State of California The Resources Agency

Memorandum

Date : October 2, 1998

To : Naser J. Bateni, Chief
Northern District

From : Koll Buer, Chief
Geology Section
Department of Water Resources

Subject: Offstream Storage Geological Investigation

INTRODUCTION

This report covers the regional seismic and fault investigation; foundation mapping and subsurface exploration; and construction materials mapping and testing program for the offstream storage component of Proposition 204.

DWR completed foundation exploration and construction material studies for the Red Bank Project in 1990; a fault and seismic investigation was completed in 1991. Investigations concluded that the foundation appeared adequate and sufficient construction materials were available.

DWR completed foundation and construction material investigations for the Thomes-Newville Project in 1982. A fault and seismic investigation were completed for DWR by Earth Sciences Associates in 1980. Investigations concluded that the foundation appeared adequate and sufficient construction materials were available.

Recent work has focused on the Sites Reservoir and Colusa Complex. The U.S. Bureau of Reclamation had studied Sites Reservoir and found the foundations at Sites and Golden Gate to be suitable and sufficient construction materials available.

The current Sites Reservoir configuration uses a dam axis that is downstream of the USBR's axis for Golden Gate Dam. Also, very little foundation and construction material investigations have been done for the Colusa Complex.

SEISMIC AND FAULT INVESTIGATION

The initial portion of this study consists of background research on seismicity and faulting. Some field work has been done on the Sites-Colusa project, particularly fault mapping at the Sites, Golden Gate, and a portion of Hunters Damsites. In the future, this study will include detailed mapping and trenching along prominent faults as well as faults crossing foundation areas.

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A major concern is the effect of new seismic criteria on project design. The Coast Range-Central Valley boundary is underlain at a depth of 5 to 10 kilometers by a series of thrust faults along the foothills of the Coast Ranges, which are directly under the damsites. This major seismic zone has only recently been recognized as being capable of a Magnitude 7 temblor, with peak horizontal ground acceleration (PGA) in the range of 0.60g. The zone is considered to be source of the two Magnitude 6-7 earthquakes that occured near Winters in 1892.

Earthquakes along this zone could potentially affect all the proposed projects. The worst case scenario is that the earthquake occurs directly underneath the damsites at depths ranging from 5 to 15 km.

Faults occur in the foundation of most of the proposed structures. Most of these are small transverse faults oriented roughly perpendicular to the regional structure; generally the amount of displacement is small. The faults have been considered to be pre-Pliocene in age by previous investigations. However, the Division of Safety of Dams requires that these be considered nominally active until proven otherwise. If they are more recent, the amount of displacement expected during an earthquake is small. Limited movement in the foundation can be accommodated by using conservative dam designs.

Maximum Credible Earthquake

Table 1 shows the draft proposed design parameters selected for the projects. These parameters are presented for planning purposes only. They are believed to be conservative, but need additional analysis.

Table 1
Draft Preliminary Design Parameters

Project	Maximum Credible Earthquake (Mw)	Distance (kilometers)	Depth (kilometers)	Peak Acceleration (g)	Duration (Seconds)	Period (Seconds)
Sites-Colusa	7.0	0	10	0.70	26	0.32
Thomes-Newville	7.0	0	10	0.70	26	0.32
Red Bank	8.3	0	35	0.72	28.5	0.42

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DWR (1978), in the report entitled, *"West Sacramento Valley Fault and Seismic Study-Glenn Complex, Colusa Reservoir, and Berryessa Enlargement,"* summarized what was known at that time about the design earthquake for these three projects. They concluded that the maximum credible earthquake for the Glenn Reservoir Complex to be a Reservoir Induced Seismicity earthquake of M6 resulting in 0.29g acceleration. A "Winters" type earthquake of M7 at a distance of 25 miles was also considered, resulting in a 0.14g acceleration. For this study, an M7 earthquake was selected as occurring directly under Newville dam at a depth of about 6 miles as the design earthquake for the Thomes-Newville Project.

The Anderson Consulting Group (1997), in their Preliminary Design report for the Funks Creek Project adopted two MCE's occurring directly under the Funks Creek damsite (Golden Gate damsite of the Sites Project). One was based on a M_L 6.5 occurring at a depth of 5 km, with a calculated Peak Ground Acceleration of 0.60, and the second was based on a M_L 7.0 occurring at a depth of 10 km with a PGA of 0.46.

Based on the above studies, the Colusa Reservoir was assigned a similar RIS of M6, resulting in 0.29g and a "Winters" type earthquake of M7 at an epicentral distance of 15 miles resulting in an acceleration of 0.23g. For this study we selected MCE's of M7 for an earthquake occurring directly under the reservoir at a depth of 6 miles on the Great Valley Fault for both Sites and Colusa. Selection of an earthquake that occurs directly under the reservoir is conservative, and justified by the fact that only limited information is available and that an earthquake can occur along a wide zone of faulting and surface deformation.

A conservative estimate of the MCE for the Red Bank Project would be a Gorda Plate earthquake of 8.3 occurring directly underneath a project damsite at a depth of 20-25 miles (35-40 kilometers).

Salt Lake Fault

The Salt Lake Fault is a major structural feature that trends within a mile of most of the damsites in the Sites-Colusa Project and possibly through the Sites Damsite. It may extend from near Sites Damsite as far north as the vicinity of Newville Damsite, a distance of about 45 miles. The fault is a high-angle thrust fault that developed adjacent to the axis of the doubly plunging, nearly isoclinal Sites Anticline. Salt water springs, gas seeps, and sag ponds on the fault trace suggest

recent fault activity. In several locations, however, the fault is concealed by unbroken Pliocene Tehama Formation, suggesting that the latest movement occurred prior to this time.

It is possible that the Salt Lake Fault, the Sites Anticline, and the Fruto Syncline are features related to the Great Valley Thrust Fault System. This would make the Salt Lake Fault either active or potentially active. The Salt Lake Fault trends within one mile of most of the Sites-Colusa Project damsites.

FOUNDATION EXPLORATION

Foundations of the Red Bank and Thomes-Newville projects were explored by both the U.S. Bureau of Reclamation and DWR. This study focused on the Sites Project and the Colusa Complex to bring the geologic knowledge to the same level as the other two projects.

Red Bank Project

The Red Bank Project, located west of Red Bluff, was initially envisioned as a number of earthfill structures. Advances in the use of roller compacted concrete created renewed interest in the project. The geology of the Red Bank Project was investigated by DWR between 1987 and 1992.

Dippingvat Damsite

The damsite is on Upper Cretaceous conglomerate (39 percent), sandstone (six percent), and mudstone (55 percent). The beds dip downstream 35 to 45 degrees and strike northwest. Three faults are in the foundation. All were intersected during drilling. Associated with the faults were narrow zones of gouge and sheared mudstone. No evidence of Quaternary to Recent displacement were found associated with any of these faults. DWR concluded that the foundation was adequate for the proposed structure.

Schoenfield Damsite

The dam foundation consists of Upper Cretaceous sandstone, mudstone, and minor conglomerate, with bedding thickness varying from less than one inch to tens of feet. The beds trend northwest and dip about 60 degrees to the east.

There are two mapped faults and several smaller faults that intersect the foundation. All are transverse faults that are roughly perpendicular to the regional strike of bedding. No evidence of Quaternary to Recent movement was seen at any of these faults and surface offset should not be a problem. DWR concluded that the foundation was adequate for the proposed structure.

Thomes-Newville Project

The Thomes-Newville Project consists of a reservoir created by Newville and Burrows Gap dams. The plan and geologic conditions were described in detail by DWR. A fault and seismic investigation was completed by Earth Sciences Associates also in 1980.

Newville Damsite

Newville Dam would be founded on sandstone, mudstone, and conglomerate of the Jurassic Stony Creek Formation and Cretaceous mudstones of the Lodoga Formation. The units strike N-S and dip 50-80 degrees to the east. There are five faults crosses the foundation area. These are all roughly parallel, striking N50E across the regional bedding. The faults range in width from a few feet to over 40 feet and typically consist of highly fractured rock with seams of mylonite. Some faults have been cemented with calcium carbonate. DWR concluded that the foundation was adequate for the proposed structure.

Burrows Gap Damsite

Foundation rocks consist mostly of sandstone and conglomerate with mudstone striking north-south and dipping 60 degrees to the east. One NE-trending fault cross the foundation area and dips to the southeast. DWR concluded that the foundation was adequate for the proposed structure.

Sites Project and Colusa Complex

Earthfill dam construction has been proposed for the dam and saddle dam of Sites Reservoir. The USBR investigated Sites and an "upper" Golden Gate Damsite in 1980. Current geologic investigations include mapping, diamond core drilling, auger hole drilling, geophysical surveying, and trenching. Damsites that have been

investigated are the Sites and Golden Gate Damsites of the Sites Reservoir, and Hunters Damsite of the Colusa Compartment.

Sites Damsite

Sites damsite consists of steeply northeasterly dipping interbedded sandstones and mudstones of the Boxer and Cortina Formations of the Upper Cretaceous Great Valley Sequence. Overall, the Sites Damsite area consists of about seventy percent sandstone and thirty percent mudstone. Preliminary analysis of water pressure testing shows that grout takes will be mostly low to moderate.

Several faults pass through or near the site. A NE-trending fault mapped by USBR, passes from the southwest across the right abutment, then through the downstream footprint of the dam to the northwest. This fault may split on the right abutment. A possible extension of the Salt Lake Fault Zone is suspected to pass near the upstream footprint of the damsite. USBR concluded that the foundation was adequate for the proposed structure and we haven't found anything to refute that conclusion.

Lower Golden Gate Damsite

Lower Golden Gate Damsite consists of NW-trending steeply NE-dipping interbedded sandstones and mudstones of the Boxer and Cortina Members, similar to Sites damsite. The overall composition is about seventy percent sandstone and thirty percent mudstone. Preliminary analysis of the water presure test data indicate that grout takes should be mostly low to moderate. Faulting is prominent with a right-lateral fault trending northeast through both abutments, with about 1,000 feet of offset. A normal fault has been identified on the left abutment.

USBR concluded that the "upper" Golden Gate foundation was adequate for the proposed structure and we haven't found anything that would change a similar conclusion for the Lower Golden Gate Damsite.

Hunters Damsite

Hunters Damsite of the Colusa Compartment consists of NW-trending steeply NE-dipping interbedded sandstones and mudstones of the Boxer and Cortina

Members of the Upper Cretaceous Great Valley Sequence. Several previously unmapped faults cut through the left abutments. Mapping at this damsite shows a lower percentage of sandstone than the Sites Project damsites, averaging 60 percent sandstone and 40 percent mudstone. The thickest sandstone unit measures forty feet. We are currently drilling the site and the results seem promising. Two diamond core drill holes have been completed, with an additional three planned. Three auger holes are also planned.

CONSTRUCTION MATERIALS

Construction materials investigations for Red Bank and Thomes-Newville projects showed that there were sufficient materials available of both quality and quantity. USBR's investigation for Sites reservoir concluded that the majority of material necessary to build the dams and saddle dams can be found within the reservoir area. Sand and gravel for concrete and drains will have to be brought in from distances of over 50 miles. Rock of marginal quality, used for riprap, can be quarried within several miles. Limited work has been done for the Colusa Complex, which would require about one hundred million cubic yards of fill material.

During our recent investigation seventeen Quaternary terrace deposit samples were sent to DWR's Bryte Laboratory for testing. Mechanical analysis and Atterberg Limit (plasticity index) testing were performed on all samples, with organic content and specific gravity testing performed on six selected samples. Results suggests that the quality of the terrace deposits will be satisfactory for use as core material in the dams, with minimal processing required.

Riprap can be supplied by the massive Cretaceous sandstones excavated at the Sites Quarry, located within one half mile from the Sites Damsite. Ten sandstone samples taken from the quarry were sent to Bryte Laboratory for compressive strength, specific gravity, percent absorption, Los Angeles Rattler Test and Durability Index tests. These results indicate that the sandstone is of marginal quality for use as riprap. If this material is used for riprap, the possibility exists that this material may have to be replaced or remediated within twenty years or so.

Sandstones from the Sites Quarry may be able to be crushed and used as concrete mix for appurtenant structures for the project. Additional testing is necessary to determine if the quality is sufficient for concrete use.