224 Stolp Avenue
Syracuse
New York 13207

March 24, 2010

Donald Connell
Fremont County Solid Waste District
P.O. Box 1400
Lander, WY 82520

Dear Mr. Connell:

This letter report constitutes an addendum to my reports: "Compartmentalization of Ground Water at the Sand Draw #2 Landfill Site: Assessing Independent and Multidisciplinary Approaches, "The Hydrogeologic Integrity of the Sand Draw Sand#1 Landfill, Fremont County, Wyoming". In these reports, I concluded that 1.) water found in monitoring wells at the Sand Draw Landfill occurs in isolated perched water bearing zones, in contrast to a continuous water bearing zone suggested by visualization in "potentiometric surface map" form in engineering reports, 2.) recharge replenishment by modern precipitation does not occur to the water-bearing zones in any meaningful way and 3.) an extensive liner system for new landfill cells would not be needed to protect a water table-- any leachate produced by degradation of the waste could not plausibly reach the perched water bearing zones underneath, let alone the regional water table over 200 feet deep.

I used six independent lines of scientific evidence to come to my conclusions:

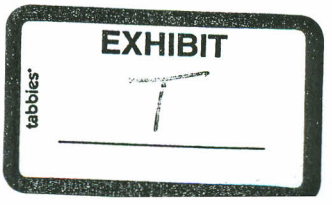
1. Dry claystone and siltstone with low permeability laterally separate water-bearing sandy zones penetrated by drilling.

2. Water levels in monitoring wells do not systematically rise after snowmelt, indicating that they are not recharged at that time of the year when recharge happens in the arid west. The water bearing zones cannot be the regional water table for this reason alone. What small water level changes occur (small enough to be caused by measurement errors or even barometric pressure changes) do not correlate between wells, clearly showing lack of hydraulic connection between them.

3. Detailed high precision earth resistivity geophysical survey data show no continuous water bearing zone, and barely the perched zones.

4. Seismic reflection studies show no continuous water bearing zone

5. Tritium activities (concentrations) in the ground water show little or no water recharged (replenished) the water-bearing zones since the mid 1960's.



6. Chemical and tritium concentration in groundwater do not systematically increase from high to lower water level elevations, completely opposite from what actually occurs in groundwater flow systems.

7. The stable isotopes of the ground water at the Sand Draw landfill are not the same as that now falling as precipitation, showing that modern replenishment has not reached the water-bearing zones in a long time, and that the sampled groundwater was recharged when the climate was very different than that today, perhaps thousands of years ago.

Since these reports, Fremont County obtained high precision radiocarbon dates for the age of water tapped by selected monitoring well and the shop well at Sand Draw landfill to determine how old the water might really be.

Bombardment of nitrogen by cosmic radiation naturally produces carbon-14 in the high atmosphere. Every 5,200 years, half of this carbon isotope decays away. Plants incorporate some of this naturally radioactive carbon as part of their tissues, which then turn back into carbon dioxide and water when the plants die and decay. Naturally, the amount of carbon-14 is balanced by the biological and geochemical systems in hydrosphere. However, when precipitation passes through the soil zone and dissolves some of the carbon dioxide in it, and then recharges the water table, the carbon-14 can no longer be replenished. From that point on, the amount of the radioisotope remaining as dissolved inorganic carbon after radioactive decay can be used to also determine when the ground water was recharged by precipitation.

Raw carbon-14 radioactivity is converted to percent modern carbon, which then can be converted to apparent carbon-14 groundwater age. In practice, accurately determining when recharge occurred from carbon-14 activity can be complicated because of chemical reactions that occur when the dissolved carbon dioxide in the ground water reacts with minerals in soils and rock and ancient organic matter in the aquifer (e.g. coal) Without taking these processes into account, measured carbon-14 ages may be older than actually present. Because of the potential complexity in getting accurate dates, some regulatory agencies view measuring ground water ages as semi-quantitative. For example, the State of Minnesota classifies its ground water as "recent, mixed, and vintage" based on tritium and carbon-14 analyses (http://www.dnr.state.mn.us/waters/groundwater_section/mapping/status.html).

I chose to use a similar approach to determine if recharge to ground water at the Sand Draw site last occurred within the last hundred years, many hundreds of years ago, or thousands of years ago. If water falling on a potential landfill site can naturally reach the water table below every year or even every decade, it may be reasonable to engineer liner systems to preclude leachage generated under a landfill at the same site from also recharging aquifers underneath. But if measureable

recharge has not happened for thousands of years ago, then potential contamination can not occur in the context of human time frames.

Table 1.0 below shows the results of this analysis.

BETA	Received	Due	Submitter No.	Service	Material Pretreatment	Measured Age	13C/12C	Conventional Age	2 Sigma Calibration (Click Link to Retrieve Plot)	Report Completed
264863	Wednesday, September 23, 2009	Wednesday, October 28, 2009	R-9D	AMS-Standard delivery	(water DIC): carbonate precipitation	21900 +/- 110 BP	-10.8 o/oo	22130 +/- 110 BP		Monday, October 19, 2009
264862	Wednesday, September 23, 2009	Wednesday, October 28, 2009	R-18	AMS-Standard delivery	(water DIC): carbonate precipitation	16900 +/- 70 BP	-7.7 o/oo	17180 +/- 70 BP		Monday, October 19, 2009
264861	Wednesday, September 23, 2009	Wednesday, October 28, 2009	R-12	AMS-Standard delivery	(water DIC): carbonate precipitation	4480 +/- 40 BP	-21.0 o/oo	4550 +/- 40 BP		Monday, October 19, 2009
264860	Wednesday, September 23, 2009	Wednesday, October 28, 2009	Shop Well	AMS-Standard delivery	(water DIC): carbonate precipitation	5790 +/- 40 BP	-11.1 o/oo	6020 +/- 40 BP		Monday, October 19, 2009

Table 1.0 Radiocarbon analysis of water from three monitoring wells and the shop well at the Sand Draw landfill.

The columns of interest are those labeled "measured age" before present (BP) and "conventional age" before present. The ages are almost identical and the small differences between related to subtle isotopic corrections that do not change my fundamental conclusion: the water tapped by the monitoring wells and shop well entered the ground as precipitation many *thousands* of years ago. Even halving the measured age, a common additional correction done to incorporate potential dissolving minerals in the rock, produces the same result--the last time water reached the perched water-bearing zones was *thousands* of years ago.

These results agree, enhance, and support all the other lines of evidence that the water-bearing zones at Sand Draw are *compartmentalized* and *isolated* from any regional water table found deeper. The regional water table, yet unidentified under the landfill site, receives its replenishment from recharge on alluvial fans immediately adjacent to the Wind River Range, and from the Wind River itself when it rises with spring snowmelt.

I repeat my conclusions stated before:

1.) Water found in monitoring wells at the Sand Draw Landfill occurs in isolated perched water bearing zones, in contrast to a continuous water bearing zone suggested by visualization in "potentiometric surface map" form in engineering reports

2.) Recharge replenishment by modern precipitation does not occur to the water-bearing zones in any meaningful way

3.) An extensive liner system for new landfill cells would not be needed to protect a water table--any leachate produced by degradation of waste could not plausibly

reach the perched water bearing zones underneath, let alone the regional water table over 200 feet deep.

Donald I. Siegel, PhD.

Hydrogeologist

Quick Search: Search

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264861	Wednesday, September 23, 2009	Wednesday, October 28, 2009	R-12	AMS-Standard delivery	(water DIC): carbonate precipitation	4480 +/- 40 BP	-21.0 o/oo	4550 +/- 40 BP		Monday, October 19, 2009
264860	Wednesday, September 23, 2009	Wednesday, October 28, 2009	Shog Well	AMS-Standard delivery	(water DIC): carbonate precipitation	5790 +/- 40 BP	-11.1 o/oo	6020 +/- 40 BP		Monday, October 19, 2009

PRECISION ANALYSIS

Office (307) 856-08
Cell (307) 851-70
www.precision-labs.cc
info@precision-labs.cc

Laboratory Analytical Report

stomer Name: Fremont County Solid Waste Disposal Department
Order ID: 10012202
)ject ID: Landfill
Report Date: 2/2/2010

) Sample ID: 10012202-01
Date Time
stomer Sample ID: Sand Draw Landfill Office
Collection: 1/22/2010 11:00 AM
trix: Aqueous
Received: 1/22/2010 11:00 AM
tes:

alyses	Result	Units	RL	Qual.	Method	Analysis Date/Time	Analys
alinity, Bicarbonate (HCO3)	200	mg/L	2		SM 2320 B	1/22/2010 4:45:00 PM	LW
alinity, Carbonate (CO3)	18	mg/L	2		SM 2320 B	1/22/2010 4:45:00 PM	LW
alinity, Hydroxide (OH)	ND	mg/L	2		SM 2320 B	1/22/2010 4:45:00 PM	LW
mide	ND	mg/L	1		EPA 300.0	1/25/2010 3:51:00 PM	LW
cium	6.7	mg/L	1		ASTM D 6919-03	1/25/2010 3:51:41 PM	LW
oride	14	mg/L	1		EPA 300.0	1/25/2010 3:51:41 PM	LW
nductivity	1150	µS/cm	10		SM 2510 B	1/22/2010 4:15:00 PM	LW
	0.08	mg/L	0.05		EPA 200.7	1/25/2010 10:56:00 PM	CL
gnesium	ND	mg/L	1		ASTM D 6919-03	1/25/2010 3:51:41 PM	I
nganese	ND	mg/L	0.02		EPA 200.7	1/25/2010 10:56:00 PM	CL
	8.79	s.u.	0.01		EPA 150.1	1/22/2010 4:29:00 PM	LW
assium	ND	mg/L	1		ASTM D 6919-03	1/25/2010 3:51:41 PM	LW
ium	290	mg/L	50		ASTM D 6919-03	1/25/2010 3:00:16 PM	LW
ntium	0.08	mg/L	0.02		EPA 200.7	1/25/2010 10:56:00 PM	CL
ate	310	mg/L	50		EPA 300.0	1/25/2010 3:00:16 PM	LW

ions:
ot Detected at the reporting limit
nalyte Reporting Limit
ding times for preparation or analysis exceeded
S-Spike Recovery outside accepted recovery limits
J-Analyte detected below quantitation limits
M-Matrix Effect
D-Diluted out of recovery limits
L-Analyzed by a contract laboratory

PRECISION ANALYSIS

Chain of Custody & Analytical Request Record

29 Country Acres, Riverton, WY 82501 • 55 Pinedale South Rd, Pinedale, WY 82941
Toll Free (866) 985-0866 • Email Info@Precision-Labs.com • www.Precision-Labs.com

Lab Use Only | Custody Seal: Y / N or NA | Intact: Y / N or NA | Signature Match: Y / N or NA | Receipt Temperature (°C):

Company Name: Fremont County Solid Waste Disposal

Contact Information: Name: Don Connell | Phone: 332-7040 | Email: fcswdd@wyoming.com | Address:

Report Mailing Address: PO BOX 1400, LANDER WY 82520

Project Name, PWS #, Permit #:

Invoice Contact Information: Name: | Phone: | Email: | Address:

Sampler Name: CORY FABRIZIUS

Report Preferences: Email ☐ Mail ☐ Fax ☐

Invoice Preferences: Open Invoice ☐ Oildex ☐ Hard Copy ☒

Sample Origin (State): WY

Purchase Order:

Quote/Bottle Order:

Regulatory Agency: UST ☐ | Drinking Water ☐ | NPDES ☐ | RCRA-EPA ☐ | OTHER ☐ | WOGCC ☐

100122702

Sample Identification (Name, Location, Interval, Etc.):	Collection Date:	Collection Time:	Number of Containers:	Sample Matrix: Water (W), Gas (G), Soil (St.), Solids (SD), Liquefied Gas (LG), Other (O)	Analysis Requested: Ca, Mg, Na, K, Fe, Mn, Sr	SO4, Cl, Br	Conductivity	pH	Alkalinity							Normal Turnaround	Rush 3-5 Days	Urgent! <3 Days	Sample Comments:
1 SAND DRAW LANDFILL OFFICE	1/21/10	11:00	2	W	✓	✓	✓	✓	✓										
2					☐	☐	☐	☐	☐										
3					☐	☐	☐	☐	☐										
4					☐	☐	☐	☐	☐										
5					☐	☐	☐	☐	☐										
6					☐	☐	☐	☐	☐										
7					☐	☐	☐	☐	☐										

Relinquished By: (Printed & Signature)	Date & Time:	Shipped By:	Received By:	Date & Time:
	1/21/10 ~~15:00~~ 11:00	HAND	CORY FABRIZIUS	11/21/10 11:00
Relinquished By: (Printed & Signature)	**Date & Time:**	**Sample Disposal:** Return to Client ☐ Lab Disposal ✓	**Received By:**	**Date & Time:**