Sustainable Biosolids Management with the Largest Biosolids Dryer in North America

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ABSTRACT
The Great Lakes Water Authority (GLWA) embraced biosolids thermal drying at the Water Resource Recovery Facility (WRRF) in Detroit as a key component to ensuring long-term compliance with their National Pollutant Discharge Elimination System (NPDES) permit through the implementation of a Long-Term Solids Disposal Plan (LTSDP). Seeking a long-term, regulatory-compliant upgrade for solids processing and disposal at the WRRF, a new Biosolids Dryer Facility (BDF) was integrated into the facility using a unique design-build-operate-maintain (DBOM) project delivery system to fast-track the project. With a peak capacity of 420 dry tons per day (dtpd), the BDF is the largest biosolids drying facility in North America.

This manuscript describes the unprecedented scale of the installation at one of the largest municipal wastewater treatment facilities in the country and shows that processing biosolids for beneficial reuse is a viable alternative to landfill disposal and sludge incineration.

KEYWORDS
National Pollutant Discharge Elimination System (NPDES), Administrative Consent Order (ACO), Biosolids, Environmental Protection Agency (EPA)

INTRODUCTION AND BACKGROUND

The Great Lakes Water Authority (GLWA) embraced biosolids thermal drying at the Water Resource Recovery Facility (WRRF) in Detroit as a key component to ensuring long-term compliance with their National Pollutant Discharge Elimination System (NPDES) permit and Administrative Consent Order (ACO) through the implementation of a Long-Term Solids Disposal Plan (LTSDP). Specifically, the NPDES permit requires sludge dewatering, conveyance, and final disposal capability for a peak capacity of 850 dry tons per day (dtpd), calculated as a 10-day average. In addition, the US Environmental Protection Agency (EPA) regulations for sewage sludge incinerators required modifications and retrofits to the WRRF's incinerators by March 2016. Seeking a long-term, regulatory-compliant upgrade for solids processing and disposal at the WRRF, a new Biosolids Dryer Facility (BDF) was integrated into the facility using a unique design-build-operate-maintain (DBOM) project delivery system to fast-track the project. (See GLWA Photo 1.)

GLWA Photo 1

The BDF is the largest biosolids drying facility in North America. The 47,500-square-foot facility is capable of processing 93% of the WRRF's average solids load. (See GLWA Photo 2.) Two new sludge feed pumps and two redundant force mains deliver blended liquid sludge from the WRRF to the BDF where eight sludge grinders and eight dewatering centrifuges work in pairs to discharge dewatered biosolids to a cake bin before further mixing and feeding into one of four dryer trains. The resulting granular Class A biosolids product is stored in silos and transported by truck for use as a 90% (minimum) dry premium fertilizer.

GLWA Photo 2

METHODOLOGY

Innovative Project Delivery

The DBOM contract structure for a public water utility was a unique delivery approach with a limited track record in Michigan. Wade Trim served as the lead design firm and subconsultant to NEFCO who was the prime contractor. With the success of design and construction bound to NEFCO's 20-year operating contract, the DBOM team focused on the project's long-term performance from an operational perspective. The NEFCO Operations team was integral to the DB team from the early phases of the study and design through construction. Project outcomes were optimized by interfacing closely throughout the development of seven design packages, incorporating 20-year operations goals into the project.

The DBOM project delivery system used demonstrates the viability and advantages of this public-private approach. Teaming strategies and agreements on stakeholder collaboration and a "team first" mindset were developed and carried forward throughout the project. To address this project's unique challenges, including the deadline to comply with March 2016 EPA air emissions guidelines, a project delivery plan was established so the DBOM team could engage key stakeholders immediately upon receiving notice to proceed.

Combining the DBOM responsibilities into one contract enabled faster, more cost-efficient and effective project delivery with a single point of responsibility for the owner. With the contractor ultimately assuming the responsibilities of operations and maintenance for 20 years, all team

members collaborated with GLWA and NEFCO operations staff to champion a design-build process that was transparent, all encompassing, operator-friendly and efficient.

Complexity

Conveying thickened sludge with highly variable flow characteristics from and through the fully developed WRRF to the new BDF proved challenging during design and installation. The sludge delivery system consists of two thickened sludge storage tanks, two sludge feed pumps, and two half-mile-long redundant sludge forcemains (12-inch and 16-inch diameter). (See GLWA Photo 3.) The BDF had to accommodate sludge ranging from 2.5% to 6% in solids concentration and flows of 350 to 2,400 gallons per minute depending on the number of operational dryer trains and solids concentration. Centrifugal chopper pumps were selected, and a recirculation system was added to recycle the portion of flow not required at the BDF back to the sludge storage tanks to ensure that the pumps' minimum flow requirements were met at times of low demand. The two redundant sludge forcemains were designed to include a flushing system to prevent sludge deposition.

GLWA Photo 3

Installing the sludge forcemains through the WRRF and connecting to existing utilities beneath W. Jefferson Avenue was difficult given the congested underground conditions. (See GLWA Photos 4 and 5.) Despite using the best available information to optimize the forcemain route during design, some locations had to be adjusted due to conflicts with existing subsurface utilities and other infrastructure. Field decisions were expedited to maintain the aggressive schedule.

Utility service connections included aged water main, sewer, natural gas, electric, and communication fiber lines from private utility companies as well as process water from the WRRF.

GLWA Photo 4

GLWA Photo 5

Located near the Detroit River, the BDF site's soft clay geology complicated structural design requirements for large gravity loads and lateral loads due to seismic activity. Heavy structures included four 90-foot-tall, 35-foot-diameter silos for pellet storage, storage bins, and pellet oil tanks. Though Detroit isn't considered a high seismic activity area, concentrated areas of mass high above ground elevation cause strong lateral forces and high overturning movements that need to be resisted by the structure's foundation. A deep foundation system was designed to support these structures and resist seismic overturning. Driven 100 feet and socketed into bedrock, 391 piles were used for the building foundation, 92 piles for the silos, and 8 piles for the pellet oil tanks. (See GLWA Photos 6 and 7.)

GLWA Photo 6

GLWA Photo 7

Building columns are supported by clusters of piles connected with large concrete pile caps. The grade level floor is a cast-in-place structural floor supported by H-piles and a series of concrete grade beams that were integrated into the floor system. In addition, major process equipment, such as dryer drums, dryer furnaces, RTUs, cake bins, recycle bins, and cyclone separators, were so large that installation through the proposed building structural steel was impossible. The sequence of construction was optimized to drive the foundation piles, install the pile caps, place the base floor slab and equipment pads, and install this equipment before the structural steel erection began (See GLWA Photos 8 and 9).

GLWA Photo 8


GLWA Photo 9.

An extremely aggressive schedule of less than three years was required to design, construct and place the BDF into operation to meet the deadline for EPA's mandated air emissions guidelines. The start of construction was expedited through completion of two early design packages which allowed some of the initial underground work to proceed while design work on the other five packages was developed. Permitting agencies were engaged early in the design process to streamline acquisition of Michigan's Department of Environment, Great Lakes and Energy (EGLE) Permit to Install (Air Permit) and Part 41 (Wastewater Construction), as well as the City

of Detroit permits. Through collaboration by all key stakeholders, the schedule was met by the project management plan developed during the proposal phase and carried out by the project team from the onset of the contract notice to proceed through the construction phase into facility operations.

Design Highlights

The BDF is a highly complex biosolids handling facility that incorporates the latest innovative technology in thermal drying and air emissions control. The sludge drying process consists of a triple-pass rotary drum for thermal drying and the air emissions control system includes Regenerative Thermal Oxidizer (RTO) technology to destroy odor causing compounds, carbon monoxide and organic vapors and two sets of scrubbers to reduce particulates and sulfur dioxide (SO2). Large gravity and lateral loads from heavy process equipment and four 90-foot-high silos required a deep structural foundation system for support and to resist seismic overturning. (See GLWA Photo 10.)

GLWA Photo 10

The thickened sludge conveyance system required highly variable flow using sludge feed pumps with a recirculation system and dual redundant forcemains to convey flow from the WRRF to the BDF. (See GLWA Photo 11.)


GLWA Photo 11

RESULTS

Benefits to the Community

The BDF has delivered numerous benefits to the community it serves. Technologically advanced air pollution, noise, and odor control systems have reduced impacts on neighboring residents while reducing overall emissions. As required by contract, there are no noticeable odors on site or in the neighboring community, and no noticeable increase in ambient sound at 500 feet from the BDF facility. In addition, the number of trucks entering and exiting the WRRF has been reduced by 75%. Construction of the facility in the heart Detroit's southwest industrial area created local jobs for the trades industry and the facility is currently being operated by 25 full-time employees. The BDF was constructed using State Revolving Fund low-interest funding through the EGLE Revolving Loan Section to minimize costs to GLWA customers.

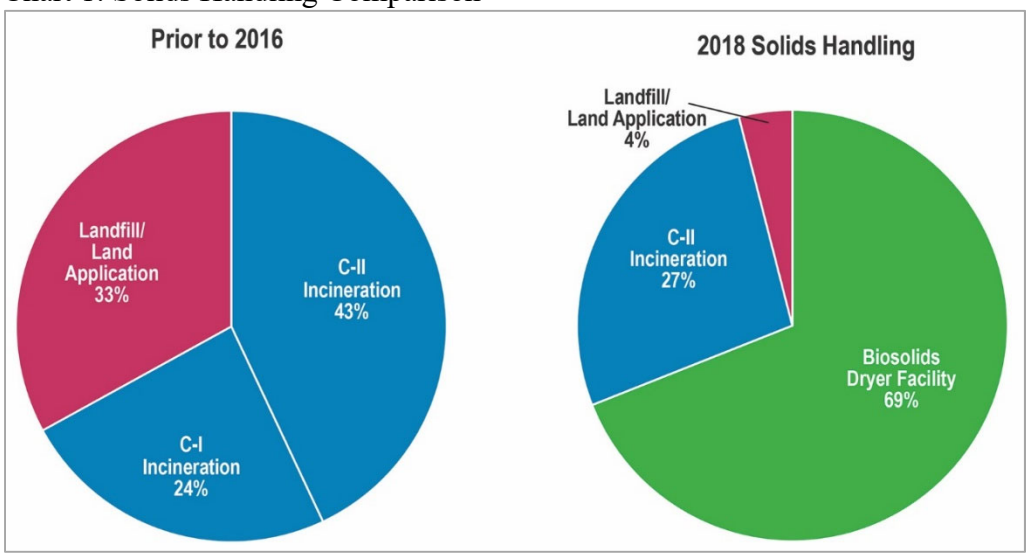
Biosolids thermal drying is a sustainable reuse solids processing alternative to incineration and landfilling that supports long-term sustainability for the environment by recycling organic matter and nutrients back into the land. (See GLWA Photo 12.) The BDF also supports the sustainability of GLWA's WRRF by enabling regulatory compliance through cost-effective and efficient operations.


GLWA Photo 12

Meeting Client/Owner Needs

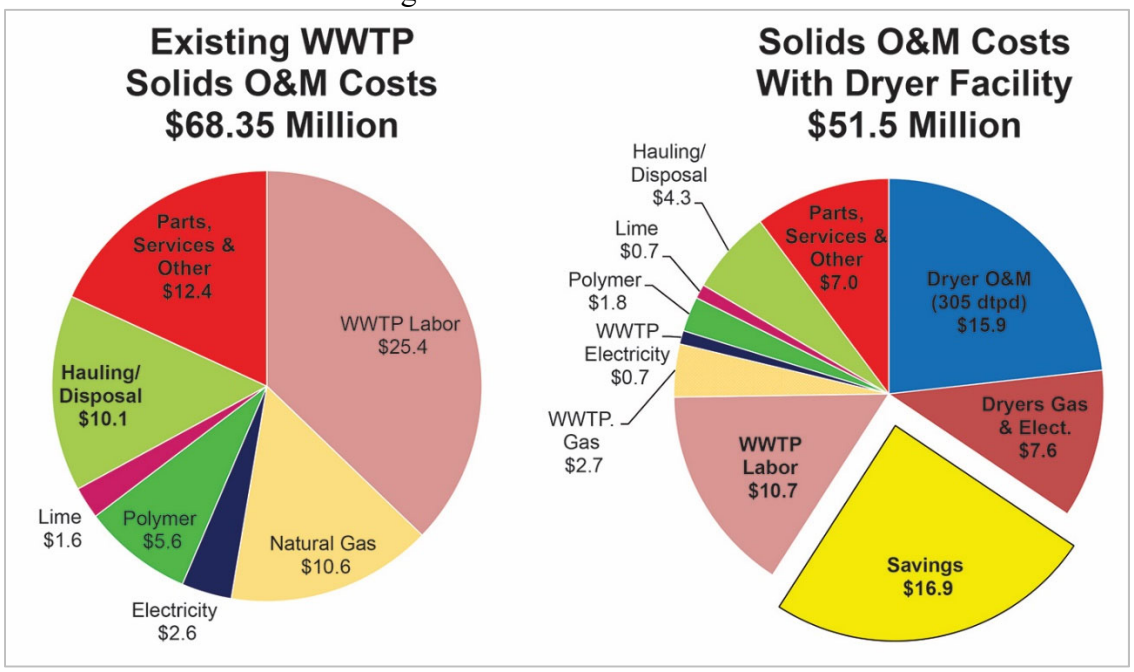
As the largest biosolids drying facility in North America, GLWA's BDF has made Detroit and Michigan a leader of this innovative green technology. The solution was a perfect fit for addressing the WRRF's regulatory compliance issues, improving operations, and transforming long-standing problems into overwhelming benefits. Historically, on an average day, Detroit incinerated 67% of its solids and hauled 33% offsite to landfills/land application. In 2018 the BDF processed nearly 70% of the sludge produced via thermal drying. The remaining sludge is processed by incineration (27%) and landfilling and/or landfarming (4%). (See Chart 1: Solids Handling Comparison.) This green technology has improved water quality in the Detroit and Rouge Rivers, reduced air emissions and greenhouse gases, reduced natural gas consumption, improved operational efficiency, reduced truck traffic in the neighborhood, and produces Class A biosolids for beneficial reuse.

Chart 1: Solids Handling Comparison



The BDF began operating before the EPA's new air emissions requirements went into effect, enabling GLWA to decommission one of their aged incineration complexes and reduce biosolids disposal in landfills. As a cornerstone to GLWA's Long-Term Solids Disposal Plan, the facility provides system durability and operational flexibility for full regulatory compliance. With total Design Build budget of $143 million, and O&M savings of $16.9 million per year, the BDF is on track to pay for itself in less than 9 years through O&M savings (See Chart 2). The BDF is a highly cost-effective and environmentally beneficial solids disposal option.

Chart 2: O&M Costs and Savings



Rooted in the BDF's long-term success, the DBOM approach optimized operational performance through the project team's efficiency and collaboration from design through construction.

Scheduled for completion by March 31, 2016, the BDF was completed one month early on February 29, 2016. With a total Design Build project cost of $134,741,707, the BDF was delivered $8 million under the $143 million budget through expeditious delivery of the DB portion of the contract and minimal changes. Compared to a traditionally delivered project, the DBOM approach reduced costs by an estimated 15% and minimized risk under the leadership of an experienced biosolids management company. GLWA will also benefit from continued operational enhancements over the next 20 years.

DISCUSSION/CONCLUSIONS

The GLWA embraced biosolids thermal drying technology as a sustainable solids processing alternative to incineration and landfilling at their Water Resource Recovery Facility. The 47,500-square-foot Biosolids Dryer Facility is a long-term, regulatory-compliant upgrade that expanded operational flexibility, reduced operation and maintenance costs by more than 20% (see Chart 2) reduced emissions and impacts to the community, and established Detroit as the nation's largest producer of environmentally-sound biosolids. Wade Trim served as the lead design firm and subconsultant to NEFCO who was the prime contractor. Design highlights include a thickened sludge conveyance system that accommodates highly variable flow using sludge feed pumps with a recirculation system and dual redundant forcemains to convey flow from the WRRF to the BDF. Large gravity and lateral loads from heavy process equipment and four 90-foot-high silos required a deep structural foundation system for support and to resist seismic overturning. A unique design-build-operate-maintain project delivery system fast-tracked the facility's startup in under 3 years with NEFCO contracted to operate and maintain the facility through 2037. Operational and maintenance savings are expected to fund the BDF's capital cost in less than 9 years and GLWA will benefit from continued operational enhancements over the next 20 years.