FINAL

TM 4.5 – WHOLE PLANT ODOR CONTROL: ODOR MANAGEMENT FOR EXISTING AND FUTURE FACILITIES AND DRIVERS

NEW Water Facility Plan

B&V PROJECT NO. 402658

PREPARED FOR

NEW Water
The brand of the Green Bay Metropolitan Sewerage District

Green Bay Metropolitan Sewerage District

1 JULY 2021

BLACK & VEATCH

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1.0 Introduction and Purpose

The Green Bay Metropolitan Sewerage District, operated under the brand name of NEW Water, collects and treats wastewater from 15 communities in a service area encompassing over 285 square miles with an estimated population of approximately 237,000 as of 2019. The NEW Water facility is comprised of the Green Bay Facility (GBF) and the De Pere Facility (DPF). The NEW Water treatment facility receives domestic, commercial, industrial wastewater, and hauled-in waste (HW)/high strength waste (HSW). NEW Water administers an industrial pretreatment program that regulates industrial contributors. To assist NEW Water with future planning efforts, Black & Veatch has been enlisted to perform modeling and system assessments, culminating in the development of a Facility Plan Capital Improvement Plan (CIP).

As part of the project solution evaluation, whole plant odor control — both near-term and long-term for the GBF and DPF — was identified as a concern and included in this planning effort. This Technical Memorandum (TM) takes a holistic look at odors, identifying considerations and solutions for odor issues that may arise from changes in loading, flows, and processes over the planning horizon.

The approach described herein builds upon the existing studies for the NEW Water facilities, including:

- Draft Green Bay Facility Influent Pump Station, Headworks Building, and Primary Clarifier Odor Study prepared by Jacobs in January 2019 (Jacobs Study): This study assessed odor control options for the primary clarifiers at GBF through the use of liquid phase and vapor phase sampling at the influent pump station, headworks, and primary clarifiers. Alternatives developed in the report considered both liquid phase and vapor phase treatment, as well as covers for the clarifiers. The study concluded that the influent pump station, primary clarifiers, and headworks were odor sources that would benefit from being odor controlled.
- Green Bay Facility Headworks Odor Control Study prepared by Strand Associates in May 2015 (Strand Study): This study summarized the evaluations and findings to assess odor control for headworks and primary treatment at the GBF based on wastewater sampling. The study concluded that the GBF influent had high sulfur loadings compared to typical domestic wastewater and identified the primary clarifiers, influent wet well, and grit dewatering as likely odor sources.

2.0 Whole Plant Odor Control Approach

The overarching objective of this task is to develop a roadmap to guide odor mitigation efforts and costs, focusing on short-term needs and long-term requirements. Building upon and expanding on previous odor studies, gaps between conditions and goals will be identified along with recommended actions to address the gaps. Short-term recommendations (next 5 years) will focus on potential modifications to existing facilities, while long-term recommendations will reflect encroaching development near the GBF, DPF, and the impact of future (5-20 years) process modifications on odor generation. Table 2-1 provides a summary of the approach for whole plant odor control.

Table 2-1 Whole Plant Odor Control Development Approach

Element	Description
NEW Water Vision for Odor Control (Section 3)	Define overall and facility-specific targets
Odor Generation Considerations (Section 4)	Discuss factors that influence odor Describe key odorants that impact odor generations and guide treatment options
Existing Odor Control Needs (Section 5)	Provide overview of existing odor control systems and odor concerns at each facility Identify gaps between current conditions and NEW Water vision Recommend actions to address gaps from current conditions
Process Expansion Impacts on Future Odor Control Needs (Section 6)	Identify process modifications that may impact odor generation and create gaps between the future conditions and the NEW Water vision Recommend actions to address gaps from process improvements
Odor Control Roadmap (Section 7)	Provide odor control recommendations for existing and near-term facilities Identify considerations for addressing odor control for future facility improvements

3.0 NEW Water Vision for Odor Control

NEW Water's vision for ongoing odor control at the GBF and DPF is centered around minimizing potential for odor complaints from nearby businesses and residents. This is of particular concern for the GBF as planned development to the north is expected to continue around the GBF site. While quantifiable odor treatment performance goals have not been established and minimal odor complaints have historically been received, NEW Water seeks to receive no odor complaints under normal operating conditions at each facility. NEW Water also seeks a more systematic process for documenting odor conditions, odor complaints and how those complaints are mitigated. While current odor control measures appear to be effective, proposed process improvements and expanding development may require additional odor control measures to ensure ongoing adequate treatment in the future. Establishing a roadmap will help navigate any challenges and allow for consistency in approach.

By targeting the process areas most likely to generate odors and adopting a proactive approach to odor control as conditions change over time, NEW Water can continue to successfully mitigate the potential for odor issues and prevent the odors from becoming a nuisance to their staff and neighbors. Figure 3-1 illustrates how these key elements can help achieve NEW Water's vision for odor control.

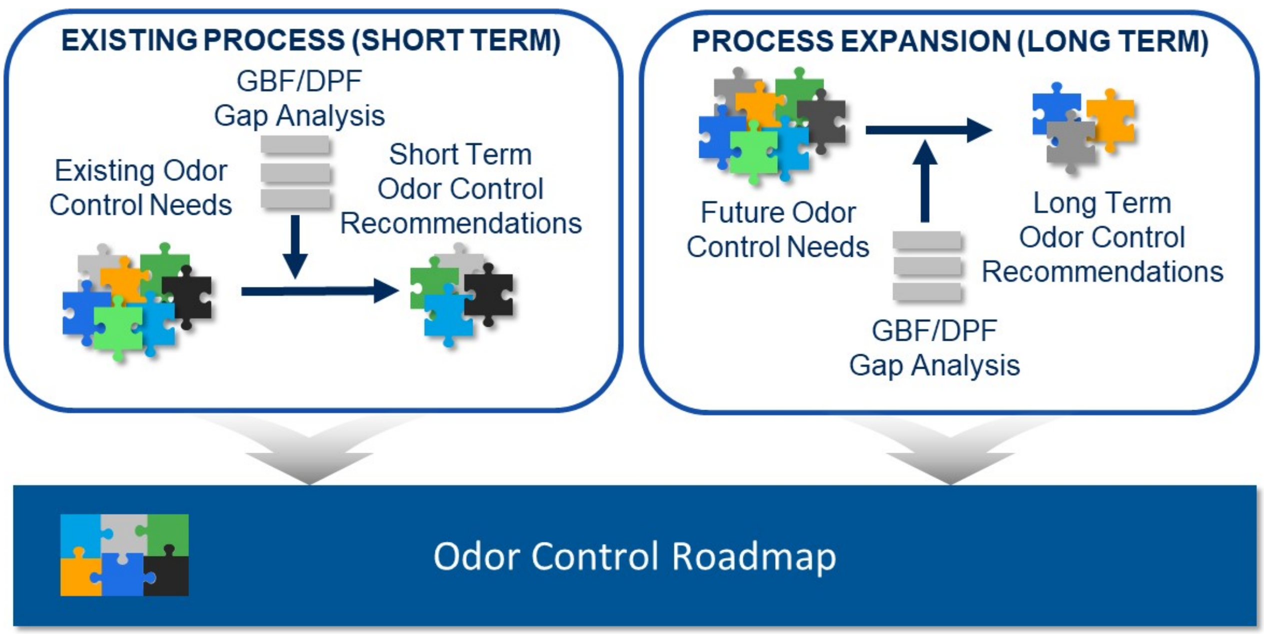

Figure 3-1 NEW Water Vision for Odor Control

4.0 Odor Generation and Treatment Considerations

Understanding contributing factors to odor generation helps guide odor mitigation efforts and treatment decisions. While each treatment facility is unique, there are some commonalities in expected odorants and factors that influence sulfide formation. Once the airstream has been characterized with respect to exhaust rate and odorants present, suitable treatment technologies can be considered to determine the recommended approach.

4.1 Odor Generation

Odors are commonly generated within collection systems and wastewater treatment facilities due to the composition of the flow, biofilm growth on pipe walls, and manipulation of the liquid and solids streams from various treatment processes. Odors from wastewater become more severe when oxygen is depleted and anaerobic conditions develop. Most odorous compounds result from the anaerobic decomposition of organic material containing sulfur and nitrogen. Common odorous compounds generated from wastewater are presented in Table 4-1.

Table 4-1 Odorous Compounds Generated in Wastewater

Odorant	Examples	Typical Sources
Inorganic Sulfur Compound	Hydrogen Sulfide – Rotten eggs	Sewer systems Wastewater treatment systems
Organic reduced sulfur compounds (RSCs)	Dimethyl Sulfide – Decayed vegetables Methyl Mercaptan – Decayed cabbage Carbon Disulfide – Sweet, disagreeable	Sludge holding, thickening, dewatering, and stabilization processes
Nitrogen Compounds	Ammonia – Sharp, pungent Amines – Fishy Skatole – Fecal, repulsive Indole – Fecal, repulsive	Wastewater anoxic basins Sludge digestion Sludge lime stabilization
Volatile Fatty Acids	Acetic Acid – Sour, pungent Butyric Acid – Rancid Valeric Acid – Fruity	Gravity thickeners Autothermal thermophilic aerobic digestion (ATAD)
Aldehydes and Ketones	Acetaldehyde – Sweet, fruity, pungent Methyl Ethyl Ketone – Sweet, acetone Acetone – Sweet, fruity	Sludge holding, thickening, dewatering, and stabilization processes

The odorant mostly commonly associated with wastewater processes is hydrogen sulfide (H_2S), which is formed from wastewater sulfide. The biological sulfate reduction to sulfide is performed by sulfate reducing bacteria (SRBs), which can use either organic compounds or hydrogen as an electron donor. Sulfide formation kinetic depends on the available sulfate concentration and the nature of organic substrates. The biological oxidation of sulfide is performed by sulfur oxidation bacteria which can use either oxygen or nitrate as an electron acceptor. Sulfide formation and cycling in wastewater is illustrated in Figure 4-1.

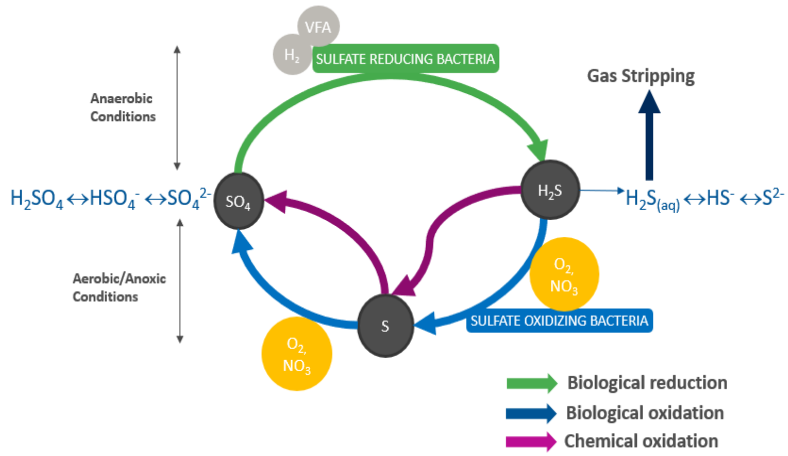

Figure 4-1 Sulfide Generation and Interactions with Oxygen and Nitrate in Wastewater

As illustrated in the figure above, vapor phase H_2S is generated when dissolved sulfide is volatilized from wastewater into H_2S gas. The potential for H_2S to form is dependent on various factors including wastewater characteristics and system design. Key parameters that affect H_2S generation and release are summarized in Table 4-2 below.

Table 4-2 Sulfide and H2S Generation Factors

Parameter	Factors Affecting Sulfide and H2S Formation
Wastewater Parameters	
Dissolved Oxygen (DO) Concentration	Low DO favors growth of SRBs and subsequent sulfide production
Oxidation Reduction Potential (ORP)	Low ORP condition favors growth of SRBs
Concentration of Organic Material and Nutrients	High concentration of organic matter will increase bacterial growth and thus increase sulfide production
Temperature	High temperature increases biological activities and DO consumption
pH	The pH is a controlling factor for dissociation of sulfide; decrease in pH results in greater H2S emission
Physical Parameters	
Detention Time	With longer retention time, more DO is consumed, ORP decreases, and the growth of SRBs increases
Areas of Turbulence	Turbulence caused by large drops in, or disruption to, laminar flow increases volatilization of wastewater sulfide to vapor phase H2S

As noted above, there are many other odorants that can contribute to odor, some of which have much lower odor thresholds than H_2S. Table 4-3 provides a summary of some of these compounds commonly found in wastewater processes.

Table 4-3 Odor Thresholds and Characteristics

Compound	Odor Threshold (ppm)	Characteristic
H_2S	0.0081	Rotten egg
Methyl Mercaptan	0.0016	Decaying cabbage
Dimethyl Sulfide	0.001	Rotten cabbage
Dimethyl Disulfide	0.000026	Rotten cabbage
Note: From Water Environment Federation Manual of Practice 25 (WEF MOP 25)		

In addition to specific compounds, methodologies exist to quantify total odor through air sampling and olfactometry to determine odor concentration. Odorant, odor concentrations, and their target removal efficiencies often guide technology selection.

While it is common for odor control systems to be designed to remove the majority of H_2S, it can be short sighted to only consider H_2S concentrations in selection of a treatment technology when the goal is to minimize odor complaints (as opposed to meeting a set permit limit for a specific compound). With complex airstreams comprised of multiple odorants, some compounds can be more challenging to treat and defining compound specific removals can be problematic. To address this issue, an overall odor removal target (defined by olfactometry in terms of dilutions-to-threshold) can be established, reflecting the various odorants expected in the airstream. This approach allows for a holistic treatment approach to minimize nuisance odor.

4.2 Odor Treatment

Odor treatment can be provided through liquid phase treatment or vapor phase treatment. Liquid phase treatment is provided through chemical addition to the wastewater upstream of the odorous processes, while vapor phase treatment targets the foul air stream. Vapor phase treatment technologies for wastewater applications generally fall into three categories: physical adsorption, biological treatment, and chemical scrubbing. These technologies can be used alone or be paired with other technologies if needed to meet treatment objectives or provide treatment redundancy. illustrates the various technology options for vapor phase odor control, while Table 4-4 provides a summary of these technologies.

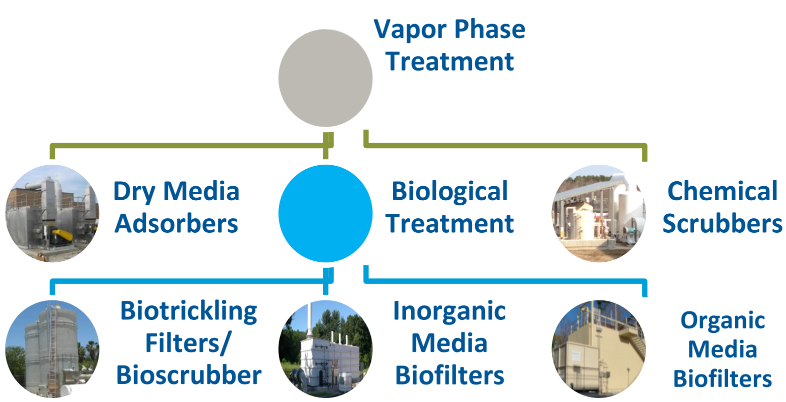

Figure 4-2 Vapor Phase Treatment Technologies

Table 4-4 Summary of Vapor Phase Treatment Technologies

Technology	Description	Advantages	Disadvantages
Dry Media Adsorption	Odorants adsorbed onto granular or pelletized carbon or alumina Suitable for low H2S (<10 ppm) or as a polishing step	Minimal O&M requirements Variety of medias available to target various odorants Lower capital cost Small footprint No water consumption	Difficult to quantify removal of some compounds Media life uncertainty Periodic media replacement Media is susceptible to grease/moisture, so pre-filter is required No acclimation period
Chemical Scrubbers	Plastic media that is wetted down with scrubbing liquid and chemical	Accommodates high airflow in single vessel No acclimation period Low capital costs	O&M intensive System complexity Storage and handling of hazardous chemicals Larger footprint when accounting for chemical storage High chemical costs
Biotrickling Filters/ Bioscrubbers	Inert plastic media for microbial growth Uses counter-current flow; foul air passes up through media layer while water is sprayed down on media Operated as either once-through or recirculated irrigation	Long media life (>10 years) Small footprint Efficient removal of high H2S	Ineffective at removal of some compounds Water (and potentially nutrient) required Acclimation period required Higher capital cost
Inorganic Media Biofilters	Uses inorganic media with irrigation system	Ability to treat broad spectrum of odorants Long media life (>10 years) Moderate footprint	Water required Acclimation period required
Organic Media Biofilters	Uses organic media (such as soil, compost, or bark) with irrigation system	Ability to treat broad spectrum of odorants	Large footprint Water required Acclimation period required Longer residence time

5.0 Existing Odor Control Needs

To identify existing odor control needs, it is critical to understand the existing plant processes and how current conditions align with NEW Water's vision for odor control. This section provides an overview of the GBF and DPF, identifies any gaps between current operations and goals, and provides general recommendations for how to address said gaps.

5.1 Green Bay Facility

The GBF treated an average of 36.6 million gallons per day (mgd) of wastewater in 2019 with a liquid treatment train consisting of influent pumping, screening, primary clarification, primary sludge grit removal, activated sludge configured for enhanced biological phosphorus removal (EBPR), secondary clarification. The GBF is disinfected with sodium hypochlorite and dechlorinated with sodium bisulfate. The solids handling treatment train includes sludge thickening with gravity belt thickeners and gravity thickeners, followed by anaerobic digestion with co-digestion of high strength waste (HSW), centrifuge dewatering, and ending with solids drying and incineration. The GBF receives hauled waste (HW), which is screened and discharged to the plant influent and HSW, which is fed to the digesters. Industrial wastewater flows are pumped to the plant from Proctor & Gamble and Fox River Fiber. Figure 5-1 provides a process schematic for the GBF.

While NEW Water has not received any odor complaints at the GBF for the past several years, there was a time from 2012 to 2014 where complaints were received primarily from the South Bay Marina. Current sensitive receptors, such as the marina and yacht club, are currently upwind of the most odorous plant sources as prevailing winds are from the northwest and west. NEW Water wants to be proactive in their approach to odor control and minimize odor potential to the extent feasible. As an example of their commitment to staying informed about plant odors, NEW Water has historically performed weekly odor patrols throughout the summer months to monitor odors within the fence line and at nearby off-site locations; however, these were discontinued in 2020 due to COVID-19. With no quantifiable odor targets or limits, it can be challenging to assess offsite impact, and it is understood that a lack of complaints does not necessarily translate to no odor issues.

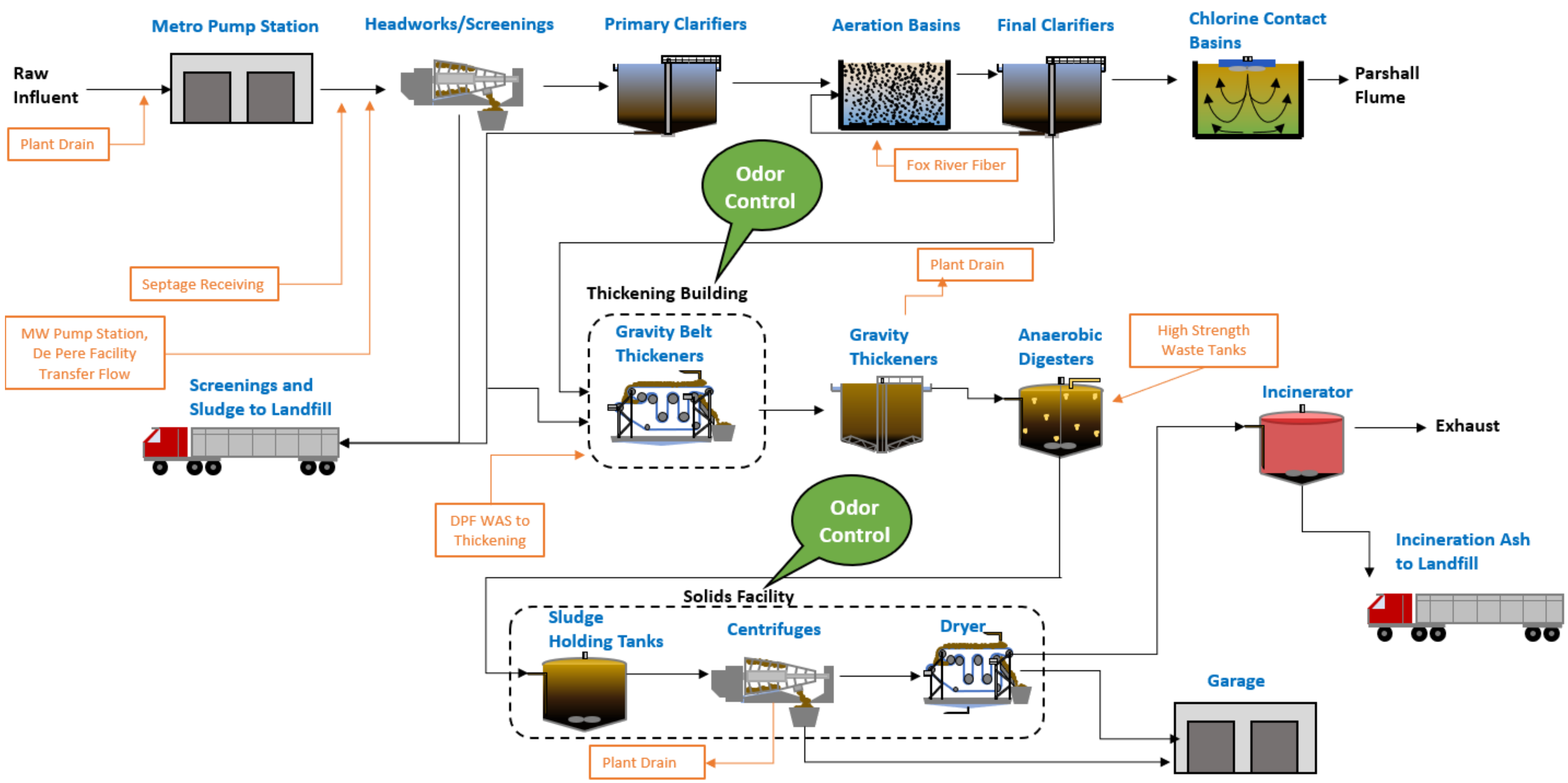

Figure 5-1 GBF Simplified Process Schematic

5.1.1 Odor Control System Overview

NEW Water currently employs multiple approaches at GBF to minimize nuisance odor. Two biotrickling filters (BTFs) with carbon polishing are used to treat foul air from the thickening building and solids facility. Table 5-1 summarizes key features of existing GBF vapor phase odor control facilities based on information provided by NEW Water. Additionally, calcium nitrate (Bioxide ®) is dosed in the interceptors upstream of the plant to reduce plant odor. NEW Water has also planted a line of pine trees at the plant's northern border to hinder puffs of odor that might move toward the marina and to serve as a visual break. In attempts to minimize odors from the primary clarifiers, NEW Water has also operated the primary clarifiers at a higher water level to reduce the fall distance from the weirs with the goal of minimizing volatilization of sulfide to vapor phase H_2S; however, the effectiveness of weir flooding is uncertain.

Table 5-1 Existing GBF Odor Control Systems

Criteria	Foul Air Source	
	Solids Facility	Thickening Facility
Technology	Two-stage; biotrickling filter with carbon	
Capacity	14,400 cfm	19,000 cfm
Controlled Areas	• P-Release Tank • Sludge holding tank • Concentrated scum tank • Scum concentrator • Centrate storage tank • Vapor condenser tank • Centrifuges • Filtrate reactors • Dryer discharge conveyor	• High strength waste storage tanks • Septage receiving screen building • Thickened sludge wet wells • Gravity belt thickeners • Filtrate/centrate channel • Thickeners effluent wet wells • WAS wet well • PSD wet well • PWAS filtrate wet well
Inlet H_2S Concentration	25 ppm average 50 ppm peak	
Outlet H_2S Concentration	Biological: ≤0.5 ppm when average inlet <50 ppm Overall: ≤0.1 ppm when average inlet <20 ppm	
Outlet Odor Concentration	≤200 D/T when average inlet <4,000 D/T	

While two stage vapor phase treatment is often quite robust, the existing systems are underperforming and several potential causes for this issue have been identified. Table 5-2 summarizes these issues for existing systems as reported by plant staff and as noted from the 2018 performance test reports. NEW Water is working directly with the equipment vendor (BioAir) to fully diagnose and resolve the issues.

Table 5-2 Summary of Existing Odor Control System Issues

Odor Control System	Issue	Impact on Performance	Comments
Thickening Building	Grease in the inlet	• Degradation of media	• Likely from dairy waste received at plant • Grease eliminator is being installed • Carbon temporarily removed while improvements are being made
	Excessive moisture in carbon layer	• High pressure drop through system • Degradation of media	
	Design capacity not achieved	• Full design airflow not being treated	• Performance test reports show that design airflow capacity was not reached during balancing and testing
Solids Facility	Airflow balancing	• Impact to the proportion of grease-laden flow distribution	
	Excessive moisture in carbon layer	• High pressure drop through system • Degradation of media	
	Freezing temperatures	• Delamination of the fiberglass reinforced plastic (FRP) vessel	• Freezing was noted as an issue since startup
	Potential odorant conversion in carbon layer	• Depending on odorants in airstream and type of dry media used, odor breakthrough can occur	• Dimethyl disulfide (DMDS) was measured at the system outlet, but not in the inlet
	Design capacity not achieved	• Full design airflow not being treated	• Performance test reports show that design airflow capacity was not reached during balancing and testing

5.1.2 Concerns

Based on discussions with NEW Water staff and information presented in previous studies, there are both community drivers and operational drivers that contribute to concerns about GBF odor. These items and key considerations are summarized in

Table **5-3**. Figure 5-2 provides a site plan showing the existing odor control systems and identified odor sources at the GBF.

Table 5-3 GBF Odor Concerns

Item	Concern
Community Issue	
Planned Development	• Land redevelopment from its current industrial use to commercial and recreational uses • NEW Water staff have noted a general trend toward development near the waterfront of Green Bay. This could reduce buffer zones between the plants and their neighbors
Sensitive Receptors	• Existing receptors include the Green Bay Yacht Club, South Bay Marina & Marine Center, and Bay Beach
Underperforming Odor Control Systems	
Thickening Building System	• Summarized in Table 5-2
Solids Facility System	• Summarized in Table 5-2
Uncontrolled Odor Sources	
IPS Wet Well	• The IPS wet well was identified as the largest odor source in the 2019 Jacobs Study
Headworks	• The headworks can be a source of fugitive odors if the doors are open
Primary Clarifiers	• The primary clarifiers were identified both by previous studies and NEW Water staff as a significant odor source
Aeration Basins	• NEW Water staff noted that the basins can occasionally have a smell
Offloading Building	• Offloading facilities can be an odor source when the incinerator is down

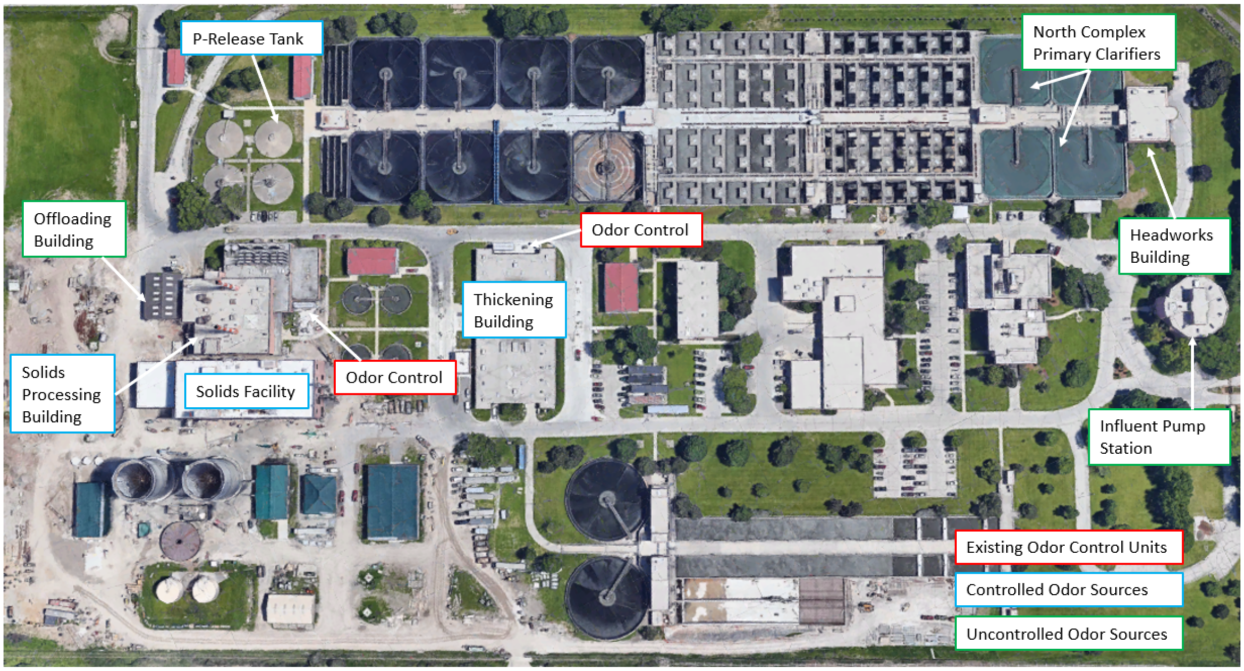

Figure 5-2 GBF Odor Sources

5.1.3 Gaps

The following gaps were identified at the GBF that may pose a conflict between current conditions and odor control goals:

- Existing odor control systems are underperforming, though ongoing work is expected to resolve the issues
- Effectiveness of a Bioxide addition upstream of the GBF is unknown from both a cost and odor reduction standpoint
- Weir flooding at the primary clarifiers is intended to reduce odors; however, the effectiveness of this operational strategy is unknown
- Odor patrol focus is currently qualitative rather than quantitative
- Odor patrols have been discontinued due to COVID-19, which can result in being reactive instead of proactive in responding to any offsite odor issues
- Uncontrolled odor sources increase the potential for offsite odor impacts and likelihood of detection from sensitive receptors
- Performance testing for existing odor control systems alludes to the presence of RSCs in the airstream, while treatment is focused on H_2S removal

To estimate the additional odor control capacity required from uncontrolled odor sources, preliminary exhaust rates were established, along with assumptions for inlet H_2S concentrations as summarized in Table 5-4. Due to the moderate H_2S concentrations anticipated, associated costs were identified for two different technologies: activated carbon adsorption and biotrickling filters. Table 5-5 provides a summary of budgetary capital costs for odor control of each source. Aeration basin odor control was not included as that particular process tends to have a minimal offsite impact.

Table 5-4 Exhausts Rates and Inlet H_2S Concentration for Uncontrolled Sources at GBF

Source	Basis for Exhaust Rate Estimate	Exhaust Rate (cfm)	H_2S (ppm)
IPS Wet Well[1]	Existing Exhaust Fan Capacity	17,000	4
Headworks[1, 2]	Varies[1, 2]	4,500	2
Primary Clarifiers[1, 3]	6 air changes per hour (ac/hr)	17,300	2
Primary Clarifiers Weirs/Launders[1, 3]	12 ac/hr	5,800	3
Offloading Building	12 ac/hr	22,800	<10[4]

(1) Source airflows and H_2S concentrations are referenced from the 2019 Jacobs Study
(2) Headworks includes influent discharge channel, bar screen channels, screenings conveyor, and grit classifiers/washers
(3) Total of four primary clarifiers
(4) Estimated concentration based on projects with similar processes

Table 5-5 GBF Odor Control Capital Costs

Source	Treatment Technology	Capital Cost
IPS Wet Well[1]	Activated carbon	$1,500,000
	Biotrickling filter	$2,400,000
Headworks[2]	Activated carbon	$810,000
	Biotrickling filter	$970,000
Primary Clarifiers[1, 3]	Activated carbon	$2,600,000 - $13,100,000
	Biotrickling filter	$2,800,000 - $14,100,000
Offloading Building[2]	Activated carbon[3]	$1,270,000

(1) Costs are from the 2019 Jacobs Study
(2) Budgetary costs estimated by Black & Veatch; exclusions and assumptions for cost factors, soft costs, construction costs, and contingencies are independent of the Jacobs Study
(3) Range represents treatment for the covered launders only (lower airflow with smaller capacity odor control system) and covered quiescent zone plus launders (higher airflow with larger capacity odor control system); cost of fiberglass reinforced plastic (FRP) covers is included
(4) As facility will be operated intermittently, activated carbon is the assumed technology as biological treatment relies on consistent loading

5.1.4 Recommended Actions to Address Gaps

To help achieve NEW Water's near-term vision for odor control, the following actions are recommended to address the identified gaps at the GBF:

- Optimize existing odor control systems and operations
  - Complete improvements for existing odor control systems
  - Assess cost-effectiveness of Bioxide dosing; compare to other liquid phase treatments to verify whether there is a more cost effective approach that meets or exceeds the current level of treatment
  - Assess efficacy of primary clarifier weir flooding operation on odor reduction through odor sampling
- Establish goals and enhance offsite odor impact monitoring
  - Establish quantifiable odor goals
  - Re-initiate weekly odor patrols to stay informed and maintain records (when safety issues permit)
  - Consider implementing quantitative odor measurements on odor patrols (field olfactometer, butanol intensity measurements, or other means)
  - Implement a procedure for receiving, documenting, and responding to odor complaints
- Quantify site odor sources and define their offsite impacts
  - Conduct odor survey at suspected sources, including sampling of H_2S, RSCs, and odor
  - Perform dispersion modeling to establish odor impacts and define prioritized odor control needs
- Perform study to identify preferred odor control approaches for prioritized odor sources (suspected to include the IPS, headworks, and primary clarifiers)

5.2 De Pere Facility

The DPF was originally constructed in 1976, with NEW Water taking responsibility of operations in 2008. The facility treated an average of 8.8 mgd of wastewater in 2019 and includes screening, influent pumping, grit removal, first stage aeration, intermediate clarifiers, second stage aeration, final clarifiers, tertiary filters, and disinfection. The DPR currently relies on the GBF for solids management via a solids transfer line between the two facilities. Additionally, a small diameter line exists at the DPF that allows a small flow transfer to the GBF.

Figure 5-3 provides a process schematic for the DPF.

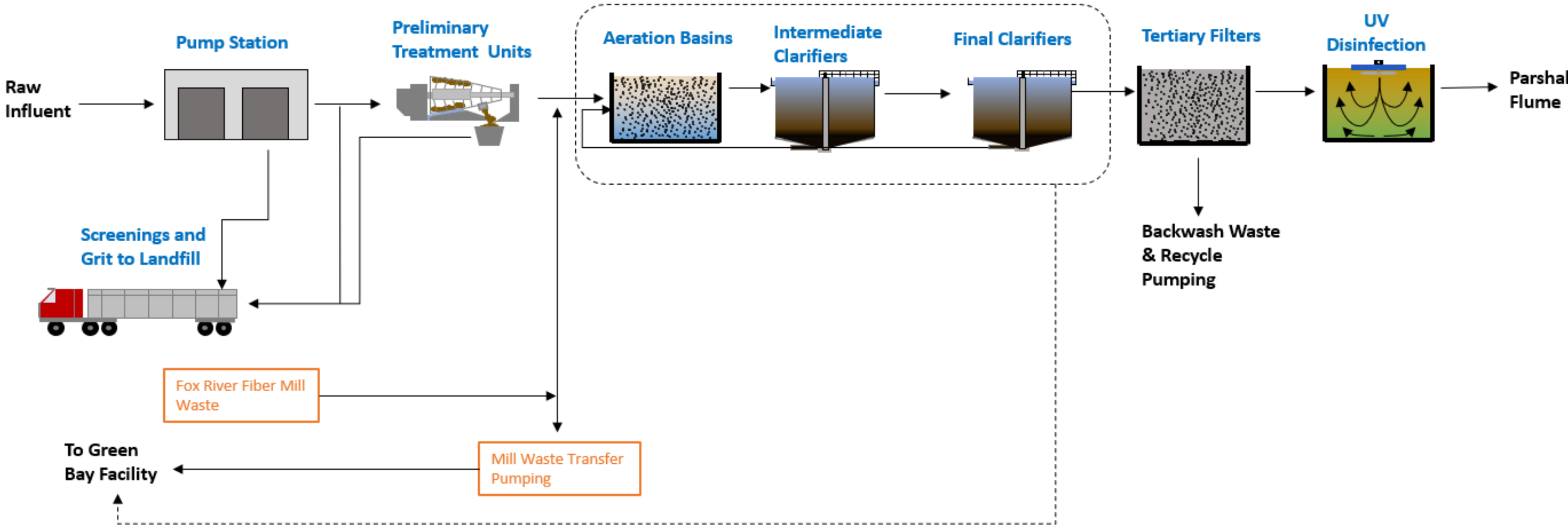

Figure 5-3 DPF Simplified Process Schematic

Odors are generally considered to be mild, and NEW Water has only received one odor complaint in recent memory. As the DPF is in close proximity to residential areas, a large park, and county fairgrounds, continuing to minimize the potential for odor complaints will reinforce NEW Water's commitment to be a good neighbor.

5.2.1 Odor Control System Overview

The DPF does not currently employ any liquid phase or vapor phase odor control.

5.2.2 Concerns

In general, the headworks of a treatment plant can be problematic from an odor perspective due to the nature of the raw sewage it receives. Based on staff observations, potential odor sources at the DPF include the influent pumping station (IPS) and preliminary treatment units (PTUs). It was noted that backwashing operations for the sand filters may also contribute to odors; however, the sand filters are scheduled to be replaced in 2021. Figure 5-4 provides a site plan showing the identified odor sources at the DPF. As development in the area expands, minimizing offsite odor impacts will continue to be a priority for NEW Water.

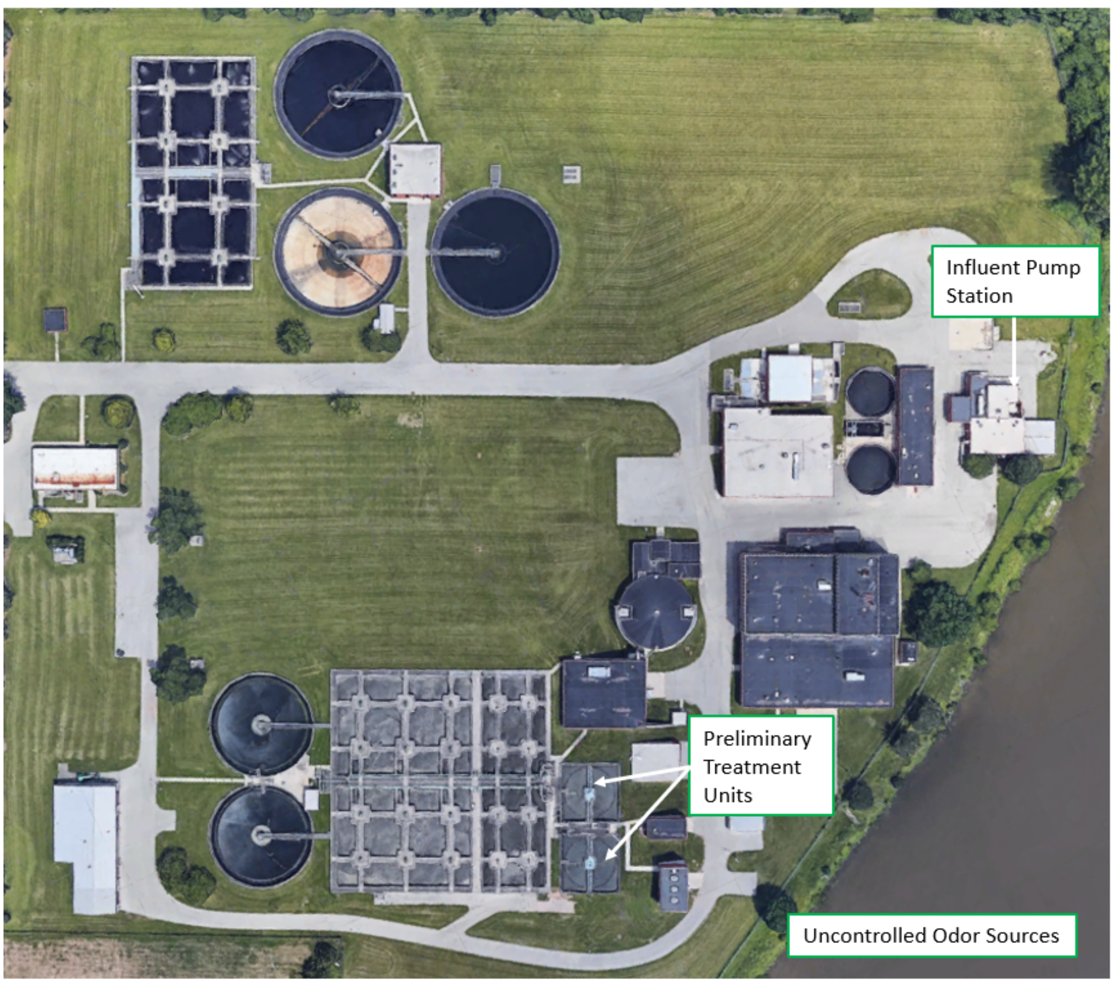

Figure 5-4 DPF Odor Sources

5.2.3 Gaps

Uncontrolled odor sources increase the potential for offsite odor impacts and likelihood of detection from sensitive receptors, particularly as future development may encroach upon the DPF site. To estimate the odor control capacity required from uncontrolled odor sources, preliminary exhaust rates were established as summarized in Table 5-6. Given the types of processes and lack of odor complaints, it is anticipated that odorant concentrations are relatively low. For comparison purposes, estimated costs were developed for both activated carbon ad biotrickling filters. Table 5-7 provides a summary of budgetary capital costs for odor control of each source.

Table 5-6 Exhausts Rates for Uncontrolled Sources at DPF

Source	Basis for Exhaust Rate Estimate	Exhaust Rate (cfm)[1]
IPS Wet Well	12 ac/hr	4,700
PTUs	6 ac/hr	4,400
PTU Effluent Trough	12 ac/hr	1,100

(1) Total of two PTUs

Table 5-7 DPF Odor Control Capital Costs

Source	Treatment Technology	Capital Cost[2]
IPS Wet Well	Activated carbon	$850,000
	Biotrickling filter	$1,010,000
PTUs[1]	Activated carbon	$460,000 - $2,920,000
	Biotrickling filter	$870,000 - $3,110,000

(1) Range represents treatment for the covered effluent trough only (lower airflow with smaller capacity odor control system) and covered quiescent zone plus effluent trough (higher airflow with larger capacity odor control system); cost of fiberglass reinforced plastic (FRP) covers is included
(2) Budgetary costs estimated by Black & Veatch

5.2.4 Recommended Actions to Address Gaps

To help achieve NEW Water's near-term vision for odor control, the following actions are recommended to address the identified gaps at the DPF:

- Establish goals and implement offsite odor impact monitoring
  - Establish quantifiable odor goals
  - Expand weekly odor patrols to include the DPF to stay informed and maintain records (when safety permits)
  - Implement a procedure for receiving, documenting, and responding to odor complaints

Quantify site odor sources and define their offsite impacts

- Conduct odor survey at suspected sources, including sampling of H_2S, RSCs, and odor
- Perform dispersion modeling to establish odor impacts and define prioritized odor control needs

- Perform study to identify preferred odor control approaches for prioritized odor sources (suspected to include IPS and PTUs), and consider planting pine trees along fence line to serve as a visual and olfactory buffer in addition to vapor phase odor control

5.3 Current Needs and Recommended Actions Summary

As discussed above, the current needs and recommended actions are largely mirrored at each facility, though the GBF has several additional considerations. Table 5-8 provides a summary of current needs and actions for each facility, with some of the key items discussed in further detail below.

- Quantify odor goals: For future consideration and through the use of dispersion modeling, quantifiable performance goals can be established to define allowable emissions and ensure consistency of treatment expectations amongst facilities. This is often defined as a maximum permissible fence line odor concentration. For each odor control facility, performance requirements would be set for the exhaust based on a minimum percent odor/odorant removal.
- Develop odor complaint procedure: NEW Water may also want to consider establishing a procedure for receipt, documentation, and resolution of any odor complaints received; adopting such a protocol allows for transparency with the public, eliminates confusion of how to address any complaints, and ensures proper record keeping.
- Perform odor survey: Characterizing the airstream at potential odor sources is critical to the accuracy of modeling efforts. The odor survey would encompass both air and wastewater parameters for a complete picture of odor potential at the GBF and DPF.
- Perform dispersion modeling: Based on input from NEW Water staff, a dispersion model has been developed for the GBF to address permitting needs. While not developed for odors, the model could potentially be modified to assess offsite odors impacts. For DPF, a new model can be developed. Dispersion modeling is a powerful tool that can be used to quantify odor and prioritize odor treatment needs. By establishing a baseline odor profile reflecting current operations, the model can then be re-run for various improvement scenarios to estimate impact to onsite and offsite odor.
- Perform odor control study: The odor control study would establish preliminary design criteria and use the dispersion model findings to confirm suitable technologies and evaluate alternatives to provide treatment recommendations. Alternatives would be evaluated on both an economic and non-economic basis.

Table 5-8 Current Needs and Recommended Actions Summary

Item	GBF	DPF
Optimize Existing Odor Control Systems and Operations		
Optimize existing odor control systems	•	
Assess cost-effectiveness of Bioxide and other liquid phase treatments	•	
Assess efficacy of primary clarifier weir flooding	•	
Establish Goals and Enhance Offsite Odor Impact Monitoring		
Establish quantifiable odor goals	•	•
Conduct weekly odor patrols	•	Possibly
Implement odor complaint procedure	•	•
Quantify Site Odor Sources and Define Offsite Impacts		
Conduct odor survey	•	•
Perform dispersion modeling	•	•
Perform Odor Control Study		
Perform odor control study to evaluate odor control for prioritized odor sources	•	•

6.0 Process and Expansion Impacts on Future Odor Control Needs

In order to meet NEW Water's long-term vision for odor control, proposed process and expansion impacts need to be considered. As described in the sections below, process improvements at both GBF and DPF may impact odor generation and treatment considerations. By building upon the recommendations to address existing needs, the odor control approach can be expanded to consider future treatment needs.

6.1 Proposed Process Improvements

As described in Technical Memorandum 4.4 – DePere Facility Long Term Vision, two primary alternatives were considered for long term improvements at the GBF and DPF; continuing to operate the DPF as a separate facility or combining the flows from DPF and GBF for treatment at GBF. The assessment concluded that continuing to operate the two facilities independently is the recommended alternative. Table 6-1 provides a summary of the recommended unit process improvements at each facility to meet NEW Water's long-term vision.

Table 6-1 Unit Process Improvements Summary

Unit Process	De Pere Facility	Green Bay Facility
Influent Pump Station	Increase capacity to 57 mgd	Increase capacity to 148 mgd
Headworks	• Improve existing headworks and add new grit removal equipment • Abandon PTUs	• Improve existing headworks • Add sludge screens
Equalization	Construct a 2 mg equalization basin for peak flows	No equalization basin required
Primary Clarifiers	N/A	• Peak flow primary clarifier diversion • Mechanism rehabilitation
Aeration Basins	One new aeration basin	Blower and aeration control improvements
Final Clarifiers	• Clarifier rehabilitation • New RAS pumps and piping	Mechanism rehabilitation
Filtration	Filtration rehabilitation	N/A
Disinfection	UV expansion to 40 mgd	New 140 mgd UV disinfection facility
Thickening	N/A	Facility rehabilitation

6.2 Potential for Future Odor Control Gaps

Operational and process changes can impact odor generation in a myriad of ways: by changing airstream characteristics, eliminating foul air sources, creating new foul air sources, and impacting capacity of odor control systems. Based on the process improvements summarized in Table 6-1, the following were identified as key considerations related to potential odor impact:

- Increase in plant and process capacity can impact volume of air to be treated and airstream characteristics, requiring additional or modified odor control
- New odor sources may emerge as a result of adding new headworks equipment, such as grit removal at the DPF and sludge screens at the GBF
- At DPF, treatment of the PTUs at DPF was identified as a near-term need; odor control for the PTUs will no longer be required if the PTUs are abandoned, and thus the timing of this modification should be considered before implementing odor control. Less robust approaches to odor control could be considered in the interim such as temporary odor control or chemical vaporization
- Equalization basins can be large area sources at treatment facilities; while it is often cost prohibitive to cover and treat the foul air, other mitigation measures such as chemical vaporization at the basin perimeter can be considered
- Rehabilitation of the thickening facilities at GBF may impact treatment needs related to capacity and odorant loading

6.3 Recommended Actions to Address Gaps

To help achieve NEW Water’s long-term vision for odor control, the following actions are recommended to address the identified gaps related to process improvements.

- Conduct additional odor sampling as plant capacity is upgraded
- Perform dispersion modeling of proposed improvements to estimate odor impacts and identify treatment needs
- Perform odor control studies to confirm suitable technologies and evaluate alternatives to provide treatment recommendations
- Revisit odor control strategy as plant improvements are implemented to ensure odor objectives are met

7.0 Odor Control Roadmap

By considering facility needs and identifying potential gaps for odor mitigation in the near term and long term, an odor control roadmap was developed to prioritize actions and odor control improvements. Figure 7-1 illustrates the identified needs and recommended actions that comprise the roadmap for an odor control strategy at the GBF and DPF.

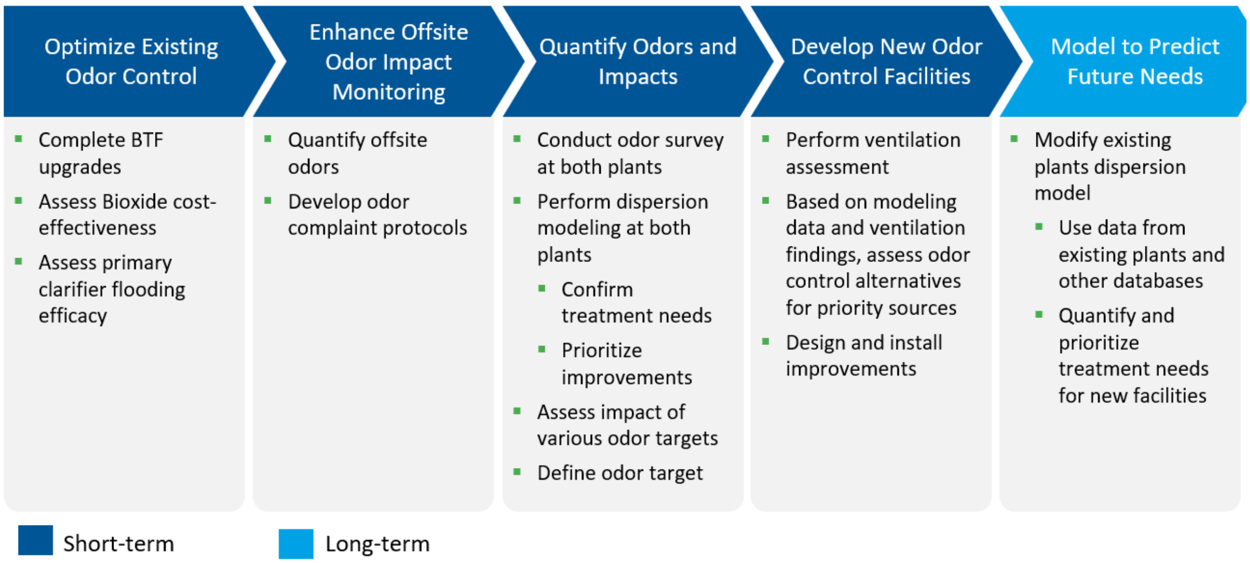

Figure 7-1 Odor Control Roadmap

7.1 Existing Facilities

Over the next five years, prioritization of improvements should focus on fixing existing odor control system issues and assessing odor control for uncontrolled sources through an Odor Control Study. The Study should include the "short-term" study (though not design) elements highlighted in Figure 7-1. The cost of an Odor Control Study is estimated to be $250,000, depending upon the final scope elements for the project. Preliminary, this effort would include collaborative definition of fence line odor targets, airstream characterization, dispersion modeling, technology screening, evaluation, and development of a phased plan. It would not include the current upgrades to the BTF.

7.2 Future Facilities

To account for process modifications and expansion, a similar odor control approach to that identified for existing facilities can be implemented to identify treatment recommendations. As improvements are considered, dispersion modeling can be performed (relying on data from NEW Water sources with expected similar emission characteristics or databases for new processes). Dispersion modeling should be repeated to quantify the effects of these changes on the plants' odor profiles and findings should be incorporated into the design of future facilities.

As planning efforts advance, public outreach and notifying the public of upcoming projects can help stakeholders feel informed, particularly as development encroaches upon the facility sites. By remaining proactive in their approach to odor management, NEW Water can continue to be a good neighbor while maintaining and upgrading the facilities as necessary to ensure capacity and treatment needs are being met in alignment with their long-term vision.