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PRODUCED WATER TREATMENT PROGRAM: A COOPERATIVE EFFORT

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I guess everyone wants to know why a weed scientist would be producing water-related work in the San Juan Basin on coal pressed methane produced water. Funding is not very good in weed science. We decided to veer a bit from our usual research with funding from the Bureau of Land Management (BLM), the oil and gas industry, and Sandia Labs. We have started some work on coal bed methane produced water to try to get grass seedlings, native and non-native, to establish quicker than they have in the last few drought years.

In the next 10 years, approximately 10,000 wells will be drilled in San Juan County, according to the BLM office. That means that 15,000 to 20,000 acres of land will be disturbed and reseeded areas will only get about 7 inches of annual rainfall, maybe 8 inches per year, and usually at the wrong time. We need to find ways to use our produced water. We must determine how much total dissolved solids (TDS) can be present before restricting seedlings growth. I am not a chemist but I'll do the best I can.

We looked at a couple of wells in the fall of 2003 and another one in 2004. The first we looked at was produced at Williams 159-A in the Rosa area about 90-95 miles from the experiment station. It takes about two hours to get there because the road is really rough, but that is where they wanted to locate it. Table 1 shows our results.

Produced Water Williams 159-A (Soil) Fall 2003

	pH	EC (mmhos /cm)	Ca (ppm)	Mg (ppm)	Na (ppm)	SAR	Tex
Before Sample	7.32	3.39	291	66.8	533	7.32	loam
After Sample	7.53	5.12	341	79.7	725	9.17	loam
Spring Sample	7.86	2.52	36	6.8	540	21.6	Silt loam

Table 1.

We took soil samples before and after and the bottom row gives results for a spring sample taken in an area adjacent to the well site on the same plot where we planted varieties of grass to see if Mother Nature would bring them up. Please pay attention to the SAR (sodium adsorption ratio) value for that soil. Our "before sample" had a soil pH of 7.32, EC (electrical conductivity) measured in mmhos/cm of 3.39, calcium (Ca) of 291 ppm, magnesium (Mg) of 66.8 ppm, sodium (Na) at 533 ppm, and a SAR value of 7.3 ppm. Most of the crops we grow in this country will not grow in the 7.3 ppm SAR range or an EC of 3. For example, alfalfa is usually around 1 SAR and the same is true for dry beans.

If we look at the "after sample," after water was applied, we get a pH of 7.53, a slight increase in pH, an increase in EC of about 2, both Ca and Mg increased, Na jumped to 725 ppm, and SAR went to 9.17. The texture of both samples was a loam.

In the spring sample, where we did not use the produced water, just Mother Nature, the pH was 7.86, a lower EC than the others, but a SAR of 21.6. This was a quite alkaline type soil. Later I will show you the Indian Ricegrass growing at that site.

In the fall of 2003, we again tested the water (Table 2). Remember that a barrel of water is 42 gallons and we used a 400-barrel tank that was located at the site and we pumped the water on with sprinklers. We applied water on August 13th and 19th and September 17th and 23rd, using 1.12 inches each time. The reason we only used about 1¼ inches was because the soil would not take more; it was pretty compacted and although I used a tractor to try to loosen the soil before planting, we could only get that amount of water on before it would start to run off. Thus, we applied basically 160 barrels per application, totaling 640 barrels, at 42 gallons per barrel.

Williams Prod Rosa 159-A Produced Water Schedule Fall 2003

Date	Amount of Produced Water Applied		
8-13-03		1.12 in	160 bar
8-19-03		1.12 in	160 bar
9-17-03		1.12 in	160 bar
9-23-03		1.12 in	160 bar
Total		4.48 in	640 bar

Table 2.

Table 3 shows results from the August/September analysis. In August we have a pH of 8.5 and in September a pH of 8.0, averaging 8.25. What was the TDS of that water? On August 19 it was 5540 mg/l. We only have two samples because we could not apply 400 barrels at once; every time we filled a 400 barrel tank, we took a new water sample.

Produced Water Analysis for W. Rosa 159-A Fall 2003

Date	pH	TDS mg/l	SAR	EC (mmhos/cm)
8-19-03	8.5	5440	71.1	16.1
9-17-03	8.0	10682	122.4	17.4
AV.	8.25	8061	96.7	16.8

Table 3.

The sample date of August 19 shows a TDS of 5440, SAR of 71.1, and very salty water with an EC of 16.1. You do not want an EC over 15. Our goal was to get a TDS of 8,000, which we got close to when averaging the two samples.

In 2004, we also looked at a well site (242-A) of ConocoPhillips. For those unfamiliar with Farmington, the site is on Middle Mesa, which lies between the two rivers that flow into Navajo Lake. It is located close to Colorado and they have had some problems with their water, also. At NAPI, where they do have wells on the Navajo Indian Irrigation Project, some wells are running 45,000-50,000 TDS, are on sandy soils, require a lot of water, and fertilizer is probably adding to some of the dissolved solids.

On Table 4, look at the "before sample" in the soil with a pH of 7.67, EC of 3.37, Ca of 324, Mg of 75, Na of 422, and a SAR of 5.49. That is a pretty good soil that is not bad for the grasses we are going to plant. After we put the water on the soil, we got a pH of 7.76. We did not run out there after the application to take the sample but waited for 2 or 3 weeks for the soil to dry in order to get a good sample. The EC went up a bit, CA went down, Mg went down, there was a slight increase in Na, and a SAR of 7.4. Both samples are from loams.

Produced Water ConocoPhillips 242-A Soil, 2004

	pH	EC (mmhos/cm)	Ca (ppm)	Mg (ppm)	Na (ppm)	SAR	Tex
Before Sample	7.67	3.37	324	75	422	5.49	loam
After Sample	7.76	3.59	282	61	526	7.4	loam

Table 4.

On April 28, 2004, at the ConocoPhillips site, we applied produced water and followed that with applications on May 10 and 18 (Table 5). On this site, we could apply one 400-barrel tank at one time because the soil was able to hold that much water; it is a very good soil, a bit rocky and somewhat porous. About 2.5 inches was applied each of three times, 400 barrels at a time. We were able to apply 7.5 inches of produced water on this sample versus only 4 inches on the Williams soil.

ConocoPhillips 242-A Produced Water Schedule

Date	Amount of Produced Water Applied	
4-28-04	2.5 in	400 bar
5-10-04	2.5 in	400 bar
5-18-04	2.5 in	400 bar
Total	7.5 in	1200 bar

Table 5.

We took water samples three times, each time we got pH readings ranging from 8.17 to 8.47, with 8.12 the lowest pH. TDS results ranged from just over 3600 to 4020, averaging 3836, very close to 4000. SAR results were very high, averaging 69. EC was basically in the mid-6's, averaging 6.81 (Table 6).

ConocoPhillips 242-A Water Analysis, 2004

Date	pH	TDS mg/l	SAR	EC (mmhos/cm)
4-28-04	8.17	3640	66.7	6.31
5-10-04	8.47	4020	75.7	7.17
5-18-04	8.12	3850	65.0	6.95
AV.	8.25	3836	69.13	6.81

Table 6.

Table 7 shows the varieties of grasses we decided to plant. I was born and raised on a farm in Farmington, went to high school there, and I've always wanted to work with grasses. Through the years, I have told people to raise San Jose Tall Wheatgrass wherever they have irrigation water and a high alkaline soil. It seems to do very well in soils high in alkalinity and with a pH up around 8 and 9. I was curious to try some other varieties of grasses at the Experiment Station to see how they would grow given enough water to germinate. We could watch them for a couple of years while applying an inch of water a month during the summer months to stress the grasses a little bit.

Most of the varieties of what we planted are included on Table 7. We had 32 varieties and chose 16 to plant. Paloma Indian Ricegrass is a very good native grass in this area.

Varieties Planted

Arriba Western Wheatgrass	Chief Inter. Wheatgrass	Luna Pubsc . Wheatgrass	Hy Crest Crested Wheatgrass
Canada Wild Ryegrass	Bozoisky Russian Wild Ryegrass	Critana Thicksike Wheatgrass	Bottle Brush Squirreltail
Redondo Arizona Fescue	Paloma Indian Ricegrass	Anatone Bluebunch Wheatgrass	Junegrass
Four-Wing Saltbush	Covar Sheep Fescue	San Luiz Slender Wheatgrass	Needle and Threadgrass

Table 7.

Figure 1 shows what we did with some of the funding I mentioned. Even the truck was included in the funding. We bought a pump with about 7.5 horsepower, 3-inch in/3-inch out. We simply bring a line from the tank to the pump and then set the lines out. The sprinklers, 9/32s, are adjustable. The pump will handle this size; if we go any smaller than that, we have trouble getting the sprinklers to work because of the coarseness of the water. So we went one size bigger to the 9/32s. The sprinklers are spaced 30 feet apart and irrigate only the plot; we tried to keep all the water on the grass seedlings.

Figure 1. Williams Rosa 159-A showing pump and 400 barrel tank

Figure 2 shows produced water being applied on Williams Rosa 159-A at about the time we were ready to shut off the sprinklers.

Figure 2. Produced water being applied on Williams Rosa 159-A on 8-19-03

Everyone wondered what in the world I was doing planting corn. “That’s not going to last more than a year,” it was predicted. What I wanted to show in Figure 3 is the salt content of the soil and that corn did all right. It is sweet corn, by the way. It was quite interesting to see that corn would grow in some of this salt-infected soil.

Figure 3. Williams Rosa 159-A showing corn tolerance to produced water

Figure 4 shows existing plant growth in the plot area, Williams Rosa 159-A. The grass shown was already there. It has no yellowing, nor chlorosis, nor salt burning. It is located in an area where salt water pooled. I believe the grass is Arriba Western Wheatgrass, which is a native grass.

Figure 4. Williams Rosa 159-A showing existing plant growth in plot area

Figure 5 shows Williams Rosa 159-A in 2004 when we took these photos. This is the area that was irrigated with the 8000 TDS. The top left photo shows Arriba Western Wheatgrass coming through, while on the right is Bozoisky Russian Wild Ryegrass. The bottom left photo shows Canada Wild Ryegrass and the right bottom photo is Hy Crest Crested Wheatgrass. When we chose these varieties, we wanted to pick some that would be palatable to most domestic animals and wildlife. One of them is not shown here, Bottle Brush Squirreltail. That grass does not seem to be as palatable as the others but we planted it anyway because it has to be in the BLM mix.

Figure 5. Top left: A. Western Wheatgrass; Top right: Bozoisky Russian Wild Ryegrass; Bottom left: Canada Wild Ryegrass; Bottom Right: Hy Crest Crested Wheatgrass

Figure 6 shows Paloma Indian Ricegrass planted in the spring 2002. We only had about 7.5 inches of moisture that year. This picture was taken on October 8, 2003. The soil has an EC of 2 and a SAR of 21.6. The Indian Ricegrass did fantastically well. Right now the Ricegrass is almost knee-high, flowering, and producing seed.

Figure 6. Williams Rosa 159-A showing Paloma Indian Ricegrass planted spring 2002, picture 10-8-03, EC 2.52. SAR 21.6

Figure 7 shows ConocoPhillips in the spring of 2004 and the soil conditions where we applied 7.5 inches of produced water with 4000 TDS.

Figure 7. Plot Area

At the top left of Figure 8 is an alfalfa variety called Ameristand 801 and is salt tolerant. It will grow in some high alkaline soils. It is a new variety that just hit the market a couple of years ago and some farmers do not know about it yet, but it does grow in highly salty soils. We also looked at Western Wheatgrass, just barely coming up; Bottlebrush Squirreltail is doing well; and Canada Wild Ryegrass.

Figure 8. Top left: Ameristand 801S Alfalfa; Top right: A. Western Wheatgrass; Bottom left: Bottlebrush Squirreltail; Bottom right: Canada Wild Ryegrass

Figure 9 shows other grasses at ConocoPhillips 242-A including Anatone Bluebunch Wheatgrass. Hy Crest Crested Wheatgrass looks like it will go ahead and come through and San Luiz Slender Wheatgrass is also doing very well.

Figure 9. Top left: Anatone Bluebunch Wheatgrass; Top right: Hy Crest Crested Wheatgrass; Bottom: San Luiz Slender Wheatgrass

Our research plans for 2005 include possibly using produced water of approximately 8,000 to 12,000 mg/l TDS on two sites in the spring. We try to keep consistent by planting in the spring on Middle Mesa because of its close proximity to the Experiment Station. We will continue to evaluate the 2002 and 2003 re-seeded areas.

I want to show you some photos of our reseeding efforts started in 2002 (Figure 10). We had difficulty getting anything to establish at the El Paso Tapasitas pipeline. You can see that Indian Ricegrass is coming in and a lot of Four-wing Saltbush. The El Paso Tapasitas plot on the right shows a lot of Four-wing Saltbush.

Figure 10. Left: El Paso Tapasitas pipeline showing Indian Ricegrass, planted 2002; Right: El Paso Tapasitas Plot area 2002

Figure 11 shows another reseeding area (Williams 159-A) where we applied produced water. The Paloma Indian Ricegrass soil sample was obtained here. Needle and Threadgrass are doing fantastically well, with a SAR of probably 20. Williams Bottlebrush Squirreltail is doing fine as are Russian Wild Ricegrass and Paloma Indian Ricegrass.

Figure 11. Top left: Bottle Brush Squirreltail, 2002; Top right: Bozoisky Russian Wild Ryegrass, 2002; Bottom left: Needle and Threadgrass; Bottom right: Paloma Indian Ricegrass

Figure 12 shows reseeding efforts at ConocoPhillips. We have developed a mix of Slender Wheatgrass, Arriba Western Wheatgrass, Hy Crest Crested Wheatgrass, and Four-wing Saltbush and you can see how the mix is coming up nicely with just Mother Nature and about 7.5 inches of moisture.

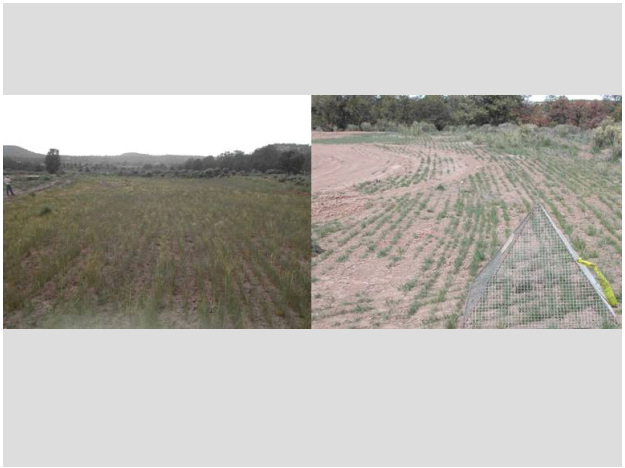

Figure 12. Left: ConocoPhillips reseeded site, 2002; Right: ConocoPhillips, reseeded site 2002

Our efforts seem to be showing some promising results. I am not sure whether we should plant in the fall or the spring or whenever we get the chance. We may plant most of our grasses in the summer and just wait for the weather to help us. In recent years, we have been very dry in this part of the country. Just this past week we got an inch of rain on Saturday and Sunday.

Funding and/or technical support for this project has been provided by Williams Production, El Paso Field Services, BP Americas, Burlington Resources, Pure Resources, XTO Energy, ConocoPhillips, BLM/ FFO, Four Corners Cattle Association, and Sandia National Labs. I would like to thank them and I would like to thank the Water Resources Research Institute for inviting me to speak today. Any questions?

Question: During the time that you applied the methane produced water, did you have rainfall during that same time period?
Answer: No we did not, not that spring. The grass only received pure produced water. We do have rain gauges set throughout the reseeded area. We can get maybe 10-12 inches of rainfall in the spring and summer, but usually our precipitation comes during the winter.

Question: Is there any concern with putting all that produced water on the surface for irrigation regarding possible pollution to the shallow groundwater systems?
Answer: Not to my knowledge. It is being injected right now into the system. I think we need to look at beneficial use and if Dr. Lee and some of his colleagues at New Mexico Tech can find a way to remove the salt from this water, it will definitely be beneficial.

I know that PNM would like some of that produced water for use in their turbines for the process they use to make electricity. That would be fine because that takes away from some of the domestic water that we use for drinking water out of the river. There has to be a beneficial use for some of the water that is said to be hazardous. Hopefully, we will find ways to use this water.