Exhibit I

IN THE UNITED STATES DISTRICT COURT
DISTRICT OF UTAH, CENTRAL DIVISION

UNITED STATES OF AMERICA, and STATE OF UTAH, *Plaintiffs,* vs. KENNECOTT UTAH COPPER CORPORATION, *Defendant*	Case No. 2:07-CV-00485-DAK Judge Dale A. Kimball

DECLARATION OF REBECCA J. THOMAS

I, Rebecca J. Thomas, in accordance with 28 U.S.C. § 1746, declare as follows:

1. I am employed by the United States Environmental Protection Agency ("EPA"), Region 8 as a Remedial Project Manager ("RPM"). Currently, I am assigned as the RPM for the Kennecott South Zone Site, located in Salt Lake County, Utah. I have personal knowledge of the general matters in this declaration and the specific supporting documentation in the site file for this case and the extensive administrative record.

2. I have prepared this Declaration to provide a technical response to comments received by the U.S. Department of Justice following lodging of the Consent Decree among the United States, the State of Utah, and Kennecott Utah Copper Corporation ("KUCC") for the remediation of a ground water plume associated with Operable Unit 2 of the Kennecott South

Zone Site. Many of the comments were restatements of prior comments submitted to EPA or the State of Utah regarding the agencies' technical decisions.

3. Many of the comments submitted were similar to comments made in connection with an earlier settlement reached in 1995 between the State of Utah and KUCC regarding natural resource damages ("NRD Settlement"). The NRD Settlement required KUCC to complete source control measures and establish a Trust Fund, the amount of which could be reduced by providing treated ground water to a municipal and industrial water purveyor. In 2004, KUCC entered into an agreement with the Jordan Valley Water Conservancy District ("JVWCD") and the State, whereby KUCC built and operates a reverse osmosis ("RO") water treatment plant to treat sulfate contaminated water from Zone A. A similar RO plant to treat water from Zone B is being funded by KUCC and will be built and operated by JVWCD. These water treatment plants deliver drinking water to a purveyor of municipal and industrial water to the public in the affected area. A copy of the State Natural Resource Damage Trustee's 2004 Response Summary and Findings & Conclusion documents are available at the State of Utah Department of Environmental Quality (168 North 1950 West, Salt Lake City, Utah 84114) or electronically at http://www.deq.utah.gov/issues/nrd/documents.htm.

4. Many of the comments were similar to those made in connection with EPA's and UDEQ's Explanation of Significant Differences ("ESD") issued in 2007. The second ESD clarified the original remedy selected for Operable Unit 2 of the South Zone Site. A number of clarifications to the remedy were required to address barrier well water management, source control measures, and performance standards. EPA and the State prepared a Responsiveness

Summary for the ESD in 2007, a copy of which is separately being provided to the Court.

Comments regarding the adequacy of the technical investigation.

5. One commentor suggested that a fuller range of alternatives should have been considered to remediate ground water contamination. A variety of technology types and process options for remediation of groundwater were presented and screened for suitability in the Feasibility Study completed in 1998. The technology types considered included Point-of-use Management (either through replacement or treatment), Containment (Physical-Chemical or Hydraulic), In-Situ Treatment (Physical-Chemical or Biological), Collection (Hydraulic or Physical), Ex-Site Treatment (Physical-Chemical or Biological) and Deliver (Treated, Untreated On Site, or Untreated Off Site). The commentor specifically mentioned biosulfide precipitation, evaporation, and crystallization. Selective precipitation was maintained as a viable alternative in the Feasibility Study as it was demonstrated to be technically implementable. However the process requires multiple treatment steps and would have required demonstration testing, so it was rated as only fair in terms of implementability. Cost for this alternative was considered moderate to high. Evaporation ponds were also considered in the Feasibility Study, although this alternative was rejected during screening due to the requirement to construct and permit costly ponds and associated piping. Crystallization was also considered in the Feasibility Study. Refrigerant would be added to the groundwater to freeze and separate contaminants. This technology was rejected during screening because it is an unproven technology on site contaminants, and it was determined to be technically infeasible due to the size of the plume. EPA ultimately selected active treatment of the groundwater because it offered the best balance

among the criteria we use to select a remedy.

Comments concerning potential impact to the Great Salt Lake ecosystem.

6. EPA has concluded that the proposed actions are protective of human health and the environment. All discharges from the North Tailings Impoundment are subject to regulatory approval. Through continued monitoring and modeling, EPA and UDEQ will audit performance and evaluate KUCC's ability to meet performance standards. EPA retains the authority under CERCLA to address any areas of non-compliance with State permits and permit limitations established by the applicable State regulatory divisions. EPA retains the authority under CERCLA to address any areas of non-compliance with State permits. UDEQ retains its separate permitting authorities to address non-compliance with permit limitations through corrective action requirements listed in each applicable permit.

7. The decision to neutralize acidic ground water in the tailings pipeline is based on years of studies documented in Appendix A of the South Facilities Remedial Design. KUCC has demonstrated that the acidic water extracted from the Zone A plume is neutralized in the tailings pipeline, the contaminants are precipitated out of the water, the contaminants are deposited in solid form in the North Tailings Impoundment and the water is clean enough to reuse in KUCC's milling process or discharge under KUCC's discharge permits. KUCC has also demonstrated (as documented in Section 6.2 of Appendix C of the South Facilities Remedial Design) that the acid waters once neutralized and the lime treatment sludges and residuals of such treatment are not characteristically hazardous and are suitable for disposal in the impoundment.

8. There are monitoring and compliance requirements under KUCC's State ground water protection permit which are designed to prevent offsite migration of contaminants via the underlying aquifer system. Periodic surface water discharge to the Great Salt Lake from the impoundment is permitted under UPDES Permit No. UT0000051 which places discharge limitations upon contaminants of concern and which can be reopened as the State promulgates new or amended water quality standards for the surface waters of the State. Lastly, there are monitoring and compliance requirements under State laws, rules, and approved control plans.

9. A ground water discharge permit issued by the Utah Division of Water Quality for the North Tailings Impoundment ("Impoundment") requires monitoring of operational flows and ground water in the vicinity of the Impoundment. KUCC has performed studies showing that the RO concentrate and neutralized acid core water from Zone A and resulting precipitates do not exhibit any hazardous characteristics. Furthermore, when the RO concentrate and neutralized acid core water are combined with tailings, they represent less than two percent of the total volume of material placed in the Impoundments, and are *de minimis* in comparison to the total amount of solids (including metals) being directed to the North Tailings Impoundment which have accumulated in the impoundment over the many years of KUCC's mining operations. In addition, significant seismic analyses of the Impoundment site and method of construction were completed as part of a final environmental impact statement conducted for the north tailings expansion project in 1995.

10. As long as the Impoundment remains at a neutral pH, the metals that are bound within the impounded substrates will remain stable and not available to the environment.

Control of acidity in the tailings slurry begins at the Copperton Concentrator and is monitored along the tailings pipeline both as a requirement of the OU2 ROD and the OM&R Plan. Any discharge to the Great Salt Lake, including post mine closure, will be consistent with the State's discharge permits and/or numerical standards that may be established for the Great Salt Lake.

Comments concerning the stability of the North Tailings Impoundment.

11. Prior to construction of the Impoundment, numerous studies were conducted addressing site, geotechnical, engineering and environmental considerations. The Impoundment is underlain by a 9 to 15 foot thick layer of Bonneville Clay that effectively limits vertical movement of material in the Impoundment, acting as a liner. The alkaline treatment of acidic water (due to blending with general mill tailings and reverse osmosis treatment concentrates) in the tailings pipeline, plus the physical addition of lime to the pipeline circuit, converts dissolved metals into stable precipitants prior to deposition within the Impoundment.

12. In addition, significant seismic analyses of the Impoundment site and method of construction were completed as part of the final environmental impact statement conducted for the Impoundment expansion project in 1995. Design and construction of Impoundment meets dam safety requirements of the Utah Division of Water Resources which consider seismic stability.

Comments concerning ground water remedial alternatives.

13. Subject to EPA's and UDEQ's direction and oversight, KUCC evaluated over 40 remediation technologies, combinations of technologies, and alternatives. This evaluation is documented in a report titled "Feasibility Study for the Kennecott Utah Copper South Facilities

Groundwater Plume" (March 16, 1998). During this evaluation various ground water treatment alternatives were evaluated and routinely reported on at technical review committee meetings. As noted in Section 5.2.2 of the 2007 Operation, Maintenance & Replacement Plan for the South Facilities Groundwater site, KUCC will continue to investigate alternative water treatment technologies to be used when active mining operations cease. The plan for post mining water management and disposal of treatment residuals will be formally updated as part of the 5-Year Reviews. At least three years prior to closure, KUCC is required to prepare a preliminary design for all aspects of post-closure water treatment for review and acceptance by EPA and UDEQ.

Comments concerning impacts to water elevations in the aquifer.

14. Source controls up-gradient from the contaminated aquifer are in place to prevent the uncontrolled release of leach water and alluvial flow water from the main drainages along the eastern front of the Oquirrh Mountains. KUCC reconstructed and upgraded the Eastside Leachate Collection System to include a series of barrier or "cutoff" walls imbedded into bedrock to intercept the underflow through the alluvium. Such improvements were completed by KUCC to meet the requirements of the NRD CD, with additional performance standards for monitoring the effectiveness of such controls being incorporated into the UDEQ/DWQ Permit No. UGW350010 – Kennecott Bingham Canyon Mine and Water Collection System in 1998. The permit establishes ground water protection limits for all wells covered by the permit. These limits are identified in Table 1 of the permit.

15. The aquifer continues to be recharged by precipitation that falls within the valley, the potential ground water that flows through the bedrock aquifer of the Oquirrh Mountains and

infiltration from the irrigation canals located in the valley. With the source control measures in place the aquifer has a finite recharge value and a certain sustainable yield without being further impacted by the continued release of acid mine drainage from the upgradient drainages. The estimated sustainable yield (7,000 acre-feet per year) from the aquifer comprising both Zone A and Zone B was assessed by UDEQ in consultation with the Utah Division of Water Rights ("UDWR"). The sustainable yield was estimated by UDEQ to assist in valuing damage caused to the ground water in Zone A and Zone B (for purposes of the State's NRD claim).

16. UDWR was consulted in the sustainable yield assessment and continues to study the implications of KUCC's operations on the aquifer as well as those of other water users and will has statutory authority to act on behalf of all water users. Within its June 2002 Groundwater Management Plan for the Salt Lake Valley ("SLV Ground Water Management Plan") UDWR calculated that the safe annual yield from the western region of the Salt Lake Valley aquifer is 25,000 acre-feet per year. Paragraph 2.3 of the SLV Ground Water Management Plan notes that applications for a change in a point of diversion or a replacement well in the area designated by UDWR as the "Southwest Remediation Area" will be critically reviewed by UDWR to avoid interfering with the ground water remediation process. Such a critical review is to occur in the area within 3000 feet of the known 250 ppm sulfate isoconcentration contour.

Comments concerning water rights associated with the aquifer.

17. The primary focus of the CERCLA remedy is containing and reducing the Zone A plume as described in the OU2 ROD. The selected remedy includes extraction of water from the barrier wells, located along the leading edge of the Zone A plume, and from wells located in the

core of the Zone A plume. These wells accomplish the remedial action objectives of containment and remediation.

18. KUCC must comply with state water rights law in its ground water extraction and remediation program, and has assigned water rights to this project to allow for extraction of water from the plume. KUCC applied for and received approval from the UDWR to move or redesignate previously held water rights for the production of process water. As a result of such redesignation, water extracted from the core area of the Zone A plume is extracted and delivered to the tailings slurry pipeline as discussed above, and water extracted from the leading edge of the Zone A plume is delivered to the Reverse Osmosis Plant for treatment and production of municipal quality water (an allowable management option for the extracted water).

19. Because of the potential to cause localized changes in water elevation, KUCC is required to develop procedures to address impacts to other water rights owners, described in Section 6.0 of the OM&R Plan attached to the Consent Decree as Appendix C. Pursuant to the SLV Ground Water Management Plan, KUCC has committed to assist adversely affected water users to obtain adequate replacement water. In addressing potential water quality impacts, KUCC will prepare an evaluation involving the water rights holder in consultation with the UDWR. If an affected water rights owner chooses not to participate in this informal process, other legal avenues may be pursued to address the claim or concern.

20. Prior to the initiation of the remediation project in the early 1990s, KUCC began a ground water monitoring program to measure the water level elevations of the aquifer in the

southwest Jordan Valley. Future monitoring data will be compared to this baseline representation to evaluate the effectiveness of the remediation and its impact on water levels and ground water quality in the valley. Data collected through this monitoring program have shown that the aquifer has historically been over extracted and water levels continue to drop as a function of current extractions both related and unrelated to the remedy. Based on the data, it has been determined that draw down of the aquifer in the immediate area of the Zone A plume is unavoidable and necessary to contain the contamination. In the absence of this extraction, the acid contaminated water in the core area of the Zone A plume could spread to contaminate other areas of the aquifer.

Comments concerning the possible arsenic poisoning of two horses.

21. The potential for arsenic in well water to have sickened two Arabian stallions that died after consuming the water from the aquifer for 17 years was investigated. The well water on the property was sampled and the analytical results indicate that the well water would not have caused the deaths of the horses. Attached to my Declaration is a copy of the sampling data.

Comments Concerning Contaminated Land Proposed for Development.

22. EPA agrees that any residual contamination following mine closure and reclamation must be addressed through the use of institutional controls.

Comments concerning the quality of the environmental cleanup in Herriman area.

23. A number of residential properties in Herriman were contaminated with lead and arsenic in soil. This soil was excavated to a depth of 18 inches and stockpiled to the north of

Herriman prior to permanent disposal in a KUCC repository. This response action was completed by KUCC with EPA and UDEQ oversight. The adequacy of this remedial action to protect human health and the environment will be periodically reviewed as required by CERCLA.

I declare under penalty of perjury that the foregoing is true and correct.

Rebecca J. Thomas
EPA Remedial Project Manager

Dated: April 15, 2008

Kennecott Utah Copper Corporation
12000 West 2100 South
P.O. Box 6001
Magna, Utah 84044-6001
Tel: (801) 569-7120 (Barney's)
Fax: (801) 569-7192 (Barney's)
Tel: (801) 569-7596 (Smelter EMC)
Fax: (801) 569-6408 (Smelter EMC)

Paula H. Doughty
Manager, Environmental Affairs and
Strategic Resources

Kennecott

December 8, 2003

Ms. Loretta Wilcox
12020 South 4000 West
Riverton, UT 84065

Dear Ms. Wilcox:

On October 22, 2003, a meeting was held at the Utah Department of Environmental Quality building to discuss the groundwater remedial plan proposed by Kennecott Utah Copper Corporation (KUCC) and Jordan Valley Water Conservancy District. The meeting was held specifically for private well owners in the southwestern portion of Salt Lake County to discuss how the proposed remedial plan may affect private wells and to hear any concerns from private well owners. During this meeting, you asked the question of how the contaminated water may affect livestock and that you had lost two Arabian horses due to kidney failure. The horses were about 15 years old and through blood work, a veterinarian had diagnosed one of the stallions as having had kidney failure, which lead to its death. One possibility that was discussed was whether the well water of which the horses consumed may have been the cause of the kidney problem. KUCC agreed to re-sample your well water and conducted this sampling on October 28, 2003. The well water had been sampled twice by KUCC in the past as part of the overall monitoring program in the southwestern part of Salt Lake County. The analytical results of the water testing do not indicate that the well water would have caused the deaths of the two horses. KUCC conducted a search for information specifically focused on water quality for livestock drinking water and have attached a document discussing appropriate water quality for livestock. A summary of information is included below comparing the results of your well water with the common constituents often found in water sources. The results of the previous sampling events on 7/26/1994, 11/14/2000 and the current results are also attached for your review.

The document referenced above is called "Water Quality for Livestock Drinking" written by Donald L. Pfost and Charles D. Fulhage, Agricultural Extension of Stan Casteel, Veterinary Medical Diagnostic Laboratory. The document discusses organic and inorganic contaminates. The organic contaminates like coliform were not measured in the past or on the current sample by KUCC because the contaminants of concern related to KUCC are inorganic. Table 1 below lists the desired and potential problem levels of pollutants in livestock water supplies:

Table 1:

Substance (unit)	Desired Range	Problem Range
Total bacteria/100 ml	<200	>1,000,000
Fecal Coliform/100 ml	<1	>1 for young animals >10 for older animals
Fecal strep/100 ml	<1	>3 for young animals >30 for older animals
pH	6.8 – 7.5	< 5.5 or >8.5
Dissolved Solids (mg/L)	< 500	> 3,000
Total alkalinity (mg/L)	< 400	> 5,000
Sulfate (mg/L)	< 250	> 2,000
Phosphate (mg/L)	< 1	Not established
Turbidity (Jackson units)	< 30	Not established

Source: Agricultural Waste Management Field Handbook

Table 2 of the document lists the safe upper limits of inorganic substances that may be contained in water for livestock and poultry. The information for this table comes from "When Is Water Good Enough For Livestock" from the Montana State University Extension. Along with this information, each of the three samples from your well are listed to compare the results. The document information in the table lists each analytical constituent in ppm or parts-per-million, which is the solid phase reporting method. For water, analytes are listed in mg/L or ug/L. One mg/L is more or less equivalent to one ppm and one ug/L is equivalent to one part per billion. For comparison in this table, the KUCC listed analyte concentrations have been converted to mg/L.

Table 2:

Substance	Safe Upper Limit of Concentration (ppm)	KUCC Sample from 7/26/1994 (mg/L)	KUCC Sample from 11/14/2000 (mg/L)	KUCC Sample from 10/28/2003 (mg/L)
Aluminum	5	NA	NA	NA
Arsenic	0.2	< 0.005	< 0.005	0.006
Boron	5	NA	0.097	NA
Cadmium	0.05	< 0.002	< 0.001	< 0.001
Chromium	1	< 0.010	< 0.010	< 0.010
Cobalt	1	NA	NA	NA
Copper	0.5	0.02	< 0.020	0.048
Fluoride	2	< 0.2	< 0.2	NA
Lead	0.05	< 0.005	< 0.005	< 0.005
Mercury	0.01	< 0.0002	< 0.0002	NA
Nitrate + Nitrite	100	2.2	1.4	NA
Nitrite	10	< 0.05	< 0.05	NA
Selenium	0.05 – 0.10	0.009	0.003	0.004
Vanadium	0.1	NA	NA	NA
Zinc	24	1.0	0.07	0.036
Total Dissolved Solids	10,000	1370	743	800
Magnesium + Sodium Sulfates	5,000	*543	*271	*284
Alkalinity	2,000	309	349	324

* magnesium, sodium and sulfate added together from the KUCC analysis
"Safe Upper Limit of Concentration" as listed from Montana State University Extension

Based upon the data as presented above, KUCC believes the water quality of your well is suitable for livestock consumption.

If you should have questions regarding information included in this letter and the attachments, please call me at 569-7120.

Sincerely yours,

Paula Doughty, Manager
Environmental Affairs and Strategic Resources

Attachment

cc: Doug Bacon, DERR
Well file HMG1623 w/attachments

Kennecott Utah Copper

Kennecott Environmental Laboratory

Certificate of Analysis -- December 4, 2003

P.O. Box 6001
Magna, UT 84044
Phone (801)569-7950
Fax (801)569-7901

Well Designation: HMG1623
Collection Date: 07/26/2004/994
Submission Date: 07/27/2004/994

	Total Metals	Dissolved Metals
KEL Sample ID Numbers:	AC06231	AC06232

Analyte	Method	Units	CRDL	Result	Result
* Conductivity	120.1	Micro mho/cm	1	2190	
* Depth To Water	KUC SOP	Feet	0.010	Not Analysed	
* Eh	KUC SOP	Millivolts	1	Not Analysed	
* pH	150.1			7.05	
* Temperature	170.1	Degrees C		14.6	
* Carbonate	KUC SOP	mg/L	1.0	Below MDL	
* Dissolved Oxygen	KUC SOP	mg/L	1.0	Not Analysed	
* Ferrous Iron	KUC SOP	mg/L	0.1	Not Analysed	
* Bicarbonate	KUC SOP	mg/L	1	300	
* Sulfide	KUC SOP	mg/l	0.1	Not Analysed	
Alkalinity	310.1	mg/L	10	309	
Total Dissolved Solids	160.1	mg/L	10	1370	
Total Suspended Solids	160.2	mg/L	1.0	1.0	
Calcium	200.7	mg/L	0.1	274	
Chloride	325.2	mg/L	5	310	
Fluoride	340.2	mg/L	0.2	Below MDL	
Mercury	245.2	mg/L	0.0002	Below MDL	
Potassium	200.7	mg/L	0.1	3.6	
Magnesium	200.7	mg/L	0.1	76	
Sodium	200.7	mg/L	1.0	90	
Nitrite Nitrogen (NO2-N)	354.1	mg/L	0.05	Below MDL	
Nitrate Nitrogen (NO3-N)	353.2	mg/L	0.20	2.20	
Sulfate	375.1	mg/L	5	377	
Silver	200.8	mg/L	0.001	Below MDL	Below MDL
Arsenic	200.8	mg/L	0.005	Below MDL	Below MDL
Barium	200.8	mg/L	0.01	0.02	0.02
Cadmium	200.8	mg/L	0.002	Below MDL	Below MDL
Chromium	200.8	mg/L	0.010	Below MDL	Below MDL
Copper	200.8	mg/L	0.02	0.02	0.02
Iron	200.7	mg/L	0.30	Below MDL	Below MDL
Manganese	200.8	mg/L	0.01	Below MDL	Below MDL
Molybdenum	200.8	mg/L	0.003	Below MDL	Below MDL
Nickel	200.8	mg/L	0.03	Below MDL	Below MDL
Lead	200.8	mg/L	0.005	Below MDL	Below MDL
Selenium	200.8	mg/L	0.003	0.009	0.008
Zinc	200.8	mg/L	0.010	1.000	1.000

Approved By: Lynn A. Hutchinson CIH
KEL Laboratory Director

* = Included for information purposes only, not performed by KEL.
N/A = Not Analyzed
The Contract Required Detection Limits (CRDL) are minimum reporting limits required by the Ground Water Characterization and Monitoring Plan (GCMP).

Kennecott Utah Copper

Kennecott Environmental Laboratory

December 4, 2003

Dissolved solids and cation/anion balance report

Well Designation: **HMG1623**
Collection Date: **07/26/~~2004~~ 1994**
Submission Date: **07/27/~~2004~~ 1994** KEL Sample ID: **AC06231**

Measured TDS:	1370 mg/l
Total Measured Solid Analytes:	1433 mg/l
Percentage Recovery of TDS:	104.60 % of TDS

CATIONS (mEq/l)		ANIONS (mEq/l)	
		Cl:	8.74
		SO4:	7.85
Ca:	13.67	HCO3:	5.90
Mg:	6.27	CO3:	0.00
Na:	3.92	NO3-N:	0.04
K:	0.09	NO2-N:	0.00
		Misc. Other Anions:	0.00
Major Cations:	23.95	Major Anions:	22.53

Percentage Difference:	6.11
Conductivity:	2190
pH:	7.05

Kennecott Utah Copper

P.O. Box 6001
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Phone (801)569-7950
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Kennecott Environmental Laboratory

Certificate of Analysis -- December 4, 2003

Well Designation: **HMG1623**
Collection Date: 11/14/2000
Submission Date: 11/15/2000

		Total Metals	Dissolved Metals
KEL Sample ID Numbers:		**AI23714**	**AI23716**

Analyte	Method	Units	CRDL	Result	Result
* Conductivity	120.1	Micro mho/cm	1	1120	
* Depth To Water	KUC SOP	Feet	0.010	55.960	
* pH	150.1			7.17	
* Temperature	170.1	Degrees C		13.3	
Alkalinity	310.1	mg/L	10	349	
Total Dissolved Solids	160.1	mg/L	20	743	
Total Suspended Solids	160.2	mg/L	3.0	Below CRDL	
Calcium	200.7	mg/L	1.0	137	
Chloride	325.2	mg/L	5	81	
Fluoride	340.2	mg/L	0.2	Below CRDL	
Mercury	245.2	ug/L	0.2	Below CRDL	
Potassium	200.7	mg/L	0.5	2.9	
Magnesium	200.7	mg/L	1.0	36	
Sodium	200.7	mg/L	1.0	64	
Nitrite Nitrogen (NO2-N)	354.1	mg/L	0.05	Below CRDL	
Nitrate Nitrogen (NO3-N)	353.2	mg/L	0.20	1.40	
Sulfate	9036	mg/L	5	171	
Silver	200.8	ug/L	1	Below CRDL	Below CRDL
Aluminum	200.8	ug/L	5	10	Below CRDL
Arsenic	200.8	ug/L	5	Below CRDL	Below CRDL
Boron	200.8	ug/L	10	97	76
Barium	200.8	ug/L	10	32	31
Beryllium	200.8	ug/L	2	Below CRDL	Below CRDL
Cadmium	200.8	ug/L	1	Below CRDL	Below CRDL
Chromium	200.8	ug/L	10	Below CRDL	Below CRDL
Copper	200.8	ug/L	20	Below CRDL	Below CRDL
Iron	236.1	ug/L	300	960	Below CRDL
Manganese	200.8	ug/L	10	37	13
Molybdenum	200.8	ug/L	40	Below CRDL	Below CRDL
Nickel	200.8	ug/L	40	Below CRDL	Below CRDL
Lead	200.8	ug/L	5	Below CRDL	Below CRDL
Antimony	200.8	ug/L	5	Below CRDL	Below CRDL
Selenium	200.8	ug/L	3	3	Below CRDL
Titanium	200.8	ug/L	10	133	118
Thallium	200.8	ug/L	2	Below CRDL	Below CRDL
Zinc	200.8	ug/L	10	70	70

Approved By: Lynn A. Hutchinson CIH
KEL Laboratory Director

* = Included for information purposes only, not performed by KEL.
N/A = Not Analyzed
The Contract Required Detection Limits (CRDL) are minimum reporting limits required by the Ground Water Characterization and Monitoring Plan (GCMP).

Kennecott
Utah Copper

Kennecott Environmental Laboratory

December 4, 2003

Dissolved solids and cation/anion balance report

Well Designation: **HMG1623**
Collection Date: **11/14/2000**
Submission Date: **11/15/2000** KEL Sample ID: **AI23714**

Measured TDS:	743 mg/l
Total Measured Solid Analytes:	837 mg/l
Percentage Recovery of TDS:	112.62 % of TDS

CATIONS (mEq/l)		ANIONS (mEq/l)	
		Cl:	2.28
		SO4:	3.56
Ca:	6.84	HCO3:	6.86
Mg:	2.98	CO3:	0.00
Na:	2.78	NO3-N:	0.02
K:	0.07	NO2-N:	0.00
		Misc. Other Anions:	0.01
Major Cations:	12.67	Major Anions:	12.73

Percentage Difference: -0.47

Conductivity: 1120

pH: 7.17

Kennecott Utah Copper

Kennecott Environmental Laboratory

Certificate of Analysis -- December 3, 2003

P.O. Box 6001
Magna, UT 84044
Phone (801)569-7950
Fax (801)569-7901

Well Designation: **HMG1623**
Collection Date: 10/28/2003
Submission Date: 10/29/2003

		Total Metals	Dissolved Metals
	KEL Sample ID Numbers:	AL26418	AL26419

Analyte	Method	Units	CRDL	Result	Result
* Conductivity	120.1	Micro mho/cm	1	1208	
* Depth To Water	KUC SOP	Feet	0.010	48.000	
* pH	150.1			7.13	
* Temperature	170.1	Degrees C		10.0	
Alkalinity	310.1	mg/L as CACO3	5	324	
Flow	KEL Methods	GPM		n/a	
Total Dissolved Solids	160.1	mg/L	20	800	
Total Suspended Solids	160.2	mg/L	3.0	4.0	
Calcium	200.7	mg/L	1.0	163	
Chloride	325.2	mg/L	5	160	
Potassium	200.7	mg/L	0.5	3.2	
Magnesium	200.7	mg/L	1.0	43	
Sodium	200.7	mg/L	1.0	77	
Sulfate	9036	mg/L	5	164	
Silver	200.8	ug/L	1		1
Arsenic	200.8	ug/L	5		6
Barium	200.8	ug/L	10		36
Cadmium	200.8	ug/L	1		Below CRDL
Chromium	200.8	ug/L	10		Below CRDL
Copper	200.8	ug/L	20		48
Lead	200.8	ug/L	5		Below CRDL
Selenium	200.8	ug/L	3		4
Zinc	200.8	ug/L	10		36

Approved By: Lynn A. Hutchinson CIH
KEL Laboratory Director

* = Included for information purposes only, not performed by KEL
N/A = Not Analyzed
The Contract Required Detection Limits (CRDL) are minimum reporting limits required by the Ground Water Characterization and Monitoring Plan (GCMP).

Kennecott
Utah Copper

Kennecott Environmental Laboratory

December 3, 2003

Dissolved solids and cation/anion balance report

Well Designation: **HMG1623**
Collection Date: **10/28/2003**
Submission Date: **10/29/2003** KEL Sample ID: **AL26418**

Measured TDS:	800 mg/l
Total Measured Solid Analytes:	919 mg/l
Percentage Recovery of TDS:	114.87 % of TDS

CATIONS (mEq/l)		ANIONS (mEq/l)	
		Cl:	4.23
		SO4:	3.41
Ca:	8.13	HCO3:	6.37
Mg:	3.54	CO3:	0.00
Na:	3.35	NO3-N:	0.00
K:	0.08	NO2-N:	0.00
		Misc. Other Anions:	0.01
Major Cations:	15.10	Major Anions:	14.02

Percentage Difference:	7.41
Conductivity:	1208
pH:	7.13

ENVIRONMENTAL QUALITY
MU Guide
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Water Quality for Livestock Drinking

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Water is a critical nutrient for livestock and poultry. As with feed ingredients, livestock water should meet the nutritional needs of the animal. An adequate and safe water supply is essential to the production of healthy livestock and poultry. Water that adversely affects the growth, reproduction, or productivity of livestock and poultry cannot be considered suitable. Although there is scant research data on the economic effects of water quality on livestock performance, logic tells us that farm water supplies, either surface or ground, should be protected against contamination from microorganisms, chemicals and other pollutants. Substances that originate on livestock farms and often contaminate water supplies include nitrates, bacteria, organic materials, and suspended solids. A high level of suspended solids and an objectionable taste, odor or color in water can cause animals to drink less than they should.

Surface water supplies to which livestock have ready access are always potential candidates for contamination. Shallow dug wells without good surface drainage away from the well may be subject to infiltration of contaminants. The presence of coliform bacteria in a well is an indication that surface water is finding its way into the well. In karst topography, sink holes, losing streams and porous soils may allow direct contamination of fractured rock aquifers.

Water can serve as a reservoir for many different disease organisms and toxins. Stagnant water contaminated with manure or other nutrients may develop blue-green algae, which can poison livestock, causing muscle tremors, liver damage, and death. Farm pond water needs to be observed for the presence of algae and other harmful organisms during hot, dry weather.

Leptospirosis and Fusobacterium are two bacterial contaminants that often use water and mud, respectively, as modes of transportation from animal to animal. Leptospirosis is spread through urine of carrier animals. This disease often manifests itself as reproductive problems. Problems may range from infertility, to low milk production, to widespread late-term abortion. The organism can survive for extended periods of time in surface waters. One should take care to avoid forcing livestock to drink from water sources that may be contaminated with urine.

Fusobacterium infection is more commonly known as "foot-rot." The bacterium is a soil-borne organism found virtually throughout the United States. It is carried on the feet of animals, which then serve to contaminate any body of water they enter. The bacteria then enter through cuts, bruises, or puncture wounds on damaged feet of other animals. Once inside an animal's body, they multiply rapidly and serve to spread the disease. Clinical signs of "foot-rot" are most commonly seen as chronic lameness, often with swelling above the foot. "Foot-rot" can usually be effectively treated with penicillin and sulfa.

When water is suspected of causing health problems in livestock, veterinary assistance should be sought to determine the actual disease. Laboratory diagnostic examination of animals as well as the water supply may be necessary to evaluate the problem. Temporarily changing to a known safe water supply is a useful test to determine whether the health problems can be solved. However, water is too often blamed for production or disease problems. Thus, the importance of an accurate diagnosis must be emphasized.

Tables 1 through 4 in this guide show the recommended limits of certain pollutants and other substances commonly found in water used for livestock and poultry. These tables should not be used as diagnostic indicators of health problems in livestock. Toxicity from a specific mineral or compound depends on its concentration and on relative levels of other components with which it interacts.

Common water contaminants

The U.S. Environmental Protection Agency recommends that livestock water contain less than 5,000 coliform organisms per 100 ml; fecal coliform should be near zero. Alkalinity is expressed either as a pH or as titratable alkalinity in the form of bicarbonates. A pH of 7 is neutral; a pH between 7.0 and 8.0 is mildly alkaline; and a pH of 10 is highly alkaline. Excessive alkalinity can cause physiological and digestive upsets in live-

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Table 1. Desired and potential levels of pollutants in livestock water supplies.

Substance	Desired range	Problem range
Total bacteria/100 ml	<200	>1,000,000
Fecal coliform/100 ml	<1	>1 for young animals >10 for older animals
Fecal strep/100 ml	<1	>3 for young animals >30 for older animals
pH	6.8–7.5	<5.5 or >8.5
Dissolved solids, mg/L	<500	>3,000
Total alkalinity, mg/L	<400	>5,000
Sulfate, mg/L	<250	>2,000
Phosphate, mg/L	<1	not established
Turbidity, Jackson units	<30	not established

Note: 1 milligram per liter (mg/L) is approximately equal to 1 part per million (ppm).
Source: From the *Agricultural Waste Management Field Handbook*, page 1-16. Based on research literature and field experience in the northeastern United States.

stock. Desired and potential problem levels of some common pollutants in livestock water supplies are listed in Table 1. Table 2 shows the safe *upper limits* for several substances that may be contained in livestock water.

Mineralized (salty) water

Residents in a large portion of the state of Missouri southeast of an irregular line running from approximately the Bowling Green region to the Nevada region are fortunate to have good quality groundwater generally available within a few hundred feet of the surface in sufficient quantity for large livestock and poultry operations. Unfortunately, northwest of this line, the water from deep, high-yield aquifers is usually too highly mineralized to be used for watering livestock. This area commonly depends on surface water supplies for farms and public uses. The saltiness of water is commonly measured by *total dissolved solids*, which is approximated by the electrical conductance of the water. The mineralized water in northwest Missouri commonly ranges from 2,000 to 10,000 ppm and as high as 30,000 ppm in total dissolved solids (TDS). Chlorides and sulfates are the main mineral constituents. Chlorides range from calcium to sodium chloride (common salt). Sulfates include calcium, magnesium (Epsom salt) and sodium salts. The Missouri Department of Natural Resources, Division of Geology and Land Survey (phone: 573/368-2190 or -2100) at Rolla can provide guidance on the quantity and quality of groundwater that can be expected at various locations and depths. Table 3 lists the effect of various levels of salinity in drinking water on livestock and poultry.

Nitrate

Nitrates are soluble and move with percolating or runoff water. Therefore, ponds with runoff from heavily fertilized or manured fields and water from poorly

Table 2. Safe upper limits for several substances that may be contained in water for livestock and poultry.

Substance	Safe upper limit of concentration (ppm)
Aluminum (Al)	5 ppm
Arsenic (As)	0.2 ppm
Boron (B)	5 ppm
Cadmium (Cd)	0.05 ppm
Chromium (Cr)	1 ppm
Cobalt (Co)	1 ppm
Copper (Cu)	0.5 ppm
Fluoride (F)	2 ppm
Lead (Pb)	0.05 ppm
Mercury (Hg)	0.01 ppm
Nitrate + Nitrite	100 ppm
Nitrite	10 ppm
Selenium (Se)	0.05–0.10 ppm
Vanadium (V)	0.1 ppm
Zinc (Zn)	24 ppm
Total dissolved solids	10,000 ppm
Magnesium + sodium sulfates	5,000 ppm
Alkalinity (carbonate + bicarbonate)	2,000 ppm

Source: *When Is Water Good Enough for Livestock?* Montana State University Extension.

cased, shallow wells may contain nitrates. Water from deep wells is usually nitrate free.

Nitrogen in the form of nitrate is not especially toxic, but when reduced in the rumen to nitrite and absorbed into the blood, nitrite reduces the oxygen-carrying capacity of the blood by reacting with hemoglobin. Ruminants have an ability to convert some nitrate to usable products. However, the rumen microbes in cattle and sheep can readily reduce nitrate to the toxic nitrite form. The total amount of nitrates in the diet is important and subject to change with growing conditions of harvested and pastured forage. For example, during a drought, corn silage may accumulate high concentrations of nitrate and when added to the nitrate present in water may result in a lethal combination. The ensiling process will reduce the nitrate level to acceptable levels after a period of aging for 60–90 days in the silo. Unlike other simple-stomached animals such as swine, horses do have a cecum containing microbes capable of converting nitrate to the more toxic nitrite form. The extent and rapidity of this chemical conversion in horses is insufficient to make them as susceptible as ruminants. Fortunately, the preformed nitrite is rarely encountered in sufficient concentrations in water and feed to be a toxic threat. Table 4 provides a guide to the use of water containing nitrates for livestock.

Achieving quality water

To achieve high-quality surface water, fence livestock out of the pond or stream and pipe the water to a

Table 3. Effect of salinity of drinking water on livestock and poultry (Water Quality Criteria, 1972).

Soluble salt (mg/L)	Effect
<1,000	Low level of salinity; present no serious burden to any class of livestock or poultry
1,000–2,999	Satisfactory for all classes of livestock and poultry; may cause temporary, mild diarrhea in livestock; and water droppings in poultry at higher levels; no effect on health or performance
3,000–4,999	Satisfactory for livestock; may cause temporary diarrhea or be refused by animals no accustomed to it; poor water for poultry causing watery feces and, at high levels, increased mortality and decreased growth (especially in turkeys).
5,000–6,999	Reasonable safety for dairy and beef cattle, sheep, swine, and horses; avoid use for pregnant or lactating animals; not acceptable for poultry, causes decreased growth and production or increased mortality.
7,000–10,000	Unfit for poultry and swine; risk in using for pregnant or lactating cows, horses, sheep, the young of these species, or animals subjected to heavy heat stress or water loss; use should be avoided, although older ruminants, horses, poultry, and swine may subsist for long periods under conditions of low stress.
>10,000	Risks are great; cannot be recommended for use under any conditions.

Source: *Agricultural Waste Management Field Handbook*, page 1-17.

Table 4. Guide to use of waters containing nitrates for livestock.

Nitrate content* as parts per million (ppm) of nitrate nitrogen (NO_3-N)**	Comments
Less than 100	Experimental evidence indicates this water should not harm livestock or poultry.
100–300	This water by itself should not harm livestock or poultry. If hays or silages contain high levels of nitrate this water may contribute significantly to a nitrate problem in cattle, sheep, or horses.
More than 300	This water could cause typical nitrate poisoning in cattle, sheep, or horses, and its use for these animals is not recommended. Because this level of nitrate contributes to the salts content in a significant amount, use of this water for swine or poultry should be avoided.

* The values shown include nitrate and nitrite nitrogen. In no case should the waters contain more than 50 ppm nitrite nitrogen (NO_2N) because of the greater toxicity of the nitrite form.

**1 ppm of nitrate nitrogen is equivalent to 4.4 ppm of nitrate (NO_3).

Note: The maximum level of nitrate as N in water for human consumption (as set by the US EPA) is 10 mg/L.
Source: *Water Quality for Livestock and Poultry*, FO-1864-GO. University of Minnesota Extension Division, 1990.

tank or other waterer. To obtain the best water from a pond, provide a grassed watershed where no chemicals or manure are applied and float a screened pipe intake about 2 feet below the surface. Water can be pumped from a stream or, in some cases, can be piped to a tank by gravity. An alternative is to allow limited access for livestock to drink from a pond or stream. Spring water may need to be pumped to the desired waterer location, or the spring may need to be developed to provide the head necessary for gravity flow.

Well sites should be graded to drain surface water away from the well casing. Wells should be cased to comply with the Missouri Well Construction Rules. Wells should be located as far as practical from septic tanks (50' minimum), septic fields (100' minimum), chemical mixing areas (300' minimum), feedlots (100' minimum), earthen manure storage basins and lagoons (300' minimum), and land application areas for manure (300' minimum).

Under the EPA's Unified National Strategy for Animal Feeding Operations, the desired outcome is for all concentrated animal feeding operations to develop and implement a comprehensive nutrient management plan. Such a plan should address, as necessary, feed management, manure handling and storage, land application of manure, land management, record keeping, and other utilization options. In addition to nutrients, the plan should address other pollutants, such as pathogens, to minimize the effects of animal feeding operations on water quality and public health.

At a minimum, the nutrient management plan should prevent the application of nutrients at rates that will exceed the capacity of the soil and planned crop needs. Soils, crop material and manure should be tested to determine nutrient needs. Manure application equipment should be calibrated to ensure that the quantity of material being applied conforms to a plan. Records of crops removed annually and the total amount of effluent applied will allow producers to maintain the desired nutrient balance.

Water testing

Annual water tests are recommended for private wells, especially for shallow wells, and whenever a problem is suspected. Owners of private wells can have their water tested by collecting a sample themselves or by hiring a qualified person to do so. The sample should be taken to a certified laboratory for analysis. Sample bottles should be obtained from the testing laboratory or local health department, because containers may be especially prepared for a specific contaminant. Sampling and handling procedures depend on the water quality concern and should be followed carefully.

Water analyses typically include the following tests:

- Total coliform bacteria
- pH (acid or alkaline level)
- Total dissolved solids
- Total soluble salt
- Salinity
- Hardness

- Nitrates
- Sulfate
- Other factors such as toxicity problems with specific minerals or pesticides, or occasionally, heavy algae growth

There are no regulations governing the number of microorganisms or bacteria in water used for livestock production unless the farm is a Grade A dairy. In that case, the water must be from a supply that provides water of safe and sanitary quality with no detectable fecal coliform bacteria. Within the state of Missouri, a Grade A milk law presents well construction guidelines for Grade A dairies. Water must be tested after any repairs or modifications to the water supply system. In addition, specific requirements prohibit backsiphoning from outdoor livestock water tanks.

Normally, hard water does not interfere with livestock performance; however, hard waters can cause difficulty in washing of milking equipment and causes water heaters to "lime up." Contaminates such as iron and sand will clog pipelines. Well water with high iron content may have problems with iron bacteria forming a red, slimy mass that can clog well screens and require periodic treatment with chlorine. Some wells produce considerable amounts of sand. A sand separator should be installed at the beginning of a pipeline in such a case. Sand separators are available through suppliers of trickle irrigation equipment. Sulfur waters are corrosive and have a bad odor.

Rural water is a reliable source but may be too costly for large livestock operations. However, consider connection to the rural source as a backup supply. Backflow prevention valves shall be used to prevent contamination of the rural water supply. In most cases, rural water districts require an air gap because backflow valves are not safe enough.

Laboratories for water quality tests at the University of Missouri-Columbia

Many commercial laboratories provide testing for water quality. Contact your local Natural Resources Conservation Service office or University Extension office for a list of commercial laboratories.

The following laboratories at the University of Missouri-Columbia perform water quality tests:

Veterinary Medical Diagnostic Laboratory
Toxicology Section
(573) 882 6811

Soil and Plant Testing Laboratory
Department of Agronomy
(573) 882-0623

For further information

Agricultural Waste Management Field Handbook, Part 651, National Engineering Handbook. Washington, D.C.: Natural Resources Conservation Department, U.S. Department of Agriculture, 1992.

Crawford, R.J., Jr., and E. Cole. 1999. Effect of water source and quality on water intake and performance of cows and calves grazing tall fescue. Southwest Missouri Agricultural Research and Education Center 1999 Research Report, pp. 2–8.

FO-1864-GO. Water Quality for Livestock and Poultry. 1990. Extension Distribution Center, University of Minnesota.

Missouri Livestock Watering Systems Handbooks 1 & 2. 1997. USDA Natural Resources Conservation Service, Columbia, Mo.

Water Quality for Livestock and Poultry, Guide M-112. 1995. New Mexico State University Extension, Las Cruses, N.M.

Available from Extension Publications
1-800-292-0969

MU publications
WQ-100, *Water Testing: What to Test For*

Midwest Plan Service publications
MWPS-6, *Beef Housing and Equipment Handbook*. Fourth Edition

The authors thank Thomas J. Fangman, DVM, and Robert L. Larson, DVM, Veterinary Medicine Extension Specialists, Commercial Agriculture Program, and William H. Fales, Ph.D., Veterinary Medical Diagnostic Laboratory, for their review of this guide.

Additional contacts regarding livestock diseases that can be caused by contaminated drinking water:

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