



## ***Fox Engineering Solutions, Inc.***

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June 29, 2012  
Rev. July 3, 2012

Todd Hutson  
Environmental Manager  
Quicksilver Resources Inc.  
Burnett Plaza  
801 Cherry Street  
Suite 3700, Unit 19  
Fort Worth, Texas 76102

Re: Xenon Pits –Liner Conditions and Recommendations  
COGCC Facility #286608, 427370, 427371 & 427372t  
N ½ Section 12, Township 7 North, Range 93 West, 6th P.M.  
Moffat County, Colorado

Dear Mr. Hutson,

In conjunction with the hydrotests conducted June 18<sup>th</sup> – 21<sup>st</sup>, 2012, Fox Engineering Solutions visually examined each pit liner noting its condition. Terracon Consultants examined each of the pits and prepare the attached geotechnical report. Although the hydrotests results, attached, were positive, they are only representative of the liner integrity below the fluid level at the time of the test. Notes of the examination, recommendations and photographs are provided herein.

### **Liners**

In general, the four pit liners above the fluid level had significant wildlife damage. Punctures caused by deer and possibly elk, tears caused by animal claws and holes from rodent activity were numerous. Our cursory count indicated 204, 38, 66, and 32 holes/tears in the Xenon Main, Upper, Middle and Lower pits, respectively. Leakage through the holes and tears of the liners has caused slumping of the side slopes at numerous locations.

Concerning liner installation, we believe that liner was not installed per industry practice or standards. All of the pits showed signs of poor or inadequate subgrade preparation. This was evident by complete and partial protrusion of rocks through the liners. Significant portions of the liner seams are oriented horizontally, that is, running parallel with rim of the pit. Standard practice is to orient the seams vertically, running from the pit rim to the bottom of the pit. Improper orientation causes stress on the seams and is evident with a seam failure noted in the Lower Pit. There was no evidence of a woven fabric underlayment below the 24 mil liner. The fabric underlayment is an industry standard to provide protection of the liner.

### **Geotechnical Slope Stability**

The Terracon slope stability analyzes of the pit embankments indicate a factor of safety ranging from 1.3 to 2.46 for the Main pit and 1.0 to 1.82 for the Upper, Middle and Lower Pits .A factor of safety of at least 1.5 is warranted for the conditions at the subject site. The slope stability factor of safety is influenced heavily by the degree of compaction during construction. Terracon's initial assessment is that the pits may have been constructed without adequate slope compaction and as such, should be re-compacted per their report. Surface slumps and tension cracks were observed in the exterior embankment slopes.

**Recommendations:**

The liners should be removed and the slope surface soils re-compacted to a depth of at least 3 feet. A new lining system, following the requirements of the Colorado Oil and Gas Conservation Commissions' Series 900 Rules, should be installed. The recommend liner system is a 60 mil polyethylene primary liner followed by a 40 mil polyethylene secondary liner underlain with a geosynthetic clay liner. A wildlife-proof perimeter fence is also recommended.

Should you have any questions or require additional information, please let us know.

Best regards,

David Fox, P.E.  
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attachments



Xenon Upper Pit – Slope slumping under liner.



Xenon Upper Pit – Rodent damage.



Xenon Upper Pit – Complete rock protrusion.



Xenon Upper Pit – Slope slumping under liner.





Xenon Middle Pit – Complete rock protrusion.



Xenon Middle Pit – Partial rock protrusions



Xenon Lower Pit – Seam failure.



Xenon Lower Pit – Spillway liner tear and slumping.