3.0 SURFACE WATER HYDROLOGY AND EROSION PROTECTION

3.1 Hydrologic Description of Site

Criterion 1 of 10 CFR Part 40, Appendix A, addresses the general goals of siting and designing facilities to provide for permanent isolation of tailings, and minimizing the potential for dispersion by natural forces, without the need for active maintenance. Information presented in Section 3.1 will be used in later sections of this standard review plan to assess the ability of the site and the site design to meet this and other requirements of 10 CFR Part 40.

It is important to note that the siting criteria presented in 10 CFR Part 40, Appendix A are intended to apply to uranium mills that have not yet been constructed. For many, if not most, uranium mills, reclamation plans are developed for sites that have existed for several decades. In fact, many mills were producing uranium before the siting criteria were developed. Therefore, the staff concludes that Criterion 1 is more relevant to new facilities (or modifications to old facilities) than to facilities that existed before regulations were developed.

3.1.1 Areas of Review

The staff should review hydrologic site characterization information, including (1) identification of the relationships of the site to surface-water features in the site area and (2) identification of mechanisms, such as floods and dam failures, that may require special design features to be implemented. This review requires identification of the hydrologic characteristics of streams, lakes (e.g., location, size, shape, drainage area), and existing or proposed water control structures that may adversely affect the long-term stability of the site design features.

3.1.2 Review Procedures

The staff should evaluate the completeness of the information and data, by sequential comparison with information available from references. On the basis of the description of the hydrosphere (e.g., geographic location and regional hydrologic features), potential site flood mechanisms are identified. The information normally presented is not amenable to independent verification, except through cross-checks with available publications related to hydrologic characteristics of the site region and through observation during site visits.

The staff should also analyze geomorphic considerations, as described in Section 1 of this standard review plan. On the basis of these analyses, the staff should estimate the potential for geomorphic instability to occur and to have a significant effect on the ability of the site and its protective features to prevent flood intrusion and erosion over a long period of time. If geomorphic problems are identified, the staff should give particular attention to several areas of the design, depending on site conditions and potential for geomorphic changes to occur. These areas include the (1) apron and toe of the disposal cell, (2) intersection of natural gullies with erosion protection features, and (3) diversion channel outlets. A detailed discussion of the erosion protection design for these and other features is given in Section 3.4.2 of this standard review plan.

3.1.3 Acceptance Criteria

The hydrologic description of the site will be considered acceptable if:

(1) The description of structures, facilities, and erosion protection designs is sufficiently complete to allow independent evaluation of the impact of flooding and intense rainfall.

(2) Site topographic maps are of good quality and of sufficient scale to allow independent analysis of pre- and post-construction drainage patterns.

(3) The reclamation plan contains sufficient information for the staff to independently evaluate the hydraulic designs presented. In general, detailed information is needed for each method that is used to determine the hydraulic designs and erosion protection provided to meet NRC regulations. NUREG–1623 (NRC, 2002) discusses acceptable methods for designing erosion protection to provide reasonable assurance of effective long-term control and, thus, conform to NRC requirements. NUREG–1623 (NRC, 2002) also provides discussions and technical bases for use of specific criteria to meet the 1,000-year longevity requirement, without the use of active maintenance. Specific design methods are provided and form the primary basis for staff review of erosion protection designs.

3.1.4 Evaluation Findings

If the staff evaluation of hydrologic and hydraulic engineering aspects of the reclamation plan confirms that the information acceptably characterizes the site and the site design features, the following conclusions may be presented in the technical evaluation report:

The staff has completed its review of the flooding potential at the _______________ uranium mill facility. This review included an evaluation using the review procedures in Section 3.1.2 and acceptance criteria outlined in Section 3.1.3 of this standard review plan.

On the basis of the information presented in the application and the detailed review conducted of the flooding potential for the _______________ uranium mill facility, the NRC staff concludes that (1) the flood analyses and investigations adequately characterize the flood potential at the site, (2) the analyses of hydraulic designs are appropriately documented, and (3) the general reclamation plan with respect to surface-water hydrology and erosion considerations, represents a feasible plan, for complying with the requirements of 10 CFR Part 40, Appendix A. The characterization of flood potential and the documentation of the site design conform to the requirements of Criterion 1 of 10 CFR Part 40, Appendix A, which requires a design that provides for permanent isolation of tailings and minimizes disturbance and dispersion by natural forces.

3.1.5 References

NRC. NUREG–1623, “Design of Erosion Protection for Long-Term Stabilization.” Washington, DC: NRC. 2002.

3.2 Flooding Determinations

3.2.1 Areas of Review

The staff should assess the flooding potential for the site, and should determine precipitation potential, precipitation losses, runoff response characteristics, and peak flow estimates for the probable maximum flood or project design flood (if a flood less than the probable maximum flood is used). The staff should review the following design analyses: (1) the analyses and justification for the use of a flood less than the probable maximum flood, if applicable; (2) the probable maximum precipitation potential and resulting runoff for site drainage and for drainage areas adjacent to the site; and (3) the modeling of physical rainfall and runoff processes to estimate flood conditions at the site.

The assessment of flooding also should include a review of possible geomorphic changes that could affect the erosion protection design for the site. As applicable, the staff should review the following: (1) identification of types of geomorphic instability; (2) changes to, and impacts associated with, flooding and flood velocities from geomorphic changes; and (3) mitigative measures to reduce or control geomorphic instability. This information must be reviewed to determine the acceptability of hydraulic engineering designs to mitigate the geomorphic conditions and to avoid the need for ongoing active maintenance.

The assessment of flooding should also include a review of potential dam failures, if upstream reservoirs exist. Peak water levels, flood routing procedures, and velocities should be reviewed in the determination of potential hazards because of failure of upstream water control structures from either seismic or hydrologic causes. If an existing analysis concludes that seismic or hydrologic events will not cause failures of upstream dams and produce the governing flood at the site, the analysis should be reviewed to verify that information that supports such a conclusion (e.g., record of contact with dam designers) is included. If an analysis is provided that concludes that a dam failure flood from a probable maximum flood or a seismically induced flood is the design-basis flood, the computations should be reviewed to verify that appropriate and/or conservative model input parameters have been used.

3.2.2 Review Procedures

The evaluation of flooding is, for review purposes, separated into two parts: (1) flooding on large adjacent streams, as applicable, and (2) localized flooding on drainage channels and protective features. The acceptability of using the probable maximum flood as the design flood event is presented in Section 2.2.1 of NUREG–1623 (NRC, 2002). The review procedure for evaluating a probable maximum precipitation/probable maximum flood event is outlined in Appendix D of NUREG–1623 (NRC, 2002). For large drainage areas, probable maximum flood estimates approved by the U.S. Army Corps of Engineers and found in published or unpublished reports of that agency, or generalized estimates, may be used instead of independent staff-developed estimates. The staff should also assess flood history in the site area by examining historic regional flood data. For many areas, historic flood peaks could be a small percentage of the probable maximum flood. If the historic maximum floods exceed or closely approximate the proposed probable maximum flood estimates, the staff should perform a detailed evaluation to determine the basis for the estimates. The staff should compare basin lag times, rainfall distributions, soil types, and infiltration loss rates to determine if there is a logical basis for the probable maximum flood values being less than historic floods. Without such estimates, the staff should generally use U.S. Army Corps of Engineers models to independently estimate probable maximum flood discharge and water levels at the site. If detailed computer models are used, the staff should review the adequacy of the various input parameters to the model, including, but not limited to, the following: drainage area, lag times and times of concentration, design rainfall, incremental rainfall amounts, temporal distribution of incremental rainfall, and runoff/infiltration relationships.

The staff should review the dam failure analyses presented in the reclamation plan or should independently estimate the peak flows at the site. Often, it may be much easier to perform simplified flood analyses assuming a dam failure, rather than detailed analyses of the seismic resistance of a dam. In such cases, the staff should review those simplified flood analyses using the procedures outlined in standard review plan Section 3.3.4.

The staff should evaluate the information presented in the reclamation plan using procedures found in Appendix C of NUREG–1623 (NRC, 2002) in those cases in which it is documented that it is impractical to design erosion protection features for an occurrence of the probable maximum flood. These procedures contain detailed information regarding justification of a stability period of less than 1,000 years. To assure that minimum NRC requirements are met, the staff should independently check and evaluate the ability of the design to resist such flood events.

In the detailed review of flooding, the staff should carefully consider the following factors that are important in determining a local probable maximum precipitation/probable maximum flood event:

- Determination of Design Rainfall Event. The staff should consult appropriate hydrometeorological reports and determine that correct values of the 1- and 6-hour probable maximum precipitation events, as applicable, have been given.

- Infiltration Losses. The staff should check calculations to verify that appropriate values of infiltration have been selected.

- Times of Concentration. The staff should verify that appropriate methods (depending on the slope, configuration, etc.) have been selected. The staff should independently verify that the methods selected compare reasonably well with various velocity-based methods.

- Rainfall Distributions. The staff should verify that the rainfall distributions (particularly the 2½-, 5-, and 15-minute distributions) compare well with the distributions suggested in Appendix D to NUREG–1623 (NRC, 2002).

For dam failures, the staff should review estimates of flood potential and water levels. Depending on the potential for flooding, the staff should verify that the dam failure analyses are either realistic or conservative by determining locations and sizes of upstream dams, assuming an instantaneous failure (complete removal) of the dam embankment, and computing the peak outflow rate.

If this simplified analysis indicates a potential flooding problem, the analysis may be repeated using more refined techniques, and the staff may request additional information and data. Detailed failure models, such as those of the Army Corps of Engineers and National Weather Service, will be used to identify the outflows, failure modes, and resultant water levels at the site.

Assessments of flooding will be used to determine the acceptability of hydraulic engineering design to avoid the need for ongoing active maintenance at the site.

If a flood less than a probable maximum flood can cause dam failure and is proposed as the design-basis flood, the staff should employ the review procedures outlined above to determine the impracticality of designing for a probable maximum flood and to determine the acceptability of the flood used.

3.2.3 Acceptance Criteria

The flooding determinations for the site will be considered acceptable if:

The designs conform to the suggested criteria in Appendix D to NUREG–1623 (NRC, 2002). NUREG–1623 (NRC, 2002) discusses acceptable methods for designing erosion protection to provide reasonable assurance of effective long-term control and to meet NRC requirements. It also presents discussions and technical bases for use of specific criteria to meet the 1,000-year longevity requirement without the use of active maintenance. Acceptable design methods are presented and form the primary basis for staff review of erosion protection designs. These methods were derived from regulatory requirements, other regulatory guidance, staff experience, and various technical studies.

Information pertinent to computation of the design flood is submitted in sufficient detail to enable the staff to perform an independent flood estimate, Specifically:

- Model input parameters are adequate.

- Staff and the reclamation plan estimates of flood levels and peak discharges are in agreement.

- Computational methods for design flood estimates are adequate.

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“Worst conditions” postulated in the analysis of upstream dam failures are (1) an approximate 25-year flood on a normal operating reservoir pool level coincident with the dam-site equivalent of the earthquake for which the remedial action project is designed, (2) a flood of about one-half the severity of a probable maximum flood on a normal reservoir pool level coincident with the dam-site equivalent of one-half of the earthquake for which the remedial action project is designed; and (3) a probable maximum flood (or design flood) on a normal reservoir pool. Conditions 1 and 2 are applied when the dam is not designed with adequate seismic resistance; Condition 3 is applied when the dam is not designed to safely store or pass the design flood.

If the proposed design is based on less than a probable maximum flood event, the licensee offers reasonable assurance of conforming to the stability requirement of at least 200 years.

Dam failure analyses are either realistic or conservative, and include locations and sizes of upstream dams, instantaneous failure (complete removal) of the dam embankment, and compute the peak outflow rate.

3.2.4 Evaluation Findings

If the staff evaluation of hydrologic and hydraulic engineering aspects of the reclamation plan confirms that the assessments of flooding are acceptable, the following conclusions may be presented in the technical evaluation report.

The staff has completed its review of the flooding potential at the ______________ uranium mill facility. This review included an evaluation using the review procedures in Section 3.2.2 and the acceptance criteria outlined in Section 3.2.3 of this standard review plan.

On the basis of information presented in the application and the detailed review conducted of the flooding potential for the _______________ uranium mill facility, the NRC staff concludes that the flood analyses and investigations adequately characterize the flood potential at the site and that the surface water hydrology and flooding considerations represent a feasible plan for meeting the requirements of 10 CFR Part 40, Appendix A.

The mill tailings at the ________________ uranium mill facility will be protected from flooding and erosion by an engineered rock riprap layer that has been designed in accordance with the guidance suggested by the staff. Flood analyses presented by the licensee demonstrate that this erosion protection is adequate, based on (1) selection of proper rainfall and flooding events; (2) selection of appropriate parameters for determining flood discharges; and (3) computation of flood discharges, using appropriate and/or conservative methods.

The licensee presented analyses to show that the site is located in an area rarely flooded by off-site floods and that it is protected from direct on-site precipitation and flooding. The erosion protection is large enough to resist flooding from the shallow depths and minimal forces of floods occurring from a probable maximum flood in the upstream drainage area. The staff therefore concludes that the erosion potential at the proposed site has been acceptably minimized, since any flooding at the site is mitigated by the erosion protection, and the forces associated with off-site floods are minimal. The staff also concludes that, because the rainfall and flooding events have very low probabilities of occurrence over a 1,000-year period, no damage to erosion protection is expected from these, or more frequent, events. Therefore, maintenance or repair of damage will not be necessary.

On the basis of the information presented in the application and the detailed review conducted of the flooding potential for the _______________ uranium mill facility, the NRC staff concludes that the flood analyses contribute to meeting the following requirements of 10 CFR Part 40, Appendix A: Criterion 1, requiring that erosion, disturbance, and dispersion by natural forces over the long term are minimized and that the tailings are disposed of in a manner that does not require active maintenance to preserve conditions of the site; Criterion 4(a), requiring that upstream rainfall catchment areas are minimized to decrease erosion potential and to resist floods that could erode or wash out sections of the tailings disposal area; Criterion 6(1), requiring that the design be effective for a period of 200–1,000 years; and Criterion 12, requiring that active maintenance is not necessary to preserve isolation.

3.2.5 References

NRC. NUREG–1623, “Design of Erosion Protection for Long-Term Stabilization.” Washington, DC: NRC. 2002.

3.3 Water Surface Profiles, Channel Velocities, and Shear Stresses

3.3.1 Areas of Review

Depending on the type of computational models used, the staff should review the model, including the determination of flooding depths, channel velocities, and/or shear stresses used to determine riprap sizes needed for erosion protection. The staff should review the various detailed computations for each model and should review the acceptability of the input parameters to the model. The staff should estimate the flood levels, velocities, shear stresses, and magnitudes, as described below. The review should be oriented toward verifying that the site will not require ongoing active maintenance.

3.3.2 Review Procedures

Using the guidance presented in Appendix D to NUREG–1623 (NRC, 2002) the staff should verify that localized flood depths, velocities, and shear stresses used in models for rock size determination or soil cover slope analysis are acceptable. For off-site flooding effects, the staff should verify that computational models have been correctly and appropriately used and that the data from the model have been correctly interpreted. The staff should verify that acceptable models and input parameters have been used in all the various portions of the flood analyses and that the resulting flood forces have been adequately accommodated.

Staff estimates may be made independently from basic data, by detailed review and checking of the reclamation plan analyses, or by comparison with other estimates that have been previously reviewed in detail. The evaluation of the adequacy of the estimates is a matter of engineering judgment, and is based on the confidence in the estimate, the degree of conservatism in each parameter used in the estimate, and the relative sensitivity of each parameter as it affects the flood level, flood velocity, or design of the erosion protection.

The staff review should evaluate whether ongoing active maintenance will be required at the site.

3.3.3 Acceptance Criteria

The water surface profiles, channel velocities, and shear stresses calculated for the site will be considered acceptable if:

The proposed designs conform to the suggested criteria in Appendix D to NUREG–1623 (NRC, 2002). NUREG–1623 (NRC, 2002) discusses acceptable methods for designing erosion protection to provide reasonable assurance of effective long-term control and to comply with NRC requirements. This document also contains discussions and technical bases for use of specific criteria to meet the 1,000-year longevity requirement without the use of active maintenance. Specific design methods are presented, and reasonable similarity to these methods forms the primary basis for staff acceptance of erosion protection designs. Specifically:

- Localized flood depths, velocities, and shear stresses used in models for rock size determination or soil cover slope analysis conform to the guidance presented in Appendix D to NUREG–1623 (NRC, 2002).

- For off-site flooding effects, computational models have been correctly and appropriately used and the data from the models have been correctly interpreted.

- Acceptable models and input parameters have been used in all the various portions of the flood analyses and the resulting flood forces have been adequately accommodated.

3.3.4 Evaluation Findings

If the staff evaluation of hydrologic and hydraulic engineering aspects of the reclamation plan confirms that the assessments of flooding are acceptable, the following conclusions may be presented in the technical evaluation report:

The staff has completed its review of the flooding models at the _____________ uranium mill facility. This review included an evaluation using the review procedures in Section 3.3.2 and the acceptance criteria outlined in Section 3.3.3 of this standard review plan.

On the basis of the information presented in the application and the detailed review conducted of the flooding models for the ____________ uranium mill facility, the NRC staff concludes that flood velocities and forces associated with flooding at the site have been acceptably computed.

The mill tailings will be protected from flooding and erosion by an engineered rock riprap layer that has been designed in accordance with the guidance suggested by the staff. Flood analyses presented by the licensee demonstrate that adequate protection is provided by (1) selection of proper models to assess rainfall and flooding events, (2) selection of appropriate parameters for models for determining flood forces, and (3) computation of flood forces using appropriate and/or conservative methods.

The staff considers that the riprap layers proposed will not require active maintenance over the 1,000-year design life, because the licensee adopted models that conservatively compute flood forces used to design the erosion protection. Thus, the use of conservative design parameters will result in no damage to the erosion protection designed using those methods. The staff further concludes that the hydraulic design features are sufficient to protect the tailings from flood forces that are very large and have very low probabilities of occurrence over a 1,000-year period. Therefore, maintenance of the rock layers will not be necessary.

The staff concludes that the analyses and models used at the _______________ uranium mill facility contribute to meeting the following requirements of 10 CFR Part 40, Appendix A: Criterion 1, requiring that erosion, disturbance, and dispersion by natural forces over the long term are minimized and that the tailings are disposed of in a manner that does not require active maintenance to preserve conditions of the site; Criterion 6(1), requiring the design to be effective for a period of 200 to 1,000 years; and Criterion 12, requiring that active ongoing maintenance is not necessary o preserve isolation of the tailings.

3.3.5 Reference

NRC. NUREG–1623, “Design of Erosion Protection for Long-Term Stabilization.” Washington, DC: NRC. 2002.

3.4 Design of Erosion Protection

3.4.1 Areas of Review

Design details and analyses pertinent to the following aspects of erosion protection will be reviewed, as applicable:

(1) Erosion protection for slopes and channel banks to protect against flooding from nearby large streams.

(2) Erosion protection for the top and side slopes of the pile.

(3) Erosion protection for the apron/toe area of the side slope.

(4) Erosion protection for drainage and diversion channels, including channel outlets.

(5) Durability of the erosion protection.

(6) Construction considerations, including specifications, quality assurance programs, quality control programs, and inspection programs.

In Section 3.4.2.4 (below), sedimentation in diversion channels is also addressed. Criterion 4(f) of 10 CFR Part 40, Appendix A, suggests that deposition of sediment in impoundment areas should be considered for enhancing the cover thickness. The staff considers it important to differentiate between beneficial and detrimental sediment accumulations. For example, if sediment could be conveniently routed to the middle of an impoundment, without long-term erosion or ponding of runoff that could affect ground-water conditions, such deposition may enhance long-term cover thickness. However, this is difficult to actually achieve. The major problem with sediment is that it tends to accumulate in diversion channels that are constructed on relatively flat slopes. High-velocity runoff from steep slopes carries sediment into low-velocity diversion channels, and that sediment can eventually accumulate and completely block the channel. Thus, it can be seen that some sediment buildup is good and some is bad. The review should evaluate the need for ongoing active maintenance of the site.

3.4.2 Review Procedures

The staff should check the analyses in the reclamation plan or perform independent review analyses of floods, flood velocities, and rock durability according to the guidelines in Appendix D to NUREG–1623 (NRC, 2002). The following areas should be evaluated.

(1) Banks of Natural Channels

The staff should review designs for riprap to be placed on the side slopes of a reclaimed pile or on natural channel banks to protect against erosive velocities from floods on large rivers. Guidance is presented in Appendix D to NUREG–1623 (NRC, 2002) for assessing floods, determining input parameters to models, and determining riprap requirements.

(2) Top Slope and Side Slopes

The staff should review input parameters to calculations and models according to the recommendations given in Appendix D to NUREG–1623 (NRC, 2002) and referenced technical procedures. The staff should assess the design flow rate, the depth of flow, angle of repose, specific gravity, and other parameters. For both the top and side slopes, the rock sizes should be checked using the recently developed, simplified procedures discussed in NUREG–1623 (NRC, 2002).

(3) Apron/Toe

The design of the apron and toe is reviewed by verifying that several design features in this area have been properly designed, in accordance with the recommendations in NUREG–1623 (NRC, 2002).

For the lower end of the side slope where it meets the toe, the staff should verify that proper consideration has been given to the potential occurrence of increased shear forces resulting from turbulence and energy dissipation produced by hydraulic jumps, when the flow transitions from supercritical to subcritical. The staff should verify that appropriate design criteria have been used to increase the rock size to account for the increased velocities or shear forces.

For the main area of the toe, the staff should assure that appropriate methods have been used to design the riprap, depending on the magnitude of the slope of the toe.

For the downstream end of the toe, the staff should verify that acceptable assumptions have been made regarding the assumed collapse of the rock into scoured areas to prevent gully intrusion. Flow concentrations, collapsed slopes, and computational models should be evaluated.

For the natural ground area at the downstream end of the toe, the staff should verify that appropriate methods have been used to compute scour depths and that natural erosion will not adversely affect long-term stability.

(4) Diversion Channels

Using the criteria and guidance presented in Appendix D to NUREG–1623 (NRC, 2002), the staff should evaluate the design of diversion channels in several critical areas.

For the main channel area, the staff should verify that appropriate models and input parameters have been used to design the erosion protection. The staff should assure that flow rates, flow depths, and shear stresses have been correctly computed.

For the channel side slopes, the staff should verify that the side slopes are capable of resisting flow velocities and shear stresses from flows that occur directly down the side slope. This occurs often when diversion channels are constructed perpendicular to natural gullies (which discharge into the diversion channel). The shear forces in these locations often greatly exceed the forces produced by flows in the channel, particularly when the slope of the natural ground in the area is greater than the slope of the diversion channel.

For the outlet of the diversion channel, the staff should evaluate the design of erosion protection to assure that erosion in the discharge area (normally a natural gully, swale, or channel) has been adequately addressed. Designs similar to apron/toe designs should be evaluated to determine their resistance to erosion. Appendix D to NUREG–1623 (NRC, 2002) discusses acceptable methods for designing channel outlets.

For the entire length of the diversion channel, the staff should evaluate the effects of sediment accumulations on flow velocities, channel capacity, and need for increased rock size. Particular attention should be given to designs in which steep natural streams discharge into relatively flat diversion channels, greatly increasing the potential for blockage of the channel. Appendix E to NUREG–1623 (NRC, 2002) discusses acceptable methods for assessing sedimentation in diversion channels.

(5) Rock Durability

The staff should review the results of durability testing of proposed rock sources to assure that durable rock will be used. Appendix D to NUREG–1623 (NRC, 2002) presents a detailed method for evaluating rock quality for various locations and applications. If durable rock is not available to the site, to the extent practical, the reviewer should review the alternative proposed by the applicant and the associated analysis to assure that the alternative provides reasonable assurance that the radon barrier will be effective for 1,000 years, to the extent reasonably achievable, and in any case, for at least 200 years.

(6) Construction Considerations

The staff should review the plans, specifications, inspection programs, and quality assurance/quality control programs to assure that adequate measures are being taken to construct the design features according to accepted engineering practices. The staff should compare the information presented with typical programs used in the construction industry. Appendix F to NUREG–1623 (NRC, 2002) contains examples of acceptable specifications and testing programs that were approved by the staff and actually applied at several sites.

(7) The review shall specifically evaluate whether the erosion protection design is sufficient to avoid the need for ongoing active maintenance at the site.

3.4.3 Acceptance Criteria

The design of erosion protection for the site will be considered acceptable if:

The proposed designs conform to the suggested criteria in NUREG–1623 (NRC, 2002) . NUREG–1623 (NRC, 2002) discusses acceptable methods for designing erosion protection to provide reasonable assurance of effective long-term control and to comply with NRC requirements. This document also contains discussions and technical bases for use of specific criteria to meet the 1,000-year longevity requirement without the use of active maintenance. Specific design methods are presented, and reasonable similarity to these methods forms the primary basis for staff acceptance of erosion protection designs. NUREG–1623 (NRC, 2002) updates and expands the final staff technical position (NRC, 1990).

If active maintenance is proposed as an alternative to the designs suggested above, such an approach will be found acceptable if the following criteria are met:

(1) The maintenance approach must achieve an equivalent level of stabilization and containment and protection of public health, safety, and the environment.

(2) The licensee must demonstrate a site-specific need for the use of active maintenance and an economic benefit.

(3) The licensee must provide funding for the maintenance by increasing the amount of the required surety. The staff should determine if the licensee's estimate of funding required for active maintenance is adequate. The licensee should also work with the long-term custodian to assess any additional funding requirements related to long-term surveillance and monitoring.

3.4.4 Evaluation Findings

If the staff evaluation of hydrologic and hydraulic engineering aspects of the reclamation plan confirms that the erosion protection designs are acceptable, the following conclusions may be presented in the technical evaluation report:

The staff has completed its review of the design of erosion protection at the _______________ uranium mill facility. This review included an evaluation using the review procedures in Section 3.4.2 and the acceptance criteria outlined in Section 3.4.3 of this standard review plan.

On the basis of the information presented in the application and the detailed review conducted of the erosion protection features, the staff concludes that the designs are acceptable.

The mill tailings will be protected from flooding and erosion by an engineered rock riprap layer. The riprap has been designed in accordance with the guidance suggested by the NRC staff. The staff considers that erosion protection that meets that guidance will provide adequate protection against erosion and dispersion by natural forces over the long term. In addition to the adequacy of the flood analyses discussed in standard review plan Sections 3.2 and 3.3, the staff concludes that adequate erosion protection designs are provided by (1) use of appropriate methods for determining erosion protection needed to resist the forces produced by the design discharge, and (2) selection of a rock type for the riprap layer that will be durable and capable of providing the necessary erosion protection for a long period of time. Further, the staff considers that the riprap layers proposed will be durable over the 1,000-year design life, for the following reasons: (1) the rock proposed for the riprap layers was evaluated using rock quality procedures suggested by the staff and is not expected to deteriorate significantly over the 1,000-year design life; (2) the rock fragments are dense, resistant to abrasion, and free from cracks, seams, and other defects; and (3) during construction, the rock layers will be placed in accordance with appropriate engineering and testing practices, minimizing the potential for damage, dispersion, and segregation of the rock.

The riprap for the relatively flat top and side slopes is designed to be sufficiently large to minimize erosion potential. The rock will be capable of resisting flooding and erosion, depending on the slope selected. Thus, the staff concludes that the relatively steep slopes, with their corresponding rock designs, are acceptable.

On the basis of its review of the designs for the _______________ uranium mill facility, the staff concludes that the hydraulic designs contribute to meeting the requirements of 10 CFR Part 40,

Appendix A: (1) Criterion 1, requiring that erosion, disturbance, and dispersion by natural forces over the long term are minimized and that the tailings are disposed of in a manner that does not require active maintenance to preserve conditions of the site; (2) Criterion 4(c), requiring embankments and cover slopes to be relatively flat after stabilization to minimize erosion potential and to provide conservative factors of safety that ensure long-term stability; (3) Criterion 4(d), requiring that the rock cover reduces wind and water erosion to negligible levels, including consideration of such factors as the shape, size, composition, and gradation of the rock particles; (4) Criterion 4(f), requiring the design to promote deposition, where feasible; (5) Criterion 6(1), requiring the design to be effective for 200 to 1,000 years; and (5) Criterion 12, requiring that active on-going maintenance is not necessary to preserve isolation.

3.4.5 References

NRC. NUREG–1623, “Design of Erosion Protection for Long-Term Stabilization.” Washington, DC: NRC. 2002.

———. “Design of Erosion Protection Covers for Stabilization of Uranium Mill Tailings Sites.” Washington, DC: NRC. 1990.

3.5 Design of Erosion Protection Covers

3.5.1 Areas of Review

If a soil or vegetative cover is proposed, the following design details, calculations, and analyses will be reviewed:

(1) Determination of allowable shear stresses and permissible velocities for the cover.

(2) Determination of allowable shear stresses and permissible velocities for the cover in a degraded state, including the effects of fires, droughts, vegetation succession, and other impacts to the ability of the cover to function without maintenance.

(3) Information on types of vegetation proposed and their abilities to survive natural phenomena.

(4) Information, analyses, and calculations of input parameters to models used.

The review will consider whether the design of covers is sufficient to avoid the need for ongoing active maintenance at the site.

3.5.2 Review Procedures

If a soil cover is proposed, the staff should evaluate the design using the general criteria outlined in Appendix A to NUREG–1623 (NRC, 2002). Particular attention should be given to the input parameters to various models.

(1) The staff should verify that the design flow rate includes an appropriate flow concentration factor that reflects consideration of settlement, soil removal by sheet flow and wind, degradation of the vegetation cover, intrusion of trees, blockage of flows by fallen trees, etc.

(2) The staff should verify that estimates of Manning's "n" value correspond to the vegetation cover proposed and are proper for estimating allowable shear stresses and permissible velocities.

(3) The staff should verify that appropriate values of allowable shear stresses and permissible velocities have been used and conservatively reflect potential changes that could occur to the cover over a long period of time as a result of fires, droughts, diseases, vegetation succession, or general cover degradation.

(4) The staff should check analyses and/or independently calculate allowable slopes using several different methods and ranges of input parameters. Using a range of flow concentration factors, shear stresses, permissible velocities, "n" values, and models, the staff should check the sensitivity of the analyses and should verify that reasonable and appropriate values of input parameters have been selected.

If a sacrificial soil cover is proposed to meet the minimum 200-year stability requirement, the staff should check the calculations using Appendix B to NUREG–1623 (NRC, 2002) and the justification for reduction of the stability period using Appendix C to NUREG–1623 (NRC, 2002).

(5) The reviewer shall determine whether the design is adequate to avoid the need for ongoing active maintenance at the site.

3.5.3 Acceptance Criteria

The design erosion protection covers for the site will be considered acceptable if:

The designs conform to the suggested criteria in NUREG–1623 (NRC, 2002). NUREG–1623 (NRC, 2002) discusses acceptable methods for designing erosion protection to provide reasonable assurance of effective long-term control and, thus, meet NRC requirements. This document also provides discussions and technical bases for use of specific criteria to meet the 1,000-year longevity requirement without the use of active maintenance. Specific acceptance criteria for many of the review areas are presented and form the primary basis for staff review of erosion protection designs. These criteria were derived from regulatory requirements, other regulatory guidance, staff experience, and various technical references.

If active maintenance is proposed as an alternative to the designs suggested above, such an approach will be found acceptable if the following criteria are met:

(1) The maintenance approach must achieve an equivalent level of stabilization and containment and protection of public health, safety, and the environment.

(2) The licensee must demonstrate a site-specific need for the use of active maintenance.

(3) The licensee must provide funding for the maintenance by increasing the amount of the required surety. The licensee should also work with the long-term custodian to assess any additional funding requirements related to long-term surveillance and monitoring.

3.5.4 Evaluation Findings

If the staff's evaluation of erosion protection covers confirms that the cover designs are acceptable, the following conclusions may be presented in the technical evaluation report:

The staff has completed its review of the design of erosion protection covers at the _______________ uranium mill facility. This review included an evaluation using the review procedures in Section 3.5.2 and the acceptance criteria outlined in Section 3.5.3 of this standard review plan.

On the basis of its review, the staff concludes that the designs are acceptable and meet the requirements of 10 CFR Part 40, Appendix A.

The mill tailings will be protected from flooding and erosion by an engineered soil cover. The staff considers that a satisfactory cover will provide adequate protection against erosion and dispersion by natural forces over the long term. In addition to the adequacy of the flood analyses discussed in standard review plan Sections 3.2 and 3.3, the staff concludes that adequate cover designs are provided by:

(1) Use of appropriate methods for determining cover slopes needed to resist the forces produced by the design discharge.

(2) Selection of a cover that will be capable of providing the necessary erosion protection for a long period of time.

On the basis of the information presented in the application and the detailed review conducted of the erosion protection covers for the ______________ uranium mill facility, the NRC staff concludes that the cover designs contribute to meeting the following requirements of 10 CFR Part 40, Appendix A: Criterion 1, requiring that erosion, disturbance, and dispersion by natural forces over the long term are minimized and that the tailings are disposed of in a manner that does not require active maintenance to preserve conditions of the site; Criterion 4(b), requiring siting and design such that topographic features provide good wind protection; Criterion 4(c), requiring that embankments and cover slopes are relatively flat after stabilization to minimize erosion potential and to provide conservative factors of safety; Criterion 6(1), requiring the design to be effective for 200 to 1,000 years; and Criterion 12, requiring that active ongoing maintenance is not necessary to preserve isolation.

3.5.5 References

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3.6 General References

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