NEVADA GOLD CYANIDE MILL TAILINGS REGULATION

A Comparison of State Design and Operating Standards to the Uranium Mill Tailings Standards

February 1997

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1. PURPOSE

1.1 Purpose

The purpose of this report is to evaluate current State of Nevada gold cyanide mill tailings facility design, operation, and closure regulations, compare them to the uranium mill tailings design and operating regulations promulgated at 40 Code of Federal Regulations (CFR) 192, and compare each to methods used at three gold cyanide mill facilities in the State of Nevada. Nevada was selected for the comparison because it is the nation's largest producer of gold,has the largest number of gold cyanide mill facilities, and has promulgated the most advanced cyanide mill tailingsfacility regulatory framework. This report is intended to enhance the Environmental Protection Agency's (EPA) understanding of how Nevada regulates its gold cyanide mill tailings. Attachment 1 provides a list of references and other materials consulted during preparation of this report.

1.2Introduction

Conventional cyanide tank leaching methods are used on gold ores with adequate grade (gold content per ton) and tonnage (quantity of ore available for leaching) to justify the complexity of design, and higher capital cost as compared to cyanide heap leach methods. A gold mill can be divided into 4 major areas: ore mining and size reduction, leaching, gold recovery, and tailings disposal. Once the ore is removed from the ground it is crushed in 1 to 3 stages to prepare the ore for grinding. The number and types of crushing stages is dependent on the hardness of the ore and the ore feed size required for the grinding mill. Rod mills and balls accept ore crushed to less than 1 to 1-1/2 inches, and autogenous and semi-autogenous mills (where the ore acts as all or part of the grinding media) can accept ore as coarse as 6 inches in diameter. Grinding is usually done wet using recycled mill water from the tailings impoundment, and additional cyanide is typically added to the mill water in order to begin leaching as soon as possible.

The product from the grinding circuit goes through a size classifier (i.e. vibrating screens, hydrocyclones) to ensure that it is fine enough to liberate as much gold as economically possible, typically 60 to 80% finer than 200 mesh (74 microns). The ground ore and mill water (pulp), is leached by mechanically agitating it in a series of tanks. During the agitated leach, additional cyanide is added along with air and/or oxygen which are necessary catalysts for the dilution of gold and silver.

The dissolved gold can be recovered from the gold-bearing cyanide solution (pregnant solution), by either adsorption on to activated charcoal or precipitation with zinc dust. When activated charcoal is used it can be added during the leach (carbon-in-leach), or after leaching (carbon-in-pulp). Once the dissolved gold is removed from the solution, the mill tailings and resulting "barren solution" are pumped to the tailings impoundment. The gold is chemically stripped from the carbon, electrowon from the solution, and melted into impure bars, called doré. When zinc dust is used to recover gold from solution, the tailings are separated from the pregnant solution and washed using a sequence of thickeners and wash water. This is known as counter-current decantation. The washed tails are pumped to the tailings impoundment. The pregnant solution is clarified by filtration, deareated in a vacuum tower, and mixed with zinc dust which precipitates the gold by electrochemical deposition. The now barren cyanide solution is returned to the leach and wash circuits.

The design and operation of the tailings impoundment is extremely important, because it serves two purposes: (1) as a settling basin for the mill water which is then recycled to the grinding and leaching circuits; and (2) as the final waste depository for the mill tailings. The size of the tailings impoundment is based upon the total expected volume of tailings produced over the life of the mine, the settling time required to separate the mill water from the tailings, the volume of mill water to be kept on hand, and the volume possible from a 24 hour- 100 year storm event.

Wastes generated from gold cyanide milling operations includes mill tailings, which contains small quantities of spent cyanide solution; residual cyanide; and solubilized metal-cyanide complexes.[1] When the supply of ore is exhausted, the final step in the life of a gold cyanide milling facility is closure. Gold cyanide milling facilities must be formally closed with certification that no wastes have been released to the environment, nor will the remaining wastes degrade the waters of the State in the future. Within the State of Nevada, facility closure requirements are in the forefront of the design and operating standards prior to the commencement of mining and milling operations.

[1] For a more in depth discussion of the gold cyanide milling process, see EPA *Technical Resource Document on Extraction and Beneficiation of Ores and Minerals for Gold* (EPA 530-R-94-013)

2. THE NEVADA CYANIDE MILL TAILINGS REGULATORY FRAMEWORK

2.1 Overview

The State of Nevada has promulgated an extensive set of regulations that govern the design, operation, and closure of mining facilities including those that produce cyanide mill tailings. In addition, the Nevada Department of Conservation and Natural Resources Division of Environmental Protection (NDEP) Bureau of Mining Regulation and Reclamation has issued guidance documents and memoranda that govern the design, operation, and closure of gold cyanide milling facilities. In general, due to the clarity of the regulations, only a few guidance documents have been required to ensure the design and operation of the facilities meets the intent of the regulations. All of these requirements are intended to address the environmental, safety, and health concerns associated with cyanide leaching. Among these concerns are the following.

- First, the gold ore itself contains hazardous constituents such as antimony, arsenic, mercury, thallium, and sulfur. During active leaching the cyanide solution mixes with and solubilizes some of these hazardous constituents.

- Second, the cyanide leaching solution which is present in both the leach circuit and the tailings impoundment contains free cyanide and metallo-cyanide complexes of copper, iron, nickel, and zinc, as well as other constituents in the ore that are mobilized during leaching.

- Finally, the mill tailings are considered to be waste as they enter the tailings impoundment, and the liners used in the tailings impoundment are considered to be waste at the closure of the facility.

Much of the process material and the waste generated during the leaching process may be exposed to the environment, with a potential for contaminant transport. For example, an improperly designed tailings impoundment could result in dam failure or a breach in the liner. The release of cyanide solution and mill tailings from a tailings impoundment may occur during snowmelt and/or heavy storms unless the impoundments are designed to hold the additional volume. Further, these constituents may degrade surface and groundwater, soil(s), and/or air quality during and after the cyanide leaching process. Birds and other animals that come into contact with the tailings impoundment and holding ponds may also be contaminated. The major contamination threat during and after cyanide leaching is the release of cyanide and/or soluble metal bearing solution into the surface and groundwater. Nevada's regulatory framework focuses on the prevention of these types of releases.

2.2 State Mining and Reclamation Permits

A basic principle of the Nevada regulations prevents the operation of any facility until State mining and reclamation permits are granted. The contents of the permit applications require the permittee to meet minimum design standards and perform advance planning to prevent degradation of waters of the State. For facilities in existence prior to September 1, 1989, the regulations require the operator to obtain a permit by no later than September 1, 1992. The permit requirement regulations are found in the Nevada Administrative Codes (NAC) as follows:

> **NAC 445.390 Permit required; operation under an existing permit** .
> 1. All facilities in existence on September 1, 1989, must obtain a valid permit within 3 years after September 1, 1989.
> 2. After July 1 , 1990 no person may begin construction of a new process component, or materially modify an existing process component, without first obtaining a permit or permit modification, or the concurrence of the department that the construction or modification is in conformance with the existing permit.

Facility - "all portions of a mining operation, including, but not limited to, the mine, waste rock piles, or piles, beneficiation process components, processed ore disposal sites, and all associated buildings and structures. The term does not include any process component or non process component which is not used for mining or mineral production..." (NAC 445A.359).

This leads to the second basic principle of the Nevada regulations: cyanide leach operations are regulated by evaluation of a process component of the facility.

> *Process Component* - "a distinct portion of a constructed facility which is [or can be] a point source. (NAC 445A.375)[2]

Thus, Nevada regulates point sources throughout the mining and milling operation, and requires that an operator who chooses cyanide leaching to recover gold from ores to clearly identify point sources for all related operations.[3] Clearly identified point sources for conventional gold cyanide mill operations require minimum design criteria including consideration for storm events and zero discharge for process components where annual evaporation exceeds annual precipitation. The regulations provide that a facility may not degrade the waters of the State and should prevent releases of contaminants that may degrade the State waters.

2.2.1 Contents of the Mining Permit Application

The requirements for mining permit applications are outlined in NAC 445A.394. The application ensures that the responsible parties are clearly identified and that the design and operation of the facility is appropriate for the physical, geological and hydrogeological conditions at the site. The application must included the following:

(1) The owner, operator, authorized agent, and legal structure of the applicant;

(2) Documentation that the local board of county commissioners has been provided notice of the proposed development;

(3) The processing rate for the facility;

(4) An area assessment, including hydrogeological, geological, topographical evaluations as described in NAC 445A.395,

(5) A meteorological report, as described in NAC 445A.396, including historical monthly averages for rainfall, 24 hour storm events with interval of recurrence, temperature variation, and characterization of waste rock, overburden, and ore samples for their potential to release pollutants;

(6) An engineering report, as described in NAC 445A.397, stamped by a Nevada registered Professional Engineer, including engineering plans showing all potential sources of release to the environment (extraction and beneficiation sites, waste rock disposal sites, mill tailings impoundment(s)); methods for control of storm water run-off; the existing geological and hydrogeological conditions beneath and adjacent to the site and the degree to which these conditions provide natural containment; fluid management system; preferential flow pathways and structural stability; a description of the liner material and installation of all tailing impoundments and ponds, including a description of the sub-base preparation; details of leak detection and site-monitoring systems; process schematics; and methods to be utilized for inspecting, testing and quality assurance and control. The information provided must be of sufficient detail to allow the NDEP to determine: 1) which of the potential sources are to be considered process components; and 2) that the design of the process components

[2] Nevada has the authority to implement the Clean Water Act NPDES program, which provides the definition of point source. The Federal NPDES program addresses point source discharges to waters of the U.S., which generally include only surface water. Nevada issues single permits that regulate (or prohibit) discharges to waters of the State, which include both surface and groundwater. Thus, the regulation of discharges to surface water in this paragraph correspond to Federal NPDES requirements, while the regulation of discharges to groundwater described here have no NPDES analogue.

[3] NAC 445A.397

and monitoring system is sufficient to protect the waters of the State from degradation.

(7) A copy of the draft operating plan as described in NAC 445A.398, including a plan for management of all process fluids; a monitoring plan (current water quality profile of ground and surface water which may be effected, monitoring locations, leak detection locations); emergency plan; a temporary closure plan; a tentative plan for permanent closure (procedures for characterizing and stabilizing mill tailings as they are generated and the estimated cost of implementation); and

(8) A report of the sample analysis required under NAC 445A.395 (meteorological report).

The requirements within the mining permit application force the permittee to consider and design the facility to accommodate existing site conditions. The design will minimize and control any releases from the process components, per minimum design criteria, as discussed later.

2.2.2 Contents of the Reclamation Permit Application

In addition to the mining permit, an appended reclamation permit is also required for existing facilities and prior to the commencement of new mining activities.

NAC 519A.120 Time when obtaining of permit and payment of fees required.
1. The operator of each ... mining operation which is active on October 1, 1990, shall obtain the permit required by NRS...519A.200,...:
(a) On or before October 1, 1993; or
(b) Before abandonment of the ...mining operation, whichever occurs first.
2. The operator of each ...mining operation which becomes active after October 1, 1990, shall obtain the permit required by NRS...519A.200, ... before engaging in ... mining.

As in the mining permit application, specific items must be included in the reclamation permit application. The reclamation permit application clearly identifies the responsible party, a statement that the applicant assumes full responsibility for the reclamation of any surface area affected by the mining operation, and for mining operations on public land (NAC 519A.150). The application must also include a complete reclamation plan, the estimated cost to execute the reclamation plan, and a map depicting the area to be covered by the surety bond.

Specific to mill operations, the reclamation plan must include:[4]

1. A topographic map of the area of the operation depicting: ...the kinds of disturbances, including: Tailings impoundments;

2. The location of any surface water body within one-half mile down gradient of the operation;

3. An estimate of the number of acres affected be each type of disturbance;

4. A proposed productive post-mining use of the land;

5. A proposed schedule for initiation and completion of all reclamation activities;

6. The proposed methods to be used in reclaiming impoundments used during the operation;

7. A statement of any constraints on the estimated time to complete reclamation caused by the residual moisture content or physical or chemical qualities of impoundments;

8. The proposed revegetation of the land for its post-mining land use.

2.2.3 Permit Approval

[4] NAC 519A.270

Prior to approval, each application goes through an extensive review by NDEP, public hearings, and comment resolution as described in NAC 445A.400 though .409. In addition, the plan of operation must be approved by the appropriate federal agency(ies) and must be accompanied by surety bond which is acceptable to NDEP. Therefore, prior to the commencement of operations, the facility must meet the minimum design criteria to prevent degradation of the waters of the State, and have approved operating, emergency and reclamation plans in place.

2.3 Minimum Design Criteria

In general, the State of Nevada minimum design criteria "establish minimum contaminant control technologies and define site and operating conditions which must be evaluated. Based on site characterization, best engineering judgement will be applied to determine the degree to which designs must provide more or less protection through engineered containment." (NAC 445A.432)

This identifies the next basic principle of the Nevada regulations which is "Best Engineering Judgement."

> *Best Engineering Judgement* - "that decision *by the department*, which, after evaluating available alternatives and levels of technology presented by the applicant, results in an acceptable design for containing contaminants from a facility in order to protect waters of the State." (NAC 445A.354, *emphasis* added)

This means that NDEP establishes minimum contaminant control technologies and operating conditions that the applicant must meet, and then evaluates, based on best engineering judgement, the specific technology and design proposed by the applicant. For example, an operator may design a tailings impoundment to the minimum design criteria; however, if it is located where groundwater is near the surface, NDEP may require a liner system with a greater degree of containment. (NAC 445A.434)

As described below, Nevada regulations establish minimum design criteria for tailings impoundments, ponds, vats and tanks, and liners.

2.3.1 Tailings Impoundments

The Nevada regulations differentiate between a tailings impoundment and spent ore from heap leaching through the definition of a tailings impoundment.

> **NAC 445A.381 "Tailings Impoundment" Defined.** "Tailings impoundment" means a process component which is the final depository for processed ore discharged from a mill.

As stated in NAC 445A.436:

(1) a tailings impoundment must utilize a system of containment equivalent to:

Twelve inches of recompacted native, imported, or amended soils which have an in place recompacted coefficient of permeability of no more than $1x10^{-6}$ cm/sec; or

competent bedrock of other geologic formations underlying the site which has been demonstrated to provide a degree of containment equivalent to paragraph (a.)

(2) NDEP may require an alternate level of containment based on:

- (a.) the anticipated characteristics of the material to be deposited;
- (b.) the soil and geology at the site;
- (c.) the degree to which the hydraulic head on the liner is minimized;
- (d.) the extent and methods used to recycle and detoxify materials;
- (e.) pond area and volume; and
- (f.) the methods used to deposit the impounded material.

2.3.2 Ponds

All ponds intended to contain process fluids must have a primary synthetic liner and a secondary liner. Between the liners there must be a material which allows any fluid entering it to rapidly flow to an accessible collection point from which it may be recovered. If at any time the system between the liners is unable to collect fluid, resulting in hydraulic head transference from the primary liner to the secondary liner, the pond must be shut down. (NAC 445A.435)

Ponds which are designed to contain excess quantities of process fluids for limited periods during storm events may be constructed with a single liner, if approved by NDEP.

2.3.3 Vats and Tanks

Conventional mill leach operations use vats or tanks to hold leach solutions during leaching and metal recovery from the pregnant solution. All vats and tanks used to confine process liquids must have secondary containment equal to 110% of the largest container provided, and be visually inspected for leaks. Any vat or tank which is partially buried, or cannot be visually inspected, must have a system to detect leaks. (NAC 445A.436)

2.3.4 Liners

Nevada ensures containment of process liquids through providing specific minimum design criteria for soil liners. As detailed in NAC 445A.438:

(1) When placed on native soils, "liners must have a minimum thickness of 12 inches and be compacted in lifts of no more than 6 inches thick. Except when used in tailings impoundments, a soil liner must have a permeability of not more than that exhibited by 12 inches of $1x10^{-7}$ cm/sec material.

(2) Synthetic liners must be rated as having a resistance to the passage of process fluids equal to a coefficient of permeability of $1x10^{-11}$ cm/sec.

(3) NDEP reviews for completeness every application for the following liner related parameters:

- (a.) the type of foundation, slope and stability;
- (b.) the over liner protection and provisions for hydraulic relief;
- (c.) the load and means of applying load;
- (d.) the compatibility of the liner material with the process solutions;
- (e.) the complexity of the leak detection and recovery systems;
- (f.) the depth from surface to all groundwater; and
- (g.) the liner's ability to remain functionally competent until permanent closure has been completed.

Also, "a quality assurance and quality control program must be developed and carried out for the construction of all liner systems. A summary of the quality control data must be submitted to the department with the as-built drawings." (NAC 445A.439)

2.3.5 Permit for Less Than Minimum Design Criteria

The NDEP may grant a permit allowing a lower level of engineered containment than that specified in the minimum design criteria.[5] To obtain this permit the applicant must clearly demonstrate one of the following:

1. The ground water is exempted by the NDEP as it is not currently or expected to serve as a ground

[5] NAC 445A.415

water source due to depth or mineralization, and it is not economically or technologically capable to make it fit for human consumption;

2. The depth from the surface to ground water is greater than 200 feet and a minimum of 50 feet with coefficient of permeability of $1x10^{-6}$;

3. Conditions at the site or facility design specifications allow a lower level of containment while ensuring that the waters of the state will not be degraded, as demonstrated through a site or engineering assessment.

2.4 Tailings Dam Permit

The Nevada State regulations for Dams and Other Obstructions appear in NRS Chapter 535. In summary, "Any person who intends to construct, reconstruct or alter a dam that has a crest height 20 feet or higher, as measured from the downstream toe to the crest, or has a crest height less than 20 feet but will impound 20 acre-feet or more of movable material, must acquire a dam safety permit prior to construction." Any dam that doesn't meet the '20/20' criteria must still file a completed application form with the State Engineer's office prior to construction. The filing fee is not applicable unless a permit is required."[6]

"Although tailings are a mobile material, they are significantly more viscous than water. The tailings are normally transported as a slurry via pipeline to the pond where it is poured on top of older tailings deposit. The fluid and slimes either leach though the tailings or evaporate, leaving a semi-consolidated mass of tailing soils. Because there is a controlled inlet, it is not necessary to have a spillway on the structure as the material should never leave the embankment. A tailings impoundment is designed such that there is enough freeboard to accommodate the 100 year, 24 hour storm without overtopping. Also, most tailings facilities are built in raises. The Division (Nevada State Division of Water Resources) prefers downstream construction for the raises although centerline and upstream raises have been approved. In order for an upstream raise to be allowed, it must be proven to the Division that the tailings, which now will be part of the foundation for the raise, have consolidated, are not fully saturated and are suitable for the size of the raise. A liquefaction and slope stability analysis is required and acceptable factors of safety must be met. Because tailings dams are built to impound tailings only, no flood waters are permitted to enter the structure. This is accomplished by diversion channels collecting flows above the dam and returning them into their natural course downstream.

"The permitting of tailings impoundments is done independent of the Division of Environmental Protection however, the two agencies are concerned about the same items, i.e. liners, leak detection systems, foundation materials, slope stability and finally reclamation. Once the mine has gone into closure, the mining company is responsible for breaching the dam or otherwise rendering the dam incapable of impounding any mobile material. All monitor wells must also be plugged and abandoned according to state regulations."[7]

The design of a dam varies depending on the type of dam or impoundment, the size, seismic zone, and downstream and upstream hazards. Some analyses which may be required for the state engineer to evaluate the design are as follows:

(a.) Stability Analysis- including loading conditions at the end of construction, steady state seepage, and rapid drawdown; static loading with an acceptable factor of safety between 1.4 and 1.6 and greater; and pseudo-static loading with an acceptable factor of safety between 1.0 and 1.1 and greater;

(b.) Submit calculations supporting the dam limiting height under static conditions;

[6] Laws and Permitting Information Pertaining to Dams, R. Michael Turnipseed, P.E., Nevada Division of Water Resources, Page 2.

[7] Ibid, page 22

(c.) Seepage Analysis-net flow and describe design features to provide lower seepage.;
(d.) Describe the various sections of the impoundment, if more than one, and how the tails will be allowed to drain and dry;
(e.) Describe the decant system;
(f.) Describe the drainage area and the system that will provide for drainage water to flow through or around the dam;
(g.) Runoff calculations;
(h.) Flood routing;
(i.) Storm design - 100 year 24 hours storm event;
(j.) Describe instrumentation to be used to detect settlement, alignment changes, seepage and downstream uplift pressures;

Prior to construction, the state engineer must review the following to ensure they are included and sufficiently addressed.

(a.) Clearing and grubbing of the construction area;
(b.) Stripping of unsuitable material;
(c.) Foundation preparation/compaction requirements;
(d.) Embankment material, classification, quality control and compaction. Specify the minimum density or relative compaction;
(e.) Geomembrane and geotextile specifications, including placement;
(f.) Erosion protection;
(g.) Concrete, soil cement and roller compacted concrete design and specifications;
(h.) Material testing requirements - frequency and type of test.

The review of the geotechnical report by the division is essential to ensure that the proposed dam site is adequate for the structure, and should contain the following information.

(a.) Surface conditions of both the foundation and the borrow areas, and surficial geology describing characteristics of all surface deposits, particularly as it relates to permeability. Describe the history of earthquakes and specify maximum probable intensity;
(b.) Strength parameters and permeability of foundation and embankment materials;
(c.) Grain size distribution and classification of all materials used;
(d.) Identify all geological hazards and faults and their potential to rupture under the deposit;
(e.) Boring and test pit results, including competency of foundation and abutments to support the proposed structure;
(f.) Depth to water in the foundation and reservoir area;
(g.) Availability of materials, and describe laboratory and field testing of this material especially tests for water content, compaction characteristics and shear strength;
(h.) Describe the earthquake stability of the proposed construction materials, including resistance to liquefaction;
(i.) Soil properties of core, drain, filter and shell material;
(j.) If tailings are to be used as construction material, comment on the gradation, clay mineral content, and water content of the tailings slurry. Comment if the tailings will be separated into sands and slimes with only sands being used for dam construction, and if so, will cycloning be used. Discuss control of the phreatic line within the embankment and uplift pressures in the foundation soils downstream of the dam.

Drawings should also be submitted to include a vicinity and location; plan view of the watershed boundary, downstream hazard, dam and reservoir area; topographical map showing contours, survey ties from section corner to center crest of dam; cross section of embankment, axis, and maximum section; elevation of dam crest; slopes of upstream and downstream faces; details of erosion protection; dimensions and locations of all pervious, semi-pervious, and impervious materials; and reservoir area/capacity curve to the top of the embankment.

2.5 Monitoring and Releases to the Environment

The mining permit application must also include a description of the type, number and location of all sampling points used to monitor the quality of all surface and groundwater resources that may be affected by the facility. Based upon the site conditions and the process design, NDEP will determine the extent and complexity to which the permittee must monitor each process component. The decision where to locate the monitoring points for the site must be made after considering the site's geology and hydrogeology (NAC 445A.440). As stated below, this is another basic principle of the Nevada regulations:

> "Systems designed to detect and control leaks from process components must be located at the interface of the process components and the adjacent environment and be able to provide the first indication that pollutants or contaminants have escaped their primary containment." (NAC 445A.442)

Per NAC 445A.441, a contaminant escaping primary containment does not result in immediate shut down of the affected process component. If NDEP determines that there has been a variation in a parameter or element which has the potential to degrade the waters of the State, then::

(1) The holder of the permit shall conduct and submit an evaluation to the department which:

- (a.) Identifies the source and escape pathways of the constituent(s) of concern;
- (b.) Determines the type, extent and ability of a system needed to contain or confine any migrating contaminant; and
- (c.) Identifies methods that can be employed to remediate the contamination during the continued operation of the facility or at permanent closure.

(2) The department shall, based on the information provided pursuant to subsection 1:

- (a.) Require immediate shutdown of the process component and the immediate initiation of cleanup activities;
- (b.) Allow continued operation of the process component that is the source of the constituent(s) of concern with concurrent cleanup activities;
- (c.) Allow continued operation of the process component which is the source of the constituent of concern while requiring the facility to continue to control the migration of the contaminant while cleanup activities are postponed; or
- (d.) Determine that no remedial action is warranted.

The determination as to whether or not the surface or groundwater have been degraded is based upon baseline data which must be collected prior to operation, and final monitoring requirements which the State of Nevada must establish. Regardless of the size or type of facility, State surface waters cannot be degraded below that allowed by Nevada Revised Statute (NRS) 445.253.[8] The quality of groundwater may not be degraded below State or federal drinking water standards, and Nevada has established maximum concentrations for Weak Acid Dissociable (WAD) cyanide of 0.2 mg/l. Additionally, NDEP may establish a numerical limit for any constituent in groundwater not otherwise regulated.[9]

While these limits will prevent degradation of the groundwater, NDEP may exempt all or a portion of a groundwater from the standards if it can be demonstrated that the impacted groundwater does not currently and will not (in the forseeable future) serve as a source of drinking water due to depth, location, a total dissolved solids concentration greater than 10,000 milligrams per liter, or is economically or technologically impractical to render fit for human consumption (NAC 445A.424 (2)).

This basic principle regarding monitoring and releases to the environment can be summarized as follows:

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[8] NAC 445A.424 (1) (a)

[9] NAC 445A.424 (1) (b)

(1) The process components are monitored at the interface between the constituent and the environment;

(2) All releases to the surface or groundwater are regulated based upon degradation of the waters of the State, and not on the solution discharged;

(3) Surface waters cannot be degraded below that allowed by NRS445.253;

(4) The groundwater may not be degraded below State or federal drinking water standards, and Nevada has established a maximum concentration for Weak Acid Dissociable (WAD) cyanide of 0.2 mg/l:

(5) NDEP may establish for groundwater a numerical limit for any constituent not regulated otherwise; and

(6) NDEP may exempt all or a portion of a groundwater from the standards if it can be shown that it does not currently and will not serve as a source of drinking water.

In order to standardize the methods used to evaluate applicant's designs and prevent degradation of the waters of the State during operation, NDEP has issued the following guidance documents:

Monitoring Well Requirements: Established to ensure a representative sample of the groundwater is obtained, including seasonal changes.

Permit Limitations for Leak Detection Systems: Provides the maximum flow rate (quarterly and annually) which can be observed from a leak detection system. In the event the permit limitations are exceeded a site-specific evaluation must be conducted by the permittee to assess the need for any additional process component or site monitoring. This may result in the need to institute mitigation procedures to bring the process component back into compliance with the permit limitations.

Waste Rock and Overburden Evaluation: Used to determine the acid generating potential of the waste rock and overburden. This allows NDEP to determine if the placement/land disposal of the mine waste has the potential to degrade the waters of the State. The results of this testing satisfies a part of the requirement to determine if the waste rock/overburden can be disposed of outside of containment.

Meteoric Water Mobility Procedure: Established to standardize the method and improve the reproducibility of test results evaluating the potential of meteoric water to liberate certain constituents from mine rock. The results of this testing satisfies part of the requirement to determine if the waste rock/overburden can be disposed of outside of containment.

2.6 Termination of Operations and Closure

Per 445A.446, the permanent closure of a facility must be initiated when the design life of that process component is reached, or for a facility under a temporary closure, within 5 years of the issuance of a permit for temporary closure. For mill tailings, permanent closure is reached once the tailings have been characterized and stabilized so as to inhibit the migration of any contaminant that has the potential to degrade the waters of the State.[10] While not specified for mill tailings, this may also include spent ore limits for WAD cyanide of less 0.2 mg/l and a pH between 6.0 and 9.0.

> "Stabilized means the condition which results when contaminants in a material are bound or contained so as to prevent them from degrading the waters of the State under the environmental conditions that may reasonably be expected to exist at a site." (NAC 445A.379)

Once closed, the reclamation and revegetation activities described in the Reclamation plan must be initiated within 2 years after completion or abandonment of the mining operation, or within 3 years after a temporary closure (NAC 519A.285). Specific to operations which produce mill tailings, NDEP may, if appropriate, require an operator of a mining operation to reclaim dams for tailings ponds, and tailings impoundments as follows (NAC 519.345):

(1) Dams for tailings ponds:

- (a.) Covering with waste rock, topsoil or growth medium;
- (b.) Revegetation; and
- (c.) Breaching the dam or rendering it incapable of storing any mobile fluid in a quantity which could pose a threat to the stability of the dam or to public safety.

(2) Tailings impoundments:

- (a.) Regrading to promote run-off and reduce infiltration;
- (b.) Covering with waste rock, topsoil or growth medium;
- (c.) Revegetation; and
- (d.) Diverting run-on.

To assist the permittee in addressing revegetation and reclamation requirements, Nevada has also issued the document <u>Interim Standards for Successful Revegetation</u>.

Though not specific to mill operations, the final disposition of waste rock from mining is covered in the NDEP guidance document, <u>Alternate Use of Mine Waste Solids - Disposal Outside of Containment.</u> This document explains which tests must be performed and the standards to be met for uncontained disposal of solid wastes. Also, following permanent closure of a mining facility, slopes created or affected by mining operations must show slope stability comparable to that of adjacent areas. Draft guidance by the State of Nevada explains how the permittee must demonstrate that this requirement is met. Finally, while not specified for post-closure mill discharge, NDEP has also issued guidance on <u>Monitoring and Analysis of Post-Closure Heap Discharge</u>. The time required for post-closure monitoring of the facility depends on the particular site and process characteristics, but in no event may the time required exceed 30 years (NAC 445A.446).

2.7 Other Regulatory Interaction

Although the scope of this report only covers the Nevada regulatory framework, it should be noted that 80 to 90

[10] NAC 445A.431

percent of Nevada mining operations are located on Bureau of Land Management (BLM) or Forest Service land. Those agencies' applicable mining and reclamation regulations, found at 36 CFR and 40 CFR, respectively, apply to operations on lands under their jurisdiction. Operations on federal lands must be conducted to "prevent unnecessary or undue degradation" of the federal lands, according to the Bureau of Land Management regulations, which govern design, operation, reclamation, bonding, monitoring, and remediation requirements. Currently, the BLM and Forest Service consider a State of Nevada operational permit adequate proof that all of their own requirements have been met (Taff 1991). For example, Nevada's reclamation permit addresses specific closure procedures, revegetation and containment of all waste to prevent runoff and erosion. During reclamation activities, either BLM, the Forest Service, or Nevada assumes lead agency responsibility. The BLM and Forest Service have signed a Memorandum of Understanding with the State of Nevada to establish coordination of their respective responsibilities.[11]

2.8 Summary of Nevada Regulations and Guidance

Attachment 1 lists the specific references which were reviewed in the preparation of this document, and Table 2.7-1 outlines the most recent regulations and guidance obtained from the State of Nevada. Table 2.7-1 is divided into design and construction; operation; and closure and reclamation requirements.

[11] October 24, 1996

Table 2-1 - Applicable Nevada State Regulations and Guidance For Mill Operations

DESIGN AND CONSTRUCTION	
Regulations	
445A.379	Stabilized Defined
445A.381	Tailings Impoundment Defined
445A.390	Permit required; operation under existing permit
445A.391	Application for permit: Preliminary meeting with representative of department
445A.393	Application for permit: Definition of site conditions, process materials, characteristics of waste and impacts
445A.394	Application for permit: Submission; contents
445A.395	Contents of application: Assessment of area of review
445A.396	Contents of application: Meteorological report; analysis of samples
445A.397	Contents of application: Engineering design report; specifications for fluid management system
445A.398	Contents of application: Proposed operating plans
445A.400-409	Application review by department, public hearing, comment resolution, and issuance of permit
445A.415	Granting of permit which allows lower level of engineered containment than required by minimum design criteria
445A.424	Limitations on degradation of water; exemptions
445A.426	Notice of Intent to commence active operation of process component
445A.431	Stabilization of tailings
445A.432	Minimum design criteria: Generally
445A.433	Minimum design criteria: Universal requirements; areas where groundwater is near surface; proximity of new process components to dwellings; liability for degradation of water
445A.435	Minimum design criteria: Ponds
445A.436	Minimum design criteria: Vats, tanks, and other containers which confine process fluids
445A.437	Minimum design criteria: Tailings impoundments
445A.438	Minimum design criteria: Liners
445A.439	Program required to control quality of construction of liner systems
445A.440	Monitoring: Site of facility
445A.442	Monitoring: Process components
519A.120-145	Reclamation Permits: Timing, Application, Duration
519A.165-210	Review of Reclamation Permit application, public hearings and comment resolution
519A.225-240	Reclamation Permit Fees
519A.245-280	Reclamation of Land: Contents of Reclamation Plan, Exemptions, Considerations, Productive Post-Mining use.
519A.350-385	Provisions of Surety
Guidance	
NDEP	Mine Plan - Plan of Operation for BLM and Reclamation - Permit Application for a Mining Operation for NDEP, April 199, Revision 0
NDEP	Monitoring Well Design Requirements, October 1990
NDEP	Waste Rock and Overburden Evaluation, September 14, 1990
NDEP	Application Requirements for Mining Operations, January 4, 1994
NDEP	Guidance Document for Preparation of Operating Plans for Mining Facilities, February 2, 1994
NDEP	Time Allowed for Review of Water Pollution Control Permit Applications, April 28, 1994
NDM	State and Federal Permits Required in Nevada Before Mining or Milling Can Begin, Revised 10/95
NDEP	Meteoric Water Mobility Procedure, May 3, 1996
NDEP	Contractor and Operator Certification of Exploration/Mining Operation Reclamation Cost Estimate

Table 2-1 - Applicable Nevada State Regulations and Guidance For Mill Operations
(continued)

OPERATIONS	
Regulations	
445A.392	Application for permit: Construction or modification of process component
445A.416-420	Minor and Major modifications of existing permits and fees, transfer and renewal of permits
445A.424	Limitations on degradation of water; exemptions
445A.425	Process components in existence on September 1, 1989: Standards; additional monitoring
445A.427	Duties of holder of permit upon construction or modification of process
445A.429	Procedures required to prevent release of contaminants; requirements concerning impoundments
445A.441	Monitoring: Procedure upon variation in parameter or element being monitored
445A.443	Monitoring: Beneficiation process
445A.444	Examples of planned and unplanned temporary closures
445A.445	Procedure upon unplanned temporary closure of process component
519A.215	Transfer of Permit
519A.220	Suspension or revocation of permit
519A.225-240	Reclamation Permit Fees
519A.285-310	Time for initiation of reclamation, extension, completion; modifications to reclamation plan
519A.350-385	Provisions of Surety
Guidance	
NDEP	Waste Rock and Overburden Evaluation, September 14, 1990
NDEP	Permit Limitations for Leak Detection Systems, December 23, 1991
NDEP	Solid Waste Mining Sites - Class III landfill Waiver, January 15, 1993
NDEP	Mining Sites - Hydrocarbon Contaminated Soil Definition and Guidelines, Authorization, April 1995
NDEP	Alternate Use of Mine Waste Solids - Disposal Outside of Containment, January 23, 1996
NDEP	Meteoric Water Mobility Procedure, May 3, 1996
NDEP	Mining Regulation Fee Schedule, July 23, 1996
NDEP	Preparation Requirements and Guidelines Permanent Closure Plans and Final Closure Reports, 7/ 23/96
CLOSURE AND RECLAMATION	
Regulations	
445A.431	Stabilization of tailings
445A.446	Permanent closure of facility
445A.447	Plans for permanent closure; sources not classified as process components
519A.215	Transfer of Permit
519A.220	Suspension or revocation of permit
519A.225-240	Reclamation Permit Fees
519A.285-310	Time for initiation of reclamation, extension, completion; modifications to reclamation plan
519A.320-330	Notification of completion, abandonment, or suspension of reclamation work; stockpiling of topsoil; revegetation
519A.335-345	Authority of the Division
519A.350-385	Provisions of Surety
Guidance	
NDEP	Nevada Interim Standards for Successful Revegetation - Attachment B, September 1, 1993
NDEP	NDEP and BLM Bond Reduction Policy, January 13, 1995
NDEP	Documentation of Reclamation Activities for Surety Release and Annual Fee Reporting, 3/16/95
NDEP	Stability Requirements for Mine Components in Post-Mining configurations, DRAFT -6/29/95
NDEP	Annual Reclamation Report Form, February 1996
NDEP	Monitoring and Analysis of Post-Closure Heap Discharge, June 3, 1996
NDEP	Preparation Requirements and Guidelines Permanent Closure Plans and Final Closure Reports, 7/23/96

3. EPA URANIUM PROCESSING FRAMEWORK

3.1 Uranium Processing Overview

Beginning in the 1940's, the United States Government purchased large quantities of uranium for defense purposes. Uranium is the basic element for nuclear explosives. The United States mined nearly 60 million tons of uranium for nuclear weapons production during the Cold War.[12] It takes approximately a ton of uranium ore to yield several pounds of uranium metal. The uranium metal is beneficiated through a milling process, whereby the ore is crushed and ground. The uranium is leached out with acid. The result is a dry purified concentrate called "yellow cake" and large volumes of sand-like byproduct called "mill tailings". These tailings contain toxic heavy metals and radioactive radium and thorium that pose a hazard to public health and the environment. Uranium mill tailings pose a risk to health, because: (1) the radium decays to radon and the radioactive decay products may become lodged into lungs; (2) people may be exposed to gamma radiation; and (3) the radioactive and toxic substances may leach into the ground and surface water, be ingested with food or the water, and inhaled from the airborne contamination. Uranium mill tailings may contain other hazardous constituents such as arsenic, molybdenum, selenium, and uranium.

Historically, uranium mills piled tailings without covers or containment, leaving some material to release into the ground and surface water, and to the air and soil. In addition, tailings have in the past been removed from the piles for use in construction and for soil conditioning. This practice may have led to elevated indoor radon levels, which exposed the public and workers to gamma radiation.[13] Today, most tailings are disposed of in tailings impoundments. In addition, most uranium milling facilities are no longer active, and many have been abandoned with the uranium mill tailings piles still exposed to the environment. These potential health hazards led Congress to enact the Uranium Mill Tailings Radiation Control Act (UMTRCA).

3.2 Regulation Summary

Congress enacted UMTRCA in 1978.[14] UMTRCA authorizes the Department of Energy to enter into cooperative agreements with certain states concerning residual radioactive material at existing sites, and to provide for the regulation of uranium mill tailings under the Atomic Energy Act of 1954[15]. According to UMTRCA Section 2, Congress found that uranium mill tailings located at active and inactive mill operations could pose a potential and significant radiation health hazard to the public, and that the protection of the public health, safety, and welfare and the regulation of interstate commerce require that every reasonable effort be made to provide for the stabilization, disposal, and control in a safe and environmentally sound manner of such tailings in order to prevent or minimize radon diffusion into the environment and to prevent or minimize other environmental hazards from such tailings. The main purposes of the Act are to provide:

(1) a program to regulate mill tailings during uranium or thorium ore processing at active mill operations and after termination of such operations; and

(2) a program of assessment and remedial action at inactive sites, including the reprocessing of tailings to extract residual uranium and other mineral values where practicable, in order to stabilize and control such tailings in a safe and environmentally sound manner and to minimize or eliminate radiation health hazards to the public.

Under the authority of Section 108 of the Act, the EPA promulgated 40 CFR 192, Health and Environmental

[12] Closing the Circle on the Splitting of the Atom, U.S. Department of Energy Office of Environmental Management, January 1995

[13] 60 Federal Register 2855

[14] 42 U.S.C. 7901-7942

[15] 42 U.S.C. 2011-2259

Protection Standards for Uranium and Thorium Mill Tailings.[16] These standards were designed to govern the disposal and cleanup of the designated inactive mill tailings sites. In September 1985, after these standards were challenged in the Tenth Circuit Court of Appeals by several parties, the court dismissed all challenges except one: it set aside the groundwater provisions of the regulations at 40 CFR 192.20 (a)(2) and (3) and remanded them to EPA. EPA published new final standards on January 11, 1995[17]. These standards are divided into the following Subparts of 40 CFR 192:

(1) Subpart A-Standards for the Control of Residual Radioactive Materials From Inactive Uranium Processing Sites;

(2) Subpart B-Standards for Cleanup of Land and Buildings Contaminated with Residual Radioactive Materials from Inactive Uranium Processing Sites;

(3) Subpart C-Implementation;

(4) Subpart D-Standards for Management of Uranium Byproduct Materials Pursuant to Section 84 of the Atomic Energy Act of 1954, as Amended; and

(5) Subpart E-Standards for Management of Thorium Byproduct Materials Pursuant to Section 84 of the Atomic Energy Act of 1954, as Amended.

In addition, Appendix I provides a list of hazardous constituents contained within the residual radioactive materials that must be considered when corrective action is necessary and for monitoring programs under Subpart A and B. Subparts A, B and C govern the remediation of designated inactive sites.[18] Subparts D and E govern the management of uranium and thorium byproduct materials respectively.

Because Subpart D and E pertain to active processing facilities, they are most relevant to a comparative analysis with the Nevada framework. Subparts D and E are quite similar, so this report summarizes Subpart D to help EPA focus on the requirements of 40 CFR 192 that are most comparable to the Nevada cyanide mill taillings design, operating and closure standards.

Subpart D governs the management of uranium byproduct materials during the processing of uranium ores, and restoration of disposal sites upon the conclusion of active operations.[19] It provides standards to stabilize, inhibit future misuse of, and reduce emissions or effluent from uranium byproduct materials during uranium ore processing operations. Uranium byproduct materials and tailings are defined as follows:

> Uranium byproduct material - the tailings or waste produced by the extraction or concentration of uranium or thorium from any ore processed primarily for its source material content. (40 CFR 192.31(b))
>
> Tailings - the remaining portion of the metal-bearing ore after some or all of the metal has been extracted. (40 CFR 192.01)

In short, the basic principle of 40 CFR 192 Subpart D is that the standards apply to the management of uranium byproduct material during and following processing of uranium ores, and to the reclamation of disposal sites. The design, operating, and closure standards are applicable to tailings impoundments only, not the leaching facilities.

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[16] 48 Federal Register 590, January 5, 1983

[17] 60 Federal Register 2854

[18] For comparative analysis, Subparts A, B, and C are not applicable to the design, operation, and closure of active facilities

[19] 40 CFR 192.30

Subpart D includes two major sections: standards, and corrective action programs. These are described below in sections 3.3 and 3.4.

3.3 Design Criteria

3.3.1 Surface Impoundments

The standard applicable to the design, construction and installation of the facility includes only:

> Surface impoundments (except for an existing portion) subject to this subpart, must be designed, constructed, and installed in such a manner to conform with 40 CFR 264.221 Surface Impoundments Design and Operating Requirements... .(40 CFR 192.32 (a) (1))

40 CFR 263.221 outlines the design and operating requirements for surface impoundments to prevent the migration of waste out of the impoundment. For example, a tailings impoundment must have three layers of solution containment; a primary containment and a secondary containment consisting of an upper and lower component. The third layer of containment (the lower component) must be designed and constructed to minimize the migration of hazardous constituents if a breach in the upper component were to occur (40 CFR 264.221(c)(1)(I)(B)).

The CFR also mandates that a leachate collection and removal system is installed between the liners, and the system also function as a leak detection system. The leachate collection system will be constructed with a bottom slope of 1% or more, using a granular drainage material with a hydraulic conductivity of $1x10^{-1}$ cm/sec or more, and a thickness of at least 12 inches, or geonet drainage materials with a minimum transmissivity of $3x10^{-4}$ m^2sec.

The regional administrator may approve alternative design practices as long as the design will prevent the migration of hazardous waste into the ground or surface water and be at least as effectively as the system described above. (40 CFR 264.221(d)(1)) Surface impoundments must also be designed, constructed, maintained, and operated to prevent overtopping, overfilling, rainfall, run-on, malfunctions of level controls alarms or human error. Surface impoundments must have dikes that are designed, constructed and maintained with sufficient structural integrity to prevent massive failure of the dikes. (40 CFR 264.221 (g) and (h))

3.4 Monitoring and Releases to the Environment

40 CFR 192.32 (a) (2) is the standard applicable to the facility during processing operations and prior to completion of closure, and includes:

(1) Uranium byproduct materials must be managed under 40 CFR 264.298 Detection Monitoring Program, to conform with the 40 CFR 264.92 groundwater protection standard, whereby:

- (a.) molybdenum and uranium were added to the list of hazardous constituents (40 CFR 264.93);
- (b.) Maximum Concentration Limits (MCL) established for radioactivity (40 CFR 264.94);
- (c.) detection monitoring required under 40 CFR 264.98 to meet 40 CFR 262.92 shall be completed in one year after promulgation;
- (d.) authority given to NRC to establish Alternative Concentration Limits (ACLs) at point of compliance; and
- (e.) designated 264 “Regional Administrator” functions and responsibilities given to NRC for facility permits;

(2) uranium mill tailings piles or impoundments that are nonoperational and subject to an NRC license or state agreement shall limit releases of radon-222 by emplacing a permanent radon barrier,

which must be constructed as expeditiously as possible after the pile or impoundment ceases to be operational; and

(3) upon emplacement, licensee must conduct appropriate monitoring.

The Detection Monitoring Program (40 CFR 264.98) references the General Groundwater Monitoring Requirements (40 CFR 264.97) to ensure that enough monitoring wells are used to accurately represent the quality of groundwater passing the point of compliance. Each monitoring well must be cased to maintain borehole integrity, screened or perforated and packed with gravel or sand to enable collection of the groundwater, and the annular space must be sealed to prevent contamination of the sample and groundwater. Additionally, the detection monitoring program requires the owner/operator to determine the water quality background levels prior to operation, establish statistical sampling and evaluation methods, and requirements and procedures for notifying the Regional Administrator in the event of a leak. The Detection Monitoring Program and the Compliance Monitoring Program (40 CFR 264.99) state that "the Regional Administrator will specify the frequency for collecting samples and conducting statistical tests..." A sequence of at least four samples from each well must be collected at least semiannually during detection and compliance monitoring.

The groundwater protection standard (40 CFR 264.92) requires compliance with:

264.93 Hazardous Constituents - shown in 40 CFR 261 Appendix VIII.

264.94 Concentration Limits - Must not exceed background or those shown in Table 1 of 264.94, which ever is greatest.

264.95 Point of Compliance - A vertical surface located at the hydraulically down gradient limit of the waste management area. This is the point where the facility must meet the MCLs according to permit standards.

264.96 Compliance Period - Begins when the owner/operator initiates a compliance monitoring program and will continue the number of years specified by the Regional Administrator in the facility permit. The compliance period may be extended if the owner or operator is engaged in a corrective action.

In addition, Subpart D Section 192.33 mandates that the licensee must develop a corrective action plan as outlined under 40 CFR 264.100 if the groundwater standards under 40 CFR 192.32 are exceeded. A "licensed site" is defined in 40 CFR 192.31 as the area contained within the boundary of a location under the control of persons generating or storing uranium byproduct materials under a license issued pursuant to section 84 of the Act. The license is analogous to the facility permit in Nevada.

3.5 Closure

40 CFR 192.32 (b) provides the following standards for use after the closure period:

(1) Disposal areas shall comply with RCRA closure standards under 40 CFR 264.111 with respect to nonradiological standards and shall be designed to provide reasonable assurance of control of radiological hazards to:

(a.) be effective for 1000 years, to the extent reasonably achievable, but at least for 200 years;

(b.) limit releases of radon-222 from uranium byproduct materials to the atmosphere so as not to exceed an average release rate of 20 picocuries per square meter per second;

(c.) exemption from this entire requirement any portion of a licensed and/or disposal site demonstrating concentration levels that do not exceed background by specified limits..

Based upon this exemption, disposal areas for nonradiological wastes would not need to comply with 40 CFR 264.111 Closure Performance Standard, and hence 264.228 Surface Impoundment Closure and Post Closure Care.

However, 40 CFR 264.221 Surface Impoundment Design and Operating Requirements references 264.228 which requires the following:

(1) Remove or decontaminate all waste residues and contaminated containment systems and manage them as hazardous waste;

or

(2) Eliminate free liquids , stabilize remaining waste to a bearing capacity sufficient to support final cover, and install a final cover over the impoundment, designed to: provide long term minimization of liquid migration through the closed impoundment; function with minimum maintenance: promote drainage and minimize erosion; and accommodate settling and subsidence to maintain the cover's integrity. In addition, the owner/operator must comply with all post closure monitoring, maintenance and reporting requirements.

Therefore, while 40 CFR 192.32(b)(1) indicates that non- radiological facilities would not need to be managed under RCRA, 40 CFR 264.221 indicates that the wastes will need to be removed or decontaminated, or capped in place.

Though surety is not specifically stated, as a "regulated unit" the financial requirements under 40 CFR 264 Subpart F apply and state "assurance of financial responsibility for such corrective actions must be provided" (40 CFR 101 (c)). These corrective actions are necessary to protect human health and the environment for all releases of hazardous waste or constituents. The specific corrective actions will be specified in the permit.

4. NEVADA MILL LEACH FACILITIES - EXAMPLES

4.1 Rain Facility - Newmont Gold Company

4.1.1 Rain Facility Description[20]

The Rain facility is owned and operated by Newmont Gold Company and is located approximately 9 miles southeast of Carlin, Nevada. The facility began producing gold on July 2, 1988, and is a mining-milling-leaching operation for recovery of finely disseminated gold from oxidized sediments. Gold concentrations range from 0.01 to 0.15 ounces of gold per ton of ore. Ore grades for heap leaching are 0.01 to 0.05 ounces of gold per ton or ore, and ore containing more than 0.05 ounces of gold per ton is sent to the mill.

In 1990, the ore reserve estimates were revised from 62.5 million tons to 80.2 million tons, of which 6.7 million tons was mill grade ore, and 11 million tons was heap leach grade ore. At a production rate of 1 million tons per year for the heap leach, the operating life of the facility would be 11 years.

As material is removed from the ground, the ore designated for conventional milling is placed in a milling ore stockpile. As needed, the ore is crushed in a jaw crusher to less than 6 inches in diameter and sized to 3/4-inch on a double screen. Material coarser than 3/4-inch is fed to a cone crusher, and the cone crusher discharge and the material finer than 3/4-inch is mixed with lime and fed to the mill fine ore stockpile. The mill fine ore is fed to the milling operation which begins with a rod mill. The rod mill discharges to a sump shared with the ball mill. Slurry from the sump is classified at 70% passing 200 mesh, with the oversize returning to the ball mill, and the undersize going to the six stage agitated leach circuit.

Leaching is performed in 6 - 190,000 gallon mechanically agitated tanks, with the slurry flowing by gravity from one tank to the next. A concrete secondary containment surrounds all six tanks and has a minimum volume of 190,000 gallons. From the sixth leach tank the Pregnant solution/ore slurry is transferred to the first of six Carbon-In-Pulp (CIP) gold recovery tanks. As the pregnant solution flows by gravity from the first stage sequentially to the last, activated charcoal is mechanically transferred from the last stage to the first stage, countercurrently. This makes it possible to put the most barren carbon in contact with the most barren leach solution (in the sixth stage), removing virtually all of the precious metals, and puts the most highly loaded carbon in contact with the highest concentration gold solution, maximizing the gold loading on the carbon. The loaded carbon is washed, and transferred by truck to the Newmont Gold Quarry facility where the gold is recovered from the carbon and the carbon is reactivated and sent back to the Rain facility for reuse. The barren solution and tailings leaves the last stage of CIP and flows to the tailings impoundment. This slurry contains approximately 35 to 40% solids, has a solution pH of approximately 10 and WAD cyanide concentration of approximately 30 parts per million (ppm).

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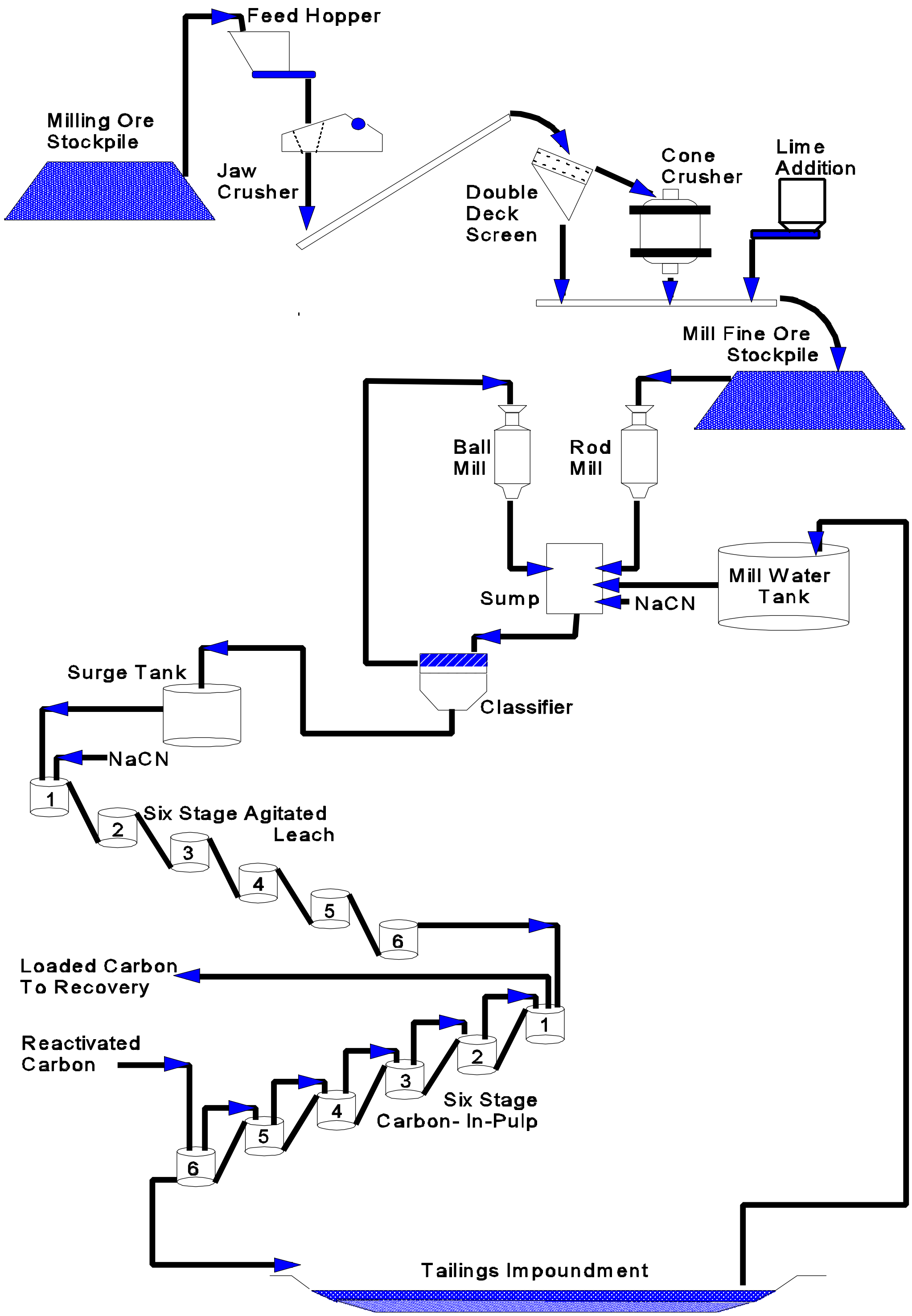
[20] The source document for this evaluation was the Technical Resource Document Extraction and Beneficiation of Ores and Minerals, Volume 2, Gold, August 1994, US EPA 530-R-94-013

Figure 4.1-1 - Rain Gold Mill Operation



4.1.2 Environmental Setting

The facility is at an elevation of 6,600 feet above sea level, and the climate is described as dry and warm. December is typically the wettest month, and the annual precipitation averages 12 inches. The surface water in the area includes the Ferdelford and Dixie creeks and baseline data predating the Rain facility show both with high pH, bicarbonate concentration, TDS and conductivity. Metal concentrations were generally low in Ferdelford creek, and Dixie creek showed arsenic, iron and manganese concentrations. Groundwater is limited with either shallow perched water which is not connected to the regional groundwater, and deeper groundwater sources existing more than 350 feet below the surface.

4.1.3 Tailings Impoundment

The Rain tailings impoundment is located downgradient from the heap leach facility and pregnant pond. The ultimate surface of the impoundment is now anticipated to be 189 acres with a total dry capacity of 6.7 million dry tons of tailings (1990). The impoundment is designed to contain the flow from the watershed for a 100 year 24 hour storm event. The structure is designed to withstand the maximum credible earthquake expected in the Newmont area. Construction on the starter embankment began in October of 1987 and four additional lifts have been added to the dam to expand the storage capacity of the impoundment. The initial dam structure was a earth fill embankment consisting of a compacted clay core with random fill shells and a near vertical chimney drain/transition zone. The upstream and down stream slopes were constructed to 2:1 (horizontal to vertical) to a crest elevation of 6409 feet. A blanket drain was constructed along the base of the embankment which is hydraulically connected to the chimney drain.

The environmental assessment indicated that most of the tailings impoundment was underlain by naturally occurring highly impermeable clay with permeability of 10^{-7} cm/sec with some areas in the 10^{-8} to 10^{-9} cm/sec range.

The first embankment modification included a downstream embankment raise of 6425 feet to crest, with upstream and downstream slopes of 2:1 and 2.5:1. The core, chimney drain, and blanket drain from the starter embankment were provided for within the embankment raise. Also a natural soil liner and gravity underdrainage collection system were constructed in the valley area to improve seepage control as the basin fills. This underdrain system consisted of a one foot-thick layer of compacted native soil (1x10-6 to 1x10-7 cm/sec) overlain with a drainage blanket/hydraulic break of 12 inches of select waste rock. Four-inch diameter perforated drainage lines were installed at intervals in the waste rock layer which discharge to an eight-inch diameter pipe which passes through the tailings dam in a concrete encasement to an underdrainage collection pond. A 30 mil PVC liner was also installed over the natural soil liner in the transition zone between the pond level and the functional elevation of the underdrainage collection system.

The second embankment modification included an upstream raise of approximately 7 feet using primarily mine waste fill with an extension of the core seal zone at the embankment extremities. Upstream and down stream slopes were maintained at 2:1 and 2.5:1 respectively. The third embankment modification included an upstream raise of 20 feet (determined by difference from phase II and phase IV crest elevations). The fourth embankment modification includes a centerline raise of 3.5 feet. Also, a 1 foot thick soil liner and underdrain system will be installed in the upper valley area. The soil liner will consist of borrowed and scarified in-place low permeability soils, moisture conditioned and compacted to 95% of standard proctor density which results in an in-place permeability of 1x10-6 cm/sec or less. A 30-mil PVC liner will be placed over the underdrain blanket and essentially provide a double liner system beneath the pond area.

A good indication that the underdrains continue to operate as designed is provided from the piezometric record, which shows periodic fluctuations of several feet in the phreatic levels, but all have stabilized after a short period of time.

4.1.4 Monitoring and Permit Requirements

As a requirement of their Water Pollution Control permit, Newmont reports quarterly on the results of the following tests shown in Table 4.1-1

Table 4.1-1 Newmont Rain Facility Monitoring Locations and Parameters

	Monitoring Location	Parameter
1.	Underdrain collection pond leak detection sump	Average daily accumulation (gpd) (Report weekly)
2.	Tails water, Reclaim water, Underdrainage water	Profile II
3.	Seepage Pond	Profile I Pumpback flow(weekly)
4.	Upstream and Downstream Trench Drains	Profile I Pumpback flow (weekly)
5.	Monitoring Wells	Profile I

Profile I includes: As, Ba, Cd, Cr, Cu, Fe, Pb, Mg, Hg, K, Se, Ag, Na, Zn Alkalinity, TDS, WAD CN, Cl, F, Nitrate, Sulfate.
Profile II includes: All constituents in Profile I and: Al, Sb, Be, Bi, Ca, Co, Ga, La, Li, Mn, Mb, Ni, P, Sc, St, Th, Sn, Ti, Va.

The permit also requires zero discharge to surface waters, and ground water releases may not cause violations of drinking water standards or result in WAD cyanide concentrations over 0.2 mg/l. Finally, the permit places flow limits from leak detection sumps at less than 150 gpd averaged quarterly and 50 gpd averaged annually.

A permanent closure plan is required by the water pollution control permit. Specific to the Rain tailings impoundment closure procedures will include measures to limit run-on of precipitation and remove existing fluids from the system. Process solutions and solutions collected in the underdrain and seepage collection ponds will be pumped to the heap leach facility for disposal. New run on diversion channels will be constructed or existing channels will be modified to prevent precipitation from flowing onto the impoundment. With gradual draining of non-capillary fluid seepage into the collection points will cease. As the tails dry, a layer (less than 12 inches) of coarse mine waste or a layer of organic material may be placed over the impoundment to prevent wind erosion. At the end of operations one or more tailings samples will be taken at a depth in the saturated zone of the tailings and analyzed using the Meteoric Water Mobility Procedure.

Recontouring and/or revegetation of the impoundment will be performed to stabilize disturbed areas and to achieve post-mine land use. This vegetation will also aid in the evapo-transpiration of any precipitation falling directly on the impoundment.

The drainage collection system will be maintained and operated as long as flow continues to come from the impoundment, and the water collected will be used in the revegetation effort. Ground water monitoring will be performed throughout the closure period and longer as agreed to by NDEP. Migration of any contaminant plume outside the facility boundary which may impair the beneficial use of the ground water will be prevented including installation of a barrier well pump back system.

4.1.5 Corrective Actions

During construction of the tailings impoundment, a 7.5 gpm seep was noted in the natural drainage channel 300 feet downgradient of the tailings impoundment dam. A tracer study determined that the seepage was coming from the dam interior, by migrating through the upstream face of the dam to the chimney drain and exiting the blanket drain on the downstream side. To control seepage, a second keyway was excavated along the toe area on the inside face of the dam, and backfilled with clayey soil. A four foot thick clay liner was also placed from the top of this keyway to the upstream toe of the dam. Down gradient of the dam, a seepage collection pond was installed and a 60-mil HDPE barrier wall backfilled with clay materials was installed to prevent further migration of the seep

4.2 Bullfrog Mine - Barrick Bullfrog, Inc.

4.2.1 Bullfrog Mill Facility Description

The Bullfrog Mine is a gold-silver mining operation currently owned and operated by Barrick Bullfrog, Inc, and is located approximately 3 miles southwest of Beatty, Nevada. Bond Gold Company began operation of the open pit mine and mill in June 1989, and LAC Minerals purchased the property in December 1991and operated it until October 1994, when Barrick Gold Corporation purchased LAC Minerals, Inc.. The project was projected to have a 15 year life, during which time a total tonnage of 60.0 million tons would be mined at 4 million tons per year.

As ore is removed from the ground, it is delivered to a gyratory crusher which reduces the ore to 80% less than 4 inch prior to being stored in an uncovered coarse ore stockpile. As needed, coarse ore is fed to the fine ore crushing plant where it is fed through two stages of cone crushers and a vibratory screen to produce 100% less than 3/8-inch fine ore. The fine ore is fed to the milling circuit where it is ground in mill solutions in four parallel ball mills. The mill slurry is pumped to a hydrocyclone and the pulp which is 45% less than 200 mesh (74 micons) is fed to the leach circuit. The oversize is returned to the ball mills. The ore is leached in three mechanically agitated tanks (each with a total capacity of 110,000 gallons) with the slurry flowing from one tank to the next by gravity. From the third tank the pregnant solution/ore slurry is transferred to the first of six Carbon-In-Pulp (C-I-P) gold recovery tanks. As the pregnant solution flows by gravity from the first stage sequentially to the last, activated charcoal is mechanically transferred from the last stage to the first stage, countercurrently. This makes it possible to put the most barren carbon in contact with the most barren leach solution (in the sixth stage), removing virtually all of the precious metals, and puts the most highly loaded carbon in contact with the highest concentration gold solution, maximizing the gold loading on the carbon. The loaded carbon is washed, and transferred to the stripping and gold recovery facility. The gold is recovered from the carbon and the carbon is reactivated and returned to the leach/adsorption circuit for reuse. The barren solution and tailings leaves the last stage of CIP and flows to the tailings impoundment via a 10-inch pipe. After settling of the solids the decanted liquid is recirculated to the mill for reuse.

4.2.2 Environmental Setting

The facility is located at an approximate elevation of 3280 above sea level and the climate is generally warm and dry. Based upon long-term climatic records from nearby Beatty, Nevada the site receives annual precipitation of 4.5 inches with the wettest month being February. The average annual snowfall is 3.3 inches, with the maximum occurring in January. The terrain adjacent to the tailings facility is relatively flat with average slopes of approximately 0.5%. The tailings facility is located on a coarse alluvial basin deposit which consist of generally well graded sands and gravel. The alluvium is reported to be up to 1000 feet deep with variable stratification of the deposit near the surface.

Groundwater at the site occurs in hydraulically distinct fractured bedrock and basin-fill alluvial aquifers within the upper Amargosa Desert hydrographic basin. The tailings impoundment is located at the northern edge of the Amargosa Desert Basin, approximately 642 feet above the water table in the alluvial aquifer. Groundwater elevations in the upper Amargosa Desert Alluvial aquifer range from 2,865 to 2,344 feet amsl, and generally reflect the south-southwest gradient.

4.2.3 Tailings Impoundment

The Bullfrog tailings impoundment is located downgradient of the mill facility, and has been built in three phases, the first of which was completed at start up of the facility. The original impoundment was constructed by clearing the vegetation and constructing the dam from overburden material from the facility. The inner dam face was lined with a clay amended soil (approximately 5% bentonite) approximately 12 inches thick, and the height of the embankment ranged from 35 feet on the north facing slopes to 100 feet on the south facing slopes. The impoundment was located over impervious clays to minimize vertical seepage of the tailings fluids into the groundwater system. The number 1 starter facility also used a PVC flexible membrane liner with perimeter and radial underdrains to reduce hydraulic head on the liner system and promote tailings consolidation. These underdrains control piezometric levels by transferring flow to a dewatering sump at the inboard toe of the ring dike. The Number 2 impoundment was completed in July 1991, and is similar to the starter impoundment except for the incorporation of a free-draining gravity piping system beneath the embankment to transfer supernatant and storm water from the ring-like decant to an external solution pond. Also radial and perimeter finger drains were modified to provide gravity drainage to the reclaim pond, and the lining system for number 2 was upgraded to include a secondary synthetic liner and leak collection and recovery system (LCRS) under the footprint of the ring dike. Liner systems were HDPE.

The number 1 and 2 tailings impoundments were combined into the composite tailings impoundment in 1993 when a vertical raise was installed using a combination of downstream and upstream construction techniques. Two additional vertical raises were planned for the composite impoundment, however, future tailings capacity at Bullfrog will be provide by the Number 3 impoundment. The expansion used 40 mil VLDPE flexible membrane liner on a prepared subgrade along all upstream embankment slopes.

Tailings deposition is performed subaerialy using 120 six-inch low-energy spigots evenly spaced around the upstream circumference of the tailings impoundment. Sedimentation results in the coarse sand fraction being preferentially deposited adjacent to existing embankments. By cycling the flow to the spigots tailings disposition occurs in thin layers, 6 to 14 inches thick, and producing large exposed tailings beaches, which slope towards the decant. The slimes and supernatant solution are transported toward the existing decant pipe where they form a supernatant pool. This pool is maintained at a maximum radius of 600 feet, and is kept as small and shallow as possible to promote maximum drying, desiccation, and consolidation of tailings. The slimes settle and the supernatant is reclaimed from the surface and is transported to the reclaim pond.

This tailings deposition management technique produces a vertical sequence of dense, partially saturated deposits which function as a positive seal against further infiltration of fluids from precipitation or subsequent tailings deposition. It should be noted that the drained and consolidated tailings have a vertical permeability of approximately $1X10^{-5}$ to $1x10^{-6}$ cm/sec, and in effect from a barrier to the vertical infiltration of water.

Two reclaim ponds were constructed to serve the tailings impoundments. Both were constructed of 60 mil HDPE primary liner and 40 mil HDPE secondary liner with a 0.25 inch thick geogrid to serve as the LCRS.

Surface water run-on does not impact the tailings impoundment as both the impoundment and the diversion ditches were designed for the 100 year 24 hour storm event. Only precipitation falling directly on the surface of the impoundment impacts the operation and closure of the facility.

4.2.4 Monitoring and Permit Requirements

As a requirement of their Water Pollution Control Permit, NEV 88023, Barrick Bullfrog has collected the following samples specific to the operation of the tailings impoundment.

Table 4.2-1 Barrick Bullfrog Tailings Impoundment Monitoring Requirements

	Material	Collection Frequency	Period	Parameter
1.	Tailings Solids	Collected Weekly and composited into quarterly samples	1st qtr 90 - 2nd qtr 92 3rd qtr 92 to present	Total Conc Profile II Meteoric Water Mobility Profile II
2.	Tailings Liquid	Collected Weekly and composited into quarterly samples	1st qtr 90 - 1st qtr 91 2nd qtr 91 - present	Profile I Profile II
3.	Reclaim Pond Water	Collected quarterly composites	2nd qtr 91 - present	Profile II

Profile I includes: As, Ba, Cd, Cr, Cu, Fe, Pb, Mg, Hg, K, Se, Ag, Na, Zn
Alkalinity, TDS, WAD CN, Cl, F, Nitrate, Sulfate.

Profile II includes: All constituents in Profile I and:
Al, Sb, Be, Bi, Ca, Co, Ga, La, Li, Mn, Mb,Ni, P, Sc, St, Th, Sn, Ti, Va.

The permit also requires zero discharge to surface waters, and ground water releases may not cause violations of drinking water standards or result in WAD cyanide concentrations over 0.2 mg/l. Finally, the permit places flow limits from leak detection sumps at less than 150 gpd averaged quarterly and 50 gpd averaged annually.

A permanent closure plan is required by the water pollution control permit. The Final Permanent Closure Plan for the tailings ponds calls for dewatering of the tailings and disposal of the water either by recycling or evaporation. Therefore the liquid component of the tailings will not exist after closure to adversely affect ground water or surface water quality. As the tailings surface slopes from the discharge points toward the supernatant pool at approximately 0.75%, no additional grading is required to provide surface drainage and minimize erosion and pooling for final closure. Cover will be placed over the tailings surface to provide the final design grade topography. The cover material will be mounded in the area of the decant pool to allow for additional settling and maintain positive drainage. Upon completion of cover placement the surface will be prepared and reseeded.

Bullfrog has proposed a five year closure monitoring and maintenance period for the composite tailings impoundment. Uniform settling across the surface of the impoundment will not be detrimental to the function of the soil cover. However settling which results in pooling or grade reversal will be mitigated as necessary. All drain down solutions will be measured for flowrate, and analyzed for solution quality. Samples will be collected from the underdrain discharge point on a quarterly basis for the first two years after solids are no longer deposited in the composite tailings impoundment, and samples will be collected on a semi-annual basis for the following three years. All samples will be submitted for Profile II analysis. The leak detection sumps will be monitored for flowrate (normalized to gallons per day) weekly for the first two years following closure, and quarterly for the following three years.

4.2.5 Corrective Actions

Prior to construction of tailings impoundment number 2, NDEP requested an investigation to determine if any leakage had occurred from number 1. Three bore holes were made into the tailings embankment and 35 samples of alluvial material were collected and analyzed for WAD cyanide. Detectable concentrations were not found. Monitoring Well MW-1 was installed downgradient of the tailings impoundment number 1 in 1991. Detectable quantities of WAD cyanide were first reported in MW-1 in 1993, at which point Barrick Bullfrog increased the frequency of monitoring and conducted an investigation to detect saturated soils or contamination plumes outside of the designed containment. Detectable quantities of WAD cyanide only exceeded State Water quality limits (0.2 mg/l) one time, however the duplicate sample did not exceed State Water quality limits. The investigation determined that the WAD cyanide detected in MW-1 probably came from tailings impoundment number 1 or the old reclaim pond, which is now out of service.

Mercury, Fluoride, Antimony and Iron concentrations from water collected at MW-1 also periodically exceed the state standard. While some evidence indicates that these concentrations occur from natural sources, high concentrations of mercury are not found in any other wells.

4.3 McCoy/Cove Mill - Echo Bay Minerals Company, Inc.

4.3.1 McCoy/Cove Facility Description

The McCoy/Cove Mine project is owned and operated by Echo Bay Minerals Company and is located approximately 30 miles southwest of Battle Mountain, Nevada. The facility includes an open pit mine and combined heap and mill leaching of gold and silver bearing ores. McCoy/ Cove has been producing gold since July 1989, and is produces approximately 8000 tons per day of mill tailings. Based upon initial reserve estimates, approximately 30 million tons of ore will be mined with an additional 70 million tons possible of mineable reserves.

As ore is removed from the ground it is stockpiled prior to being crushed to minus 5-inches in a gyratory crusher, and fed to the coarse ore stockpile. The coarse ore is fed to a vibrating screen which separates the oversize and undersize 1/2-inch material. The oversize goes to a secondary crusher which sends its product to a second vibrating screen. The 1/2-inch oversize from the second screen is discharged to a tertiary crusher, which feeds a third double deck screen in closed circuit with the third stage of crushing. All 1/2-inch undersize material is fed to the mill storage bins prior to being fed to the primary ball mills where it is ground with mill solution to 80% less than 200 mesh (74 microns). The ball mill discharges in closed circuit to a bank of hydrocyclones which discharge a small portion of the oversize to gravity concentration and the majority of the oversize to flotation. The oversize flotation tails are recycled to the ball mills for further grinding. The cyclone undersize is thickened and sent to flotation, with the concentrate being mixed with the oversize concentrate for leaching. The undersize flotation tails and leach tails are sent to the tailings impoundment. The flotation concentrates are further ground to 80% less than 325 mesh in a tower mill, further concentrated by flotation. This flotation concentrate, which is approximately 11% of the total mill feed, is leached with cyanide, steam, and strong caustic solutions to dissolve the gold. The tails are separated from the pregnant solution by thickening and filtration, and the precious metals are recovered from the pregnant solution by precipitation with zinc dust (Merrill-Crowe recovery). The tailings produced from the mill are placed in a lined tailings disposal facility located south east of the mill. The tailings impoundment is designed to meet the regulatory requirement of zero discharge, and after settling of the solids the water is recycled to the mill.

4.3.2 Environmental Setting

The tailings impoundment is located at an elevation of 4800 feet on the valley floor, which is characterized by predominantly coarse grained soils. The slope of the ground surface is relatively flat, ranging from 1.3 to 2.2 percent sloping from west to east/northeast. The average annual precipitation as estimated from nearby Battle Mountain is 8 inches with the wettest month being June. The mean annual snowfall was estimated at 28.4 inches and can be expected to occur between October and May. Temperatures range from 28.5 to 72.5 ºC, and the pan evaporation for the site is 62.5 inches per year.

The Facility lies within the Reese River groundwater basin, and the Reese River is the major watercourse within the general vicinity of the facility. The Reese River is an intermittent stream which collects discharge from within the immediate site vicinity. Only one spring is within direct proximity of the facility, however, it is remote and significantly upgradient from the impoundment site.

Groundwater is relatively deep ranging from 100 to 220 feet below the existing ground surface at a depth of approximately 4660 feet, and is of relatively good quality. The gradient of the piezometric surface generally slopes from west to east towards the Reese River

Seismic activity in the Great Basin area has included five major events. In closest proximity to the site was the Pleasant Valley earthquake of 1915 which registered 7.6 M and involved faulting of 20 to 25 miles along the western face of the Sonoma Range. The project site is located approximately 40 miles from the rupture zone.

4.3.3 Tailings Impoundment

The original impoundment design was developed to provide a total of 30 million tones of storage volume accomplished through construction in two stages. The permeability of the alluvium soils in the tailings impoundment basin were measured to evaluate their use as a liner material and to estimate seepage transmission rates into the vadose zone, should seepage occur. Average permeabilities of $1x10^{-4}$ were identified. Based on the permeability of the soil, the tailings impoundment design included complete lining of the basin and embankments with 30 mil Very Low Density Polyethylene (VLDPE) over a prepared sub-base. The permeability of the prepared sub-base was not reported. To protect the liner a two foot thick layer of bedding material consisting of waste rock sands and silts was placed over the top of it. to minimize hydraulic head on the liner and to enhance tailings dewatering a drainage network was placed above the bedding layer and covered with uncompacted spent ore from the existing heap leach operation. The impoundment was bermed into three cells to allow deposition of tailings in only one area at a time. This allows time for drying and desiccation of the tailings while deposition is occurring in another cell. Tailings deposition will be done using a thin-lift deposition scenario where tailings will enter the impoundment at the upstream end to allow drainage toward the embankment. As the tailings lose energy the solids will settle and the water will continue to flow towards the embankment, evaporating and seeping into previously deposited tailings as it flows. When the water reaches the embankment a network of pipes direct the water through the embankment and into the seepage collection ponds.

The three seepage collection ponds collect the water from the tailings impoundment, promote settling of the fines, and store the water from all storm events. These ponds are all double lined using 60 mil HDPE for the primary liner and 30 mil VLDPE for the lower liner.

The tailings impoundment, diversion ditches and seepage ponds were all designed to accommodate flows from 100 year 24 hour storm events.

The potential seepage from the tailings impoundment system was calculated and compared to the permeability, percent moisture and saturation point of the soils beneath the impoundment. The analysis determined that even under maximum leak condition that it would be unlikely for the solutions to reach the groundwater.

4.3.4 Monitoring and Permit Requirements

As a requirement of their water pollution control permit, NEV 88009, Echo Bay reports on the following samples and analyses pertinent to the operation of the tailings impoundment, as shown in Table 4.3-1.

Table 4.3-1 Echo Bay Tailings Impoundment Monitoring Requirements

	Material	Reporting Frequency	Parameter
1.	Water Supply Wells	Annually	Profile I, Depth to groundwater
2.	Ground water monitoring wells	Annually	Profile I. Depth to groundwater
3.	Monitoring Wells	Quarterly	Profile I. Depth to groundwater
4.	Tailings and Reclaim solutions	Quarterly	Profile II
5.	Tailings Solids	Quarterly	Meteoric Water Mobility analysis
6.	Channel Leak Detection	Daily	Flow, in gpd

Profile I includes: As, Ba, Cd, Cr, Cu, Fe, Pb, Mg, Hg, K, Se, Ag, Na, Zn
Alkalinity, TDS, WAD CN, Cl, F, Nitrate, Sulfate.

Profile II includes: All constituents in Profile I and:
Al, Sb, Be, Bi, Ca, Co, Ga, La, Li, Mn, Mb,Ni, P, Sc, St, Th, Sn, Ti, Va.

The permit also requires zero discharge to surface waters, and ground water releases may not cause violations of drinking water standards or result in WAD cyanide concentrations over 0.2 mg/l.

Upon termination of the active use of the tailings impoundment, the deposited tailings material will dry to form an impermeable seal over the impoundment. A low berm will be built around the top to contain precipitation and allow evaporation. The sides of the impoundment will be flattened to a slope of 2-1/2:1 or flatter, and the entire impoundment will be covered with stockpiled soil and reseeded. Seepage from the impoundment will be collected until seepage stops, and the diversion ditches installed during construction will remain in place. Solutions in the ponds will be evaporated and the resulting solids will be sampled and analyzed to determine if it has any potential to degrade the waters of the State. If so, it will be removed and disposed of in a manner approved by NDEP. If acceptable it will be folded in with the primary liner and buried with the pond. Pond areas will be backfilled, and graded, and after spreading of topsoil will be reseeded. All slopes will be stabilized and berms and ditches destroyed.

4.3.5 Corrective Actions

During compliance inspections, NDEP noted the recurrence of process solution discharge from the west side of the mill building onto native soils. During one inspection, NDEP personnel found that the saturated soils resulting from a release had been covered up with about 5 inches of uncontaminated soil. Echo Bay Minerals Company responded by completing repairs which initially caused the spill, and investigating clean up of the original release. While the contaminated soil had been removed and replaced with uncontaminated soil, no records had been kept regarding the amount of material removed and improper clean up procedures were used. Echo Bay performed a second remediation and performed the necessary sampling to ensure all the contaminated soil was removed and processed through the mill facility. Disciplinary action was taken against the personnel involved in the first clean up, and an HDPE liner was installed on the upper part of wall within the mill building to ensure no further releases from the mill building would occur.

In a separate case, Echo Bay also reported to NDEP changes in water chemistry which were detected in monitoring wells. These changes included high levels of fluoride and increased pH levels. Echo Bay retained a hydrogeologic consulting firm to determine the if contamination of the groundwater occurred and the source. The consulting firm determined that the fluoride levels were naturally occurring and the increased pH levels were caused by improper monitoring well sampling protocols. Echo Bay revisited and revised their monitoring well sampling plans accordingly.

5. COMPARATIVE ANALYSIS

5.1 Statement of Purpose

The purpose of 40 CFR 192 is to correct and prevent contamination of air and the groundwater beneath and in the vicinity of inactive uranium processing sites. These sites were contaminated throughout the cold war during uranium mining and milling operations. EPA promulgated 40 CFR 192 after the enactment of the UMTRCA, which was enacted to remediate these abandoned facilities. In general, 40 CFR 192 governs management of the waste, i.e. uranium byproduct material and the design, operation, and closure of surface impoundments and facilities through cross reference to the RCRA regulations. The RCRA regulations provide standards applicable to the design, operation and closure of facilities with tailing impoundments.

Nevada, on the other hand, promulgated its State regulations governing the design, construction, operation, and closure of its mining operations to prevent degradation of the water from active operations. Nevada regulates the design, operation, and closure of its leaching facilities, along with the tailings and disposal sites specifically to ensure protection of the waters of the State during operation and after closure. Nevada's framework is intended to govern the design and operation of the process component of the facility prior to the waste generation. In practice, of course, since most tailings impoundments are left in place at closure, the regulations effectively address waste management design as well.

Provisions are made for facilities in existence prior to promulgation of the regulations. However, Nevada mining regulations require planning for the proper handling of mill tailings, and facility closure and site reclamation is determined during the design and construction phases of the projects.

5.2 Technical Differences

When comparing the two frameworks it is necessary to remember that recovery of gold from ores does not produce a radioactive waste with potential radioactive environmental and health effects. Second, the value of the ores is substantially different due to each ton of ore yielding either several pounds of uranium metal compared to 0.08 and higher troy ounces (approximately 0.006 pounds) of gold.

In regulating the design, operation and closure of tailings impoundments The State of Nevada uses to their advantage the low precipitation, high evaporation, and relatively deep groundwater typical throughout the state. This would be extremely difficult for the federal regulations to enact do to the varied environmental conditions found throughout the United States.

5.3 Regulatory Comparison

A tabular comparison of the regulatory criteria applicable to heap leaching for Nevada, 40 CFR 192, and the three facilities discussed is shown in Table 5.3-1.

Table 5.3-1 - Comparison of the Regulatory Criteria for Mill Facilities and Tailings Impoundments

Regulatory Criteria	Nevada Regulations NAC 445A, 519A	40 CFR 192	Newmont Rain Facility	Barrick Bullfrog Mine	Echo Bay McCoy/Cove
Permits required	Mining, reclamation and dam permits required prior to operation	Licenses to operate waste management and disposal units. No reclamation or dam permits required	State Water Pollution control permit. Reclamation Permit Dam Permit	State Water Pollution control permit. Reclamation Permit Dam Permit	State Water Pollution control permit. Reclamation Permit Dam Permit
Geological Assess.	Ability of geology to inhibit contaminant migration	Only specified if seeking an exemption to liner requirements	Assessed Soils and clays underlying tailings impoundment and ability to prevent solution seepage into the groundwater.	Assessed Soils and clays underlying tailings impoundment and ability to prevent solution seepage into the groundwater.	Assessed Soils and clays underlying tailings impoundment and ability to prevent solution seepage into the groundwater.
Hydrogeological Assessment	Identify all drinking water wells within 5 miles down gradient of the site. Depth of surface to groundwater. Quality, uses and potential uses of the ground and surface water within the area of review.	Only to exclude constituents from the 40CFR261 appendix VIII list - 264.92(b)(1)	Identified groundwater sources, quality, and depth to groundwater.	Identified groundwater sources, quality, and depth to groundwater.	Identified groundwater sources, quality, and depth to groundwater.
Topographical Evaluation	Identify known surface waterways, streams, springs, and seeps within 1 mile radius. Distance to all surrounding bodies of surface water.	Not specified	Identified surface water sources including seeps. Identified topographical slope and placement of the tailings impoundment	Identified surface water sources including seeps. Identified topographical slope and placement of the tailings impoundment	Identified surface water sources including seeps. Identified topographical slope and placement of the tailings impoundment

Regulatory Criteria	Nevada Regulations NAC 445A, 519A	40 CFR 192	Newmont Rain Facility	Barrick Bullfrog Mine	Echo Bay McCoy/Cove
Meteorological Report	Identify boundaries and area of up gradient watershed, and 10, 25 and 100 year, 24 hour storm events.	Only to exclude constituents from the 40CFR261 appendix VIII list - 264.92(b)(2) Identify and design to 25 year 24 hour storm event.	Prepared designs contain average annual precipitation and to meet 100 year 24 hour storm event. Also evaluated the evaporation rate to define settling and drying of tailings within the impoundment.	Prepared designs contain average annual precipitation and to meet 100 year 24 hour storm event. Also evaluated the evaporation rate to define settling and drying of tailings within the impoundment.	Prepared designs contain average annual precipitation and to meet 100 year 24 hour storm event. Also evaluated the evaporation rate to define settling and drying of tailings within the impoundment.
Ore/Waste Rock/Overburden Characterization	TCLP, Meteoric Water Mobility, and Acid Generating/ Neutralization Potential	Not specified	Meteoric Water Mobility, Acid Generating/ Neutralization Potential	Meteoric Water Mobility, Acid Generating/ Neutralization Potential	Meteoric Water Mobility, Acid Generating/ Neutralization Potential
Regulation basis	Clearly identified process components - a distinct portion of a facility which is a point source.	Point source compliance and compliance to design standard.	Identified potential point sources and designed accordingly to prevent degradation of waters of the State.	Identified potential point sources and designed accordingly to prevent degradation of waters of the State.	Identified potential point sources and designed accordingly to prevent degradation of waters of the State.
Surety Requirements	Estimated and obtained prior to reclamation permit and the start of operations	40 CFR 264.101 states that assurances of financial responsibility for corrective actions must be provided.	Part of reclamation permit.	Part of reclamation permit.	Part of reclamation permit.
Waste rock and over burden disposition	Evaluated by meteoric water mobility procedure. Any material which fails must be evaluated for containment or neutralization, and approved by NDEP prior to operation.	Not specified.	Waste rock pile. Seepage is monitored, after corrective action.	Waste rock pile. Seepage is monitored.	Waste rock pile. Seepage is monitored.

Nevada Gold Cyanide Milling Regulation

Regulatory Criteria	Nevada Regulations NAC 445A, 519A	40 CFR 192	Newmont Rain Facility	Barrick Bullfrog Mine	Echo Bay McCoy/Cove
Water Management	Water management plan approved prior to operation. Identify storm flow runoff control	Not specified	Water Management plan in place.	Water Management plan in place.	Water Management plan in place.
Permit approval	Review and approval by NDEP after public comment period and resolution.	Not specified	Operation in place prior to regulations.	Operation in place prior to regulations.	Operation in place prior to regulations.
Tailings Impoundments	<u>Minimum Design Criteria</u> Equivalent to 12 inches of soil liner with coeff. of perm. of $1x10^{-6}$ cm/sec. Or competent bedrock demonstrated equivalent to $1x10^{-6}$cm/sec.	Criteria for <u>Surface Impoundment</u> Three layers of solution containment Primary liner, e.g. geomembrane. Composite bottom liner - upper component e.g. geomembrane, -lower component: > 3 feet compacted soil with k no greater than $1x10^{-7}$ cm/sec	Tailings Impoundment has a 12" thick underdrain liner of compacted naturally occurring clays with permeabilities of 10^{-6} to 10^{-7} cm/sec. Also the area is underlain with naturally occurring highly impermeable clays with permeabilities ranging from 10^{-8} to 10^{-9} cm/sec.	12-inch thick clay amended soil (5% bentonite). Also, drained and consolidated tailings have a vertical permeability of 10^{-5} to 10^{-6} cm/sec.	Basin and embankment lined with 30 mil VLDPE over a prepared sub-base. No data on permeability of sub-base. Area overlain has permeability of 10^{-4} cm/sec.
Ponds - Minimum Design Criteria	Primary synthetic liner and secondary liner. System between liners to recover any fluid entering. Storm event ponds may be single liner systems.	Not specified - Use Surface impoundment	Double liner. 80-mil HDPE upper liner on top of unspecified grade HDPE lower liner. Geotextile between liners to direct leakage to sump. Under lower liner is 12 inches of compacted native clay. (This is a description of the heap leach ponds.)	Double liner. 60 mil HDPE upper liner with 40 mil HDPE lower liner. 0.25-inch geotextile between liners to act as LCRS.	Double liner. 60 mil HDPE upper liner with 30 mil VLDPE lower liner. No mention of geotextile between liners to act as LCRS.

Regulatory Criteria	Nevada Regulations NAC 445A, 519A	40 CFR 192	Newmont Rain Facility	Barrick Bullfrog Mine	Echo Bay McCoy/Cove
Liners - Minimum Design Criteria	Soil liners - minimum 12 inches thick compacted in lifts < 6 inches, perm of not more than $1x10^{-7}$cm/sec (except for tailings impoundments) Synthetic liners - coeff of perm. Not less than $1x10^{-11}$ cm/sec.	Not specified.	Synthetic - 80 mil HDPE native soils - 12 inch soils or native clays, coefficient of permeability was not specified.	Meets state requirements.	Meets state requirements.
Leak Detection	When installed under a single liner system, must include a means of recovering process fluids.	Must also serve as leachate collection and removal system. > 1% bottom slope, and 12 inches of Granular drainage material with $k=1x10^{-1}$ cm/sec or more; or Geonet drainage material with minimum transmissivity = $1x10^{-4}$ m^2sec	No leak detection for impoundment. Leak detection installed between synthetic liners for the ponds.	No leak detection for impoundment. Leak detection installed between synthetic liners for the ponds.	No leak detection for impoundment. No leak detection installed between synthetic liners for the ponds.
Monitoring location	At the interface between the process component and the adjacent environment	Determined by Regional Administrator, minimum must accurately represent water passing the point of compliance.	Underdrain collection pond leak detection sump, tails water and solids, seepage pond, upstream and downstream trench drains, monitoring wells	Tailings solids and water, reclaim pond water, monitoring wells.	Water supply wells, monitoring wells, tailings solids and water, channel leak detection.

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Regulatory Criteria	Nevada Regulations NAC 445A, 519A	40 CFR 192	Newmont Rain Facility	Barrick Bullfrog Mine	Echo Bay McCoy/Cove
Point of compliance	At the groundwater, to prevent degradation of the waters of state.	192.32(a)(2)(iv) >500 m from edge of disposal area or outside the site boundary. 264.95 Vertical surface located at the hydraulically down gradient limit of waste management area.	At the groundwater, to prevent degradation of the waters of state.	At the groundwater, to prevent degradation of the waters of state.	At the groundwater, to prevent degradation of the waters of state.
Monitoring frequency	Determined by NDEP	Specified by Regional Administrator, but no less than a sequence of 4 samples from each well at semiannually for both detection & compliance.	Leak detection flows - daily Monitoring wells quarterly	Collected weekly and composited into quarterly sample.	Leak detection flows - daily Monitoring wells quarterly supply wells-annually
Monitoring constituents	Per NDEP form 0090	Per 261 appendix VIII	Seepage and Monitoring Wells - Profile I includes: As, Ba, Cd, Cr, Cu, Fe, Pb, Mg, Hg, K, Se, Ag, Na, Zn, Alkalinity, TDS, WAD CN, Cl, F, Nitrate, Sulfate. Tailings solids and water - Profile II includes: All constituents in Profile I and: Al, Sb, Be, Bi, Ca, Co, Ga, La, Li, Mn, Mb, Ni, P, Sc, St, Th, Sn, Ti, Va. Tailings solids - meteoric water mobility	All - Profile II includes: All constituents in Profile I and: Al, Sb, Be, Bi, Ca, Co, Ga, La, Li, Mn, Mb, Ni, P, Sc, St, Th, Sn, Ti, Va. Tailings solids - meteoric water mobility	Seepage and Monitoring Wells - Profile I includes: As, Ba, Cd, Cr, Cu, Fe, Pb, Mg, Hg, K, Se, Ag, Na, Zn, Alkalinity, TDS, WAD CN, Cl, F, Nitrate, Sulfate. Tailings solids and water - Profile II includes: All constituents in Profile I and: Al, Sb, Be, Bi, Ca, Co, Ga, La, Li, Mn, Mb, Ni, P, Sc, St, Th, Sn, Ti, Va. Tailings solids - meteoric water mobility

Nevada Gold Cyanide Milling Regulation

Regulatory Criteria	Nevada Regulations NAC 445A, 519A	40 CFR 192	Newmont Rain Facility	Barrick Bullfrog Mine	Echo Bay McCoy/Cove
Monitoring reporting requirements	Minimum - quarterly	Reporting required only upon significant evidence of contamination.	Complete analysis-quarterly	Complete analysis-quarterly	Complete analysis-quarterly
Corrective Action by Permittee - Release to the environment	Identify source, determine extent of system to contain or confine, identify remediation methods.	Notify Regional Administrator, resample at regular intervals. May be required to	Identified source, contained contamination, prepared remedial action plan	Identified source, contained contamination, prepared remedial action plan	Identified source, contained contamination, prepared remedial action plan
Corrective Action by Regulatory Agency - Release to the environment	Require immediate shutdown, allow continued operation during cleanup or control, or indicate no remedial action.	If statistically significant may require a corrective action plan.	Allowed continued operation	Allowed continued operation	Allowed continued operation
Surface Water stds.	NRS 445.253				
Groundwater stds.	Not less than federal drinking water standards WAD CN < 0.2mg/l NDEP may add other unregulated constituents	Not less than federal drinking water standards	Do not degrade waters of the state to less than state drinking water standards and WAD CN < 0.2mg/l.	Do not degrade waters of the state to less than state drinking water standards and WAD CN < 0.2mg/l.	Do not degrade waters of the state to less than state drinking water standards and WAD CN < 0.2mg/l.
Groundwater exemptions	NDEP may exempt all or a portion of groundwater if not currently or potential drinking water source. Based on depth, location, TDS >10,000 mg/l.	Regional Administrator may exempt a constituent from monitoring if it does not pose a potential threat to human health or the environment.	No exemptions granted.	No exemptions granted.	No exemptions granted.

Regulatory Criteria	Nevada Regulations NAC 445A, 519A	40 CFR 192	Newmont Rain Facility	Barrick Bullfrog Mine	Echo Bay McCoy/Cove
Closure requirements	Remove process solutions from the system, limit run-on precipitation, prevent wind erosion, and ensure no degradation to waters of the state.	Remove solids and containment systems and handle as hazardous waste; or eliminate free liquid, stabilize solids to sufficient bearing capacity and install final cover.	Drain down impoundment, remove and process solutions, provide new run-on diversion channels, cover with waste rock regrade and reseed.	At the end of operation impoundment will be drained down. Solutions will be removed and reused. The impoundment will be covered, prepared and reseeded. Monitoring of seepage will continue for 5 years.	Dry tailings material will act as seal to the impoundment. Construct low berm to contain precipitation for evaporation, cover impoundment with stockpiled soil and reseed. Seepage will be collected until seepage stops.
Final closure slope stability	Permittee must show that all slopes created by mining operations have an erosional stability comparable to adjacent areas. For slopes >3:1, Mass stability should consider Infinite slope, circular slope, block slope, and wedge slope failures, all for static and pseudo static scenarios. Minimum safety factor of 1.3 for static and 1.05 for pseudo-static.	Not specified.	Recontoured per requirements to achieve post mining land use.	Recontoured per requirements to achieve post mining land use. final slope will be 0.75% from natural deposition of tailings in the impoundment.	Recontoured per requirements to achieve post mining land use. Embankments will be flattened to achieve 2-2/1:1 slope or flatter.
Revegetation requirements	provided	Not specified	Per requirements	Per requirements	Per requirements

Regulatory Criteria	Nevada Regulations NAC 445A, 519A	40 CFR 192	Newmont Rain Facility	Barrick Bullfrog Mine	Echo Bay McCoy/Cove
Post closure monitoring	Depends on site, but no greater than 30 years.	Minimum 30 years.	Groundwater monitoring will be performed throughout the closure period and longer as agreed to with NDEP. Any migration of contaminant plume outside the facility boundary which may impair beneficial use of the groundwater will be prevented including installation of a barrier well pumpback system.	5 year closure and monitoring and maintenance period	Seepage is collected until it stops.

6.0 CONCLUSIONS

Along with the distinct differences in the recovery processes discussed in section 5.2, the following items can be concluded regarding the two regulatory frameworks and the application of the Nevada regulations at three facilities.

- The minimum design criteria for the State of Nevada and 40 CFR 192 are substantially different. The State of Nevada minimum design criteria for tailings impoundments include a 12 inch thick soil liner with a coefficient of permeability of 10^{-6} cm/sec, or equivalent. The design criteria for tailings impoundments under 40 CFR 192 requires three layers of solution containment - two of flexible geomembrane and a bottom liner of 3 feet of compacted soil with a coefficient of permeability no greater than 10^{-7} cm/sec, with geotextile leak detection collection system between the liners.

- Nevada regulations require review of dam design, construction and maintenance requirements prior to issuing a dam permit. 40 CFR 192 does not specify requirements for the dam associated with a tailings impoundment.

- Nevada State regulations are written and enforced to prevent degradation to the waters of the state, where the 40 CFR 192 regulations are written to prevent any release to the groundwater. Because of this difference the Nevada regulations require identification of all drinking water sources, groundwater and surface water sources and quality.

- Nevada closure requirements are focus on preventing degradation of the waters of the state, and converting the land to a post-mining use. Also due to the low precipitation and high evaporation rates, typically state wide, final covers are designed to hold precipitation for subsequent evaporation. 40 CFR 192 requires dewatering, stabilization, and installation of a cover which will prevent precipitation from moving through the impoundment.

- Nevada regulations for post closure monitoring are established on a facility basis, but is no longer than 30 years. 40 CFR 192 requires monitoring of no less than 30 years.

- The three mines evaluated generally adhered to the requirements of the State of Nevada, however, the lack of some documentation made it difficult to verify liner thickness and coefficient of permeability.

- All of the mine sites promptly responded to the NDEP requests for further information or corrective actions for deficient operations.

Attachment 1

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