

UNITED STATES ENVIRONMENTAL PROTECTION AGENCY
REGION 8

2016 DEC -6 PM 1:26

In the Matter of:)
Pioneer Natural Resources)
USA, Inc.)
Respondent)

Proceedings under Section 1431(a) of)
Safe Drinking Water Act,)
42 U.S.C. § 300i(a))
_____)

FILED
EPA REGION VIII
Docket No. SDWA-08-2017-0005
HEARING CLERK

Administrative Order

On Consent

INTRODUCTION

The United States Environmental Protection Agency, Region 8 (EPA) and Pioneer Natural Resources USA, Inc. (Respondent) enter into this Administrative Order on Consent (AOC) to address contamination of underground sources of drinking water in the East Poplar Oil Field in the area of the Biere 1-22 production well owned by Respondent.

AUTHORITY

1. The EPA may issue an order pursuant to section 1431(a) of the Safe Drinking Water Act (Act), 42 U.S.C. § 300i(a), upon receipt of information that a contaminant which is present in or is likely to enter a public water system or an underground source of drinking water may present an imminent and substantial endangerment to the health of humans, and other state or local authorities have not acted, or do not have the authority to act, to protect human health.

2. The EPA enters into and issues this AOC under the authority vested in the EPA Administrator by section 1431(a) of the Act, 42 U.S.C. § 300i(a), which has been delegated to the undersigned EPA officials.

PARTIES BOUND

3. The provisions of this AOC shall apply to and be binding upon Respondent, its officers, contractors, directors, agents, successors and assigns. Respondent shall give notice of this AOC to any successor in interest prior to Respondent's transfer of any legal interests with respect to the Biere 1-22 well. Action or inaction of any persons, firms, contractors, employees, agents, or corporations acting under, through or for Respondent, shall not excuse any failure of Respondent to fully perform its obligations under the AOC.

4. Respondent neither admits nor denies the Findings of Fact and Law in paragraphs 8 through 25 of this AOC.

5. Under SDWA Section 1431(b), any person who violates or fails or refuses to comply with any order issued by the Administrator under subsection (a)(1) may, in an action brought in the appropriate United States district court to enforce such order, be subject to a civil penalty of up to \$21,500 per day of violation under the Act, as adjusted by the Federal Civil Penalties Inflation Adjustment Act of 1990, amended by the Debt Collection Improvement Act of 1996, and the subsequent Civil Monetary Penalty Inflation Adjustment Rule, 40 C.F.R. Part 19.

6. Nothing in this AOC shall be construed to create any rights in, or grant any cause of action to, any person not a party to this AOC.

DEFINITIONS

7. Terms used in this AOC that are defined in the Act shall have the meaning assigned to them in the Act or in such regulations, unless otherwise provided in this AOC.

Whenever terms listed below are used in this AOC, the following definitions shall apply:

- a. “Act” shall mean the Public Health Service Act, also known as the Safe Drinking Water Act, 42 U.S.C. §§ 300f through 300j-26;
- b. “AOC” shall mean this AOC and all appendices attached hereto;
- c. “Day” shall mean a calendar day unless expressly stated to be a working day, and in computing any period of time under this AOC, where the last day would fall on a Saturday, Sunday, or federal holiday, the period shall run until the close of business of the next working day;
- d. “EPA” shall mean the United States Environmental Protection Agency and its successor departments, agencies, or instrumentalities.
- e. “Monitoring Well” shall mean a well listed on Table 1. These wells are used exclusively for monitoring purposes.
- f. “Paragraph” shall mean a portion of this AOC identified numerically;
- g. “Parties” shall mean the EPA and Respondent;
- h. “Pore Volume” shall mean the total volume of void space between the rocks and mineral grains that comprise an aquifer or specific region of an aquifer.
- i. “Recovery Well” shall mean a well listed on Table 3. These wells are used for the extraction of groundwater in connection with the remediation

of contamination in USDWs in the area of the Biere 1-22 well. They have an “RW” designation.

- j. “USDW” shall mean an underground source of drinking water as defined by 40 C.F.R. § 144.3.

FINDINGS OF FACT AND LAW

8. The East Poplar Oil Field is an oil field where brine is a byproduct of crude oil production.

9. Mesa Petroleum previously conducted oil and gas production operations in portions of the East Poplar Oil Field, located within Township 28 North, Range 51 East on the Fort Peck Indian Reservation in Roosevelt County in the State of Montana.

10. As part of these operations, in 1970 Mesa installed a production well known as the Biere 1-22 well, located at Township 28 North, Range 51 East, Section 22, 1980 feet from the south line, 660 feet from the west line.

11. Mesa plugged the Biere 1-22 well in September 1984.

12. Within nine months of plugging the Biere 1-22 well, the cement used for plugging failed and fluid flowed to the surface at the Biere 1-22 wellhead.

13. In July 1985 a relief well was drilled and was used to inject additional cement into the formation, an action which appeared to prevent further leakage from the well for 8-12 years.

14. Respondent subsequently acquired Mesa assets, including the Biere 1-22 well.

15. Respondent is a Delaware corporation and therefore a “person” as that term is defined in section 1401(12) of the Act, 42 U.S.C. § 300f(12).

16. In approximately 2000, Respondent collected samples from near the Biere 1-22 well which showed the presence of certain contaminants, including total dissolved solids (TDS) and “free” oil as well as benzene, toluene and ethylbenzene and xylenes (BTEX), and suggested that the well was again leaking and that fluid from the well was entering the Quaternary deposits in the area.

17. The Quaternary deposits in the East Poplar Oil Field include USDWs within the meaning of 40 C.F.R. § 144.3.

18. The U.S. Geological Survey conducted an extensive groundwater investigation of saline-water contamination in and around the East Poplar Oil Field and found TDS levels as high as 91,000 mg/l.

19. TDS is comprised of inorganic salts such as calcium, magnesium potassium, sodium, chlorides and sulfates which have been associated with adverse health effects in humans under certain conditions.

20. Background levels for TDS in this area are 4,500 mg/l. See Exhibit 1.

21. The National Secondary Drinking Water Regulations establish a standard of 250 mg/l for chlorides.

22. The National Primary Drinking Water Regulations establish maximum contaminant levels (MCLs) for BTEX compounds of 5 µg/l benzene, 1,000 µg/l toluene, 700 µg/l ethylbenzene, and 10,000 µg/l xylenes.

23. In August 2001, the EPA issued an “Emergency Order on Consent” which required Respondent to take further action to stop the leak and to monitor groundwater near the well to verify that the leak had been successfully stopped.

24. Respondent implemented the steps required by the Emergency Order on Consent.

25. Respondent later voluntarily began a program to remediate groundwater impacted by historical leaks from the Biere 1-22 well. According to Respondent, Respondent has removed 10,886,121 barrels of pore volume liquid to date, which constitutes approximately 82% of the estimated pore volume liquid.

26. This AOC embodies the remedial program in an enforceable document with remedial goals and sampling and monitoring requirements to ensure that Respondent addresses to the extent technically practicable any impacts to USDWs resulting from historical leaks from the Biere 1-22 well in order to protect human health.

27. The EPA has determined that the release of contaminants from the Biere 1-22 well includes high levels of TDS and BTEX to USDWs found in the Quaternary deposits in the East Poplar Oil Field, that such release may present an imminent and substantial endangerment to the health of persons, and that no other governmental entity has taken action to protect the health of such persons.

EMERGENCY ORDER

Without any admission of fact or law by Respondent, the EPA and Respondent agree as follows:

CONTINUATION OF REMEDIAL PROGRAM

28. Respondent shall continue to sample each Monitoring Well until the requirements in either Paragraph 31 or Paragraph 32 are met. Once those requirements are met for a particular Monitoring Well, Respondent may cease sampling of that well. The wells listed in Table 2 have already met the standards set forth in Paragraph 31 and shall not be subject to further monitoring requirements.

29. Respondent shall continue to operate each Recovery Well and shall continue to sample each Recovery Well until the requirements of either Paragraphs 31 or Paragraph 32 have been met. Operation of a Recovery Well shall include pumping the Recovery Well to remove groundwater, conveyance of the extracted groundwater from the Recovery Well to a central location, and injection of extracted groundwater into a Class V injection well. Once the requirements of either Paragraph 31 or Paragraph 32 are met Respondent may cease operating that Recovery Well, but shall continue to sample the well in accordance with Paragraph 33.

30. Water from each Monitoring Well and each Recovery Well must be sampled for analytical parameters listed in Tables 1 and 3, respectively.

a. Frequency: Samples collected no more frequently than quarterly may be evaluated for AOC remediation criteria.

b. Reporting: Respondent shall provide sampling report copies to the EPA on an annual basis by January 15th of the following year. Reports must provide sample results and, for wells where applicable, analysis of results to determine if remediation criteria have been met.

c. Split samples: Split samples must be provided to EPA upon request.

ACHIEVEMENT OF REMEDIAL OBJECTIVES

31. Each Monitoring Well and each Recovery Well shall be sampled until three consecutive sampling results for that well show that values are at or below either 4500 mg/l for TDS or 250 mg/l for chloride. At specific wells, designated in Table 1, Monitoring Wells shall be sampled until three consecutive sampling results for that well show that values are at or below 5 µg/l Benzene, 1,000 µg/l Toluene, 700 µg/l Ethylbenzene, and 10,000 µg/l Xylenes.

32. Alternatively, if a well has not met the numerical objectives set forth above, operation of a Recovery Well or sampling of a Monitoring Well may cease if results demonstrate that concentrations of any constituent for which the objective has not been met do not decrease by more than 5% (based on a best-fit linear regression) with 95% confidence that the decrease is not more than 15%.

- a. The decline shall be compared to the average concentration of samples taken during the time period being considered.
- b. The time period may begin at any point after the remediation system began operating (in August 2008), but must continue through the most recent sample.
- c. Sampling may be no more frequent than quarterly.

POST REMEDIATION MONITORING

33. Once a Recovery Well has met the remedial objectives set forth in Paragraphs 29 or 30, the well shall continue to be sampled annually for three years.

- a. If no significant increase (defined as greater than or equal to 15% per year) is observed, Respondent may cease any further sampling of the well.
- b. If a significant increase has been observed at a well, sampling of that well shall continue for an additional two years. If, at the end of the two-year period, the remedial objectives set forth in Paragraphs 31 or 32 have not been achieved in the well, Respondent shall investigate and identify the source of the increase and submit a report to the EPA summarizing the results of its investigation. If the remedial objectives have been achieved at the end of the additional two-year period, Respondent may cease further sampling of the well.

NOTICES AND SUBMISSIONS

34. Notifications, sampling results, reports, or other communications required pursuant to this AOC shall be deemed submitted on the date (a) postmarked and sent by certified mail, return receipt requested, or by regular first-class mail; (b) sent by email; or (c) sent by overnight delivery service. Except as otherwise provided, when written notification to or communication with a party is required by the terms of this AOC, it shall be addressed as follows:

As to EPA:
Amy Swanson, Attorney
Legal Enforcement Program (8ENF-L)
U.S. EPA Region 8

1595 Wynkoop Street
Denver, CO 80202-1129
Fax: (303) 312-6953
Email: swanson.amy@epa.gov

AND

Sarah Teschner, Hydrogeologist
Technical Assistance Unit (8EPR-S)
U.S. EPA Region 8
1595 Wynkoop Street
Denver, CO 80202-1129
Fax: (303) 312-7151
Email: teschner.sarah@epa.gov

As to Pioneer:
Thomas C. Jackson
Baker Botts LLP
1299 Pennsylvania Ave., N.W.
Washington, DC 20004-2400
Fax: (202) 585-1040
Email: thomas.jackson@bakerbotts.com

AND

Michael Jacobs
Remediation Manager

Pioneer Natural Resources USA, Inc.
4815 E. Hwy 80
Midland, TX 79706
Fax: (432) 656-1252
Email: michael.jacobs@pxd.com

As to the Fort Peck Tribes (sampling reports
under Paragraph 30(b) only):
Deb Madison
Environmental Director
Assiniboine and Sioux Tribes
P.O. Box 1027
Poplar, MT 59255-1027

FORCE MAJEURE

41. Respondent shall perform the actions required of it under this AOC within the time limits set forth in this AOC, unless the performance is prevented or delayed solely by events which constitute a Force Majeure event. A Force Majeure event is defined as any event arising from causes beyond the control of Respondent, including its employees, agents, consultants and contractors, which could not be overcome by due diligence and which delays or prevents the performance of an action required of it in this AOC within the specified time period. A Force Majeure event does not include, inter alia, increased costs of performance, changed economic circumstances, changed labor relations, normal climatic conditions, or failure to obtain federal, state or local permits if such failure is due to unjustified delay or negligence on the part of Respondent. When circumstances are occurring or have occurred which may delay the completion of any requirement of this AOC whether or not due to a Force Majeure event, Respondent shall so notify the EPA in writing within fifteen (15) days after Respondent learns, or in the exercise of reasonable diligence under the circumstances should have learned, of the delay or anticipated delay. The notice shall describe in detail the basis for Respondent's contention that it experienced a Force Majeure delay, the anticipated length of the delay, the

delay, and the timetable by which those measures will be implemented. Failure to so notify the EPA shall constitute a waiver of any claim of Force Majeure as to the event in question. If the EPA finds that a delay in performance is, or was, caused by a Force Majeure event, it shall extend the time for performance in writing for a period to compensate for the delay resulting from such event and the EPA will not seek imposition of any penalty for such period. In any proceeding regarding a dispute with respect to delay in performance, Respondent shall have the burden of proving that the delay is, or was, caused by a Force Majeure event, and that the additional time requested is necessary to compensate for that event.

GENERAL PROVISIONS

42. Respondent waives any and all remedies, claims for relief and otherwise available rights to judicial or administrative review that Respondent may have with respect to this AOC, including any right of judicial review under section 1448(a) of the Act, 42 U.S.C. § 300j-7(a).

43. This AOC does not relieve Respondent of any responsibilities or liabilities established pursuant to any applicable local, tribal or federal law except as otherwise specifically set forth in this AOC.

44. This AOC shall not constitute a waiver, suspension, or modification of any requirement of the Act. Issuance of this AOC is not an election by the EPA to forgo any civil or criminal action.

45. The EPA and Respondent agree to bear their own costs and attorneys' fees in connection with this matter, including all administrative and judicial proceedings to date.

46. Respondent agrees that upon termination of this AOC it is responsible for the ultimate disposition of the wells and related system components identified in Tables 1 through 3 and comprising the ground water monitoring program and that it will undertake such disposition in accordance with applicable local, tribal and federal law and permits, leases and agreements to ensure timely and appropriate surface and subsurface restoration and protection of USDWs.

46. This AOC shall terminate upon written request to and approval by the EPA following successful completion of the Post Remediation Monitoring period described in Paragraph 31 of the Emergency Order section herein. Approval by the EPA shall terminate Respondent's obligation to undertake the remedial program for the Biere 1-22 well as set forth in the Emergency Order section of this AOC.

47. This AOC supersedes Emergency Administrative Order Upon Consent No. SDWA-08-2001-27, which shall be of no further force or effect.

ISSUANCE PROCEDURES FOR THIS AOC

48. The issuance date of this AOC shall be the date a fully executed, file-stamped copy is filed with the EPA Region 8 Hearing Clerk.

49. The EPA shall mail a copy of the file-stamped AOC to Respondent using Certified U.S. Mail on the date of filing or on the next business day.

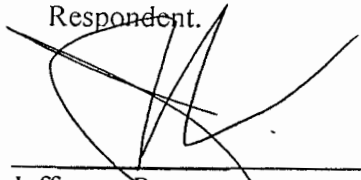
50. The EPA shall telephone and email Respondent on the day the AOC is file-stamped, informing Respondent of the AOC's issuance date.

51. Each of the undersigned representatives of the parties to this AOC certifies that he or she is fully authorized by the party represented to execute and legally bind the party to the terms and conditions of this AOC.

IT IS SO AGREED AND ORDERED:

**PIONEER NATURAL RESOURCES
USA, INC.,**
Respondent.

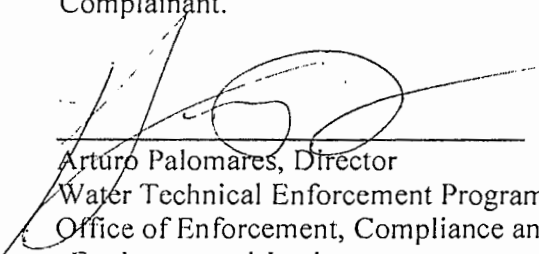
Date: 11/21/2016



Jefferson Rees
Vice President, Domestic Law
5205 North O'Connor Blvd, Suite 200
Irving, TX 75039

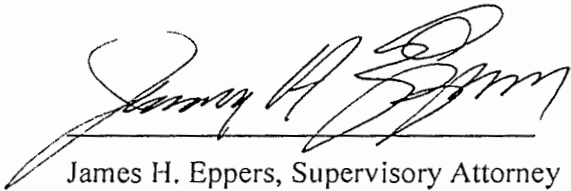
**UNITED STATES ENVIRONMENTAL
PROTECTION AGENCY, REGION 8,**
Complainant.

Date: 11/30/2016



Arturo Palomares, Director
Water Technical Enforcement Program
Office of Enforcement, Compliance and
Environmental Justice

Date: 11/28/16



James H. Eppers, Supervisory Attorney
Regulatory Enforcement Unit
Office of Enforcement, Compliance and
Environmental Justice

Table 1. Monitoring Well and Sampling Parameter List

Site ID	Analytical Parameters ¹
M-28 (Lockman)	TDS, Cl, BTEX
PNR-14-16 (replaced PNR-14)	TDS, Cl
PNR-27-16 (replaced PNR-27)	TDS, Cl
PNR-28-16 (replaced PNR-28)	TDS, Cl
PNR-31-06 (replaced PNR-21)	TDS, Cl, BTEX
PNR-42-07 (replaced PNR-26)	TDS, Cl, BTEX
PNR-43-07 (replaced PNR-25)	TDS, Cl, BTEX

Table 2. Wells Meeting Standards

Site ID	Analytical Parameters ¹
PNR-6	TDS, Cl
PNR-13	TDS, Cl
PNR-22	TDS, Cl
PNR-23	TDS, Cl
PNR-24	TDS, Cl

Table 3. Brine Recovery Well and Sampling Parameter List

Site ID	Analytical Parameters ¹
PNR-RW-1	TDS, Cl, BTEX
PNR-RW-2	TDS, Cl, BTEX
PNR-RW-3	TDS, Cl, BTEX
PNR-RW-4	TDS, Cl, BTEX
PNR-RW-5	TDS, Cl, BTEX
PNR-RW-6	TDS, Cl
PNR-RW-8	TDS, Cl
PNR-RW-9 (replaced USGS 93-3)	TDS, Cl, BTEX
PNR-RW-11	TDS, Cl, BTEX

¹ TDS = Total Dissolved Solids, Cl = Chloride, BTEX = Benzene, Toluene, Ethylbenzene, and Total Xylenes

PNR-RW-12	TDS, Cl
PNR-RW-13	TDS, Cl, BTEX
PNR-RW-15 (formerly PNR-20-13)	TDS, Cl, BTEX
PNR-RW-16 (formerly M- 31-13)	TDS, Cl, BTEX

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PNR-RW-1	TDS, Cl, BTEX
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PNR-RW-4	TDS, Cl, BTEX
PNR-RW-5	TDS, Cl, BTEX
PNR-RW-6	TDS, Cl
PNR-RW-8	TDS, Cl
PNR-RW-9 (replaced USGS 93-3)	TDS, Cl, BTEX
PNR-RW-11	TDS, Cl, BTEX

¹ TDS = Total Dissolved Solids, Cl = Chloride, BTEX = Benzene, Toluene, Ethylbenzene, and Total Xylenes

PNR-RW-12	TDS, CI
PNR-RW-13	TDS, CI, BTEX
PNR-RW-15 (formerly PNR-20-13)	TDS, CI, BTEX
PNR-RW-16 (formerly M- 31-13)	TDS, CI, BTEX



Exhibit 1

UNITED STATES ENVIRONMENTAL PROTECTION AGENCY REGION 8

1595 Wynkoop Street
DENVER, CO 80202-1129
Phone 800-227-8917
<http://www.epa.gov/region08>

August 31, 2016

MEMORANDUM

SUBJECT: Justification for clean-up requirements set forth in the AOC regarding Pioneer Natural Resources' aquifer remediation system for the Biere plume area, Poplar, MT
FROM: Sarah Roberts, Regional Hydrogeologist
TO: Amy Swanson, Legal Enforcement Program Lead

The purpose of this memorandum is to summarize the information that provides a basis for the clean-up requirements set forth in the agreement on consent (AOC) regarding Pioneer Natural Resources' (PNR's) aquifer remediation system for the Biere plume area. The clean-up goals are organized into two tiers. The first tier has concentration goals for total dissolved solids (TDS), chloride, and benzene, toluene, ethylbenzene, and xylene (BTEX). The second tier defines the method for determining if further reduction of concentration of a compound is technically impracticable (in other words, additional remediation efforts are not likely to result in additional concentration decrease). This document contains information regarding determination of background TDS levels at the site, information regarding drinking water quality from groundwater aquifers in eastern Montana, and the risk to drinking water resources posed by elevated TDS, chloride, and/or BTEX levels.

A. Tier 1 clean up goals

a. TDS concentration of 4500 parts per million (ppm)

- i. TDS concentrations are considered in the clean-up goals because the contamination from the Biere well is high in TDS, affecting overall groundwater quality. While high chloride levels are the best indicator of contamination, TDS levels are a better representation of overall water quality. A TDS clean-up goal is included to determine when the aquifer is restored to a similar quality to background level. TDS concentration of 4500 ppm is an appropriate estimation of background levels for this area. The water quality in this region is highly variable due to the geology of the shallow aquifer (1). Additionally, groundwater quality measurements at this specific location prior to influence from oil and gas development are not available. Because of these two factors, estimating background levels of TDS in this area is difficult. The best approximation comes from looking at the TDS concentrations at wells in the area where chloride levels are low (suggesting the wells are uninfluenced by the brine contamination). A summary of the methodology used to determine this background estimation for TDS is contained in the document "Evaluation of Water Quality and Major Ion Concentrations in Background Waters in the Biere Aquifer Area" (2). This evaluation was conducted by PNR and the methodology is deemed to be appropriate by EPA. However, EPA does not agree with the inclusion of two wells in the analysis. The sample results from PNR40-12 and MOC-5 both indicate that water quality is outside the range identified by the USGS as "uncontaminated" with respect to TDS (3). While the chloride levels indicate that the oilfield brine is not likely the source, the anomalously high TDS levels in these wells suggests they are influenced by groundwater that is not likely analogous to the groundwater drawn from the drinking water wells in the area. The assessment conducted without these two wells still provides a range of TDS values that encompasses 4500 ppm.
- ii. EPA collected information to determine if an aquifer restored to 4500 ppm may be considered a drinking water source in Eastern Montana with respect to TDS. This memorandum contains information regarding the private well drinking water quality in Eastern Montana from two sources:
 1. Laboratories that test private drinking water well quality in Montana were called and questioned about whether or not they have analyzed private drinking water well samples that contain 3500 ppm TDS or greater. 3500 ppm TDS was the number discussed because, before the evaluation on water quality in the area was conducted, this number was expected to be close to the background TDS estimation. The information received is also helpful in evaluating their ability for an aquifer with water quality at 4500ppm TDS to be considered a water source. While drinking water wells do not commonly have TDS levels as high as 4500 ppm across the country, from these conversations it is clear that in Eastern Montana, this is not unusual. Because of this, while 4500 ppm may not be an appropriate clean-up goal for other locations, it is acceptable for this site. The information from these sources is summarized in the records of conversation (attachment 3).

2. Elevated levels of total dissolved solids can contaminate a drinking water source, causing risk to human health and/or the resource to become unpalatable and thus undrinkable. The level of TDS which may render a resource undrinkable due to taste is subjective and not defined. However, information from the Well Educated Program, which test private drinking water wells, demonstrates that in eastern Montana, groundwater with TDS levels reaching up to 5590 is used in private drinking water sources (attachment 3). This information does not indicate whether onsite treatment is conducted prior to consumption.

Drinking water with high TDS (high salinity) can cause a number of human health effects. Dehydration can occur due to an imbalance of solutes and water in the blood. Blood cells exposed to a fluid containing about 9000 ppm of solutes will maintain osmotic pressure – meaning that the degree of hydration will not change. Exposure to a fluid containing more than 9000 parts per million of solutes will draw water out of blood cells, causing dehydration while exposure to a fluid containing less than 9000 parts per million of solutes will cause blood cells to draw water out of the fluid. Because humans consume additional salt in food, the consumption of freshwater (water low in solutes) is essential for maintaining hydration. The concentration of TDS in water that will result in dehydration depends on the diet of the consumer and the volume of fluid consumed (4,5,6)

The individual components of TDS have human health risks associated with them. See attachment 2 for a toxicological review of the potential effects of sodium and chloride. Sodium and chloride are present in high levels in the brine contamination and compose much of the TDS in the affected groundwater.

- b. Chloride concentration of 250 ppm
 - i. For chloride, the secondary MCL is 250 ppm. Above 250 ppm, EPA has determined that chloride may be a nuisance to a water supply based on the detection of a salty taste. (<https://www.epa.gov/dwstandardsregulations/secondary-drinking-water-standards-guidance-nuisance-chemicals>)
 - ii. Chloride is included as a clean-up goal because elevated chloride levels are an indication of brine contamination from the Biere well. If the chloride levels are reduced below the secondary MCL at a well site, the influence of brine contamination at that well is minimal.

B. Tier 2: Technical Impracticability Standard

- a. EPA recognizes that this goal may not be feasible for all areas of the aquifer. Over decades, the contamination may have entered areas of lower hydraulic conductivity in the aquifer through diffusive transport. However, the remediation system will only affect areas of the aquifer open to advective transport. Some wells may be placed in areas of lower hydraulic conductivity and these areas may not demonstrate decrease in TDS or chloride concentrations regardless of how long this system is left on. Additionally, it has been determined that, for brine remediation, this pump and dispose system is the best remedy for the site. Other remediation technologies are not expected to provide additional treatment beyond that which the current system is capable. If the goals in Tier 1 appear to not be feasible, technical impracticability of remediation must be demonstrated according to the criteria of Tier 2.
- b. Technical impracticability, for this site, is demonstrated that TDS concentrations do not decrease by more than 5.0% (based on best-fit linear regression) with 95% confidence that the decrease is not more than 15% since the system was turned on (August 2008). This standard was developed with the assistance of EPA statistician, Brad Venner for the site-specific data. The percentiles were chosen to keep for the fluxuations in concentrations caused by natural variability from requiring an unrealistic number of samples to be needed to satisfy the statistical test of technical impracticability. This approach is consistent with the Guidance for Evaluating the Technical Impracticability of Ground-Water Restoration and the Statistical Analysis of Groundwater Monitoring Data at RCRA Facilities Unified Guidance (7, 8).
- c. Concentration decline is compared to the average concentration of samples taken during the time period being considered as measured in fractions of years from the first sample point considered. The period being considered may begin at any point after the system was operating but must continue through the most recent sample. This is to allow for a situation where samples from a well show initial decline but then, after a certain point in time, the concentrations no longer decrease. The sampling may be no more frequent than quarterly to avoid a situation where samples are taken too frequently and artificially demonstrate that concentrations are remaining the same.

C. Post Remediation Monitoring

Continued monitoring may be used to alert EPA and PNR about existence of any continuing sources so that action can be taken to mitigate any negative effects associated with presence and potential migration of continuing contamination.

a. Potential Monitoring Outcomes:

- i. Concentration decrease – this may be due to dilution and is expected over time.
- ii. No significant change in concentration – this may be due to lack of groundwater flow and may be expected.
- iii. Concentration increase – this may be due to plume movement or a continuing source. If this scenario is observed, the cause must be determined.

b. Monitoring Requirements:

- i. Sample annually for three years after treatment system shut-off day.
 1. If no significant increase (greater than or equal to 15% per year) is observed at a well, the well can be removed from the monitoring program.
 2. Sample the remaining wells annually for the following two years.
 3. If a significant increase in concentration is observed, the source of the increase must be identified. If the source is related to the Biere well, additional steps may be required to address any ongoing contamination.

Sources:

1. Thamke, Joanna N., and Karen S. Midtlyng. Ground-water quality for two areas in the Fort Peck Indian Reservation, northeastern Montana, 1993-2000. US Department of the Interior, US Geological Survey, 2003.
2. Evaluation of Water Quality and Major Ion Concentrations in Background Waters in the Biere Aquifer Area. Michael A Jacobs, Environmental Remediation Manager, Pioneer Natural Resources USA, Inc.
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Attachments

1. Evaluation of Water Quality and Major Ion Concentrations in Background Waters in the Biere Aquifer Area - Michael A Jacobs, Environmental Remediation Manager, Pioneer Natural Resources USA, Inc.
2. Total Dissolved Solids and the Poplar, MT Site - Susan Griffin, Senior Toxicologist, US EPA Region 8
3. Records of Conversation regarding TDS levels in drinking water resources in Eastern Montana

Attachment 1

Evaluation of Water Quality and Major Ion Concentrations in Background Waters in the Biere Aquifer Area -
Michael A Jacobs, Environmental Remediation Manager, Pioneer Natural Resources USA, Inc.

Evaluation of Water Quality and Major Ion Concentrations in Background Waters in the Biere Aquifer Area

Michael A. Jacobs, Pioneer Natural Resources USA, Inc

Brief Summary of Pioneer Studies of the Regional Hydrogeochemistry

A preliminary investigation of the regional variation of the geochemical character of the non-impacted ground water of the Poplar River area aquifers suggest that the distribution pattern of dissolved constituents in these aquifers is not random and may be organized in a specific manner. Generally outside of the Poplar River flood plain the chemical character of the ground water changes progressively from east to west in the direction of the hydraulic gradient and these different hydrochemical facies appear to be defined within distinct geological settings related to the different glacial terraces and other geomorphological surfaces found in the area. These terraces (Terrace 1, Terrace 2, Terrace 3, the Ancestral Poplar River Valley, and the Modern Poplar River Valley) are described in the 2014 US Geological Survey (USGS) Scientific Report titled "*Delineation of Brine Contamination in and near the East Poplar Oil Field, Fort Peck Indian Reservation, Northeastern Montana, 2004-09*". Figure 14 from this report (attached) show the general outlines of these terraces.

Regionally from east to west there appear to be three distinct types of water quality (facies) that can be recognized: 1) an area of relatively high mineral concentrations which carries water close to 5,000 mg/L total dissolved solids (TDS) which can be found along on the USGS Terraces 2 and 3 the older, upper bench glacial terraces; 2) a zone of moderately high ionic concentrations occupying the intermediate terrace designated as the Ancestral Poplar River Valley (heavy dashed black line on Figure 14). This area is defined geologically and geophysically by the USGS and Pioneer Natural Resources (Pioneer) as an area where the thickest basal gravels and sands occur along an older structurally low bedrock valley incised in the underlying Cretaceous Bearpaw Shale; and 3) a zone of relatively low ionic concentrations occupying the aquifer adjacent to the current path of the Poplar River.

The geospatial distribution patterns of dissolved constituents in the ground water between both the upper terraces and lower terraces and valley fill aquifers appear to be related to a few dominant factors. Elements that typically influence the dissolved major ionic composition in ground water are residence time (age of the water) as well as other important factors such as proximity to their recharge zones. For instance the uncontaminated ground water in the Poplar River flood plain and lower terraces are influenced by surface/ground water interactions and have some of the lowest ionic concentrations regionally. In the upper reaches of the Poplar River flood plain and lower terraces of the study area Pioneer has measured as much as 20 feet of change in water level in wells adjacent to the river. This water level change appears to be in direct response to surface water/ground water interactions and changes in the Poplar River discharge and fluctuations of river stage. Clearly ground water recharge in the Poplar River flood plain (USGS' Modern Poplar River Valley Terrace) and the Ancestral Poplar River Valley Terrace is mostly if not wholly from the Poplar River. Aquifers found on Terraces 1, 2 and 3 represent older former flood plains formed when streams flowed across these higher elevations areas. These abandoned higher terraces are not hydraulically connected to the Poplar River and therefore do not receive any recharge from the Poplar River. In addition to being topographically higher the aquifers on these terraces consists of the oldest glaciofluvial deposits in the area and therefore have waters of a much older age than waters located in the lower terraces found in the Modern and Ancestral Poplar River Valleys. The zone of recharge for the Biere #1-22 area is most likely from Slims Coulee approximately five mile to the northwest of the Biere #1-22 site. Water levels on the Biere upper terrace generally have a much smaller fluctuation on the order of from 4 to 6 feet although a few wells do exhibit a higher change in water level.

Pioneer Study of the Hydrogeochemistry of the PNR Mesa Biere #1-22 Area

Pioneer Natural Resources has conducted a "site-specific" study of uncontaminated background ground water in 14 wells situated in the Mesa Biere #1-22 plume area. All but three of the wells used in this study are identified in the 2014 USGS Scientific Report as being uncontaminated (represented as blue dots on Figure 14) and all wells are located on USGS Terrace 3 the same terrace as the Mesa Biere #1-22 plume (the upper Biere terrace). Two wells, the PNR40-12 and PNR41-12 wells included in the Pioneer study are not included in the 2014 USGS report because they were drilled after the limited five year (2004-2009) time frame for data used in the report. These wells while in very close proximity to the Biere Plume have ionic constituents consistent with the ranges of parameters defining uncontaminated water quality as published in the report therefore they are included in the set of uncontaminated wells. Monitor well MOC-5, not shown on Figure 14 of the USGS report was also added to the dataset. This well is located on Figure 5 of the USGS report and is also clearly located within Terrace 3 and exhibits ion concentrations similar to the other wells and is considered to be representative of uncontaminated background waters. In the Pioneer study the results presented in Table 1 represent the analyses of constituent values from all of the analytical sampling events during the period of record for each well rather than restricting the data to a five year period. Where available the Pioneer includes data through the latest sampling event through September 2014.

The Pioneer study shows that the hydrogeochemistry of the uncontaminated background waters on the USGS Terrace 3, the upper Biere Terrace appear to be variable in some of their major ion constituents. This variability in constituent values holds true not only geospatially across the terrace but appear to vary with time in any given individual well. Within the USGS Terrace 3 there are relatively high median concentrations of Total Dissolved Solids (TDS) and Sulfate (SO₄). All of the uncontaminated background ground water samples in the Biere #1-22 aquifer area exceed the USEPA secondary (aesthetic quality) maximum contaminant level (SMCL) for TDS and SO₄ in drinking water supplies of 500 mg/L and 250 mg/L respectively (USEPA, 2000). The average TDS value of all the non-impacted wells in the study is 4,250 mg/L. The average value for SO₄ in non-impacted waters on the Upper Bench Biere Aquifer is 2,111 mg/L. Although high in sulfate and TDS, all of the 14 wells in the study were below the SMCL for chlorides (Cl) with an average value of 98 mg/L. SO₄ is included in this study as it is a major ion that defines the hydrogeochemical facies of this area and sets it distinctively apart from the other areas. The SO₄ values in the water on this terrace will not change regardless of any ongoing brine removal operations and as such due to these high concentrations of SO₄ along with other constituents in the non-impacted water all of the water samples in the Biere Aquifer will forever also exceed the SMCL for drinking water for TDS at or above the average concentrations shown below in Table 1. The data used in this table is taken from the appendices table in the 2014 USGS Scientific Report and from the tables submitted semi-annually in Pioneer's reports to the USEPA.

Table 1, below, shows the maximum and minimum value of these constituents (Cl, SO₄ and TDS) in each of the 14 wells in addition to the average constituent value for each well. Note that the average constituent concentrations presented for each individual well in the table below is not the calculated average of the maximum and minimum values shown but rather the actual average tabulated for all of the analyses for each well. The number of analyses used to calculate the averages varies as each well has a different number of sampling events during the period of record. At the bottom of the chart, below the average constituent column is a number which represents the calculated average of the averages values listed above in the individual wells rows. Also shown at the bottom of the table is the range between the minimum and maximum values recorded for all wells in the table for each constituent. The maximum recorded constituent value in each well when compared to the corresponding minimum recorded value show that these constituent concentrations may vary from around 15% to as much as 70% within an individual wells sampling period or record. It is this variability within each wells sampling period of record that provides evidence for the potential misrepresentation of water quality when using a single data point in time as being representative of the water quality in and around the area of that particular well. In fact 50% (light brown shaded wells) of the background wells in the Biere #1-22 area have at one time or another had TDS values above the proposed 4,500 mg/L TDS level for cleanup. Basically, the average TDS values for these same wells are also at or above the 4,500 mg/L level.

Well Name	Chloride Max	Chloride Min	Chloride - AVG	Sulfate - Max	Sulfate - Min	Sulfate - AVG	TDS - Max	TDS - Min	TDS - AVG
MOC-5	190	103	147	3,170*		3,170	8,620		8,620
MOC-3	76	65	74	1,930	1,710	1,856	3,500	3,140	3,360
MOC-20A	388	112	156	3,390	2,760	3,199	5,500	4,800	5,274
PNR-16	33	9	22	3,460	2,360	3,020	5,110	3,430	4,852
PNR36-07	265	136	198	1,240	1,010	1,133	2,810	2,450	2,643
PNR-12	148	58	71	2,250	1,830	2,104	4,720	3,860	4,135
USGS92-12	15	3	6	1,840	733	1,235	3,160	1,610	2,186
MOC-1B	96	64	76	2,280	2,110	2,218	4,070	3,540	3,893
PNR-18	127	42	69	1,820	1,220	1,666	3,570	2,740	3,155
PNR33-06	134	73	106	2,700	2,390	2,570	4,890	4,170	4,476
PNR-29	181	81	106	2,150	1,860	2,015	4,960	4,250	4,723
LAW-MO1	26	17	22	1,430	1,120	1,285	2,910	2,350	2,625
PNR40-12	224	173	195	3,400*		3,400	7,660	6,670	7,260
PNR41-12	220	86	130	687*		687	1,990	1,830	1,935
AVERAGE VALUE:	152	73		2,226	1,737		4,534	3,449	
AVG/AVG VALUE			98			2,111			4,250
Range of Values	15-388	3-173	6-198	687-3,460	733-2,760	687-3,400	1,990-8,620	1,610-6,670	1,935-8,620

Table 1. Maximum, Minimum and Average Values for Selected Uncontaminated Wells in the USGS Terrace 3-Biere #1-22 Area.

The most probable source of the elevated TDS and SO₄ in the waters all along Terrace 3 is the Late Cretaceous, Bearpaw Shale which crops out or is near the land surface throughout most of the Poplar River drainage area. In the Biere #1-22 area the gravels and sands are relatively thin and range from around 30 feet in the Biere #1-22 area (PNR-17) to just 10 feet or less in the western and lower reaches of the channel at the contaminant plume front (PNR-RW8). The Biere Channel itself is a glaciofluvial channel which is incised into and directly overlies the Bearpaw Shale. The Biere Channel is overlain by a thick section of very compact glacial till.

A detailed geochemical study of the Pierre Shale was conducted in 1962 by Harry A. Tourtelot with the United States Geological Survey (USGS). The Bearpaw Shale Formation is the geological equivalent of the Pierre Shale in North Dakota and other western and central states. His paper, titled "*Preliminary Investigation of the Geologic Setting and Chemical Composition of the Pierre Shale, Great Plains Region*" is an excellent reference for understanding the geological and geochemical nature of the Pierre Shale and its equivalent Bearpaw Shale. In this paper, a bed of weathered Pierre Shale (Bearpaw) in Fergus County, Montana was described. At this locality, joints and bedding planes in this roadcut were stained with iron oxides and coated with minute gypsum crystals. There were numerous iron and manganese concretions present as well. The iron oxides and sulfates, and gypsum were more abundant on the surface of the black shale than they were a foot or so beneath the surface. Core samples taken in this study also indicated that sulfide minerals, such as pyrite or marcasite, in the rock are oxidized to sulfate compounds at a very early stage in the weathering of an outcrop. No doubt the soils formed on this Cretaceous shale in this area are most likely rich in sulfate-bearing minerals (e.g., gypsum, pyrite, jarosite) all of which are the principal source of the high sulfate in the shallow ground water of the upper terraces in the Poplar River watershed. The USGS06-3 well on the western side of the Poplar River where there is only a very thin veneer of soils above the Bearpaw Shale has a SO₄ concentration >6,000 mg/L.

Picture 1 below shows a typical outcrop of Bearpaw Shale taken along the western margin of the Poplar River Valley. Shown in the picture are numerous beds of iron and manganese concretion nodules. This outcrop is very similar to the outcrop and core descriptions at other localities and is representative of the bedrock underlying the Biere #1-22 area and the USGS Terrace 3.



Picture 1-Outcrop of Bearpaw Shale on the western edge of the Poplar River flood plain showing typical weathering patterns of the Bearpaw Shale into low rounded hills. Seen in the outcrop are numerous thin beds of iron and manganese nodules.

Summary of Pioneer Evaluation of Water Quality and Major Ion Concentrations in Background Waters in the Biere Aquifer Area

Pioneer Natural Resources has conducted a "site-specific" study of uncontaminated background ground waters in 14 wells situated in the Mesa Biere #1-22 plume area. The purpose of the study was to determine reasonable "site-specific" water quality goals for their brine recovery and monitoring wells that are part of Pioneer's Biere #1-22 ongoing ground water remediation program and to determine when wells can be dropped from further recovery and monitoring activities as per site-specific closure criteria. Based on the extensive data set summarized in Table 1 for the Biere #1-22 Plume Area, Pioneer has proposed a SMCL cleanup level of either 250 mg/L chlorides or 4,500 mg/L TDS as a reasonable and technically sound targets for a well to be dropped from further monitoring and for site cleanup. Requiring remediation below these levels would mean that Pioneer would be cleaning up background concentrations.

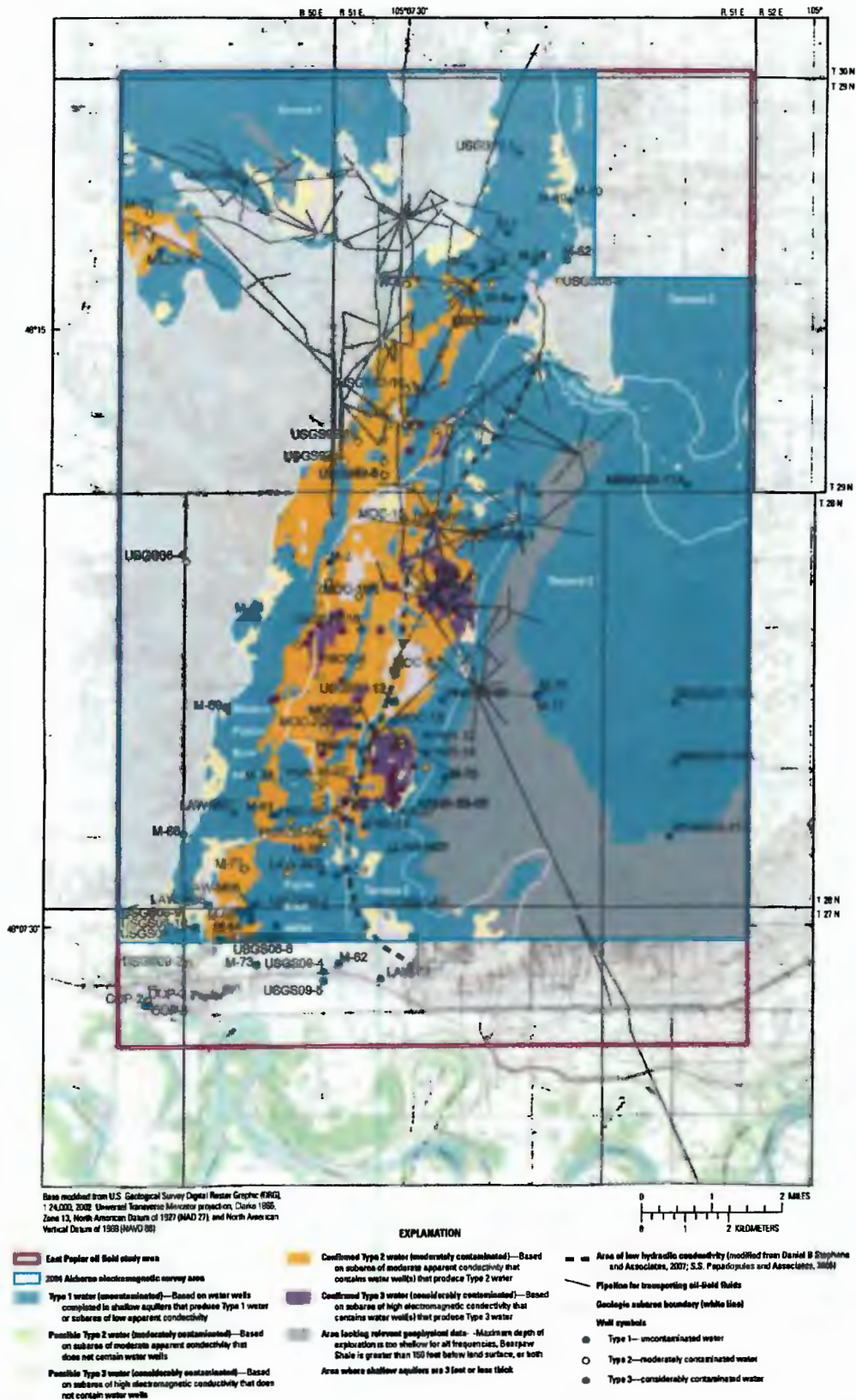


Figure 14. Delineating possible and confirmed areas of brine contamination in shallow aquifers, known pipelines, and types of water in shallow aquifers, in and near the East Poplar oil field study area, 2004–09.

Modified from Thamke, J.N. and Smith, B.D., Delineation of brine contamination in and near the East Poplar oil field, Fort Peck Indian Reservation, northeastern Montana, 2004-09; U.S. Geological Survey Scientific Investigations Report 2014-5024, pg. 31, <http://dx.doi.org/10.3133/sir20145024>.

Attachment 2

Total Dissolved Solids and the Poplar, MT Site - Susan Griffin, Senior Toxicologist, US EPA Region 8



**UNITED STATES ENVIRONMENTAL PROTECTION AGENCY
REGION 8**

1595 Wynkoop Street
DENVER, CO 80202-1129
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<http://www.epa.gov/region08>

March 16, 2015

MEMORANDUM

SUBJECT: Total Dissolved Solids and the Poplar, MT Site

FROM: Susan Griffin, PhD, DABT
Senior Toxicologist

TO: Sarah Roberts
Hydrogeologist

The Poplar site is an oil field located in northeastern Montana where brine is a byproduct of crude oil production. Handling and disposal of brine at the site has resulted in contamination of shallow aquifers and drinking water wells. The total dissolved solids (TDS) in those wells range from 1500 – 69,000 mg/L. Typically, water with TDS levels ranging from 10,000 – 30,000 mg/L are classified as saline and levels greater than 30,000 are classified as brine. The USEPA has a secondary standard of 500 mg/L for TDS based on aesthetic qualities. The EPA does not have a health based standard for TDS. I was unable to locate toxicity information for TDS as a mixture. However, TDS is comprised of inorganic salts such as calcium, magnesium potassium, sodium, chlorides and sulfates which have been associated with adverse health effects in humans.

This memo will focus on the levels of sodium and chloride measured in the wells, since no analytical data was provided on the other inorganic salts found in TDS. The levels of sodium ranged from 70 to 25,000 mg/L (directly proportional to the TDS levels). The effect of sodium intake on population health remains controversial. Mean intake of sodium in populations ranges between approximately 2,700 mg and 4,900 mg/day (McCarron et al 2013). Past studies have suggested that increased sodium intake is associated with hypertension, cardiovascular disease and stroke (Institute of Medicine 2004). A number of recent studies indicate that the association between salt intake and hypertension is overestimated and factors such as genetics, body mass index and age may be more critical determinants of hypertension (Lelong et al 2015, Graudal et al 2014). A recent meta-analysis of over 270,000 people did, however, find a significant increase in cardiovascular disease with a high sodium intake defined in the study as greater than 5,000 mg/day (Graudal et al 2014). If people were to ingest 2 liters of water per day from the contaminated wells found at the Poplar site, many would be taking in sodium far in excess of the level associated with an increase in cardiovascular disease in the Graudal et al study. For sodium levels in well water ranging from 70 – 25,000 mg/L, the daily intake would be 140 – 50,000 mg of sodium.

Chloride levels in wells at the Poplar site ranged from 2 – 43,000 mg/L. Chloride has an EPA secondary standard 250 mg/L based on aesthetic qualities. The EPA does not have a health based drinking water standard for chloride. Chloride toxicity has not been observed in humans, except in the case of impaired sodium chloride metabolism (e.g., congestive heart failure). There is no known toxicity factor at this time. Since excess chloride is excreted from the body, healthy individuals can tolerate the intake of large quantities of chloride provided there is a concomitant intake of fresh water.

References

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Lelong H., Galan P., Kesse-Guyot E., Fezeu L., Hercberg S. and Blacher J. (2015). Relationship Between Nutrition and Blood Pressure: A Cross-Sectional Analysis from the NutriNet-Sante Study, A French Web-based Cohort Study. *Am J. Hypertension* 28(3): 362-371

Institute of Medicine (2004). *Dietary Reference Intakes: Water, Potassium, Sodium, Chloride, and Sulfate*. National Academies Press: Washington DC.

McCarron DA, Kazaks AG, Geerling JC, Stern JS and Graudal NA. (2013). Normal Range of Human Dietary Sodium Intake: A Perspective Based on 24-hour Urinary Sodium Excretion Worldwide: *Am. J. Hypertension* 26(10): 1218-1223.

Attachment 3

Records of Conversation regarding TDS levels in drinking water resources in Eastern Montana

Records of Communication Regarding Private Well Water Quality in Eastern Montana

Sarah Roberts (Teschner)

January, 2015

A. Energy Laboratories, Inc. Record of Telephone Conversation

Time: 8:00 am

Date: 1/8/2015

Person Documenting Conversation: Sarah Roberts, Regional Hydrogeologist

Organization: 8ENF-EPR

Person Spoken With:

Lynn Pippin, Project Manager

Energy Laboratories, Inc.

1120 South 27th Street, Billings, MT 59101

(406) 252-6325

Subject: Domestic Drinking Water Supply Well Samples – Groundwater Quality

Summary: I asked Lynn about the quality of drinking water from domestic supply wells in terms of TDS. I clarified that I was not looking for laboratory results for specific locations as that is information that she said she could not provide. I said that I was interested in knowing if 3500 ppm TDS is considered drinkable for domestic water supply well users in Montana. I did not specify a location or circumstance for consumption. Lynn stated that most of the time, 3500 ppm is not considered palatable but in Eastern Montana it is. She stated that she believes the municipal water supply for the City of Jordan is approximately 2500-3000 ppm. She also stated that consuming water at 3500 ppm TDS is not harmful, likening it to consuming a calcium supplement (in terms of calcium). Lynn added that some ranchers have been drinking TDS levels higher than 3500 ppm for generations. Lynn stated she did not have an accessible way to provide a range of TDS values for an area of Montana but referred me to the Well Educated Program run by Montana State University, Bozeman because they do maintain a database of these results.

According to the website, <http://waterquality.montana.edu/docs/WellEducated.shtml>, "The goal of the Well Educated program is to provide private well owner education about water quality as it relates to health, and quality of life. The program is a collaborative effort between MSUEWQ, and partners in participating counties that provides well owners with materials to sample their well water quality. The outcome is a service that helps prevent nonpoint source ground water contamination from private wells through well owner education while simultaneously providing means to monitor ground water quality."

B. Montana State University Well Educated Program Record of Telephone Conversation

The Well Educated Program compiles the water quality results from participating private well owners across Montana.

Time: 9:45 am

Date: 1/8/2015

Person Documenting Conversation: Sarah Roberts, Regional Hydrogeologist

Organization: 8ENF-EPR

Person Spoken With:

Katie Kaylor, M.S. Research Associate

Department of Land Resources and Environmental Sciences

2 Marsh Labs

Bozeman, MT 59717

(406) 994-7381

kkaylor@montana.edu

Subject: Domestic Drinking Water Supply Well Samples – Groundwater Quality

Summary: I asked Katie about the quality of drinking water from domestic supply wells in terms of TDS. I said that I was interested in knowing if 3500 ppm TDS is considered drinkable for domestic water supply well users in Montana. Katie said domestic drinking water supplies at 3500 ppm is definitely a reality in Montana. She said she has seen samples from domestic drinking water wells range on the upper end from 2000-5000 ppm. Katie stated that some homeowners have on-site treatment for TDS (reverse osmosis units) but there are many that just drink it. She stated that 3500 ppm is "not unusual or out of the question for eastern Montana." I informed Katie that I was wondering specifically about the drinking water well quality for eastern Montana and she said that she could search for average and maximum sample values by county. I asked for this information for Roosevelt County and other neighboring counties. She said she could provide this information by email but that she didn't believe she had very many sample results from this area.

C. Montana State University Well Educated Program Database Results for TDS in Eastern Montana

Katie Kaylor emailed the average and maximum water quality laboratory results for six counties in eastern Montana to me on 1/8/2015. The values are displayed in the table below. For several counties, the maximum TDS concentrations exceed those of the proposed clean-up goal, 4500 ppm. This illustrates that this is a realistic goal and is within the range of observed drinking water well quality for the area.

County	Average TDS (mg/L)	Max TDS (mg/L)	# samples
Roosevelt	1027	1580	4
McCone	2005	3770	7
Richland	337	337	1
Daniels	1343	5590	15
Valley	313	313	1
Dawson	1675	4690	14