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May 16, 2005

Arjun Makhijani
Institute for Energy and Environmental Research
6935 Laurel Avenue, Suite 201
Takoma Park, MD 20912

Dear Dr. Makhijani:

I have completed my review of the article, "An Assessment of Long-term Erosion Potential at the WCS Facility, Andrews County, Texas," by Thomas M. Lehman, Department of Geological Sciences, Texas Tech University. I have also reviewed the TNRCC Preliminary Staff Memo that discusses erosion at the WCS Site.

With respect to the Lehman paper, I have the following concerns:

1. Rates of erosion (denudation) are highest for semi-arid environments; the climate at the WCS site is semi-arid, consequently this geographic location should be expected to have a net loss of sediment with time, not a net accumulation; I agree with the TNRCC Preliminary Staff Memo on this issue that the WCS site is an erosional area.

2. The Lehman paper seems to dismiss climate change as important to the WCS site, although indicating at the bottom of page 3 that the last episode of incision by streams near the WCS site was 20,000 years ago to 12,000 years ago, a period of time that was associated with the most recent ice age; this paper later (page 15) dismisses climate change as a potential problem by noting that increased aridity is predicted to result in the formation of sand dunes consistent with nearby geomorphological features and further stating that increased humidity will result in denser vegetative cover with associated decrease in erosion. In fact, increased aridity may result in increased erosion because vegetation cover is decreased, moreover erosion by water is the most potent erosive agent in deserts; maximum rates of denudation in arid regions are sometimes unknown and may exceed rates observed in semi-arid regions, rates in excess of 100 cm in 1000 years. If precipitation increases at the site, it is uncertain how rapidly vegetation density will increase with increased moisture levels. Erosion rates may be very high initially until vegetation density increases.

3. The most uncertain aspect of long-term erosion rates at the WCS site is the affect that changes in climate will have. Construction of the WCS facility should include a design for erosion mitigation. The maximum rate of erosion observed anywhere is that which occurs in Badlands-type topography, up to 1 meter of erosion per year (100,000 cm over 1000 years; Saunders and Young, 1983, "Rates of surface processes on slopes, slope retreat and denudation," Earth Surface Processes and Landforms, v. 8, pp. 473-501). Rates or denudation in semi-arid regions are 10 to 100 cm over 1000 years (0.01 to

0.1 cm per year) and rates of denudation in arid regions range from as little as 1 cm per 1000 years to a maximum amount that is not known. Given this highly variable rate of erosion, the design of the WCS facility should include erosion control.

4. Rates of erosion for different climates are listed below and are from the Saunders and Young, 1983, article that is referenced in item 3 above:

Climate	Relief	Range of Erosion Rates
Glacial	Normal (ice sheets)	5 – 20 cm / 1000 years
	Valley Glaciers	100 – 500 cm / 1000 years
Polar		1 – 100 cm / 1000 years
Temperate maritime	Normal	1 – 10 cm / 1000 years
Temperate continental	Normal	1 – 10 cm / 1000 years
	Steep	10 – 20+ / 1000 years
Mediterranean	Normal	1 – ? cm / 1000 years
Semi-arid		10 – 100 cm / 1000 years
Arid		1 - ? cm / 1000 years
Subtropical		1? – 100? cm/1000 years
Savanna		10 – 50 cm / 1000 years
Rainforest	Normal	1 – 10 cm / 1000 years
	Steep	10 – 100 cm / 1000 years
Any Climate	Badlands	100 – 100,000 cm / 1000 yrs

Please let me know if you have any questions about this letter, or need clarifications of any statements herein.

Yours truly,

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Professor, Geological Sciences and Engineering