September 30, 2020

Cardno

Christiana Executive Campus
121 Continental Dr., Suite 308
Newark, DE 19713
USA

Phone +1 302 395 1919
Fax +1 302 395 1920

www.cardno.com

Mr. Darrin Gordon
General Manager
Lewes Board of Public Works
107 Franklin Avenue
Lewes, DE 19958

RE: Wetland Impact Assessment for December 2019 Bypass Event, City of Lewes Wastewater Treatment Facility

Dear Mr. Gordon,

As you know, Cardno, Inc. (Cardno) was retained by the Lewes Board of Public Works (BPW) to perform an assessment of wetlands potentially impacted by a discharge of partially treated wastewater at the Lewes Waste Water Treatment Facility (WWTF). This assessment was required by the Delaware Department of Natural Resources and Environmental Control (DNREC) as part of its Notice of Violation (W-20-SWD-01) for the above-referenced incident. The following letter report presents the findings of our investigation for submission to DNREC.

Incident Overview

On December 19, 2019, the failure of filter membranes used in the normal wastewater treatment process required flow to be temporarily rerouted in a manner that bypassed inoperable components and prevented effluent discharge via the established outfall. Instead, partially treated wastewater was discharged to wetlands adjacent to the WWTF once on-site storage was filled to capacity. During the bypass event, wastewater influent was screened, allowed to settle in the equalization tank and former clarifier, and disinfected with either hydrogen peroxide (H_2O_2) or calcium hypochlorite ($Ca(ClO)_2$). According to the BPW, wastewater was then pumped to a discharge point in a gravel swale near the south side of the WWTF where it flowed overland through a grassy area before entering adjacent wetlands. Bypass flow ended on December 28, 2019 following replacement of the damaged equipment. A second bypass lasting 2 hours occurred on January 1, 2020. During the 10-day bypass event, an estimated 3.9 million gallons of partially treated wastewater was discharged to the adjoining wetland.

Assessment Approach

Cardno's assessment approach, which was approved by DNREC, entailed qualitative early- and mid-season inspections of potentially affected wetlands in the vicinity of the WWTF. During these inspections representative locations were visually surveyed for evidence of impacts to vegetation including, but not limited to chlorosis (e.g., vegetation yellowing), which is indicative of phytotoxicity; stunted growth; or early die-back that could potentially be linked to chemical or physical impacts from the bypass event. Assessment areas were also inspected for evidence of any unusual impacts to biota, and physical impacts such as sedimentation that could adversely impact wetland functions and values. Photo-documentation was collected in representative areas including those with the greatest potential for impact; areas exhibiting other types of environmental stress; and areas appearing healthy and normal. GPS track logs were collected with a Garmin eTrex handheld unit to document survey routes and geo-reference photos.

The assessment approach is based on the premise that areas closest to the discharge point where partially treated wastewater entered the marsh have greater potential for physical and/or chemical impact than locations farther away. This is due to the ameliorating effects of tidal exchange and interaction with surface water entering from Lewes and Rehoboth Canal, which is the major source of wetland hydrology for the assessment area. As such, the canal is both a source of dilution and a buffer against potential changes to wetland hydrology. The strength of this influence is expected to vary based on relative proximity to the discharge point and Lewes and Rehoboth Canal.

Visual inspections focused primarily on vegetation and sought to identify locations exhibiting recognizably different, atypical, or uncharacteristic vegetation conditions or patterns as potential indicators of bypass-related impact. The early season inspection included searching for, among other things, areas where vegetation appeared slower than normal to break dormancy and resume seasonal growth. The mid-season inspection included searching for stressed vegetation as a potential indication of latent bypass-related impacts triggered by the compounding effects of seasonal stressors like heat and drought. The degree to which such conditions could be attributed to causes or stressors unrelated to the bypass was also considered.

Vegetation condition was assessed in areas proximal to the discharge point as well as those farther away in an attempt to identify differential effects. For reasons stated above, areas farther from the discharge point were assumed to be at lower risk than those in closer proximity. As such, more distant locations were used as informal reference areas. Vegetation stress observed both in areas close to and farther away from the discharge point was attributed to causes unrelated to the bypass event. Indications of vegetation stress only observed proximal to the discharge were scrutinized further using a process of elimination to determine the likelihood that effects could be attributed to the bypass discharge and not some other known stressor.

Assessment Area

The Lewes WWTF, also known as the Howard Seymour Water Reclamation Facility, is located at 106 American Legion Road in Lewes, Sussex County, Delaware. The study area for this assessment includes a 36-acre wetland tract bounded by American Legion Road to the north, Savannah Road to the west, Lewes and Rehoboth Canal to the south, and a rails-to-trails bike path near US Route 9 to the east. The WWTF is located on a 5.6-acre upland parcel situated in the northeast corner.

Wetlands within the assessment area consist of intertidal salt marsh typical of coastal and estuarine shorelines commonly found throughout Delaware and elsewhere in the Mid-Atlantic region. Vegetation exhibits typical zonation based on land surface elevation within the tidal prism, which dictates wetland hydrology and species composition. Regularly flooded low marsh is dominated by *Spartina alterniflora* (smooth cordgrass), while high marsh contains primarily *Spartina patens* (salt meadow hay) with lesser amounts of *Distichlis spicata* (spike saltgrass). Higher marsh elevations contain typical salt marsh shrubs including *Iva frutescens* (marsh elder, high tide bush) with lesser amounts of *Baccharis halimifolia* (groundsel bush) and *Morella cerifera* (southern bayberry, wax myrtle). *Juncus gerardii* (blackgrass, saltmeadow rush), and invasive, non-native *Phragmites australis* (common reed) are also present in the high marsh often growing in and around marsh shrubs. While *Phragmites* is present in most locations, infestation levels are generally low and limited spatially to a narrow band along the wetland-upland margin. Other species present include *Salicornia virginica* (glasswort, pickleweed), *Limonium carolinianum* (sea lavender), *Atriplex prostrata* (spearscale, triangle orache), *Solidago sempervirens* (seaside goldenrod), and *Panicum virgatum* (switchgrass) among others.

The marsh contains several anthropogenic features that potentially affect hydrology and flow patterns, which could influence the potential for bypass-related impacts. As mentioned, the Lewes and Rehoboth Canal is the primary source of wetland hydrology for the assessment area. Tidal water enters from overbank flooding along the canal frontage, as well as three tidal creeks entering from Lewes and Rehoboth Canal. These generally linear features appear to be remnants of historic grid ditches constructed for mosquito control that have since assumed more sinuous patterns. Remnants of lateral ditches or borrow ditches, many of which have revegetated, are still present and provide preferential flow paths. The broad extent of low marsh indicates that most of the assessment area regularly floods at high tide. Consequently, tidal creeks and ditch remnants may exert greater influence on flow patterns during lower tidal stages.

Portions of the assessment area are bisected by remnants of the former Junction and Breakwater Railroad. Historic fill comprising the railbed forms a series of linear features extending vertically several feet above the surrounding marsh plain. Aside from historical interest, these features influence wetland hydrology by directing tidal flow through intermittent gaps where fill has either been removed or never existed. Despite hydrologic connections provided by gaps, the railbeds are likely to impede surface water flow and reduce flushing within certain portions of the assessment area.

A utility corridor spanning between the WWTF and Lewes and Rehoboth Canal bisects the eastern portion of the assessment area. The corridor contains a buried pipe that transports wastewater effluent from the plant to its outfall under Lewes and Rehoboth Canal. This pipe was replaced recently as part of facility upgrades. Following construction, the open cut trench was backfilled to an elevation slightly higher than the surrounding marsh in some areas, though still within the range of wetland species (and potentially subject to additional settling). Higher elevations within portions of the utility corridor may impeded surface water flow and alter wetland hydrology at least during certain tidal stages.

The alignments of historic railbed segments and the utility corridor subdivide the marsh into discrete units that are expected to differ in terms of their hydrology and potential for tidal exchange. These units have been designated Areas A-F for purposes of this assessment. Hydrologic connection to Lewes and Rehoboth Canal is greatest in Areas B, C, and D due to direct connection and presence of tidal creeks. Areas A, E, and F are located inland of the historic railbeds, which are assumed to reduce the amount of tidal flushing and surface water exchange. The utility corridor along the eastern boundary of Area A may limit hydrologic connection to the tidal creek in Areas B and C, at least at lower tidal stages. However, there are indications of at least partial hydrologic connection between Areas A and B at higher stages.

According to BPW, partially treated effluent was discharged to a gravel swale and adjoining grassy area along the south side of the facility during the bypass event. From there, effluent flowed overland a short distance through an upland-wetland transition zone containing *Phragmites,* wetland shrubs, and a few other native species before entering salt marsh in Area A. The potential for bypass-related wetland impacts was assumed to be greatest in Area A and along associated flow paths.

Figure 1 depicts the wetland assessment area including the subdivisions described above.

Findings

Early and mid-season inspections of the potentially affected wetlands were performed by the author on June 3, 2020 and August 12, 2020, respectively. A brief follow-up to the mid-season visit was performed on September 4, 2020. All inspections were conducted at low tide when the marsh surface was not inundated except for standing water in closed depressions. Figure 2 depicts pedestrian survey routes for each inspection date.

Area A contains both high marsh and low marsh. The presence of low marsh is significant for two reasons. First, it indicates that at least some portions of Area A are subject to daily tidal flushing with water from Lewes and Rehoboth Canal, which enters via gaps in the railbed (and possibly Area B under certain conditions). This “clean” water represents a source of dilution during high tide cycles when the low marsh is flooded. Second, during low tide cycles, surface water, including bypass discharge, can drain from Area A. This avoids prolonged impoundment, which helps limit exposure to any elevated concentrations of residual disinfection chemicals or by-products potentially still remaining in wastewater. Low tide drainage also minimizes alteration of natural hydrology patterns due to the additional water inputs. Although there are 3 gaps in the railbed separating Area A and D, field observations and review of aerial photos suggest that the southern-most gap is the primary flow path, especially at lower tidal stages when flow is more channelized. From there, flow appears to follow the eastern-most of the two tidal creeks in Area D before entering Lewes and Rehoboth Canal.

Area A (as well as the other areas) contains evidence of historic ditching including remnant spoil piles (slightly elevated circular mounds) as well as linear ditches, most of which have filled with sediment and partially, if not completely, revegetated. Portions of a remnant ditch in Area A running parallel to the railbed were sparsely vegetated containing stunted *Spartina alterniflora* or stubble and *Salicornia virginica* (glasswort, pickleweed). These linear depressions were determined to be poorly drained remnants of historic ditches. Poor drainage of marsh soils can lead to water-logging, which is known to stunt and eventually eliminate plant growth. Unless widespread, such features are generally not problematic since they contribute to microhabitat diversity (e.g., pools and pannes), create additional edge habitat, and provide important foraging habitat and low-tide refugia for wildlife. The sparsely vegetated features in Area A and elsewhere are clearly visible on aerial photos taken prior to the bypass event. Similar areas of stunted low marsh vegetation including dead or dying *Spartina alterniflora* or stubble were also observed in poorly drained features within Area D including sites closer to Area A and sites farther away not located on a connecting flow path.

Beyond the sparsely vegetated low marsh areas, there were no indications of widespread vegetation impact in Area A during the June site visit. A few localized instances of discolored (browning) vegetation and potential die-back affecting high marsh species were observed along the high marsh-low marsh interface. Die-back was no longer visible in most of these areas by August except where noted otherwise. Where dead plants were still visible in August, evidence of regrowth was often present with the exception of a few small areas that may be undergoing species shifts associated with conversion of high marsh to low marsh presumably in response to sea level rise.

During the June site visit, most wetland shrubs growing along the margins of the railbeds in Areas A and D appeared dead or still dormant, though adjacent tall form *Spartina alterniflora* appeared healthy and normal. A few shrubs exhibited die-back with limited amounts of patchy growth. Wetland shrubs along the wetland-upland transition bordering the WWTF, possibly at slightly higher elevations, exhibited greater amounts of live vegetation, but new growth was still patchy. Some additional growth was evident when these areas were revisited in August, but most shrubs appeared dead.

Interior portions of Areas E and F were not surveyed in June, but were thoroughly inspected during the August and September site visits. Conditions appeared similar to those observed in Areas A and D with healthy low marsh vegetation except in poorly drained depressions, which exhibited signs of vegetation stunting and die-back due to waterlogging. Wetland shrubs (primarily *Iva frutescens*) in Areas E and F, including along the railbeds and higher elevation areas closer to American Legion Road, also showed high mortality. Herbaceous vegetation growing under and around wetland shrubs in Areas E and F, in particular, as well as some other locations tended to be dominated by *Juncus gerardii* with lesser amounts of *Spartina patens* and *Distichlis spicata. Juncus gerardii* was consistently found to be dead or dying during the August and September site visits, though other high marsh herbaceous species appeared normal.

A correlation between dead and partially dead wetland shrubs and dead *Phragmites* (standing dead stems) was noted throughout the assessment area. This phenomenon was most prominent within Areas E, F, and A along the border with the WWTF, and to a lesser extent along the railbed on the north side of Area D. Notable, most such areas exhibited little to no regrowth of *Phragmites* (new green stems). Where limited (stunted) *Phragmites* regrowth was observed, shrubs tended to be at least partially alive still. In a few locations, full-height *Phragmites* with tasseling seed heads was present in August and September intermixed with wetland shrubs that appeared healthy and normal. It was subsequently learned that the City of Lewes has embarked on a *Phragmites* eradication program that includes burning, spraying, and mowing. The area around the WWTF was treated with herbicide by aerial and ground application in August 2019 (Darrin Gordon, pers. comm.). No evidence of burning or mowing was observed; however, impacts to wetland shrubs were consistent with collateral damage to non-target vegetation resulting from use of a non-selective herbicide such as glyphosate, which is commonly used to treat *Phragmites*.

Impacts to *Juncus gerardii* growing in and around wetland shrubs are not believed to be related to herbicide treatment. If so, *Spartina patens* and *Distichlis spicata* growing with *Juncus gerardii* is expected to have been affected as well. However, both species, while less prevalent than *Juncus gerardii*, appeared normal and healthy. Additionally, a large area of dead *Juncus gerardii* was observed in Area A along the south side of the WWTP in August. While some *Phragmites* was present along the upland border, *Juncus gerardii* extended into the high marsh well beyond the band of *Phragmites* at the upland edge. This particular patch of *Juncus gerardii* appeared healthy during the June site visit, as did this species elsewhere in the assessment area. Furthermore, *Distichlis spicata* intermixed with *Juncus gerardii* in this patch appeared normal in August and September.

Juncus gerardii prefers non-saline, waterlogged soils, and while not particularly sensitive to drought, research has shown it to be intolerant to flooding (Watson et al. 2015, Charpentier et al. 1998, Rozema et al. 1985). Differential tolerance/response to salt water flooding among *Juncus gerardii*, *Spartina patens*, and *Distichlis spicata*, all of which occupy similar niches within the high marsh, could explain the loss of the former with little apparent impact to the latter two. Coastal flooding associated with the remnants of Hurricane Isaias, which impacted the area one week before the August site visit, or similar events could have triggered such a response. Differing sensitivity to herbicide overspray could also explain this response. The absence of any recognizable spatial pattern or gradient associated with *Juncus gerardii* impacts, as well as its vertical position above the regularly flooded low marsh, which would have had more direct, prolonged exposure to partially treated effluent, suggest that impacts to this species are unrelated to the bypass event.

Other Observations

A variety of wildlife species typical of Mid-Atlantic salt marshes were observed during the site visits. Invertebrates observed included fiddler crab (*Uca* spp.), mudsnail (*Ilyanassa obsoleta*), ribbed mussel (*Geukensia demissa*), and blue crab (*Callinectes sapidus*). Small fish, likely mummichog (*Fundulus heterclitus*) or similar, were observed in tide pools and partially flooded pannes. Birds observed included two pairs of nesting osprey (*Pandion haliaetus*), American bittern (*Botaurus lentiginosus*), clapper rail (*Rallus crepitans*), green heron (*Butorides virescens*), great egret (*Ardea alba)*, and snowy egret (*Egretta thula*) and various gulls. A large black snake, likely a northern black racer (*Coluber constrictor constrictor*), and a white-tail deer (*Odocoileus virginianus*) were also observed along the marsh periphery. There was no evidence of recent or past wildlife mortality events (e.g., empty shells, gaping mussels, fish carcasses, etc.), though it is acknowledged that such evidence is unlikely to persist for long periods.

Hydrogen sulfide (H_2S) odor (rotten eggs smell) was observed during each site visit throughout all portions of the marsh including those proximal to the discharge point as well as other locations farther from the WWTF. This odor is common/normal in salt marshes and is an indication of biogeochemical cycling associated with bacterial degradation of organic matter in the sediment under anaerobic conditions. Hydrogen sulfide odor is most pronounced at low tide when mud on the marsh surface is directly exposed to the atmosphere. When the marsh is flooded at high tide, the presence of surface water limits off-gassing, which reduces hydrogen sulfide odor. Conversely, atmospheric (thermal) inversions and still air conditions, such as early in the morning on non-windy days, can make hydrogen sulfide odor more noticeable.

Conclusions & Recommendations

Based on thorough investigation of the assessment area, including three (3) site visits spanning a major portion of the growing season, there is no discernable evidence that the discharge of partially treated wastewater during the bypass event resulted in any significant, widespread, or long-term adverse ecological impacts to the receiving wetlands.

This finding is not surprising given several potential mitigating factors. By its nature, the partially treated effluent is not expected to be highly toxic to plants and animals. Neither hydrogen peroxide nor calcium hypochlorite, which were added to the wastewater at different times as disinfectants, persist in the environment for long periods of time. Nor does either bioaccumulate in organisms or environmental media such as sediment. Hydrogen peroxide readily decomposes into primarily oxygen and water through various chemical and biological mechanisms. In fresh water, hypochlorites rapidly decompose into non-toxic components when exposed to sunlight, whereas in seawater, hypobromite may form, which can be toxic to aquatic organisms (USEPA 1991). However, there is evidence that at least some fish species will avoid water with elevated residual chlorine levels as a behavioral response (USEPA 1985), which could help mitigate harmful effects to certain biota.

Residual chlorine levels in the effluent at the time of discharge into the marsh are not known. However, dosing was managed to reduce free residual chlorine at the time of discharge to as close to zero (0.0) as possible. Dilution and flushing provided by twice-daily tides would have further reduced concentrations of residual disinfection chemicals in wastewater discharged to the marsh. Lastly, the discharge was of relatively limited duration (10 days) at a time when living resources in the marsh experience a state of seasonally reduced biological activity. These same factors would have also helped mitigate impacts from nutrient additions, as well as freshwater inputs into an otherwise saline-adapted environment. Screening and settling of wastewater prior to discharge prevented the introduction of any significant amount of solids into the receiving wetlands.

Those impacts that were observed, including impacts to low marsh and high marsh herbaceous vegetation and wetland shrubs, can be attributed to causes unrelated to the bypass. Stunted growth and localized die-back of *Spartina alterniflora* in the low marsh occurred in areas of poor drainage associated with remnants of historic ditching that are too wet to support normal vegetation growth. Impact to high marsh vegetation was limited to one species, *Juncus gerardii*, and is believed to be a response to coastal flooding from which plants are expected to recover. Finally, impact to wetland shrubs appears to be collateral damage from treating *Phragmites* with herbicide. These types of impacts are not uncommon in marshes that have been historically altered by ditching, filling, or stormwater inputs, or are undergoing active management to address degradation.

Despite these impacts, tidal wetlands within the assessment area appear to be generally healthy, resilient, and capable of providing characteristic wetland functions and values. Completion of the impact assessment program described herein fulfills the agreed upon scope of work and applicable requirements of DNREC's NOV. Given the lack of observable adverse impact attributable to the bypass event, no further action is recommended including additional monitoring, investigation, and/or mitigation.

References

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Rozema, J., E. Luppes, and R. Brockman. (1985) Differential response of salt-marsh species to variation of iron and manganese. *Vegetatio* **62**: 293–301.

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USEPA. (1991) *R.E.D. FACTS Sodium and Calcium Hypochlorite Salts*. Pesticides and Toxic Substances (7508W). 738-F-91-109.

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Sincerely,

Christopher E. Pfeifer
Senior Principal
for Cardno
Direct Line: (302) 395-3346 **|** (302) 598-1988 (mobile)
Email: chris.pfeifer@cardno.com

Attachments

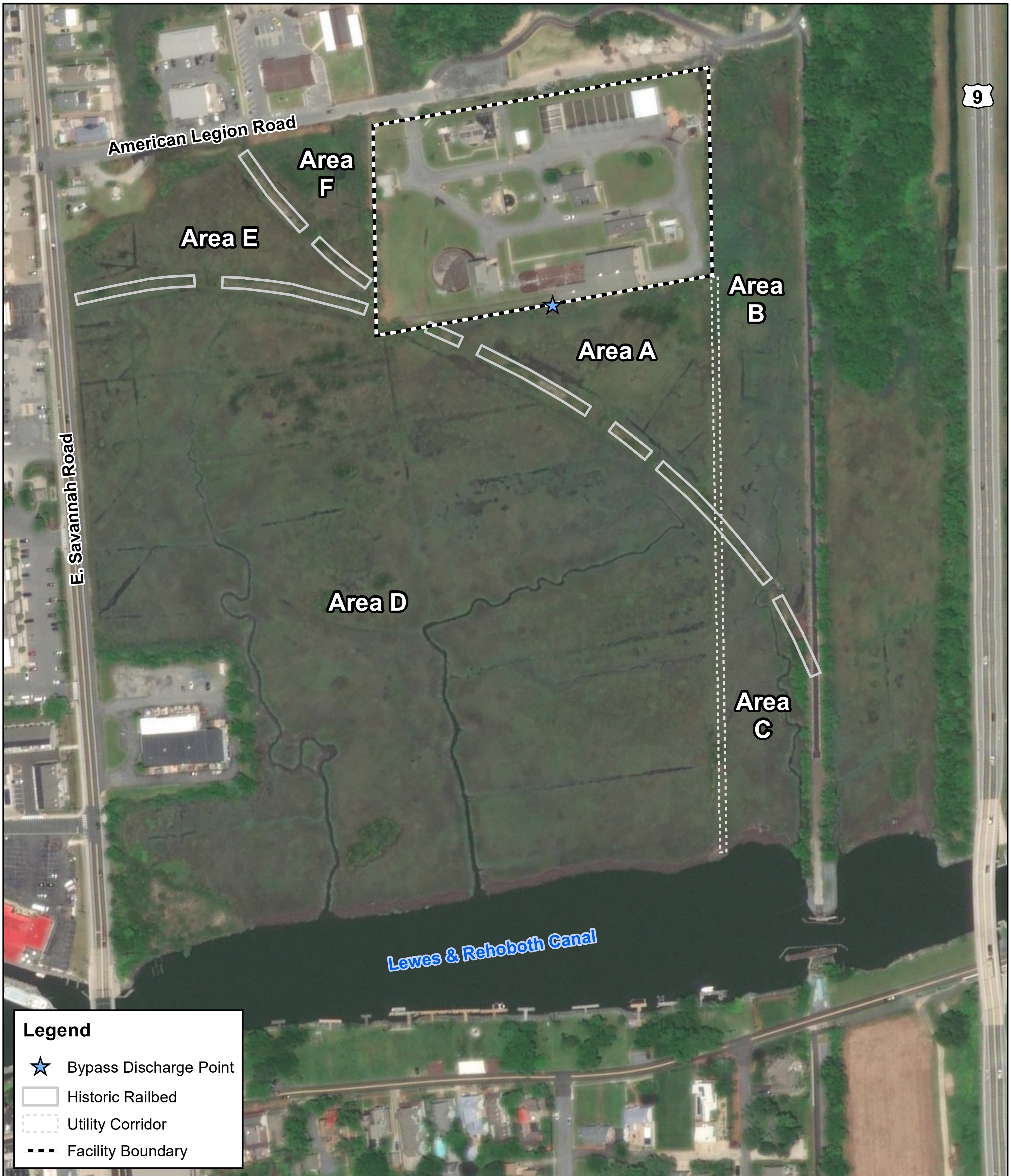

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Figure 1 - Wetland Assessment Area

City of Lewes - Wastewater Treatment Facility
Sussex County, Delaware

0 100 200 300 400 Feet
0 25 50 75 100 125 Meters

Cardno

121 Continental Drive, Suite 308
Newark, DE 19713 USA
Phone (+1) 302-395-1919 Fax (+1) 302-395-1920
www.cardno.com

Date Created: 9/23/2020 Date Revised: 9/23/2020 File Path: S:\GIS\City of Lewes\Wastewater Treatment Facility\MXD\Figure 1 - Wetland Assessment Area.mxd
GIS Analyst: Peter.Marsey

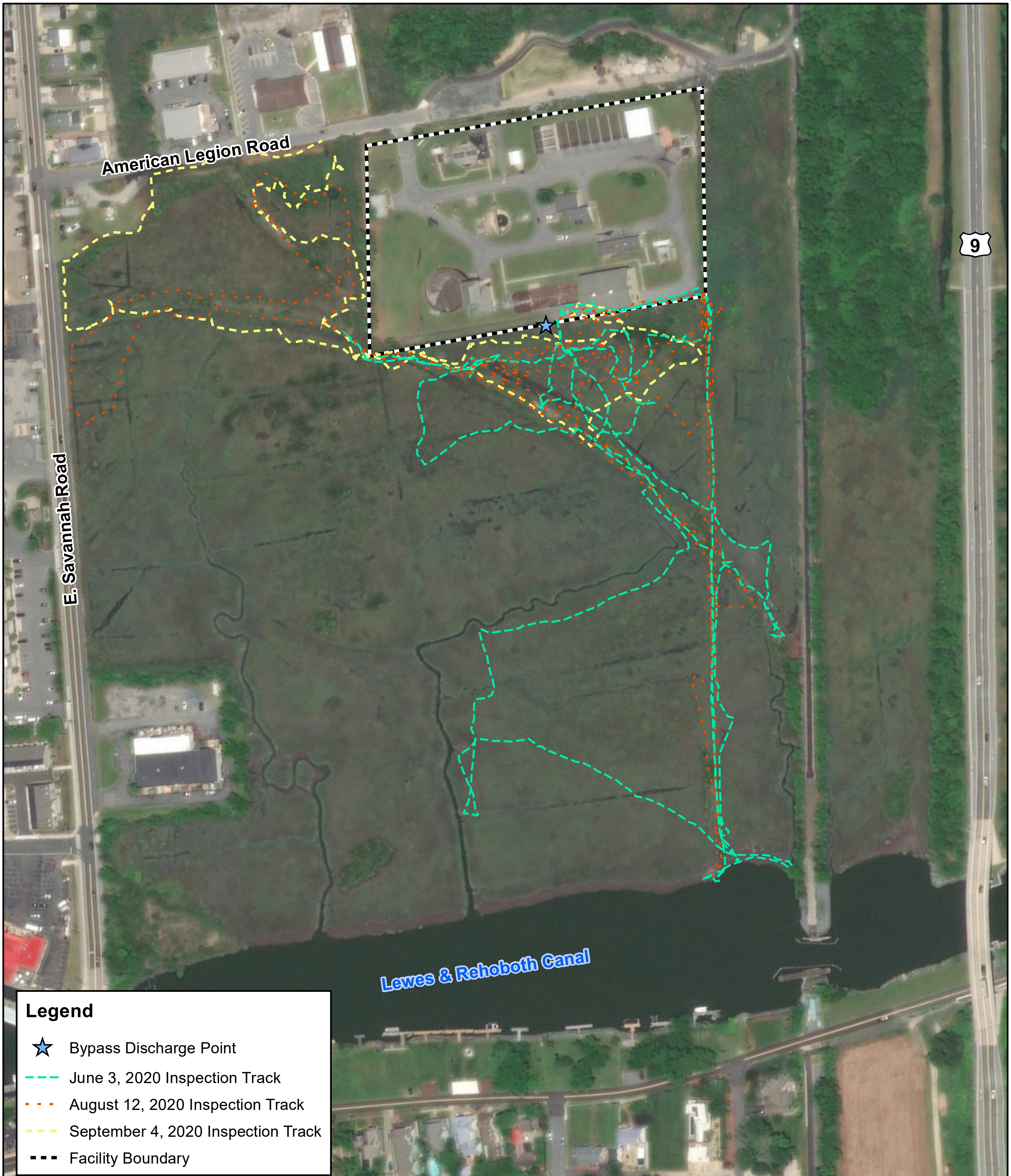

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Figure 2 - Pedestrian Survey Routes

City of Lewes - Wastewater Treatment Facility
Sussex County, Delaware

0 100 200 300 400 Feet
0 25 50 75 100 125 Meters

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121 Continental Drive, Suite 308
Newark, DE 19713 USA
Phone (+1) 302-395-1919 Fax (+1) 302-395-1920
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Date Created: 9/23/2020 Date Revised: 9/23/2020 File Path: S:\GIS\City of Lewes\Wastewater Treatment Facility\MXD\Figure 2 - Pedestrian Survey Routes.mxd
GIS Analyst: Peter.Marsey

Photo 1. General location of bypass discharge into gravel swale along south fence line of WWTF where effluent then flowed overland into adjacent tidal salt marsh in Area A. (June 3, 2020)

Photo 2. Healthy *Spartina alterniflora* low marsh bordering south side of WWTF near bypass discharge entry point into Area A. Note dead wetland shrubs and *Phragmites.* (June 3, 2020)

Photo 3. Dead high marsh vegetation in Area A at high marsh-low marsh transition. (June 3, 2020)

Photo 4. Backfilled discharge pipe trench in utility corridor separating Area A (left) and Area B (right). (June 3, 2020)

Photo 5. Remnant of historic railbed separating Area A (left) and Area D (right). Note dead wetland shrubs along each side at margin. (June 3, 2020)

Photo 6. Remnant mosquito ditch in Area A. Note sparse low marsh vegetation and stubble as a result of waterlogging due to poor drainage. (June 3, 2020)

Photo 7. Healthy *Spartina alterniflora* low marsh and remnant mosquito ditch in Area A along flow path to Area D. Note dead wetland shrubs along railbed. (June 3, 2020)

Photo 8. Healthy *Spartina alterniflora* low marsh and dead wetland shrubs along railbed in Area D. (June 3, 2020)

Photo 9. Relic spoil mounds along revegetated former mosquito ditch in Area D looking towards Savannah Road. Note egrets foraging on marsh. (June 3, 2020)

Photo 10. Northernmost gaps in railbed between Area A (background) and Area D (foreground). Note die-back of *Spartina alterniflora* in opening due waterlogging/poor drainage. (June 3, 2020)

Photo 11. Dead wetland shrubs *(Iva frutescens*) and high marsh herbaceous vegetation (*Juncus gerardii*) in Area F. Note dead *Phragmites* stems and patch of health low marsh on right. (August 12, 2020)

Photo 12. Dead *Juncus gerardii* along utility corridor separating Area D (left) and Area C (right). (August 12, 2020)

Photo 13. Dead *Juncus gerardii* under dead wetland shrubs in Area F. September 4, 2020)

Photo 14. Live *Spartina paten*s and *Distichlis spicata* under dead wetland shrubs and *Phragmites* in Area F. (September 4, 2020)

Photo 15. Area A near bypass discharge entry location. (August 12, 2020)

Photo 16. Dead wetland shrubs and *Phragmites* along remnant railbed separating Area E (left) and Area D (right). (August 12, 2020)

Photo 17. Patch of dead *Juncus gerardii* in high marsh near southeast corner of WWTF in August 2020. Note healthy marsh in foreground. (August 12, 2020)

Photo 18. Same patch of *Juncus gerardii* in high marsh near southeast corner of WWTF in June 2020 with no signs of impact. Note healthy marsh in foreground. (August 12, 2020)