It's Screen Time: Largest Headworks Design Under Construction in Florida!

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Miami Dade County (county) is among the top ten most populous counties in the United States with 2.7 million people. The Miami Dade Water and Sewer Department (MDWASD) owns and operates three wastewater treatment plants (WWTPs): North District, Central District, and South District. Unlike other utilities in the state, MDWASD is faced with the dual challenges of providing increased treatment capacity for growth, while also preparing for more stringent discharge requirements at each of its plants. Both challenges must be met using the aged infrastructure of the existing plants.

The project site is the Central District Wastewater Treatment Plant (CDWWTP), which is located on Virginia Key. Principal components of the system associated with CDWWTP were constructed in the 1950s and '60s, making it the oldest and largest of the three MDWASD facilities. Although the system has been growing and expanding for the last 70 years, the last major expansion and upgrades were completed over 30 years ago in the 1980s.

The plant has undergone numerous expansions and upgrades from its original permitted capacity of 47 mil gal per day (mgd) as a modified activated sludge process to its current configuration as a 143-mgd average annual daily flow (AADF) and 360-mgd peak flow high-purity oxygen-activated sludge facility. The CDWWTP has two separate liquid process treatment streams: Plant 1 is rated at 60 mgd AADF and Plant 2 is rated at 83 mgd AADF.

Existing Headworks

Influent wastewater to CDWWTP is conveyed and distributed through four large-diameter force mains to Plant 1 and Plant 2. The raw wastewater discharges into two identical aerated grit chambers at each plant that consists of two aerated grit baffled channels, air piping, submerged diffusers, grit removal rake/elevator mechanism, and odor control. Currently, screening of influent raw wastewater does not take place at the plant, but is provided at the two major pump stations that deliver the wastewater to CDWWTP for treatment.

Peak Flow Methodologies

Several peak flow methodologies were considered as part of the design flow determination. The first methodology, which is the maximum "planned" peak, consisted of following the Ocean Outfall Legislation (OOL) Compliance Plan (June 2013) by MDWASD. This plan has a recommended alternative, which consisted of consideration that, by 2035, the proposed West District Wastewater Treatment Plant (WDWWTP) will be operational and will reduce some influent to CDWWTP.

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Under this plan, the projected average day and maximum day flows in 2035 are 83 mgd and 333 mgd, respectively.

The second methodology reviewed three years (2011 to 2013) of historic influent wastewater flows and determined that the average peak factor was 2.9. This peak factor, when applied to the permitted capacity of 143 mgd of CDWWTP, results in a projected peak flow of 412 mgd. The third methodology reviewed past historic plant influent flows from year 2001 to 2003, and the more-recent historic plant influent flows from years 2011 and 2013 were also reviewed. The maximum day flow recorded at the plant over these periods was approximately 360 mgd. Based on stakeholder consensus, it was concluded that the projected flows for headworks improvements will consider average day flow of 143 mgd and maximum day flow of 333 mgd.

Technology Options

Several screening and grit removal options were considered. The options, short list, and selection of screening options are shown in Figure 1. The perforated plate-type screens were further considered for design.

Currently, grit is removed using aerated grit chambers at CDWWTP; therefore, the aerated grit chamber and the application of the multiple-tray grit removal system (HeadCell®) were assessed relative to the new grit removal facilities. Although the existing aerated grit chambers were reported to be undersized and not as efficient in grit removal, this technology was assessed further, since the existing struc-

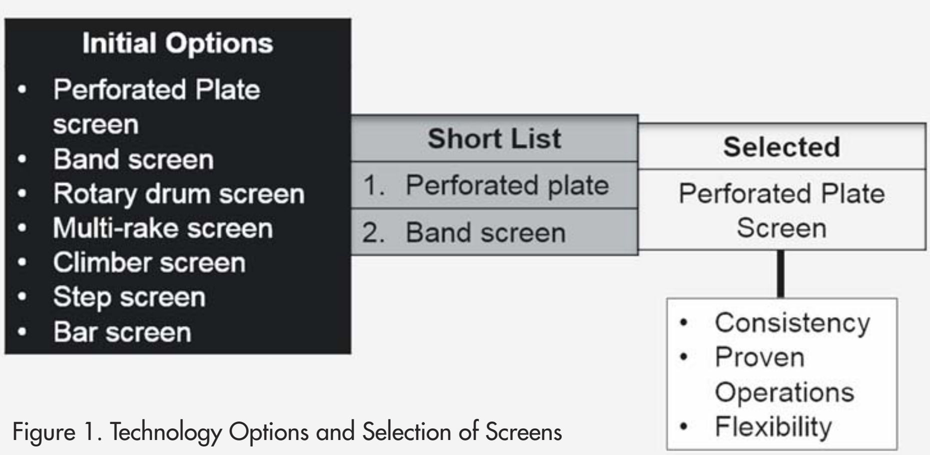

Figure 1. Technology Options and Selection of Screens

tures are in place. The HeadCell technology represents the most recent advance technologies for the removal of fine sand particles found in south Florida and can be scaled to match required capacities. Both process options reviewed for grit removal present viable approaches to this unit operation for alternative evaluations.

Headworks Upgrade Alternatives

Three alternative configurations were evaluated for this project:

1. *Retrofit* – New fine screens in the existing structure, and grit removal using the existing aerated grit chambers.
2. *Hybrid* – New coarse and fine screens in a new screenings building, and grit removal using existing aerated grit chambers.
3. *New* – New headworks building consisting of coarse and fine screens, and new grit removal (aerated grit chambers or HeadCell technology).

The retrofit alternative consisted of a total of eight 6-millimeter (mm) perforated plate-type fine screens retrofitted in exiting grit channels, such that there were two parallel screens per channel where each screen was designed with a capacity to handle 70 percent of the flow. The remaining portion of the grit channel was used for grit removal.

The hybrid alternative incorporated a new screening building where all raw influent would be screened. A total of five 20-mm coarse screens, followed by five 3-mm perforated plate-type fine screens, along with one bypass channel, were planned for this alternative. The existing aerated grit chambers were planned to be used exclusively for grit removal. The influent force mains were to be rerouted and manifolded to feed into the new screening building.

The new alternative considered a new screening building, like the hybrid screenings structure and a new grit removal structure. Grit removal had two subprocess options: 1) aerated grit chamber (AGC) and 2) HeadCell. The screenings portion was the same as the hybrid alternative, with a total of five 20-mm coarse screens, followed by five 3-mm perforated plate-type fine screens, along with one bypass channel. The influent force mains to the headworks were rerouted and manifolded to feed into the new building.

The alternative approaches presented for headwork improvements range from a straightforward rehabilitation/upgrade (retrofit) to a complex total replacement (new), along with an alternative in between these two extremes (hybrid). Such large variability in the basic approaches complicates the relative assessment of alternatives in that the final facilities are so different that it's challenging to make direct comparisons. The selection of a preferred alternative represented a philosophical choice to some degree.

Based on the qualitative and quantitative assessments, and in consultation with MDWASD personnel, the recommended approach for CDWWTP's headworks improvements was the retrofit alternative. The ability of this alternative to handle project peak flows left its long-term viability in question. An additional separate investigation was undertaken to evaluate hydraulics to verify the retrofit alternative's ability to handle projected peak flows. This included the development and assessment of an approach different than the current operations and considered potential modifications to the existing infrastructure.

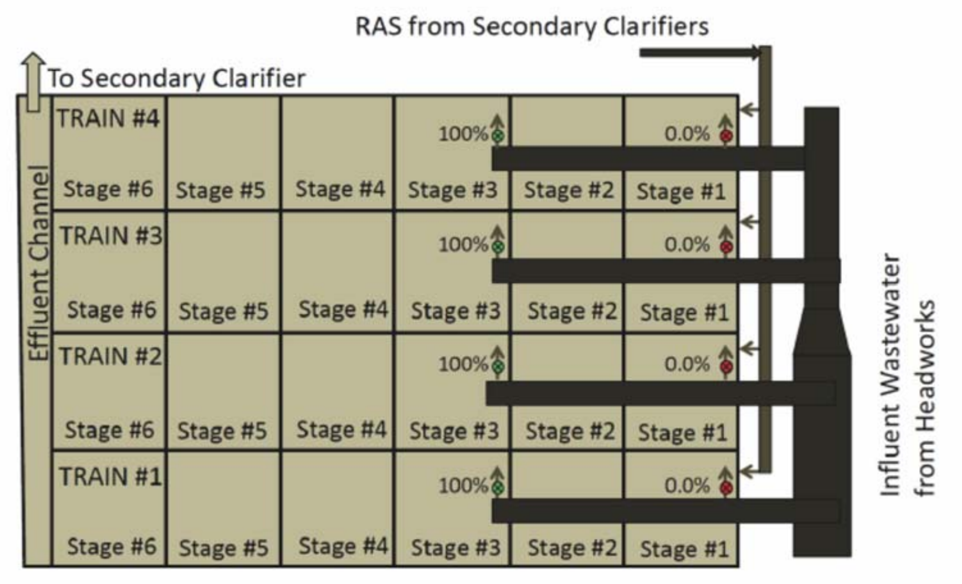

Figure 2. Oxygenation Train Process Configuration

Other Replacements and Improvements

Return Activated Sludge Replacement and Contact Stabilization at Plant 2

Plant 2 had an original return activated sludge (RAS) configuration where it was fed into the influent of each oxygenation trains using a 48-in. line, which is currently abandoned. Currently, RAS is being fed into the effluent box of headworks where it's mixed with influent and directly piped to the effluent box of oxygenation train. The original RAS configuration is being replaced in-kind from the effluent RAS manifold, along with new 18-in. magnetic flow meters at each basin inlet and reactivated.

Currently, the oxygenation trains operate in plug flow mode at Plant 2. Contact stabilization is a modification of the activated sludge process in which the introduction of the raw wastewater is moved downstream in the aeration tank. This provides a relatively short detention time for the mixed liquor suspended solids (MLSS) to be in contact with the feed stream before mixed liquor leaves the reactor for solids separation. This configuration was determined to offer MDWASD better peak flow management and treatment stability. Under this configuration, the raw wastewater will be added to Stage 3 of each process train, as noted in Figure 2. The RAS will be added at the head of the aeration tank inlet separately and aerated before being blended with the mainstream influent. The existing mode of operation will still be used during average flow conditions.

Relocation of Electrical Equipment

The existing motor control centers (MCCs) were residing within the headworks building, and they were surrounded by a corrosive environment due to the presence of moisture and hydrogen sulfide off-gas emission of raw sewage. The design included new electrical equipment for air scrubbers and electrical equipment for headworks to be housed in a new building. The designed layout has an environmentally controlled (air-conditioned and air-purified) atmosphere. The finished

Continued on page 24

Continued from page 23
floor elevation was adjusted to confirm with the climate adaptation goals of MDWASD.

Unique Design Features

Building Information Model Software

Repair and rehabilitation projects are challenging when it comes to accurately depicting existing conditions, particularly for older infrastructure with limited and unreliable as-built drawings. For the headworks project, three layout alternatives were evaluated using a building information model (BIM), which allowed the designers to efficiently create and present multiple options in a visual environment to facilitate better decisions with fewer surprises. This software allowed for multiple disciplines to work on different elements of the building design at the same time, allowing for improved clash detection. In addition, designers can share information, such as specific design details from another discipline, which can be incorporated as a background and built upon during various phases of the design.

For this project, Revit® modeling was an essential design tool that allowed discipline leads to coordinate their designs and reduce potential conflicts. The use of BIM software for the design provided a visual environment for effective communication and collaborative decision making. During the detailed design, review meetings were expedited by navigating through the model to visualize comments and obtain collaborative input on comment resolution. With BIM, the team was able to see the goal before it was constructed, which helped ensure that the final constructed facility matched the client's needs and expectations. Figure 3 and Figure 4 illustrate the 3D renderings of the improvements to the oxygenation train and headworks.

Sea Level Rise and Climate Change

As a result of a county ordinance, a sea level rise (SLR) assessment was incorporated into all design and construction activities. The SLR design criteria for existing assets within wastewater treatment plants were adopted by MDWASD based on recommendations in the report, "Technical Memorandum: Central District Wastewater Treatment Plant Engineering Approach for Climate Adaptation and Resiliency," prepared by MWH (2014). A design elevation of 16 ft was highlighted for all three regional WWTPs. The design of the electrical buildings that would house critical equipment, such as MCCs and remote telemetry units (RTUs), commenced with a planned elevation of 19 ft, which was later changed to 20.3 ft.

Design challenges for the project varied for each of the design disciplines that were required for this project. The MDWASD requested that, since the building is being elevated, it preferred the ground floor to be open and accessible, with at least one wall opening and walls on the remaining three sides. The electrical buildings were designed to have blocks and stucco, with no gap/veneer in between. Since the building was elevated, an equipment-handling platform was needed to move the equipment in and out to perform maintenance. A hinged double door and a rollup door (with manual operation) were provided for access to the equipment. Additionally, a 5-ft-wide exterior platform with removable side-mounted handrails was provided. An elevated building required multiple stairs to provide two means of egress; therefore, platforms and staircases were provided along both sides of each building.

Fast Tracking Procurement and Permitting

Since this project is part of a consent decree, the project is required to meet the compliance schedule. There are stipulated liquidated damages associated with substantial completion of construction projects. A workshop was conducted to explore alternative approaches to implementation of the headwork's improvements with the intent of reducing the overall schedule for consent decree compliance. Two strategies were discussed:

- Incremental – Reductions in all of the individual implementation steps.
- Fundamental – Go to an alternative delivery approach.

The merits of each were reviewed and discussed. The MDWASD management was involved in committing to reduction in procurement durations. The timing for contractor procurement was committed at 180 days, and for permitting, 120 days. These activities were conducted simultaneously, such that the contractor procurement was for the governing duration.

Additionally, since the last original structure was constructed in the 1980s, the condition of the existing grit chambers was questionable. It was known that some structural repairs would be needed for portions of grit chambers. The use of a "private provider" to accelerate the procurement of permits from the City of Miami building department was also considered.

An approach involving employment of an alternative delivery mechanism was also considered. The conventional design-bid-build approach is limited relative to acceleration potential, and design-build also offered limited time savings for this type of project. Another approach with potential significant schedule savings was construction management at risk (CMAR). A major drawback to such an approach, however, was MDWASD's lack of experience; therefore, an incremental approach

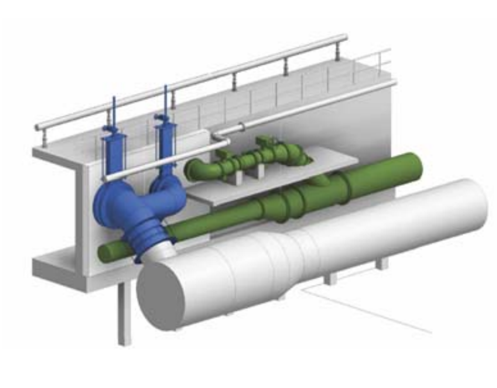

Figure 3. 3D Rendering of Oxygenation Train Configuration

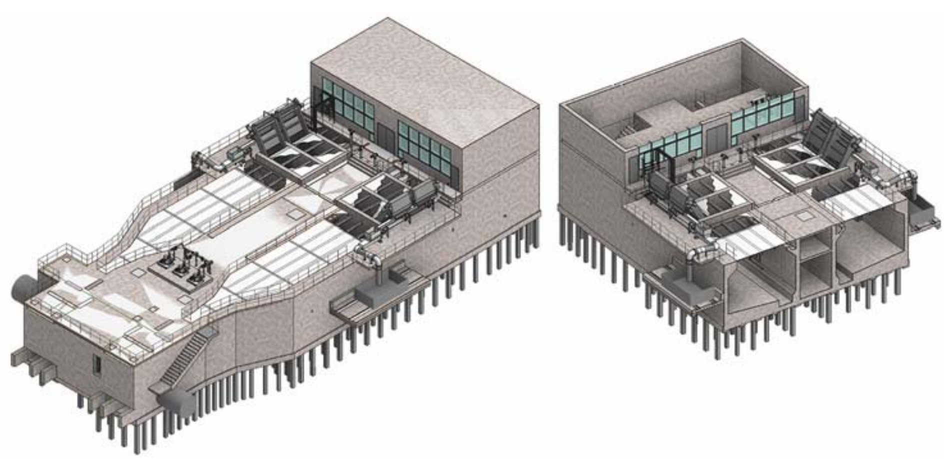

Figure 4. 3D Rendering of Headworks Improvement

was selected to reduce durations in individual project phases.

Equipment prepurchase of long lead equipment (equipment, product, or system that is identified at the earliest stage of a project to have a delivery time long enough to directly affect the overall lead time of a project) was performed with this project, where screens, washer, compactor, MCCs, and RTUs were planned to be purchased by the owner and handed over to the contractor to save time in the overall picture. The design was completed in eight months, with procurement of major equipment initiated at 60 percent design phase, and contractor procurement was initiated in parallel to dry run permit approvals.

Figure 5. Owner-Furnished Screenings Equipment Under Installation

Project Challenges

Aging Infrastructure

Plant 1 grit chambers were constructed in 1951 (with repairs in 1996) and Plant 2 was constructed in 1974 (with repairs in 2000). While the design of the project was in progress, it was important to determine the condition of the chambers from within. Since headworks is a critical infrastructure, the assessment was scheduled to be performed during the dry season (November to May), where a chamber could be taken out of service to perform the inspections and tests. Since only one chamber was available at a time for inspection and tests, inspection of the influent box and effluent box was limited to visual observation.

Assessment efforts were conducted for grit chambers in parallel with permitting and procurement of the design package. Several nondestructive and destructive tests were performed to assess the condition. The tests indicated that the existing concrete in the grit chamber was sound, with no substantial distress or damage; minor concrete repairs were required upstream of the flume; and major repairs to the concrete surfaces and steel embeds downstream of the flume were needed. Additional structural repair details were developed and included in the bid package. A line-item-level dedicated allowance was assigned to unknown repairs that were anticipated to be needed in the influent box and effluent box of each headworks structure. During construction, the assessment and repairs to the influent box and effluent box were scheduled to be performed during the dry season, which required the entire plant to be out of service for a limited amount of time.

Owner-Furnished Equipment

The general contractor (GC) package was designed around one vendor, with conservatism built into the design. Equipment was awarded to a supplier different from the vendor, around which the GC package was designed. The low-bid vendor package had to be closely reviewed by procurement since the original prequalified vendor had undergone an acquisition. There were differences in the package submitted by the low-bid vendor and the vendor around which the GC package was prepared, including no brush drives, additional deflector drives, and wider chutes. To minimize any ambiguity for the GC and potential future claims, the design team quickly coordinated these changes among all disciplines, and updated the permit resubmittal and bid documents to capture the changes. These documents were submitted to purchasing as an addendum during the bid phase to avoid repermitting, and potential budget and schedule claims. Illustrated in Figure 5 are the owner-furnished screens, conveyer, washer compactor, and chute assembly during installation at Plant 1.

Hydraulics

The MDWASD indicated that, based upon cost and schedule constraints, the retrofit alternative was the preferred approach; however, the hydraulic model indicated limitations with this alternative that did not allow it to convey the peak design flow. The hydraulic calculations and assumptions were further reviewed to overcome the hydraulic constraints. Several options were evaluated in order to either increase the driving head through the system or decrease the headloss through the existing hydraulic structures. The options considered included raising the elevation of existing structures, new relief piping, new structures (splitter boxes), and new routing connections to existing piping.

The most-effective approach was using the existing piping to increase the conveyance capacity from the headworks to the oxygenation tanks downstream for Plant 2. This required a side weir to be added downstream of each grit chamber in Plant 2. The weirs would discharge into the existing Plant 2 bypass channel to reduce headloss through the Parshall flume. Weir elevations would be adjustable so that the amount of flow discharged into the existing bypass channel is limited to the amount necessary to prevent overtopping at the grit chambers. The existing bypass channel feeds into a pipeline that currently bypasses the entire secondary process feeding into the secondary clarifiers' effluent channel. This pipeline was modified to feed directly into the oxygenation tanks using four feed lines. A valve was placed on the Plant 2 bypass pipeline to prevent the wastewater from bypassing secondary treatment.

Results from the hydraulic model analysis indicated that these modifications would increase the hydraulic capacity of the retrofit alternative. When plant inflows reach 360 mgd, approximately 11 percent of the total plant flow will be conveyed through the Plant 2 bypass. Figure 6 depicts the hydraulic bypass relief.

Recognizing the limitations of the computerized hydraulic model, a second approach was proposed by MDWASD and consisted of

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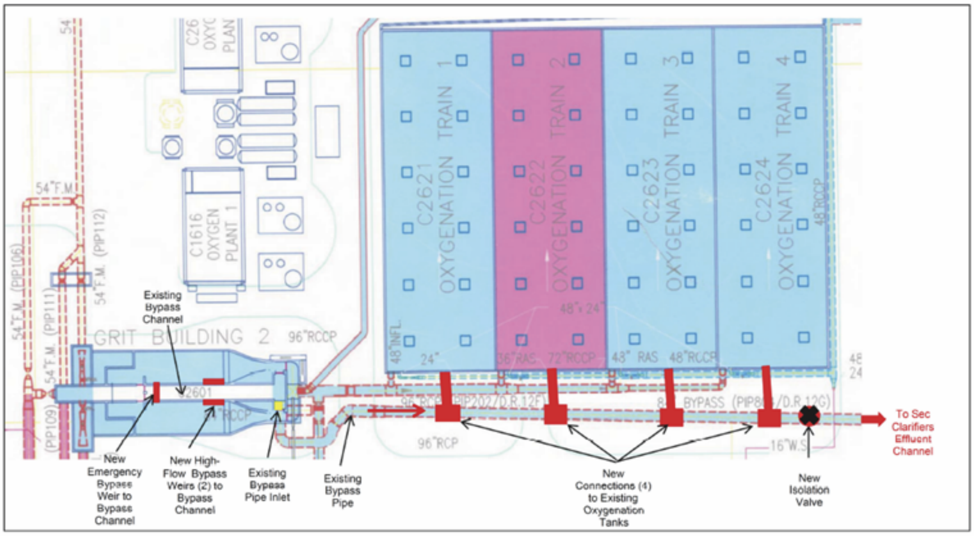

Figure 6. Hydraulic Relief for Plant 2

Figure 7. Special Prefabricated 48-in.-by-36-in. Connections at Plant 2

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performing a hydraulic stress test of the Plant 2 headworks. Testing was carried out in the field to simulate peak flow conditions and determine available free board under this high-flow scenario. Hydraulic field test was carried out during high flow conditions, in which flows over 100 mgd in each of the Plant 2 flumes were sustained for the duration of the test without overtopping the hydraulic structure. The hydraulic profile for Plant 2 was updated using the field data from the calibrated flowmeters and observed water level upstream of the Parshall flumes, coupled with the estimated losses through the screens. Based on the field data gathered from flowmeters, the Plant 2 profile reflecting flows of 194 mgd that were previously based on modeling results and were substituted with the hydraulic stress test results. These results negated the need for the previously proposed bypass.

Operational Strategies During Construction

A preliminary sequence of construction was developed for this project to consider allowing enough treatment capacity of the plant to remain in service for the anticipated flows. The proposed screen configuration was developed to allow operation of three grit chambers at a time, as the work was to be performed on the one remaining chamber, thus avoiding the need to completely shut down either Plant 1 or Plant 2 headworks or limiting construction to the dry season.

To permit full operation of CDWWTP, a longitudinal wall in the bypass channel and four new slide gates were proposed to be located downstream of the existing gates and at the edge of the new screens. A divider wall in the bypass channel was proposed between the existing pair of gates and the proposed new gates; the additional gates were necessary to be provided upstream of each screen. This allowed each grit chamber to be isolated, dewatered, and the grit removed, followed by minor structural improvement; coated, fine screen channels constructed; and equipment installed.

Two chambers could therefore be retrofitted with screens at the same time during the dry season, and one chamber could be retrofitted during the wet season.

Only one oxygenation train out of four trains at Plant 2 could be worked on at any given time. The downtime on the influent line to oxygenation train could be a maximum of four hours. A special prefabricated 48-in.-by-36-in. connection was designed, as shown in Figure 7, to accommodate the four-hour downtime constraint from operations in order to construct the contact stabilization connection, while minimizing the downtime for the oxygenation tanks.

Plant 1 has achieved substantial completion and Plant 2 was commissioned in April 2019.

Conclusion

A project with such magnitude of complexity can only be successful with collaboration and clear communication. There were a multitude of MDWASD parties contributing to the successful completion of such a fast-paced project, including:

- Management and operations department, procurement department, and compliance department
- Designers, consisting of various subconsultants
- Program management and construction management (PMCM) team
- Equipment supplier
- Contractor
- Permitting agencies

The lines of communication were open and each party understood the common goal and critical timeline. Challenges arise in any project, but proactive and effective identification of the challenge, reporting on it, and coming up with corrective action is the key to the successful completion of a project.

The design challenges encountered during this project offered an opportunity for all stakeholders to work together collaboratively and throughout the various phases of the project.

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