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WORKPLAN

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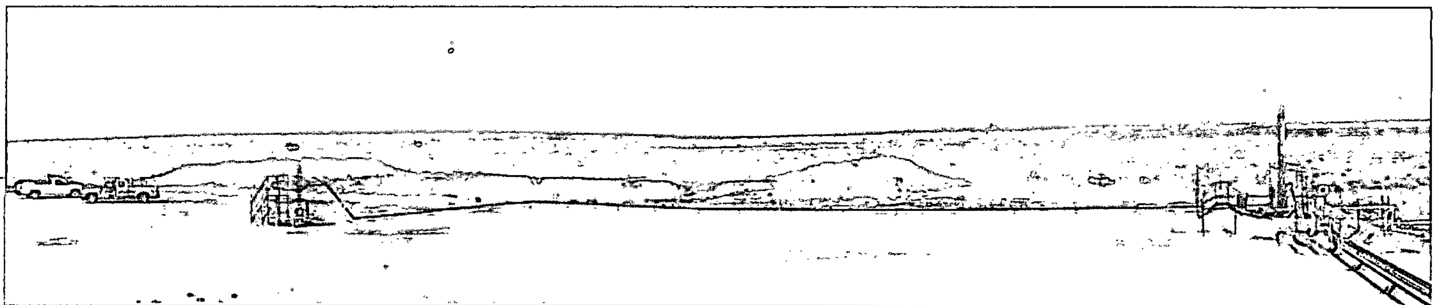

Reserve Pit Closure Plan

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September 21, 2006

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1.0 Introduction to Closure Plan Design for Pits, Below-Grade Tanks and Accidental Releases

Data and modeling demonstrate that, in the absence of a vadose zone remedy residual chloride beneath the pits, below grade tanks and accidental release can represent a threat to ground water quality. However, data and analysis generated by characterization activities coupled with long-term testing data available through Sandia National Laboratories (SNL) show that placement of a evapotranspiration (ET) infiltration barriers will effectively protect fresh water, public health, and the environment from residual constituents of concern in the vadose zone.

The purpose of an ET Barrier is not to permanently isolate these constituents in the vadose zone, although that may be the ultimate result. An ET barrier will minimize the downward and upward migration of soluble salts such that the rate of vertical migration, down or up, has no material impact on ground water quality or soil productivity. Patch seeding for the vegetative cover placed at a time of year recommended by a range specialist is a key component of successful re-vegetation in environments where precipitation is sporadic.

As described in this document, evapotranspiration barriers are routinely employed as the final covers for hazardous and radioactive waste landfills. Sandia National Laboratories (SNL) compared the efficacy of ET barriers to other landfill cover designs and concluded that this system can work very well in arid and semi-arid environments, such as New Mexico. For many sites, including this one, modifications to the landfill cover designs evaluated by SNL, while not absolutely necessary, can improve the efficacy. Unsaturated zone modeling using site-specific data for numerous sites has been consistent with the findings in the SNL report (Appendix A).

▼ 2.0 PROPOSED INFILTRATION BARRIER DESIGN AND CONSTRUCTION PROTOCOLS

At the Livestock 30 site, exportation of reserve pit material and over-excavation of the former pit results in a shortage of on-site fill material. Clean fill is available from a state-owned facility (caliche gravel) and from the landowner (fine-grain material and top soil). The design for the Livestock site is a Modified Capillary ET Infiltration Barrier identified as Test Cover 2 in the SNL Report (SAND 2000-2427) in Appendix A. Figure 8 of that report showing the ET Soil Cover design is reproduced below as Figure 1 of this report.

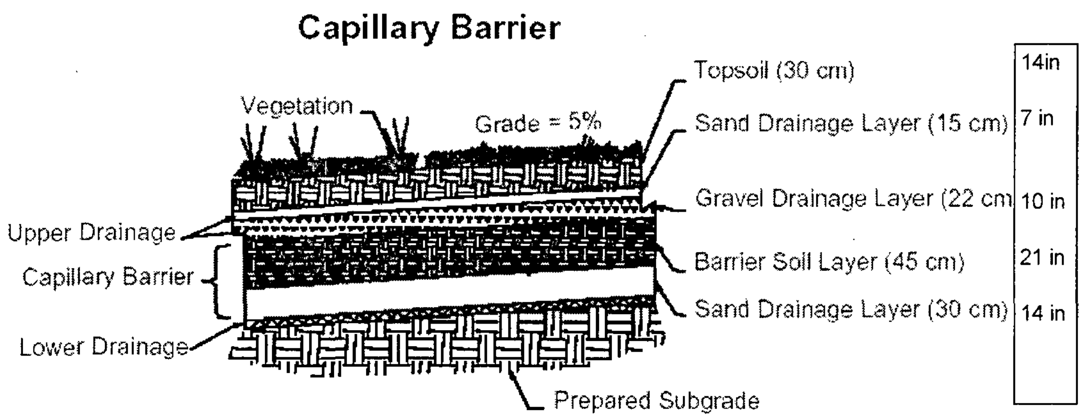


Figure 1: ET Soil Cover Design from SNL Report SAND 2000-2427. Dimensions in inches shown as a modification to the SNL figure.

Simulation modeling at other sites shows that chloride and other soluble salts can migrate upward from a depth of about 4 feet. To eliminate the potential of such upward migration and subsequent impact to the vegetation cover, the design calls for the installation of a coarse grain (caliche gravel) layer above the chloride impacted material. Figure 2 shows the design of the Capillary Barrier ET cover for the Livestock Reserve Pit site. The design for the Livestock site differs from the SNL tested design by increasing the thickness of the coarse-grained drainage layers as shown below.

SNL-Tested Design Thickness (inches)	Livestock Design Thickness (inches)	
14	18	Topsoil
7	18	Sand Drainage
10	24	Gravel Drainage
21	24	Fine-Grained Material
14	36	Sand and Gravel Drainage
66	120	Total Thickness

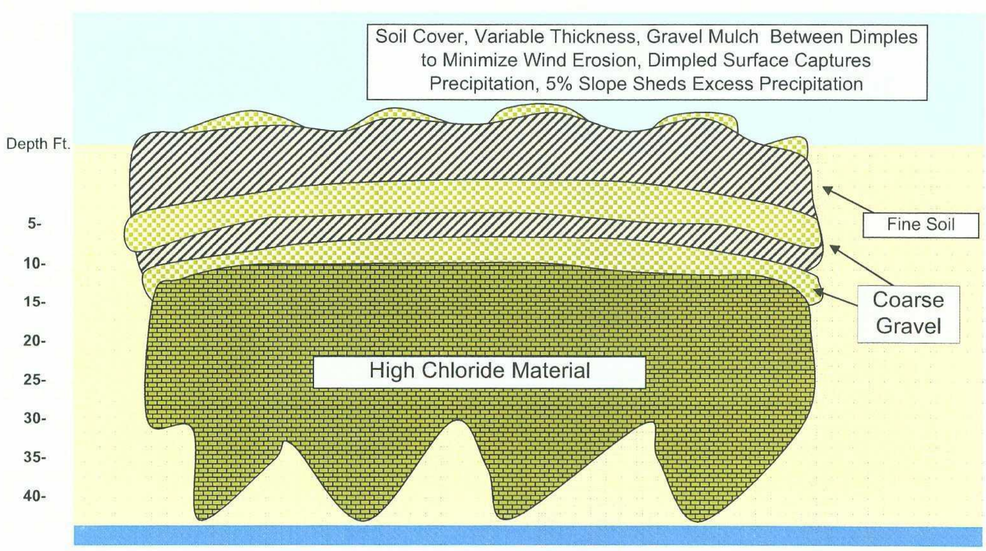


Figure 2: Final closure design

Prior to the construction of the capillary ET barrier, TMW-1 will be plugged with bentonite.

Field conditions will determine the specifics of the design and "as-built" drawings will be maintained that confirm compliance with the design concept described herein. The design calls for the following elements:

1. A 5% grade at the surface that will prevent excess accumulation of precipitation over the ET barrier and shed excess water away from the former pit area.
2. A topsoil dressing with "dimples" allows for concentration of small volumes of precipitation in areas of exposed soil. These dimpled areas, which may be about 20 feet square, will contain a 5-10 foot square area of the 1.5-foot thick soil area that is planted with warm- and cold-weather grasses and forbs.
3. A very thin (about 1-inch) layer of gravel or coarse-grained caliche will be placed between the dimpled/seeded areas. The gravel will create a cover/mulch that is more resistant to wind or water erosion and will reduce evaporation of infiltrated precipitation. These thin soil areas will not be seeded except as occurs naturally due to surrounding vegetation.
4. Beneath the topsoil cover is the capillary barrier design as described above. The coarse-grained drainage layers should be installed in 1-2 foot lifts and may be washed with fresh water to remove the fines to the base of the lift.

The final grading at the site will depend upon mandates of the landowner, availability of fill and other factors. As indicated above, as-built drawings showing conformance to the design outlined above are planned for submission to NMOCD.

Construction protocols proposed for this remedy consist of the following:

A. A qualified person who is versed in construction earthwork, oilfield activities and environmental protection will supervise all aspects of implementation of the proposed vadose zone remedy and act as a supervisor of completed work.
B. The grade of the prepared surface will be surveyed to document a grade of at least 5% and the supervisor will retain the records of this survey.
C. The supervisor will select areas for seeded "dimples" and direct the placement of topsoil and gravel mulch.

D. The supervisor will direct the seeding effort utilizing a mix provided by the landowner.
E. The supervisor will prepare a report that provides the documentation of appropriate construction of the remedy and submit the report to NMOCD.

Samson will visually monitor the site and, as required, conduct efforts to encourage natural re-vegetation of the site. Such actions could include very limited application of fresh water to the dimpled/seeded areas or fencing the area in to prevent grazing for one or two years after the completion of the restoration project. We recommend that Samson request final closure for this site after the former pit area is re-vegetated to 70% of the ground cover observed in adjacent areas that are not affected by oilfield activities.

▼ 3.0 Background Data and Proof of Concept

We researched the performance criteria of numerous landfill closure designs included examination of the following documents, all of which are available through the Internet:

- www.sandia.gov/caps provides a synopsis of landfill liner cover performance for the proposed designs
- www.sandia.gov/caps/designs.htm#landfill1 describes the various landfill cover designs tested by SNL
- cluin.org/products/altcovers/usersearch/lf_list.cfm provides links to performance monitoring of similar sites
- www.sandia.gov/caps/alternative_covers.pdf is the Sandia National Laboratory Report that fully describes the landfill cover evaluation project
- www.epa.gove/superfun/new/evapo.pdf provides useful links and data
- www.beg.utexas.edu/staffinfo/pdf/scanlon_vadosezj.pdf provides more case studies of ET cover performance

From this literature, we identified several alternatives that we believed could be feasible for the closure of pits, below grade tanks, and sites where accidental releases created a subsurface mass of constituents of concern. These alternatives are:

1. RCRA Subtitle C Barrier –with minor modification
2. Capillary ET (Evapotraspiration) Barrier
3. Monolithic ET Barrier

The SNL website references provide a brief description of each barrier design (see also Appendix A).

▼ 4.0 Examination of Alternatives

The references listed above represent years (and sometimes decades) of field monitoring and simulation modeling, clearly demonstrate the efficacy of these designs. The EPA Fact Sheet included in Appendix A provides a recent summary of the monitoring data including the three barrier systems that we considered for the vadose zone remedy. Below is a data table from the Fact Sheet that presents the measured infiltration rates below these cover systems (Table 1).

	1997 (May 1 - Dec 31)		1998		1999		2000		2001		2002 (Jan 1 - Jun 25)	
	Precip. (mm)	Perc. (mm)	Precip. (mm)	Perc. (mm)	Precip. (mm)	Perc. (mm)	Precip. (mm)	Perc. (mm)	Precip. (mm)	Perc. (mm)	Precip. (mm)	Perc. (mm)
Monolithic ET	267.00	0.08	291.98	0.22	225.23	0.01	299.92	0.00	254.01	0.00	144.32	0.00
Capillary barrier ET	267.00	0.54	291.98	0.41	225.23	0.00	299.92	0.00	254.01	0.00	144.32	0.00
Anisotropic (layered capillary barrier) ET	267.00	0.05	291.98	0.07	225.23	0.14	299.92	0.00	254.01	0.00	144.32	0.00
Geosynthetic clay liner	267.00	0.51	291.98	0.19	225.23	2.15	299.92	0.00	254.01	0.02	144.32	0.00
Subtitle C	267.00	0.04	291.98	0.15	225.23	0.02	299.92	0.00	254.01	0.00	144.32	0.00
Subtitle D	267.00	3.56	291.98	2.48	225.23	1.56	299.92	0.00	254.01	0.00	144.32	0.74

The systems that performed best during the first year after installation were the Subtitle C Cover (0.04 mm/year), the Monolithic ET barrier (0.08 mm/year) and the layered Capillary Barrier (0.54 mm/year). All three of the infiltration barrier systems under consideration performed equally well four years after installation and did not measure any infiltration. The efficacy of these three systems being equal, we considered other factors such as ease of installation and potential traffic to the site in making our recommendation:

A Layered Capillary Barrier can be more difficult to install than other considered systems under oilfield conditions. Although the layered design performs no better than the Subtitle C or Monolithic design, we elected to recommend this option because the coarse-grained material required to install this design is available near the site. A capillary break is a proven technology to prevent salts from upward migration from the waste to the root zone – a factor that was not important in the SNL study and was not fully considered.

The Subtitle C Barrier performs best during the first year of operation and we strongly considered this design. Because the clay-rich drilling fluids were removed from the site, no nearby clay is available to meet the design criteria of a 60 cm compacted clay layer. Importation of clay to the site would create significant truck traffic, dust and diesel exhaust. The environmental gain relative to other designs is only a short-term and may be offset by the environmental impact of the traffic.

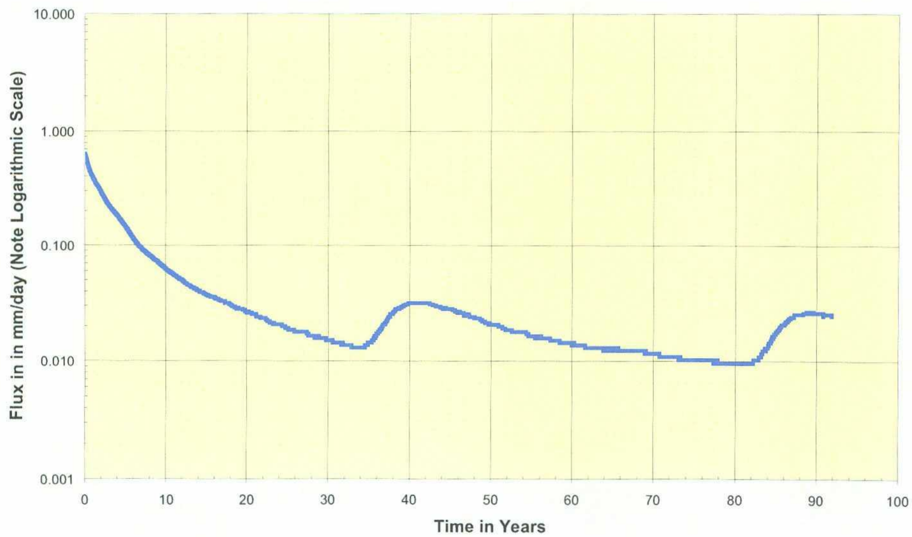
The Monolithic ET Barrier is easy to install and performs well as a landfill cover. This design is typically our preferred alternative. At the Livestock site, high concentrations of salt exists in the subsurface and this design provides no barrier to the upward migration of salt and the attendant impact on surface vegetation. At some sites, a synthetic liner is added to the design to prevent the upward migration of salt. At this site, the earthwork contractor determined that the nature of the site was not conducive to installing a synthetic liner.

▼ 5.0 Simulation Modeling of Modified Monolithic ET Barrier

In order to predict the effect of the proposed layered capillary ET Barrier at the Livestock 30 site, we used HYDRUS-1D and a ground water mixing model with site-specific data. Appendix B describes the input data and our assumptions employed in this site-specific modeling. In this simulation, we assumed 60 days of a constant head of brine within a leaking reserve pit were required to create the observed chloride concentration in ground water of 2500 mg/L. The head was removed after the sixty day period and the site dried and drained for two years. This becomes the resultant initial condition employed for installation of vadose zone chloride concentration data collected at that time. The simulation was then allowed to continue to drain for another year to the present. before installation of a single layered Capillary Barrier. As data characterizing the vadose zone chloride concentration profile was collected approximately 2 years after cessation of pit activities, this data understates original concentrations.

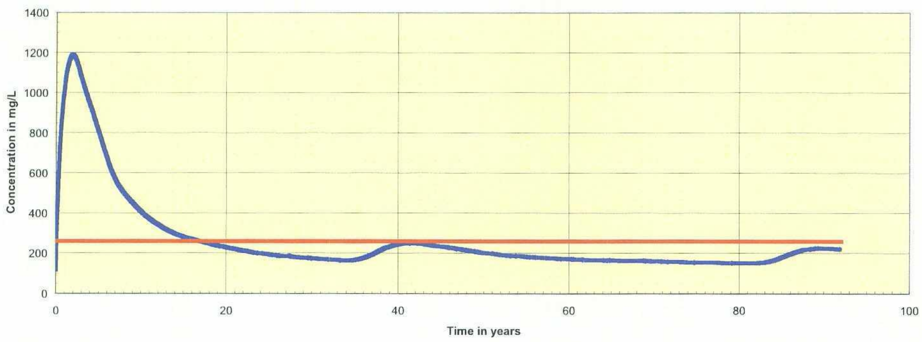
Placement of the ET Barrier over the chloride mass causes the infiltration rate to ground water to decline by an order of magnitude in about 10 years, according to the highly conservative input data used in the model (Figure 4).

Figure 4: Vadose Zone Water Flux into the Aquifer, Livestock Site, ET Barrier Installed at Time = 1.1 Years



Figures 5 show the results of this simulation experiment. The ET Barrier is installed at time = 1.1 years, representing the present in Figure 4. The HYDRUS-1D simulation of the ET Barrier slows the migration of the vadose zone chloride mass such that ground water may exceed standards for a period of nearly 17 years in the absence of any chloride removal from the aquifer due to pumping.

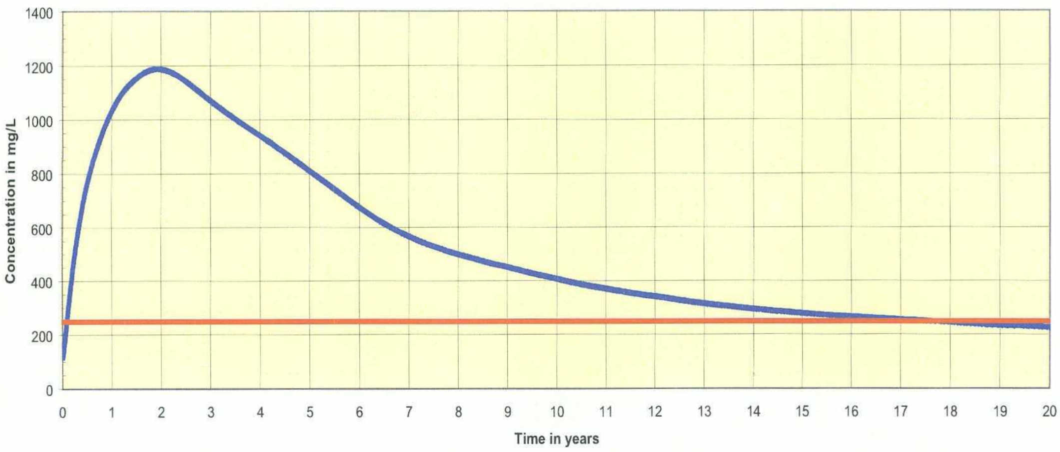
Figure 5: Chloride Concentration in the Aquifer, Livestock Site, ET Barrier Installed at Time = 1.1 Years



As stated above, Figure 5 shows the impact to ground water quality due to continued unsaturated flow from the vadose zone to the aquifer. As described in Appendix B, Figure 5 assumes that ground water moves very slowly beneath the site because the hydraulic gradient is essentially flat and the background chloride concentration in ground water is 100 mg/L. From Figure 5, we can conclude that unsaturated flow in the absence of the ET Barrier adds about 1100 mg/L of chloride to ground water (the concentration at year 1.1 of the simulation). Thus, the modeling suggests that about 1000 mg/L of the observed 2000-2500 mg/L chloride in ground water is caused by continued drainage of chloride-rich water from the vadose zone with the other 1000 mg/L of chloride caused by the initial release.

Figure 6 shows the same data as Figure 5 during the first 20 years of the simulation. The ET Barrier has an immediate effect of limiting deep percolation and reducing the chloride flux from the vadose zone to the aquifer. According to the model predictions, four years after installation of the barrier (year 5 of the simulation) continued drainage of the vadose zone causes an increase of 700 mg/L in the underlying 10-foot thick mixing zone. Althought the modeling assumed a single capillary layer in the ET Barrier, we believe that muliple gravel layers in the ET barrier will have little to no impact on the long-term performance. According to the SNL report, however, the layered Capillary ET Barrier may improve the short-term performance.

Figure 6: Chloride Concentration in the Aquifer, Livestock Site, ET Barrier Installed at Time = 1.1 Years



The model predictions show that Samson must be prepared to monitor this site for 20 years. If the proposed ground water monitoring program outlined in the Stage 1&2 Abatement Plan demonstrate that the mixing zone in the aquifer is 20 feet thick rather than 10 feet, then the ET Barrier causes compliance with WQCC Standards in 10 years. If the mixing zone is 30-feet thick, compliance with standards occurs in about 7 years. Also controlled application of fresh water (as prescribed in the construction specifications) will accelerate chloride migration to ground water and accelerate the vadose zone remedy. Because a robust ground water recovery program is proposed, the movement of chloride from the vadose zone to the aquifer is beneficial at this site.

Ground water data, not modeling predictions, will determine how long Samson must actively monitor the site.

Appendix A

included on the enclosed CD

Appendix B

HYDRUS-1D numerically solves the Richard's equation for water flow and the Fickian-based advection-dispersion equation for heat and solute transportation. The HYDRUS-1D flow equation includes a sink term (a term used to specify water leaving the system) to account for transpiration by plants. The solute transport equation considers advective, dispersive transport in the liquid phase, diffusion in the gaseous phase, nonlinear and non-equilibrium sorption, linear equilibrium reactions between the liquid and gaseous phases, zero-order production, and first-order degradation.

The ground water mixing model uses the chloride flux from the vadose zone to ground water provided by HYDRUS-1D and instantaneously mixes this chloride and water with the ground water flux of chloride plus water that enters the mixing cell beneath the subject site. We refer the reader to API Publication 4734, Modeling Study of Produced Water Release Scenarios (Hendrickx and others, 2005) for a general description of the techniques employed for this simulation experiment.

A description of the model input parameters are listed below.

HYDRUS-1D INPUTS:

Soil Profile - Information for the soil profile (or vadose zone thickness and texture) is based upon the boring log from the monitoring well installed at the site. A vadose zone thickness of 45 feet was used in the modeling based upon recent depth to ground water measurements in the monitoring well.

Dispersion lengths - Conservative dispersion lengths were employed. Standard practice calls for employing a dispersion length that is 10% of the model length. Lengths equal to 6% of the model length were used based on previous experience with similar soils in this area. This choice is conservative of ground water quality

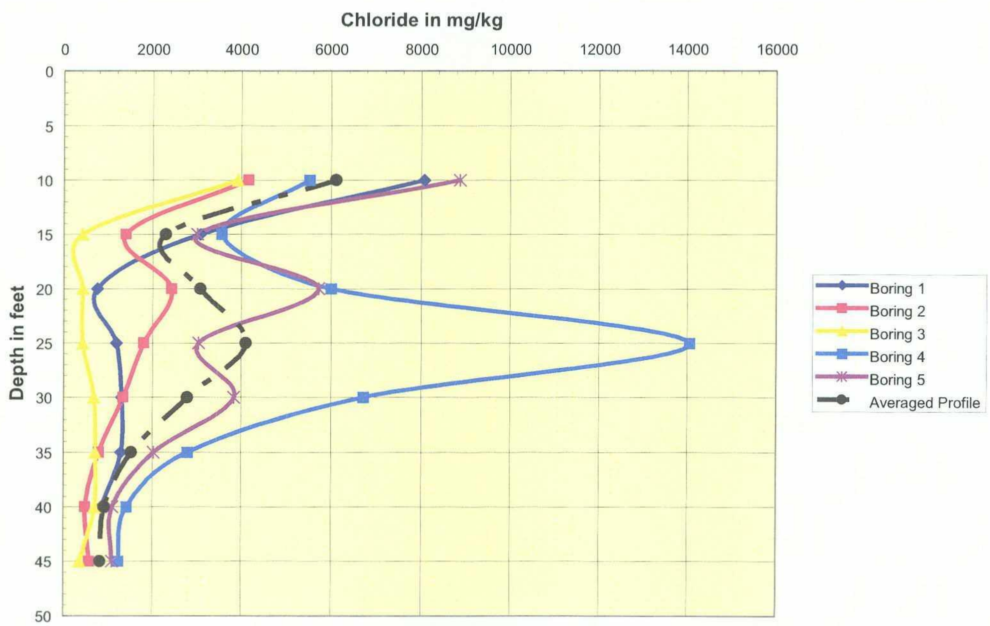
Climate - Weather data used in the predictive modeling was from the Pearl Weather Station (46 years of data), approximately 14 miles north of the Livestock site. This is the closest station featuring sufficiently complete weather data for the HYDRUS-1D input files.

HYDRUS-1D can also employ a uniform yearly infiltration rate that will obviously smooth the temporal variations. Because the atmospheric data are of high quality and nearby to the site, we have elected to allow HYDRUS-1D to predict the deep percolation rate and the resultant variable flux to ground water. This choice results in higher peak chloride concentrations in ground water due to temporally variable high fluxes from the vadose zone. As such, this choice is conservative and will over-predict impairment to ground water quality.

Soil Moisture - Because soils are relatively dry in this climate and vadose zone hydraulic conductivity varies with moisture content, it is important that simulation experiments of different remedial strategies begin with an initial "steady state" soil moisture content. The calculation of soil moisture content begins with using professional judgment as an initial input and then running sufficient years of weather data through the model to establish a "steady state" moisture content. Because only minimal changes in the HYDRUS-1D soil moisture content profile occurred after year 40 of the initial condition calculation, 92 years (2 cycles of the 46 years of weather data) was considered more than sufficient to establish the initial moisture condition.

Initial Chloride Profile – Field chloride soil concentrations (mg/kg) were obtained at depths of 10,15,20,25,30 and 35 feet below ground surface (bgs) from the 5 borings drilled within the pit at the Livestock site (Figure 1). The chloride data from the five borings were averaged with equal area weighting to calculate a representative chloride concentration profile. An integration of the chloride contained within the profile yielded a chloride load of 41.7 kg/m2 . The averaged soil concentration values (mg/kg) were linearly interpolated to correspond to the HYDRUS 1-D soil profile nodes. Using the volumetric moisture content from the HYDRUS 1-D initial condition and a default dry bulk soil density of 1390 kg/m3 , soil water moisture concentrations (mg/L) were calculated for the HYDRUS 1-D soil profile nodes. These chloride concentrations were installed in the HYDRUS-1D model.

Figure 1, Chloride Concentration in Soil at the Livestock Site



As described in API Publication 4734, the ground water mixing model takes the background chloride concentration in ground water multiplied by the ground water flux to calculate the total mass of ground water chloride entering the ground water mixing cell, which lies below the area of interest. The chloride and water flux from HYDRUS-1D is added to the ground water chloride mass and flux to create a final chloride concentration in ground water at an imaginary monitoring well located at the down gradient edge of the mixing cell (the edge of the release site).

MIXING MODEL INPUTS:

Influence Distance - The influence distance is defined as the maximal length of the release parallel to groundwater flow direction. As this exact direction is not known, the maximum dimension of the pit, approximately 100 feet was used.

Background Chloride Concentration – from regional data, a value of 100 mg/L chloride for ground water was used at this location.

Hydraulic Conductivity - R.T. Hicks Consultants believes that the hydraulic conductivity of the saturated zone at the release site is similar to that observed for the Ogallala Aquifer throughout the general area. McAda (1984) simulated water level declines using a two-dimensional digital model and employed hydraulic conductivity values of 51-75 feet/day (1.9 E-4 to 2.8 E-4 m/s) in the area. More recently, Musharrafieh and Chudnoff (1999) employed values for hydraulic conductivity within this area of interest between 81 and 100 ft/day, for their simulation. According to Freeze and Cherry (1979), these values correspond to clean sand, which agrees with nearby lithologic descriptions of the saturated zone. For the Livestock site, the saturated hydraulic conductivity of the uppermost saturated zone is assumed as 75 feet/day.

Groundwater Gradient - From USGS well data (1996) ground water flows southeast in the area under a hydraulic gradient of approximately 0.002 ft/ft. The resulting ground water flux is 4.6 cm/day.

Aquifer Thickness - A restricted aquifer thickness of 10 feet was employed in the mixing model as a conservative measure to cause over-estimation of chloride concentration in an imaginary receptor well.

For all variables for which field data did not exist, assumptions conservative of ground water quality were made. A summary of the input parameters and a description of the source information used in the HYDRUS-1D model for this application are provided in Table 1 below.

Table 1: Modeling Inputs for Samson Livestock Site

Input Parameter	Source
Vadose Zone Thickness - 45 feet	Monitoring Well at Site
Vadose Zone Texture	Monitoring Well Bore Log
Dispersion Length - 6% of model length	Professional judgment
Climate	Pearl, N.M. Weather Station Data
Soil Moisture	HYDRUS-1D initial condition simulation
Initial soil chloride concentration profile F	rom 5 Borings within Site
Length of release parallel to ground water flow - 100 feet	Maximum Dimension of Pit
Background Chloride in Ground Water - 100 ppm	Regional Data
Ground Water Flux - 4.6 cm/day	Calculated from published data
Aquifer Thickness - 10-feet	Conservative Assumption

Vegetation was allowed at the site

Model of the Livestock Site with an Installed Infiltration Barrier

The remedy modeled consists of backfilling the pit with six feet of material from on-site; installation of 1.5 foot thick capillary barrier with placement of an additional3.5 feet of loam with vegetation above the barrier. In order to model this remedy, the following steps were necessary.

1) An initial condition was calculated for a 45 foot thick lithologic column. It is composed of caliche from ground surface to 30 feet bgs, a sandy caliche from 30-38 feet bgs, and a sand from 38 feet bgs to 45 feet bgs.

2) For a period of 60 days, a head of one foot was applied to the lithologic column. This was then subjected to normal atmospheric inputs for 700 days.

3) As chloride data from the site was collected at about this time relative to pit operations, the vadose zone chloride concentrations were installed at this time within the soil column. The simulation was continued from this point in time for another 400 days to represent the present.

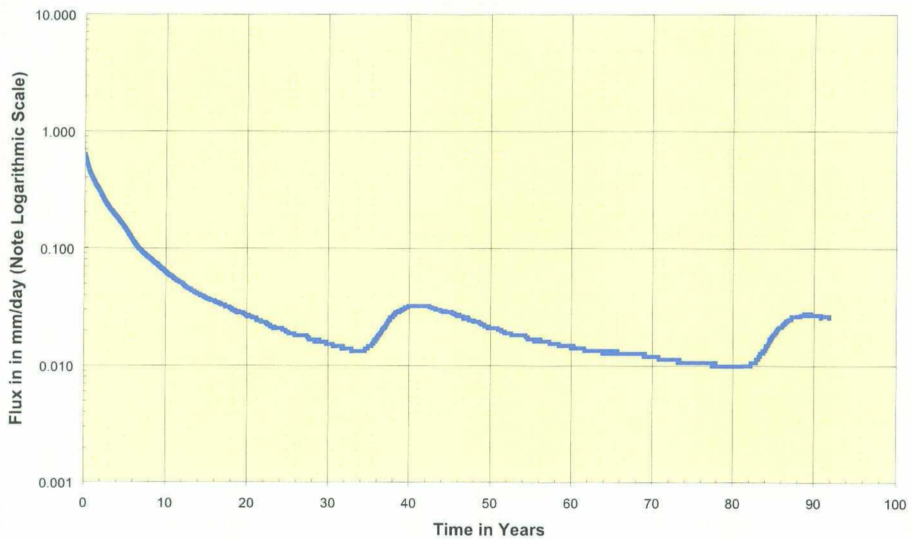
4) The as above described soil profile was then altered to represent the installation of the 10 foot thick ET Barrier as described in the Proposed Reserve Pit Closure Plan. Chloride concentrations of the materials used in the ET Barrier were assigned a soil concentration of 250 mg/kg. This is conservative as all samples from the background borings had concentrations less than this measurement.

5) This modified soil profile was then allowed to run for 92 years into the future.

6) Output from the different HYDRUS-1D runs were used as inputs to the later HYDRUS-1D models as well as being input to the mixing model. As explained earlier, output from the mixing model represents the impact of the release in ground water in an imaginary well at the down gradient edge of the pit.

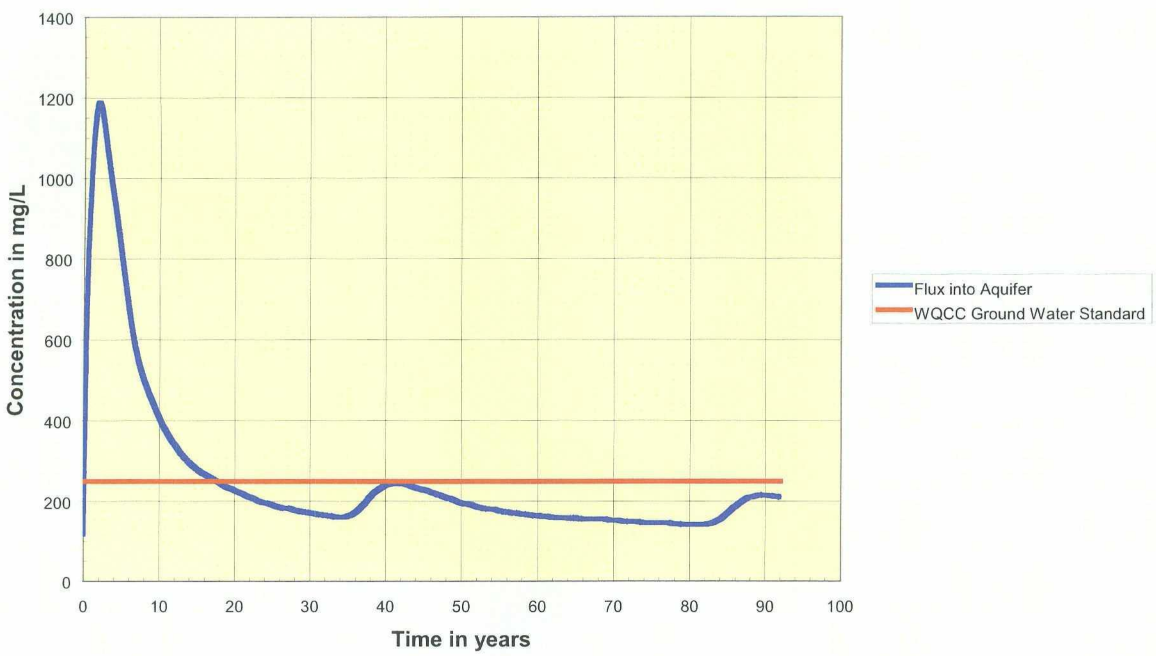
Figure 2 represents the vadose zone water flux to ground water after installation of the proposed ET Barrier. Within about 12 years, the vadose zone water flux to ground water is reduced by an order of magnitude from 0.37 mm/day to about .04 mm/day.

Figure 2: Vadose Zone Water Flux into the Aquifer, Livestock Site, ET Barrier Installed at Time = 1.1 Years



Predicted chloride concentrations in ground water are shown in Figure 3. Predicted chloride concentration in ground water peaks at about 1200 mg/L one year after installation of the ET Barrier. Chloride concentration then declines. The model predicts that chloride concentration declines below 250 mg/L approximately 17 years after installation of the ET Barrier in the absence of any other action.

Figure 3: Chloride Concentration in the Aquifer, Livestock Site, ET Barrier Installed at Time = 1.1 Years



As chloride data was obtained at approximately two years after cessation of use of the reserve pit, the vadose zone chloride load characterized by the sampling is less than that present in the vadose zone at the end of operations. Therefore, the simulation underestimates chloride concentration in ground water (1200 mg/L predicted compared to a measured 2500 mg/L) at present times as chloride that has entered ground water prior to the characterization activities is not accounted for.