URS

March 6, 2013

Mr. Jeremy Franz, PE
Design Review Engineer
1313 Sherman Street
Room 818 Centennial Building
Denver, CO 80203

Subject: Response to October 26, 2012 review of Design and Construction Documents for the Continental Dam Rehabilitation Project.
CONTINENTAL DAM, DAM ID: 200110
Water Division 3, Water District 20
Construction File No.: C-0259C

Dear Matthew:

This letter documents URS Corporation's (URS) responses to the State of Colorado, Division of Water Resources review letter dated October 26, 2012 regarding the Design and Construction Documents for the Continental Dam Rehabilitation project.

General

1. Please provide a written response to each or our review comments indicating how the comment is addressed, including identifying all changes made to the design and construction documents after the original submittal. In addition, please identify any other changes made to the design documents that are not specifically related to our review comments.

   Response: Comment adopted.

2. A construction file number, C-0259C, has been assigned to this project. This file number should appear in the lower right-hand corner of all sheets of the Construction Drawings and on the cover of Technical Specifications and Reports per the requirements of the Rules.

   Response: Comment adopted.

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Design Report

Section 4 – Hydraulic Analysis

3. Appendix A of the Design Report presents the rating curve for spillway discharge, but detail on the development of the rating curve is lacking. Please provide detail on the hydraulic calculations used to develop the spillway rating curve including for both inlet and chute control conditions.

   Response: Hydraulic control occurs at the side channel spillway weir for lower heads and within the chute for higher heads as the side channel weir becomes submerged. Hydraulic control at the side channel weir was reviewed and adopted from the USACE 1978 Phase 1 Report. Hydraulic control from within the chute was developed using a HEC-RAS model. Appendix A includes a calculation, "Proposed elevation-storage-discharge relationship for the Continental Dam Reservoir – REV2 12/20/12" which was updated to include a more detailed rating curve description.

4. Under Section 4.3 Stilling Basin, it is stated that erosion of the downstream river channel is acceptable. We concur that some erosion is tolerable for infrequent events; however, we need to verify that extensive damage during the Spillway Design Flood will not compromise the safety of the dam. Please provide a basis for demonstrating that erosion sustained during the Spillway Design Flood will not compromise the safety of the dam.

   Response: The stilling basin will discharge flows away from the toe of the dam. The existing spillway has been in place since the 1930's and minimal erosion has been observed downstream from the stilling basin. The trajectory of discharge from the stilling basin is away from the toe of the dam and would have to headcut approximately 70 feet behind the stilling basin outlet to erode the embankment. The stilling basin is founded on bedrock. Some erosion and headcutting may occur during events less frequent that the 100-year; however, URS believe this is a maintenance issue and unlikely this would not create a dam safety concern.

5. The HEC-RAS model in Appendix A-4 appears to correspond to a preliminary design. Please update the model to reflect the proposed conditions or provide a clarification indicating that the model is satisfactory to support the proposed design.

   Response: The HEC-RAS model was updated to match the final design spillway profile.

6. The Hydraulic Analysis Section does not provide any discussion indicating that the chute wall will not be over-topped during the spillway design flood. Please provide engineering analyses demonstrating that the spillway design flood will not overtop the chute at any point, and that there is an appropriate amount to residual freeboard during the event.

Response: A new calculation was added to Appendix A which indicates that the chute walls have more than 2.65 feet of freeboard at all locations during the IDF.

Section 5 – Geology and Subsurface Investigations

7. Appendix C, Geotechnical Analyses, provides seepage models that were used to develop the filter blanket and seepage collection system sizing. It is stated that the phreatic surface level observed in piezometer CE-1 and the elevation of seepage on the downstream slope of the dam were projected to the maximum section to conservatively model the worst-case scenario. The hydraulic conductivities of the soils were calibrated until the phreatic surface from the model matched the water level in CE-1 and the elevation of the seepage observed on the downstream slope. The unit flux was then applied over the length of the dam, and the total seepage from the embankment matched the seepage measured under the conditions described above.

   The application of the unit flux over the length of the embankment assumes uniform seepage control over the length of the dam. This is inconsistent with field conditions observed. Specifically, seepage is known to occur primarily through preferential flow paths associated with the left abutment and groin. While the assumptions summarized above may be adequate for developing an appropriately conservative phreatic surface through the embankment for the purposes of conducting stability analyses, we do not feel that it is appropriate to assume uniform seepage distribution in terms of the filter blanket and seepage collection system. Please provide calculations demonstrating that the filter protection and seepage collection system in the left groin are robust enough to collect the high rates of seepage known to occur during periods of high reservoir storage. In addition, we suggest that you consider extending the filter blanket into the abutment to ensure that seepage does not by-pass the system to an unprotected exit beyond the vertical or lateral extents of the collection system.

   Response: Additional seepage analyses were completed and are presented in Section 6.3. The existing condition was modeled for two sections, Stations 2+68 and 1+10. Station 2+68 simulates the behavior near the left abutment/groin where four of the six piezometers were installed. The hydraulic conductivities for the core, shell, foundation, and bedrock materials were calibrated to measured levels in piezometers CE-2, B-2, B-3A, and B-3 and the flume readings for a reservoir elevation of 10,268.9 feet as recorded during the summer of 1995. Each design section has a modeled length to calculated total seepage flow, which are 150 feet for Station 2+68 and 80 feet for Station 1+10. The results from seepage conveyance in drain gravel and sizing of toe drain are included in the seepage calculations in Appendix C. The drawings were modified to include the two-stage filter at the left groin to reflect the requirements of the additional seepage analyses.

8. In Appendix C, as stated in Item 7 above, the piezometer level from CE-1 was projected to the maximum section to calibrate that seepage model. According to the

monitoring data presented in Attachment E, at the gage heights used to calibrate the model, the water level in piezometer CE-2 was approximately 15 feet higher than that observed in CE-1. Please provide an analysis or explanation of why the much higher level in Piezometer 2 is not of concern in conducting the seepage and stability analyses.

Response: The performance of both CE-1 and CE-2 were included in seepage model calibration as further discussed in Section 6.2.

9. In Appendix C, under the heading Flux, it is indicated that Parshall Flume readings are included in Attachment D. They are located in Attachment E.

   Response: The seepage calculations was revised and corrected.

10. Section 5.7.3, Filter Compatibility, indicates that filter compatibility and references are presented in Appendix C. No filter compatibility calculations were found in Appendix C.

    Response: The filter compatibility calculations were incorporated in Appendix C.

11. To the extent that information from the Harza Geotechnical Investigation (1995) is being used for design criteria, such as engineering properties of base soils, the appropriate engineering information should be re-produced in Appendix C.

    Response: The reference was included in Appendix C.

12. Under Section 5.8.1, Seepage Analyses Results, it is stated that the seepage model was used to estimate the phreatic surface through the raised embankment. It is our understanding that there is no dam raise associated with this project and the language should reflect that.

    Response: The language was reflected to state downstream modifications.

13. Sections 5.8.1 and 5.8.2 indicate that the seepage and stability analyses were conducted using a reservoir elevation of 10,268.8 feet. Our Rules require that these analyses be conducted with the reservoir under full pool conditions. Please revise the analyses as appropriate.

    Response: The seepage and stability models were revised and performed for normal pool conditions at elevation 10,280 feet, see Sections 6.2 and 6.5.

14. Under Section 5.8.2, it is indicated that the peak ground acceleration used for the pseudo-static loading condition was 0.010g. This value does not appear to be consistent with the Harza report or the analyses included in Appendix C. In addition, the analyses conducted should be consistent with requirements of the applicable sections of Rule 5.9.2.

Response: The analyses have been revised to include a PGA of 0.26g with an earthquake magnitude of M6.5 for the 5,000-yr return period. A post-earthquake analysis with reduced shear strengths for the existing embankment shell and core materials have been performed instead of a pseudo-static analysis, as described further in Section 6.5.

<u>Section 8 – Construction</u>

15. Section 8.2, Reservoir Level During Construction, indicates that the reservoir level during construction will be limited to a maximum of elevation 10,267.80’. The basis for this operating level in the design report is strictly hydrologic. Given that the proposed operating level is the restricted storage level, at which elevation seepage becomes excessive, it will not be desirable excavate the slope under these conditions. The proposed reservoir level is acceptable for the spillway modifications; however we suggest that you re-consider the appropriate reservoir level for improvements to be constructed on the downstream slope.

    Response: The reservoir will be evacuated to the appropriate level during construction. The appropriate level will be determined prior to construction.

Construction Plans

<u>Sheet 5</u>

16. Add equations to describe spillway rating curve. Add tabular data describing spillway rating.

    Response: The spillway rating curve was developed using a HEC-RAS model and no single equation represents the spillway rating curve. Tabular data describing the spillway rating curve was added to Sheet 5.

<u>Sheet 7</u>

17. The width of the upper bench is shown to be 20 feet, but the minimum width is called out as 12 feet. Was the stability model run for this condition? If there is not enough common fill to construct the fill to the minimum dimensions shown, has a borrow area been identified to make up the difference?

    Response: The stability model was revised and drawings were updated to show the revised geometry.

<u>Sheet 14</u>

18. On the profile at Sta 0+38.16, the call out indicates a vertical bend, but it appears it should be a Tee as shown on the plan view.

    Response: Comment adopted.

Sheet 15

19. Call out slotted pipe where appropriate on toe drain details, i.e. sections A and B. Call out solid pipe where appropriate, i.e. Section C.

    Response: Comment adopted.

Sheet 17

20. Please revise scale of sections to ensure they are legible on ½-size drawings.

    Response: Comment adopted.

Sheet 18

21. The details on this Sheet indicate a 1-foot raise on the spillway crest elevation, which would raise the normal reservoir pool by one foot. The project was submitted as a rehabilitation project with no change in storage for the reservoir. Please clarify.

    Response: Based on the URS survey, the existing side channel spillway crest elevation is 10280.00 feet. The drawings and spillway rating curve was updated so that the new spillway will maintain the same normal pool elevation.

22. Provide a detail similar to Detail 2, only showing the reinforcement and dimensions of the of the side-slope overlay.

    Response: We concur that the anchors are not necessary on the horizontal slab due to installation of foundation anchors. A detail has been provided to show reinforcement and anchors on the side-slope overlay.

23. Detail 2 calls out a double mat of #5's EW, EF, but the calculations in the design report appear to indicate that they should be #6's. Please verify and revise as needed.

    Response: Calculations were updated with 8 feet of uplift (consistent with the Design Summary Report), to show that reinforcement should be #5 bars as shown on the drawings.

Sheet 24

24. The thickness of the slab in Section A is shown at 2'-3". In all the other details is shown at 2'-9".

    Response: The slab was updated to show a 2'-9" in Section A.

Construction Specifications

Section 2330 Earthwork

25. Please provide a specification for placement and compaction requirements of the filter material, and any special measures to prevent contamination of zones.

Response: Placement and compaction for the filter sand and drain stone materials is covered in Section 02330 Part 3.3 Filter Sand and Drain Gravel Placement. This part also specifies required controls to prevent contamination and to remove contaminated filter or drain material. To address "special measures to prevent contamination of zones" an additional specification was inserted as 3.3.B to provide additional direction to the contractor as follows:

> *3.3.B: To the degree practical, maintain filter sand materials one foot above the adjacent embankment materials to prevent contamination.*

Please contact me (Telephone: 303-740-3949 or Email: ed.toms@urs.com) if you have any questions regarding the information contained in this letter.

Sincerely,

URS Corporation

Ed Toms, P.E., Vice President
Project Manager