Attachment 1

Review of 100 Percent Leachate, 25 Percent Fly Ash/Soil Leachate and Carrington Research Extension Center Pond Runoff Data - "Demonstration of Coal Ash for Feedlot Surfaces" North Dakota Department of Health, Division of Waste Management

June 25, 2003

In 1999 the Energy and Environmental Research Center (EERC), working with the Carrington Research Extension Center, initiated a study to determine the potential for utilizing coal combustion materials for stabilizing soil in feedlot pens. The study performed replicate analysis of four coal combustion materials utilizing the Synthetic Groundwater Leaching Procedure (SGLP) and performing analysis at 18 hours, 30 days and 60 days. They also used the SGLP to assess a 25 percent ash to soil mixture as well as a clean sample of soil from the Carrington, North Dakota site. Some analysis of pond runoff was also performed. Working with the four generators of coal combustion byproducts (Great River Energy's Coal Creek Station near Underwood, North Dakota; Great River Energy's Stanton Station near Stanton, North Dakota; Otter Tail Power Company's Coyote Station near Beulah, North Dakota; and, Otter Tail Power Company's Hoot Lake Station near Fergus Falls, Minnesota), the EERC and the companies are seeking approval to utilize coal combustion waste materials for stabilizing approved feedlot surfaces. This review addresses much of the data associated with the four sources of coal combustion material used in the study.

The study also analyzed bottom ash from the four plants utilizing the SGLP and analyzing material at 18 hours, 30 days and 60 days. Some of the bottom ash may be co-mingled with ash or Flue Gas Desulfurization (FGD) sluice water in the handling process and thus may be contaminated with other material.

As discussed in the NDDH's general review, there are a number of issues regarding the experimental protocol and quality of data from the ponds. Samples of water from the ponds were not taken until well after most product was applied, missing the first flush after ash application. Many of the samples from the ponds were taken after the introduction of animals.

Coal Creek Station

100 percent fly ash leachate analysis

Reviewing the 100 percent fly ash leachate information for Coal Creek Station ash, **aluminum** in the 18-hour extraction test ranges from 4,450 micrograms per liter (ug/L) to

11,600 ug/L. At the 30-day interval the level was reduced, ranging from 584 ug/L to 2,650 ug/L. The two 60-day analyses showed the level of aluminum generally increased to 3,210 ug/L and 4,420 ug/L. These levels exceed the recommended drinking water standard for aluminum of 200 ug/L.

Arsenic levels in the 100 percent fly ash leachate at 18 hours ranges from 20.4 to 30.8 ug/L, exceeding the new federal drinking water standard of 10 ug/L. The level appears to go down over time to be below the new standard. **Barium** increased in the 100 percent fly ash leachate over the time period. The initial, 18-hour results showed barium to range from 375 ug/L to 1,120 ug/L. The 60-day results showed 4,190 ug/L and 5,280 ug/L for barium, exceeding both the surface water standard for barium of 1,000 ug/L and the drinking water standard of 2,000 ug/L. **Boron** concentrations in the Coal Creek Station ash did not appear to lessen significantly over the 60-day, leachate extraction. At sixty (60) days the boron levels ranged from 10,500 ug/L to 11,200 ug/L. The surface water standard is 750 ug/L. **Chromium** in the Coal Creek Station ash appeared to lessen somewhat in the time period; however, all values exceed the safe drinking water standard of 100 ug/L. At 18 hours the levels of chromium ranged from 150 ug/L to 215 ug/L. At 60 days the level of chromium was 101 ug/L and 140 ug/L. **Selenium** levels decreased from the 18-hour extraction to the 60-day extraction. At 18 hours selenium ranged from 150 ug/L to 215 ug/L, exceeding the safe drinking water standard of 50 ug/L and the surface water standard of 5 ug/L. At the 60-day period the levels were 27.6 ug/L and 36.1 ug/L, which still exceed the surface water standard of 5 ug/L.

Sulfate levels in the Coal Creek Station ash are quite low and decrease over time. The **pH** in the Coal Creek Station ash does not change substantially over time. At sixty (60) days the pH is approximately at 12.3.

25 Percent Fly Ash/Soil Leachate Data

Reviewing the 25 percent fly ash/soil leachate data for Coal Creek Station's fly ash, the level of **aluminum** ranges from 5,410 ug/L at 18 hours to 2,660 ug/L in the 30-day extraction to 2,160 to 2,190 ug/L at the 60-day period, exceeding the recommended drinking water standards for aluminum of 200 ug/L. **Boron** again stays quite high in the ash/soil leachate and the results do not go down over time. At 60 days the boron levels range from 5,600 ug/L to 5,740 ug/L, exceeding the surface water standard of 750 ug/L. The 25 percent ash/soil leachate levels for **chromium** do not change appreciably over time and generally, on average, are at or slightly below the drinking water standard of 100 ug/L.

Pond Runoff Data

The pond runoff information from the area receiving Coal Creek Station ash showed elevated levels of **boron** (ranging from 1,240 to 3,130 ug/L), exceeding the surface water standard of 750 ug/L. Two of the four analyses for **aluminum** exceed the recommended drinking water standard of 200 ug/L. **Arsenic** ranged from 23.1 ug/L to 63.5 ug/L,

exceeding the new federal drinking water standard of 10 ug/L. (Note, the control pond for this study also exceeded the arsenic standard in three of four analyses, ranging from 4.96 to 30.6 ug/L.)

Coal Creek Bottom Ash

Coal Creek Station bottom ash shows elevated levels of **aluminum**, exceeding the recommended drinking water standard of 200 ug/L. **Arsenic** is also somewhat elevated, especially in the 30-day and 60-day leachate analyses, ranging from 8.94 ug/L to 13.1 ug/L. The new drinking water standard for arsenic is 10 ug/L. **Boron** appears to increase over the sampling period from a low of 911 ug/L in one 18-hour analysis to a high of 3,810 ug/L in one of the 60-day analyses. All the analytical data for boron in the Coal Creek Station bottom ash exceeded the surface water standard of 750 ug/L. **Chromium** appears to increase in the bottom ash over time; two analyses slightly exceed the surface water standard of 11 ug/L. There also appears to be a minor elevation in **sulfate** levels which slightly exceed the recommended drinking water standard of 250 ug/L.

Hoot Lake

100 Percent Leachate Analysis

The 100 percent leachate analysis for the Hoot Lake Station ash showed very high levels of **aluminum** over the entire range of 18-hour, 30-day and 60-day extraction tests. The levels ranged from 89,300 ug/L to 188,000 ug/L, well exceeding the recommended drinking water standard of 200 ug/L. **Barium** varied over the testing period ranging from a low of 109 ug/L to 2,190 ug/L. The surface water standard is 1,000 ug/L and the drinking water standard is 2,000 ug/L for barium. **Boron** generally was relatively low in the Hoot Lake ash with a high of 160 ug/L, below the surface water standard of 750 ug/L. **Chromium** in Hoot Lake ash did not change significantly over time, ranging from 158 ug/L to 356 ug/L, exceeding drinking water standards of 100 ug/L. **Selenium** also did not vary much over time, ranging from 64.6 ug/L to 91.1 ug/L, exceeding both the surface water standard of 5 ug/L and the drinking water standard of 50 ug/L. **Sulfate** generally was not a significant problem in the Hoot Lake ash. **Thallium** shows one exceedance in the Hoot Lake ash. The **pH** in the Hoot Lake ash test stayed above 12.

25 Percent Fly Ash/Soil Leachate

The 25 percent fly ash/soil leachate analysis of Hoot Lake ash showed high **aluminum** levels in the 18-hour and 30-day tests. The levels, ranging from 36,200 ug/L to 42,400 ug/L, well exceeded the recommended drinking water standard of 200 ug/L. **Barium** appeared to increase over time; the 30-day value of 1,320 ug/L and the 60-day value of 1,430 ug/L exceeded the surface water standard of 1,000 ug/L. **Boron** did not change appreciably over time, ranging from 1,010 ug/L to 1,410 ug/L, exceeding the

surface water standard of 750 ug/L. **Selenium** also did not change much over time, ranging from 26.7 to 27.5 ug/L, exceeding the surface water standard of 5 ug/L.

Pond Runoff Data

The pond runoff data for the area utilizing the Hoot Lake ash were somewhat mixed for **boron,** ranging from 246 ug/L to 1,360 ug/L. The latter value exceeds the surface water standard of 750 ug/L. The results for **aluminum,** ranging from 280 ug/L to 617 ug/L, exceeded the recommended drinking water standard of 200 ug/L.

Hoot Lake Bottom Ash

Aluminum in the Hoot Lake bottom ash (from a sub-bituminous coal source) is the highest of any tested, ranging from a low of 7,990 ug/L to a high of 75,300 ug/L. Generally, the levels of aluminum appear to go down over the 60-day testing period; however, all the analyses exceeded the recommended drinking water standard of 200 ug/L. Two of the 10 analyses exceeded the new drinking water standard for **arsenic** of 10 ug/L. **Boron** is lower than the surface water standard at 18 hours, but becomes elevated in the 30-day and 60-day analysis, ranging from 1,180 ug/L to 1,940 ug/L, exceeding the surface water standard of 750 ug/L. Hoot Lake bottom ash exceeds the surface water standard for copper at 7.9 ug/L. Nine of 10 analyses of Hoot Lake ash exceed the surface water standard for **chromium** of 11 ug/L. Four of the 10 analyses exceed the drinking water standard of 100 ug/L for **chromium**. There are a few exceedances of surface water standards for **selenium**. Finally, all analyses of Hoot Lake bottom ash for **sulfate** exceeded both the surface water standard of 450 ug/L and the recommended drinking water standard of 250 ug/L.

Stanton Station

100 Percent Fly Ash Leachate Data

The 100 percent fly ash leachate data for the Stanton Station ash showed **aluminum** levels becoming elevated over time. Levels in the 18-hour leachate were quite low; the 30-day levels ranged from 735 ug/L to 3,260 ug/L. At 60 days the levels were 1,110 ug/L to 11,100 ug/L. The recommended drinking water standard is 200 ug/L. **Barium** levels are highest at 30 days, with a mean value of 18,475 ug/L. At 60 days barium ranges from 776 ug/L to 17,400 ug/L. The surface water standard is 1,000 ug/L and the drinking water standard is 2,000 ug/L. **Boron** levels appear to decrease over time. At 18 hours the levels range from 1,010 to 5,630 ug/L. By 60 days the levels are below the surface water standard of 750 ug/L. **Selenium** also decreases over time in the Stanton Station ash. The 18-hour data ranges from 19.7 ug/L to 27.8 ug/L. The 60-day results are above the surface water standard of 5 ug/L, but below the drinking water standards of 50 ug/L. **Thallium** shows a few exceedances in the Stanton Station ash. While there appeared to be a problem with detection limits in several of the analyses, five values exceeded the surface

water standard of 1.7 ug/L and three values exceeded the drinking water standard of 2 ug/L. The **pH** also stays quite high in the Stanton Station ash, well above 12.

25 Percent Fly Ash/Soil Leachate Data

Twenty-five (25) percent fly ash/soil leachate data shows elevated **aluminum** levels ranging from 1,320 ug/L to 2,160 ug/L, exceeding the recommended 200 ug/L drinking water standard. **Barium** is also elevated, ranging from 2,360 ug/L to 4,390 ug/L, exceeding both the surface water and drinking water standard of 1,000 and 2,000 ug/L, respectively. The **pH** is elevated, ranging from 11.8 to 12.

Pond Runoff Data

The pond runoff data for the area utilized for Stanton Station ash shows some elevated levels for **sulfate. Boron** ranges from 1,290 ug/L to 1,170 ug/L, exceeding the surface water standard of 750 ug/L. One value for **aluminum** exceeded the drinking water standard. The pond runoff water was not analyzed for **selenium**.

Stanton Station Bottom Ash

Stanton Station bottom ash exceeded the recommended drinking water standard of 200 ug/L for **aluminum**, ranging from 410 ug/L to a high of 8,290 ug/L. **Boron** becomes elevated in the 30-day and 60-day analyses, ranging from 947 ug/L to 3,450 ug/L, exceeding the 750 ug/L surface water standard. **Chromium** also appears to show some exceedances above the surface water standard of 11 ug/L. Some elevation for **selenium** and **sulfate** is also noted in the Stanton Station bottom ash.

Coyote Station

Coyote Station material is not pure fly ash, rather it is a mixture of fly ash and FGD waste from the scrubber system at the plant. Thus, the Coyote Station material has the highest sulfate levels of any of the materials reviewed. All extraction tests showed sulfate levels exceeded the recommended drinking water standards of 250 ug/L and the surface water standards for Class I and II streams of 450 ug/L. Coyote Station material was not analyzed in the field.

100 Percent Fly Ash Analysis

The 100 percent fly ash analysis for the Coyote Station material showed **aluminum** levels increased in time from relatively low levels in the 18-hour test to higher levels in the 60-day tests, ranging from 2,850 ug/L to 4,020 ug/L. These levels exceed the recommended drinking water standard for aluminum of 200 ug/L.

Arsenic levels in the Coyote Station ash/FGD material generally increased over time. The 60-day analysis showed arsenic levels ranging from 46.1 ug/L to 79.3 ug/L, exceeding the new federal drinking water standard of 10 ug/L. **Barium** levels showed quite a bit of variability in the Coyote Station material. Only one of the 10 analyses exceeded the surface water standard of 1,000 ug/L.

Boron levels in the Coyote Station ash/FGD material were high at the 18-hour results, ranging from 839 ug/L to 1,780 ug/L, exceeding the surface water standard of 750 ug/L. These levels decreased over time to roughly half the surface water standard at the 60-day interval.

Selenium levels in the Coyote Station ash/FGD material did not show a definite trend over time. Levels ranged from 13.8 ug/L to 68.8 ug/L., averaging 39.21 ug/L. Some values exceeded the drinking water standard of 50 ug/L and all exceeded the surface water standard of 5 ug/L. **Sulfate** levels in the Coyote Station ash/FGD, as indicated above, were elevated, ranging from 940 ug/L to 1,820 ug/L, exceeding the recommended drinking water standard of 250 ug/L. The **pH** levels in the 100 percent leachate data exceeded 12 in all tests.

25 Percent Fly Ash/Soil Leachate

The 25 percent fly ash/soil leachate data shows Coyote Station ash/FGD to exceed the recommended 200 ug/L drinking water standard for **Aluminum** in all tests, ranging from 611 ug/L to 947 ug/L. **Boron** varied significantly in the various tests, generally decreasing over time in the ash/soil leachate test. One of the three slightly exceeded the surface water standard of 750 ug/L. **Selenium** values did not change significantly from 18 hours to 60 days, ranging from 12.3 ug/L to 16.8 ug/L, exceeding the surface water standard of 5 ug/L. **Sulfate** ranged from 683 ug/L to 707 ug/L, above the recommended drinking water standard of 250 ug/L and the surface water standard for Class I and II streams.

Coyote Station ash/FGD material was not tested in the field, thus, there was no runoff data.

Coyote Station Bottom Ash

Coyote Station bottom ash also has elevated levels of **aluminum**, ranging from 696 ug/L to 2,600 ug/L, exceeding the recommended drinking water standard of 200 ug/L. **Arsenic**, especially in the 30-day and 60-day analyses, slightly exceeds the new drinking water standard of 10 ug/L.

Conclusions

Aluminum and boron frequently appear elevated in the 100 percent material leach analysis, fly ash/soil leachate data and the pond runoff data. The Hoot Lake ash appears to be substantially higher in aluminum than the North Dakota lignite ashes. With the new arsenic

standard of 10 ug/L for drinking water, arsenic is an issue in some materials, most notably the Coal Creek product. The levels of sulfate in the Coyote Station fly ash/FGD waste exceeds surface water standards and recommended drinking water standards due to the presence of FGD waste material.

The pond sampling effort missed the earliest rainfall events after ash application. There appear to be some issues regarding the experiment protocol and quality of data from the runoff ponds. While the control pond shows some elevated constituents, it is important to keep in mind that the 18-hour, 30-day and 60-day leachate extraction analysis of the Carrington soil showed no elevated parameters or exceedances of drinking water or surface water standards.

Generally, the data from the runoff ponds is lower in concentrations than the 25 percent fly ash/soil leachate results except for the boron levels in the pond associated with the Stanton Station ash. Boron levels in the Stanton Station ash runoff pond data are substantially higher than the analysis of the 25 percent ash/soil mixture data would suggest. Even the mean of the 100 percent Stanton Station ash leachate analysis is less than what is shown from the Stanton Station pond runoff data.

Elevated parameters in the control pond and elevated boron in the Stanton Station ash pond suggest input from other sources. Carrington water and/or the feed given to the animals may have been contributing factors. More likely, cross-contamination occurred from the placement, weathering and/or abrasion of the low-strength fill pads that were constructed of Coal Creek Station fly ash and bottom ash in each pen before animal placement.

The variety and levels of constituents in the 100 percent ash leach analysis suggests that prudent management and use of the material is appropriate. These are not benign or inert materials. The analysis of the bottom ashes from these four plants show some elevated parameters, although at generally lower levels than the fly ash or fly ash/FGD materials. Prudent management of these materials appears appropriate.

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