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ROCKY MOUNTAIN ENERGY COMPANY

DOCKETED USNRC JUN 19 1980 NMSS MAIL SECTION DOCKET CLERK

June 3, 1980

RECEIVED JUN 16 1980 U.S. Nuclear Regulatory Commission NMSS Mail Section

Mr. Jack Rothfleisch
U.S. Nuclear Regulatory Commission
Uranium Recovery Licensing Branch
Williste Building
7915 Eastern Avenue
Silver Springs, MD 20910

Dear Mr. Rothfleisch:

Re: License No. SUA-1228; Amendment Request of March 31, 1980

As a follow up to our telephone conversation yesterday regarding the proposed conditions to the above referenced amendment request, I would like to clarify a few points. The statements and commitments made in this letter will supersede any potentially conflicting statements contained in the amendment request of March 31, 1980 or subsequent correspondence pertaining to the amendment request.

1. As stated on page 10, paragraph 4 of the amendment request, groundwater baseline (or background) for the Pattern 4 production zone will be established prior to leaching by sampling the production well a minimum of 5 times over a period of approximately 2 months. This is also true for the pattern monitor wells; however, the shallow monitor well was just completed recently and will be sampled 5 times over a shorter time period. It is expected that the background water quality for the shallow monitor well will be similar to that of existing shallow monitor wells.

2. Contrary to the statement contained in paragraph 1, page 11, baseline values for the monitor wells will be established for all 32 parameters listed on page 11 of the amendment request. In accordance with the provision of Part IV, B. 7. a. (1), page 18, of the DEQ's Guideline No. 8 (Hydrology), attached, the parameter list will be abbreviated to eliminate those parameters present in insignificant or non-detectable amounts, based upon initial monitoring results. The abbreviated parameter list will be approved by the DEQ, Land Quality Division, prior

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to use. It makes little sense to spend a great deal of time and money performing analyses for parameters present in trace or non-detectable quantities, such as boron, cadmium, flouride, etc.

3. As stated on page 10, paragraph 3 of the amendment request, Pattern 4 monitor wells will be sampled twice per month for the excursion parameters and water levels. Page 3 of the table entitled "Requested Sampling Changes" incorrectly states that monitor wells will be sampled monthly. Also, as discussed with you, monitor wells will be analyzed on a monthly basis for arsenic, selenium, radium and thorium in addition to the excursion parameters. On a quarterly basis, the wells will be analyzed for the full suite of parameters listed in Guideline No. 8, as mutually abbreviated by RMEC and DEQ, Land Quality Division.

4. The table in the amendment request entitled "Requested Sampling Summary" should be corrected to state that the samples identified as yellowcake, yellowcake decant, yellowcake filtrate, R/O brine and R/O product will be analyzed for Ra^{226} at a minimum of a monthly frequency.

5. The restoration target, or goal, for Pattern 4 will be background water quality. Although this will be the goal, it is probable that, after a resonable number of restoration pore volumes, one or more elements on the restoration target list will exceed background levels. If this proves to be the case, those elements which can not be reasonably and economically returned to background or better quality will be returned to a concentration which will allow the water to be suitable for the pre-mining use category. In the case of Pattern 4, this would be a return of affected waters to the stockwater use category.

It is hoped that the corrections and commitments made herein will supply the information you require to finalize approval of the March 31, 1980 amendment request. If there are any questions concerning this material, I assume that a phone call would serve to resolve any problems. I look forward to receipt of the approved license amendment.

Sincerely,

Michael R. Neumann

M. R. Neumann
Field Environmental Coordinator

cc: Dennis Morrow (DEQ)
Margery Hulburt (DEQ)
Tom Mueller (DEQ)
Russ Hynes (RME)
Kent Loest (RME)
Peter Bosse (RME)
Rick Iwanicki (RME)

WYOMING DEPARTMENT OF ENVIRONMENTAL QUALITY
LAND QUALITY DIVISION
GUIDELINE NO. 8

HYDROLOGY

This document is a guideline only. Its contents are not to be interpreted by applicants, operators, or DEQ staff as mandatory. Its preparation is the result of numerous requests from applicants and operators, who have expressed a need for guidance to assist them in preparation of a comprehensive initial application or amendment containing all required information.

I. INTRODUCTION.

A. The guideline follows the following format:

Part II: Definitions for the purposes of this guideline.

Part III: Surface Water

- A. Pre-Mining Studies
- B. General Hydrologic and Hydraulic Information-Application
- C. Structural Designs-Application

Part IV: Groundwater

- A. Pre-Mining Studies
- B. Mine Plan
- C. Reclamation Plan

B. The guideline outlines criteria and data collection for evaluating the following:

1. Baseline data to describe and understand the hydrology and hydraulics of surface water hydrology, geohydrology, and their interactions.
2. Baseline description of the existing fluvial system to aid in the reclamation of surface drainage systems.
3. Suitable surface water control engineering methods.
4. Evaluating local and regional hydrologic impacts on existing water rights and water resources caused by the mining operations.
5. Prediction of groundwater drawdown and dewatering rates.
6. Estimate the aquifer characteristics likely to exist after reclamation.

II. DEFINITIONS FOR PURPOSES OF THIS GUIDELINE.

1. "Adjacent area" Those natural and human resources contiguous to or near the affected land which may be impacted by mining and reclamation operations conducted within a permit area during the life of a mine.

2. "Affected aquifer" An aquifer whose natural state or physical properties have been, will be, or may be disturbed as a result of mining operations.

3. "Affected land" The area of land from which overburden is removed, or upon which overburden, development waste rock or refuse is deposited, or both, access roads, haul roads, mineral stockpiles, mill tailings, impoundment basins, and all other lands whose natural state has been or will be disturbed as a result of the operations.

4. "Aquifer" A zone, stratum, a group of strata that can store and transmit water in sufficient quantities for a specific use.

5. "Perched aquifer" An aquifer which is underlain by an aquitard and which is also underlain by geologic strata which are unsaturated or only partially saturated.

6. "Piezometer" A well constructed in such a manner that it will respond to changes in hydraulic head in one aquifer or a portion of one aquifer. The casing and the annulus between casing and wall of the open hole must be sealed in such a manner that there is no direct hydraulic communication along the outside of the casing with other aquifers.

7. "Potentiometric surface" The surface that everywhere coincides with the static level of water in an aquifer. The surface is represented by the levels to which water from a given aquifer will rise under its full head.

8. "Stream" A water body carrying suspended and dissolved substances and flowing down a slope within a channel. It includes perennial, intermittent, and ephemeral flow.

III. SURFACE WATER.

A. Pre-Mining Studies (Appendix D-6)

1. Quantity

Surface water quantity measurements should be taken for a minimum of one year on all streams within the permit area. Recommended measurement techniques include:

a. Monthly reading of crest gages for ephemeral channels.
b. Continuous recording gages for intermittent and perennial streams.

A stage/discharge rating curve should be developed for every gage.

(III. Continued)

2. Quality.

Quality samples should be taken at quantity measuring points. Sampling upstream and downstream of the potential affected lands should be strongly considered. Quality chemical parameter and sampling methodology may be referenced in Guideline No. 8 Appendices 2 and 3. Sediment samples should be taken to accurately identify wash load and bed load fractions for perenrial streams. Washload is considered the very fine sand size, and smaller, while bedload includes the fine sand fraction and larger. Sample location should be identified with respect to discharge, stream width, and stream depth. Composite samples may be required for large streams.

3. Channel characteristics for stream replacement or relocation.

The following information is recommended to define existing channel characteristics:

a. Stream gradient.
b. Cross-section of channel, terraces, and alluvium to bedrock every 2000 feet of stream length, with no less than 2 cross-sections per stream.
c. Longitudinal profile of the stream and underlying bedrock.
d. Depth to saturated alluvial zones, if applicable.
e. Meander loop characteristics (such as wave length and frequency).
f. Drainage density.
g. Stream identification as losing or gaining.
h. Relationship of the stream as a source of groundwater recharge.
i. Channel side and substrata texture.
j. Alluvial texture and extent.
h. Vegetation characteristics of the channel and flood plain.

4. Stream erosional stability.

Existing aggradational and degradational reaches of the stream channel should be identified for all streams.

5. Infiltration rates.

If necessary, estimates of surface soil infiltration rates should be performed to aid in defining groundwater recharge areas.

B. General Hydrologic and Hydraulic Information-Application

1. Hydrologic events.

All calculations should consider the return period flood caused by a snowmelt/precipitation event.

(III. Continued)

Suggested methods for calculating flood peaks and/or volumes in Wyoming may be found in the following references:

a. Craig, G.S. and J.B. Rankl. 1977. Analysis of Runoff from Small Drainage Basins in Wyoming. USGS Open File Report 77-727.

b. Lowham, H.W. 1976. Techniques for Estimating Flow Characteristics of Wyoming Streams. USGS Water Resources Investigation 76-112.

c. SCS Trangular Method. (Numerous publications, including Design of Small Dams, Bureau of Reclamation, 1974). Calculations should be thoroughly justified with site-specific information when applying this method.

2. Hydrologic design criteria.

The following information should be provided to evaluate hydrologic design; if applicable.

a. Methodology, assumptions, and calculations.
b. Drainage basin characteristics (area, elevation, concentration time design, curve number, antecedent moisture, etc., as required by the method used).
c. Maximum relief (ft.) and basin slope (ft/mi) defined in Craig and Rankl (1977).
d. Channel width (described in Lowham, 1976).
e. Estimated snowpack depth, and water content; and flooding events associated with snowmelt and rainfall.

3. Hydraulic design criteria.

The following hydraulic design criteria should be provided if applicable:

a. Equations, calculations, and assumptions.
b. Estimate life of the structure.
c. Typical cross-sections.
d. Wetted perimeters.
e. Hydraulic radii.
f. Roughness coefficients.
g. Slopes.
h. Flow depths.
i. Velocities.
j. Discharges.

(III. Continued)

4. Erosion control measures.

Areas requiring significant erosion control measures should be located on a map, and when applicable, corresponding structural designs should be submitted. If riprap is required, its size distribution should be based on the design velocity. Seeding mixtures and planting times should correspond with mining and reclamation plans.

5. Maps.

To aid in examining an application, the following maps should be submitted:

a. A surficial geology map, including fault locations.
b. A hydrologic surface water control map, showing surface water control timed with the mine plan.
c. A sedimentation plan map, identifying sedimentation control measures, locations, and outlining the contributing drainage to sediment ponds. This map should correspond with the mine plan.

C. Structural Designs - Application

1. Temporary channel diversions.

a. Hydrologic design.

Design storm duration should be equivalent to either the concentration time of the drainage area or to a 24-hour time period, if applicable. Acceptable design event criteria for temporary diversions are listed below:

Life of Diversion	Design Flood
≤ 3 years	10 year
3 to 10 years	25 year
10 to 20 years	50 year
≥ 20 years	100 year

b. Additional design criteria.

The following information should be provided:

(1) Hydrologic and hydraulic properties (reference Part III.B.).
(2) Location on a map.
(3) Typical cross-sections of the diversions.
(4) Design of entrances and/or exits.
(5) Texture of the reclaimed channel.
(6) Erosion control measures and locations, if applicable.
(7) Freeboard (0.5 feet minimum).
(8) Diversion side slopes (no steeper than $1\frac{1}{2}$:1).

(III. Continued)

c. Maximum permissible velocity.

Maximum permissible velocities should be calculated using 10-year flood design. For an erodable soil with an established sod-forming grass lining, the maximum permissible velocity is 3 fps. For the same channel in nonerosive soils, the maximum permissible velocity is 5 fps. A channel constructed in competent rock should be identified on a map.

d. Topsoil.

In cut and fill areas, all suitable topsoil should be salvaged. The topsoil may be placed at a uniform depth over the ditch banks and reseeded. During reclamation, if the ditch bank slopes do not exceed 2.5:1, topsoil should be salvaged and replaced after final grading of the ditch area.

2. Channel restoration and permanent diversions.

a. Hydrologic design.

An acceptable redesign of channel characteristics should be based on existing channel properties. For example, channel cross-sections would generally include a low probability channel (as a 5-year or 10-year flood event) and a flood plain designed for a 100-year flood event. Reference Part II.A.3. for further details.

b. Design Criteria.

The following information should be provided:

(1) Hydrologic and hydraulic properties (reference Part III.B.2. and III.B.3.).
(2) Typical cross-sections.
(3) Channel texture after reclamation.
(4) Erosion control measures and locations.
(5) Location.
(6) Seeding details.

c. Channel stability.

Special considerations should be given to promote the erosional stability of channels passing over reclaimed areas. Baseline data describing the existing fluvial system may aid in the design and evaluation of the channels. Suggested methods include but are not limited to:

(1) Retention of, or reclamation of, a stable bedrock base-level below the reclaimed channel.
(2) Differential compaction of material beneath and within the channel.

(III. Continued)

(3) Long-term velocity reduction within the channel, such as increasing channel roughness and slope reduction.
(4) Special stability measures within the transition zone between the existing land surface and the reclaimed spoils.

d. Additional considerations.

(1) Impacts upon the hydrologic balance and water rights both on and off site due to the stream diversion should be discussed.

(2) A 100 foot buffer zone about intermittent and perennial streams should be maintained unless otherwise specified by the Land Quality Division. The Wyoming Game and Fish Department should be consulted prior to affecting this area.

(3) The Wyoming Game and Fish Department should assess the impacts to fish and wildlife habitats upon the diversion of an intermittent or perennial stream.

(4) Pond, pool, stockponds, and reservoir replacement should coincide with the final land use.

(5) Surface infiltration rates should be reclaimed to mimic pre-mining conditions.

3. Culvert design.

a. Culverts should pass the design flood peak using the head available at the entrance. The structure containing the culvert should not be overtopped. Suggested design floods are found in Part II.C.1. of this Guideline. The minimum culvert diameter acceptable for Wyoming is 18 inches.

b. Locations, diameters, and erosion control measures should be addressed.

c. Trash racks should be placed over culvert entrances to prevent clogging.

4. Sediment ponds.

a. Sediment ponds should generally be used to capture runoff from disturbed areas. Upstream sediment control methods are, however, encouraged.

(III. Continued)

b. General design considerations.

(1) Storage volume (Reference Guideline No. 8 Appendix 1).

(a) Pond design should retain the volume of water and sediment contributed from the 10-year, 24-hour flood event.
(b) In addition, a dead sediment storage volume designed to hold a minumum of 3 years accumulated sediment should be provided.
(c) The Universal Soil Loss Equation and sediment delivery ratio should be used to determine sediment accumulation.

(2) Ponds should provide at least 24-hour detention time for the 10-year, 24-hour flood event. This detention time may be reduced to a minimum of 10 hours if the applicant demonstrates prior to construction that appropriate effluent standards will be met.

(3) Spillways must pass a 25-year flood event. The spillway may be required to pass up to 100-year flood event depending on the on-site conditions.

(4) A plan for sediment cleanout should be provided when the dead storage is approximately 60% of capacity. A method to visually determine if this capacity has been reached should be provided.

(5) Water collected in the pond from the design flood should be removed no more than 15 days after the event.

(6) Designs should minimize the amount of disturbed surface area.

c. Design criteria for review.

(1) Hydrologic and hydraulic design of spillways and pond (Reference Part III.B.).
(2) Location on map.
(3) Estimated volume of the design flood and mean annual sediment inflow.
(4) Outflow sediment volumes.
(5) Water and sediment storage volume and pond surface area (an area-capacity curve or table is sufficient).
(6) Detention time.
(7) Appropriate cross-sections and plan views of spillway(s) pond, and embankment.

(III. Continued)

(8) Dam compaction and fill, and spillway material.
(9) Inflow and outflow erosion control.
(10) Baffles, if any.
(11) Certification by a professional engineer.
(12) For sediment ponds greater than 20 ac-ft of storage volume or with an embankment greater than 20 feet high (from the upstream toe to the crest of the emergency spillway):

(a) The top width should be (H + 35)/5, where H (ft) is the distance from the upstream toe to the top of the embankment.
(b) A static safety factor of 1.5, calculated at the maximum water level during design flood conditions, is required.
(c) The plans should include anti-seepage controls.

(13) Any other information, such as particle size distrubition and settling velocities required to justify detention time reduction, should be submitted.

d. Additional considerations.

(1) Sediment removed from the pond should be tested for hazardous properties if used as topsoil. For example, if coal fines are deposited within the sediment ponds, special sediment handling procedures should be outlined.

(2) For ponds designed with a permanent pool, a bypass ditch able to handle a minimum 100-year, 25-hour design flood should be included. In addition, the effect of ponding water upon surface water rights should be discussed.

(3) Settling pond outflow quality should be periodically sampled to establish that effluent standards have been met. If the appropriate standards are not met, remedial action to meet those standards must be undertaken.

(4) Freeboard design should include the effects of wind-formed waves.

(5) Sediment pond design also requires the approval of the Wyoming State Engineer and the Water Quality Division. Additional design requirements should be solicited from the Water Quality Division ((307) 777-7781 and the State Engineer (307) 777-7354)).

IV. GROUNDWATER.

The geohydrologic reconnaissance program requires a prior general knowledge of the mining method, extent, depth and duration of mining and possible impacts to surrounding water resources and water rights. The program should be designed to determine the hydraulic characteristics of aquifers that may be affected by mining, determine the quantity and quality of groundwater to be dewatered at various stages of mining, estimate the areal extent of static water level declines in local and regional aquifers, evaluate impacts on the quantity and quality of adjacent water resources and water rights due to mining activities or dewatering, and estimate groundwater conditions and aquifer characteristics likely to exist after reclamation.

A. Pre-Mining Studies.

1. Geologic framework.

   a. Stratigraphy within the permit area and adjacent areas should be identified using lithologic and geophysical logs, geologic maps, and published data. The extent, thickness, and continuity of all aquifers and confining layers should be identified.

   b. Geologic features that could influence aquifer properties such as the stratigraphic dip, faulting, conglomerates, coarse sands or scoria, well sorted or poorly sorted sediment horizons, clay or shale, etc., should be identified.

   c. Potential hydrologic boundaries, recharge and discharge areas, and significant perched aquifers should be identified.

2. Potentiometric surface.

   a. Wells or piezometers should be used to define the pre-mining potentiometric surface of all aquifers that may be affected by mining.

   b. The project hydrologist, or a representative, should be present to interpret drilling data and authorize necessary changes. A log of drilling activities including any decisions made, intervals showing fluid loss, and drilling time for the various strata encountered should be included in the application.

   c. It is recommended that wells be completed so that the open interval does not span more than one aquifer. Multiple completions (i.e. more than one well in a single hole) are acceptable.

(IV. Continued)

d. Particular care should be taken to fully develop wells which are drilled with bentonite. The development techniques used should be summarized briefly.

e. Suggested well or piezometer density is three data points per affected aquifer per square mile. This recommendation should not be interpreted as a strict requirement, for piezometer density must reflect site specific conditions. The Land Quality Division should be contacted for further specific recommendations.

f. Potentiometric surface measurements should generally be recorded quarterly. Continuous monitoring should be considered where hydrographs for groundwater recharge or discharge zones are desired.

3. Aquifer characteristics.

a. Multiwell pumping tests.

(1) Long-term constant-discharge pumping tests with observation wells placed at various distances and locations from the pumped well should be performed within each affected aquifer.

(2) Pumping tests should be used to determine transmissivities and storage coefficients, and other important properties, such as hydrologic boundaries, leakance, and aquifer homogeneity and isotropy. The test should be performed for a sufficient period of time to define these properties. In most cases, three days of pumping should be sufficient; however, longer or shorter tests may be appropriate depending on site-specific considerations. In all cases it is recommended that recovery measurements be taken after the test for a period of time at least equal to the duration of pumping. Correction factors or data adjustments (i.e. barometric pressure, etc.) needed to interpret the results should be applied to the data.

(3) Static water level measurements should be taken at least twice a day for several days prior to the test to determine pre-existing water level trends. During the aquifer test, water levels should be measured with sufficient frequency to accurately define drawdown and recovery curves. It is recommended that the initial drawdown reading be taken within one minute of pump start-up and the initial recovery reading within one minute of shut-down. One recommended approach for decreasing measurement frequency with time is:

(IV. Continued)

(a) Take water level measurements at one minute intervals until the change in water level between successive readings is less than one inch.

(b) Decrease the frequency to two minute intervals until the change in water levels is again small.

(c) Using the above criteria, continue to gradually decrease the measurement frequency to 5, 10, 20, 50, 100, 200 minutes, etc.

Both drawdown and recovery measurements should be plotted in the field on semi-log paper. Semi-log plots permit rapid calculation of transmissivity and storage coefficient, are good indicators of boundary conditions, and can be used effectively to determine when the test has been run for a sufficient period of time.

(4) Two or three long-term pumping tests per affected aquifer within a permit area may be adequate. When large volumes of dewater are anticipated, multiple aquifers with high transmissivities exist, severe faulting or extensive environmental impact are suspected, or when a groundwater impoundment is proposed for final reclamation, additional pumping tests may be needed. The Land Quality Division should be contacted for specific recommendations.

b. Other methods.

(1) Single hole tests.

Recovery tests, slug tests, bailer tests, open end tests, packer tests, or other single hole tests are acceptable to augment the data derived from the long-term pumping tests. Single hole tests may be used in aquifers exhibiting low transmissivities. They are useful in determining the variable horizontal and vertical transmissivity or the hydraulic conductivity within an aquifer.

(2) Single hole tests normally require a high degree of control over a number of variables and measurements. They should not be used if this control cannot be maintained in the field. A description of the field methods used to conduct such tests should be given.

c. Problems may arise during aquifer tests. Thus, to ensure correct interpretation of pumping test data, a log should be maintained by the project hydrologist during all aquifer tests. The log should be placed within the application in tabular form and identify both the chronological order of events and decisions that were made during testing.

(IV. Continued)

4. Groundwater quality.

   a. Wells constructed for the purpose of water level measurements may also be used for water quality sampling. Representative groundwater samples should be taken at a frequency sufficient to characterize potentially affected aquifers. Samples should be analyzed for the parameters referenced in Appendix 2.

   b. Prior to sampling, wells should be pumped until the electrical conductivity of the discharged water remains constant for approximately one casing volume. If a well cannot produce a steady discharge of water for sampling by pumping, the sample may be retrieved using other methods and the circumstances noted.

   c. EPA approved techniques for collection, preservation and analysis should be used for baseline sampling. One acceptable sampling method is provided in Appendix 3.

5. Reporting results.

   a. Piezometer and well information.

      (1) A brief description of the various well or piezometer drilling, completion, and development techniques should be given.

      (2) The following information should be tabulated and expressed both as depth and elevation, when applicable:

         (a) Field identification number and Wyoming permit number.
         (b) Location, date drilled, and aquifer represented.
         (c) Ground elevation and elevation of the measuring point.
         (d) Drill bit and casing diameter.
         (e) Packer base.
         (f) Casing and total depth.
         (g) Perforation, screened, or open interval.
         (h) Static water level and data measured.

   b. Due to changing technology and well completion techniques, the Land Quality Division should be contacted regarding changes or additions to the above list.

(IV. Continued)

(1) All data derived from the aquifer tests and measurements necessary to evaluate the testing results should be included in the application. The mathematical formulas used should be written, and a sample calculation using on-site data for each method used should be performed. References should be listed, and references written in a language other than English should be translated and submitted to the Land Quality Division with the application.

(2) Pumping test data should be evaluated using various methods, and the analysis should consider partial penetration of wells, the conversion from confined to unconfined conditions, leakance, delayed gravity drainage, or other phenomena which deviate from the classic Theis assumptions for aquifers and aquifer tests.

(3) Graphs plotting the data and showing the appropriate straight line or curve fits should be presented at a readable scale. Important times and other features, including boundary effects, casing storage effects, pump breakdown, discharge adjustments, t_o, match point and values for "u" and "W(u)" or other dimensionless terms and well functions, etc., should be identified on the graph. Type curves should be provided at the same scale as the matching graphs representing the field data. All terms should be defined.

(4) If correction factors are used, supportive data and the method used for the data adjustment should be given.

(5) Single hole test data should be plotted and important features noted on the graph.

(6) The following information should be presented in a tabular format when applicable.

   (a) Well identification number and the aquifer represented.
   (b) Type of test.
   (c) Radius of the pumped well or distance of observation wells to the pumped well.
   (d) Hydraulic conductivity.
   (e) Transmissivity.
   (f) Storage coefficient or (apparent) specific yield.
   (g) Other appropriate information.

(IV. Continued)

c. Water quality data.

(1) The results of quarterly analyses should be tabulated in the application. The following should be reported for each sample:

(a) Parameters outlined in Appendix 2. It should be specified whether such analyses represent total or dissolved concentrations.

(b) A charge balance when a complete analysis of the major ions is made. Such information will serve as a check for the reliability of the data. The information should include:

(i) Total equivalents of major cations.
(ii) Total equivalents of major anions.
(iii) Absolute value of

$$\frac{\text{Major cation equivalents} - \text{major anion equivalents}}{\text{Major cation equivalents} + \text{major anion equivalents}} \times 100$$

(c) Total dissolved solids, as a further check on major ion concentrations. The method of determination should be reported.

(2) A brief description of the methods used for sample collection and preservation should be included.

d. Maps.

The following information should be presented in the map section:

(1) Cross-sections extending through and beyond the area to be mined, including identifying lithology, the stratigraphic position of the mineral to be mined in relation to other geologic features, the extent of mining, aquifers, aquitards, areas of aquifer communication, perched aquifers, boundaries, recharge and discharge areas, and potentiometric surface. The location and elevation of the holes used for the construction of the cross-section should be identified on the cross-sections.

(2) Supporting geophysical and/or lithologic logs. Geophysical logs should be readable and should include pertinent operational data, such as SP medium and deflection scales.

(IV. Continued)

(3) Geohydrologic features superimposed on topographic maps should be submitted, including:

(a) Well locations.
(b) Significant groundwater recharge and discharge areas.
(c) A potentiometric surface map encompassing the affected lands and adjacent areas. A map should be presented for each aquifer.
(d) Potentiometric surfaces at various dates (if significant fluctuations of the surface occur because of boundaries or seasonal effects).
(e) An isopach map of aquifer and aquitard thickness for all affected aquifers.

e. Data analysis.

Using the geohydrologic information and water quality data, the following items should be analyzed and summarized concerning the groundwater system:

(1) Number of aquifers and their relationships.
(2) Direction of flow and significance of recharge and discharge areas on the sites.
(3) Aquifer characteristics and variability.
(4) Significance of boundary conditions.
(5) Relationships between surface and groundwater.
(6) Baseline water quality.
(7) The effect of any existing adjacent operations on the pre-mining information and data.

f. Regional analysis.

(1) Flow net analysis or other regional approaches used to determine aquifer properties are acceptable to augment data derived from the long-term pumping tests.

(2) State Engineer records or other published data used in the analysis should be field checked. All field data should be included in the application.

B. Mine Plan

1. Aquifer characteristics should be used in developing the mine plan to minimize possible impacts to water resources and water rights. The mine plan should include an estimate of the volume of dewater and the extent of drawdown in the potentiometric surfaces of all affected aquifers. The effects of existing mines adjacent to the proposed operation on projected dewatering and drawdown estimates should be assessed.

(IV. Continued)

2. Dewatering.

   a. The applicant should specify the methods to be used to dewater all affected aquifers.

   b. The quantity and quality of groundwater removed at various stages of mining should be described. Ponds should be designed for this water volume.

   c. All methods, calculations, and numerical values used in the dewatering assessment should be provided.

   d. If groundwater is discharged into a stream channel, anticipated discharge rates, water quality, and estimated seasonal discharge should be tabulated.

   e. The discharge rate may be used to evaluate downstream flood potential and the availability and suitability of this water for downstream water users.

3. Drawdown.

   a. Drawdown of the potentiometric surface anticipated at various stages of mining should be shown on a topographic map for each affected aquifer.

   b. All methods, calculations, and numerical values used for the drawdown assessment should be provided.

4. Blasting.

   The effect of blasting operations on backfill water quality and on aquifer properties within the adjacent area should be discussed.

5. Water quality.

   The potential effects of mining on groundwater quality should be assessed. If specialized procedures are to be used to protect existing water quality, these should be discussed in detail.

6. Water rights.

   a. Potential effects of mining on existing water rights should be assessed.

(IV. Continued)

b. A map showing the locations of all water rights within the permit and adjacent areas should be submitted on the same scale as the drawdown map.

7. Monitoring.

a. A groundwater monitoring program should be designed to confirm drawdown estimates and to detect groundwater pollution.

(1) The monitoring schedule, chemical species, and water sample collection and preservation techniques to be used should be described in the application. Water quality parameters should follow Appendix 2. This parameter list may be abbreviated, based on initial monitoring results, upon approval of the Land Quality Division.

NOTE →

(2) The anticipated well completion information (location, time of installation, total depth, and elevation of open interval) for all monitor wells installed during mining operations should be described.

(3) A topographic map identifying present and future monitor wells should be presented.

(4) The realized volume of groundwater removed due to dewatering activities should be monitored for water quality and quantity.

(5) The monitoring program should be designed to include disposal or storage areas for acid-forming or toxic materials. An assessment of the potential impact of these materials on groundwater quality should be made when considering the disposal method.

b. The monitoring program should be designed to yield the following information:

(1) Water quality and quantity results from the hydrologic monitoring program.

(2) Drawdown map for each affected aquifer.

(3) Quantity and quality of water removed from pit or mineral deposit and details of disposal.

(4) Comparison of hydrologic monitoring results to baseline data and/or predicted deviations from baseline.

(IV. Continued)

(5) Additional results of the hydrologic monitoring program, including any changes in the monitoring program, locations and completion data on new monitor wells, and any research done on monitoring.

(6) Impacts to quantity or quality of adjacent water resources or water rights.

(7) Anticipated changes to the hydrologic monitoring program.

8. Computer modeling.

a. Computer modeling should not be used in lieu of a comprehensive field program. It may be useful as a predictive tool if the study area is small and input parameters are well defined.

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b. A thorough description of computer models used for predictive purposes in hydrology should be submitted so that their use can be evaluated. The following should be included:

(1) A definition of the physical problem to be solved and the type of approach taken to model it. This is intended to be a general introduction, understandable to the lay person, to how the modeling approach can aid in solving the hydrologic problem.

(2) A written description of the equations that are solved. The theoretical development of major equations should be presented or a copy of the pertinent reference provided.

(3) A list of simplifying assumptions made in the development or use of the governing equations.

(4) A description of all boundary conditions and sinks or sources applied to the system.

(5) The type of model and numerical techniques used. The model should be identified as finite element, finite difference, particle tracking, etc. The numerical representation of the governing equations and boundary conditions should be presented. The method of solution should be described as explicit or implicit, direct or iterative, or a combination of these. Solution techniques should be identified by name (i.e. gaussian elimination, Doolittle Method, etc.) or described. The error associated with the solution techniques used should be assessed.

(IV. Continued)

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(6) Grid characteristics and the time steps used. The effects of these parameters on stability should be addressed. A copy of the grid, superimposed on a base map or cross-section, should be submitted.

(7) A description of checks and balances programmed into a model.

(8) The types of program output available.

(9) A tabulation of all data put into the program. All input data should be supported by field testing. Interpretive methods used to derive input parameters from field data should be described.

(10) A tabular, graphical, or map representation of the program output.

(11) A copy of the program and major references.

C. Reclamation Plan.

1. Aquifer Reclamation.

a. An estimation of the post-reclamation groundwater system should be provided by the applicant. The discussions and maps should be based upon data and referenced material, and should include:

(1) Final aquifer hydraulic properties, including those of backfilled overburden.
(2) Final groundwater quality.
(3) The anticipated post-reclamation static water level.
(4) Post-reclamation effects on adjacent aquifers, wells, springs, and surface waters.

b. If confined conditions are important to water resources or existing water rights within the permit area or adjacent areas, confined aquifers should be reclaimed to a confined state.

c. The reclamation plan should be designed to restore pre-mining aquifer use and water quality. This may be accomplished by including:

(1) An ongoing hydrologic monitoring program of the replaced spoil to determine the best replacement material and techniques. The initial results may be applied to later reclamation.

(IV. Continued)

(2) A program to isolate and bury unsuitable material out of the zone of fluctuation of the estimated post-reclamation potentiometric surface (see Land Quality Division Guideline No. 1).

(3) A plan to segregate and compact suitable spoil material to adequately restore pre-mining aquifer properties.

d. Any post-reclamation subsidence effects on aquifer properties should be assessed.

2. Reclaimed topography.

a. Care should be taken to ensure that the reclaimed topography will not be below the reestablished water table.

b. If the post-mining static water level approaches or intersects the reclaimed topography, a special revegetation plan will be needed. A reclamation plan that proposes to reclaim to a subirrigated condition should consider the effect of salt accumulation and demonstrate that such reclamation will satisfy the post-mining land use requirements of the Environmental Quality Act and Land Quality Division regulations.

3. Monitoring.

a. An application should contain a discussion of the placement of wells in reclaimed spoils to collect water quality samples, measure static water levels, and determine post-reclamation aquifer properties. Anticipated well locations should be shown on the reclaimed contour map.

b. Anticipated well completion information, monitoring schedules, and chemical species to be analyzed should be described. Water quality parameters should follow Guideline No. 8 Appendix 2 unless an abbreviated list is approved by the Land Quality Division.

4. Groundwater impoundments.

a. If a permanent, groundwater-fed impoundment is proposed, the applicant should perform pre-mining groundwater studies in the area of the proposed site including:

(IV. Continued)

(1) Aquifer characteristics.
(2) The rate of groundwater recovery after dewatering within the impoundment area.
(3) The final water surface elevation and expected water level fluctuations.
(4) The yearly evaporative rate from the impoundment surface.
(5) The anticipated final water quality of the impoundment and its relationships to the proposed use of the impoundment.

b. Surface water runoff and channelized flow should be diverted about the impoundment in order to reduce evaporative losses from the streamflow, protect surface water rights and preserve the water quality of the impoundment.

c. The application should demonstrate that enough groundwater is available to fill the impoundment, the on-site transmissivity is sufficient to supply groundwater to the impoundment, the impoundment is a justifiable post-mining land use, and the anticipated final water quality is suitable for the proposed use.

WYOMING DEPARTMENT OF ENVIRONMENTAL QUALITY
LAND QUALITY DIVISION
GUIDELINE NO. 8
APPENDIX 1

SEDIMENT POND SEDIMENT STORAGE

I. INTRODUCTION.

The Universal Soil Loss Equation (USLE) is a recognized regression estimating yearly or storm soil loss on a site-specific basis. The USLE computes gross erosion from a site, and use of a sediment delivery ratio estimates downstream sediment deposition. Information concerning the use of this equation may be found in:

A. EPA, 1977. Preliminary Guidance for Estimating Erosion on Areas Disturbed by Surface Mining Activities in the Interior Western United States, Interim Final Report. EPA-908/14-77-005.

B. Stewart, et. al., 1975. Control of Water Pollution, Volume I, EPA Report. EPA-600/12-75-026a.

II. R-FACTOR.

The R-factor represents rainfall energy, determined using the maximum 30-minute rainfall storm intensity, I_{30} (in/hr). In the equation, R is determined by:

$$R = E\, I_{30}/100, \text{ and}$$

$$E = 916 + 331 \log_{10} I_{30}$$

where E is the empirical kinetic energy of a storm (ft-tons/ac-in).

III. 10-YEAR, 24-HOUR DESIGN STORM.

The maximum 30-minute intensity of a 24-hour storm is not easily obtainable. An estimate of this intensity can be made using the 25-year, 30-minute rainfall which may be found in:

A. Miller, Frederick, and Tracy. 1973. Precipitation - Frequency Atlas of the Western United States. Volume II - Wyoming. Department of Commerce, NOAA Atlas 2.

B. Department of Commerce, 1961. Rainfall Frequency Atlas of the United States, Tech. Ppr. No. 40.

IV. YEARLY SEDIMENT ESTIMATES.

Yearly sediment R-factors are computed for the state. They may be found in the first publication referenced in this handout.

R. Peterson/January, 1979/Rev. 1

WYOMING DEPARTMENT OF ENVIRONMENTAL QUALITY
LAND QUALITY DIVISION
GUIDELINE NO. 8
APPENDIX 2

WATER QUALITY PARAMETERS

I. INTRODUCTION.

Water quality parameters that should be included in connection with pre-mining (baseline), mining, and post-mining monitoring programs are listed below.[1] Site specific conditions, mining operations, and the purposes of collecting chemical data may warrant modifications to this list. An explanation for such modifications should be provided with the monitoring programs to the Land Quality Division.

II. FIELD MEASUREMENTS.

pH (reported to nearest 0.1 pH units)
Temperature ($^{\circ}C$)
Conductivity (micromhos/cm corrected to 25° C)
Chlorine*
Alkalinity
Discharge Rate
Turbidity*
Dissolved Oxygen*
Water Level (for wells)
Pumping Time (for wells)

III. LABORATORY MEASUREMENTS.

A. Cooling To $4^{\circ}C$ and H_2SO_4 To pH Less Than 2 Is The Field Preservation Technique For:[2]

Ammonia (NH_3^+)
Nitrate (NO_3^-) as N or
Total Nitrite (NO_2^-)/Nitrate (NO_3^-) as N

B. Cooling To $4^{\circ}C$ and HNO_3 To pH Less Than 2 Is The Field Preservation Technique For:[2,3]

Aluminum (Al)
Arsenic (As)
Barium (Ba)
Cadmium (Cd)
Chromium (Cr)
Copper (Cu)
Iron (Fe)
Lead (Pb)
Manganese (Mn)
Mercury (Hg)
Molybdenum (Mo)
Nickel (Ni)
Selenium (Se)
Zinc (Zn)

* Site specific - not for all samples.

C. Cooling to 4°C Is The Field Preservation Technique For:[2]

- Bicarbonate[4] (HCO_3^-)
- Carbonate[4] ($CO_3^=$)
- Calcium (Ca^{++})
- Chloride (Cl^-)
- Boron (B)
- Fluoride (F^-)
- Magnesium[5] (Mg^{++})
- Potassium[5] (K^+)
- Sodium[5] (Na^+)
- Sulfate ($SO_4^=$)
- Total Dissolved Solids (TDS)

IV. ADDITIONAL ANALYSES

A. For uranium mines, including in-situ leaching operations and borehole mining, add Vanadium (V), Uranium (U), and Radium (Ra-226) to the laboratory measurement list. Samples should be preserved with nitric acid (HNO_3) to pH less than 2 and cooled to 4°C.

B. For trona mines add total phosphorus to the laboratory measurement list. Cooling to 4°C and H_2SO_4 to pH less than 2 is an acceptable sample preservation prodecure[2].

C. For in-situ coal gasification add total or dissolved organic carbon, COD, Eh, sulfide, bromide, cyanide, borate-thiocyanate, phenolics (i.e. phenol and C_1-, C_2-, and C_3- alkyl phenols, indanols, and naphthols), heterocyclics (i.e. pyridine), and polynuclear aromatics (i.e. C_1- and C_2- alkyl naphthaline, acenaphthene, and phenanthrene). Preservation methods are too numerous to mention in this Appendix. See footnote 2 for EPA approved methods.

FOOTNOTES:

[1] See ADDITIONAL ANALYSES above for special requirements.

[2] All preservative methods can be found in Methods for Chemical Analysis of Water And Wastes. EPA-600/4-79-020, March, 1979.

[3] Water samples should be field filtered using a 0.45 micron membrane filter if dissolved metal concentrations are to be reported.

[4] Total alkalinity is determined in the field by preference.

[5] EPA recommends that this ion should be preserved using HNO_3. Most laboratories servicing Wyoming operators indicate that this ion is routinely preserved as shown in this guideline. The Land Quality Division will accept either preservation method (specify).