OROVILLE EMERGENCY RECOVERY – SPILLWAYS
Board of Consultants Memorandum

DATE: December 17-18, 2018

TO: Mr. Anthony Meyers, Project Manager
Oroville Emergency Recovery – Spillways
California Department of Water Resources

FROM: Independent Board of Consultants for
Oroville Emergency Recovery – Spillways

SUBJECT: Memorandum No. 22

INTRODUCTION

On Monday December 17, 2018, the Independent Board of Consultants (BOC) met at the Department of Water Resources (DWR) Oroville Field Division Office Main Conference Room at 8:00 am. The group departed soon afterwards with representatives from the DWR Division of Engineering, the Division of Safety of Dams (DSOD), the Federal Energy Regulatory Commission (FERC), DWR Division of Operations and Maintenance, and industry consultants working on the Oroville Spillway Recovery project to tour the Oroville Dam Site and observe construction progress since the last BOC meeting held on October 11 and 12, 2018.

The following construction features were observed:

- The FCO chute (see Figure 1);
- Placement of backfill behind the FCO chute walls (see Figure 2);
- Test surface treatment of crystalline waterproofing on a spillway slab;
- Completed Emergency Spillway stepped Roller-Compacted Concrete (RCC) apron and RCC Ogee Buttress Section (see Figure 3), and
- The preparation of the Ogee Emergency Spillway Section for the placement of reinforced concrete buttress transition section (see Figure 4).

Figure 1. Completed FCO Chute.

Figure 2. Placement of backfill behind FCO chute walls.

Figure 3. Emergency Spillway RCC Apron and Buttress formwork.

Figure 4. Preparation of the Ogee Emergency Spillway section for placement of Reinforced Concrete Buttress Transition section.

At 10:30 am, the BOC returned to the Oroville Field Division Office Main Conference Room for updates on:

- Oroville Spillways Recovery Overview;
- Spillway Hydraulic Analyses;
- FCO Aeration Update;
- Spillway Drains Video Camera Inspections;
- List and Schedule of DWR Spillways Recovery Reports;
- DSOD Comments;
- Oroville Comprehensive Needs Assessment (CNA) Project Status Update; and
- 2017 and 2018 Construction Highlights from Kiewit.

On Tuesday December 18, 2018 at 8:00 am, the BOC met at the Oroville Field Division Office Main Conference Room to deliberate and prepare their report. Descriptions and comments made on the individual presentations and the BOC's responses to the DWR questions are included in this report.

A reading of the BOC's draft report was made at 12:00 noon to representatives from DWR Engineering Division, DSOD, FERC, DWR Division of Operations and Maintenance, and industry consultants working on the Oroville Spillway. The meeting was adjourned following the reading of the report. BOC members present were Eric Kollgaard, John Egbert, Kerry Cato, Faiz Makdisi and Paul Schweiger.

QUESTIONS FOR THE BOC

1. ***Does the BOC have any recommendations or comments on the recovery overview?***

   Response

   Two excellent overview presentations were made to the BOC, one by DWR on the "*Oroville Spillway Recovery Overview*" and one by Kiewit on the "*2017 and 2018 Construction Challenges*". The presentations summarized the February 2017 spillway incident, including DWR's response and Kiewit's intense construction effort and a chronology of the reconstructed and enhanced FCO chute and Emergency Spillway. The BOC appreciated the presentations and encourages DWR to make a recording of a version of the presentations available online to

accurately document and convey the challenges and successful completion of the recovery project.

2. Does the BOC have any recommendations or comments on PMF spillway hydraulics?

Response

The Design Team conducted additional hydraulic numerical modelling to evaluate approach losses to the Emergency Spillway and FCO for flows up to the probable maximum flood (PMF). The Design Team used two-dimensional hydraulic analyses to evaluate the approach conditions using original as-built topographic information. The analyses confirm that the approach velocities and associated head losses are relatively low and do not materially impact the stage-discharge relationships for the spillways. The BOC appreciates this information.

The hydraulic analyses show that the left Emergency Spillway training wall is marginally overtopped during the PMF. The BOC recommends that the left training wall be raised in this area as needed to prevent overtopping.

The BOC believes that the area upstream of the right Emergency Spillway control section may have been modified since the original construction with the construction of a paved parking lot, and that the parking lot may be higher than the control section. The BOC recommends that the area upstream of the right Emergency Spillway control section be surveyed in its final configuration and, if higher than the Emergency weir crest, be lowered below the control elevation. The final elevation configuration of this surface should be used in future hydraulic modelling.

The hydraulic modelling shows that the FCO together with the emergency spillway have the capacity to convey the PMF design flows. While the Emergency Spillway can safely pass the flood flows, the BOC continues to have concern that, should significant flows occur, such an occurrence could produce extensive erosion downstream of the secant pile wall. This will result in sedimentation in the Feather River and associated tailwater rise that would adversely impact the operation of the Hyatt Power Plant. The BOC is aware that the current Comprehensive Needs Assessment (CNA) is addressing these issues.

3. Does the BOC have any recommendations or comments on the FCO aeration design project?

Response

The BOC appreciates the update concerning potential construction of aeration features. While the BOC believes the FCO chute surface as constructed is capable of operating without special aeration provisions, the BOC has no objection to constructing aeration features in the FCO spillway as an added precaution to eliminate any risk of cavitation damage provided it can be demonstrated that such provisions do not adversely impact the hydraulic performance of the spillway.

4. Does the BOC have any recommendations or comments on the spillway drain inspections?

Response

The interior of the underdrains in the FCO chute and Emergency Spillway were inspected using a video camera to establish baseline conditions. The videos showed that the as-built conditions are satisfactory.

5. Does the BOC have any recommendations or comments on list of DWR spillway recovery reports?

Response

The BOC believes the list of spillway recovery project reports is comprehensive and that the reports will provide a detailed documentation of the work performed, and the design and construction effort. A significant portion of the reports are geologic and geotechnical in nature and are scheduled to be completed within the first 6-months of 2019 with the rest being substantially completed by end of 2019. The BOC looks forward to receiving and reviewing these reports.

6. Does the BOC consider the dam, with the completed spillway recovery construction, adequate to resume reservoir storage; and, are there any terms or considerations that should be included in the certificate of approval for Oroville Dam?

Response

The BOC has provided engineering review and advice on the design and construction of the Oroville Spillways Emergency Recovery project since its inception in March 2017. The BOC's involvement has spanned the concurrent Design and the Construction Phases of the project, including participating in and preparing reports for 22 meetings.

Based on our close involvement in the review of design documents, our knowledge of the foundation conditions and materials used in construction, and observation of the construction progress, to the best of our knowledge, the BOC affirms that the reconstructed Oroville Spillways have been completed in accordance with the design documents. The BOC believes that the restored condition of the FCO chute and Emergency Spillway is a significant improvement over the original design. Remaining spillway reliability issues that need to be evaluated and potentially addressed include: (1) the erosion of the Emergency Spillway channel downstream of the newly-constructed secant pile cutoff wall, (2) confirmation of the integrity of the Emergency Spillway to prevent breaching of the control section(s) for flows up to the PMF, and (3) the adequacy of existing cavitation damage defense measures incorporated into the FCO chute for flows exceeding approximately 160,000 cfs.

The BOC believes that with the completion of the Emergency Spillway Monolith Buttress and downstream RCC apron, the spillways are adequate to resume full reservoir storage per the Water Control Manual. The BOC does not have any terms or considerations that should be included in the certificate of approval for Oroville Dam beyond addressing the three remaining spillway performance issues noted above. The BOC is aware that the current CNA is addressing these issues.

7. Does the BOC have any other recommendations or comments?

Response

1. ***Surface Treatment of FCO Slab with a Crystalline Waterproofing System.*** The BOC appreciates the Design Team's implementation of its recommendation to evaluate this relatively new technology and determine if it has merit to further enhance and protect the surface of the FCO chute slabs. This system is reported to cause the concrete to become sealed against the penetration of liquids from any direction, seals hairline cracks, and helps protect the concrete from deterioration.

As noted in BOC Report No. 21, the BOC considers the current surface condition of the slabs to be satisfactory. When viewed wet from the light rain falling during the site tour, the surface had the appearance of a polished showroom terrazzo floor and is exceptionally smooth and well finished. Never-the less, the BOC is in favor of evaluating the use of crystalline waterproofing to seal minor surface cracks and enhance the robustness and reliability of the spillway chute.

During the site visit the BOC observed a test section where a crystalline waterproofing treatment was applied to the surface of a FCO chute slab. The surface finish of the applied crystalline treatment was observed to have a very rough broom finish with a thickness that appeared to exceed the maximum 1/16-inch thickness recommended by the manufacturer. The BOC believes that the rough finish of the crystalline waterproofing treatment observed at the test section is less desirable than the smooth untreated slab surface and recommends that the existing test treatment be removed, if possible, and the surface restored to its original smooth condition. The BOC recommends that further tests of the crystalline waterproofing treatment, if undertaken, be performed with onsite assistance of the product manufacturer and in a manner that maintains the original smoothness of the slab surface as much as possible. This may require the use of specialized spray equipment to apply the treatment. The treatment may also be limited to the application along hairline cracks where it is of greatest benefit. If a satisfactory smooth surface cannot be obtained using a crystalline waterproofing treatment, the BOC would recommend not evaluating this treatment further.

2. ***Log of BOC Recommendations.*** The BOC reviewed the log of BOC recommendations and acknowledges that all comments have been addressed or are being actively pursued.

Concluding Comments:

The date for the next meeting of the BOC is tentatively planned for some time in March 2020. The purpose of this meeting is to review the performance of the structure one-year post-construction.

The BOC congratulates the Design Team for their focused and thoughtful design efforts over the course of this intense and strenuous endeavor under very difficult

circumstances and recognizes the contributions and timely review of the FERC and DSOD, and DWR's field inspection and quality control staff. The BOC also acknowledges the remarkable construction achievements by the contractor (Kiewit). The construction of the project was completed safely, on schedule, and of very high quality.

The BOC has thoroughly enjoyed working with the many team members participating on this important project.

BOC RECOMMENDATIONS SUMMARY

M22-1 The hydraulic analyses show that the left Emergency Spillway training wall is marginally overtopped during the PMF. The BOC recommends that the left training wall be raised in this area as needed to prevent overtopping.

M22-2 The BOC recommends that the area upstream of the right Emergency Spillway control section be surveyed in its final configuration and, if higher than the Emergency Weir crest, be lowered below the control elevation.

M22-3 The BOC believes that the rough finish of the crystalline waterproofing treatment observed at the test section is less desirable than the smooth untreated slab surface and recommends that the existing test treatment be removed, if possible, and the surface restored to its original smooth condition. The BOC recommends that further tests of the crystalline waterproofing treatment, if undertaken, be performed with onsite assistance of the product manufacturer and in a manner that maintains the original smoothness of the slab surface as much as possible. If a satisfactory smooth surface cannot be obtained using a crystalline waterproofing treatment, the BOC would recommend not evaluating this treatment further.

Respectfully submitted,

Eric B. Kollgaard **Faiz Makdisi** **Kerry Cato**

John Egbert **Paul Schweiger**