Safety Evaluation Report for
Petrotomics Company Mine Tailings Retention Dam
Getty Oil Company
Source Material License No. SUA-551
Docket No. 40-6659

Introduction.

The applicant, Getty Oil Company, has submitted a proposal for the design and construction of a homogeneous earthfill embankment. The proposed earthfill dam would be an addition to the existing Petrotomics Company mill tailings retention dam and would be constructed using the "downstream construction method" as discussed in reference 1. Location of the Petrotomics Company mill tailings retention dam is shown on Figure 1 of reference 11. Plan, profile, and cross sections of the proposed dam are presented on the full-size drawings which were inclosed in reference 11 with the exception that a cutoff trench, as noted in reference 13, will be excavated along the full length of the proposed embankment. The proposed embankment will have a length of 6,900 feet and a crest elevation of 7,100 feet above mean seal level. At the maximum section, the embankment will be 70 feet above the original ground surface and 35 feet above the crest of the existing dam. The maximum pool elevation will be at 7085, thus providing 15 feet of freeboard. Design of the mill tailings retention dam is presented in references 4, 7, 11, and 13. Construction specifications are presented in references 12 and 13.

As discussed in reference 11, the Petrotomics Company mill and tailings retention dam are located in the eastern portion of the Shirley Basin. Broad, shallow valleys and broad intervalley divides are indicative of the gently rolling terrain in this area. The Little Medicine Bow River, which flows in a southerly direction, drains the basin. Spring Creek and Sand Creek are the principal tributaries of the Little Medicine Bow River and are shown on Figure 1 of reference 11.

Geology.

Downwarping in the Shirley Basin area began in the latter part of the Cretacious age and died out in the Eocene age. As discussed in reference 11, the basin axis trends northwest-southeast and is approximately 3/4-mile west of the dam site. A general geologic cross section in the vicinity of the project site is shown on Figure 2 of reference 11. The lower Eocene age Wind River formation, consisting of approximately 300 feet of noncemented, well-consolidated claystone, siltstone, and sandstone overlies the Cretacious age sedimentary rocks, consisting primarily of marine shale with some sandstone.

Seismicity of Project Area.

According to the Department of the Army Engineer Manual, EM 1110-2-1902, Engineering and Design, Stability of Earth and Rock-Fill Dams, dated 1 April 1970, central Wyoming is located in seismic zone 1 which is considered to be of relatively low seismic activity. Seismic history for the region is discussed in reference 11 and locations of earthquake epicenters and fault zones are shown on Figure 3 of reference 11.

Fault length, distance from the dam site, and maximum earthquake intensity are tabulated in reference 11 for the South Granite Mountain Fault Zone, which is the nearest fault zone to the dam site.

The seismic coefficient of 0.05 which was used in the stability analyses for earthquake condition and presented in reference 11 corresponds to that recommended in EM 1110-2-1902, dated 1 April 1970, for the geographical location of the dam site.

Method and Scope of Subsurface Investigations.

Subsurface investigations for the proposed Petrotomics Company mill tailings retention dam consisted of 11 auger holes and 2 core holes. Subsurface investigations in August 1976 consisted of eight auger holes: S-2, S-4, S-8, S-12, N-2, N-4, N-8, and N-12. Auger Hole TH-1 was drilled in September 1976, and auger holes S-20 and N-20 were drilled in April 1977. The locations and logs of the exploratory holes are shown on Figures 4, 6, 7, and 9 of reference 11. The above holes were drilled using a truck-mounted, 4-inch continuous flight auger. Standard penetration tests were performed in the 4-inch-diameter auger holes, using a California drive sampler. The results of the standard penetration tests and locations of the California drive samples are shown on the drilling logs on Figures 6, 7, and 8 of reference 11.

In June 1977, further subsurface exploration was performed by redrilling holes S-4 and N-4 adjacent to the previous locations for auger holes S-4 and N-4. Exploratory hole S-4 was drilled from 0.0 to 20.0 feet using a truck-mounted, 8-inch-diameter, hollow-stem auger. From 20.0 to 104.5 feet, exploratory hole S-4 was cored with NX coring equipment. Exploratory hole N-4 was drilled from 0.0 to 40.5 feet using a truck-mounted, 8-inch-diameter, hollow-stem auger. The remainder of exploratory hole N-4, from 40.5 to 101.0 feet, was cored with NX coring equipment. Detailed logs of exploratory holes S-4 and N-4 are presented in Appendix A of reference 11.

In June 1977, exploratory holes S-8, S-4, S-2, N-4, and TH-1 were redrilled adjacent to the locations of the previously drilled auger holes. These exploratory holes were drilled with a truck-mounted, 8-inch-diameter, hollow-stem auger. Undisturbed samples were obtained

Foundation Preparation.

Foundation preparation for the proposed tailings embankment addition will be performed in accordance with the construction specifications, reference 12. As discussed in reference 12, foundation preparation for the proposed tailings dam embankment addition shall consist of the removal of all unsuitable materials within the foundation area of the proposed mine tailings retention dam. This includes stripping of vegetation, topsoil, organic material, boulders, loose rock, debris, stumps, roots, and all other objectionable material, excavation of wet, soft materials in the existing seepage pond located downstream of the existing tailings retention dam, and removal of all loose, soft, and disintegrated materials from pockets, irregularities, and depressions in the foundation.

All cavities, depressions, and irregularities encountered within the foundation area of the embankment are to be filled with suitable impervious embankment materials and compacted to the requirements as specified for the impervious fill for the embankment.

The foundation for the embankment shall be prepared in such a manner as to provide a suitable bonding surface with the initial layer of the earthfill. This would consist of grading, scarifying, moistening, and compaction of the foundation materials prior to fill placement.

In addition to the above, specifications for construction of the tailings embankment addition, reference 12, shall be revised to include foundation preparation for the required excavation of the cutoff trench to the top of sandstone or claystone bedrock.

Embankment fill materials shall not be placed until the foundation has been dewatered and prepared in accordance with the approved construction specifications.

The strength and compressibility properties of the foundation materials as determined by field and laboratory testing are adequate and, therefore, the embankment foundation materials are suitable for the proposed earthfill construction.

Embankment Design.

a. Cross Section.

The proposed Petrotomics Company mill tailings retention dam will be a homogeneous, rolled earthfill embankment with a crest length of approximately 6,[illegible] feet, a crest width of 50 feet, and side slopes of 1V on 2.5H. Design top of the earth dam is at elevation 7100, approximately

70 feet above the ground surface at maximum section. General plan, profile, and cross sections of the embankment are presented on the full-size drawings which were inclosed in reference 11. The cross sections are to be revised to include a downstream drainage blanket, 4 feet in thickness, and a cutoff trench which will be located within the central portion of the embankment and excavated to bedrock along the full length of the embankment.

b. Embankment Materials.

Except for the downstream drainage blanket, the embankment will be constructed of impervious fill consisting of sandy clay and/or claystone selected from required borrow excavation in the mine pit area. As specified in reference 12, the impervious borrow materials shall have at least 80 percent by dry weight passing the United States Standard No. 200 sieve, a liquid limit of at least 40, and a plasticity index of at least 16. The downstream drainage blanket, located 95 feet from centerline of the future embankment and 4 feet in thickness, will be provided for seepage control as discussed in references 13 and 14.

As specified in reference 13, the moisture content of the impervious fill after compaction shall be within the limits of 1.0 percent dry and 2.0 percent wet of the standard optimum moisture content as determined by the "Standard Proctor Compaction Test," given in ASTM D698-70. The impervious fill shall be placed and compacted to at least 95 percent of its standard Proctor maximum dry density.

As indicated in references 13 and 14, the specifications for construction, reference 12, will be revised to include gradation, placement, moisture control, and compaction of the filter material required for construction of the downstream drainage blanket.

c. Seepage and Seepage Control.

As discussed previously, foundation materials for the proposed embankment consist generally of overburden materials underlain by sandstone, siltstone, and claystone bedrock.

Seepage from the existing tailings retention dam impoundment and collection of this seepage in ponds located downstream of the existing dam were observed during field investigations. Because of the existing seepage condition, seepage analyses and flow net studies were made for the maximum section of the future embankment and foundation with a hydrostatic head corresponding to maximum pool. As discussed in reference 13, the seepage analyses performed by Chen and Associates, Inc., and presented in reference 11 was considered to be incorrect and unsatisfactory. Therefore, seepage analyses and flow net studies were made by personnel of the U.S. Army Corps of Engineers, Albuquerque District, and presented in reference 13.

As previously stated, field permeability tests were performed in the exploratory holes and laboratory permeability tests conducted on California samples from exploratory holes and remolded samples from the borrow area. The results of the field and laboratory permeability tests are shown on Tables B-I and B-II, Appendix B, of reference 11. Representative permeabilities for the foundation and borrow materials are presented on Table B-III, Appendix B, of reference 11. These representative permeabilities were used for the seepage analyses.

The seepage analyses and flow net studies presented in reference 13 for the impervious embankment indicate that a downstream drainage blanket, 4 feet in thickness and located 95 feet from centerline of the future embankment, will provide adequate seepage control. As discussed in reference 13, the amount of through seepage does not appreciably change with or without the downstream drainage blanket. However, the seepage path is controlled by means of the drainage blanket, thus preventing any sloughing of the downstream toe of the embankment and potential piping.

The seepage analyses and flow net studies presented in reference 13 for the condition of an impervious embankment placed on a pervious sandstone foundation indicated that the factor of safety against uplift at the toe of the dam is approximately 3.2 and that the underseepage is not detrimental to the safety of the structure. As also discussed in reference 13, seepage control measures are not required to protect the dam against underseepage; however, the quantity of underseepage, approximately 0.023 cubic foot per minute per 1 foot of dam (12,086 cubic feet per year per 1 foot of dam), is substantial. Since the permeability of the overburden materials could be as much as 10 times greater than the permeability of the sandstone foundation, the amount of seepage through the overburden materials would be much greater than that from the sandstone layer. Based on the above, excavation of a cutoff trench along the length of the future embankment through the overburden materials to the foundation sandstone or claystone was recommended in reference 13 as a design feature of the embankment. It was also recommended in reference 13 that the cutoff trench be located within the central portion of the future embankment, have a bottom width of 10 feet, and 1V on 2H side slopes, and backfilled with impervious fill to the same requirements as specified for the impervious embankment fill. It was agreed in reference 14 that a cutoff trench will be constructed. It was also noted in reference 13 that the cutoff trench will not affect the amount of seepage through the sandstone. Therefore, collection of any seepage downstream by means of collection ponds similar to those being used for the existing tailings retention dam and pumping of this seepage back into the reservoir will be required.

In addition, present observation wells and the two new observation wells to be installed south of the dam site should be monitored to determine

the water level and radioactivity in the groundwater. The locations of the observation wells are shown on Figure 2 of reference 7.

d. Settlement.

Swell-consolidation tests were performed on samples of claystone from exploratory holes N-20 and S-20. The results of these tests are shown on Figure 10 of reference 11. Based on the maximum height of embankment and corresponding applied pressure indicated on the swell-consolidation test results, it is estimated that the amount of foundation consolidation will be less than 2 feet. It is estimated that the amount of embankment consolidation would be less than that expected for the foundation. In addition, loss of freeboard through embankment and/or foundation settlement should not be detrimental because the license condition requires maintenance of 15 feet of freeboard throughout the operational life of the project.

e. Stability Analyses.

Stability analyses were made by Chen and Associates, Inc. using the modified Fellenius Method of slices and a modified Morgenstern-Price non-circular method. The modified Fellenius Method considers circular failure surfaces and neglects the interaction of side forces between the slices of the circular arcs. The Morgenstern-Price Method was used to analyze various wedges within the downstream portion of the embankment. This non-circular method of analysis was used to investigate a weak layer in the foundation, 2 feet in thickness.

The maximum embankment section was analyzed for the conditions of post-construction, partial pool, and steady seepage with reservoir at maximum pool elevation. The above conditions were also analyzed for earthquake loading. The earthquake analysis is a pseudo-static analysis for evaluating seismic effects. It is assumed that the earthquake impacts an additional horizontal force acting in the direction of potential failure. As discussed in the section, Seismicity of Project Area, of this report, a seismic coefficient of 0.05 was used in the stability analyses for earthquake condition.

The stability analyses, performed by Chen and Associates, Inc. are presented in reference 11, including the manual solutions for the critical arcs found for each loading condition. Factors of safety for the critical failure arcs using the modified Fellenius Method are conservative since the interaction of side forces between the slices of the circular arcs are neglected.

As discussed in reference 13, stability analyses were also performed by the U.S. Army Corps of Engineers, Albuquerque District. The modified Swedish Method which considers side forces acting on the slice boundaries

was used for the method of analyses. The stability analyses were performed for the same loading conditions as those presented in reference 11. The phreatic line used for the steady seepage condition was determined by flow net studies which are presented in reference 13. Due to the interaction of side forces between the slices of the circular arcs, factors of safety for the critical failure arcs were found to be greater than those indicated in reference 11. The stability analyses indicate that the future embankment will be stable.

f. Liquefaction.

The possibility of liquefaction in the foundation sands and noncemented sandstone caused by earthquake dynamic loadings was considered and discussed in reference 11. As discussed previously in this report, the project site is located in a relatively low seismic area. The gradation of the foundation sands and sandstones are generally within the medium range. Very fine-grained sands which are most susceptible to liquefaction are not present. Based on these considerations and the low seismic area, the possibility of foundation liquefaction is extremely low.

g. Slope Protection.

Upstream slope protection will be provided for the future mine tailings retention dam as discussed in reference 14. As required in the license conditions, the requirements for slope protection will be included in the construction specifications and submitted to the NRC for review and approval prior to construction.

h. Instrumentation.

The instrumentation system is required to monitor and evaluate foundation and embankment performance during and after construction. In addition to the two new observation wells to be installed south of the dam site for monitoring the water level and radioactivity in the groundwater, the instrumentation system consists of open well piezometers in the embankment and foundation and surface displacement monuments located along the crest of the dam and along the downstream slope of the dam at elevation 7065. Horizontal and vertical measurements will be controlled by installing reference monuments at the ends of each line of surface displacement monuments. Open well piezometers will be installed in the embankment and foundation to monitor pore water pressure during and after construction. The embankment and foundation piezometers will be installed at stations 25+00, 37+50, 42+50, 47+50, and 55+00 as discussed in references 12 and 15.

The schedules for reading the surface displacement monuments and open well piezometers are presented in reference 15. As required in the license conditions, the instrumentation readings are to be submitted to NRC for review and evaluation.

Conclusions.

Based on the review of the submitted documents, commitments by the applicant that are contained in the attached references and adherence to the design requirements and construction specifications as discussed in the attached references, the design of the Petrotomics Company mine tailings retention dam meets the intent of U.S. Nuclear Regulatory Commission Regulatory Guide 3.11 and will result in the construction of a safe retention structure.

REFERENCE

1. Draft of U.S. Nuclear Regulatory Commission Regulatory Guide 3.11, "Design, Construction, and Inspection of Embankment Retention Systems for Uranium Mills," revision 1, dated March 1977.

2. Letter from William P. Gammill, Assistant Director for Site Technology, Division of Site Safety and Environmental Analysis, Office of Nuclear Reactor Regulation, U.S. Nuclear Regulatory Commission, to Mr. Thomas McDaniel, Chief, Soils Design Section, U.S. Army Corps of Engineers, Albuquerque District, 8 April 1977.

3. Letter from J.H. Whitman, Manager, Petrotomics Company, Getty Oil Company, to Mr. C.L. Rouse, Chief, Fuel Processing and Fabrication Branch, Division of Fuel Cycle and Material Safety, U.S. Nuclear Regulatory Commission, 5 October 1976.

4. Report by R.E. Killillay, Getty Oil Company, entitled, "Application for Amendment to Source Material License No. SUA-551, Docket No. 40-6659, for the Purpose of Modifying the Present Petrotomics Company Tailings Dam," 5 October 1976.

5. Memorandum from L.G. Hulman, Chief, Hydrology-Meteorology Branch, Division of Site Safety and Environmental Analysis, Office of Nuclear Reactor Regulation, U.S. Nuclear Regulatory Commission, to L.C. Rouse, Chief, Fuel Processing and Fabrication Branch, Division of Fuel Cycle and Material Safety, NMSS, U.S. Nuclear Regulatory Commission, 15 April 1977.

6. Letter from J.H. Whitman, Manager, Petrotomics Company, Getty Oil Company, to Mr. L.C. Rouse, Chief, Fuel Processing and Fabrication Branch, Division of Fuel Cycle and Material Safety, U.S. Nuclear Regulatory Commission, 6 May 1977.

7. "Response to NRC Comments on Application for Amendment to Source Material License No. SUA-551, Docket No. 40-6659, for the Purpose of Modifying the Present Petrotomics Company Tailings Dam," prepared by R.E. Killillay, 5 May 1977.

8. Letter SWAED-TA, dated 10 May 1977, from Jasper H. Coombes, Chief, Engineering Division, U.S. Army Corps of Engineers, Albuquerque District, to Mr. J.D. Kane, NRC Site Technology, U.S. Nuclear Regulatory Commission, Washington, D.C.

9. Letter SWAED-TA, dated 18 May 1977, from Jasper H. Coombes, Chief, Engineering Division, U.S. Army Corps of Engineers, Albuquerque District, to Mr. J.D. Kane, NRC Site Technology, U.S. Nuclear Regulatory Commission, Washington, D.C.

10. Letter from C.J. Kundert, Minerals Engineering Manager, Getty Oil Company, to Mr. L.C. Rouse, Chief, Fuel Processing and Fabrication Branch, Division of Fuel Cycle and Material Safety, U.S. Nuclear Regulatory Commission, 21 July 1977.

11. Report by Chen and Associates, Inc., Casper, Wyoming, entitled, "Soil and Foundation Investigation for Proposed Tailings Dam Embankment Addition, Petrotomics Company, Shirley Basin, Wyoming, July 1977."

12. Construction specifications prepared by Chen and Associates, Inc., entitled, "Technical Construction Specifications for Tailings Dam Embankment Addition, Shirley Basin, Wyoming, 1977, Source Material License No. SUA-551, Docket No. 40-6659, Petrotomics Company."

13. Letter SWAED-TA, dated 23 August 1977, from Jasper H. Coombes, Chief, Engineering Division, U.S. Army Corps of Engineers, Albuquerque District, to Mr. J.D. Kane, NRC Site Technology, U.S. Nuclear Regulatory Commission, Washington, D.C.

14. Letter from C.J. Kundert, Minerals Engineering Manager, Getty Oil Company, to Mr. L.C. Rouse, Chief, Fuel Processing and Fabrication Branch, Division of Fuel Cycle and Material Safety, U.S. Nuclear Regulatory Commission, Washington, D.C., 2 September 1977.

15. Letter SWAED-TA, dated 20 October 1977, from Jasper H. Coombes, Chief, Engineering Division, U.S. Army Corps of Engineers, Albuquerque District, to Mr. William P. Gammill, Assistant Director for Site Technology, Division of Site Safety and Environmental Analysis, Office of Nuclear Reactor Regulation, U.S. Nuclear Regulatory Commission, Washington, D.C.

Petrotomics Company Mine Tailings Retention Dam
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Recommended License Conditions for Operating Tailings Retention System

1. The construction specifications and drawings, after all revisions have been made as discussed in the documents referenced in the safety evaluation report, should be submitted to NRC for review and approval prior to construction.

2. Collection of any seepage downstream by means of collection ponds similar to those being used for the existing tailings retention dam and pumping of this seepage back into the reservoir will be required.

3. The Applicant will provide a commitment to maintain 15 feet of freeboard throughout the operational life of the project.

4. The Applicant will submit a construction report summarizing specification requirements, construction equipment, construction procedures, construction experience including changed conditions, problems encountered during construction, and methods employed to resolve these problems, field control and record control test data, and embankment performance as monitored by instrumentation during and after construction. The report will provide significant information required to reevaluate the embankment in the event unsatisfactory performance occurs.

5. As-built drawings for the construction of the embankment and installation of the required instrumentation devices are to be submitted to NRC after completion of construction.

6. Instrumentation readings and graphical presentation of these data are to be submitted to NRC for review and evaluation during and after construction.

7. The Applicant shall notify NRC 2 weeks prior to inspection fy U.S. Army Corps of Engineers personnel of the following construction features:

a. After excavation of the cutoff trench and immediately prior to embankment fill placement.

b. During embankment fill placement at approximately 25 percent completion of construction.

UNITED STATES
NUCLEAR REGULATORY COMMISSION
WASHINGTON, D.C. 20555

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