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Americo Energy
Denton #1 SWD Mainline
Work Plan
Unit J, Section 11,Township 15S, Range 37E
Lea County, New Mexico

November 15, 2004

Prepared for:

Americo Energy
10940 Old Katy Road
Houston, Texas 77043

By:

Safety & Environmental Solutions, Inc.
703 E. Clinton Suite 102
Hobbs, New Mexico 88240
(505) 397-0510

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I. Company Contacts

Rusty Arnold	Americo	713-984-9700	rusty.arnold@americoenergy.com
Bob Allen	SESI	505-397-0510	ballen@sesi-nm.com

II. Purpose

The purpose of this work plan is to propose a plan for the cleanup of the area identified as the Denton #1 SWD Mainline. The site is located in Unit J, Section 11, Township; 15S, Range 37E. The land is owned by Mr. Darr Angell.

III. Background

On July 25, 2004 the Denton # 1 SWD Mainline, which is a 10" red thread fiberglass pipe, breached and released approximately 10,000 barrels of salt water. The line was shut down and excavated with a backhoe. The damaged section of the line was removed and replace with new.

IV. Contaminant and Size of Area

The suspected contaminant is salt water. Approximately 10,000 barrels of salt water were released. The release covered an area approximately 500' X 1,000'.

According to Permian Production Chemical, an analysis of the produced water which flows through this line indicates a chloride concentrations of 53,053 ppm.

V. Vertical and Horizontal Extent of Contamination

As reported in the Delineation Report dated September 28, 2004 SESI installed six boreholes in the area. With the exception of Borehole #1 in which auger refusal was encountered at 30' all other boreholes indicate the vertical extent of contamination to be between 20 and 25 feet in some areas. Installation of the monitor well which is reported in the Monitor Well Installation Report dated November 11, 2004 indicated the contamination has not reached the groundwater.

VI. Groundwater

Monitor wells installed by SESI within ½ to ¾ of a mile of the subject site have respective depths to water of 56.04' and 67.78'. During installation of the monitor well on this site the depth to groundwater was found to be 59.1 feet.

VII. Action Plan

The installation of boreholes and the subsequent analysis of the soil extracted from them indicate that the vertical migration of the chlorides does not extend deeper than 30'. The analysis of the groundwater extracted from the monitor well installed in the mostly heavily contaminated area confirms that the chloride contamination has not reached the groundwater.

While researching seeking an alternative to the conventional dig, haul and replace or partial excavation and liner methods of cleanup of sites contaminated with saturated brine

New Considerations for SES/Americo/Angell Salt Spill Remediation - DRAFT
GreenBridge EarthWorks (GBEW) 1/21/05

This communication provides follow-up information requested during the meeting among the above organizations on 1/7/05 at the Safety & Environmental Solutions, Inc. (SES) office in Hobbs, NM. Data and commentary provided by the landowner, the operator, SES, various knowledgeable individuals, organizations, and publications were relied on and considered. Recommendations are also based on brief site visual observations, and data compilation, reduction, synthesis, and interpretation by GBEW, and are subject to revision if warranted by new information.

Summary
The primary environmental considerations are to prevent/mitigate negative impact on good quality groundwater, to prevent expansion of the salt-affected area, and to avoid creating new problems due to remediation activities.

Although the topsoil salinity was very high when measured in late September 2004, an attempt to save the topsoil and mitigate salinity in situ by biotic remedial interim revegetation with salt-requiring/salt-tolerated forage plants under dryland conditions is recommended as a trial by GBEW. This approach would include soil surface preparation to physically mitigate surface soil salinity by enhancing rainfall capture and retention in the spill area, minimization of evaporation in the spill area, light fertilization, incorporation of hay mulch, and topdressing with wind-stabilized hay and hydromulch cover. An electric fence is recommended to control interference by cattle.

Biotic remediation employs the water pumping and salt-extraction capabilities of salt-requiring/salt-tolerant forage plants. Candidate plants for this site include Alkali sacaton (Sporobolus airoides), Salt alkali grass (Puccinella disinans), Jose tall wheatgrass (possibly the Elytriga ponticum or Thinopyrum ponticum), and Inland saltgrass (Distichlis spicata subspecies stricta). This combination of winter and summer forage grasses exhibit the best combination of salt tolerance, salt extraction, and minimal pest potential of a number of species considered for this project.

These species are not considered pest plants. The Alkali sacaton, and Inland saltgrass variety selected are not expected to migrate beyond the salt affected site because they will not compete well in non saline soils. Although the Salt alkali grass and Jose tall wheatgrass may migrate beyond the spill area, they are winter grasses. Some plant specialists consider Jose tall wheatgrass to be a forage of similar value to the blue gamma (Boutelous gracilis) which is favored by the landowner. A firm no-migration restriction would limit phytoremediation species to Alkali sacaton and Inland saltgrass.

The potential for success of this biotic (phyto)remediation program depends on mitigation of salinity to levels lower than that measured in late September. Factors projected to contribute to the success of this program are mitigation of topsoil salinity by mulch, interruption of downward migration of salts due to unsaturated flow cone of depression and salt uptake resulting from plant water extraction and transpiration. The observation of numerous green volunteer plants on the spill site at the time of the GBEW site visit in early January, 2005 indicates a much lower topsoil salinity than indicated by laboratory analyses. This is a common occurrence as weather conditions manipulate the ebb and flow of soil pore water. Spatial and topographic (even very slight elevation differences are important) variability at the site can cause in these observations. Further, as remediation plants gain foothold in various spill site locations, they will expand into increasingly salt-distressed areas as they are able. As salt is removed from the spill site, the salt requiring plants will diminish and be replaced by nearby species that do not require high salinity.

The alternative/fall-back remedial action would be mechanical removal and/or replacement of excessively saline topsoil, or possibly importation and placement of new topsoil above the current spill area. Additional considerations to mechanical remediation would include steps to prevent lateral and vertical migration of residual salts due to introduced disturbance of soil physical/chemical factors.

Chemical remediation is contraindicated due to difficulty with solubility of remediation chemicals, lack of voluminous leaching water, the need to over irrigate to achieve a leaching fraction which would create a hydraulic head below the root zone, and problems associated with capture of draining soil pore water within a 6 – 28 inch deep topsoil.

Discussion

Technologies which can be used for remediation of salt impacted oilfield soils can be divided into three categories: mechanical (dig and haul), chemical (use of a chemical amendment and suitable internal soil drainage (deep profile sufficiently isolated from useable groundwater), and biotic (use of plants as biological water pumps, soil ecology restorers, soil surface protectors, and salt extractors).

At the site in question, biotic remediation is the most practical remedy. The impacted site is approximately four to five acres of total vegetation kill with spotty vegetation kill on the remaining impacted area. Mechanical remediation is impractical due to undulation in underlying caliche and because some salts have already entered the underlying caliche. Chemical remediation is impractical due to a) an inability to install an effective subsurface drain in the caliche, b) the fact that the caliche already has preferential flow paths, and c) the fact that some salts have already passed below any reasonable drainagewater recovery depth.

Biotic remediation under dryland conditions provides the best opportunity to arrest downward migration of salts because the plants will have the primary effect of decreasing hydraulic head by evapotranspiration forces near the soil surface. Plants capable of growing in saline conditions will draw water into plant roots creating an unsaturated cone of depression regarding soil water potential. The unsaturated cone of depression will influence soil moisture potential some distance from the plant roots including moisture below the root zone. The effect should be to deprive salts below the root zone of additional hydraulic head from above, therefore mitigating further downward migration of salts after the roots have become established.

Requests have been made to several organizations and individuals to obtain forage nutrition data for relevant species, as have inquiries regarding the location of halophyte plots in a relevant geomorphic location. Functional replies will be forwarded as soon as they are received.

Technical Consideration Appendix

In late September, 2005 the surface soil chloride (Cl^-) content averaged about 26,650 mg/kg. This would suggest a sodium (Na^+) concentration of about 16,850 mg/kg for a total NaCl concentration of about 42,500 mg/kg. This value equates to about 4.25% NaCl salt in the topsoil. For the Kimbrough-Lea soil complex, assuming a typical moderately coarse-grained topsoil porosity equating to an estimated saturated paste moisture percentage of about 37%, this salt content may have approximated 180 dS/m {deciSiemens/meter} in the saturated paste extract (which equals the same value in the antiquated salinity units, i.e., 180 mmhos/cm {millimhos/centimeter}) on the date the samples were collected. For the more moderately textured heavy clay loam Stegall soil, an assumed saturation percentage nearing 50% would equate to a salinity of about 130 dS/m on the date measured. The saturated paste extract takes into account the effect of soil porosity and minimizes the influence of cation exchange capacity which would otherwise contribute to weight based, but not plant root applicable soil solution salt totals. The saturated paste extract is utilized because this is the level of salts which plant roots would experience when soil pores are saturated with water. Saturated paste extract values of 180 dS/m and 130 dS/m are numerically about three to four times higher than seawater (which is approximately 46 dS/m). Applied mulch can be expected to bring these values down substantially.

During development of salt spill remediation techniques, it quickly became evident that biotic technology would often be the remediation method of choice. After making inquiries of numerous halophyte specialists, the professional name most consistently mentioned was Dr. Nick Yensen. After discussions a halophyte technology firm, NyPa-GreenBridge, a partnership, was formed to utilize the soils background of of GBEW and the halophyte background of NyPa-International. Dr. Yensen's input is presented below:

Dr. Yensen indicates a site visit will be important to help him gain a clearer perception of the most suitable plants for this remediation project. The ability of conductor plants to pass salt from roots to leaf blades is important to the maintenance of the soil salt levels. The strong soil penetrating effect of certain halophyte roots (the sharpe penetrating {rhizocanicular} effect of these rhizomes) opens up and oxygenates the soil. The rhizocanicular effect is a function of very sharp, powerful, and aggressive rhizomous (from rhizomes or runners, subsurface in the case of Distichlis, and explorationally radiating away from the central plant like wheel spokes) root tips of some Inland saltgrass species. These roots can be expected to explore current preferential channels, including penetration of caliche fractures. This can be expected to result in a very large volume of root exploration from which the unsaturated cone of depression will emanate. By contrast, typical accumulator plants are less capable in this regard.

Dr. Yensen also notes that:

1. Accumulators will remove only about 1-10% of the amount of salt that conductors could.
2. Most accumulators will require some irrigation at least to et started.
3. The candidate remediation grass species listed above are not exotic, and most occur all over New Mexico. Except for the sterile Distichlis spicata var. Yensen-4, the only reason they are not already on the landowner's property is lack of salty soil.
4. The Alkali sacaton and Distichlis grasses prefer salty soil and are easily out competed when the salt level becomes reduced, which may take only 2-3 years compared to 20-30 years for accumulators.
5. Accumulators plants also require harvest to remove salts.
6. The amount of wind borne salt (very fine hair-like crystals wafted and suspended into the air and commonly dispersed great distances from conductor plants by even slight winds) that settles out of the air is typically of an amount ideal for growth stimulation in other grasses.
7. The conductors actually work well in semi-arid to arid conditions than in more humid locations.
8. While the protein content of Distichlis spicata var. Yensen-4 is not a good as alfalfa (which requires substantial water), it can be of a high energy level with a protein level consistent with meat production according to University of Arizona animal feed specialists. Extensive nutritional data from all over the world shows protein varies from 6% (ungrazed lignified material) to 19 % with a typical level around 10-12%. Primary design use for this project would be to remediate the soil so that freshwater forages would ultimately reestablish there.

Nutritional Characteristics of NyPa Forage, *Distichlis spicata* var. *yensen-4*, (Poaceae)

Dr. Nicholas P. Yensen

NyPa, Inc., 727 N. Ninth Ave., Tucson, AZ 85705, USA
Tel. (520) 624-7245, fax. 908-0819, email: nypa@aol.com

The use of highly saline water for animal forage production has had limited success due to either the accumulation of salts and toxic compounds in forage plant tissues which limits the percent allowed in diets (c.f. Chaenopodiaceae). While most grasses (Poaceae) also may accumulate salts and have reduced productivity, some grasses have been shown to be euhalophytes (true halophytes which perform much better under saline conditions than non-saline conditions) with increased productivities with increased salinities. Herein is described a euhalophyte grass that does not have an accumulation of salts or toxic compounds and has value as animals feed when grown at high salinities (>10 dS/m). [10 dS/m in saturated paste extract equates to about 7,000 mg/L, TDS]

I have developed a new variety of saltgrass, *Distichlis spicata* var. *yensen-4* (named by L. Acker and C.R. von Hellens) which has productivities as high as three or more times the typical productivity of *Distichlis spicata.* In one trial it produced an above-ground, harvestable, dry-weight biomass of 5.7 T/A/4-month period compared to 1.6 – 0.5 T/A/4-month period for other species and varieties of *Distichlis.* Productivity increased with increasing salinity to an optimal salinity of between 20-30 dS/m salinity. Above 30 dS/m salinity the productivity drops gradually allowing the new variety to grow at full-strength sea water (circa 46 dS/m).

The new variety is the result of over 20 years of research on salt-tolerant grasses and the breeding and selection of thousands of varieties and populations from around the world.

Recent trials in various countries suggest that under proper management and cultivation practices the forage variety can produce forage suitable for goats, sheep, and beef-cattle. The use for dairy cows, ostrich, poultry, aquaculture and horses requires diet formulation, but can constitute the bulk of the diet.

The chemical composition is: 5.94-15.2 % protein, 8.13 % gross fat, 47.02 % non-nitrogenous matter (by difference), 20.74-37 % gross fiber/cellulose, 5.72-14.3 % ash, 1245.7 KJ/100 g (3.75 **protein+4**carbohydrates+9*fat*4.186), 6.8-5.1 % lignin, 0.23-0.93 % Ca, 0.1-0.97 % P, 0.69-1.17 % K, 0.14-.33 % Mg, 0.18-0.27 % S, 0.21-2.76 % Na, 0.84-1.10 % Cl, 2-5 ppm B, 4.1-200 ppm Cu, 250-600 ppm Fe, 39-75 ppm Mn, and 30-66.9 ppm Zn.

Yearling calves grew virtually as well with a formulated new variety forage diet as with a conventional formulated diet.

This NyPa-Forage is a sterile plant and must be planted as a plug. The sterility and salt dependence of this plant prevents it from migrating except as rhizomes.

Some further information from Dr. Yensen on recommended plants:

1. Alkali sacaton (Sporobolus airoides) is a grass, commonly found on sandy alkaline soils in Mexico and the US, that has a demonstrated salt-tolerance of 14 dS/m (some populations withstanding up to 45 dS/m). The seeds were a complimentary food source for the Native Americans, often mixed with corn to make a finely ground meal, baked into bread or cooked as gruel. Although considered famine food by the Hopi Indians, further nutritive studies and plant selection is necessary to determine its potential as human and/or animal feed. Even though alkali sacaton is considered an attractive reclamation grass, it is used infrequently for forage, erosion control, and ornamental purposes. Of the candidate species list Alkali sacaton has the greatest potential. It is a mild conductor of salt. It is a reasonable forage that needs to be seeded soon in order to become established. It has a poor rhizocanicular effect and thus will not benefit the soil as much as a good rhizocanicular species.

2. Salt alkali grass (Puccinella disinans) may survive in salinities up to those which may be at the site, but productivity will be minimal above 10 g/l and would probably need fencing to get established. It has good forage value only in the winter. It may be too late to plant this year, except maybe by plugs. It may not survive the low rainfall and aridity. It has been a big success in wetter areas of Australia. A friend, James Darling, in SE Australia sells tons of seed and has a restored cattle ranch ... and is very interested in NyPa Forage.

3. Jose tall wheatgrass (a cultivar of Elytriga ponticum or perhaps Thinopyrum ponticum)
Jose tall wheat grass is a variety of *Agropyron elongatum* which is the wheat grass that is commonly used in saline areas. Again, productivity will drop after 10 g/l salinity and it grows best in winter. It is questionable as to whether it will survive the dry periods.

4. Inland saltgrass (Distichlis spicata or other varieties of Distichlis)
There is great variation in the quality of this grass in the wild. Some varieties are excellent forages with soft palatable leaves and protein contents up to 20%. These are the best salt conductors known and are capable of dispersing wafted salts up to hundreds of miles away and to the benefit of the environment. There may not be enough rain to establish them well enough to survive the summer. If established, however, appropriate varieties will remove salt until virtually no salt is left, even under droughty conditions. At low salinity most selected varieties cannot compete with freshwater (glycophyte) plants. Many are incapable of surviving in low rain fall and/or freshwater conditions. The potential of certain varieties becoming a weed is virtually zero.

With regard to surface mulch GBEW have formed the following new considerations:
Although hay mulch, including peanut hay mulch, would be ideal if it could be held in place, there are other types of mulch available. It would be possible to apply halophyte and other types of seeds suitable to the landowner using hydromulching techniques. Hydromulching can also apply soil and mulch tackifiers, and this can be done at a reasonable cost. It is also possible to staple unrolled hay surface mulch. Biodegradable twine net stapled with reverse-grooved long thin wooden stakes (e/g., 1/4" dowel) could be used to tie down the mulch against wind blow. Again, an electric fence would be used to keep cattle from

interfering until biodegradation and halophyte growth semi-incorporated it into the soil. Unrolled peanut hay mulch could also be slightly covered at the edges by plowed soil. A guar or 'Slicky Sticky' tackifier could be used to assist with hay stability against wind. A wood/paper mulch could be used if hay mulch is deemed not acceptable, but I'm not sure that it would provide the same degree of moisture balance enhancement. A polymer tackifier could also be used to minimize soil susceptibility to wind erosion. Mulch and surface preparations will be applied to enhance rainwater entrapment and infiltration. These factors should substantially improve the survival capability of the candidate species.

Because irrigation is not a readily available option, and because irrigation may involve adverse coincident hydraulic head, this proposed remediation effort will be attempted under essentially dryland practices.

Dr. Yensen and possibly a local hydromulching specialist should be invited to visit with our project planning group to facilitate more direct communication.

I realize that Mr. Angell would prefer more concrete responses, but we can only provide what we have available to us at present. At this point, it is difficult to visualize any other viable route to this remediation effort.

Please let me know if additional information is required. We would be very pleased to provide remediation services if requested.

Sincerely, David J. Carty, Ph.D., CPSS, P.G.
GreenBridge EarthWorks
NyPa-GreenBridge
504 S Parkway
El Dorado, AR 71730

gbew@txcyber.com
979/229-6795 (cell)
870/863-9148 (H/O)

water, SESI contacted Dr. David J. Carty, PH.D, CPPSM P.G. Dr. Carty is a well known expert in the produced/salt water field.

Dr. Carty responded with a letter suggesting that Halaphyte crop plants that are compatible with our arid climate be planted on this site. Halophyte technology is a form of bioremediation which employs plants that require spilled saltwater ions (including otherwise problematic sodium and chloride) as fertilizer nutrients for growth. Halophyte plants that may be adapted to the environment at the subject site include forage, fiber, and fuel crops among others. Some halophyte forages suitable for the subject site have almost dairy quality protein, can be grazed or harvested as hay, provide tasty mineral nutrients for cattle, and are tender to mouth parts of cattle and otherwise quite palatable.

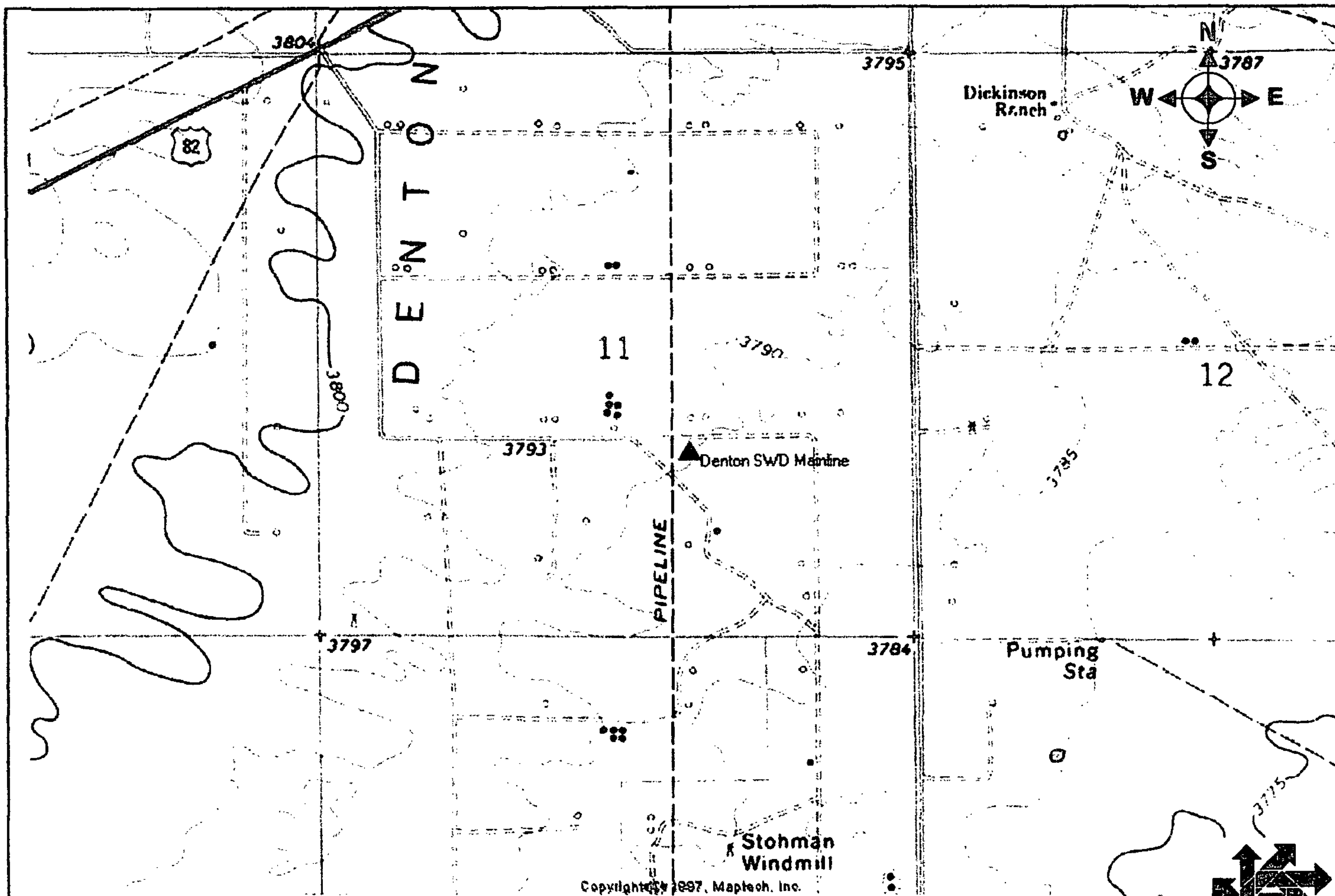
Dr. Carty's Statement of Qualifications can be found in Appendix A. Dr. Carty's letter detailing the use of Halophyte technology may be found in Appendix B.

Americo Energy would like to implement Dr. Carty's suggestion to use Halaphote technology at the subject site. Upon approval of this request, Americo Energy would submit to the NMOCD a detailed action plan documenting the number and type of plants to be used, a timeline for the planting of the folage as well as a schedule for the monitoring and evaluation of the project. Meanwhile, Americo Energy would continue to sample the existing monitor well on a semiannual basis and timely report the findings to the NMOCD.

VIII. Figures & Appendices

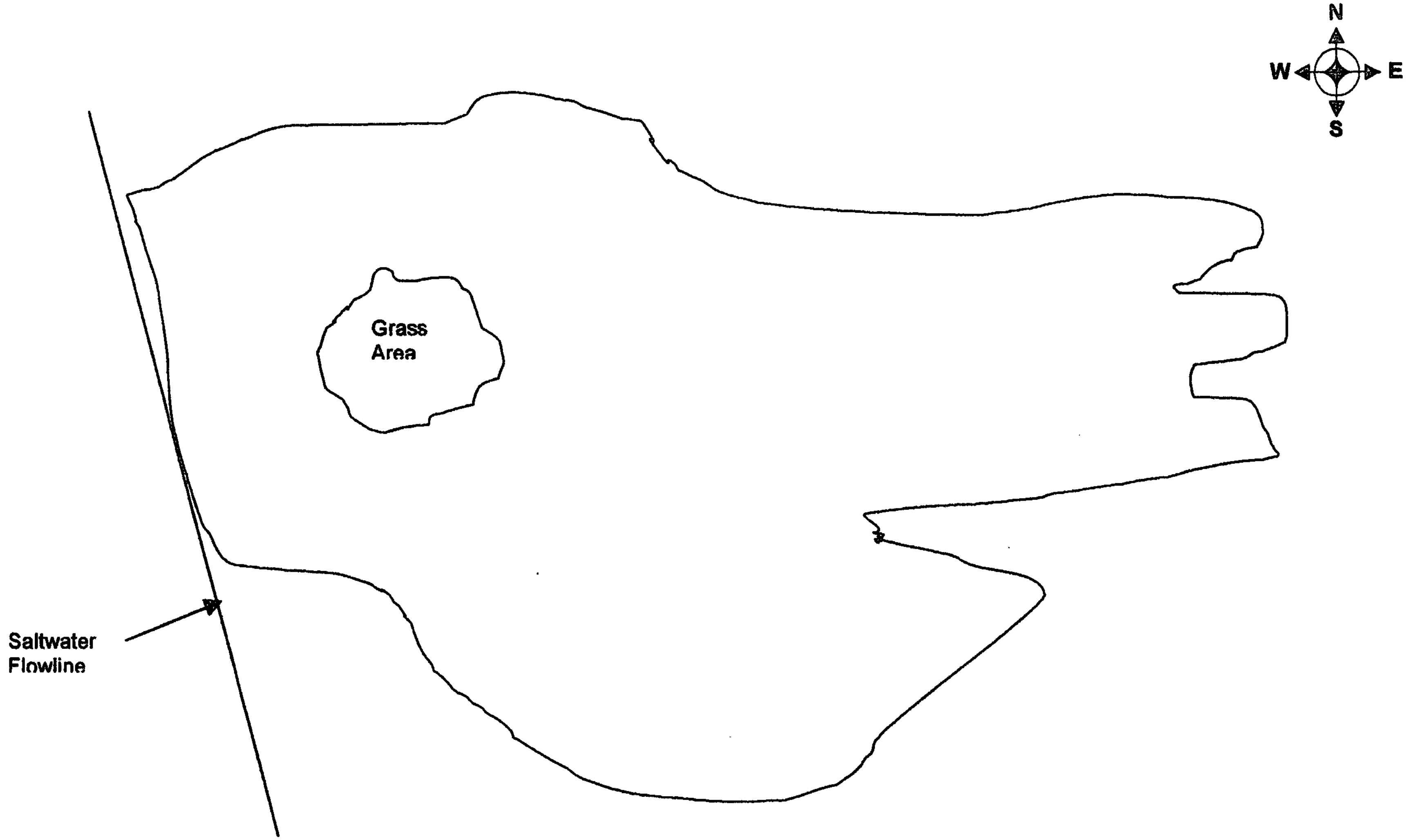
Figure 1. - Vicinity Map
Figure 2. - Site Plan
Appendix A - C-141
Appendix B - David J. Carty Statement of Qualifications
Appendix C - David J. Carty Recommendations

Figure 1
Vicinity Map



Americo Energy	Denton #1 SWD Mainline Unit J, Sec 11, T15S, R37E Lea County, New Mexico	Safety & Environmental Solutions, Inc.

Figure 2
Site Plan



Not to Scale

Americo Energy	Denton #1 SWD Mainline Unit J, Sec 11, T15S, R37E Lea County, New Mexico	Safety & Environmental Solutions, Inc.

Appendix A
C-141

District I
1625 N. French Dr., Hobbs, NM 88240
District II
1301 W. Grand Avenue, Artesia, NM 88210
District III
1000 Rio Brazos Road, Aztec, NM 87410
District IV
1220 S. St. Francis Dr., Santa Fe, NM 87505

State of New Mexico
Energy Minerals and Natural Resources

Oil Conservation Division
1220 South St. Francis Dr.
Santa Fe, NM 87505

Form C-141
Revised October 10, 2003

Submit 2 Copies to appropriate District Office in accordance with Rule 116 on back side of form

Release Notification and Corrective Action

OPERATOR

☑ Initial Report ☐ Final Report

Name of Company AMERICO ENERGY RESOURCES	Contact STEVE SMITH
Address 18940 OLD KATY Rd. HOUSTON, TX 77043	Telephone No. 441-0926
Facility Name BENTON SWD #1	Facility Type SALTWATER DISPOSAL LINE

Surface Owner DALE HAGELL	Mineral Owner	Lease No.

LOCATION OF RELEASE

Unit Letter	Section	Township	Range	Feet from the	North/South Line	Feet from the	East/West Line	County
	11	15S	37E	UNK	UNK	UNK	UNK	LEA

Latitude______________ Longitude______________

NATURE OF RELEASE

Type of Release SALT WATER	Volume of Release 10,000 / Volume Recovered 0
Source of Release WATER LINE	Date and Hour of Occurrence 7/25 / Date and Hour of Discovery 7/25 11 AM
Was Immediate Notice Given? ☑ Yes ☐ No ☐ Not Required	If YES, To Whom? DALE HAGELL / GARY WINK
By Whom?	Date and Hour
Was a Watercourse Reached? ☐ Yes ☒ No	If YES, Volume Impacting the Watercourse.

If a Watercourse was Impacted, Describe Fully.*

Describe Cause of Problem and Remedial Action Taken.* 10" RED THREAD FIBERGLASS PIPE, SPLIT ALL THE WAY THROUGH. Shut Down LINE, EXCAVATED w BACKHOE, REMOVED BAD SECTION OF PIPE AND REPLACED w NEW.

Describe Area Affected and Cleanup Action Taken.* APPROXIMATELY 500' X 1000' PASTURE GRASS. CONTACTED LANDOWNER, HE ADVISED HE WANTED ENTIRE AREA ESCAVATED AND NEW DIRT put in its place.

I hereby certify that the information given above is true and complete to the best of my knowledge and understand that pursuant to NMOCD rules and regulations all operators are required to report and/or file certain release notifications and perform corrective actions for releases which may endanger public health or the environment. The acceptance of a C-141 report by the NMOCD marked as "Final Report" does not relieve the operator of liability should their operations have failed to adequately investigate and remediate contamination that pose a threat to ground water, surface water, human health or the environment. In addition, NMOCD acceptance of a C-141 report does not relieve the operator of responsibility for compliance with any other federal, state, or local laws and/or regulations.

	OIL CONSERVATION DIVISION	
Signature: [signature]		
Printed Name: STEPHEN B. SMITH	Approved by District Supervisor:	
Title: CONSULTANT PUMPER / FIELD REP.	Approval Date:	Expiration Date:
E-mail Address: SMITHSERV@HOTMAIL.COM	Conditions of Approval:	Attached ☐
Date: 8/5/04 Phone: 441-0926		

Attach Additional Sheets If Necessary

Appendix B
David J Carty Statement of Qualifications

David J. Carty, Ph.D., CPSS, P.G.
dba GreenBridge EarthWorks; NyPa-GreenBridge

Soil Chemist/Environmental Consultant

Specialist in Intermediation, Testimony, Strategic Planning, Technical Innovation, Applied Research, and Soil and Water Remediation Related to Salt-Affected Soils and Halophyte Vegetation at Oilfield, Mining, and Chemical Industry Sites

Contact

Address	c/o UCCD 612 N Flenniken, El Dorado, AR 71730
Phone	979/229-6795(best); 870/863-9148; 870/863-8634; 870/864-0492(fax)
E-mail	<gbew@txcyber.com>

Education

Ph.D., Soil Science, North Carolina State University, 1986
M.S., Soil Science, Texas A&M University, 1980
B.S., Plant and Soil Science, Texas A&M University, Magna Cum Laude, 1977

Professional History

Principal, GreenBridge EarthWorks (4 yrs), President, NyPa-GreenBridge (2 yr)
Senior Scientist/Consultant, K. W. Brown Environmental Services (8+ yrs)
Staff Scientist/Consultant, private firm (3+ yrs)
Assistant Professor, Abraham Baldwin Agricultural College (1+ yr)

Work Areas

Pit and land treatment unit closure
Reclamation of saline and sodic soils
Bench screening and field plot testing
Design of precision excavation procedures
Expert witness testimony and litigation support
Permit issues (NPDES, RCRA Part B, and Louisiana 29-B)
Phytoremediation using salt-tolerant (halophytic) vegetation.
Organization and coordination of multi-party remediation efforts
Bioremediation and land treatment of hazardous waste and oilfield waste
Soil, surface water, and groundwater environmental sampling and statistics
Development of Quality Assurance Project Plans (QAPjP)
Subsurface injection of chemical amendment
Applied research and development trials
Negotiation and intermediation
Analytical laboratory liaison
Soil chemistry and fertility
Environmental training
Wetlands delineation
pH adjustment

Typical Projects

Preparation of guidance manuals and training programs for remediation of oilfield salt-affected soils for oil company and API

Teach 8-hour API short-course sessions on remediation of oilfield salt-affected soils

Deposition, interogatory, testimony preparation support and exhibit preparation regarding hazardous and non-hazardous constituents including organics, metals, and salts in the environment regarding toxicity, risk assessment, fate and transport, and groundwater, vadose zone, air, soil, and ingestion pathways and involving multiple PRPs and plaintiffs

Case preparation and testimony to Texas Railroad Commission regarding environmental effects of oilfield produced water salts at commercial nonhazardous oilfield waste disposal facilities

Site assessment and strategic planning pertaining to irrigation of halophyte crops with oilfield produced water

Determination of provenance of potentially-impacting multiple-origin saltwaters using bromide/chloride and boron isotope ratios

Bench and field testing of oilfield salt-remediation chemical and physical amendments

Negotiation of technical and administrative cooperative efforts with multiple Arab, Australian, and African biosaline agriculture and environmental remediation participants

Assistance in expression and publicizing recent breakthroughs in industrial desaliniation technology

Technical design and coordination of multi-party oilfield salts remediation projects

Remediation and closure of salt-, metal-, and hydrocarbon-contaminated soils, pits, and discharge water

Document preparation including permits, operation manuals, guidance manuals, monitoring reports, closure plans, short-course manuals, and scientific reports

Verbal presentations and negotiations with regulatory agencies on behalf of clients

Conceptualization, design, and coordination of multiparty (federal, state, industry, landowner), multisector, multicounty exploration and production brine spill remediation efforts

Preparation of document describing multiple contributing anthropogenic and natural causes of salt-affected soils at a mine site

Design and construction supervision for land treatment facilities including subsurface drainage systems and lysimeters and placement of groundwater monitoring wells

Development of first accepted protocol and quality assurance practices related to clean closure of RCRA hazardous waste land treatment units

Planning, direction, and supervision of first-ever clean closure of fully Part B permitted RCRA hazardous waste land treatment units

Development of rationale for first-ever accepted background criteria of mean plus five standard deviations (X+5S) for metals at a RCRA site

Typical Projects (continued)

Development of first-ever accepted protocol in Utah for eliminating phthalates in absence of other organic constituents, as indicators of contamination by petrochemical wastes at a RCRA site

Development of first EPA-recognized national standards to distinguish between waste and waste-affected soil

Development and supervision of diverse and site-specific surface, unsaturated zone, groundwater, and soil sampling activities

Interpretation and presentation of analytical results including quality assurance, and formulation of recommendations

Leadership, formulation, development, and presentation coordinator of science and engineering team which won the technical competition for providing quality assurance oversight for the destruction of chemical and biological weapons at Dugway, Utah for the Utah Department of Environmental Quality

Development of inexpensive inorganic techniques for reclaiming salt affected soil

Development of state and federally approved rationale for increasing stormwater discharge pH permit limits to 9.5 as warranted by upgradient background and analytical technique

Certification of clean-closure

Certifications/Training/Professional Organizations

Certified Professional Soil Scientist (CPSS) #2590 (ARCPACS)

Licensed Professional Geoscientist (P.G., Soil Science) #492 (Board of Professional Geoscientists, State of Texas)

RCRA Hazardous Waste Management Training (40 CFR 260-281) (HAZWOPER)

Soil Science Society of America (SSSA) and American Society of Agronomy (ASA)

Int'l Symposium on "Prospects of Saline Agriculture in the GCC Countries" in Dubai, United Arab Emirates, sponsored by (ICBA, IDB, ICARDA, and MAF)

Prof. Soil Scientists Assoc. of Texas (PSSAT) and Nat. Soc. of Cons. Soil Scientists (NSCSS)

Wetlands Delineation Short Course - 40 hour (TEEX)

Negotiating Environmental Agreements Short-Course - 3 day (MIT)

Council of Soil Science Examiners (CSSE) for Soil Science Society of America's, Fundamentals and Professional Practice Examinations

Project References

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Appendix D
David J. Carty Recommendations

504 S Parkway
El Dorado, AR 71730

September 1, 2004

Dave Boyer
Safety & Environmental Solutions, Inc.
PO Box 1613
Hobbs, NM 87241-1613

RE: preferred remediation alternative for saltwater spill near Hobbs, NM

Dear Dave:

Based on information you have provided, it is clear that minimization of downward hydraulic gradient and mitigation of spilled produced water salts will be best accomplished using halophyte technology. Halophyte technology in this context is a form of bioremediation which employs plants that require spilled saltwater ions (including otherwise problematic sodium and chloride) as fertilizer nutrients for growth.

Halophyte plants adapted to the environment near Hobbs, NM include forage, fiber, and fuel crops among others. Some halophyte forages adapted to your spill area have almost dairy quality protein, can be grazed or harvested as hay, provide tasty mineral nutrients for cattle, and are tender to mouth parts of cattle and otherwise quite palatable.

Substantial references to these plants are given in –

1) Carty, D.J., S.M. Swetish, W.F. Priebe, and W.W. Crawley (K. W. Brown Environmental Services). 1997. *Remediation of Salt-Affected Soils at Oil and Gas Production Facilities*. Publication No. 4663. Health and Environmental Sciences Department, American Petroleum Institute, Washington, D.C. [the American Petroleum Institute (API) guidance manual]

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Halophyte crop plants will remediate the site as follows: They will minimize downward percolation of rainwater by prolific root interception and by increasing matric tension in the soil above the caliche. They will minimize erosion by establishing protective cover. Symbiotic microbial biota will respond favorably to the presence of halophytes and biodegrade and utilize petroleum hydrocarbons that might have been entrained in the spilled liquid. The surface soil will be remediated from a potential sealed and anoxic condition (due to sodium dispersion after evaporation events) to a beneficial aerobic aggregated condition by improved biodrainage and removal of sodium. Use of halophye crop plants will improve the biomass productivity of the affected land.

Based on information provided, the alternative of dig and haul represents a waste of natural resources. Substantial fuel will be required to remove and replace topsoil. It is unlikely that subsurface caliche would be removable in a practical manner. Valuable topsoil would have to be removed from its current borrow location. Salt-affected topsoil at the spill site would have to be removed to another location where it may continue to present an environmental problem, or may expand the environmental problem even further.

Similarly, chemical remediation depends on fresh leaching water and deep or interception drainage to remove sodium and chloride from the surface soil. Without concurrent installed subsurface drainage, leached salts may migrate into and possibly below the caliche. The amount of fresh leaching water required may be substantial. Application of inorganic chemical amendments simply translates to addition of even more salt (essentially all fertilizers and inorganic amendments are salts) and salinity would initially increase. It may be impractical to put a subsurface drain system at this location, and the interception of salts may not be as effective as plant roots. A subsurface drain may require permitting, monitoring, and maintenance depending on state and potentially federal requirements. Further, the drain system will not provide for potential upward wicking and removal of salts from caliche as halophyte roots would. Upward wicking of salts would be disadvantageous for glycophyte (plants which do not like appreciable salts) plants, whereas halophytes and animals which graze on them use the salts as fertilizer nutrients or for osmotic purposes.

Although cost should not be a primary consideration, installation of low cost halophytes with attendant minimal preparation, maintenance, regulatory concern, and the attendant beneficial environmental attributes of surface and subsurface water and soil protection, and projected long-term profitable return to the landowner regarding livestock and hunting, is clearly the preferred category of remediation activity. Recognizing these benefits, regulatory agencies in a number of states continue to look with increasing favor toward such bioremediation alternatives.

Although test plots may provide some advantages, time is a potential issue. Therefore, GreenBridge EarthWorks suggests consideration of an initial wide-spaced planting of plugs of several halophytes – specific specie(s) to be determined based on continued discussion. This would provide a wider range of data which could be used to interplant at more intensive spacing later. It is not typically difficult or prohibitively costly to install electric fence around a four-acre plot to minimize premature grazing on tender plugs or shoots. However, irrigation is determined to be required, smaller test plots would lessen equipment cost. Topical hay mulch is usually warranted, to retain soil moisture, and some fertilizer may be advisable based on inexpensive topsoil fertility tests. These issues can be discussed further at the client's request.

Please do not hesitate to contact me if you have any further questions or comments. I can be reached at 979/229-6795 (cell), 870/863-9148 (H/O), and at gbew@txcyber.com. We would be very pleased to be invited to cooperate and participate in remediation of this site.

Sincerely,

DCarty

David J. Carty, Ph.D., CPSS, P.G.
Principal, GreenBridge EarthWorks