Scheduled to become operational this fall, the Thornton Composite Reservoir marks a major expansion in the long-running effort to reduce combined sewer overflows in the Chicago metropolitan area.

METROPOLITAN WATER RECLAMATION DISTRICT OF GREATER CHICAGO, BOTH

STORM WATER

Thornton Composite Reservoir Greatly Boosts Chicago's CSO Storage Capacity

THIS FALL, the Metropolitan Water Reclamation District of Greater Chicago (MWRD) will begin operating the 7.9 billion gal Thornton Composite Reservoir, a key component of efforts to reduce flooding and improve water quality throughout the region. Completion of the massive flood control reservoir at the site of a former aggregate quarry will dramatically boost the storage capacity of Chicago's renowned Tunnel and Reservoir Plan (TARP), the network of deep tunnels and reservoirs that are intended to capture combined sewer overflows (CSOs) throughout the metropolitan area. With the $429-million Thornton reservoir operational, the TARP system will boast 10.2 billion gal of storage, a significant increase from the previous total of 2.3 billion gal.

Faced with the growing problem of CSOs, the MWRD began developing the TARP in 1972. Among the largest engineering projects on the planet, the TARP is intended to control flooding and reduce CSOs within a 352 sq mi area that is home to 3.75 million people. The system comprises four large tunnels and three reservoirs that will have a combined storage capacity of 20.55 billion gal upon its completion in 2029. Construction of the 109 mi of tunnels began in 1975 and was completed in 2006. The 350 million gal Gloria Alitto Majewski Reservoir was completed in 1998. To be built in two stages, the McCook Reservoir will have 3.5 billion gal of storage capacity when it opens in 2017 and 10 billion gal upon the completion of its second stage in 2029.

The TARP is designed to collect and store CSOs during storm events and hold the water until capacity is available at a nearby water reclamation plant (WRP). For this reason, drop shafts connected to the combined sewer system send CSOs to the tunnels, which are designed to drain to a reservoir. After a storm, the reservoirs are sealed off while the tunnels are drained by pumping stations that convey the water to a WRP. Once the tunnels have been emptied, the reservoirs are opened so that the stored water can flow back through the tunnels to the pumping stations and then on to a WRP.

Serving 556,000 people in 14 communities across the south side of Chicago and the southern suburbs of Cook County, Illinois, the Thornton Composite Reservoir will protect 182,000 structures from flooding and provide $40 million annually in flood control benefits. By helping the MWRD control CSOs, the new reservoir will also improve water quality in the Little Calumet River, as well as in the Calumet River and the Calumet-Saganashkee ("Cal-Sag") Channel.

The Thornton Composite Reservoir is part of the TARP's Calumet Tunnel System, which serves a 91 sq mi area. Within this service area, approximately 60 drop shafts send CSOs to the Calumet Tunnel. Nearly 37 mi long and up to 30 ft in diameter, this tunnel has a storage capacity of 630 million gal. Approximately 20 storms per year generate enough rainfall to exceed this capacity, at which point the tunnel will drain to the Thornton Composite Reservoir. The tunnel and the reservoir were designed so that flows could pass from one to the other by means of gravity, said Allison Fore, a spokesperson for the MWRD, who provided written responses to questions posed by *Civil Engineering.* "The tunnel is pitched away from the reservoir, so in order to fill the reservoir, some pressure head needs to develop in the tunnels and shafts to force the water into the reservoir," Fore explained. Conversely, when the time comes to drain the reservoir, its water will exit through two gates into the tunnel, where it will flow for approximately 6 mi until it reaches the Calumet TARP pumping station. From there, the water is pumped 350 ft up to ground level to the Calumet WRP, which discharges to the Little Calumet River.

A new connecting tunnel 1,200 ft long and 30 ft in diameter links the Calumet Tunnel to the Thornton Composite Reservoir. Within the connecting tunnel, a gate shaft divides the tunnel into two chambers. Both chambers contain a primary and a backup stainless steel wheel gate, each weighing approximately 100 tons. When closed, the 18 ft wide, 29 ft tall, and 4 ft thick gates seal off the reservoir, isolating it from the tunnel system. When it is time to drain the reservoir, a 42 in. diameter jet flow gate within the primary wheel gates is opened, releasing water back into the tunnel. The jet flow gates were included to prevent cavitation and potential damage to the tunnels, Fore said.

With a depth of 292 ft and a surface area of 83 acres, the Thornton Composite Reservoir can hold up to 7.9 billion gal. The basin is expected to reach capacity as a result of a 20-year storm event, although the reservoir "may fill more often during back-to-back storms if there isn't sufficient time to drain it between the storms," Fore said. Once full, the reservoir will require approximately a month to drain, depending on the availability of treatment capacity at the Calumet WRP.

The project design took pains to ensure that the former quarry became a watertight reservoir. Although an impermeable layer of shale at the bottom of the reservoir prevents water from entering the ground below, significant effort was required to seal the perimeter of the reservoir. To this end, a double-row vertical grout curtain was installed along the nearly 2 mi long perimeter. From the surface, 4 in. diameter holes were drilled to a depth of 500 ft into the dolomite bedrock. Spaced 5 ft apart, the holes were drilled at a 15-degree angle. Behind the first row, a second row of 4 in. diameter holes was drilled, also at an angle of 15 degrees but in the opposite direction. "The holes in this double-row grout curtain were filled in stages with pressurized grout, which migrated into the cracks and fissures of the surrounding dolomite to reduce the permeability of the rock mass," Fore said. To ensure that there are no leaks, groundwater monitoring wells around the reservoir will be sampled every quarter and after major fill events.

The design also had to protect the operations of an adjacent active quarry. Achieving this goal required sealing off a gap between the reservoir and the active quarry. Previously used as a haul road, the gap was closed by means of a 116 ft tall dam comprising 32,000 cu yd of roller-compacted concrete. At its base, the dam is 140 ft long and 84 ft wide, while at its top it has a length of 226 ft and a width of 36 ft. Two haul tunnels connecting the former quarry and the active quarry also had to be sealed. The tunnels were plugged by means of steel-reinforced, high-strength concrete bulkheads that were anchored and grouted in place to form a permanent seal.

With a depth of 292 ft and a surface area of 83 acres, the Thornton Composite Reservoir can hold 7.9 billion gal of combined sewer overflows.

The expected maximum flow into the reservoir is 22,000 cfs, while the anticipated maximum velocity is 31 ft/s. Because of the significant force of the flows entering the reservoir, a diffuser apron was constructed to dissipate energy and prevent erosion at the reservoir's entrance. The 3 ft thick apron is made of concrete having a compressive strength of 8,000 psi, and its perimeter is connected to the reservoir floor by means of a shear key. The diffuser slab and the shear key are anchored 12 ft deep into the reservoir floor by means of number 11 anchor bars.

Because solids are expected to settle to the reservoir floor and decompose, the MWRD will maintain a minimum pool of approximately 5 ft of water in the reservoir to prevent odors. To ensure adequate oxygen levels in the pool and prevent the formation of septic conditions, seven floating aerators using solar power will be deployed in the reservoir.

The Thornton Composite Reservoir was designed by the MWRD with assistance from MWH Global, Inc., of Broomfield, Colorado, and Black & Veatch, of Overland Park, Kansas. Construction was carried out by two general contractors: a joint venture comprising the Walsh Construction Company and II in One Contractors, Inc., both of Chicago, and a second joint venture comprising F.H. Paschen, S.N. Nielsen, Inc., and the Cabo Construction Corporation, both also of Chicago. —JAY LANDERS