RESERVOIR RESTORATION FOR MUNICIPALITIES

SUMMARY STATEMENT OF QUALIFICATIONS

BRADY
Reservoir Restoration

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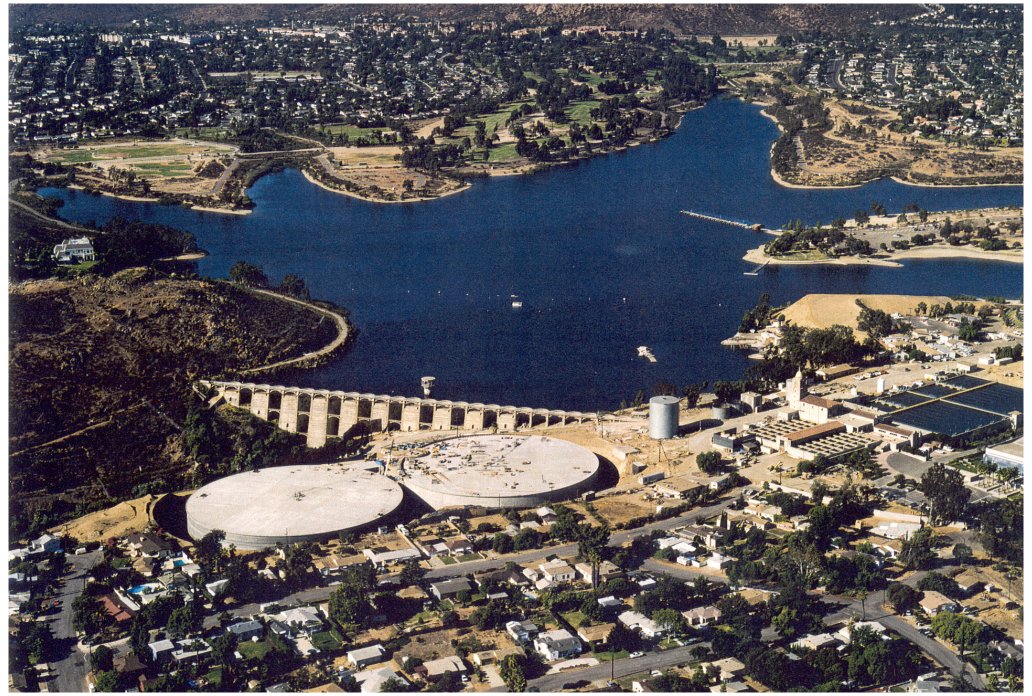
INTRODUCTION TO BRADY RESERVOIR RESTORATION

BRADY is internationally recognized as a leader in the field of water storage facilities. Our team includes two of the industry's foremost experts in reservoirs: Richard Brady, P.E., BCEE who has managed more than 50 reservoir design projects of all types, shapes and sizes, and Max Dykmans, S.E. who has completed more than 3,000 prestressed concrete reservoir projects around the world over the past 40 years.

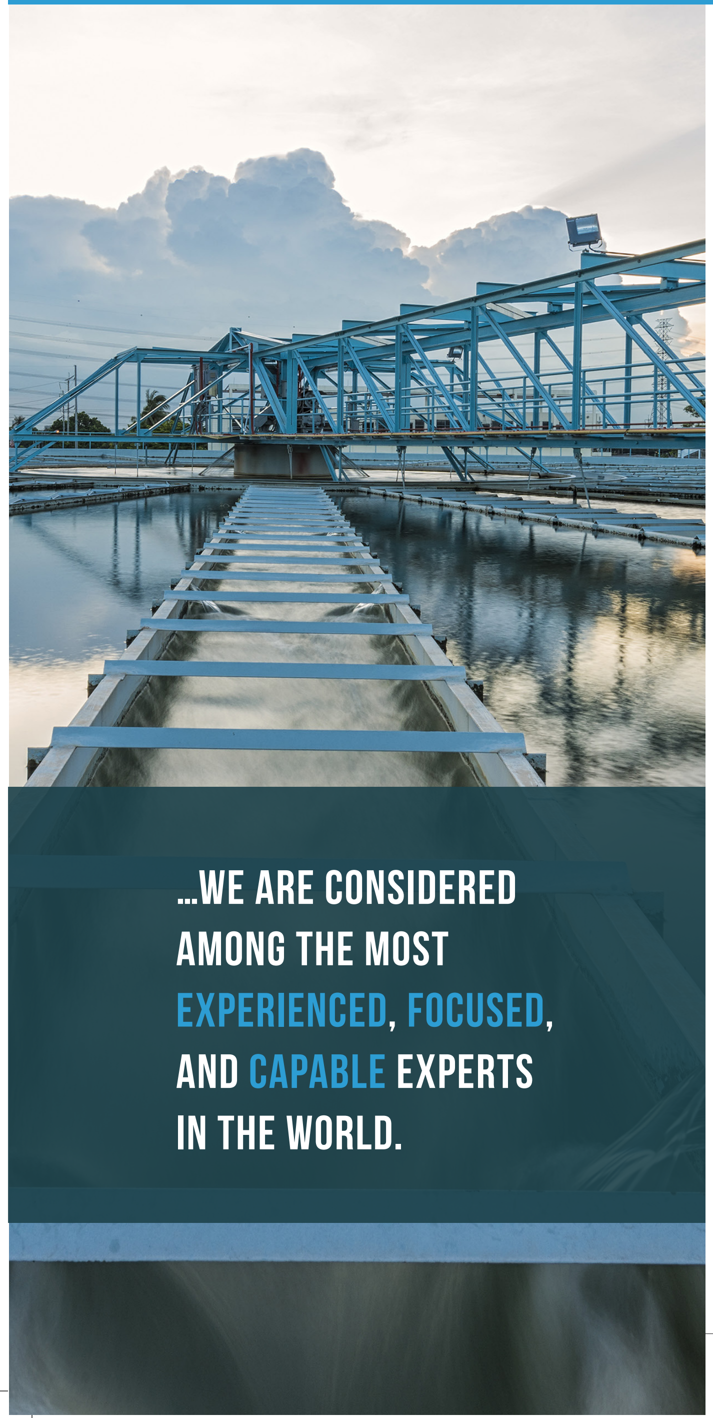
We have successfully provided services to clients both locally and globally in all aspects of reservoir and storage tank design, construction, operations and maintenance. Our service offerings include:

- Design and design build of reservoirs, storage tanks and associated appurtenances
- Design and design-build of reservoir repairs, restoration, and structural upgrades
- Reservoir inspections and condition assessments
- Structural evaluations of reservoirs
- Seismic evaluations and retrofits
- Construction management services

BRADY'S Reservoir Restoration business line has a singular focus: the most effective code compliant and safe restoration of municipal water storage reservoirs. Our core team offers **100+ years** of combined expertise and **1000s** of completed reservoir projects; our approach saves up to **35%** on projects costs and up to **33.5% faster** project completion times when using our **r360™** progressive design-build process.



BRADY RESERVOIR RESTORATION CORE TEAM



...WE ARE CONSIDERED AMONG THE MOST EXPERIENCED, FOCUSED, AND CAPABLE EXPERTS IN THE WORLD.

Our core BRADY Reservoir Restoration team has 100+ years of water project engineering experience tackling some of most significant reservoir projects. From the 35 million gallon Earl Thomas reservoir in San Diego, CA - the world's largest prestressed concrete reservoir at the time in 2005 - to working on over 1+ billion gallons of storage capacity, we are considered among the most experienced, focused, and capable experts in the world.

100+ years of combined experience

1+ billion gallons of storage capacity project experience

1000s of collective reservoir projects

Expert witness experience in high-stakes water projects

OUR TEAM

Richard Brady

Richard Brady is the founder, President and Chief Executive Officer of Richard Brady & Associates (BRADY). He has 36 years of experience in water resources planning and in the design, management, and construction administration of drinking water supply projects. His fields of specialization include: predesign, design, value engineering, construction management, and start-up services for many large drinking water treatment plants, pump stations, and reservoir projects. Mr. Brady is a graduate of Harvard Business School's "Leading Professional Service Firms" and the "Owner-President Management" program. He is also an internationally-recognized water engineer, and a contributing author to the AWWA's "Water Treatment Plant Design". He has served as the Project Manager for water treatment plant projects plant sizes ranging in size from 5 mgd up to 2,000 mgd. His resume for surface water treatment plant projects exceeds 6 billion gallons per day.

Ralph Lee Biggers

Lee Biggers, S.E., has over 40 years of experience in the structural engineering profession, and has been responsible for the structural design of construction projects collectively totaling over $500M in construction cost. He has designed single and multi-story residential buildings, schools, waterfront structures, bridges, water / wastewater structures, and airfield hangars. Mr. Biggers has also performed forensic investigations, peer reviews, rehabilitations, seismic studies, expert witness litigation, and value engineering over the course of his career. He has prepared PS&E packages, provided structural design, assessed structural stability and load-bearing capacities, and conducted seismic evaluations for new and existing structures. Reflecting his contributions to the profession, Mr. Biggers was inducted as a Fellow of the Structural Engineers Association of California.

Max Dykmans

Max Dykmans is a civil/structural engineer with over 45 years of relevant experience in the design and construction of water and wastewater reservoirs and supporting infrastructure. Mr. Dykmans has designed and/or constructed over 2 billion gallons (500 MG in Southern California) of reservoir capacity. Prior to joining BRADY in 2011, he was the Founder and President of DYK Incorporated (now DN Tanks, Inc.), responsible for planning, development and coordination of multiple multi-million dollar projects from design phase through construction of prestressed concrete water and wastewater storage reservoirs. He is responsible for millions of gallons of storage for Orange County and Southern California clients, which include LADWP, Azusa, Huntington Beach, Newport Beach, Anaheim, San Clemente, San Juan Capistrano, Garden Grove, Laguna Beach, Irvine, El Toro, Moulton Niguel, and San Diego. International tank projects include Egypt, Qatar, Trinidad and Singapore.

He has extensive experience assessing structural stability and load bearing capacity of structures, providing structural design for reservoirs, rehabilitation, preparing technical memoranda, construction cost estimates, and record drawings. His experience includes new reservoir design and construction and the rehabilitation/upgrade work of existing reservoirs for the majority of Southern California's municipalities.

As an active Committee member of AWWA, Mr. Dykmans was instrumental in developing the AWWA D110 standard, which includes a robust evaluation of the ability of reservoirs to withstand earthquakes. Mr. Dykmans' expertise includes evaluations of all types of concrete reservoirs, including conventionally reinforced concrete structures and steel reservoirs. This storage experience includes review and design of concrete, aluminum, and wood roof structures and reservoirs with sloped floors (concrete and lined).

STATISTICS

Estimated amount of deferred maintenance of CA water storage reservoirs up to 35MG needed to become code compliant and safe.

UP TO
$620M

Number of municipal water storage reservoirs built before 1970.

HUNDREDS

Estimated damage caused by the Oroville reservoir spillway failure.

$4.7M PER DAY

ACCORDING TO THE DEPARTMENT OF WATER RESOURCES.

Estimated percentage of CA municipalities that have water storage reservoirs up to 35MG that require restoration to be code compliant and safe.

UP TO
70%

Estimated dollar value of savings in CA waiting to be unlocked by reservoir restoration vs. replacement.

UP TO
$200M

THE BENEFITS OF RESERVOIR RESTORATION

COST

Project costs reduced by 15% – 35% with equivalent outcome

SPEED AND PRECISION

BRADY's r360™ progressive design-build integrated delivery method is estimated at delivering the reservoir restoration project 33.5% faster**

REPLACE ONLY FAILED COMPONENTS

Use entire lifecycle of infrastructure vs. early and unnecessary replacement

FAQ

1 What is reservoir restoration?

1A The process of identifying and applying engineering and construction restoration solutions to compromised water infrastructure, while maintaining its functioning components.

2 What is the difference between reservoir restoration and replacement?

2A The outcome is the same. A fully code-compliant, safe, and functioning reservoir; however, restoration is often considered superior because it preserves existing components that do not require repair or replacement. Thus, restoration is equally effective, yet more cost efficient. In most installations, reservoir restoration can be considered a maintenance activity as opposed to new capital construction. Environmental hurdles are much easier to clear when considered a maintenance activity.

3 Why would a reservoir be a candidate for restoration?

3A Reservoirs - particularly those built prior to 1970 – have often reached their maximum life cycle and are susceptible to costly, and unfortunately, sometimes catastrophic failures.

4 What is the cost comparison between reservoir restoration and replacement?

4A It certainly varies, but typical is between 15% - 35% of replacement cost.

5 Is allowing a reservoir to exist until failure a more cost effective option?

5A Generally no, and the unforeseeable safety hazards and reputational risk can be calamitous.

6 Does a restored reservoir have an equivalent service life compared to a replaced reservoir?

6A Yes. A restored reservoir is restored to applicable code and best longevity and safety practices. Within the restoration process, any components that require complete replacement are specified and replaced, such as often the roof and the prestressed wire strands (in the case of a prestressed circular reservoir).

7 Do any operation and maintenance savings result from a restored reservoir?

7A An overwhelming majority of BRADY Reservoir Restoration projects experience an immediate improvement in reduced operations costs based upon reduced water leakage. Additionally, the ability to confidently rely upon the restored condition of the reservoir for decades results in predictably low maintenance costs.

PROJECT APPROACH AND GETTING STARTED

PHASE 1

Assessing the health of the tank and the optimal restoration plan

Physical Evaluation

- Engineering inspection of interior and exterior
- Boat inspection of the underside of the reservoir roof
- Diver inspection of the entire reservoir while in service
- X-ray
- Non-destructive testing

PHASE 2

Generating a detailed engineering report

Task 1 – Structural Analysis

A structural analysis is performed for all component elements of the subject reservoir. An assessment is made of each component's design capacity relative to the requirements of the following applicable codes:

CBC 2016	California Building Code (for tanks located in California)
ACI 318-14	Building Code Requirements for Structural Concrete
ACI 350-06	Code Requirements for Environmental Engineering Concrete Structures
ACI 350.3-06	Seismic Design of Liquid Containing Structures
ASCE 7-10	Minimum Design Loads for Building and Other Structures

Task 2 – Report/Findings

Conclusions as to the design adequacy of each structural component element are provided. Recommendations are made which provide corrective measures to address each determined deficiency. Sketches are provided as a report appendix which indicate remedial repairs to bring each deficient component up to current code requirements of all applicable codes. Calculations are included as a report appendix.

PHASE 3

Selecting a Delivery Method

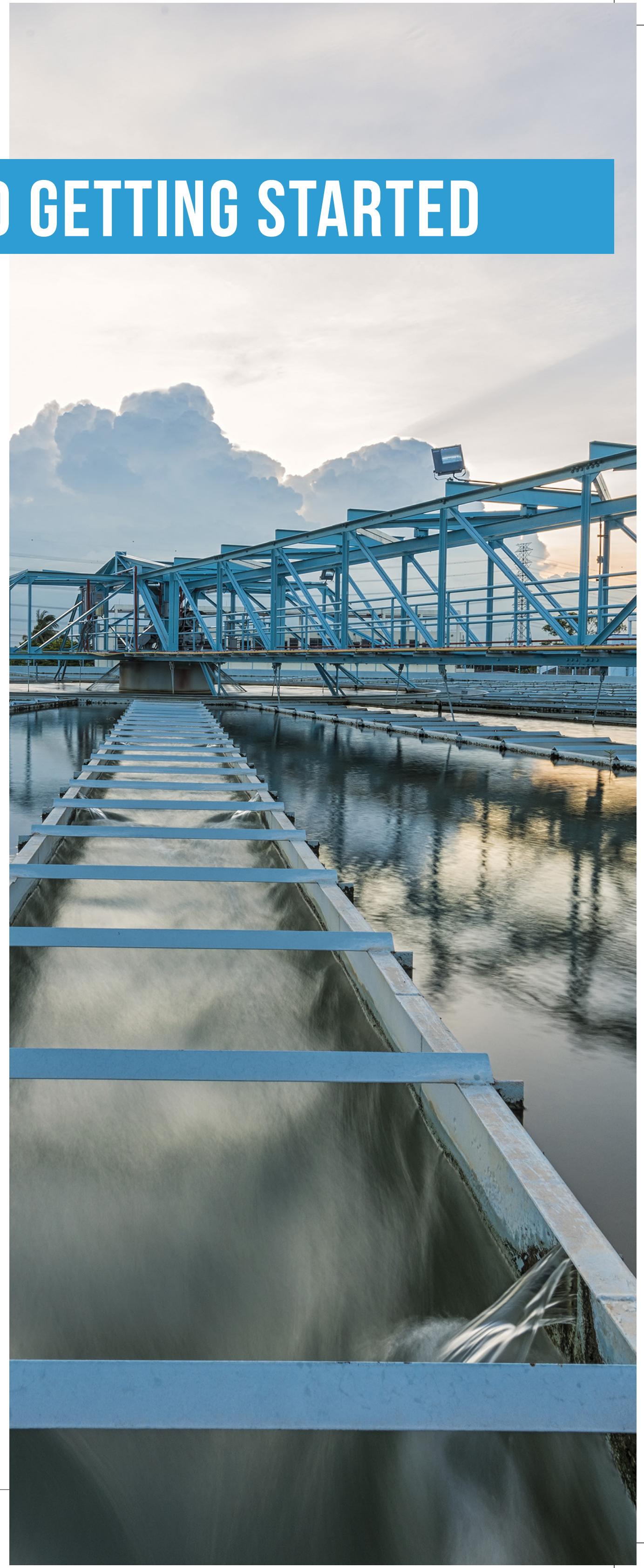
Comprehensive Design - Bid - Build package, or BRADY Reservoir Restoration's r360™ progressive design-build process.

Design - Bid - Build

- Prepare detailed drawing and specifications
- Prepare bid packages
- Assist with contractor selection
- Assist with construction phase services

r360™ Progressive Design-Build

- BRADY is design-build entity and a licensed General Contractor
- Detailed drawing and specifications integrated with contracting process
- Construction begins almost immediately
- BRADY the is single contract holder and responsible for every aspect of engineering, construction, and construction management
- Typical NTP until completion using our r360™ process is up to 33.5% faster.



PROJECT DESCRIPTIONS

7.5MG Pritzker Tank Replacement

City of Upland, CA

Completion Date

Design: 2016 - Ongoing

Client

City of Upland, CA

Problem

The City's 7.5MG Reservoir was built in the mid 1970s and is similar in design to the failed 5 MG Westminster, CA, tank in 1998, and exhibits the following:

> Visible leaks at several locations
> Cracked walls, roof, and mid spans
> Sagging roof and mid spans
> The need to reduce THM formation potential

Solution

BRADY was contacted to perform a visual inspection of the reservoir and immediately recommended the City remove the reservoir from service because the remaining life and integrity of the reservoir is unknown. However, this was impossible because the reservoir is serving as the "heart of the City's system"; therefore, the only solution is to construct a new reservoir at the earliest possible date utilizing "best available" project delivery methods. During the time of print (April, 2017), BRADY is designing a new 7.5 MG reservoir adjacent to the existing Pritzker tank, while evaluating options to strengthen the existing reservoir to provide a measure of safety as the clocks continues to tick away.

Cost

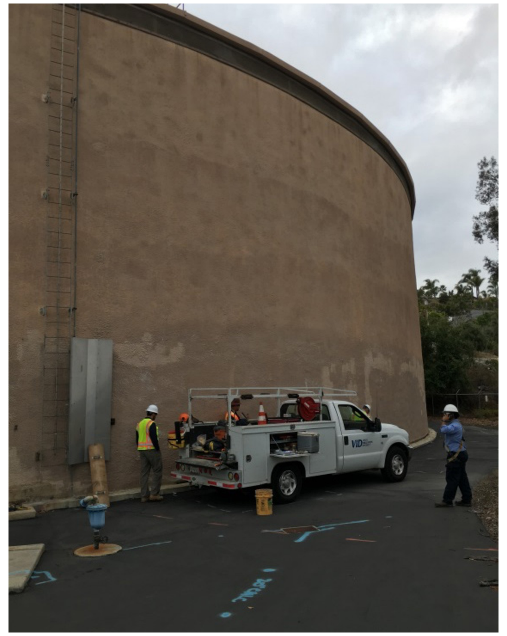
$600,000

Anticipated Delivery Method

BRADY was awarded a fast-track design contract to evaluate the most effective design and contracting method.

Anticipated Outcomes

> Unexpected tank failure was averted
> THM reduction expected to within 80% of regulatory limits
> Fully code compliant reservoir
> Time is of the essence due to the potential for catastrophic failure, without any warning symptoms
> The 1998 Westminster failure confirmed the need to pay close attention to tanks designed and constructed from a different era. A key finding of the Westminster failure was the lack of any indicator that failure was imminent. A Fire Station was located adjacent to the reservoir and on the day before the tank rupture, there was no evidence of leakage, a creaking noise, or any other indicator of impending doom even to the trained eyes of first responders.



5MG HP Reservoir Restoration Project

Vista Irrigation District (VID), CA

Completion Date

Design: 2016
Construction: 2017 - Ongoing

Client

Vista Irrigation District, CA (VID)

Problem

VID experienced a serious structural issue with a critical 5.0 MG, 55 year old prestressed concrete reservoir. In particular, the exterior prestressing wire and the roof integrity showed significant signs of distress.

Solution

At BRADY's strong recommendation due to the possibility of failure in the event of a seismic event, the tank was immediately drained and removed from service to prevent a potential catastrophic safety hazard. The reservoir was constructed in 1961 in a remote area of Vista's service area. In 2017, the reservoir is now surrounded by residential communities, extending right up to the site perimeter fencing. Concurrently, VID awarded BRADY a sole sourced contract whereby BRADY, using its r360® Design/Build Method (acting as general contractor and designer of record) developed a fast track restoration plan.

Cost

$3,490,000 (50% savings anticipated compared to new tank, not including the costly and environmentally challenging demolition of the existing 5 MG concrete reservoir)

Delivery Method

r360® Design/Build Method

Anticipated Outcomes

> Application of new 7-wire galvanized strand prestressing and automated shotcrete.
> New wall footing and seismic cables.
> New low-profile aluminum roof installed.
> OSHA approved roof ventilation, exterior stairwell, and interior stairwell.
> A multitude of supporting design and repair upgrades resulting in a fully-code compliant and safe reservoir with many decades of enhanced service life.

PROJECT DESCRIPTIONS

Earl Thomas Reservoir

San Diego, CA

Completion Date
2005

Client
City of San Diego

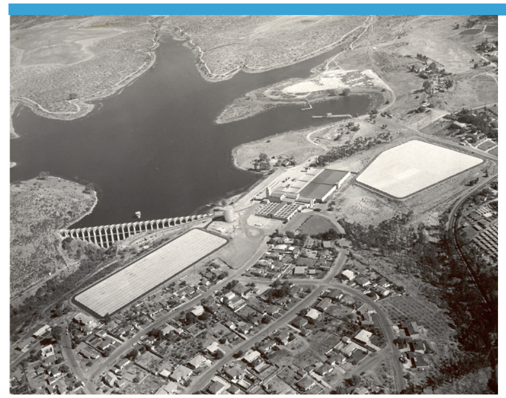
Problem
The Earl Thomas Reservoir was constructed in 1957. However, in the late 1990's, the reservoir fell under the ever-increasing scrutiny of the State of California Department of Safety of Dams due to its age and severe deterioration. The reservoir was considered a "house of cards", highly susceptible to failure due to a seismic event. Therefore, the reservoir was removed from service in 1998. The reservoir roof was so unstable it was unsafe to even walk on the reservoir roof. (See Civil Engineering Magazine article "Earl Thomas Pre-Stressed Concreter Reservoir is World's Largest", June 2005).

Solution
BRADY staff conducted both internal and external inspections and prepared a structural and operational reliability analysis to determine the feasibility of rehabilitation, repair or replacement of the aging reservoir. BRADY was then retained to design the replacement of the Earl Thomas Reservoir, which included the redesign of Alvarado's main treatment plant entrance, originally constructed in 1950, to improve security and appearance. BRADY also provided resident engineering services for the project and was responsible for day-to-day construction administration of civil site work, including the appurtenant piping, pumping, and flow control equipment required for operation of the new reservoir. The work also included a 60-inch diameter tunnel that hydraulically connected the Earl Thomas Reservoir to the twin 21.5 MG reservoirs completed in 1998.

Cost
$26,805,651

Delivery Method
BRADY acted as Project Manager, Designer, and Construction Administrator (advisor)

Outcomes
The Earl Thomas Reservoir project was an award winning project for the City of San Diego Water Department. All design work for this project was performed in accordance with the strictest project-specific quality control procedures, and in cooperation with client quality assurance requirements. The design was accomplished within budgetary and schedule parameters. Our stringent cost control procedures resulted in minimized construction change orders. **At project completion, Richard Brady, P.E., BCEE was recognized by City of San Diego Mayor Jerry Sanders as the "100 Million Gallon Man", due to Mr. Brady's personal responsibility for planning, designing, and managing the construction of more than 100 million gallons of new and rehabilitated reservoir storage for the City of San Diego.**



2-21MG Regulating Reservoirs, Alvarado

San Diego, CA

Completion Date
Design: 1992-1994
Construction: 1998

Client
City of San Diego, CA

Problem
The City of San Diego was constrained by a site for a treatment plant designed in 1946, and had to expand due to a growing city and the more stringent drinking water quality regulations mandated by the Safe Drinking Water Act of 1986. The Alvarado Water Treatment Plant was required to ensure the adequate supply of clean drinking water to its 1.2 million residents via a water plant originally sized at 66 million gallons per day (mgd), that now required 200 mgd and new state-of-the-art clearwell reservoir storage, given the entire City of San Diego's water supply to 500,000 residents was at risk in the event of a serious seismic event that would result in the collapse of the plant's aging clearwells. The existing 20 MG rectangular reservoir, state of the art for its time in 1946, had already suffered the collapse of a roof panel that resulted in operational chaos. BRADY was tasked with designing new clearwell storage to meet the demands of a much larger city. In the end, BRADY successfully designed two new 21.5 MG reservoirs to fit in the existing 20 MG footprint – more than doubling the size without the additional need for a single yard of new real estate.

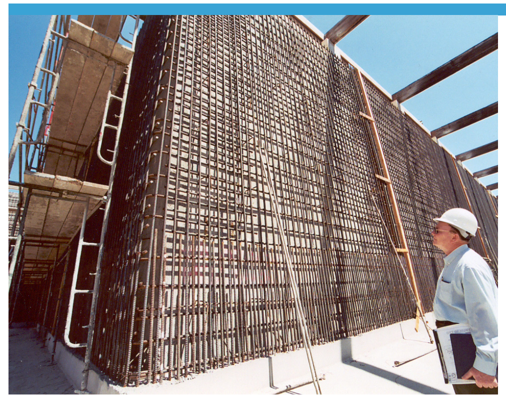
Solution
The design of two, 21.5 MG each, circular, prestressed concrete reservoirs, which serve as clearwells to the treatment plant and satisfy the daily water demands for a planned 2060 population of 1 million citizens. At the time of construction, the 21.5 MG size was the largest prestressed concrete reservoir in the state of California. And we built two, in the original 20 MG footprint.

Cost
$27,000,000

Delivery Method
Richard Brady, CEO of BRADY, was the Engineer of Record and served as Project Manager during the extensive design-bid-build process.

Outcomes
Public Awareness: The reservoirs are partially buried and a portion of the roof on one reservoir is dedicated to a Native Plant Demonstration Garden. The reservoirs were primarily designed to provide the City with storage facilities to meet their present and future needs; concurrently, this design enhanced the public's awareness and understanding of local water issues.

Nationwide Project Award. The Alvarado Regulating Reservoirs project was awarded the American Society of Civil Engineers Outstanding Civil Engineering Project Award in 1998 in the water facilities category, and the American Public Works Associations 1999 National Project of the Year Award. The project also earned the recognition of the Associated General Contractors for Excellence in Underground Utility Construction. In addition, on May 4, 1999, by resolution of the City Council, City of San Diego, the Alvarado Reservoirs and Garden project was officially recognized as an important component of the City's water distribution system.



21.5MG Overmyer Reservoir and Booster Pump Station Rehabilitation

Huntington Beach, CA

Completion Date

2004

Client

City of Huntington Beach, CA

Problem

The City of Huntington Beach required a sensible solution for rehabilitating an existing conventionally designed, irregular shaped concrete reservoir. The existing roof was leaking potentially contaminated water into the reservoir, a serious water quality issue, and the existing walls were leaking considerably through vertical cracks that required the reservoir to be operated at approximately 50% of the 21.5 MG design capacity. Though only dating to 1971, the reservoir was thought to be seismically inadequate, an assumption that was later confirmed by BRADY's structural engineers. As the City's largest reservoir serving as the "heart" of the City's system, operating at less than one half of the design capacity presented serious operating problems for the City's staff. Operating and contingency storage was less than required given the need to maintain sufficient fire storage. Through no fault of their own, City Operations staff tasked with the 24/7 operation of the City's system serving 200,000 residents were justifiably on edge.

Solution

BRADY was fortunately positioned to come to the rescue. BRADY conducted a thorough internal and external inspection along with a seismic code compliance analysis and found that the 21.5 MG Overmyer Reservoir would be an ideal candidate for a rehabilitation and structural upgrade. Given the reservoir was partially buried and the site was severely space constrained, BRADY engineers developed a "first of its kind" solution. The reservoir roof was removed to allow the construction of new internal walls assuming cast in place concrete was the best solution. However, a bid alternate for "shotcrete" was allowed and accepted by BRADY, resulting in a $1M cost savings to the project. What quickly became known as the "Overmyer Solution" stimulated considerable dialogue within BRADY about what might be possible in the future to maximize a reservoir's "footprint value". Ultimately BRADY's "Tank within a Tank" value centered idea took hold within the water industry, providing a means to deliver 21st century construction quality and code compliance, at a fraction of the cost of building a new tank at a new site.

Cost

$6.5M (over $1M saved vs. full replacement at a new site)

Delivery Method

Design/Build/CMAR

Outcomes

> Complete structural upgrade of the below-ground retaining wall system and roof supporting columns
> New 25-foot high cast-in-place reinforced concrete retaining walls
> Structural upgrade columns
> New 80,000 square foot replacement
> Reservoir appurtenance improvements to valves, vaults, piping
> Complete rehabilitation and upgrade of an adjacent water booster pump station

Water Treatment

Earl Thomas Prestressed-Concrete Reservoir Is World's Largest

The largest prestressed-concrete reservoir in the world was recently constructed at San Diego's Alvarado Water Treatment Plant (wtp). The reservoir replaces a 50-year-old, 35 million gal (132 million L) reinforced-concrete and earthen dam reservoir that had been unusable for the past decade because of cracking, seismic instability, and inadequate water circulation. The new, partially buried reservoir is to be surrounded by palm trees and have a road across its roof.

Named for Earl Thomas, a former superintendent of the city's water department, the new potable water reservoir is nestled in the ground near the front of the wtp's main building. Its 406 ft (124 m) diameter reinforced-concrete roof is all that can be seen. The reservoir \ has been designed so that its roof is in keeping with the Moorish design of the main building, which has a roof of red tiles and a tower capped with an onion-shaped dome.

In tests carried out on the previous reservoir, engineers found that it was outdated and near collapse. **"It was basically like a house of cards ready to fall down," says Richard Brady,P.E.,dee, the president of San Diego-based Richard Brady & Associates, which managed the design of the new reservoir.** The old reservoir became a stumbling block to city managers as they looked for ways to increase the wtp's capacity so that it would be able to serve the city's growing population. When they found they had no alternative but to replace the tank, they wanted something that would stand the test of time and meet San Diego's growing needs. They were convinced that prestressed concrete would last longer and require less maintenance than conventionally reinforced concrete.

The new reservoir is also better suited to San Diego's active seismic zone than the preceding tank. Rubber pads 11/4 in. (32 mm) thick have been placed between the wall and the roof, and pads 2 in. (51 mm) thick between the wall and the floor will act as shock absorbers during an earthquake. Cables have been installed near the pads to manage seismic displacement.The reservoir can thus resist both vertical and horizontal earthquake loads, as well as water movement and overturning moments.

According to Brady, the 241 columns supporting the roof would typically be roughly 24 in. (610 mm) in diameter. However, in this case the columns were designed to support the additional loads imposed by vehicles on the road and by the 2 ft (0.6 m) of soil that will be added if administrators choose to fully bury the reservoir, an option they are considering. To support the additional loads, the column diameters are 30 in. (762 mm).The roof is 18 in. (457 mm) thick.

The reservoir's circular concrete wall tapers in thickness from 38 in. (965 mm) at the base to 12 in. (305 mm) at the top and contains little steel reinforcement.To prestress the concrete, vertical steel tendons 13/8 in. (35 mm) in diameter were embedded in the wall and posttensioned, causing the wall to compress. According to Galit Ryan, P.E., the vice president of sales and marketing for dyk, Inc., of El Cajon, California, the company that designed and constructed the reservoir, the compressed concrete wall will resist cracking and last much longer than steel. To counteract water-induced loads, 3/8 in. (9.5 mm) diameter steel cables, each comprising seven strands, encircle the tank.

The concrete and earthen dam reservoir contained a single pipe that conveyed water into and out of the tank. After 40 years of use,the pipe became inadequate owing to its size and configuration,and the water quality decreased because residual water sat stagnant in the tank for extended periods.The new reservoir contains multiple pipelines and internal baffles to better circulate the water and maintain higher water quality.

The reservoir will be fully functional this summer, and it will increase the wtp's storage capacity from 42 million gal (159 million L) to 77 million gal (291 million L).The wtp will then serve approximately half of San Diego's 1.2 million residents. Other engineering firms associated with the project include ch2m hill, of Englewood, Colorado, and Malcolm Pirnie, Inc., of White Plains, New York. The general contractor for the project was C.E.Wylie Construction Company, of San Diego.

–Brett Hansen

"IT WAS BASICALLY LIKE A HOUSE OF CARDS READY TO FALL DOWN"

The Earl Thomas Reservoir is nestled in the ground near the main building of San Diego's Alvarado Water Treatment Plant. The reservoir will hold 35 million gal (132 million L) of potable water, making it the largest prestressed- concrete tank in the world. After backfilling and landscaping have been completed, palm trees will grace the reservoir's perimeter and a road will traverse its roof.

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