R. T. HICKS CONSULTANTS, LTD.

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January 20, 2015

Dr. Tomáš Oberding
NMOCD District 1
1625 French Drive
Hobbs, New Mexico 88240
VIA EMAIL

RE: Bettis 20 State Com #2H Temporary Pit, In-place Burial Notice
API #30-025-41436, Pit Permit #P1-06545
Unit P, Section 20, T24S, R33E, Lea County

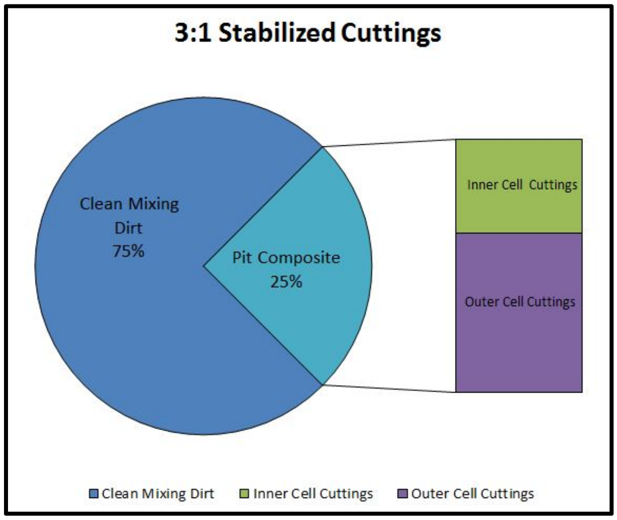
Dr. Oberding:

On behalf of Murchison Oil and Gas, Inc., R. T. Hicks Consultants provides this notice to NMOCD with a copy to the State Land Office (email return receipt in lieu of US Mail per approved variance request) that closure operations at the above-referenced pit is scheduled to begin as early as **Friday afternoon, January 23, 2015 in order to meet the closure deadline without an extension request**. Please note that we enclose a **variance request** submitted concurrently with this notice. Should NMOCD approve the variance, the closure process should require about two weeks, depending on the weather and the availability of machinery. If NMOCD or the State Land Office desires additional time to review this variance, we respectfully request a 3-month extension to allow for NMOCD review.

The "In-place Burial" closure plan for the pit was approved by NMOCD on February 28, 2014 with the C-144 temporary pit application. The following timeline describes the well history as it relates to the closure of this temporary pit:

2/28/2014	Pit application approved
3/16/2014	Spudded well
4/18/2014	Released rig
4/29/2014	Frac began and pit was utilized for flowback fluid; unable to complete
6/5/2014	Casing inspection log found split in casing at 12,150 feet
6/16/2014	Lateral was plugged and abandoned
July 2014	Rig returned and a new lateral was drilled using the pit; well completed
7/23/2014	Rig released; pit was utilized again for subsequent frac and flowback
10/22/2014	Applied Micro-Blaze® to pit
10/28/2014	Sampled pit for closure; did not meet Table II criteria for GRO+DRO, TPH
12/3/2014	Re-sampled pit; all constituents meet closure criteria *except* GRO+DRO
12/4/2014	Re-applied Micro-Blaze® to cuttings using air sparge injection
1/23/2015	Deadline for closure of the temporary pit

Visible inspection of the pit contents after the well was completed suggested the possibility of high hydrocarbon concentrations. In an effort to mitigate hydrocarbon entrained in the cuttings, Micro-Blaze® microbial product was applied to the surface of the pit cuttings on October 22, 2014. On October 28, 4-point composite samples were collected from the inner horseshoe cell, outer horseshoe cell, and from the clean soil of the berms (beneath the liner) of the pit for laboratory analyses. The calculated concentrations of the "3:1 stabilized" material did not meet Table II closure criteria for GRO+DRO or TPH. The pit was re-sampled on December 4, 2014 and this time, all Table II target concentrations were met except for GRO+DRO. In anticipation of chemical heterogeneity as observed in other pits, 2 representative composite samples were collected from the outer cell of the pit—2 points from the discharge side (AB) and 2 from the suction side (CD)—to compose a weighted composite of the outer cell. The table below demonstrates the calculated concentration for "3:1 stabilized" material that results when the pit contents are combined with available mixing soil during the closure process. The calculated value mathematically mixes 3 parts clean soil (mixing dirt) with 1 part of the weighted pit composite calculation, as depicted in the adjacent chart. The pit composite consists of 37% solids from the inner cell of the drilling pit and 63% of solids from the outer cell (1:1.7 ratio), representative of the volume of cuttings in each cell.



Bettis 20 St Com #2H: Composition of "3:1 Stabilized Cuttings"

Bettis 20 St. Com #2H pit Sample Name	**Sample Type**	**Sample Date**	**Chloride** *80,000*	**Benzene** *10*	**BTEX** *50*	**GRO+ DRO** *1000*	**TPH** *2500*
Outer Composite (A+B)	2-pt comp. (discharge)	12/3/2014	38,000	0.92	15	1,870	2,300
Outer Composite (C+D)	2-pt comp. (suction)	12/3/2014	42,000	1.6	22.2	7,210	17,000
Outer Pit Composite (AB=82.1%, CD = 17.9%)			*38,716.42*	*1.04*	*16.29*	*2,826.42*	*4,932.84*
Inner Composite	4-pt comp.	12/3/2014	31,000	8.6	78.8	12,560	23,000
Mixing Dirt Composite	5-pt comp.	10/28/2014	ND	ND	ND	ND	ND
3:1 Stabilized Cuttings CALCULATED *(3 parts mixing dirt, 1 part weighted pit cuttings)*			***9,238.67***	***0.69***	***7.64***	***1,262.17***	***2,264.44***

ND = Not detected at the laboratory's reporting limit

all values are mg/kg

The formula used in the table to calculate the 3:1 Stabilized Cuttings is:

$$\text{3:1 Stabilized Solids} = \frac{[(\text{Outer Composite}*0.77169)+(0.22831*\text{Inner Composite})+(\text{Mixing Dirt}*3)]}{4}$$

The day after the final sampling, additional Micro-Blaze® was applied to the pit as recommended by the product representative, this time using an air sparge system to inject a mixture of water/air/product into the cuttings. Our experience shows that time alone should be sufficient to degrade the hydrocarbon enough to meet Table II criteria within months of the December 3 sampling concentrations, if not before. The injection of the Micro-Blaze® is intended to accelerate the process.

We hope that NMOCD will consider the diligent monitoring and active treatment of hydrocarbon in the pit as Murchison's commitment to close this pit in a manner that provides the best net environmental benefit. I will follow-up this notice to you with a phone call today as required by the Pit Rule and to discuss this variance request. As explained in the enclosed "Statement Explaining Why the Applicant Seeks a Variance", our understanding of thermodynamics, fluid dynamics, and our experience with pit closure sampling will "demonstrate that, after the waste is solidified or stabilized with soil or other non-waste material at a ratio of no more than 3:1 soil or other non-waste material to waste, the concentration of any contaminant in the stabilized waste is not higher than the parameters listed in Table II of 19.15.17.13 NMAC" at the time that the geomembrane cover will be installed or soon after.

Sincerely,

R.T. Hicks Consultants

Kristin Pope

Kristin Pope

Enclosure: Variance Request with attachments

Copy: Murchison Oil and Gas, Ed Martin
New Mexico State Land Office
via E-Mail

Statement Explaining Why the Applicant Seeks a Variance

The prescriptive mandates of the Rule that are the subject of this variance request are the following subsections of 19.15.17

19.15.17.13 CLOSURE AND SITE RECLAMATION REQUIREMENTS:

D (7) If the concentration of any contaminant in the contents, after mixing with soil or non-waste material to a maximum ratio of 3:1, from a temporary pit or drying pad/tank associated with a closed-loop system is higher than constituent concentrations shown in Table II of 19.15.17.13 NMAC, then closure must proceed in accordance with Subsection C of 19.15.17.13 NMAC.

The residual solids in the drilling pit meet the Table II standards for chloride, TPH, benzene and total BTEX. The concentration of GRO is relatively low and is not materially different from concentrations observed in other drilling pits that meet the Table II standards after stabilization. The calculated stabilized concentration of MRO is 200.8 mg/kg and DRO is 1196. Thus, DRO+GRO is higher than the burial standard of 1,000 mg/kg.

The operator has expended resources and time in an effort to reduce the GRO+DRO+MRO concentration of the pit solids. This time and effort has been partially successful, but not sufficient to meet the closure criteria of Table II for GRO+DRO). Excavation and removal of the solids to the nearest surface waste management facility is technically possible and meets the prescription of the Rule. However, we contend that fresh water, public health and the environment are better served by allowing a higher burial standard for this pit via an approved variance.

Demonstration That the Variance Will Provide Equal or Better Protection of Fresh Water, Public Health and the Environment

The two lines of logic that support in-place burial of the residual pit solids in accordance with all other mandates of the Rule (i.e. stabilized, relatively dry and beneath a liner and a 4-foot thick soil cover) are:

1. Over time (perhaps decades), natural attenuation processes will effectively reduce the residual petroleum hydrocarbons to below Table II standards.
2. When compared to excavation and removal, in-place burial provides a greater Net Environmental Benefit as described below.

Natural Attenuation Processes

The attached EPA Fact Sheet explains the natural attenuation processes that reduce the mass of buried hydrocarbons. There are numerous peer-reviewed reports that discuss the conditions that favor and inhibit natural attenuation of hydrocarbons. The EPA 2004 publication also provides a good summary (http://www.epa.gov/oust/pubs/tum_ch9.pdf). The rationale presented below draws upon EPA documents as well as other publications.

Sequestration of Hydrocarbons after In-Place Burial under NM Pit Rule

At this site, the stabilized, relatively dry drilling waste will be buried more than 100 feet above groundwater and beneath a geotextile liner and a 4-foot soil cover as prescribed by the Pit Rule. These conditions effectively sequester the drilling solids for many decades, preventing hydrocarbon constituents from entering the soil horizon, the atmosphere or groundwater. Natural attenuation of hydrocarbons in the vadose zone over this exceptionally long sequestration timeframe is generally not investigated or discussed in publications.

To estimate the rate of downward moisture migration from the buried waste (beneath the 20-mil LLDPE cap and 4-foot soil cover as prescribed by the Pit Rule) to groundwater we used HYDRUS 1D. As explained in Attachment 1, a realistic, worst-case condition shows a measurable mass of soil moisture (chloride ions) penetrating the groundwater table 125 years after in-place closure of the pit. The center of mass of the downward migrating soil moisture penetrates groundwater in 250 years – according to the model. Thus, we conclude with a high degree of certainty that many decades are required between the time of solids burial to the time where soil moisture and entrained constituents from the buried waste will reach groundwater.

With respect to the upward migration of soil moisture (and entrained hydrocarbons) from the buried waste to the soil horizon, two mechanisms effectively eliminate this pathway for many decades (probably for many centuries):

- The placement of 20-mil LLDPE over the stabilized solids prevents the upward migration of moisture via capillary flow for the lifespan of the buried liner. Our communications with the Geosynthetic Institute suggest that a 20-mil LLDPE buried liner will hold integrity for about 80 years and then slowly degrade (oxidation/cracks/tears) over a period of about 200 years (a half-life of 100 years at 20 degrees C). This estimate is ½ of the lifespan of HDPE as reported in http://www.geosynthetic-institute.org/papers/paper6.pdf .
- Over the first 80 years after in-place closure, the soil moisture in the buried solids, which is higher than the surrounding vadose zone, will move downward due to gravity. Lateral movement in response to the pressure gradient between the buried solids and the vadose zone will also occur to some extent during this same 80-year period. Thus, the buried solids will dry over time as moisture flows downward (due to gravity and pressure) and laterally (due to pressure alone). When the liner cap begins to degrade around year 80, the soil moisture in the buried solids will be lower than the soil moisture immediately above the liner where the downward migration of infiltrated precipitation meets the impermeable boundary of the liner. Thus, when a fissure in the liner inevitably occurs, the moisture flux is from the soil above the liner toward the underlying, drier drilling solids (gravity flow and capillary flow). Upward wicking of chloride or hydrocarbons will not occur.

We conclude with a high degree of scientific certainty that the buried, stabilized drilling waste will not migrate upward and is isolated from the soil horizon.

Upward migration of hydrocarbon vapors is a concern where volatile hydrocarbon constituents exist. At the location, the concentration of BTEX is very low as is the concentration of GRO. Given the nature of the buried material, the upper liner and the circuitous route such vapors must travel from the buried waste to the surface, we conclude with a high degree of certainty that harmful vapor will not migrate to the surface to any degree that would endanger public health or the environment.

Natural Attenuation of GRO+DRO+MRO in Drilling Pits

The reduction of hydrocarbon concentration/mass over time is documented in numerous published reports and is consistent with the Second Law of Thermodynamics (entropy). In all of the available publications we examined, the experimental or observational timeframe was days or several years – not decades. Natural degradation rates observed for diesel or crude in soil, including clay soil, range from a 30% reduction in mass/concentration after 10-30 days to 50% after two years[1]. However, these degradation rates were observed in unsaturated soil directly exposed to the atmosphere, not conditions similar to saturated residual drilling solids in a drilling pit or conditions after in-place burial pursuant to the Pit Rule.

In drilling pits, we observe degradation of petroleum hydrocarbons, which is consistent with Thermodynamics and published reports. The charts below show a rate of natural attenuation in drilling pits with relatively low GRO+DRO (Murchison Oil and Gas, Inc. pits) is about 50% in 50 days.

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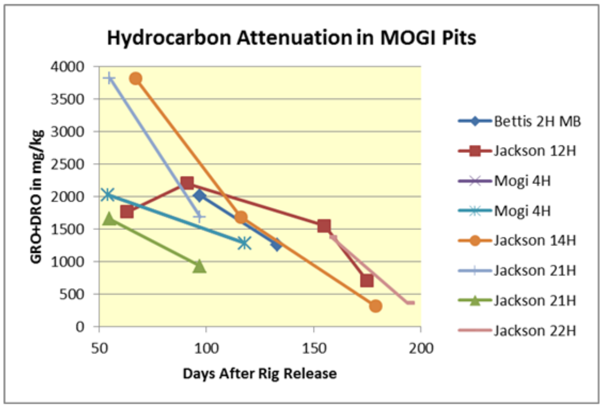
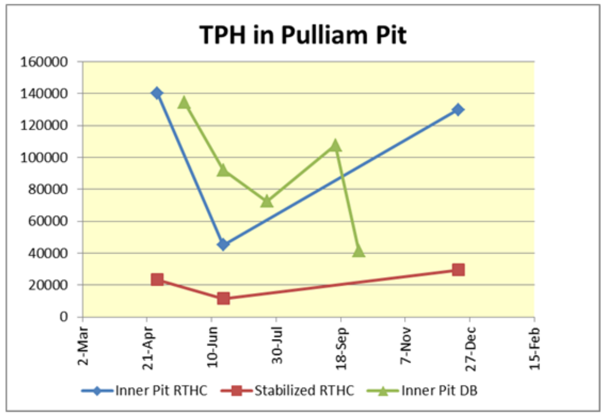
[1] See www.ajol.info/index.php/ajb/article/download/97267/8658,
http://nepis.epa.gov/Exe/ZyPDF.cgi/30002379.PDF?Dockey=30002379.PDF,
http://www.epa.gov/oust/pubs/tum_ch9.pdf,





In the Pulliam Pit in northern Lea County, the samples taken by Don Board (MicroBlaze® Representative) from the inner pit show a natural attenuation rate of about 70% in 135 days. The samples collected by RT Hicks Consultants do not display the same relationship. The data from the three RT Hicks Consultants sampling events do not suggest that GRO+DRO is being created in the pit, rather we can conclude with certainty that the RTHC data is consistent with the problems associated with sampling highly heterogeneous media, as observed at other locations and explained by previous submissions and discussions with NMOCD. As suggested above, the complexity of sampling heterogeneous solids did not create a problem for the Murchison pits.

Natural Attenuation of GRO+DRO+MRO During and After Pit Closure
During the 7-14 days of the closure process, stabilization with dry earth material and evaporation of entrained fluid will expose the pore spaces and surfaces of the drilling solids to the atmosphere and oxygen. Hydrocarbon vapors will be released during material mixing of the closure process. After burial, soil moisture drainage (unsaturated flow) will open more pore space in the stabilized material. Molecular diffusion and barometric pumping (exchange of soil gas with the atmosphere) will allow some oxygen to be available to the buried drilling solids and a small mass of hydrocarbon vapors may escape (to the atmosphere and adjacent vadose zone). Thus, the conditions for continued removal of hydrocarbons from the stabilized solids are present after burial. However, the rate of hydrocarbon degradation after burial is expected to be much slower than measured values in drilling pits or values reported in the literature for surface piles and tilled soil.

For low concentration material, we can assume a conservative biodegradation rate of 50%/year after burial. Thus, the buried drilling solids of the Bettis 2H will meet Table II standards in the first half of 2015.

Net Environmental Benefit Analysis

The attached document describes the NEBA process as it applies to this site. Below is a brief summary of the findings.

The alternatives considered for a semi-quantitative Net Environmental Benefit Analysis (NEBA) are

A. Dig and haul all drilling solids to a surface waste management facility pursuant to the Pit Rule.
B. In-place burial under an approved variance
C. Trench burial under an approved variance
D. More aggressive surface treatment/landfarming to meet the GRO+DRO burial standards of the Pit Rule with an approved variance followed by in-place burial

The matrix presented below presents the rankings for each alternative considered. Although the total score of Remedy B is about 40% better (lower) than Remedy A, the reader should not interpret this result as suggesting that the remedy provides a 40% greater net environmental benefit. Rather, the more correct interpretation of the results in the matrix are:

- Remedy B provides the highest benefit
- Remedies C and D provide equal benefit (a 15% difference)
- Remedy A provides the least environmental benefit

	Multiplication Factor - Site Conditions	**Multiplication Factor - Stakeholders**	Remedy A Dig-Haul-Dispose		Remedy B In-Place Closure		Remedy C Trench Burial		Remedy D Surface Treatment	
			Score	Weighted Value	Score	Weighted Value	Score	Weighted Value	Score	Weighted Value
Ground Water	1	3	2	6	2	6	2	6	1	3
Surface Water	0	2		0		0		0		0
Air Quality										
Dust generation	1	1	2	2	1	1	1	1	2	2
Exhaust generation	1	2	2	4	1	2	1	2	2	4
Off gassing	1	1	1	1	1	1	1	1	1	1
Habitat > 5 years										
Restore Vegetation/Forage	3	2	1	6	1	6	2	12	1	6
Restore Original Landforms	1	2	1	2	1	2	1	2	1	2
Wildlife	1	2	1	2	1	2	1	2	1	2
Human Safety	2	3	3	18	1	6	1	6	2	12
Impact on Resources										
Water	2	2	2	8	1	4	1	4	2	8
Cost	1	2	3	6	1	2	2	4	3	6
Total Score				**55**		**32**		**40**		**46**

The reader should keep in mind that the attached document is in DRAFT form as final scoring must be subject to consensus between the stakeholders.

Net Environmental Benefit Analysis

Explanation of Scoring

The alternatives considered for a semi-quantitative Net Environmental Benefit Analysis (NEBA) are

A. Dig and haul all drilling solids to a surface waste management facility pursuant to the Pit Rule.
B. In-place burial under an approved variance
C. Trench burial under an approved variance
D. More aggressive surface treatment/landfarming to meet the GRO+DRO burial standards of the Pit Rule with an approved variance followed by in-place burial

NEBA methodologies are described by several authors, including:

- Efroymson and others (2003, www.esd.ornl.gov/programs/ecorisk/documents/NEBA-petrol-s-report-RE.pdf)
- Robertson (2006, www.freshwaterspills.**net**/**neba**/**neba**.ppt)
- ASTM (2006, http://www.astm.org/Standards/F2532.htm)
- Kealy and others (2001, www.iosc.org/papers/01338.pdf)

For the evaluation of alternatives for managing drilling solids that do not meet Table II standards, we elected to modify the NEBA method described by Robertson (2006) and ASTM (2006). Because the site comprises less than 1-acre, the use of Habitat Equivalency Metrics, as presented by Kealy and others (2001) is not appropriate. While Robertson uses a color-coded ranking system (green, yellow, red) that allows the user of the NEBA to visually discern which response action provides a more favorable outcome, we used a numerical ranking system where a score of 1 provides the greatest benefit (or least harm for these four alternatives considered), and a ranking of 4 provides the least benefit. The 1-4 scoring system is a ranking of the four alternatives. For many factors, the ranking of all four alternatives is the same. When this is the case, each receives a score of 1. Like golf, the lowest total score is the best result.

Each criterion has two multiplying factors: one that considers the importance to stakeholders and a second that considers the importance of the criteria to the site-specific environmental setting. In theory, the site-specific environmental setting would be established by good data. In practice, one stakeholder may conclude that site data demonstrate the absence of a water table aquifer beneath the site. According to that stakeholder, ground water quality cannot be impaired and a site multiplication factor of zero is appropriate. Another stakeholder may conclude that data do not demonstrate with a reasonable degree of scientific certainty that a water table aquifer is absent. This second stakeholder may assign a site multiplication factor of 2. Consensus, which is critical to the NEBA process, could create a final site multiplication factor of 0.5, 1 or zero – depending upon which stakeholder is most convincing to the group.

The stakeholder multiplication factor considers the importance of the criteria to the stakeholder. A stakeholder with a surface grazing lease may have sufficient water supplied by a small dam or distant well and protecting ground water quality beneath the site may not be important. To this surface leaseholder, forage for livestock may be the most important criteria and assigned a multiplication factor of 3 while protection of ground water would be assigned a factor of 1. Consensus may create a simple average of the various stakeholder scores. This document is a draft because we have not yet solicited input from the surface landowner (State Land Office) or others.

The score/ranking and the two multiplication factors are used to calculate a weighted value for each remedy. This weighted value = (Site Multiplication Factor*Score) + (Stakeholder Multiplication Factor * Score).

Most publications that describe the NEBA process emphasize that success requires a consensus among stakeholders. This DRAFT report is the first step in creating a consensus between all stakeholders. After review of this DRAFT by OCD, the operator and the surface owner, we can finalize this document if necessary.

Summary

The matrix presented below presents the various multiplication factors as well as the rankings for each alternative.

	Multiplication Factor - Site Conditions	**Multiplication Factor - Stakeholders**	Remedy A Dig-Haul-Dispose		Remedy B In-Place Closure		Remedy C Trench Burial		Remedy D Surface Treatment	
			Score	Weighted Value	Score	Weighted Value	Score	Weighted Value	Score	Weighted Value
Ground Water	1	3	2	6	2	6	2	6	1	3
Surface Water	0	2		0		0		0		0
Air Quality										
Dust generation	1	1	2	2	1	1	1	1	2	2
Exhaust generation	1	2	2	4	1	2	1	2	2	4
Off gassing	1	1	1	1	1	1	1	1	1	1
Habitat > 5 years										
Restore Vegetation/Forage	3	2	1	6	1	6	2	12	1	6
Restore Original Landforms	1	2	1	2	1	2	1	2	1	2
Wildlife	1	2	1	2	1	2	1	2	1	2
Human Safety	2	3	3	18	1	6	1	6	2	12
Impact on Resources										
Water	2	2	2	8	1	4	1	4	2	8
Cost	1	2	3	6	1	2	2	4	3	6
Total Score				**55**		**32**		**40**		**46**

Although the total score of Remedy B is about 40% better (lower) than Remedy A, the reader should not interpret this result as suggesting that the remedy provides a 40% greater net environmental benefit. Rather, the more correct interpretation of the results in the matrix are:

- Remedy B provides the highest benefit
- Remedies C and D provide equal benefit (a 15% difference)
- Remedy A provides the least environmental benefit

Additionally, the final scoring must be subject to consensus between the stakeholders.

Because transport of drilling solids from the site to a landfill only transfers a potential problem from one locality to another, consideration of the environmental factors at the landfill site are appropriate for this benefit analysis.

Ground Water Scoring

Data demonstrate that ground water is present at the site at a depth exceeding 100 feet beneath the pit (see C-144 application). We also know from the logging of the Bettis 2H and a nearby rathole borings (e.g. Yates Caravan 6H), that a water table aquifer does not exist at the site. At the Bettis 2H site, the redbeds were encountered at 55 feet and the Caravan 6H rathole penetrated the top of the redbeds at 87 feet below surface. However, a water table aquifer does appear to exist to the south, near the Ranch Headquarters. Due to the lack of a water table aquifer, a site multiplication factor of zero may be appropriate; we assigned a factor of 1 to the groundwater scoring matrix due to the documented nearby water table aquifer. We also assigned a stakeholder scoring factor of 3, as groundwater in southeast New Mexico is a highly important commodity.

At many landfill sites, groundwater is also present. While some landfills are lined (e.g. Gandy-Marley), some are not (e.g. R360). Lined or unlined, the large scale of commercial operations and the history of landfills creating groundwater impairment a site multiplication factor of 2 could be used. Because the drilling pit solids from this well represent a very small portion of the material in a landfill, a more appropriate multiplication factor is 1.

Remedies A, B and C received the same rank/score of 1 and a weighted score of 6 because all of the remedies pose the same threat to groundwater quality. Remedy D causes the drilling solids to meet the in-place burial criteria and results in a better ranking: a weighted score of 3.

Surface Water

A surface water body (a playa or an arroyo that may hold water for several days) is not present near the pit (see permit application). This condition creates a multiplication factor for surface water of zero for both the site and stakeholders. At the landfill, we assume that the permit calls for control of runoff from any large, elevated pile. Therefore, this location also receives a site multiplication score of zero. We conclude that the probability of impact to surface water is essentially nil, and this factor does not contribute to ranking of alternatives.

Air Quality

Dust generation

Our evaluation suggests that the footprint of the drilling pit covers less than one acre. Under Remedy A (dig-haul-dispose), we estimate that negligible dust generation would occur due to the excavation. However the transport of about 50 trucks over about 1-mile of dirt road between the landfill and the site would generate some dust. Dust is also generated at the landfill site and during tilling of the solids removed from the pit under Remedy D. We assigned a score of 2 for Remedies A and D. Remedies B and C would generate less dust and received a score of 1.

We believe that dust generated by any remedy will not be significant relative to the dust generated by the other oilfield activity in the area, therefore we assigned a site multiplication value of 1 for dust generation. Dust is an annoyance to stakeholders, but something that we live with in the southwest; thus the assigned stakeholder multiplication factor is 1.

Exhaust Generation

The 90-mile round-trip haul distance to a landfill creates a relatively large exhaust impact to Remedy A so we assigned it a score of 2. The periodic transport of machinery to till excavated solids and the act of tilling also generates exhaust, thus Remedy D also received a score of 2. Remedies B and C require only one mobilization to the site to bury the solids and received a score of 1. Because all remedies require movement of the cuttings (to trucks, to the surface or stabilization for burial, only the transport element adds exhaust.

From a stakeholder perspective, air pollution and generation of greenhouse gas appears more important than dust generation at this site; creating a stakeholder multiplication factor of 2. The site multiplication factor is 1 for many of the same reasons discussed above for dust generation.

Off-gassing of Hydrocarbons

We considered the off gassing of hydrocarbons generated by each remedy. In our opinion, tilling (Remedy D), stabilization (Remedies B and C), and loading/offloading and spreading (Remedy A) probably create the same release of gas. Therefore we assigned the same score to all remedies.

While off-gassing may be important to stakeholders (a multiplication score of 2), the typical wind combined with off gassing from all of the other E&P activity cause a site multiplication factor of 1 (not very important).

Habitat Restoration

Restore Native Vegetation/Forage

Over the long-term, reducing the disturbance footprint and transforming the area to natural vegetation (habitat and forage) is important and received a site multiplication factor of 3. With respect to the stakeholder importance, we assigned this criteria a multiplication factor of 3 – we believe all stakeholders desire restoration of the site to as close as practical to the pre-disturbance condition.

Based upon previous experience with pit closures (in-place and trench burial), we are confident that restoration of grasses will occur within 5 years. Therefore, Remedies B and D received a ranking of 1. If the upper liner of a trench burial is breeched or if the cap is constructed poorly, saline fluids can accumulate on the bottom liner. This perched brackish water could rise via capillary action into the root zone. Although the probability of this occurring is extremely small, Remedy C received a rank of 2. Remedy A also received a score of 1, as we assume that reclamation of a landfill to include the growth of native grasses over the final surface of the pile.

Restore Original Landforms
Although the volume of pit solids transported to a landfill is very small relative to the size of a landfill (e.g. R360), we assigned a rank of 2 to Remedy A. The original landform in this area will not be restored.

Our experience with pit closures demonstrates that the final grade after solids burial will conform to the nearby landforms. Therefore, Remedies B, C and D received the same score of 1.

Wildlife
The small area of the pit is not a critical habitat for wildlife and restoration of this small area will have little impact on wildlife, given the existing oil and gas development in the area. We assigned a site multiplication factor of 1 and a stakeholder multiplication factor of 2. By assuming that all remedies will succeed, all of the remedies are ranked equal 1 for the protection of wildlife, all receive a weighted value of 2.

Human Safety

All remedies require on-site earthwork and some vehicular transport. The safety threat posed by transport is greater than on-site earthwork as this element can involve the public. Remedy A requires the greatest amount of vehicular transport (waste to the landfill) and we assigned it a score of 3. Remedies B and C require only one mobilization and both received a score of 1. Due to the need for multiple mobilizations to the site for tilling, the score/rank for Remedy D is 2

Human safety should be the most important stakeholder factor; a multiplication factor of 3 is assigned. Because nearly all transportation is on two-lane roads filled with oilfield traffic, the site multiplication factor is 2.

Impact on Resources

Water
Remedies A and D will use more water than Remedies B and C. The landfill presumably uses water for dust control (although they may use produced water) and on-site treatment of the solids to enhance natural microbial action also requires some water. Therefore Remedies B and C were ranked as 1 and Remedies A and D were assigned a rank of 2.

Because the water use for Remedies A and D are not large, we used a value of 2 for both multiplication factors.

Cost
Cost is the only consideration where the ranking of alternatives is clear. Remedy A is more expensive than Remedy D. Remedy B is the least expensive and Remedy C is probably $10,000 more than Remedy B. The alternatives were ranked according to their respective costs.

Regardless of the selected alternative, cost will be incurred by the operator. So the site multiplication factor is 1. Cost is an important consideration for the operator and is less important to other stakeholders, resulting in a multiplication factor of 2.

R. T. HICKS CONSULTANTS, LTD.

901 Rio Grande Blvd NW ▲ Suite F-142 ▲ Albuquerque, NM 87104 ▲ 505.266.5004 ▲ Fax: 505.266-0745

October 21, 2014

Memo: Yates Petroleum Caravan State Unit #6H Rat Hole Evaluation

The Caravan State #6H well site is located approximately 3.5 miles south of Bell Lake and has a surface elevation of 3,469 feet above sea level. It is located on the same drilling location as the Caravan State #9H well.

On October 17, 2014 I witnessed the drilling of the rat hole at the above referenced site. Butches Oil Field Service Company performed the work using a track-mounted 30-inch auger-drilling rig. The boring was spud within the 8-foot deep cellar, but all soil description depths are measured from the pad surface.

From the surface to a depth of 55 feet the drilling advanced quickly. At a depth of 55 feet a well-rounded, well-sorted sand formation was encountered that required the addition of water to prevent the hole from caving. From a depth of 55 to 70 feet, 40 bbls of drilling mud was added, then at a depth of 70 feet another 40 bbls of drilling mud was added. The drilling rate decreased dramatically at a depth of 87 feet when a clay formation (Top of the Triassic) was encountered. At a depth of 105 feet, drilling rig required repairs in order to complete the planned 120-foot hole. The RT Hicks representative left the site at that time so the lithologic descriptions were terminated at 105 feet.

During the drilling operation each auger was carefully inspected to identify any appearance moisture in the soil prior to it being spun off and removed from the drilling pad. Had an indication of shallow moisture been identified in the soil, the operation would have been suspended to allow for the accumulation of measurable water.

The photograph to the left was taken from the soil recovered at a depth of 50 feet as it is being spun from the auger. This photograph demonstrates the lack of moisture in the cuttings. It is believed that any potential moisture from the bottom or walls of the boring would have been easily identified during the drilling process as each trip into the hole should contact wet soil if it is present at any depth.

Following the addition of the drilling mud, consolidated chunks of soil from the auger were inspected to determine the level of saturation. The appearance of dry soil confirmed that groundwater was not present above the Triassic red beds and to a depth of 18 feet into the Triassic. During the drilling operations, soil samples were collected and described as shown on the adjacent log.

Log	Lithologic Description
	0 - 20 Ft: SAND with silt and caliche, dark reddish-brown medium grain, subrounded, and well sorted sand.
	20 - 35 Ft: SILTY SAND,Reddish-brown to light reddish-brown, fine grained, sub angular, medium sorted, increasing caliche with depth.
	35 - 53 Ft: CALICHE, with some very light brown to pinkish brown silty sand.
	53 - 79 Ft: SAND, Reddish brown to dark reddish brown, fine to medium grain, well rounded, and well sorted, with very little silt. Caving hole required addition of mud.
	79 - 87 Ft: SILTY SAND, Light yellowish-brown, med-grain, sub-rnd, m/s.
	87 - 105 Ft: SILTY CLAY, Greenish-gray with some red (mottled) layers, interbedded with gray shale (Top of Triassic).
no sample	**TD = 120 Feet**

Based on the evaluation of the cuttings it appears that the Ogallala is primarily sand and caliche in this area. The hard greenish-gray clay at a depth of 87 feet identifies the top of the Triassic and dry clay and shale extends to at least a depth of 105 feet.

In light of the geology observed from the rat hole samples and the absence of any detectable moisture (pre-mud) and saturated soil (post-mud) during the drilling operation, it has been determined that Ogallala or Alluvium groundwater is not present at this site. Groundwater from the Triassic rocks (Chinle Formation) if present is located at a depth of greater than 105 feet below the surface.

Please contact me if you require additional information.

Dale T. Littlejohn

Dale Littlejohn

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Memorandum

From: Kristin Pope

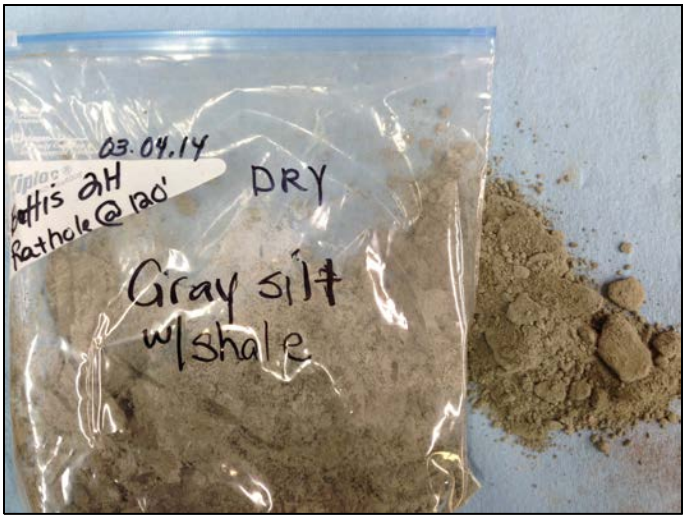
Date: March 5, 2014

RE: Murchison Oil and Gas, Bettis 20 State Com 2H, Rat Hole Evaluation

The Bettis 20 State Com 2H well site has a surface elevation of 3,531 feet and the nearest wells with reliable groundwater data are approximately 1 mile away. Based on data from area wells, published sources, and our experience, the regional groundwater table in this area is expected to occur at approximately 3,375 feet, or 156 feet below the surface of the subject site. As a condition of approval for the C-144 temporary pit application for this well, NMOCD requested that we log the cuttings from the rat hole installation to confirm that the distance between the bottom of the proposed reserve pit and groundwater is greater than 100 feet, as stated in the permit application.

On March 3rd and 4th, 2014 I witnessed the drilling of the conductor hole for the Bettis 20 State Com 2H well, located in eastern Lea County. Ready Drill LLC of Monahans, Texas performed the work using a track-mounted 30-inch auger drilling rig as shown in the photograph above.

On March 3rd, I arrived at the site at 9:50 am when the auger just began to break ground, beginning at 8 feet below ground surface (the depth of the cellar). Cuttings were continuously monitored for moisture (none observed) and lithology with each trip into the hole. At 26 feet, a loose, fine “sugar sand” (shown in adjacent photograph) was encountered which caused progress to slow and eventually cease at 38 feet due to collapse and sand flow. No water or drilling fluids were used to drill up to this point, but after 2 hours with no returns, water was added to the hole to aid advancement beyond the sand. Adding water to the hole seemed to make the sand flow worse and create voids in the walls of the hole so drilling mud was needed. The mud was not available until the next day.



On March 4, 2014, the hole was resumed using drilling mud only to advance past the sand. The driller reported that he progressed out of the sand at 53 feet and cuttings returned dry again at 76 feet. No water or drilling fluids were used in the remainder of the hole. I arrived on site at approximately 3:30 pm when the depth was approximately 80 feet and returns consisted of dry, massive, purplish-red clay. I continued to monitor the cuttings as they were returned until total depth of 120 feet was reached at approximately 6:30 pm. An absence of moisture was noted in the 0-38 feet and 80-120 feet intervals that I observed. The following lithologic log was assembled based on my observations and the driller's descriptions:

18-26 feet	Dry, tan sand with red clay
26-53 feet	Dry, fine, loose brown sand
53-55 feet	Dry, tan clay and silt (base of alluvium and/or Ogallala)
55-60 feet	Dry, green and purplish-red clay, massive (top of red beds)
60-87 feet	Dry, purplish-red clay, massive
87-96 feet	Dry, green clay, massive
96-102 feet	Dry, green clay with some gray shale
102-115 feet	Dry, loose, red clay
115-120 feet	Dry, loose, gray silt with shale (sample shown in photograph above)

Based on my evaluation of the cuttings, data from area wells, published sources, and anecdotal descriptions of other rat holes in the area by the same driller, I conclude that no groundwater is present below this site to at least 120 feet below ground surface (3,411 feet below sea level).

Kristin Pope

Final trip out of hole at 6:30 pm
Dry cuttings at 120 feet

To simulate the soil moisture downward flow and possible effects on ground water chloride concentration from the buried drilling solids in the Bell Lake area, we used HYDRUS-1D to simulate gravity-driven vertical water flow through the vadose zone. The resultant chloride flux to ground water is used as input to a simple ground water mixing model. The output of the mixing model is a predicted chloride concentration in ground water at the down gradient edge of the affected area as would be observed in a monitoring well at this location. From the mixing model output, one can easily observe the time required for the first penetration of seepage to groundwater from the drilling solids as well as the time required for the center of mass to impact groundwater quality.

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.

To model the implementation of the closure method, a number of steps are necessary.

- First, the soil profile has to be constructed and an initial soil moisture condition calculated (see below in Hydrus Inputs section).
- Pit closure activities result in there being an impermeable synthetic liner placed four-feet below ground surface. This upper four feet of soil consists of a clean fill material (assumed as loam at the surface and loamy sand beneath the surface material). For this model, we have assumed that the liner is impermeable for 50 years and degrades completely over the following 125 years. To model this situation, the soil profile is separated into two models while the liner still exists.
- The upper four-foot soil profile is run for two time intervals to simulate the intact liner (50 years) and then to simulate the degrading liner (an additional 125 years). These two intervals are modeled by using different lower boundary conditions.
- For the first 50-years (an intact liner), the lower boundary condition allows drainage when saturation has occurred above the liner. The moisture is in effect removed from the system. This is equivalent to the moisture draining off to the side of the liner and moving downwards outside the burial pit footprint. Vegetation was also assumed to exist in the soil profile above the liner.
- For the next 125 year time period, the upper four feet of soil were modeled to represent the time period in which the liner degrades by changing the lower

boundary condition. It is changed to that of a "free drainage boundary condition", i.e. a cell below the boundary cell is assumed to have the same flux as the cell on the boundary. This output was stored and then modified and used as the input to the buried cuttings and the lower soil. The nature of the modification was to take the lower boundary condition output and assume that the liner begins linearly degrading at 50 years plus one day and is completely gone at Time =175 years (a 125 year degradation period or a 62.5 year half life). Hence, at 50 years plus one day, moisture begins to infiltrate into the lower soil profile (the stabilized drilling solids) in a very tiny amount (calculated from the upper four-foot soil profile lower boundary condition). As suggested above, 112.5 years after pit closure, the moisture flux to the lower soil profile (stabilized cuttings) is half of the upper soil profile boundary condition output (50% liner degradation); and at 175 years, all of the moisture flux from the upper four foot soil profile enters the lower soil profile (100% liner degradation)

- The soil profile beneath the liner is constructed of four feet of cuttings (saturated sandy clay). This material was placed on top of the original soil profile minus its upper-eight feet. It is assumed that in the closure process, the drilling pit liner was functionally destroyed.

- This lower soil profile was run for 50 years with a no-flow upper boundary condition to represent the intact burial liner installed at closure. It was then run for an additional 125 years using the modified output from the upper four-foot soil profile to simulate the degrading liner. As a note, for this 125 year time interval, no evapotranspiration was allowed to simulate conditions four-feet below ground surface.

- After the 175 year time period, the soil profiles were rejoined and run as one model now that the liner no longer existed.

A description of the model input parameters are listed below and are synopsized in Table 2.

HYDRUS 1-D INPUTS

Soil Profile - The HYDRUS 1-D soil profile was chosen to be conservative of ground water quality by choice of materials having hydraulic conductivities greater than or equal to those observed from nearby borings logged by R.T. Hicks Consultants.

Dispersion lengths - Standard practice calls for employing a dispersion length that is 10% of the model length and was used in this simulation.

Climate – Weather data used in calculation of the initial condition and the predictive modeling was from the Pearl, New Mexico weather station, about 20 miles north of the area. This station is the closest station to the proposed study area for which the necessary HYDRUS-1D input file exists. Climate on the eastern plains of New Mexico is similar enough that this was considered an acceptable choice. The weather data spans the 46. 5 year period from July, 1946 to December, 1992,

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, 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 predicted peak chloride concentrations in ground water due to temporally variable high fluxes from the vadose zone than would be predicted by an averaged infiltration rate. As such, this choice is conservative of 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 simulations are started with representative soil moisture content. Commonly, 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.

For this simulation, a number of initial conditions were calculated. First, a soil profile from the ground to the water table was given 46.5 years (1 cycle) of the weather data. This was considered sufficient to establish an initial moisture condition as no large changes in soil moisture content were observed after about 12.5 years. Portions of this vadose zone moisture content profile were used as the initial condition for subsequent simulations as appropriate.

Initial Chloride Profile – Within the model’s vadose zone soil profile, the mass of chloride was simulated by placement of a four-foot thick layer of sandy clay placed 4 feet below ground level. This layer was modeled as having an average volumetric soil moisture content of saturation (0.38) with a chloride concentration of 10,000 mg/L. Because chloride is a conservative tracer (i.e. this ion neither mineralizes, volatilizes nor degrades over time), the chloride concentration within the modeling can be multiplied by a scaling factor to simulate other concentrations. Calculation of this scaling factor is discussed below.

At this site, the composite soil samples had a calculated chloride concentration of 9,240 mg/kg when mixed with clean fill at a ratio of 1:3. We assume that the cuttings were saturated (0.38 moisture content) and that the clean fill dirt was relatively dry (0.10 moisture content). As such the stabilized cuttings have an average volumetric moisture content of 0.17. Calculation of the soil moisture chloride concentration (using a dry bulk density of 1500 kg/m^3) yields 93,240 mg/L .

Keeping in mind that the cuttings are assumed as saturated in the model, a chloride mass equal to that in the stabilized cuttings has to be installed in the model. Calculation of this chloride mass for the one dimensional model also requires an average depth of stabilized cuttings. From discussion with the contractor and pit dimensions, we take this dimension as 4.5-feet. The chloride mass within the stabilized cuttings is given by:

Chl Mass = cuttings thickness * thickness proportion that is water * Chl conc. of water
= 4.5 feet * 0.17 * 93,240 mg/L
= 71,328 feet-mg/L

We require that:

Chl Mass in Model = Chl Mass Stabilized Cuttings
Height_model * moisture content * C = 71,328 feet- mg/L
4 feet*0.38 * C = 71,328 feet-mg/L
C = 46,926 mg/L

As mentioned above, the model is constructed with a concentration of 10,000 mg/L. The model’s output was scaled by a factor of 4.7 to yield an equivalent mass to that contained within the stabilized cuttings. Within the model, the cuttings are assumed as saturated. The additional moisture results in a higher hydraulic conductivity for this section of the soil profile. As such, this assumption is conservative of ground water quality.

MIXING MODEL INPUTS

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 burial site).

Influence Distance - The influence distance is defined as the maximal length of the release parallel to groundwater flow direction. To be conservative of ground water quality, we used the maximum diameter of the pits, 220 feet was parallel to ground water flow.

Background Chloride Concentration – A 75.0 mg/L chloride concentration was used as the concentration of chloride in ground water based on common conditions in SE New Mexico.

Hydraulic Conductivity - Musharrafieh and Chudnoff (1999) assigned hydraulic conductivities of 81 to 100 feet/day for this area. Further east, they assigned hydraulic conductivities of 41 to 60 feet/day. To be conservative of ground water quality at this site, the saturated hydraulic conductivity of the saturated zone is assumed as 60 feet/day.

Groundwater Gradient - Hydraulic gradient from the 1996 USGS data was calculated as about 0.003. The resulting ground water fluxes are about 0.15 feet/day.

Aquifer Thickness – An aquifer thickness of 50 feet was employed for the monitoring well in the mixing model.

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: Input Data for Simulation Experiment

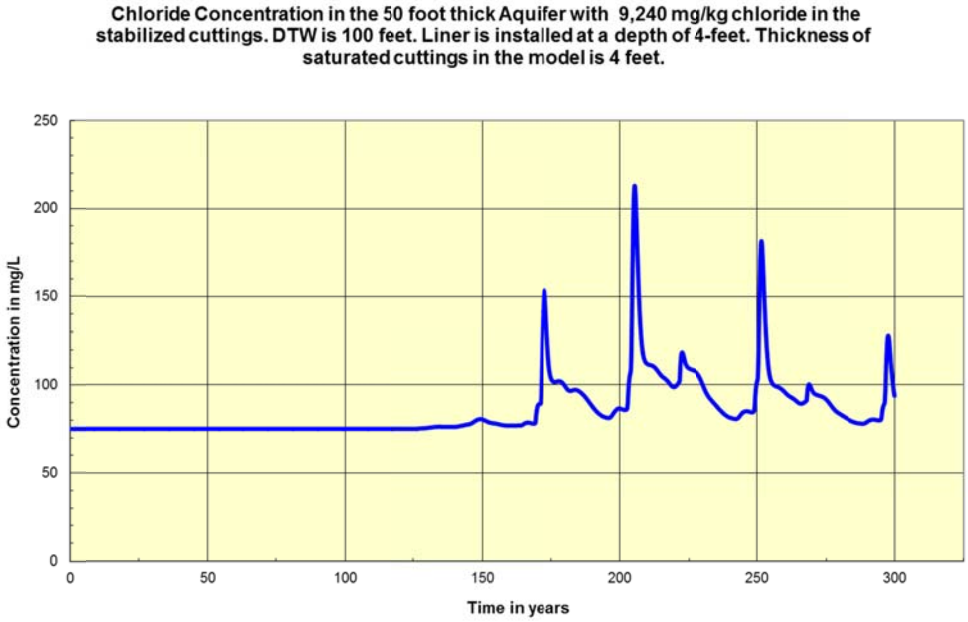
Input Parameter	Source
Vadose Zone Thickness - 100 feet	Conservative Assumption
Vadose Zone Texture	Borings From Nearby Sites
Dispersion Length - 10% of model length	Standard Modeling Practice
Climate	46.5 years of Pearl N.M., Weather Station Data
Soil Moisture	HYDRUS-1D initial condition simulation
Initial soil chloride concentration profile	Four-feet of cuttings are assumed to have a uniform concentration of 46,500 mg/L based upon composite samples and discussion above
Length of possible impact parallel to ground water flow - 220 feet	Greatest possible dimension beneath pits that could be parallel to ground water flow
Background Chloride in Ground Water - 75 ppm	Common result for SE New Mexico
Ground Water Flux - 0.15 feet/day	Calculated from published data
Aquifer Thickness - 40-feet	From nearby wells

RESULTS AND CONCLUSIONS OF MODELING

Shown in Figure 1 is predicted chloride concentration in a simulated monitoring well at the down–gradient edge of the in-place burial. Assumptions include:

1) The synthetic liner capping the stabilized drilling solids remains intact for 50 years.
2) The synthetic cap begins degradation at 50 years. It degrades completely in a linear fashion over a 125 year period.
3) A monitoring well penetrates the full saturated thickness of the aquifer (40 feet), and is placed at the down gradient edge of the burial site.
4) The hydraulic conductivity of the aquifer is 50 feet/day
5) Water samples from this fully-penetrating well represent the water quality of the entire aquifer with higher quality water entering the well from the base of the aquifer

Figure 1



As can be seen by the slight change in slope at about 125-years after burial, no effect can be seen in ground water is apparent. Peak concentration in the well is about 205 mg/L more than 200 years from now, representing the time when the center of soil moisture mass from the buried cuttings intercepts a water table.The cyclic nature of the output is due to the repetition of the 47-year weather input file. A number of El Nino events in close succession are resposible for high vadose zone fluxes to ground water (with attendant chloride). Using this input data is conservative of ground water quality as it results in higher predicted peak chloride concentrations in ground water than would be predicted by an averaged infiltration rate.

As can be seen, no exceedance of New Mexico WQQC standards is predicted. The model is constructed to be conservative of ground water quality by use of inputs that:

- exagerrate vadose zone flux to ground water and
- minimize ground water flux

for all variables for which field data does not exist.

With respect to migration of petroleum hydrocarbons (or other constituents that attenuate during transport or time), attenuation processes (sorption to sand/clay sediment, volitilization, biodegradation) will act upon the constituents for at least 125 years prior to the soil moisture containing any residual hydrocarbons will intercept a water table aquifer.