have far-reaching, long-term consequences. Delays of minutes can create or exacerbate life-threatening situations. Personnel must be ready to respond to emergency situations immediately. All personnel will know their own responsibilities during an emergency, know who is in charge during an emergency, and the extent of that person's authority. This section outlines personnel roles, lines of authority, and communication procedures during emergencies.

In the event of an emergency situation at the site, the site manager will assume total control and will be responsible for onsite decision-making. The designated alternate for the site manager will be the SHSO. These individuals have the authority to resolve all disputes about health and safety requirements and precautions. They will also be responsible for coordinating all activities until emergency response teams (ambulance, fire department, etc.) arrive onsite.

The site manager and/or SHSO will ensure that the necessary USAF personnel, Parsons ES personnel, and agencies are contacted as soon as possible after the emergency occurs. All onsite personnel must know the location of the nearest phone and the location of the emergency phone number list.

6.4 EVACUATION ROUTES AND PROCEDURES, SAFE DISTANCES, AND PLACES OF REFUGE

In the event of emergency conditions, decontaminated employees will evacuate the area as instructed, transport decontaminated injured personnel, or take other measures to ameliorate the situation. Evacuation routes and safe distances will be decided upon and posted by the field team prior to initiating work.

6.5 DECONTAMINATION OF PERSONNEL DURING AN EMERGENCY

Procedures for leaving a contaminated area must be planned and implemented prior to going onsite. Decontamination areas and procedures will be established based on anticipated site conditions. If a member of the field crew is exposed to chemicals, the emergency procedures outlined below will be followed:

- Another team member (buddy) will assist or remove the individual from the immediate area of contamination to an upwind location.
- Precautions will be taken to avoid exposure of other individuals to the chemical.

- If the chemical is on the individual's clothing, the clothing will be removed if it is safe to do so.
- Administer first aid and transport the victim to the nearest medical facility, if necessary.

If uninjured employees are required to evacuate a contaminated area in an emergency situation, emergency decontamination procedures will be followed. At a minimum, these would involve moving into a safe area and removing protective equipment. Care will be taken to minimize contamination of the safe area and personnel. Contaminated clothing will be placed in plastic garbage bags or other suitable containers. Employees will wash or shower as soon as possible.

6.6 EMERGENCY SITE SECURITY AND CONTROL

For this project, the site manager (or designated representative) must know who is onsite and who is in the work area. Personnel access into the work area will be controlled. In an emergency situation, only necessary rescue and response personnel will be allowed into the exclusion zone.

6.7 PROCEDURES FOR EMERGENCY MEDICAL TREATMENT AND FIRST AID

6.7.1 Chemical Exposure

In the event of chemical exposure (skin contact, inhalation, ingestion) the following procedures will be implemented:

- Another team member (buddy) will assist or remove the individual from the immediate area of contamination to an upwind location.
- Precautions will be taken to avoid exposure of other individuals to the chemical.
- If the chemical is on the individual's clothing, the clothing will be removed if it is safe to do so.
- If the chemical has contacted the skin, the skin will be washed with copious amounts of water, preferably under a shower.
- In case of eye contact, an emergency eyewash will be used. Eyes will be washed for at least 15 minutes. Emergency eyewashes will comply with ANSI Z-358.1 and filled with tempered water maintained no cooler than 60°F and no warmer than 95°F. Eyewashes will be capable of delivering 0.4 to 0.8 gallons of water to both eyes for a minimum of 15 minutes. Each jobsite will have at least one emergency eyewash station. Each crew will have, at a minimum, an ANSI-approved personal eyewash suitable for initial eye flushing while the injured person is moved to an emergency eyewash station or medical facility.
- If necessary, the victim will be transported to the nearest hospital or medical center. If necessary, an ambulance will be called to transport the victim.

6.7.2 Personal Injury

In the event of personal injury:

- Field team members trained in first aid can administer treatment to an injured worker.
- The victim will be transported to the nearest hospital or medical center. If necessary, an ambulance will be called to transport the victim.
- The SHSO or site manager is responsible for the completion of the appropriate accident report form.

6.7.3 Fire or Explosion

In the event of fire or explosion, personnel will evacuate the area immediately. Administer necessary first aid to injured employees. Personnel will proceed to a safe area and telephone the emergency support services designated in the appropriate sit-specific addendum. Upon contacting the emergency support services, state your name, nature of the hazard (fire, high combustible vapor levels), the location of the incident, and whether there were any physical injuries requiring an ambulance. Do not hang up until the emergency support services personnel have all of the additional information they may require.

6.7.4 Emergency Contacts

In the event of any emergency situation or unplanned occurrence requiring assistance, the appropriate contacts should be made from the lists below. A list of emergency contacts must be posted at the site.

6.7.4.1 Emergency Contacts for Travis AFB

Contingency Contacts

All Emergency Services

Travis AFB Security

Poison Control Center

Site Contact: Glenn Anderson

60 AMW/EM

580 Hickam Avenue

Building 246

Travis AFB, CA 94535-2176

Telephone Number

911

(707)424-3293

(800)523-2222

(707)424-4359/3739

Medical Emergency

USAF Medical Center

Building 777

Travis AFB, CA

Telephone Number:

(707)424-7520

(707)424-7300 (Emergency Room)

Directions to the Base Hospital from Building 755

Turn left (east) on Ellis Drive and proceed to Ragsdale Street. Turn left (north) onto Ragsdale Street and continue to Hickam Avenue. Turn left onto Hickam Avenue and proceed west one-half mile. The hospital is on the north side of Hickam Avenue and 1,000 feet west of Parker Road. The emergency room is on the southwest corner of Building 777.

6.7.4.1 Emergency Contacts for Altus AFB

Contingency Contacts

Telephone Number

All Emergency Services

911

Site Contact: Dan Staton
97th CES/CEVR
401 L Avenue
Building 396
Altus AFB, OK 73523

(580)481-7346

Medical Emergency

Telephone Number:

Altus AFB Hospital
Building 46
North of B Avenue between Altus Road
(emergency entrance) and 1st Street (main
entrance)
Altus AFB, Altus, OK

911 or (580)481-5970

Directions to the Base Hospital from Site 17

Turn left (west) onto Ordinance Road and follow the road through the turns and curves. Ordinance Road becomes 1st Street which continues through the circle at the main entrance to the base. Continue on 1st Street to the hospital which is on the left (west) side of the street.

6.7.4.3 Parsons ES Contracts

Contact

Telephone Number

Bill Plaehn
Project Manager

(303)764-8729 (work)
(303)465-0438 (home)

Tim Mustard, CIH
Program Health and Safety Manager

(303)764-8810 (work)
(303)450-9778 (home)

Ed Grunwald, CIH
Corporate Health and Safety Manager

(678)969-2394 (work)
(404)299-9970 (home)

Judy Blakemore
Assistant Program Health and Safety Manager

(303)764-8861 (work)
(303)828-4028 (home)
(303)817-9743 (mobile)

SECTION 7

LEVELS OF PROTECTION AND PERSONAL PROTECTIVE EQUIPMENT REQUIRED FOR SITE ACTIVITIES

7.1 PERSONAL PROTECTIVE EQUIPMENT

The personal protection level prescribed for the phytostabilization demonstrations is OSHA Level D (no respiratory or chemical protective clothing), with a contingency for the use of OSHA Level C or B as site conditions require (Figure 7.1). Unless certain compounds are ruled out through use of appropriate air monitoring techniques such as Dräger® tubes, portable sampling pumps, or an onsite gas chromatograph (GC), Level C respiratory protection (air-purifying respirator [APR]) cannot be used. Level C protection may only be used on this project when vapors in air are adequately identified and quantified and Level C respirator-use criteria are met. Level B (supplied air) respiratory protection must be used on this project in the presence of unknown vapor constituents or if benzene is detected at or above 1 part per million, volume per volume (ppmv). This is based on the toxicity and warning properties (high odor threshold) for benzene. Air monitoring must be conducted in the worker breathing zone when the potential occurrence of these compounds exists.

Ambient air monitoring of organic gases/vapors (using photoionization detectors such as an HNU® or Photovac® MicroTIP®, or by colorimetric analysis with Dräger® tubes) will be used to select the appropriate level of personal protection. The flow chart presented in Figure 7.1 will be used to select respiratory protection against volatile hydrocarbon constituents. If the portable air monitoring equipment indicates organic vapor concentrations of 0-5 meter units (mu), site workers will continue air monitoring in a Level D ensemble. If organic vapors reach 5-25 mu for more than 30 seconds, and benzene concentrations exceed 1 ppmv, site workers will evacuate the area or upgrade to Level B ensemble, if trained to do so. If benzene concentrations are less than 1 ppmv in the breathing zone, and vapors are in the range of 5-25 mu, the site crews may continue in Level D ensembles with periodic air monitoring. If organic vapor concentrations reach 25-50 mu for more than 30 seconds and benzene concentrations exceed 1 ppmv in the worker breathing zone, site crews will evacuate the area or upgrade to Level B ensembles. If benzene concentrations are less than 1 ppmv, and vapors are in the range of 25-50 mu, site workers will don full facepiece APRs equipped with organic vapor cartridges (National Institute for Occupational Safety and Health [NIOSH]-approved), and continue periodic monitoring. If organic vapor concentrations reach 50-500 mu for more than 30 seconds, site crews will evacuate the site or upgrade to Level B ensembles. If organic vapor concentrations exceed 500 mu for more than 30 seconds, site crews will evacuate the site.

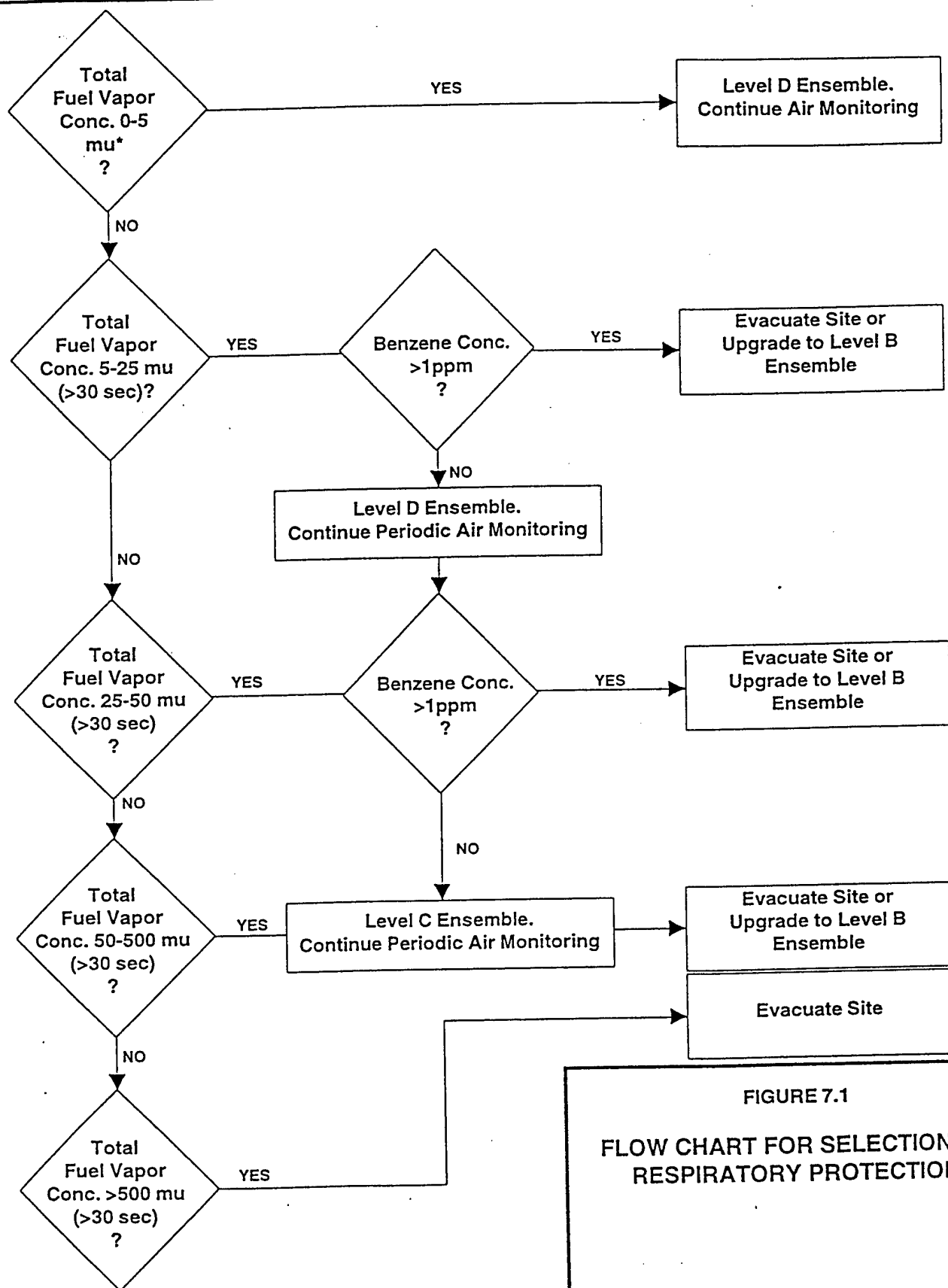


FIGURE 7.1
FLOW CHART FOR SELECTION OF
RESPIRATORY PROTECTION

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Denver, Colorado

* mu = Meter Units

For respiratory protection against chlorinated compounds at Travis and Altus AFBs, the procedures below will be followed.

A reading of 1 part per million (ppm) above background in the worker breathing zone as indicated by a photoionization detector (PID) will require the use of a Dräger® tube or the equivalent to determine if vinyl chloride is present at a concentration greater than or equal to the permissible exposure limit (PEL) of 1 ppm. Due to the inadequate warning properties of vinyl chloride, Level B protection must be used if concentrations of vinyl chloride exceed 1 ppm above background in the worker breathing zone.

Similarly, a reading of 2 ppm above background in the worker breathing zone will require the use of Dräger® tubes or the equivalent to determine if carbon tetrachloride and/or chloroform are/is present. Level B protection must also be used if concentrations of carbon tetrachloride and/or chloroform meet or exceed 2 ppm above background in the worker breathing zone.

Based on previous investigations at Travis and Altus AFBs, the contaminants of concern are not expected to pose an inhalation problem. However, since there are no Dräger® tubes for 1,2-dichloroethane, 1,1-dichloroethene, and 2-hexanone (Travis AFB only), the following will occur. If sustained air monitoring readings in the worker breathing zone indicate vapor concentrations greater than or equal to 1 ppm above background for 30 seconds or longer, the field crew will be forced to evacuate and ventilate the area until readings are less than 1 ppm in the worker breathing zone. If ventilation is inadequate, air samples will be taken to confirm or deny the existence of the contaminants of concern and/or the crew will upgrade to Level B respiratory protection. These air samples will be sent to a lab to be analyzed by Environmental Protection Agency (EPA) Compendium Method TO-14 or the equivalent.

Periodic testing of vapor concentrations for the presence of vinyl chloride will be performed if concentrations persist above 1 ppm above background in the worker breathing zone, as indicated by the PID.

Before work can be performed in Level B respiratory protection, the project manager must be notified. He will initiate the change order process with the USAF or decide to halt activities at that site. (Level B operations require approval from Parsons ES corporate health and safety.) The SHSO will determine whether it is safe to continue activities without respiratory protection or assign an upgrade to Level C protection.

The use of PPE will be required when handling contaminated samples and working with potentially contaminated materials. The SHSO must ensure that all field personnel are properly trained in use, maintenance, limitations (including breakthrough time), and disposal of PPE assigned to them, in accordance with federal OSHA regulations in 29 CFR 1910.132. Disposable PPE will be used whenever possible to simplify decontamination, to reduce generation of contaminated washwater, and to avoid potential problems with chemical permeation (breakthrough). Single-use PPE (such as Tyvek®) will be disposed of whenever personnel go through decontamination. At most, a single item of disposable PPE (including respirator cartridges) will be used for no more than one day and will then be disposed of. Double layers of gloves will be

used when personnel are handling contaminated soil or water, or equipment to minimize breakthrough. If personnel note chemical odors on their hands, clothing or skin after wearing PPE, or develop skin irritation or rashes, consult with the SHSO and decide on alternate actions and/or seek medical attention.

Hard hats will be worn in the vicinity of the auger drilling rig and Geoprobe® unit. Steel-toed, steel-shank leather workboots will be worn by all field personnel.

The following personal protective ensemble is required only when handling contaminated samples or equipment.

Mandatory Equipment

- Vinyl or latex inner gloves
- 4H or SilverShield® outer gloves

Optional Equipment

- Air-purifying respirator (equipped with organic vapor/high-efficiency particulate air [HEPA] cartridges)
- Self-contained breathing apparatus or air-line respirator in pressure-demand mode
- Rubber safety boots
- Disposable Tyvek® coveralls
- Outer disposable boot covers
- Saranex® suits
- Chemical goggles

7.2 EQUIPMENT NEEDS

Each field team will have the following items readily available:

- Copy of this program health and safety plan, site-specific addendum, and a separate list of emergency contacts;
- First aid kit which includes PPE for bloodborne pathogens;
- Eyewash bottle;
- Paper towels;
- Duct tape;
- Water (for drinking and washing);
- Plastic garbage bags;
- Fire extinguisher; and
- Earplugs.

7.3 EQUIPMENT DISPOSAL

All reusable PPE (such as hard hats and respirators), if contaminated, will be decontaminated in accordance with procedures specified in Section 10 of this health and safety plan. Contaminated single-use PPE (such as Tyvek® suits and protective gloves) will be properly disposed of according to USAF requirements.

SECTION 8

FREQUENCY AND TYPES OF AIR MONITORING

Air monitoring will be used to identify and quantify airborne levels of hazardous substances. Periodic monitoring is required during on site activities. The types of monitoring and equipment to be used are as follows:

<u>Type of Equipment</u>	<u>Minimum Calibration Frequency</u>	<u>Parameter(s) to be Measured</u>	<u>Minimum Sampling Frequency</u>	<u>Sampling Locations</u>
Photoionization Detector	1/day	Benzene Organic Vapors	2/hour for general site activities	Breathing Zone
Explosivity Meter	1/day	Combustible Gases	2/hour	Soil Borings Monitoring Wells
Sensidyne® or Drager® Tubes	None (check manufacturer's requirements)	Benzene Organic Vapors	When PID exceeds lowest PEL of the contaminants of concern	Breathing Zone
Dosimeter Badges	None	Benzene Organic Vapors	As needed on workers with greatest exposure to contamination initially detected by Drager® tubes	Breathing Zone
Portable Air Sampling Pumps	Prior to and after each use	Benzene Organic Vapors	As needed on workers with greatest exposure to contamination initially detected by Drager® tubes	Breathing Zone

During phytostabilization demonstration activities, a photoionization detector (such as an HNU® or MicroTIP®) with a 11.7 electron volt (eV) (HNU®) or equivalent will

be used to measure ambient air concentrations in the worker breathing zone. The size of the PID lamp was determined based on the ionization potential of the contaminants.

Evacuation may be necessary if the lowest PEL of a contaminant of concern is exceeded above background in the breathing zone of the site workers. This evacuation will be necessary until the area is well ventilated or the respiratory protection is upgraded, if possible. Any detectable concentration above background concentrations in the breathing zone will necessitate following the respiratory protection flowchart (Figure 7.1). The explosivity meter will be used at last twice per hour to measure combustible gas levels at the wellhead or borehole when a potential exists for combustible vapors. During drilling or other intrinsic activities in former or existing landfill areas, monitoring with an explosivity meter will be performed at the ground surface and in the worker breathing zone. At 10 percent of the LEL, evacuate the area and allow the borehole to ventilate.

Worker exposure monitoring will be conducted to document any exposures of Parsons ES site personnel to organic vapors. Portable air sampling pumps or dosimeter badges will be used for personal exposure monitoring, if necessary. The following general protocols will be followed if badges or pumps are used.

Passive Dosimeter Badges

An organic vapor monitoring badge will be attached in the worker's breathing zone for an eight-hour period when the potential for exposure exists. The exposed badges and a blank will be sent to the laboratory for analysis. These personal dosimeter badges work by means of diffusion eliminating the need for a pump, calibration or batteries.

Portable Sampling Pumps

- The portable pump will be calibrated to the required flow rate (in liters per minute) following the manufacturer's calibration procedures.
- The pump will be equipped with the appropriate sorbent tube for the particular organic compounds to be monitored (e.g., charcoal for volatile organics).
- A personal air monitoring data sheet (provided in Appendix A) listing pump flow rates, start and stop times, sorbent tube used, etc. will be completed.
- The pump will undergo a post calibration to determine final flow rates.
- The laboratory analytical results will be disclosed to the employee(s) monitored.
- The analytical results will be placed in the employee's permanent medical file for documentation of any exposures received.

SECTION 9

SITE CONTROL MEASURES

The following site control measures will be followed to minimize potential contamination of workers, protect the public from potential site hazards, and control access to the sites. Site control involves the physical arrangement and control of the operation zones and the methods for removing contaminants from workers and equipment. The first aspect, site organization, is discussed in this section. The second aspect, decontamination, is considered in the next section.

9.1 SITE ORGANIZATION-OPERATION ZONES

The following organization-operation zones will be established on the site or around a particular site feature (e.g., the drill rig).

- Exclusion Zone (Contamination Zone),
- Contamination Reduction Zone, and
- Support Zone.

The site manager and/or SHSO will be responsible for establishing the size and distance between zones at the site or around the site feature. Considerable judgment is required to ensure safe working distances for each zone are balanced against practical work considerations.

9.1.1 Exclusion Zone (Contamination Zone)

The exclusion zone includes the areas where active investigation or cleanup operations take place. Within the exclusion zone, prescribed levels of PPE must be worn by all personnel. The hotline, or exclusion zone boundary, is initially established based upon the presence of actual wastes or apparent spilled material, or through air monitoring, and is placed around all physical indicators of hazardous substances. For drilling operations, the hotline will be located at a distance equal to the drilling rig boom height or 25 feet, whichever is greater, from the drill rig. For backhoe operations, the hotline will be located at a distance from the backhoe equal to the limits of the swing radius. The hotline will consist of an easily identifiable physical boundary (e.g., cones or bright orange or yellow flagging attached to stakes, and may be readjusted based upon subsequent observations and measurements. This boundary will be physically secured and posted or well-defined by physical and geographic boundaries.

Under some circumstances, the exclusion zone may be subdivided into zones based upon environmental measurements or expected onsite work conditions.

9.1.2 Contamination Reduction Zone

If decontamination is required, a contamination reduction zone will be established between the exclusion zone and the support zone. This zone provides an area to prevent or reduce the transfer of hazardous materials which may have been picked up by personnel or equipment leaving the exclusion area. All decontamination activities occur in this area. The organization of the contamination reduction zone, and the control of decontamination operations, are described in Section 10.

9.1.3 Support Zone

The support zone is the outermost area of the site and is considered a noncontaminated or clean area. The support zone contains the command post for field operations, first-aid stations, and other investigation and cleanup support. Normal work clothes are appropriate apparel within this zone; potentially contaminated personnel, clothing or equipment are not permitted.

9.2 SITE SECURITY

Site security is necessary to prevent exposure of unauthorized, unprotected individuals in the work area. The areas immediately surrounding the work area will be clearly marked through use of warning signs, traffic cones, barrier tape, rope, or other suitable means.

Site security will be enforced by the SHSO or a designated alternate who will ensure that only authorized personnel are allowed in the work area and that entry personnel have the required level of PPE, are trained under the requirements of 29 CFR 1910.120, and are on a current medical monitoring program.

9.3 SITE COMMUNICATION

Internal site communication is necessary to alert field team members in the exclusion and contamination reduction zones to:

- Emergency conditions;
- To convey safety information; and
- Communicate changes or clarification in the work to be performed.

For internal site communication, the field team members will use prearranged hand signals (and responses). Radios and/or compressed air horns may also be used for communication.

External site communication is necessary to coordinate emergency response teams and to maintain contact with essential offsite personnel. A telephone will be available

for use in external site communication. A list of emergency contact telephone numbers will be provided in subsequent addenda.

9.4 SAFE WORK PRACTICES

To ensure a strong safety-awareness program during field operations, field personnel will be adequately trained for their particular tasks. In addition, standing work orders will be developed and communicated to all field personnel, as will the provisions of this program health and safety plan and the appropriate addenda. Sample standing work orders for personnel entering the contamination reduction zone and exclusion zone are as follows:

- No smoking, eating, drinking or chewing of tobacco or gum;
- No matches or lighters;
- No personal vehicles;
- Check in/check out at access control points;
- Use the buddy system;
- Wear appropriate PPE;
- Avoid walking through puddles or stained soil;
- Upon discovery of unusual or unexpected conditions, immediately evacuate and reassess the site conditions and health and safety practices;
- Conduct safety briefings prior to onsite work;
- Conduct daily safety meetings; and
- Take precautions to reduce injuries resulting from heavy equipment and other tools.

SECTION 10

DECONTAMINATION PROCEDURES

10.1 PERSONNEL DECONTAMINATION PROCEDURES

An exclusion zone, contamination reduction zone, and support zone will be established whenever field personnel are using PPE. Decontamination station layout will be made on a site-specific basis and will be based on the level of PPE used, the types of chemical hazards encountered, and the site conditions, including topography, wind direction, and traffic patterns. Defined site access and egress points will be established and personnel will enter and exit only through these points. As a general rule, persons assisting in the decontamination station may be in one level lower of respiratory protection than required in the work zone.

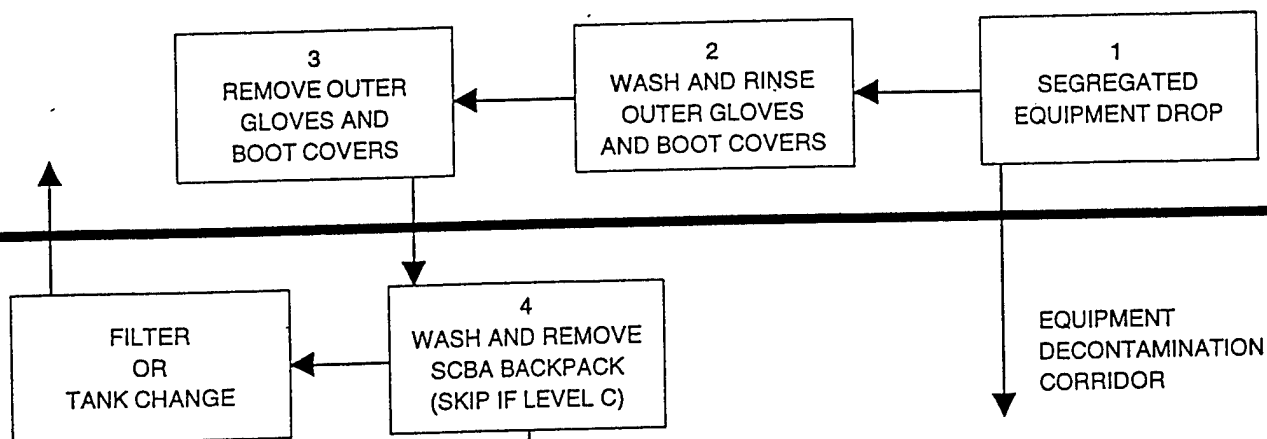
A guideline for personnel decontamination is presented in Figure 10.1. This procedure may be modified by the SHSO if necessary.

If personnel are in Level D-modified protection (no respirator but using protective gloves and/or suits and other equipment), a portable decontamination station will be set up at the site. The decontamination station will include provisions for collecting disposable PPE (e.g., garbage bags); washing boots, gloves, vinyl rain suits, field instruments and tools; and washing hands, face, and other exposed body parts. Onsite personnel will shower at the end of the work day. Refuse from decontamination will be properly disposed of in accordance with USAF installation protocols.

Decontamination equipment will include:

- Plastic buckets and pails;
- Scrub brushes and long-handle brushes;
- Detergent;
- Containers of water;
- Paper towels;
- Plastic garbage bags;
- Plastic or steel 55-gallon barrels;
- Distilled water; and
- An eyewash station.

EXCLUSION ZONE



WIND DIRECTION

CONTAMINATION REDUCTION ZONE

SUPPORT ZONE

FIGURE 10.1

DECONTAMINATION
STATION LAYOUT
LEVEL B AND C PROTECTION

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10.2 DECONTAMINATION OF EQUIPMENT

Decontamination of drilling rigs will be conducted at a designated location. High-pressure steam-cleaning of the rig will be necessary prior to the beginning of the drilling operation, between borehole locations, and before the drilling rig leaves the project site. All sampling equipment will be decontaminated prior to use, between samples, and between sampling locations.

SECTION 11

AIR MONITORING EQUIPMENT USE AND CALIBRATION PROCEDURES

11.1 PHOTOVAC MICROTIP® AIR ANALYZER

The MicroTIP® is a direct-reading instrument used in conjunction with the span gas kit. To calibrate the MicroTIP® press the power switch. Allow the MicroTIP® to warm up; the display will read Ready. Press the calibration switch; the display will read Connect zero gas then press enter. Connect the bag of zero gas to the MicroTIP® inlet (or allow the MicroTIP® to sample clean air) and press enter; the display will read Calibrating now please wait. The display will then read "Span Conc.?" Enter the span concentration (usually 100 ppmv isobutylene). Connect the bag of span gas to the tip inlet and press enter; the display will read Connect span gas then press enter. The MicroTIP® will then calibrate. When the display reads Ready, the MicroTIP® has completed the calibration and is ready for use. Repeat the calibration daily.

To use the MicroTIP®, press the power switch and wait for the instrument to display the date, time, event number, current detected concentrations, and instrument status ready. The minimum, maximum, and average concentrations measured in each 15-second period are automatically recorded in memory. The keyboard also allows for direct numeric entry.

Since a calibration gas (i.e., isobutylene) is used which typically differs from the contaminants of concern, it may be necessary to combine the instrument reading with a response factor to more closely approximate the concentration of the contaminants of concern.

Relative response factors are found in Table 11.1 for MicroTIP® models MP-100 and HL-200 with a 10.6 eV lamp. For these instruments, a more accurate concentration may be obtained by dividing the instrument reading by the appropriate relative response factor from Table 11.1 for the contaminant of concern.

For MicroTIP® instrument models MP-1000, HL-2000, IS-3000, and EX-4000 with a 10.6 eV lamp, the instrument reading is multiplied by the appropriate response factor from Table 11.2 for the contaminant of concern.

TABLE 11.1
MICROTIP® RELATIVE RESPONSE FACTORS (10.6 eV LAMP)
INSTRUMENT MODELS MP-100 & HL-200

Compound	Relative Response Factor	Compound	Relative Response Factor
Acetaldehyde	0.17	Hydrogen Sulfide	0.25
Acetic Acid	0.09	Isobutyl Acetate	0.52
Acetone	0.86	Isobutyraldehyde	1.02
Acetone Cyanohydrin	0.93	Isopentane	0.12
Acrolein	0.28	Isoprene	2.12
Allyl Chloride	0.26	Isopropyl Acetate	0.43
Ammonia	0.10	Isopropyl Alcohol	0.23
Benzene	1.78	Methyl Bromide	0.45
1,3-Butadiene	1.43	Methyl tert-Butyl Ether	1.22
n-Butanol	0.27	Methyl Ethyl Ketone	1.10
see-Butanol	0.36	Methyl Isobutyl Ketone	0.87
n-Butyl Acetate	0.35	Methyl Mercaptan	1.60
n-Butyl Acrylate	0.53	Methyl Methacrylate	0.67
n-Butyl Mercaptan	1.36	Monoethylamine	1.25
n-Butylaldehyde	0.65	Monomethylamine	1.06
Carbon Disulfide	0.65	n-Octane	0.39
Chlorobenzene	2.24	n-Pentane	0.09
Cyclohexane	0.53	Perchloroethylene	1.40
Cyclohexanone	1.11	n-Propyl Acetate	0.31
1,2-Dichlorobenzene (ortho)	2.25	n-Propyl Alcohol	0.18
cis-1,2-Dichloroethylene	1.20	Propionaldehyde	0.56
trans-1,2-Dichloroethylene	2.21	Propylene	0.87
Diisobutylene	2.10	Propylene Oxide	0.13
1,4-Dioxane	0.83	Styrene	2.20
Epichlorohydrin	0.11	Tetrahydrofuran	0.65
Ethyl Alcohol	0.13	Toluene	1.91
Ethyl Acetate	0.25	Trichloroethylene	1.61
Ethyl Acrylate	0.30	Trimethylamine	1.35
Ethylene	0.09	Vinyl Acetate	0.84
Ethyl Mercaptan	1.82	Vinyl Bromide	2.24
Furfuryl Alcohol	1.43	Vinyl Chloride	0.51
n-Heptane	0.27	Vinylidene Chloride (1,1-DCE)	1.16
n-Hexane	0.20		

Note: Concentration = $\frac{\text{Instrument Reading}}{\text{Relative Response Factor}}$

TABLE 11.2
MICROTIP® RESPONSE FACTORS (10.6 eV LAMP)
INSTRUMENT MODELS MP-1000, HL-2000, IS-3000 & EX-4000

Compound	Response Factor	Compound	Response Factor
Acetaldehyde	6.6	n-Hexane	5.6
Acetic Acid	18.9	Hydrogen Sulfide	3.7
Acetone	1.2	Isobutyl Acetate	2.3
Acetone Cyanohydrin	1.2	Isobutyraldehyde	1.1
Acrolein	3.7	Isopentane	7.8
Allyl Chloride	4.3	Isoprene	0.6
Ammonia	10.1	Isopropyl Acetate	2.4
Benzene	0.6	Isopropyl Alcohol	4.5
1,3-Butadiene	0.7	Methyl Bromide	2.3
n-Butanol	4.6	Methyl tert-Butyl Ether	0.8
see-Butanol	3.0	Methyl Ethyl Ketone	0.9
n-Butyl Acetate	2.9	Methyl Isobutyl Ketone	1.1
n-Butyl Acrylate	1.9	Methyl Mercaptan	0.6
n-Butyl Mercaptan	0.7	Methyl Methacrylate	1.5
n-Butylaldehyde	1.9	Monoethylamine	0.8
Carbon Disulfide	1.4	Monomethylamine	1.0
Chlorobenzene	0.4	n-Octane	2.6
Cyclohexane	1.9	n-Pentane	10.8
Cyclohexanone	0.9	Perchloroethylene	0.7
1,2-Dichlorobenzene (ortho)	0.4	n-Propyl Acetate	3.5
cis-1,2-Dichloroethylene	0.8	n-Propyl Alcohol	6.3
trans-1,2-Dichloroethylene	0.4	Propionaldehyde	1.9
Diisobutylene	0.6	Propylene Oxide	7.1
Dimethylamine	1.5	Styrene	0.5
Di-n-propylamine	0.5	Tetrahydrofuran	1.5
1,4-Dioxane	1.2	Toluene	0.5
Epichlorohydrin	10.3	Trichloroethylene	0.6
Ethanol	11.1	Trimethylamine	0.9
Ethyl Acetate	4.2	Vinyl Acetate	1.2
Ethyl Acrylate	3.3	Vinyl Bromide	0.4
Ethylene	10.0	Vinyl Chloride	2.0
Ethyl Mercaptan	0.6	Vinylidene Chloride (1,1-DCE)	0.9
n-Heptane	3.7		

Note: Concentration = Instrument Reading x Response Factor

11.2 HNU® PHOTOIONIZATION DETECTOR

To calibrate the HNU®, turn the function switch to the standby mode and use the zero control to zero the instrument. Connect a bag of span gas (usually 100 ppmv isobutylene). Turn the function switch to the 0-200 range position and adjust the span control setting to read the ppmv concentration of the standard. Recheck the zero setting as previously described. If readjustment is needed, repeat the calibration step. This provides a two-point calibration to zero and the gas-standard point. Repeat the calibration daily. If the span setting from calibration is 0.0 or if calibration cannot be achieved, then the lamp must be cleaned.

To use the HNU® connect the probe to the instrument by matching the alignment slot in the probe connector to the key in the 12-pin connector on the control panel. Twist the probe connector until a distinct snap and lock is felt. Turn the function switch to battery check position. The needle should read within or above the green battery arc on the scale plate. If the needle is in the lower position of the battery arc, the instrument should be recharged before use. If the red light comes on, the battery ®

11.3 EXPLOSIVITY METER

An explosivity meter is used to measure oxygen and combustible gas levels. The instrument provides characteristic warning signals when deficient oxygen conditions or unacceptable levels of combustible gas are detected.

To use the explosivity meter, turn the unit on and wait a few seconds for the readings to stabilize. Check the battery charge and the alarms before using the instrument. Set the LEL indicator to zero and the oxygen indicator to 20.9 percent.

To calibrate the instrument, attach a bag, bulb or balloon of span gas and wait for the readings to stabilize. Adjust the instrument to read the LEL percent of the calibration gas. Remove the span gas and allow the instrument to exhaust. The combustible sensor will read 000-percent LEL in clean air.

11.4 SENSIDYNE® OR DRÄGER® COLORIMETRIC GAS ANALYSIS TUBES

Colorimetric tubes can be used to give an instantaneous reading of various organic compounds. Their aim is to determine very small concentrations of a compound in the shortest amount of time. To sample with a colorimetric tube use the Dräger® or Sensidyne® bellows pump and select the appropriate tube (for example, a tube marked benzene to look for benzene). Break off both ends on the pump's break-off plate. Insert the tube into the pump head (the tube should be inserted with the arrow pointing towards the pump). There is a specific number of suction strokes for each tube/compound. Each box of tubes will have instructions for how many suction strokes are required for that compound.

APPENDIX A
PROJECT HEALTH AND SAFETY FORMS

PLAN ACCEPTANCE FORM

PROJECT HEALTH AND SAFETY PLAN

Instructions: This form is to be completed by each person to work on the subject project work site and returned to the safety manager.

I have read and agree to abide by the contents of the Health and Safety Plan for the following project:

Signed

Date

RETURN TO:

Office Health and
Safety Representative
Parsons Engineering Science, Inc.
1700 Broadway, Suite 900
Denver, CO 80290

SITE SPECIFIC TRAINING RECORD

Project: _____

Project No.: _____

Date: _____

Trainer: _____

On this date, the following individuals were provided site-specific training in accordance with OSHA regulations contained in 29CFR1910.120(e):

Name (Print)

Employee No.

Employee Signature

Forward this form to:

Office Health and Safety Representative
Parsons Engineering Science, Inc.
1700 Broadway, Suite 900
Denver, Colorado 80290

PARSONS ENGINEERING SCIENCE, INC.

FIELD EXPERIENCE DOCUMENTATION FORM

OSHA requires (29CFR1910.120(e)) that personnel involved in hazardous waste operations have 40-hours of initial training and a minimum of three days field experience working under the direction of a trained and experienced supervisor. This form serves to document the three days of additional field training/experience.

Employee Name: _____

Employee Number (or Social Security No.): _____

Project Name(s): _____

Project Number(s): _____

Dates of Field Training: _____

Summary of Activities Performed: _____

Levels of Respiratory Protection Used: _____

Comments:

Field Supervisor Signature: _____

Date: _____

Return this form to the Office Health and Safety Representative

LOG

DATE OF INVESTIGATION:

[illegible]

APR Performance Comments:

Project H&S Officer
or
Parsons ES Project Manager

Date _____

Return to the Office Health and Safety Representative
at the Completion of field activities.

LOG

LOCATION:

DATE OF INVESTIGATION:

[illegible][illegible]

SAR Performance Comments:

Project H&S Officer
or
Parsons ES Project Manager

Date _____

Return to Office Health and Safety Representative at the completion of field activities.

LOG

DATE OF INVESTIGATION:

[illegible]

SCBA Performance Comments:

Project H&S Officer
or
Parsons ES Project Manager

Date _____

Return to Office Health and Safety Representative
at the completion of field activities.

Project: _____

EMPLOYER

1. Name: _____
2. Mail Address: _____
(No. and Street) (City or Town) (State and Zip)
3. Location (if different from mail address): _____

INJURED OR ILL EMPLOYEE

4. Name: _____ Social Security No.: _____
(first) (middle) (last)
5. Home Address: _____
(No. and Street) (City or Town) (State and Zip)
6. Age: _____ 7. Sex: male () female ()
8. Occupation: _____
(specific job title, ~~not~~ the specific activity employee was performing at time of injury)
9. Department: _____
(enter name of department in which injured person is employed, even though they may have been temporarily working in another department at the time of injury)

THE ACCIDENT OR EXPOSURE TO OCCUPATIONAL ILLNESS

10. Place of accident or exposure: _____
(No. and Street) (City or Town) (State and Zip)
11. Was place of accident or exposure on employer's premises? Yes () No ()
12. What was the employee doing when injured? _____
(be specific--was employee using tools or equipment
or handling material?)

13. How did the accident occur? _____
(describe fully the events that resulted in the injury or occupational illness.
Tell what happened and how. Name objects and substances involved. Give details on all factors that led to
accident. Use separate sheet for additional space).

14. Time of accident: _____

15. ES WITNESS TO
ACCIDENT

(Name)

(Affiliation)

(Phone No.)

(Name)

(Affiliation)

(Phone No.)

(Name)

(Affiliation)

(Phone No.)

OCCUPATIONAL INJURY OR OCCUPATIONAL ILLNESS

16. Describe injury or illness in detail; indicate part of body affected:

17. Name the object or substance that directly injured the employee. (for example, object that struck employee; the vapor or poison inhaled or swallowed; the chemical or radiation that irritated the skin; or in cases of strains, hernias, etc., the object the employee was lifting, pulling, etc.).

18. Date of injury or initial diagnosis of occupational illness: _____ (date)

19. Did the accident result in employee fatality? Yes () No ()

20. Number of lost days ____/restricted workdays ____ resulting from injury or illness?

OTHER

21. Name and address of physician: _____
(No. and Street) (City or Town) (State and Zip)

22. If hospitalized, name and address: _____
(No. and Street) (City or Town) (State and Zip)

Date of report: _____ Prepared by: _____

Official position: _____

“NEAR MISS” INCIDENT INVESTIGATION REPORT FORM

- 1) Project name and number: _____
- 2) “Near miss” location: _____
- 3) Incident date and time: _____
- 4) Personnel present (optional): _____
- 5) Describe incident: _____

- 6) What action or condition contributed to incident? _____

- 7) What action was taken or suggested to prevent reoccurrence? _____

- 8) Comments _____

- 9) Date of report _____ Prepared by _____
- 10) Office health and safety representative review:

Signature

Date

PARSONS ENGINEERING SCIENCE
SHIPPING PAPER

Shipping Paper No.:_____

Page 1 of

Parsons Engineering Science

Date: _____

(name of carrier)

[illegible]

PLACARDS TENDERED: yes ☐ no ☐

I HEREBY DECLARE THAT THE CONTENTS OF THIS CONSIGNMENT ARE FULLY AND ACCURATELY DESCRIBED ABOVE BY PROPER SHIPPING NAME AND ARE CLASSIFIED, PACKED, MARKED, AND LABELED, AND ARE IN ALL RESPECTS IN PROPER CONDITION FOR TRANSPORT ACCORDING TO THE APPLICABLE INTERNATIONAL AND NATIONAL GOVERNMENT REGULATIONS.

Name and Title of Shipper	Place and date
Emergency Telephone Number CHEM-TEL, 800/255-3924	Signature of Shipper

ATTACH MATERIAL SAFETY DATA SHEETS

Date: _____

Project No.: _____

Name(s): _____

[illegible]

PROJECT NAME: _____

PROJECT NUMBER: _____

[illegible]Other

Model_____	Model_____	Model_____
Serial #_____	Serial #_____	Serial #_____
Cal. * Gas_____	Cal Gas_____	Cal Gas_____
Cal. Reading_____	Cal. Reading_____	Cal. Reading_____
BG Reading_____	BG Reading_____	BG Reading_____

* Cal = Calibration
**BG = Background

PARSONS ENGINEERING SCIENCE, INC.
DAILY VEHICLE INSPECTION REPORT

☐ = OK

☒ = Adjustment Made

☐ R = Repair Needed

Date: _____

Time: _____

License Plate Number: _____

Vehicle Make and Type: _____

Rental Agency _____

General Vehicle Inspection:

- | | | | |
|---------------------|--------------------------|------------------------|--------------------------|
| 1. Windshield | ☐ | 3. Vehicle Interior | ☐ |
| 2. Vehicle Exterior | ☐ | 4. Leaks under Vehicle | ☐ |

Check that the following are in proper working order:

1. Lights:

- | | |
|--------------------|--------------------------|
| a. Headlights | ☐ |
| b. Taillights | ☐ |
| c. Turn Signals | ☐ |
| d. Brake Lights | ☐ |
| e. Back-up Lights | ☐ |
| f. Interior Lights | ☐ |

- | | |
|---|--------------------------|
| 2. Brakes | ☐ |
| 3. Horn | ☐ |
| 4. Tires properly inflated (refer to sticker on door or vehicle manual) | ☐ |
| 5. Spare tire present and properly inflated | ☐ |
| 6. Windshield wipers | ☐ |
| 7. Windshield washers | ☐ |
| 8. Defrosters/Defoggers | ☐ |
| 9. Battery terminals free of corrosion | ☐ |
| 10. Cooling system hoses | ☐ |
| 11. Belts | ☐ |

12. Fluid levels: (Circle approximate level)

- | | | |
|--|--------------------|-------------------|
| a. Oil: Full | 1 Quart low | Does not register |
| b. Coolant: Full cool | Needs some coolant | Does not register |
| c. Transmission: Full | 1 Pint low | Does not register |
| (NOTE: Check transmission fluid while vehicle is running!) | | |
| d. Fuel: | E 1/4 1/2 3/4 F | |

Please note any problems, unusual conditions, repairs made or fluids added (except fuel):

APPENDIX E

MONITORING X™ MONITORING SYSTEM

MonitorX[™] Monitoring System



MEASURETEK

P.O. Box 1717 Corvallis, Oregon 97339

Ph: (541) 757-8564 Fax: (541) 753-5754

E-Mail: products@measuretek.com

MonitorXTM Monitoring System

May 3, 1999

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Section 1: Introduction

1.1 Welcome

Welcome to the MonitorX™ monitoring system by MeasureTek. Combining high quality components with user-friendly software, the MonitorX system is designed to give you years of useful data and information at your fingertips.

Your MonitorX system consists of the following three components:

- LARGE MonitorX Monitoring Station
- Sensors:
 - (8) Watermark soil moisture sensors.
 - (2) Druck pressure transducers.
 - (2) Dynagage® sap flow sensors.
 - (1) Soil Temperature sensor.
- Software:
 - *Connect* + software for data collection.
 - *ResultX Lite Database* software for data storage and analysis.

1.2 System Expansion

Not all of the features of the monitoring system are being utilized.

The system can monitor up to 16 Watermarks although only 8 are being utilized. The sixteen Watermark ports are located in the RemoteX expansion box.

The system could be expanded to monitor any or all of the following parameters: air temperature, relative humidity, solar radiation, wind speed and rain. All of these sensors (less the raingage) would be required to monitor potential evapotranspiration.

Section 2: Equipment List

2.1 LARGE MonitorX Monitoring Station

- MonitorX-10 Processor:
 - Campbell Scientific CR10X Datalogger
- RemoteX Remote Expansion Module:
 - Campbell Scientific AM416 Multiplexer
- Power Supply:
 - Solarex MSX10 10-Watt Solar Panel
 - SunSaver-6 Voltage Regulator
 - 12V External Lead Acid Battery
- Cellular Phone Kit:
 - Campbell Scientific DC112 Phone Modem
 - Motorola Bag Phone
- Environmental Enclosures:
 - Hoffman Electrical Box
- Field Stand:
 - Manufactured by MeasureTek

2.2 Sensors

- Soil Moisture Sensors:
 - Irrometer Company Watermark Soil Moisture Sensors
- Sap Flow Sensors:
 - Dynamax Dynagage[®] Sap Flow Sensors
- Pressure Transducers:
 - Druck PDCR 1830 Depth/Level Pressure Transducers w/ 20 psi gauge
- Soil Temperature Sensor:
 - MeasureTek Soil/Water Temperature Sensor

Section 3: MonitorX Monitoring Station

3.1 Station Installation

Your MonitorX station consists of the following components:

- 1) MonitorX Processor in Environmental Enclosure (Figure 3-2)
- 2) RemoteX Expansion Module in Environmental Enclosure
- 3) Field Stand:
 - Base
 - Pole stand
 - Stakes
 - Ground wire
 - Ground rod & ground clamp
- 4) Solar Panel
- 5) Cellular Phone Antenna

Installation Procedures (Figure 3-1):

- 1) Screw the Pole Stand tightly into the Base.
- 2) Dig a square hole 6-8" deep to bury the foot of the field stand base; level the bottom of the hole such that the Pole Stand sits solid and is vertically level.
- 3) Stake the Base in place.
- 4) Backfill the hole.
- 5) Install the RemoteX box on the Pole Stand with the supplied U-bolts.
- 6) Install the MonitorX box on the Pole Stand with the supplied U-bolts.
- 7) Drive the Ground Rod into the surrounding soil, in cases of shallow soil it is best to install the rod in a horizontal or slanted position.
- 8) Attach the Ground Wire to the Rod with the Ground Clamp, and attach the other end to the ground clamp on the MonitorX and RemoteX boxes.
- 9) Clamp the Solar Panel to the Pole Stand such that the panel is facing toward the sun, at an angle approximately perpendicular to the sun's rays at its highest point in the sky.

- 10) Mount the magnetic base of the Cellular Phone Antenna to the top of the MonitorX box. Run the cable through an opening in the bottom of the enclosure, and thread to the cellular phone inside.
- 11) Connect the cables "A" and "B" between the MonitorX and RemoteX units as labeled on the underside of the enclosures.
- 12) Connect the sensors as described on the enclosure label affixed to the inside of the MonitorX and RemoteX boxes.

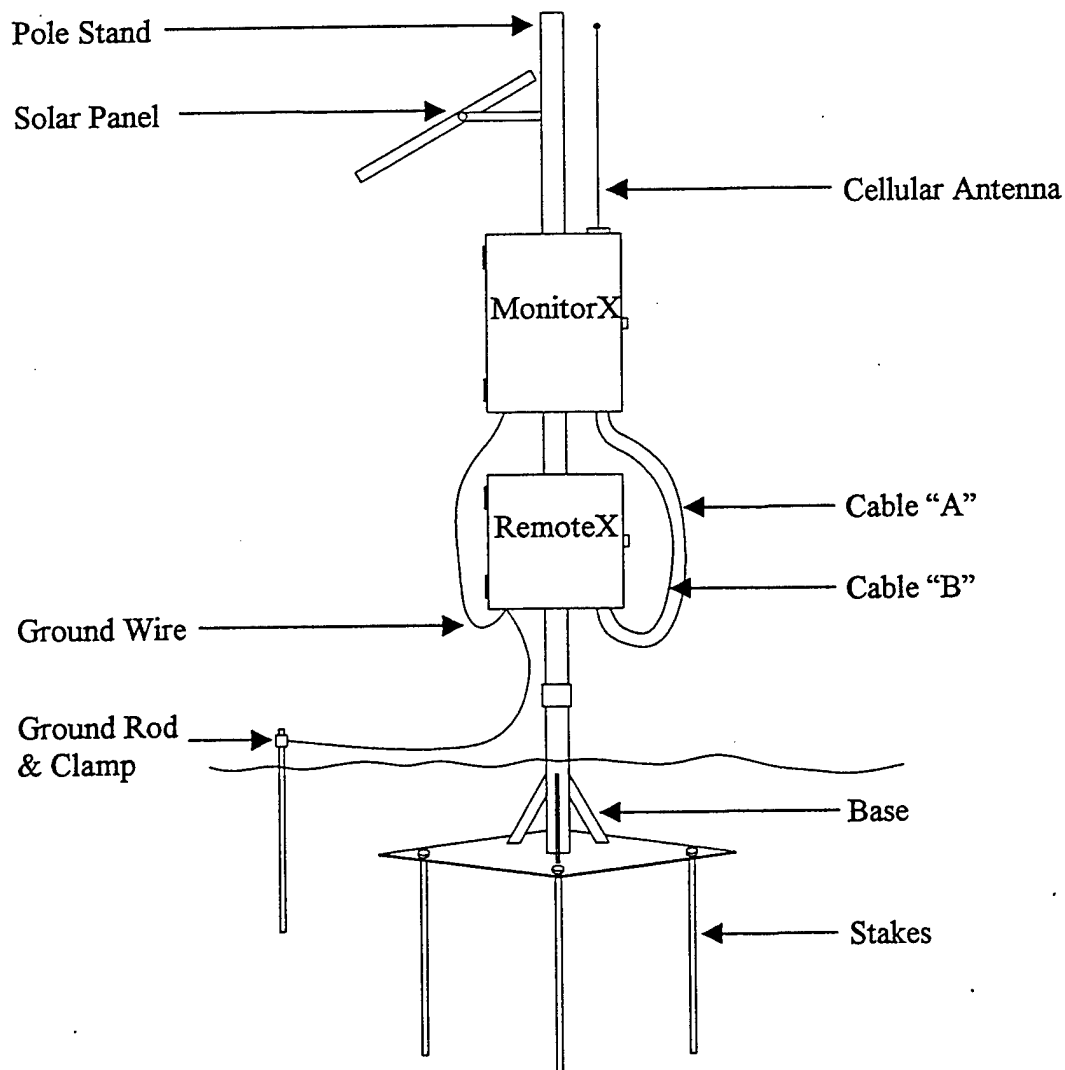


Figure 3-1. MonitorX station installation diagram.

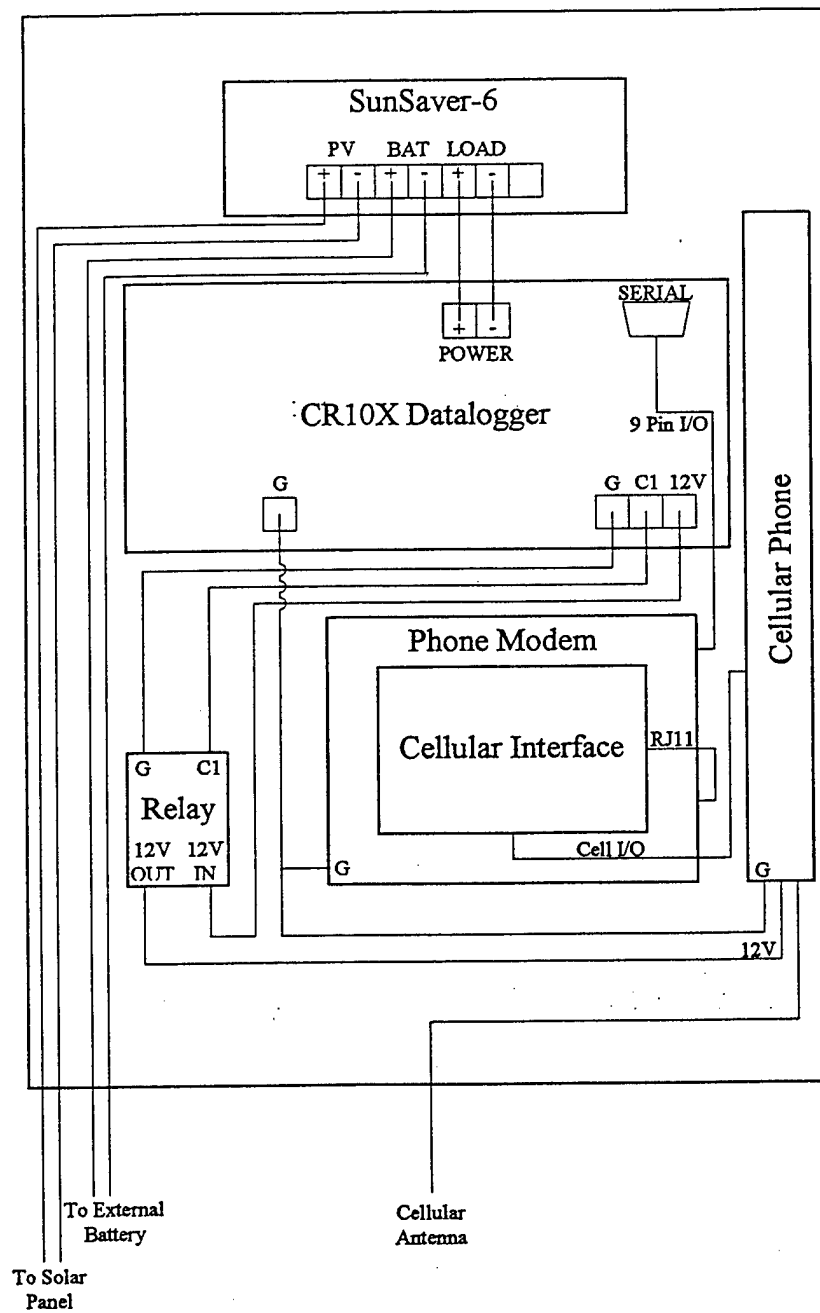


Figure 3-2. MonitorX component wiring diagram

3.2 Station Specifications

Station Name: ACTUS: PLYTO
 Station ID: 1 Serial Number: 1509
 Processor: MonitorX-10
 Communication: Cellular Phone
 Description: Monitoring 8 soil moistures, 1 soil temperature, 2 pressure transducers,
 and 2 sap flow sensors.
 Controlling: None

3.2.1 Measurement Locations

The following is a description of the data as viewed "real time" directly with the laptop or computer via cellular phone.

Location	Description	Units
1	Station ID	
2	Battery Voltage	volts
3	Depth #1	ft
4	NewDepth #1	ft
5	Depth #2	ft
6	NewDepth #2	ft
7	Soil Temperature	F
8-23	Soil Moisture #1-#16	cbar
25	Sap Flow #1	g/hr
26	Kshapp #1	W/mV
27	dT #1	C
28	Power Input #1	W
29	Qv #1	W
30	Qr #1	W
31	Qf #1	W
32	Flow Accum #1	kg
41	Sap Flow #2	g/hr
42	Kshapp #2	W/mV
43	dT #2	C
44	Power Input #2	W
45	Qv #2	W
46	Qr #2	W
47	Qf #2	W
48	Flow Accum #2	kg

3.2.2 Description of Data Output

The following describes the data as stored in the raw data file, 'stationX'.dat or 'stationX'.old; where 'stationX' is the name of the station:

Column	Daily Data	Processing	Units	Hourly Data	Processing	Units
1	Key Value = 24			Key Value = 60		
2	Station Number = 1			Station Number = 1		
3	Year			Year		
4	Day			Day		
5	Time			Time		
6	Battery Voltage	Sample	volt	Depth #1	Average	ft
7	Depth #1	Average	ft	Depth #2	Average	ft
8	Depth #1	Maximum	ft	Soil Temperature	Average	F
9	Depth #1	Minimum	ft	Soil Moisture #1	Sample	cbar
10	Depth #2	Average	ft	Soil Moisture #2	Sample	cbar
11	Depth #2	Maximum	ft	Soil Moisture #3	Sample	cbar
12	Depth #2	Minimum	ft	Soil Moisture #4	Sample	cbar
13	Soil Temperature	Average	F	Soil Moisture #5	Sample	cbar
14	Soil Temperature	Maximum	F	Soil Moisture #6	Sample	cbar
15	Soil Temperature	Minimum	F	Soil Moisture #7	Sample	cbar
16	Soil Moisture #1	Sample	cbar	Soil Moisture #8	Sample	cbar
17	Soil Moisture #2	Sample	cbar	Sap Flow #1	Average	g/hr
18	Soil Moisture #3	Sample	cbar	Kshapp #1	Average	W/mV
19	Soil Moisture #4	Sample	cbar	dT #1	Average	C
20	Soil Moisture #5	Sample	cbar	Power Input #1	Average	W
21	Soil Moisture #6	Sample	cbar	Qv #1	Average	W
22	Soil Moisture #7	Sample	cbar	Qr #1	Average	W
23	Soil Moisture #8	Sample	cbar	Qf #1	Average	W
24	Soil Moisture #1	Maximum	cbar	Sap Flow #1	Total	kg
25	Soil Moisture #2	Maximum	cbar	Sap Flow #2	Average	g/hr
26	Soil Moisture #3	Maximum	cbar	Kshapp #2	Average	W/mV
27	Soil Moisture #4	Maximum	cbar	dT #2	Average	C
28	Soil Moisture #5	Maximum	cbar	Power Input #2	Average	W
29	Soil Moisture #6	Maximum	cbar	Qv #2	Average	W
30	Soil Moisture #7	Maximum	cbar	Qr #2	Average	W
31	Soil Moisture #8	Maximum	cbar	Qf #2	Average	W
32	Soil Moisture #1	Minimum	cbar	Sap Flow #2	Total	kg
33	Soil Moisture #2	Minimum	cbar			
34	Soil Moisture #3	Minimum	cbar			
35	Soil Moisture #4	Minimum	cbar			
36	Soil Moisture #5	Minimum	cbar			
37	Soil Moisture #6	Minimum	cbar			
38	Soil Moisture #7	Minimum	cbar			
39	Soil Moisture #8	Minimum	cbar			
40	Sap Flow #1	Average	g/hr			
41	Sap Flow #1	Maximum	g/hr			
42	Sap Flow #1	Minimum	g/hr			
43	Sap Flow #1	Total	kg			
44	Sap Flow #2	Average	g/hr			
45	Sap Flow #2	Maximum	g/hr			
46	Sap Flow #2	Minimum	g/hr			
47	Sap Flow #2	Total	kg			

The optional 30-minute output is identical to the hourly output, except *Key Value* = 30.

Section 4: Monitoring Sensors

4.1 Watermark Soil Moisture Sensors

The Watermark soil moisture sensor is a solid state, no maintenance, electrical resistance type sensor manufactured by the Irrometer Company. It provides accurate soil moisture measurements from 10 centibars to 200 centibars, the soil moisture range required for most irrigated agriculture. The sensor includes internally installed gypsum, which buffers the effect of salinity levels normally found in irrigated soils. Since the sensor does not degrade over time and is unaffected by freezing temperatures, it is designed to remain in the soil, maintenance free, for many years.

4.1.1 Locating Moisture Sensors

Sensors should be located in areas of the field where soil moisture depletion is of concern. For irrigation scheduling, this is generally the "dry" areas of the field where soil type, interfaces, and contour limit moisture penetration and/or soil water holding capacity. For an overall view of field soil moisture, useful for evaluating irrigation effectiveness and wetting fronts, sensors should be placed in locations that encompass soil variations.

Sensors should be planted within the effective root zone of the overlying crop. For evaluating wetting fronts, moisture depletion, and irrigation effectiveness, it is often desirable to plant sensors at two or more depths per location.

A "common" and a single "hot" wire will be run to each Watermark sensor. Be sure to consider station placement and wire burial when designing a sensor layout (Figure 4-1).

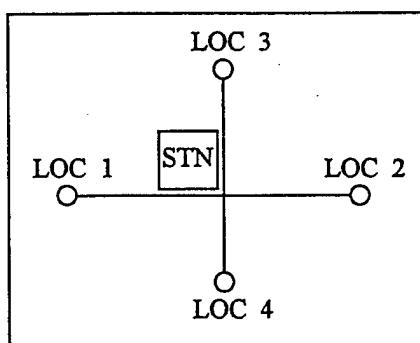


Figure 4-1. Typical sensor layout with station in middle.

4.1.2 Moisture Sensor Installation

- 1) Soak the sensors overnight in water. Always “plant” a wet sensor. If time permits, allow the sensor to dry for one day after soaking, and repeat the soak-dry cycle twice to improve sensor response during the first couple of weeks.
- 2) Dig an access hole to within 6 inches of the desired sensor depth. Use a rod or pipe to dig a 7/8” diameter shaft from the access hole at a 45° angle down to the desired sensor depth (Figure 4-2). Installing the sensor in a shaft dug at an angle will ensure that the sensor is located beneath native, undisturbed soil. Always install sensors in the active root zone of the crop.

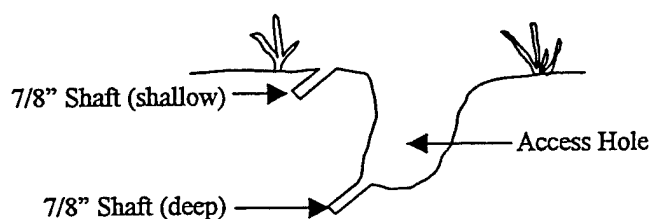


Figure 4-2. Watermark sensor installation.

- 3) A snug fit in the soil is most important. Fill the 7/8” diameter shaft with a slurry made from native soil and water. Coat the sensor with the slurry and push it down in the hole until it “bottoms out”. A length of 1/2” Class 315 PVC fits snugly over the sensor collar and can be used to push in the sensor.
- 4) Carefully backfill the access hole with native soil to eliminate any air pockets.

4.1.3 Moisture Sensor Wiring

Inside the MonitorX enclosure are two terminal blocks for wiring the Watermark soil moisture sensors. Number 18 - 20 AWG stranded wire, such as irrigation control wire, should be used for the sensors. The wire should be suitable for burial or enclosed in conduit. All sensors share the same COMMON with one lead, and the other lead connects to "hot" terminals inside the MonitorX enclosure (Figure 4-3). It does not matter which sensor lead is COMMON. Wire length can be up to 1500 feet without affecting measurements, contact MeasureTek if longer lead lengths are desired.

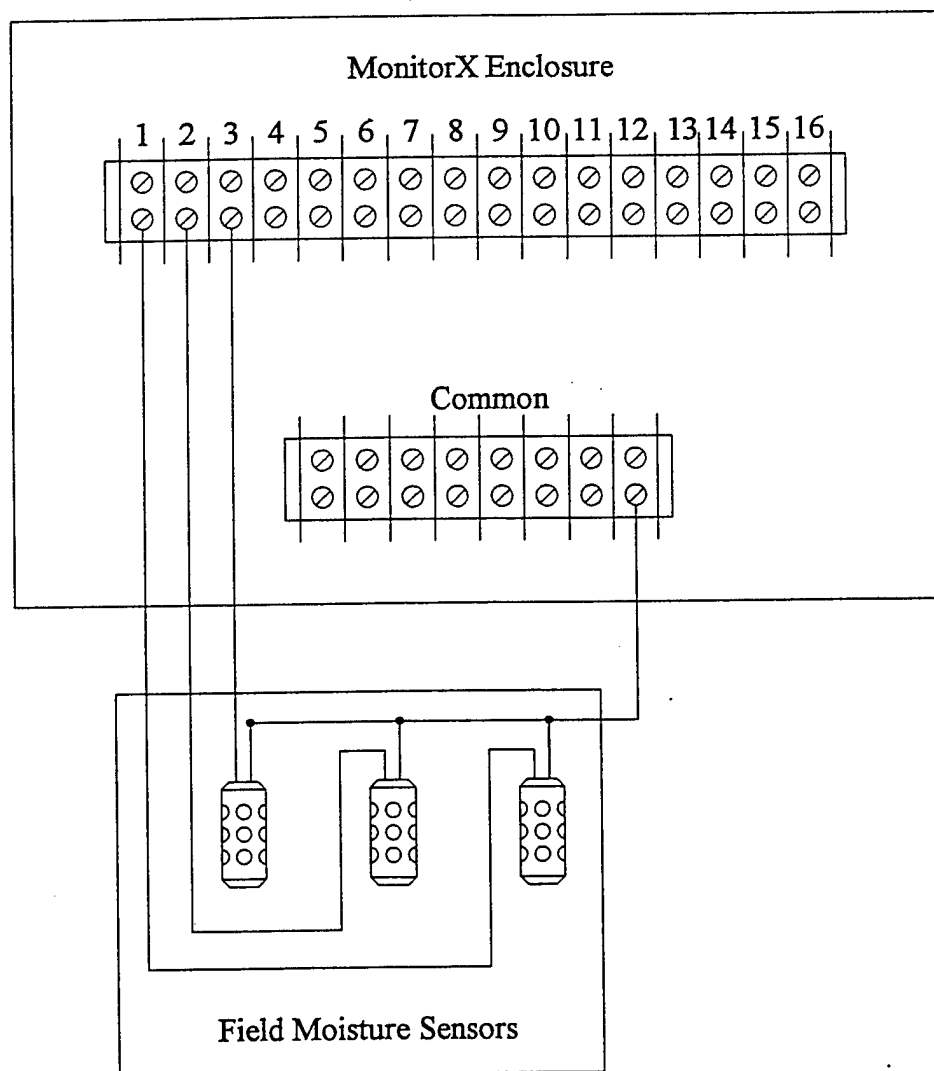


Figure 4-3. Watermark sensor wiring diagram.

4.2 Druck Pressure Transducers

The Druck Pressure Transducer measures pressure at the conical tip of the transducer, which is directly related to the height of water above the sensor (1 psi = 2.31 ft H₂O). The included Druck PDCR 1830 Pressure Transducers are rated at 20 psi, and can measure 46.2 ft of water (0.5% FSR accuracy).

4.2.1 Pressure Transducer Installation

Placement of the transducer should be as deep as possible within the range of the transducer. Avoid areas with high silt deposition, or provide silt barriers and have a maintenance schedule to periodically remove the silt buildup. The transducer itself should not be left in frozen water as the expansion and contraction of the ice will damage the transducer diaphragm. Water may be frozen above the sensor, but not at the sensor level.

The exact vertical placement at a location is not critical as long as the sensor doesn't move up and down. Once placed in the well, a water level is entered into the MonitorX station by a technician, from which an offset is automatically calculated.

All Druck pressure transducers have a unique calibration (multiplier) which must be set in the MonitorX station program.

The station multiplier is calculated as follows:

$$\text{Multiplier} = (\text{Full Scale Range}) \left(\frac{\text{Calibrated Sensitivity}}{\text{Calibration Supply}} \right)$$

Where:

$$\text{Full Scale Range} = (20 \text{ psi}) \left(\frac{2.31 \text{ ft}}{\text{psi}} \right) = 46.2 \text{ ft}$$

$$\text{Calibration Supply} = 10 \text{ volts}$$

$$\text{Calibrated Sensitivity} = \text{Unique to each sensor, taken from sensor calibration sheet.}$$

The calculated multiplier for each of the two Druck pressure transducers is:

$$\text{Sensor S/N 1164465, Calibrated Sensitivity} = 92.30, \text{ Multiplier} = 5.0054$$

$$\text{Sensor S/N 1164466, Calibrated Sensitivity} = 92.47, \text{ Multiplier} = 4.9962$$

The offset is taken into account automatically when zeroing the Station.

4.2.2 Pressure Transducer Wiring

The two pressure transducers are wired directly to the MonitorX processor as follows (Figure 4-4):

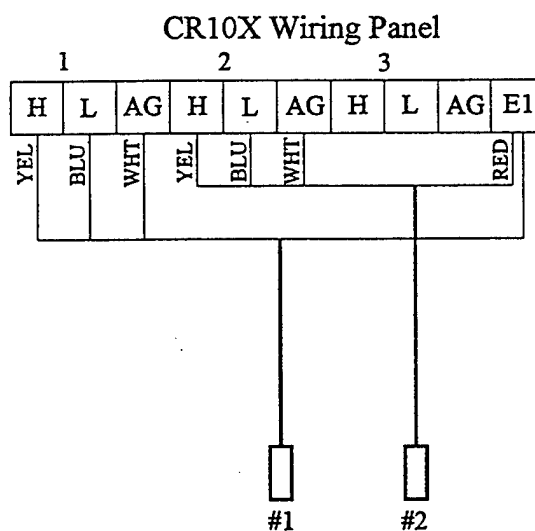
Pressure Transducer #1:

Excitation E1: Red
Channel 1H: Yellow
Channel 1L: Blue
Ground AG: White

Pressure Transducer #2:

Excitation E1: Red
Channel 2H: Yellow
Channel 2L: Blue
Ground AG: White

Wiring Diagram:



4.3 Dynagage® Sap Flow Sensors

Information provided in this manual was taken from the *Dynagage Installation and Operation Manual* published by Dynamax and provided with your station. Refer to the Dynagage manual for complete installation and operation instructions.

The Dynagage® sap flow sensor utilizes a heat balance to measure the amount of heat lost through the sap flow (Q_f). The heat is then divided by the heat capacity and temperature increase to obtain a sap flow in grams/hour (Figure 4-5).

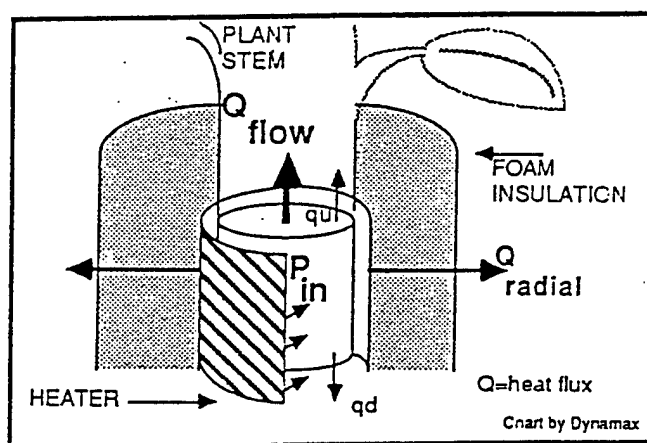


Figure 4-5. Stem Heat Balance

The gage is firmly fitted around the plant stem or trunk. A constant source (P_{in}) of heat is applied to the gauge and the amount of heat lost radially (Q_r) to the atmosphere, upward (Q_u) through the stem and downward (Q_d) through the stem are measured.

The energy balance is therefore:

$$P_{in} \text{ (Watts)} = Q_r + Q_u + Q_d + Q_f$$

Power Input:

The power input is calculated by measuring the voltage input and knowing the impedance of the gauge.

$$P_{in} = \frac{V^2}{R}$$

Radial Heat Transfer:

Q_r = measured with a thermopile around the cork.

$$Q_r = (K_{sh})(CH)$$

Where:

K_{sh} = thermal conductance for a gauge installation (W/mV).

CH = the signal $C-H_c$ which is proportional to the temperature difference between the inner and outer layers of cork, and the heat transfer radially (mV).

K_{sh} is the thermal conductance constant for a particular gauge. It relates the radial heat flux to the thermopile output CH .

K_{sh} is entered as a constant for the installation, and then the apparent K_{sh} is "fine tuned" by observing the calculated K_{sh} (output with the data) under no flow conditions. Under no flow conditions $P_{in} = Q_r + Q_v$ and $Q_r = P_{in} - Q_v$, therefore $K_{sh} = (P_{in} - Q_v)/CH$. No flow conditions can be obtained with an excised stem, or by looking at pre-dawn conditions.

Vertical Heat Transfer:

$$Q_v = Q_u + Q_d$$

$$Q_u = (K_{st})(A)\left(\frac{dT_u}{dx}\right)$$

$$Q_d = (K_{st})(A)\left(\frac{dT_d}{dx}\right)$$

Where:

K_{st} = thermal conductivity of stem (W/m K).

A = stem cross sectional area (m^2).

dT/dx = temperature gradient (dx is fixed for any given gauge).

The differentially wired thermocouples (A-Ha and B-Hb) measure the difference in temperature from the upper and lower thermocouples. By subtraction of the signals:

$$BH - AH = (B - Hb) - (A - Ha) = (B - A) + (Ha - Hb)$$

dx is constant, therefore:

$$Q_v = \left(\frac{(K_{st})(A)(BH - AH)}{dx} \right) \left(\frac{0.040 \text{ mV}}{C} \right)$$

Where:

0.040 = unit conversion to convert temperature to degrees C.

Sap Flowrate Calculations:

$$F = \left(\frac{P_{in} - Q_v - Q_r}{(C_p)(dT)} \right) \text{ in (g/s)}$$

Where:

C_p = specific heat of water (4.186 J/g C).

dT = temperature increase of the sap (C).

The two differentially wired thermocouples (AH and BH) are averaged to measure the increase or decrease in sap temperature (dT).

4.3.1 Sap Flow Sensor Installation and Setup

Materials Needed:

- Girth tape or caliper
- Wire ties
- Silicone based G4 sealing compound
- Fine sandpaper
- Refrigerator plastic wrap
- Aluminum foil
- Insulation strips

Installation and Setup Procedures:

- 1) If possible, select a plant in a shaded area within the canopy, not near a road or the edge of the canopy.
- 2) Select a stem or trunk free from petioles, leaves, scars, or other irregularities.
- 3) Lightly sand the bark to remove dead bark. Do not sand into the live cambium layer.
- 4) Measure the stem girth or diameter of the mid-section of the application area.
- 5) Wrap plastic wrap around the application area to prevent gauge contamination from sap and transparent water.
- 6) Do a trial installation of the gauge and check fit. The gauge should be snug. If the insulation is too loose, 2-3 mm of the insulation may be cut off and sealed with G4. The small wedge cut off should be kept for later plant growth. A small strip of insulation material may be used to cover gaps.
- 7) Squeeze a small amount of G4 onto the plant stem area and rub evenly. Apply to entire length of section to be covered. The G4 will keep out moisture and protect the sensor.
- 8) Apply a small amount of G4 to the inside of the Dynagage.
- 9) Install the gauge on the stem with the arrows pointed in the direction of sap flow. The heater strip should wrap around the stem at least once inside the insulation. Tighten the Velcro straps securely. Secure the cable to the trunk with wire ties.
- 10) Put a strip of mastik around the top edge of the sensor to prevent water from seeping into the sensor.

- 11) To prevent sunlight from affecting the energy balance, wrap aluminum foil around the gauge and the section of trunk from the gauge to ground.
- 12) Turn on the AVRDC voltage regulator.
- 13) Adjust the AVRDC to the desired voltage. The voltage adjustment knobs are at 1.5 volts at the far left, which is where you should start. Check the voltage with a voltmeter, and adjust the voltage upward to the desired voltage output. Clockwise rotation increases the voltage, counter clockwise decreases the voltage. One revolution of the adjustment knob changes the output by about 1 Volt. Repeat for the second sensor.
- 14) Connect the sensors to the proper cable. The two sap flow sensor cables attach to connectors labeled "S1" and "S2" on the bottom of the RemoteX enclosure.
- 15) With *Connect +* software, enter the calibration constants and view real-time data readings as described in the *System Operation* section of this manual. Enable nighttime readings if desired (only recommended for checking Ksh as described below).

Dynagage (SGB25) Setup and Specifics:

Gage Height: 4.3 in

Stem Range: 24-32 mm

Thermocouple Gap: 7 cm

Heater Input:

	<u>Min</u>	<u>Typical</u>	<u>Max</u>
Voltage (volts)	3.5	4	5
Power (watts)	0.26	0.4	0.5

Sensor Resistance (Impedance):

Each sensor has a fixed resistance (or impedance) which is printed on the sensor cable. Following are the resistance values:

SGB25 S/N 985017: 41.4 ohms

SGB25 S/N 995102: 40.9 ohms

Selecting the Heater Input Voltage:

The optimal input voltage will vary with plant species & seasonal changes in ambient conditions.

In general:

A **Minimum** setting can be used for low sap flow species and seasons (winter).

Typical power for higher sap flow and spring, summer and/or fall seasons.

Maximum power for very high flows and summer conditions.

Determining the Ksh Value:

The default value for the SGB25 is 0.8 W/mV. This can be used at startup, but should be determined by one of two methods. Each method is designed to give accurate Ksh values by establishing "no flow" conditions as described previously.

The first method is by installing the gauge on an excised stem or trunk of the same diameter. Monitor the Ksh for a minimum of two hours, and after reaching the calculated minimum value (output in the data), input this value as the Ksh. Be sure to enable 30-minute output.

The second method is to operate the gauge overnight by enabling the overnight operation and the 30-minute output. Utilize the minimum value observed over the nighttime period, usually just before dawn, and especially after a day of saturating rain or irrigation.

Thermal Conductivity:

The thermal conductivity is generally 0.54 for herbaceous plants, and 0.42 W/m K for woody plants.

The following tables can be used to keep a history of installation and setup values:

SGB25 #1, S/N 985017

Date	Vin (volts)	Resist. (ohms)	Stem Dia. (cm)	Stem Area (cm ²)	Thermal Cond. (W/m K)	Thermo. Gap (cm)	Ksh App. (W/mV)
4/28/99	4.75	41.4	2.73	5.85	0.42	7	0.8

SGB25 #2, S/N 995102

Date	Vin (volts)	Resist. (ohms)	Stem Dia. (cm)	Stem Area (cm ²)	Thermal Cond. (W/m K)	Thermo. Gap (cm)	Ksh App. (W/mV)
4/28/99	4.75	40.9	2.73	5.85	0.42	7	0.8

4.3.2 Sap Flow Sensor Output

The Dynagage outputs sap flow in grams/hour and cumulative sap flow for each sensor, as well as several calculated values for data analysis. Below is a list of the Dynagage outputs:

- Sap Flow (grams/hr)
- Ksh Apparent (W/mV)
- dT (C)
- Power Input (W)
- Q_v (W)
- Q_r (W)
- Q_f (W)
- Sap Flow Total (kilograms)

See Section 3.2.2 for a complete list of the output and format of data output.

4.3.3 Discontinuing Sap Flow Measurements

Simply shut off the voltage regulator contained in the RemoteX expansion box. This cuts off power to the sensors to conserve battery power.

4.4 MeasureTek Soil Temperature Sensor

The soil temperature sensor is a device that changes resistance with temperature, called a thermistor. The accuracy is ± 0.2 C with a range of -0.5 to 40 C, or ± 0.4 C from -33 to 48 C.

4.4.1 Soil Temperature Sensor Installation

1. Place the sensor in a representative location of the monitored area. Avoid areas near roads or waterways where soil temperature would be affected.
2. Dig a hole to the desired depth. If being used with soil moisture sensors, use a depth equivalent or average of the depth of soil moisture sensors.
3. At the desired depth, horizontally or at a slight angle, insert a screwdriver into the soil to make a small diameter hole and remove. Gently insert the tip of the soil temperature sensor into the hole. Backfill the hole and bury the cable back to the monitoring box.

Section 5: System Operation

High quality components and user-friendly software make the MonitorX system easy to set up and use. After hardware installation and sensor connection, you are ready to install the software and begin using your MonitorX system. You will be referring to the *Connect +* and *ResultX Lite Database* software user's guides included in this manual.

5.1 Powering Up the Station

The MonitorX station automatically begins collecting data when the external station battery is connected. The battery connects to the "P" connector on the MonitorX enclosure. A "green" light on the voltage regulator inside the MonitorX enclosure indicates that the battery is being charged by the solar panel.

5.2 Installing Software

Install the *Connect +* software from the compact disk included with your MonitorX system. Insert the *Connect +* compact disk into your computer's CD-ROM drive. Select **Run** from the **Start** button. Enter Q:\CONNECT\SETUP.EXE, where Q is the drive letter of your CD-ROM drive, and select **OK**. Follow the instructions on the screen.

Install the *ResultX Lite Database* software from the same compact disk by running Q:\RESULTX\SETUP.EXE, where Q is the drive letter of your CD-ROM drive.

5.3 Configuring Software

Start the *Connect +* software and follow the instructions in section 3.2 of the *Connect +* user's guide to set up your MonitorX station. During station setup you will be asked to provide an 8-character *station name*, as well as the *phone number* and device parameters for the *phone modem* connection. You will also be asked to insert the *MonitorX Instruction Disk* included with your system. This floppy disk contains information unique to each MonitorX station and is identified by the MonitorX serial number located both on the disk and the inside panel of the station enclosure.

Start the *ResultX Lite Database* software and follow the instructions in section 3.4 of the *ResultX Lite* user's guide to set up your MonitorX station. Again, you will be asked to insert the *MonitorX Instruction Disk* included with your system. After finishing the station setup, verify that the *Auto Import* box is checked on the ResultX main menu.

5.4 Connecting to the Station

You are now ready to connect to the station and test the communication link. Go back into the *Connect +* software and select *Station – Connect* from the main menu. On the “Connect to Station” screen, select the station and press the *Connect* button. It will take several moments for the cellular connection to be made.

To conserve battery power, the cellular phone at the station is programmed to turn ON only between 0700 and 1800 CST each day, for 15 minutes before and after the top of the hour (i.e. 0745 – 0815, 0845 – 0915, etc.)

5.5 Viewing Current Measurements

After connection is established, you will be viewing a list of real-time sensor measurements at the station. The MonitorX station takes measurements once per minute, with the current value continuously being updated on your screen.

5.6 Setting the Station Clock

You will likely need to set the current time at the station. Switch to the *Maintenance* tab of the “Connected to Station” screen and press *Set Clock* to set the station clock according to your PC clock.

5.7 Initializing Pressure Transducers

The current water level must be set at the MonitorX station, so that it corresponds with a level gage. Setting the current water level is in essence, setting the sensor offset. Once set, the readings should be routinely verified, as the offset may change due to settling or movement of the sensor, bed changes, or long term sensor drift. To set the current water level:

- 1) Switch to the *Maintenance* tab of the “Connected to Station” screen in *Connect +* to view the current water levels.
- 2) Enter the correct depth into the location *NewDepthX*, where X is either 1 or 2 depending on the appropriate sensor. Enter the value by double-clicking on the *NewDepthX* value and entering the correct depth.
- 3) Wait 60 seconds and the correct depth value will be displayed and the “*NewDepthX*” value will be zeroed.

5.8 Entering Sap Flow Sensor Calibration Constants

During setup, calibration constants must be entered for each of the two sap flow sensors. These constants must be set directly with a laptop computer. To enter the calibration constants for the sap flow sensors:

- 1) Connect a laptop to the station via the provided laptop cable.
- 2) Switch to the *Maintenance* tab of the "Connected to Station" screen in *Connect +* and press the *Set Calibration Constants* button.
- 3) Enter the following values for each sensor (sensors are labeled 1 and 2):

Ksh1, Ksh2 = Thermal conductance for gauge installation (W/mV).

Kst1, Kst2 = Thermal conductivity of stem (W/m K).

R1, R2 = Heater Resistance (ohms).

A1, A2 = Stem Area (cm²).

Resetting these constants recompiles the station "brains" which will immediately shutoff the cellular phone because the "brains" are keeping the phone "on". If constants must be set remotely, MeasureTek has the ability to do this remotely, or an interface switch can be obtained from MeasureTek if this feature is needed routinely.

5.9 Data Storage Interval

Depending on your monitoring needs, you may wish to adjust the data storage interval. By default, data are measured and calculated once per minute, and the station will store data in its memory once per day, at midnight. Data are also stored every hour, and can be stored at 30-minute intervals if desired.

Enable 30-minute output only if you need the data, more data means more storage space and longer processing time on the computer. To enable 30-minute output, click on the *30 Minute Data* function key on the *Maintenance* tab of the "Connected to Station" screen.

5.10 Enabling Nighttime Sap Flow Measurements

By default, sap flow measurements are disabled from 0900 to 1700 each day to conserve station battery power. To enable sap flow measurements between 0900 through 1700, click on the *Nighttime Sap Flow* function key on the *Maintenance* tab of the "Connected to Station" screen. You will need to closely monitor battery voltage when taking nightly sap flow measurements, as the station battery is not being recharged by the solar panel during this time.

5.11 Data Collection

The MonitorX station has internal memory to store up to 90 days of daily and hourly data. After the station memory is filled, new data will continuously overwrite the oldest data in memory. Therefore, you should regularly collect data from the station before it is overwritten in memory (about 90 days).

To collect data you can either:

- 1) Use the *Manual Data Collection* feature of the *Connect +* software as described in section 3.5 of the *Connect +* user's guide.
- 2) Use the *Automatic Data Collection* feature of the *Connect +* software as described in section 3.6 of the *Connect +* user's guide.

All data from the station goes into one data file, 'stationX'.dat in the data folder, and new data is continuously appended to the data file. This data is a comma-delimited text file without headings.

With *ResultX Lite Database* running and the *Auto Import* box checked, this raw data will automatically be imported into ResultX for storage and analysis in both graphical and report form.

Note: Data are not removed from the station memory when collected, but rather copied into a file on your computer. Therefore, any number of computers with licensed *Connect +* software installed can retrieve data from the station.

5.12 Data Analysis

Data analysis is done using the *ResultX Lite Database* software. *ResultX Lite* allows you to generate custom reports and graphs in both US English and SI Metric units. Data may also be exported to Excel or other spreadsheets for further processing. Refer to the *ResultX Lite Database* software user's guide included in this manual or the software's electronic HELP for complete instructions.

Section 6: *Connect +* User's Guide

6.1 Introduction

Welcome to *Connect +*, a data collection and real-time viewer for MonitorX monitoring stations. *Connect +* gives you the ability to collect data and monitor real-time conditions at MonitorX stations. Data can be collected manually, or *Connect +* can be configured to automatically retrieve data from any number of stations on a regular schedule.

Connect + is designed to work in conjunction with the ResultX Database software to provide automatic collection and import of data from your MonitorX stations. *Connect +* serves as a "link" between your MonitorX stations and ResultX Database. Data is automatically collected from your stations using *Connect +* and subsequently imported into ResultX Database where it is available for review and analysis in graphical and report form.

In addition to this manual, *Connect +* provides complete electronic HELP to assist you with its many features. Access HELP on a specific topic by pressing the **F1** key on any screen.

6.2 Installation

Connect + requires a 100% IBM compatible 100 MHz Pentium processor or higher, 16 MB of RAM, Windows 95[®], and a mouse. A minimum of 10 MB of hard disk space is required for software installation.

Insert the first *Connect +* disk in drive A:. Select **Run** from the **Start** button. Enter A:SETUP and select **OK**. Follow the instructions on the screen. *Connect +* lets you choose a working directory name to install the program.

Double-click the *Connect +* icon in the *Connect* folder to start the program.

6.3 Program Features

6.3.1 Main Menu

The Connect + main menu is divided into two windows, SELECT and DO. The SELECT window contains a list of available options in Connect +. Highlighting an option in the SELECT window will bring up a list of features for that option in the DO window. Double-clicking a feature in the DO window or highlighting a feature and pressing the OK button will start the event.

6.3.2 Station Setup

Each MonitorX station must be set up in Connect +. A station setup tells Connect + which type of station you have (MINI, BASIC, LARGE), how to communicate with the station (COM port, modem), and what parameters are being monitored (i.e. soil moisture, air temperature, rainfall). Before you can begin using Connect +, you must create a station setup for each of your MonitorX stations.

To set up each of your MonitorX stations, select **Setup – Stations** from the main menu. Press **Add** to create a new station setup.

1. At the "Connection to Station" screen:
 - a. Enter a *Name* for the station (8 characters maximum).
 - b. Select the *Station Type* (MINI or BASIC/LARGE).
 - c. Select the *Connection Type* (Direct or Modem) and supply the appropriate COM port or modem parameters and phone number. See section 6.4 of this manual for an explanation of each communication parameter.
 - d. Press **Next** to continue with the new station setup.
2. Insert the "MonitorX Instruction Disk" provided with your station to load the information necessary for real-time measurement viewing. The "MonitorX Instruction Disk" is unique to each MonitorX station, so be sure to insert the correct disk for the station you are setting up. If you skip this step you can load the information necessary for real-time viewing at a later date by supplying a **Station Instruction File** and selecting **Load Descriptions...** from the "Station Edit" screen. Press **Next** to continue with the station setup.

3. On the **Station** tab of the "Add New Station" screen:
 - a. Give a brief *Description* of the station (30 characters maximum).
 - b. Enter a unique *Station ID* number (1-254). Each MonitorX station must have a unique *Station ID* number to import data into ResultX Database. All MonitorX stations ship with a *Station ID* = 1. You must change the *Station ID* if you have more than one station. Changing the *Station ID* requires Connect + to communicate with the station. If you are unable to communicate with your station at this time, you can change the *Station ID* at a later date by editing the station setup. Remember that you will not be able to import data into ResultX Database if the *Station ID* is not unique.
 - c. Identify any *Satellite Stations* you have connected. *Satellite Stations* are special MonitorX stations designed to communicate through a main station for data collection and real-time measurement viewing. *Satellite Stations* rely on the main station for all communication, and therefore do not require their own communication hardware.
4. On the **Measurements** tab of the "Add New Station" screen:
 - a. Enter/verify the descriptions of each measurement location for real-time data viewing. Your MonitorX station has 254 "locations" where real-time data is stored for viewing. Refer to the "Your Station(s)" chapter of the MonitorX manual for a listing of your measurement "locations".
 - b. If no location descriptions are displayed, they may be loaded from the station instruction file by pressing the **Load Descriptions from Station Instruction File** button.

Press **Save** at the bottom of the screen to store the new station setup.

6.3.3 Connecting to a MonitorX Station

To establish communication with a station, select **Station – Connect** from the main menu. On the "Connect to Station" screen, select the desired station and press the **Connect** button. It may take a minute or so for a connection to be established when communicating using a modem.

If a *Direct* connection cannot be established, verify that the station is connected to the correct COM port using the supplied communication cable. If a *Modem* connection cannot be established, verify that the computer modem is properly configured and plugged into a working phone jack. If you are connecting to a station that uses a cellular phone, verify that the current time is within the window that the cellular phone is turned ON by the station. If a connection still cannot be established, refer to section 6.4 for possible modifications to the station communication parameters.

6.3.4 Viewing Real-Time Measurements

Connect to the station as described in section 6.3.3. On the **View Data** tab of the “Connected to Station” screen the *Current Measurements* will be displayed. The layout of the measurements can be customized as follows:

- Click on a label to change the 8-character description of the measurement. Measurement descriptions and layout are stored for each MonitorX station.
- You can drag and drop individual measurements to different locations on the display.
- Add additional measurements by highlighting a location and pressing **Add**.
- Remove measurements from the display by highlighting a location and pressing **Remove**.
- Return the measurement display to the default order by pressing **Reset View Order**.
- Use the **Next** and **Previous** buttons to move between pages of measurements.
- View all 254 possible measurements in a list by checking the **View in List Form** box.

6.3.5 Manual Data Collection

To manually retrieve data from a station, connect to the station as described in section 6.3.3. On the **Collect Data** tab of the “Connected to Station” screen, verify the path and filename where data will be stored. Select whether to collect the *Data Since Last Call*, *All Data*, or a *Specific Number of Records*. In most instances, you will want to collect the data since last call.

When collecting a specific number of records the requested number of most recent records will be collected. A “record” refers to data stored at a single point in time. For example, if you are storing hourly data, one “record” is generated each hour.

6.3.6 Automatic Data Collection

One useful feature of Connect + is the ability to set up automatic data collection schedules for each MonitorX station. This allows you to automatically collect data on a regular interval. This collected data can then be automatically imported into the ResultX Database software as described in the ResultX manual.

To set up scheduled data collection for each of your MonitorX stations, select **Setup – Data Collection** from the main menu. Highlight the desired station and set the following parameters:

<i>Collection Interval:</i>	Time (days or hours or minutes) between data collection from the station.
<i>Time to Begin Collection:</i>	Time to first begin data collection. Connect + must be running on your computer during this time for data collection to take place.
<i>Date to Begin Collection:</i>	Date to first begin data collection.
<i>Data File:</i>	Name and path of data file to store collected data.
<i>Schedule On:</i>	You must check this box for scheduled data collection to occur.

Press **Save** to store the collection schedule.

****Important:** For scheduled data collection to occur you must be running Connect + on your computer and leave the program on the **Main Menu**. Also, the *Schedule On* box must be checked for each station where data collection is to occur.

6.3.7 Setting the Station Clock

Connect to the station as described in section 6.3.3. On the **Maintenance** tab of the “Connected to Station” screen the *Computer* and *Station* time will be displayed. To set the station time to match that of the computer, press the **Set Clock** button.

6.3.8 Station Function Keys

Depending on your station configuration, you may be able to modify the data recording interval by enabling one of the station function keys. This feature is commonly used to add 15 minute data recording in addition to the default daily and hourly recording. Use only the station function keys that are described in your MonitorX user's manual.

To modify the station function keys, connect to the station as described in section 6.3.3. On the **Maintenance** tab of the "Connected to Station" screen you will find the *Station Function Keys*. You may optionally change the F1 – F8 key descriptions by clicking on them with the mouse.

6.3.9 Send New Instructions to Station

The MonitorX station processor requires programming instructions to take measurements from sensors. In some situations you may be instructed by MeasureTek to send new instructions to a station. An example of when this would need to be done is if at a later date you added additional sensors to a station that required the programming to be changed. Do not send new instructions to a station unless authorized to do so by MeasureTek, as the station may no longer function properly and/or data loss may occur.

If you are authorized to send new instructions to a station, connect to the station as described in section 6.3.3. On the **Maintenance** tab of the "Connected to Station" screen, verify the path and filename of the *Station File* and press the **Send** button.

6.3.10 Compress System Database

Continued use of Connect + can cause the database to become fragmented and use disk space in a manner that is less than optimal. Periodically, you should compress the system database to defragment the file. This will usually result in a smaller file size, which saves disk space and increases the software performance. Depending on the size of your database, it may take several minutes to complete this operation.

****Note:** If your system database ever becomes corrupted, this may happen if the computer unexpectedly shuts off when Connect + is running, using the Compress System Database feature will likely fix the problem.

6.4 Connection Setup Parameters

6.4.1 Direct Connection Setup Parameters

- COM Port:* Communications port of the computer (COM1 or COM2) where the station is connected.
- Baud Rate:* Transfer rate for COM port (default = 9600).
- Maximum Time On-Line:* Maximum number of seconds allowed for automatic data collection during an individual call. Data collection will be terminated if the number of seconds is exceeded.
- Maximum Packet Size:* The data are transmitted and received in groups called packets. If a communication link is unstable, a packet size smaller than the default value of 1024 may be required. Maximum Packet Size may be any number from 32 to 2048 bytes.
- Extra Response Time:* Typically the software estimates the time-period that the computer will wait for a response. The estimation is based on the number and type of interfaces in the communication link. If Connect + is timing out during data transmission, increase the response time.

6.4.2 Modem Connection Setup Parameters

- COM Port:* Communications port of the computer (COM1 or COM2) where the phone modem is installed.
- Baud Rate:* Transfer rate for phone modem (default = 1200).
- Modem Pick List:* Common modems are available in the Modem Pick List. When a modem is chosen from the list, the remaining parameter fields are automatically filled in with default values for that particular modem. These default values can be changed by editing the desired field.
- If the modem you are using is not listed, choose **<default modem>** and edit the remaining parameters according to your modem's specifications.
- Modem Name:* A new modem can be created by editing an existing modem name or entering a new name.
- Modem Reset String:* This string is sent to return the modem to a known state. This state is such that the modem is off-line and ready to receive dialing commands.
- Modem Initialization String:* This string is used to prepare the modem for use with the station field or voice modem. Typically these commands disable flow control, compression, non-numerical or extended result codes, and additional error checking.
- Dialing Prefix String:* This string is sent prior to the phone number. It contains the actual dialing commands.
- Maximum Time On-Line:* Maximum number of seconds allowed for automatic data collection during an individual call. Data collection will be terminated if the number of seconds is exceeded.
- Maximum Packet Size:* The data are transmitted and received in groups called packets. If a communication link is unstable, a packet size smaller than the default value of 1024 may be required. Maximum Packet Size may be any number from 32 to 2048 bytes.
- Extra Response Time:* Typically the software estimates the time-period that the computer will wait for a response. The estimation is based on the number and type of interfaces in the communication link. If Connect + is timing out during data transmission, increase the response time.

Section 7: *ResultX Lite Database* User's Guide

7.1 Introduction

Welcome to ResultX™ Lite Database, a data management system for MonitorX™ monitoring stations. ResultX Lite Database gives you the ability to store, retrieve, and interpret data collected from MonitorX stations. Collected data is easily presented in graphical and report form for review and analysis in both US English and SI Metric units.

ResultX Lite Database is designed to operate in conjunction with MeasureTek's *Connect* software for minimal user setup and intervention. MeasureTek's *Connect* software is used to retrieve data from each of your MonitorX stations. For "hands-off" operation, *Connect* can be configured to automatically collect data from all of your MonitorX stations. Once retrieved from the station, ResultX Database automatically imports this data into its own tables for storage and reporting. For security, two backup copies of your original raw data are maintained.

This manual is divided into two sections: **Quick Start** and **Features in Depth**. **Quick Start** provides information on the basic features of ResultX Lite Database and step by step instructions to get you up and running for the first time. **Features in Depth** gives a full discussion of the advanced features of ResultX Lite Database.

In addition to this manual, ResultX Lite Database provides complete electronic HELP to assist you with its many features. Access HELP on a specific topic by pressing the F1 key on any screen.

7.2 Installation

ResultX Database requires a 100% IBM compatible 133 MHz Pentium processor or higher, 16 MB of RAM, Windows 95®/98®, and a mouse. A minimum of 20 MB of hard disk space is required for software installation. Additional disk space is required as the size of your database increases with data imported from MonitorX stations.

Insert the ResultX Database compact disk into your CD-ROM drive. Select **Run** from the **Start** button. Enter Q:\RESULTX\SETUP.EXE, where Q is the drive letter of your CD-ROM drive, and select **OK**. Follow the instructions on the screen. ResultX Database lets you choose a working directory name to install the program (default directory = C:\RESULTX). Data is stored in the file RsltData.mdb in a sub-directory named DATA.

Double-click the ResultX icon in the ResultX folder to start the program.

7.3 Quick Start

7.3.1 Login

Entry into the ResultX Database is restricted by the use of a login name and password. Initially, the only valid User ID is "ADMIN", with a password of "1234". Enter this *User ID* and *Password* at the "Login" screen and press **OK** to begin ResultX Database. Refer to section 7.4.1 of this manual for instructions on creating and managing additional user names and passwords as well as instructions on how to disable the login screen.

7.3.2 Introduction Screen

After logging in to ResultX Database, an introduction screen will appear to help you get started with the program. You may want to **Start ResultX in Demo Mode**. The demo mode of ResultX allows you to experiment with the features of ResultX using several demonstration data sets from which you can generate reports and graphs. Pop-up windows will inform you along the way of the many features available in ResultX.

Before you can import data into ResultX from your own MonitorX station, you will need to **Setup a New MonitorX Station**. Section 7.3.4 of this manual explains how to proceed with configuring your first MonitorX station.

After becoming familiar with ResultX, you can **Start Using ResultX** and may want to disable this screen entirely by unchecking the **Show this Screen on Startup** box. To show this introduction screen again at any time, select **Setup - Help** from the main menu.

7.3.3 Main Menu

The ResultX Database main menu is divided into two windows, **SELECT** and **DO**. The **SELECT** window contains a list of available options in ResultX Database. Highlighting an option in the **SELECT** window will bring up a list of features for that option in the **DO** window. Double-clicking a feature in the **DO** window or highlighting a feature and pressing the **OK** button will start the event.

Between the **SELECT** and **DO** windows is the word **English**. This refers to the type of units used throughout ResultX Database. To switch between US English units and SI Metric units, double-click on the word **English**. The word will change to **Metric**, and all data will be presented in SI Metric units. Double-click on the word **Metric** to return to US English units.

Complete descriptions of the features available from the main menu in ResultX Database are described in section 7.4 of this manual. The remainder of this section of the manual highlights the features necessary to setup and begin using ResultX Database.

7.3.4 Station Setup

A *station* refers to a precise location where data samples are taken by a MonitorX station. Before you can begin using ResultX Database with your MonitorX stations, you must complete a station setup.

To set up each of your MonitorX stations, start the "Station Setup Wizard" by selecting **Setup a New MonitorX Station** from the introduction screen that appears when you first start ResultX Database. Another way to start the "Station Setup Wizard" is to select **Setup – Stations** from the main menu and **Add** a new station. Complete the following steps to set up your MonitorX station:

1. If you are using MeasureTek's *Connect* software on the same computer as ResultX Database, pick a station to configure from the list of station's already setup in *Connect*. If you have not set up any stations in *Connect*, please do so first then return to ResultX. After selecting a station, press **Next** to continue with the station setup and skip to step 3.
2. If you are not using *Connect* software for data collection, or have *Connect* installed on a different computer, complete the following:
 1. Supply a unique *Station Name* (8 character maximum). The *Station Name* should be the same one used in *Connect*.
 2. Supply a brief *Description* of the station (30 characters maximum).
 3. Each MonitorX station must have a unique *Station ID* number to import data into ResultX. All MonitorX stations ship with a *Station ID* = 1. Use the *Connect* software to change the *Station ID* if you have more than one station.
 4. Fill in, or use the button to select a *Data File*. The *Data File* is a DOS path and filename where data downloaded from the MonitorX station will be stored. This path corresponds to the *Data File* used in the *Connect* software to store data downloaded from the MonitorX station. ResultX can import data from multiple stations located in the same *Data File* as long as each station's data is distinguished by a unique *Station ID*.
 5. Press **Next** to continue with the station setup.
3. Insert the "MonitorX Instruction Disk" provided with your station to load the *sample definitions* necessary to import data from this station. The "MonitorX Instruction Disk" is unique to each MonitorX station, so be sure to insert the correct disk for the station you are setting up. Refer to section 7.4.2 of this manual for detailed information about sample definitions. If you skip this step you will not be able to import data from this station. Press **Next** to continue with the station setup.

4. Optionally *Define Sensor Locations*. If you have more than one sensor of the same type at a station (i.e. several soil moisture sensors), locating sensors provides increased flexibility to generate graphs containing multiple sensors at the same location or depth/height. You can also *Define Sensor Locations* at a later date by selecting **Setup – Stations** from the main menu.
5. Press **Finish** to complete the station setup.

7.3.5 Collecting Data

To collect data from your MonitorX stations, use the *Connect* software as described in sections 6.3.5 and 6.3.6 of the *Connect* user's guide. *Connect* should be configured to store collected data in the same filename as specified in the *Data File* section of the ResultX station setup.

7.3.6 Import Data

To access your data in ResultX Database, the data must first be imported from the files collected from each station. ResultX Database can easily be configured to automatically import new data by checking the **Auto Import** box on the ResultX main menu. When the **Auto Import** box is checked and ResultX Database is running, the program will automatically detect when a new data file has been placed in the *Data File* assigned during station setup. When a new data file is found a notification message will appear, and then the data will automatically be imported into ResultX Database. Use the **Auto Import** feature of ResultX in conjunction with the **Automatic Data Collection** feature of the *Connect* software to completely automate this process. The process of importing data can take several minutes to complete. For additional information on importing data and the backup features of ResultX Database, refer to sections 7.4.8 and 7.4.13 of this manual.

7.3.7 Viewing/Printing Reports

A basic feature of ResultX Database is the ability to create reports based on collected station data. To provide an introduction to reports, several demonstration data sets have been included with ResultX Database. The “zDemo1 Weather Station” demonstration data includes three months of hourly and daily data collected from a MonitorX station monitoring air temperature, leaf wetness, rainfall, relative humidity, wind speed, soil temperature, and soil moisture at two depths. To create reports based on this demonstration data, select **Reports – Station Data** from the main menu.

At the “Station Report” screen, press the ‘down’ arrow on the *Station* box and select “zDemo1 Weather Station” as the station to generate reports from. Use the ‘down’ arrow on the *Data* box to select the measurement to be viewed in the report (for this example, select “Air Temperature”). To view a report of daily data, verify that “Daily Data” is

selected as the *Summary Period*. In the "Select Dates" box, you may select *All* to view a report of the entire data set, or enter a specific *Date Range* to view a select range of dates/times. Dates are entered as {month/day/year} (i.e. 6/15/1998) or time may be included in hourly reports as {month/day/year hh:mm} (i.e. 6/15/1998 13:00). The demo data was collected from 4/1/1998 through 7/8/1998. Press the **Show Me** button to view the selected report.

A report will be generated with each month of data on a separate page and a summary of data for that month at the bottom of each page. Use the arrow keys in the lower left corner of the screen to switch between pages and the magnifying glass to zoom in on sections of the report. Choose the "printer" icon to print the report. Press the "X" in the upper right corner of the screen to close the report. Create other reports from the demonstration data to become familiar with the report process. Remember that you can toggle between US English and SI Metric units as described in section 7.3.3.

7.3.8 Viewing/Printing Graphs

ResultX Database provides the ability to view and print color graphs of station data. A demonstration data is used to provide an introduction to graphs. To create graphs based on the demonstration data, select **Graphs – Graph Station Data** from the main menu.

At the "Graph Station Data" screen, press the 'down' arrow on the *Station* box and select "zDemo1 Weather Station" as the station to generate graphs from. Use the 'down' arrow on the *Data* box to select the measurement to be viewed on the graph (for this example, select "Air Temperature"). For "Air Temperature", check the *Avg*, *Max*, and *Min* boxes as the data to graph. To view a graph of daily data, verify that "Daily Data" is selected as the *Summary Period*. In the "Select Dates" box, you may select *All* to view a graph of the entire data set, or enter a specific *Date Range* to view a select range of dates. Dates are entered as {month/day/year} (i.e. 6/15/1998) or time may be included in hourly reports as {month/day/year hh:mm} (i.e. 6/15/1998 13:00). The demo data was collected from 4/1/1998 through 7/8/1998. Press the **Show Me** button to view the selected graph. Press the "X" in the upper right corner of the screen to close the graph.

Now change the *Station* to "zDemo Soil Moisture Station" and select one of the eight "Soil Moisture" entries in the *Data* box. Since there are more than one measurement of soil moisture at this station, you have the option of graphing *All* soil moisture measurements, the *Single* soil moisture measurement selected in the *Data* box, or a select range of soil moisture measurements grouped by *Identifier*, *Location*, or *Depth/Height*. The *Identifier* is an assigned number corresponding to a specific sensor at the station (refer to MonitorX enclosure label for sensor numbering). The *Location* and *Depth/Height* refer to user-defined sensor locations made in the "Station Setup" as described in section 7.3.4 of this manual. For now, select *All* in the "Series on Graph" selection box and press the **Show Me** button to view the graph. The graph will display all eight soil moisture measurements. To graph soil moisture measurements by *Location*,

select a location from the drop-down box. Experiment with creating different graphs based on *Location* and *Depth/Height* using the demonstration data set.

When multiple sensors of the same type are used at a station (i.e. multiple soil moisture sensors) you may wish to plot "Graph Calculations" of the average, maximum, and minimum of sensor readings. Select *Values* to display a graph of individual sensor measurements and/or *Avg*, *Max*, *Min* for graph calculations.

To print a graph, check the *Print Preview* box before pressing the **Show Me** button. The graph will be displayed in a printable format. Use the magnifying glass to zoom in and out on sections of the graph, and the "printer" icon to print the graph. Create other graphs from the demonstration data sets to become familiar with the graphing process.

Remember that you can toggle between US English and SI Metric units as described in section 7.3.3.

7.4 Features in Depth

7.4.1 Users

Entry into ResultX Database is restricted by the use of a login name and password. Initially, the only valid User ID is "ADMIN", with a password of "1234". To add, modify, or delete users, select **Setup – Users** from the main menu. At the "User List" screen you may **Add**, **Delete**, or **Change** user profiles. A user profile consists of a unique 4-letter *Code* word used to track changes to the database by individual users, a *User name*, and *Password*.

To disable the login screen, enter a User ID of "DISABLE" and a password of "1234" at the login prompt. To re-enable the login screen, select **Data Table Functions – Login as Different User** from the main menu and enter a User ID of "ENABLE" and a password of "1234". The enable/disable passwords can be changed using the **Setup – Users** feature.

7.4.2 Sample Definition

Each set of data from a MonitorX station that is routinely imported into ResultX Database is called a "sample" of data. The data are defined by the type and order in which they are received, and the organization of this data for importing is called the *Sample Definition*. The sample definition consists of a sequence of data types in a particular order according to the imported data file. A station will have more than one sample definition if you collect data on more than one time scale. For example, a station collecting data on an hourly and daily basis will have two sample definitions created for it. A *Key Value* located in a *Key Value Column* distinguishes multiple sample definitions for a station. When you set up a new MonitorX station, sample definitions are loaded from the "MonitorX Instruction Disk" included with each station. You can load additional sample definitions from a "MonitorX Instruction Disk" or create your own as outlined below.

To create or load a new sample definition, select **Setup – Sample Definitions** from the main menu. At the "Sample Definition List" screen, press **Add** to import sample definitions from a "MonitorX Instruction Disk" or to manually create a new sample definition. A sample definition consists of the following elements:

<i>Code:</i>	Unique 6-letter word used to identify each sample definition.
<i>Description:</i>	Description of sample definition.
<i>Summary Period:</i>	Data collection interval (Daily, Hourly, etc.)

<i>Key Value Column:</i>	Column number in data file where the <i>Key Value</i> is located. Used to distinguish between samples taken on different time scales at the same station.
<i>Key Value:</i>	Refer to the "Your Station(s)" chapter in the manual provided with your MonitorX station for correct <i>Key Value</i> parameters (i.e. <i>Key Value</i> = 24 for daily data, <i>Key Value</i> = 60 for hourly data).
<i>Year:</i>	Column number in data file where the year is located.
<i>Day:</i>	Column number in data file where day is located.
<i>Time:</i>	Column number in data file where time is located.
<i>Test Definition:</i>	Individual measurements made at the station.
<i>Identifier:</i>	The identifier is a number used to distinguish between multiple sensors taking the same measurement at a station. For example, if you have 5 soil moisture sensors at a station, these would be identified as 1, 2, 3, 4, and 5.
<i>Column:</i>	Column number in data file where the specific measurement is located.

To create a sample definition, complete the top portion of the "Adding Sample Definition" form, then press the **OK Add** button to save the newly created sample definition. The "Test Definition" window at the bottom of the form will now become available. Press **Add Measurement** to assign *Test Definitions*, *Identifiers*, and *Data Columns* to the sample definition. Refer to the "Your Station(s)" chapter in the manual provided with your MonitorX station for correct *Test Definition* and *Data Column* locations. To load *Test Definition* and *Data Column* values from an existing sample definition into the current one, select the desired sample definition in the *Load Sample Def Template* box.

7.4.3 Station Setup

A **station** refers to a precise location where data samples are taken by a MonitorX station. A station may have more than one data sample, for example hourly and daily samples, each defined by a sample definition. If you add additional MonitorX stations at a later date, setups will need to be created for each station as outlined below.

To set up a station, select **Setup – Stations** from the main menu. At the "Station List" screen, press **Add** to create a new station setup. A station setup consists of the following elements:

- Station Name:* Unique 8-letter word used to identify each MonitorX station.
- Description:* Description of station.
- Station ID:* Each MonitorX station must have a unique *Station ID* number to import data into ResultX. All MonitorX stations ship with a *Station ID* = 1. Use the *Connect* software to change the *Station ID* if you have more than one station
- Latitude:* Station latitude. (used in ResultX full version only)
- Longitude:* Station longitude. (used in ResultX full version only)
- Elevation:* Station elevation. (used in ResultX full version only)
- Data File:* DOS path and filename of data downloaded from the station using the *Connect* software. The *Data File* is a fixed DOS path and filename where data downloaded from the MonitorX station will be stored. This path corresponds to the *Data File* used in the *Connect* software to store data downloaded from the MonitorX station. ResultX can import data from multiple stations located in the same *Data File* as long as each station's data is distinguished by a unique *Station ID*.
- Station Type:* Type of data collected at MonitorX station. (used in ResultX full version only)
- Samples Taken at this Station:* List of *sample definitions* defining the type and order of data to be imported from the station.
- Define Sensor Locations:* If you have multiple sensors of the same type at a station (i.e. multiple soil moisture sensors), you may optionally locate the sensors by "Location" and "Depth/Height". Locating sensors provides increased flexibility to generate graphs containing multiple sensors at the same location or depth/height.

To manually create a station setup, complete the top portion of the "Adding Station" form, then press the **OK Add** button to save the newly created station setup. The "Station types", "Samples taken at this Station", and "Define Sensor Locations" options at the bottom of the form will now become available.

Press **Add Sample** to assign *sample definitions* the station. A station will have more than one sample definition if you collect data on more than one time scale. For example, a

station collecting data on an hourly and daily basis will have two sample definitions created for it. Both of these sample definitions must be assigned to the station.

After adding all sample definitions, press **Define Sensor Locations** to assign "Location" and "Depth/Height" to desired sensors.

7.4.4 Custom Report Setup

It is often desirable to generate a report containing more than one measured parameter. ResultX Database provides the ability to create custom reports containing any combination of data collected at a station. To set up a custom report, select **Setup – Custom Report** from the main menu. At the "Custom Reports" screen, press **Add** to create a new custom report. A custom report consists of the following elements:

Report Code: Unique 6-letter word used to identify each custom report.

Description: Description of custom report.

Report Type: Type of custom report. (for use in future versions of ResultX Lite, for now choose "Custom")

Report Title 1: First line of the title appearing at the top of the printed report.

Report Title 2: Second line of the title appearing at the top of the printed report.

Report Footer: Line of text appearing at the bottom of the printed report.

To create a custom report, complete the top portion of the "Adding a Custom Report" form, then press the **OK Add** button to save the newly created custom report. The report column window at the bottom of the form will now become available. Press **Add** to assign measurements to each report column. A report column consists of the following elements:

Reference Station: Choose a station to limit the choices in the *measurement* box, or leave the selection at "All Stations" to choose from all available measurements.

Summary Period: Choose a summary period to limit choices in the measurement box, or leave the selection at "Any" to choose from all available measurements.

Column Number: The desired report column number (1-100) for the measurement. Only the first 12 columns will display on the printed report, but reports with up to 100 columns may be created for export to a file as described in section 7.4.5 of this manual.

- Measurement:* Station data to be displayed in the current column.
- Heading 1:* First line of the report column heading. If this box is left empty, a default column heading will appear on the report.
- Heading 2:* Second line of the report column heading. If this box is left empty, a default column heading will appear on the report.
- Number Format:* Choose a format indicating the number of decimal places desired in the printed report.
- Page Summaries:* Check which summaries you would like on the report column (average, maximum, minimum, total).

After a custom report is created, data from any station can be used to generate the report. If you have several stations monitoring the same parameters, it is not necessary to create a custom report for each station. Refer to section 7.4.5 of this manual for viewing/printing custom reports.

7.4.5 Viewing/Printing Custom Reports

To provide an introduction to custom reports, several demonstration data sets have been included with ResultX Database. The "zDemo1 Weather Station" demonstration data includes three months of hourly and daily data collected from a MonitorX station monitoring air temperature, leaf wetness, rainfall, relative humidity, wind speed, soil temperature, and soil moisture at two depths. A demonstration report has been created to illustrate the custom report feature. To generate a custom report based on the demonstration data, select **Reports – Custom Report** from the main menu.

At the "Custom Report" screen, press the 'down' arrow on the *Station* box and select "zDemo1 Weather Station" as the station to generate reports from. Use the 'down' arrow on the *Report* box and select "zDemo Weather Report". To view a report of daily data, verify that "Daily Data" is selected as the *Summary Period*. In the "Select Dates" box, you may select *All* to view a graph of the entire data set, or enter a specific *Date Range* to view a select range of dates. Dates are entered as {month/day/year} (i.e. 6/15/1998) or time may be included in hourly reports as {month/day/year hh:mm} (i.e. 6/15/1998 13:00). The demo data was collected from 4/1/1998 through 7/8/1998. Press the **Show Me** button to view the selected custom report.

A report will be generated with each month of data on a separate page and a summary of data for that month at the bottom of each page. Use the arrow keys in the lower left corner of the screen to switch between pages and the magnifying glass to zoom in on sections of the report. Choose the "printer" icon to print the report. Press the "X" in the upper right corner of the screen to close the report. To create custom reports based on your specific MonitorX station data, refer to section 7.4.4 of this manual.

If you use Microsoft Excel or a different software package to analyze data, you may wish to create custom reports and select the **Export to File** button on the "Custom Report" screen to save the data in Microsoft Excel or comma delimited text format. Custom reports with up to 100 columns can be created for export to a file, although only the first 12 columns will appear on reports viewed in ResultX Database.

7.4.6 Leaf Wetness Analysis

Leaf wetness analysis is available through **Reports – Leaf Wetness** for MonitorX stations collecting hourly leaf wetness data. At the "Leaf Wetness Analysis" screen, select the *Station* and *Date Range* for leaf wetness analysis. Leaf wetness values are reported on an index scale of 0-10, with 0 being dry and 10 being very wet. Enter a value for *leaf wet point* (0-10), indicating an index value at which the leaves are considered wet (default = 5). Enter a value for *time to dry* (hours), indicating the number of hours it takes for the leaves to dry (default = 5). When you are finished entering values, press the **Calculate** button to compute a leaf wetness summary report. The leaf wetness summary for the selected *Date Range* contains the following items:

<i>Hours Wet:</i>	Total number of hours where leaf wetness is above the <i>leaf wet point</i> .
<i># of Wet Periods:</i>	Number of time periods where leaf wetness is above the <i>leaf wet point</i> .
<i>Avg Temp when Wet:</i>	Average air temperature when leaf wetness is above the <i>leaf wet point</i> .
<i>Avg Index when Wet:</i>	Average wetness (0-10) of leaves above the <i>leaf wet point</i> .
<i>Long Period:</i>	Greatest length of time (hours) where leaf wetness is above the <i>leaf wet point</i> .
<i>Events:</i>	Date/time when "Ascospore Infection Threshold" was met when running an <i>Apple Scab</i> leaf wetness report.

To view/print a summary of the leaf wetness analysis, press the **View Report** button.

7.4.7 Degree Day Calculations

Degree Day calculations based on average daily temperature are available through **Reports – Degree Days**. At the “Degree Day Calculations” screen, select the *Station* and *Date Range* for calculations. You may change the value for *maximum allowed average daily temperature* to set an upper bound on the calculations (default = 100 °F). Enter a value for the *base temperature* (default = 50 °F). When you are finished entering values, press the **Calculate** button to compute degree days. The *Cumulative Degree Days* during the selected *Date Range* will be displayed. To view/print a summary of the degree day calculations, press the **View Report** button. To view a graph of accumulated degree days, press the **View Graph** button. To print the graph, check the *Print Preview* box before pressing the **View Graph** button. The graph will be displayed in a printable format. Use the magnifying glass to zoom in and out on sections of the graph, and the “printer” icon to print the graph.

7.4.8 Import Data

Instead of using **Auto Import** as described in section 7.3.6, you may choose to manually import data into ResultX Database. To manually import data, select **Data Table Functions – Import Data** from the main menu. At the “Import Sample” screen, choose to import data from *All* stations or a *Specific* station.

ResultX Database maintains two backup copies of your original raw data for security. Raw data is appended to a *.old file in the data directory before the import process. The *.old file for each station contains a running list of all data ever imported from that station. In addition, the newest raw data file imported from a station is stored as a *.bak file. This file is replaced each time a new set of data for a station is imported. After the import process, the original *.dat file is set to zero bytes, with the data moved to a *.bak file where it can be retrieved if necessary.

7.4.9 View/Edit Raw Data

To view, add, change, or delete the raw data imported from a MonitorX station, select **Data Table Functions – Data Listing: Enter/Edit**. Optionally select the desired *Station*, *Measurement*, *Identifier*, and *Dates* to search for, then press **Requery** to display the raw data in the “Search Results” box. Use the **Add**, **Change**, and **Delete** buttons at the bottom of the screen to modify the raw data.

7.4.10 Compress System Database

Repeated import, archive, and purge of data can cause the database to become fragmented and use disk space in a manner that is less than optimal. Periodically, you should compress the system database to defragment the file. This will usually result in a smaller file size, which saves disk space and increases the performance of data retrieval for reports and graphs. To compress the system database select **Data Table Functions – Compress System Database**. Depending on the size of your database, it may take several minutes to complete this operation. For maximum security, you may wish to first create a system backup as described in section 7.4.13 of this manual before compressing the system database.

7.4.11 Archive/Purge Data

Maximum database performance is achieved through minimum database size. To decrease the size of your database, you should consider archiving any unused data. Available through **Data Table Functions – Archive/Purge Data**, unused data can be moved to an archive file. Data may be archived by station, summary period, and/or date. You may archive data to a new filename, or choose an existing archive to append data to. The **Archive and Purge** command will move data from the system database into an archive file. In contrast, the **Purge** command will permanently delete data from the system database with no archive created. Therefore, the **Purge** command should be used with caution. Depending on the size of your database, it may take several minutes to complete an archive/purge operation. Archived data can be restored to the system database using the restore feature described in section 7.4.12 of this manual.

The archive command stores only raw and calculated data in the archive file. Since no station setup, sample definition, custom report, or function data is stored, archiving data is not a substitute for the system backup described in section 7.4.13 of this manual.

7.4.12 Restore Data

Archived data can be restored to the system database using the **Data Table Functions – Restore Data** feature. After selecting an archive file, you may restore data by station, summary period, and/or date. Restored data remains in the archive file, so it is not necessary to archive the data again unless changes are made.

7.4.13 Create System Backup

It is strongly recommended that you keep a current system backup of your database in the event of hard disk or computer failure. This feature is available under **Data Table Functions – Create System Backup**. Depending on the size of your database, it may take several minutes to create a system backup.

7.4.14 Reattach Data File

ResultX Database consists of two database files; the program file (ResultX.mdb) and the data file (RsltData.mdb). In some instances you may use multiple data files in conjunction with the program file. The **Data Table Functions – Reattach Data File** feature is used to switch between multiple data files.

Section 8: Maintenance

8.1 MonitorX Station

Your MonitorX station is designed to be a reliable, durable, low maintenance system. Sensitive electronics are contained within an environmental enclosure designed to withstand "normal" weather and field conditions. MeasureTek recommends twice yearly preventative maintenance, including cleaning and inspection of the MonitorX station. Regular maintenance should include:

- Periodically check the station battery voltage, either by viewing real-time measurements with the *Connect +* software or using *ResultX Lite Database*. Battery voltage dropping below 12 volts could indicate a failing battery or damaged solar panel. When the voltage drops below 10 volts, you will be unable to communicate with the station via phone, and must make a site visit with a laptop to correct the problem.
- Clean the MonitorX enclosure and remove any insects that may have moved in. Check for indications of water or rodent damage in and around the station.
- Check for loose sensor wires inside the station enclosure. Tighten all connectors running into the station.
- Clean and inspect the solar panel for damage. The solar panel is the most sensitive component in the MonitorX system and is subject to damage from severe weather (i.e. hail, flying debris) and vandalism (i.e. shotgun).
- Check and maintain the lead acid battery water level.

8.2 Sensors

8.2.1 Watermark Soil Moisture Sensors

The Watermark soil moisture sensor is a self-contained, sealed device that requires no regular maintenance.

8.2.2 Druck Pressure Transducers

The Druck Pressure Transducer must be located such that the transducer does not freeze, get buried with silt, or move horizontally and/or vertically. By avoiding these problems, the maintenance and trouble with the sensor will be minimized.

A delicate diaphragm within the sensor is used to measure the water pressure. Expansion and contraction caused by freezing will damage the sensor. Trapped silt within the sensor can also cause the diaphragm to break or limit movement. Continual horizontal movement of the sensor, and hitting well or stilling well casings, can lead to a broken diaphragm. Vertical movement of the sensor, if not causing physical damage, will lead to erroneous water level analysis.

Because the sensor is encapsulated for durability, there is little that can be done to “fix” a broken sensor.

8.2.3 Dynagage® Sap Flow Sensors

The Dynagage is not a long term, maintenance free measurement device. It is important to keep the gauge free of moisture and out of harm from abrasions caused by pulling on cables and removing/installing gauges.

The cable connectors should be sealed by wrapping in electrical tape. Wires shorted due to moisture or broken cables can damage the Dynagage.

If removing G4 compound is desired, use only an acetone paint thinner by applying a small amount to a soft cloth and wipe excess grease away.

By installing a Dynagage sensor, you are installing a collar around the plant stem or trunk. As the plant stem or trunk increases in diameter, the gauge must be adjusted to prevent damage and to ensure accurate measurements.

It is recommended to check for proper fit weekly. During the weekly visit, check for dirt and sap buildup and clean if necessary. If sap is oozing from beneath the gauge, allow the wound to heal before re-installation.

8.2.4 MeasureTek Soil Temperature Sensor

The soil temperature sensor cable should be checked for proper burial to avoid being cut, plowed or tripped on.

8.3 Software

MeasureTek strongly recommends that you make regular backups of your collected data and store these backups in a safe location. Use the *Data Table Functions – Create System Backup* feature in the *ResultX Lite Database* software for this purpose.

To maintain system performance, you should periodically compress the *ResultX Lite* system database using the *Data Table Functions – Compress System Database* feature.

This will usually result in a smaller data file size, which saves disk space and increases the performance of data retrieval for reports and graphs.

Maximum *ResultX Lite Database* performance is achieved through minimum database size. In addition to compressing the database, you should consider archiving any unused data to further decrease the size of your database. Use the *Data Table Functions – Archive/Purge Data* feature in *ResultX Lite* for this purpose. Most users find it convenient to archive data based on water year or growing season.

Section 9: Troubleshooting

9.1 Troubleshooting MonitorX Station

The most common problems with the MonitorX station involve a failure to establish a connection using the *Connect +* software. To correct a communication problem:

- 1) Verify that you are attempting to connect within the time window the cellular phone is turned on (7:00 a.m. to 6:00 p.m., 15 minutes before through 15 minutes after the hour). Continue to try the connection in 15-minute intervals, as the station clock may be incorrect.
- 2) Verify that the connection settings in the *Connect +* software are correct. Refer to the *Connect +* user's guide for a description of the connection settings.
- 3) Check the battery and battery cable (should be +12 V). A dead battery may be an indication of a damaged solar panel. Check the "green" charging light on the solar panel voltage regulator. If nighttime sap flow measurements are enabled, they may be drawing the battery down too much for the solar panel to recharge.
- 4) Verify that the MonitorX processor is connected to the phone modem with the blue 9-pin cable.

9.2 Troubleshooting Sensors

9.2.1 Watermark Soil Moisture Sensors

Problems with the Watermark sensor are often detected when the sensor abruptly reads 200 centibars, or is continually reading higher than expected measurements in comparison to field observations of moisture.

Most problems with the Watermark sensor result from situations in the field, and not with the actual sensor. The most common problems in the field are:

- 1) The sensor lead wires have been accidentally cut. This will cause soil moisture readings to abruptly change to 200 centibars. A cut lead wire can be caused by farm equipment (plowing or deep ripping through wires), rodent damage to wires, or other accidental damage. Look for visual signs of damage and replace/repair broken wires with waterproof splices.

- 2) The sensor does not have a snug fit in the soil. This usually happens when the shaft made for the sensor is oversized, or backfilling of the sensor hole is not complete. Re-install the sensor nearby, installing the sensor in a 7/8" diameter shaft and carefully backfilling the access hole.
- 3) The sensor is not in an active portion of the root system, or the irrigation is not reaching the sensor area. This can happen if the sensor is sitting on top of a rock or below a hard pan which may impede water movement. Re-installing the sensor usually solves this problem.
- 4) When the soil dries out to the point where you are seeing readings higher than 80 centibars, the contact between soil and sensor can be lost. The soil starts to shrink away from the sensor. An irrigation which only results in a partial rewetting of the soil will not fully re-wet the sensor, which can result in continued high readings. Full rewetting of soil and sensor usually restores the soil/sensor contact. In severe cases, re-installing of the sensor is required.

If everything appears normal in the field, it is time to test the individual sensor:

- 1) Submerge the sensor in water for at least 15 minutes. The sensor reading should be zero (range from 0 to 3 cbar). If the sensor fails to read zero, it needs to be replaced.
- 2) Air-dry the sensor for 48 hours. Depending on the ambient temperature, humidity, and air movement, the sensor reading should gradually increase to 150 centibars and beyond. If the sensor fails to read a high tension, it needs to be replaced.
- 3) Re-submerge the sensor in water. The sensor readings should return to zero. If the sensor has passed the tests in steps 1-3, it is time to re-check conditions in the field.

9.2.2 Druck Pressure Transducers

The most common problems with the Druck pressure transducer are:

- 1) A consistent error is observed in the water level measured by the sensor. This problem is easily fixed by entering a correct *NewDepth* for the sensor in the *Connect* + software to correct the offset.
- 2) An inconsistent error is observed in the water level measured by the sensor. This problem is likely caused by vertical movement of the sensor, and can be corrected by properly securing the sensor.
- 3) The sensor is reading -6999 or -99999. Check the sensor cable to see if it has been accidentally broken or incorrectly connected to the MonitorX station. If all wiring seems correct, the sensor diaphragm may have broken. Contact MeasureTek for repair.

9.2.3 Dynagage® Sap Flow Sensors

The most common problems with the Dynagage sap flow sensors are:

- 1) The sensor is reading -6999 or -99999 for AH, CH, BH, or Vin. Check the sensor cable to see if it has been accidentally broken or incorrectly connected to the MonitorX station. Check for a broken heater element. Check the resistance of the pins on the extension cable (should be 0.2 – 2.5 ohms).
- 2) Negative sap flow is being reported. The Ksh value needs to be adjusted. Re-check no-flow Ksh conditions and adjusts the value.
- 3) No sap flow is being reported. The system needs to run for 30 minutes before readings will appear. If readings still to not appear, check the power input to the control regulator (should be +12 V) and the power output at V1 and V2.
- 4) The sensor is reporting inconsistent readings and/or high temperature swings. Check the sensor for a proper and snug fit. If necessary, install more solar shielding. If the fit and shielding are acceptable, adjust the voltage input upward by about 20%.

9.2.4 MeasureTek Soil Temperature Sensor

Very few problems are found with the soil temperature sensor, however most problems will be due to 1) a cut, or “chewed” sensor cable, or 2) a loose or disconnected connector.

Section 10: Warranty and Technical Support

10.1 MonitorX Station and Sensors

The MonitorX Processor is warranted by MeasureTek to be free from defects in materials and workmanship under normal use and service for 3 years from the date of shipment unless specified otherwise. Communication devices and sensors are warranted to be free from defects in materials and workmanship under normal use and service for 1 year from the date of shipment unless specified otherwise. MeasureTek's obligation under this warranty is limited to repairing or replacing (at MeasureTek's option) defective products. The customer shall assume all costs of removing, reinstalling, and shipping defective products to MeasureTek. This warranty will not apply to MeasureTek products that have been subjected to modification, misuse, neglect, accidents of nature, or shipping damage. This warranty is in lieu of all other warranties, expressed or implied, including warranties of merchantability or fitness for a particular purpose. MeasureTek is not liable for special, indirect, incidental, or consequential damages.

Products may be returned after receiving prior authorization. Return authorization is obtained by calling (541) 757-8564. MeasureTek's shipping address is:

MeasureTek
557 SE Powell Avenue
Corvallis, Oregon 97333

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10.2 *Connect + and ResultX Lite Database Software*

MeasureTek warrants that the diskette on which the accompanying computer software is recorded and the documentation provided with it are free from physical defects in materials and workmanship under normal use. MeasureTek warrants that the computer software itself will perform substantially in accordance with the specifications set forth in the Instruction Manual published by MeasureTek. MeasureTek warrants that the software is compatible with IBM PC/XT/AT and PS/2 computers and 100% compatible computers only. MeasureTek is not responsible for incompatibility of this software running under any other operating system other than those specified in the Instruction Manual.

The above warranties are made for ninety (90) days from the date of original shipment.

MeasureTek will either replace or correct any software that does not perform substantially according to the specifications set forth in the Instruction Manual with a correct copy of the software.

MeasureTek is not responsible for any costs incurred as a result of lost profits or revenue, loss of use of the software, loss of data, cost of re-creating lost data, the cost of any substitute program, claims by any party other than licensee, or for other similar costs.

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