Morro Reservoir Rehabilitation Project

The Fabricated Geomembrane Institute (FGI) at the University of Illinois at Urbana-Champaign, presented its inaugural Fabricated Geomembrane Engineering Innovation Award to Hilts Consulting Group of Yorba Linda, California, on 11 May, 2016 during its annual membership meeting in Miami Beach, Florida during Geo-Americas 2016. The Fabricated Geomembrane Engineering Innovation Award provides recognition for engineers who have creatively used fabricated geomembranes to successfully fulfill a client's need including technical requirements, scheduling, and budget. Hilts Consulting Group was selected as the recipient for the award based on their Morro Reservoir Project in Fallbrook, California.

Reservoir in service draining prior to project.

Morro Reservoir was originally constructed in 1964. In the 1970's, the reservoir underwent a significant rehabilitation, which included: excavation of at least 6 feet of volcanic debris and volcanic materials in the subgrade that was replaced with a compacted earth blanket, foundation grouting at the inlet/outlet structure, buttresses to stabilize downstream embankment slopes, and the addition of a multi-layered hydraulic asphalt concrete lining system with 4-inch subdrain pipes serving as a leakage collection system below the asphalt liner.

Morro Reservoir has a maximum storage capacity of 151 million gallons (MG), a surface area of 12.5 acres, and a maximum water depth of 60 feet. The man-made earthen reservoir has 2:1 (horizontal: vertical) side slopes. A paved vehicular road is provided around the reservoir top for access. Prior to the recent improvements, the upper portions of the hydraulic asphalt concrete (HAC) lining system had weathered and cracked due to age and exposure (see Figure 1). Significant leakage through the leak collection system under the HAC lining system was reported at higher water surface levels, which limited reservoir operations and storage.

The owner, Rainbow Municipal Water District, was required to provide some improvements to the previously uncovered reservoir to comply with the Safe Drinking Water Act, which in general required the reservoir to be covered or provide treatment on the reservoir outlet. The floating cover construction bid was $8.37 million.

From 2010 through 2012, the reservoir underwent a major rehabilitation project which included a new composite geosynthetic liner system (see Figure 2) and a floating cover (see Figure 3) to protect the potable water. A washwater system was also provided to enable cleaning of the floating cover. The washwater system includes a trailer mounted booster pump system, connection point to onsite tank, buried PVC piping around the reservoir, and warf heads spaced around the reservoir perimeter. A gravity drain system consist-

Figure 1. Reservoir drained immediately prior to starting construction.

ing of buried PVC pipe was installed in the reservoir perimeter road to collect nuisance water on the road and also served as the floating cover rainwater removal system discharge

A new concrete curb was constructed along the reservoir perimeter (see Figure 3) inboard of the reservoir perimeter road to prevent site water from flowing into the reservoir and provided a means to anchor the new composite geomembrane liner system and floating cover system at the reservoir top of slope. The composite geomembrane liner was installed to reduce/minimize seepage into soils below reservoir, eliminate possible exchange between potable water and groundwater, and preserve water quality. The new composite geosynthetic liner system was installed on the reservoir floor and side slopes to maximize the allowable reservoir drawdown rate and provide the most operational flexibility. To allow for the most operational fluctuations drawdown, a leak collection system was installed below the new geomembrane liner system to convey leakage water away from the geomembrane, thereby minimizing the hydrostatic head on the backside of the new geomembrane liner system.

The liner leakage collection pipe and drainage gravel backfill were installed above the existing HAC lining and below the new liner system. The reservoir low point was filled and compacted with clean, washed, rounded drainage gravel to a minimum depth of 12-inches. The gravel was covered with a nonwoven geotextile and then covered with the composite drainage course and fabricated geomembrane. The liner system leakage collection pipe was connected to the existing reservoir seepage collection subdrain system, which consists of a series of perforated pipes located on the reservoir floor and connected to an existing drain pipe that drains liner system leakage to a subdrain located outside the reservoir perimeter. The allowable leakage rate was determined based on site specific criteria and was set at 21 gpm. At the completion of construction, reservoir startup, and testing the leakage rate was measured to be less than 1 gpm.

The composite geomembrane liner was installed to reduce/minimize seepage into soils below reservoir, eliminate possible exchange between potable water and groundwater, and preserve water quality. The new composite geosynthetic liner system was installed on the reservoir floor and side slopes to maximize the allowable reservoir drawdown rate and provide the most operational flexibility.

Figure 2. Geomembrane liner and inlet pipe extension during construction.

The reservoir composite geomembrane liner system includes a Chlorosulfonated Polyethylene (CSPE) geomembrane liner manufactured by Burke Industries. The geomembrane component of the liner system is a 60-mil, 5-ply CSPE geomembrane. The liner is anchored to underwater structures with stainless steel anchors and stainless steel batten bars. The liner termi-

nates at the top of slope and is anchored to a perimeter concrete curb with stainless steel anchors and stainless steel batten bars. Liner vents spaced at regular intervals are provided at the top of slope.

A new floating cover was included to provide compliance with potable drinking water regulations. The floating cover protects the drinking water quality, provides a barrier to wind driven contaminants, reduces evaporation, eliminates birds and animal access, and reduces the overall use of chemicals. The geomembrane floating cover is weight tensioned to enhance rainwater drainage and to allow personnel access onto the floating cover while in service to conduct as-needed water quality tests and perform necessary inspections and maintenance activities. The floating cover is tensioned by a series of strategically placed weights and floats, which will also serve as the rainwater removal troughs. The floating cover was designed in accordance with American Water Works Association (AWWA) Flexible-Membrane Covers and Linings for Potable-Water Reservoirs, M-25 and AWWA California-Nevada section Reservoir Floating Cover Guidelines. The main component of the floating cover system is a 45-mil, 3-ply, scrim reinforced CSPE geomembrane also manufactured by Burke Industries. The floating cover terminates at the top of slope and is anchored to perimeter concrete curb with stainless steel anchors and stainless steel batten bars.

A new floating cover was included to provide compliance with potable drinking water regulations. The floating cover protects the drinking water quality, provides a barrier to wind driven contaminants, reduces evaporation, eliminates birds and animal access, and reduces the overall use of chemicals.

Layfield Environmental of Spring Valley, California was the General Contractor, as well as the Geomembrane Installer, for the Morro Reservoir Project.

Figure 3. Floating cover rainwater collection troughs in service.

The floating cover has stainless steel access hatches supported on pontoon float assemblies at various locations throughout the floating cover. The access hatches allow venting of air trapped under the floating cover, diver access for inspections while reservoir in service, obtain water quality grab samples, and inflation for blowers and personnel access underneath the floating cover when reservoir dewatered. Vacuum vents are located at the overflow, outlet, and inlets to vent air from underneath the floating cover, and also to provide a vacuum break to prevent the floating cover from being drawn into a structure or pipe while reservoir water is drawn down.

There were some minor changes during construction due to varying site conditions where work was added and deleted from the contract. The primary changes were related to pipelines outside of the reservoir but adjacent to the reservoir, perimeter fencing changes, and changes to CIPP pipeline rehabilitation. The total change orders resulted in a reduction of $370,000.

Pipe grillages are located at inlet and outlet points to support the floating cover over large openings and/or equipment when the reservoir is filled and emptied.

The rainwater removal system was designed in accordance with AWWA California-Nevada section Reservoir Floating Cover Guidelines and site specific rainfall criteria. The rainwater removal system consists of four submersible pumps located in the rainwater removal troughs. The pumps discharge hoses are laid on the floating cover and routed to gravity drain collection points located at the top of slope.

The floating cover requires regular maintenance, inspections, and periodic cleanings. The construction contract required the Contractor to perform floating cover quarterly maintenance work for the first 2 years. Rainbow has since taken over the maintenance and inspection duties. **L&W**

by Timothy D. Stark, Ph.D., P.E., D.GE, F.ASCE; Douglas Hilts, S.E. & Jennifer Miller, M.S.

For more information, contact Timothy D. Stark, Ph.D., P.E., F.ASCE, FGI Technical Director, at Email: tstark@illinois.edu, or Douglas Hilts, S.E., Hilts Consulting Group, at Email: doug.hcg@HiltsConsulting.com, or Jennifer Miller, M.S., FGI Coordinator, at Email: fabricatedgeomembrane@gmail.com.