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November 6, 2018

VIA PRIVATE CARRIER

Robert P. Rushlow
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Wetlands & Waterways Program
Maryland Dept. of the Environment
1800 Washington Blvd, Suite 430
Baltimore, MD 21230

Subject: Transmittal of the Cow Pen Creek and Dark Head Cover SAV Restoration and Monitoring Report
Lockheed Martin Corporation; Middle River Complex
2323 Eastern Boulevard, Middle River, Baltimore County, Maryland

Dear Mr. Rushlow:

For your review please find enclosed two hard copies with a CD of the above-referenced document. This report describes the methods used to source native submerged-aquatic vegetation seed, and dispersal of that seed, and includes the results from the initial site monitoring (via diver survey), per the methods outlined in *Cow Pen Creek and Dark Head Cove SAV Restoration and Monitoring Work Plan*. This report also provides an early assessment of restoration success and, as part of an adaptive management strategy, recommendations for future efforts at Lockheed Martin's Middle River Complex in Middle River, Maryland.

If possible, we respectfully request to receive MDE's document review comments, or approval of the document, by December 20, 2018.

I am available for your questions; my office phone is (301) 548-2209.

Sincerely,

Thomas D. Blackman
Project Lead, Environmental Remediation

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COW PEN CREEK AND DARK HEAD COVE SAV RESTORATION AND MONITORING REPORT LOCKHEED MARTIN MIDDLE RIVER COMPLEX 2323 EASTERN BOULEVARD MIDDLE RIVER, MARYLAND

Prepared for:
Lockheed Martin Corporation

Prepared by:
Tetra Tech, Inc.

November 2018

Approved by:
Lockheed Martin, Inc.

Revision: 0

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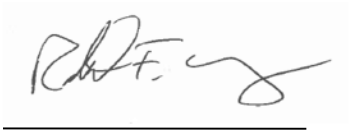

Robert Murphy
Project Manager

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ACRONYMS AND ABBREVIATIONS

BRF	Biological Resources Facility
cm	centimeter(s)
Lockheed Martin	Lockheed Martin Corporation
m^2	square meter(s)
MDE	Maryland Department of the Environment
MRC	Middle River Complex
SAV	submerged aquatic vegetation
Tetra Tech	Tetra Tech, Inc.
USACE	United States Army Corps of Engineers
VIMS	Virginia Institute of Marine Science

SECTION 1
INTRODUCTION

This report describes the methods used to source native submerged-aquatic vegetation seed, and dispersal of that seed, and includes the results from the initial site monitoring (via diver survey), per the methods outlined in *Cow Pen Creek and Dark Head Cove SAV Restoration and Monitoring Work Plan* (Tetra Tech, 2017). This report also provides an early assessment of restoration success and, as part of an adaptive management strategy, recommendations for future efforts.

1.1 BACKGROUND

The Lockheed Martin Middle River Complex, which is part of the Chesapeake Industrial Park, is located at 2323 Eastern Boulevard in Middle River, Maryland, approximately 11.5 miles northeast of downtown Baltimore. The complex consists of approximately 161 acres and twelve main buildings. The property also includes an active industrial area and yard, perimeter parking lots, an athletic field, a concrete-covered vacant lot, a trailer and parts storage lot, and numerous grass-covered green spaces along the facility's perimeter. Locked chain-link fences surround all exterior lots and the main industrial area. The site is bounded by Eastern Boulevard (Route 150) to the north, Dark Head Cove to the south, Cow Pen Creek to the west, and Martin State Airport to the east (Figure 1).

Beginning in late 2014, Lockheed Martin initiated the removal of sediment in Dark Head Cove and Cow Pen Creek. These sediments were contaminated by historical operations in adjacent areas of the site. As part of this work, portions of Dark Head Cove and the lower reaches of Cow Pen Creek were dredged and restored by the placement of a six-inch-thick sand layer (residual management layer). During this sediment remedial action, approximately 6.5 acres of submerged aquatic vegetation (SAV) were damaged or removed. Submerged aquatic vegetation serves as critical habitat for a variety of aquatic organisms, including ecologically important fish and invertebrates (Smart et al., 1996). In addition, submerged aquatic vegetation serves as an excellent food source for several waterfowl species, particularly in the freshwater and oligohaline portions

of the Middle River and Chesapeake Bay (Bergstrom et al. 2006). Submerged aquatic vegetation is considered a sensitive aquatic habitat in Maryland and is protected as a habitat area of particular concern by the National Marine Fisheries Service under the Magnuson-Stevens Act, legislation that regulates impacts to essential fish habitat. To mitigate impacts to submerged aquatic vegetation, and in accordance with Maryland Department of the Environment Tidal Wetlands License No. 15-1119 and United States Army Corps of Engineers Authorization No. 2016-61958-M02, the 6.5-acre impact area was to be re-seeded with native submerged aquatic vegetation and monitored for a period of five years. In response to the temporary loss of these ecosystem services, and in compliance with the United States Army Corps of Engineers (USACE) permit and Maryland Department of the Environment (MDE) Tidal Wetlands License, Lockheed Martin implemented a large-scale submerged aquatic vegetation restoration project in 2017-2018.

Baseline Survey (2015)— Tetra Tech conducted a survey of submerged aquatic vegetation coverage and species composition in Dark Head Cove and Cow Pen Creek in July 2015 to document existing conditions. The baseline survey documented seven species in the project area (Table 1), dominated by coontail (*Ceratophyllum demersum*) and Eurasian milfoil (*Myriophyllum spicatum*). Milfoil is a non-native species, so it would be inappropriate to restore the population of this species. Coontail, a native species, is difficult to work with for restoration because its reproductive nut is difficult to harvest. Furthermore, coontail is a rootless plant that would likely recolonize impacted areas from floating plants elsewhere in Middle River. Wild celery is an excellent plant for waterfowl and provides habitat for a variety of finfish and other aquatic organisms. Additionally, wild celery produces a readily harvestable seed pod that can be collected in large numbers for use in restoration (Moore and Jarvis, 2007). Therefore, the baseline survey recommended reintroducing wild celery via seed disbursal into suitable areas within Dark Head Cove and Cow Pen Creek; methods for seed dispersal were outlined in the work plan (Tetra Tech, 2017). Note that the 2015 baseline survey revealed that submerged aquatic vegetation had not established adjacent to the cove bulkhead (Figure 2) because surface water in that location is too deep (greater than three meters deep) for seed survival.

1.2 OBJECTIVES

The specific objectives for the submerged aquatic vegetation restoration and monitoring effort include:

- locating and collecting enough native wild celery seed from local (within 30 miles) populations, to provide a minimum 100,000 viable seeds per acre
- providing viable seed that demonstrates at least 80% germination during testing
- dispersing seeds over the impact area, so that they are distributed at a minimum of 100,000 seeds per acre
- installing and successfully maintaining grazing exclosures
- achieving a 10–15% rake cover (density) in Cow Pen Creek and a 5–10% rake cover (density) in Dark Head Cove (not completed during this initial monitoring event) by 2022
- implementing a robust post-seeding monitoring program using divers (in 2018 and 2019) and boat-accessible rake surveys (in 2020-2022) (Tetra Tech, 2017)

SECTION 2
SAV RESTORATION ACTIVITIES

The preferred sources of *Vallisneria* (wild celery) seed were local populations genotypically adapted to the local environment and therefore had the highest likelihood for successful restoration (Moore and Jarvis, 2007). The Middle River and surrounding tributaries support several beds of freshwater and oligohaline submerged aquatic vegetation (SAV) species, some of which are mixed species while others are mono-specific stands. Since SAV beds are dynamic and vary in size and distribution, mapping data from the previous three years (2014-2016) was used to locate persistent beds from which seeds could be collected. The Virginia Institute of Marine Science (VIMS) conducts annual aerial surveys of the entire Chesapeake Bay region, including tidal tributaries and coastal bays; this survey maps the density, extent, and composition of SAV beds in these areas. Survey results are digitized and available online for public use. These maps were used to determine the likely locations of beds (in 2017) that were monitored for seed development (Figure 3).

Wild celery typically enters the sexual reproductive phase (flower and seed production) in the middle of summer (McFarland, 2006), with female flowers reaching the water's surface, or just below, where they can be observed from a boat or via wading. The female flower is fertilized by pollen from male flowers, and seed maturation begins. The stalk of the flower will begin to coil after fertilization, drawing the seedpod downward where it will continue to develop underwater. Each of the seedpod capsules contains approximately 150-500 seeds. Starting in August 2017, several *Vallisneria* beds in the Middle River area were monitored to assess the maturation of the seedpods. Since one bed may mature at a different rate than an adjacent bed, several beds were monitored regularly. Once seedpods had begun the maturation process, the seeds were collected over several days from multiple beds, as described below.

2.1 SEED COLLECTION

Starting in August 2017, several *Vallisneria* beds in Middle River were monitored to assess the maturation of the seedpods. Reproductive shoots showed evidence of maturity (Figure 4) by mid-August, at which point teams conducted multiple days of hand-harvesting to collect seedpods.

Seedpods were transferred to a cooler on the boat filled with river water where they were kept until the conclusion of each collection day (Figure 5).

2.2 SEED STORAGE AND GERMINATION TESTING

Seed pods were transported to Tetra Tech's Biological Resources Facility (BRF) in Owings Mills, Maryland. The BRF is equipped with a walk-in refrigerator where the seedpods were stored at ≤4ºC. Approximately 4,000,000–4,500,000 seeds were collected; this number exceeded the minimum number required to provide 100,000 viable seeds per acre for the 6.5-acre restoration area. Seedpods were stored over winter in 10-gallon aquaria; the pods eventually broke down via natural decomposition with the mature seeds settling to the bottom of the tanks. At this point, seeds were sieved (Figure 6) from any remaining debris and transferred to one-liter storage bottles (Figure 7).

Per protocols outlined in the work plan (Tetra Tech, 2017), a small subset of seeds were separated for germination testing in the laboratory (warmed to 20ºC) to determine the expected rate of germination in the field. During warming, approximately 40% of the warming tanks (10 of 25) contained seeds that had started to germinate. However, controlled germination testing in a temperature-controlled refrigerator resulted in very low germination rates (<10%). A subset of seed (n=100) was taken from each collection event (event = donor bed on a given date) and placed in damp paper towel on a petri dish, and subsequently exposed to 24 hours of light. Germinated seeds were counted after 10 days incubation. Germination rates were lower than anticipated (expected >80%), but with the collection of more seed than originally planned, the seeding density was increased to compensate for low germination rates, as specified in the work plan (Tetra Tech, 2017). While it is not possible to say with absolute certainty why the germination rates were lower than expected, we hypothesize that the seeds may have needed to remain at ambient room temperature longer before being placed in refrigerators for over-wintering. Continued monitoring (see below) will provide information on natural germination rates and possibly the need for additional seeding.

2.3 SEED DISPERSAL

Prior to seed dispersal, Tetra Tech erected 12 exclosures as outlined in the work plan. The purpose of the exclosures are to prevent herbivory on the young plants by turtles, waterfowl, or other organisms, thereby allowing the plants to mature and reproduce into a more sustainable bed. The exclosures were erected April 24–26, 2018 (see Figures 8 through 12).

Once water temperatures warmed in spring 2018, seeds were dispersed throughout Cow Pen Creek and along the shoreline of Dark Head Cove. Seeds were dispersed by hand from a boat as it motored within Cow Pen Creek and along the Lockheed Martin property side of Dark Head Cove.

Based on a low germination rate (10%), approximately 400,000 - 450,000 seeds were spread in exclosures (Figure 8) and over the 4.42-acre region (Figure 9 and 10) on April 26, 2018, with an estimated density of approximately 90,500 - 102,000 seeds per acre (Figure 12). In consultation with the Maryland Department of Natural Resources, Tetra Tech made an in-field decision to spread seed over a reduced area (4.42 acres instead of 6.5 acres) due to greater than anticipated depths in some regions of Dark Head Cove. Some dredged regions were deeper than three meters, thereby precluding adequate survival of any seed spread in this environment (Batiuk et al., 2000). Rather than waste seed in these areas, seed dispersal was concentrated in areas that would sustain wild celery habitat.

SECTION 3
MONITORING

The first monitoring event was conducted on August 8, 2018, by Tetra Tech scientific divers, using SCUBA gear to inspect 13 transects and count plants within 0.25 square meter (m^2) quadrats along each transect (Figure 13). Water clarity in both Cow Pen Creek and Dark Head Cove was significantly reduced, likely due to rainfall before the dive. Visibility was below 50 centimeters (cm), and approaching 10 cm. Poor water clarity necessitated using touch to locate seedlings within the quadrats.

Eight transects were established in Dark Head Cove, extending up to five meters out from the bank. Three measurements were made on each transect: one at two meters from the bank, one at three meters from the bank, and the last approximately five meters from the bank. The depth or type of substrate (i.e., gravel and cobble) were not conducive to submerged aquatic vegetation (SAV) growth at any of the assessed quadrat locations. Depth ranged from two meters at the bulkhead on Dark Head Cove to approximately four meters at the five-meter survey point. Five transects were surveyed in Cow Pen Creek, extending from bank to bank, and consisting of 10 survey points across each transect equidistant apart, per the work plan. The shallower depths and substrate in Cow Pen Creek were much more conducive to SAV establishment as compared to Dark Head Cove. Plant counts per cubic meter are shown in Table 2.

Results indicate that SAV is not well established within the transects in Dark Head Cove. Note, however, that SAV is becoming established in areas of Dark Head Cove outside of the transect locations. In particular, a large SAV bed is established along the bulkhead in the area between transects 4 and 5.

SAV in Cow Pen Creek was well established. Much higher numbers of SAV were counted in survey points near the banks as compared to survey points in the middle of Cow Pen Creek, likely due in part to the shallower water depths near the banks. Three species of SAV were noted: the planted wild celery (*Vallisneria americana*), milfoil (*Myriophyllum spicatum*), and sago pondweed

(*Stuckenia pectinata*). In addition to plants growing from planted seed, it appears that natural recruitment of other SAV species is occurring in Cow Pen Creek. Overall, densities ranged from zero to 42 plants per square meter. This wide range demonstrates natural variability, as plants respond to the conditions within the system, and multiple species compete for available habitat.

SECTION 4
CONCLUSIONS AND RECOMMENDATIONS

No objectives for plant density were established for the first diver-based survey completed after the sediment remediation project. However, the survey does provide data relevant to number of seedlings established after the dredging operations. At this point, it seems that submerged aquatic vegetation (SAV) is becoming established in Cow Pen Creek from a combination of seeding and natural recolonization. As anticipated, water depths and substrate in Dark Head Cove may not be conducive to submerged aquatic vegetation growth and establishment (Batiuk et al., 2000).

Our preliminary results indicate that SAV is growing in the area, from both planted seed and natural recruitment of other species. These initial findings suggest we wait until the 2019 diver survey before recommending additional seeding. At this point, forecasting the restoration trajectory to meet the goal of 15% cover (via rake survey 2020-2023) by 2023 as noted in the work plan (Tetra Tech, 2017) is difficult. Diver monitoring in early August 2019 will provide critical data needed to adapt management decisions regarding further seeding. Water depths in Dark Head Cove are typically deeper than those at which submerged aquatic vegetation flourish in the Chesapeake Bay.

SECTION 5
REFERENCES

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FIGURES

Figure 1 Middle River Complex location, bordered by Cow Pen Creek to the west and Dark Head Cove to the south

Figure 2 SAV density in Dark Head Cove and Middle River (2015 survey)

Figure 3 Map of collection locations (red stars) overlaid the VIMS 2016 survey map

Figure 4 *Vallisneria* seed pods at different stages of development; full developed pod is on far right

Figure 5 Collecting seed pods in Middle River

Figure 6 Sieving seeds from remaining detritus

Figure 7 Seed stored in one-liter containers

Figure 8 Constructing Exclosure in Cow Pen Creek

Figure 9 Location of Exclosures in Middle River Complex area

Figure 10 Seed dispersal within Exclosure in Dark Head Cove

Figure 11 Seeds, held in water, prior to dispersal

Figure 12 Location of seed distribution in April 2018

Figure 13 Location of monitoring transects within Cow Pen Creek and Dark Head Cove

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Figure 2 SAV density in Dark Head Cove and Cow Pen Creek (2015 survey)
Note sparse to non-existent beds off bulkhead where water depths will not support growth

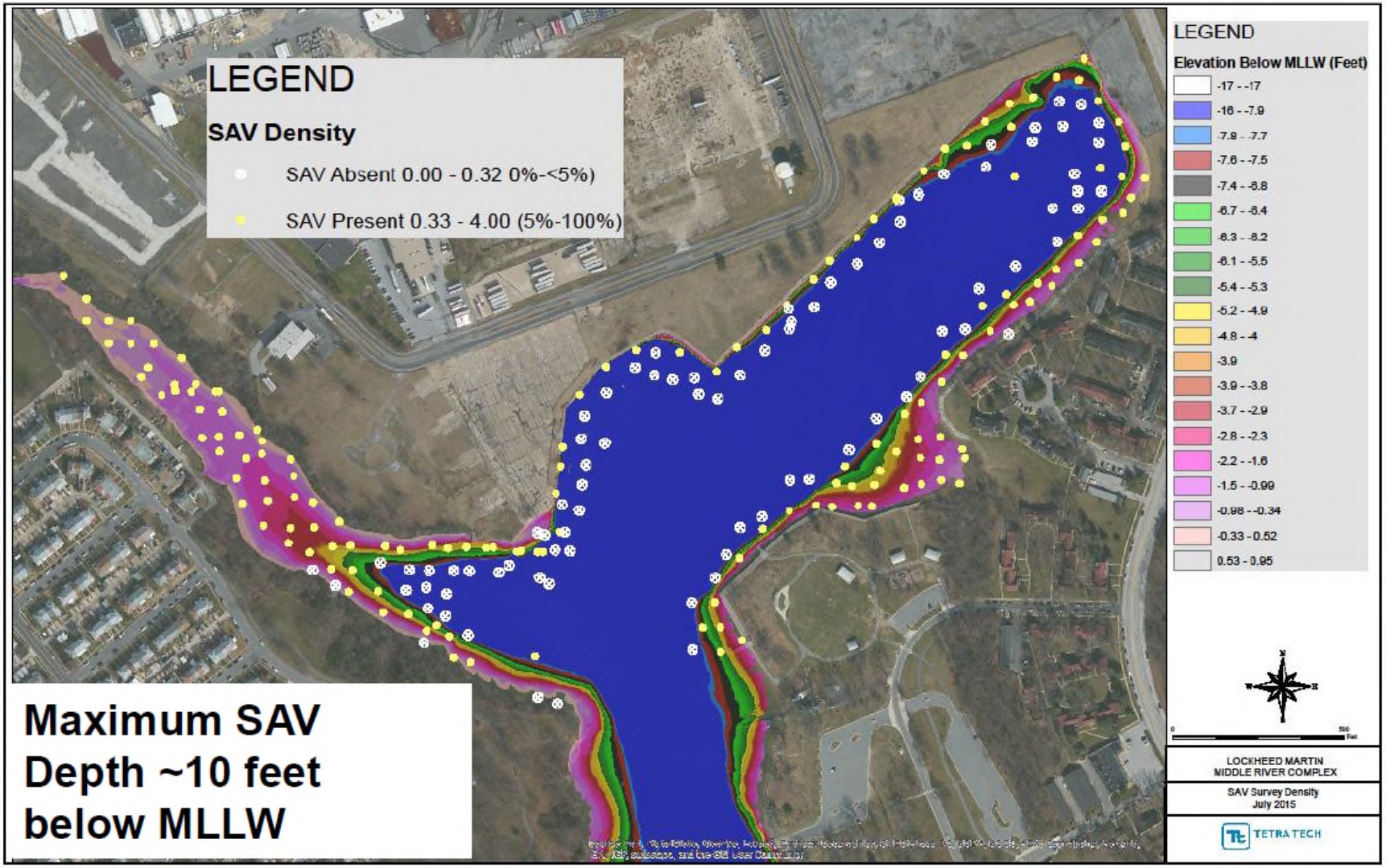
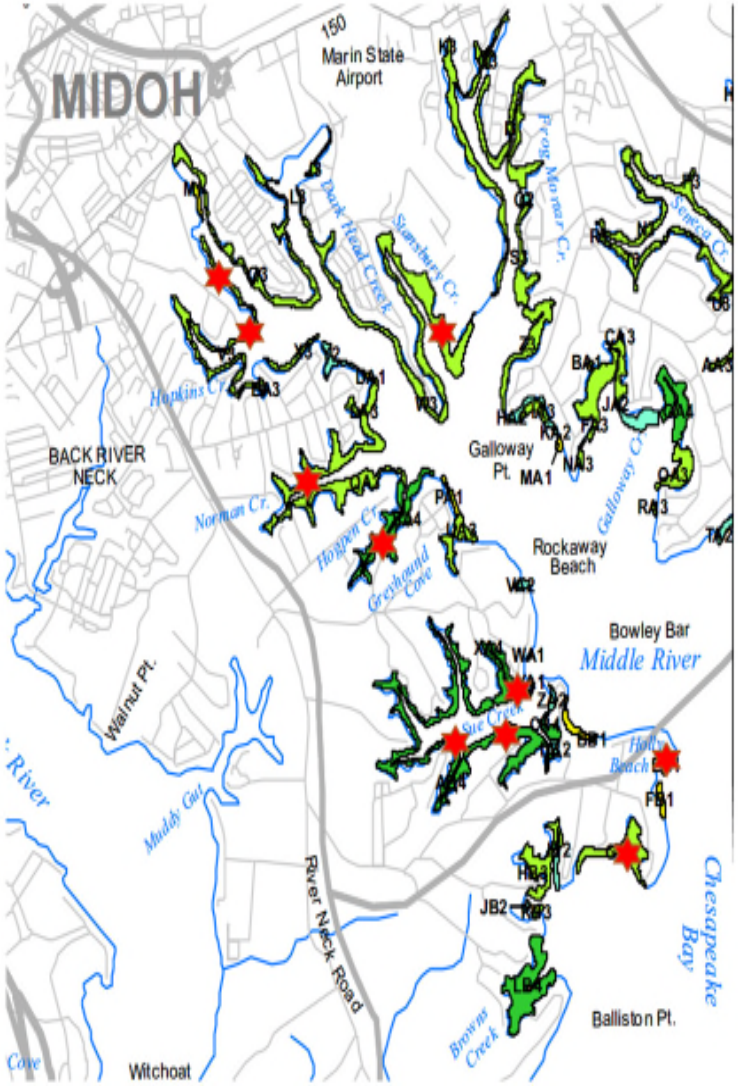


Figure 3 Map of collection locations (red stars) overlaid the VIMS 2016 survey map



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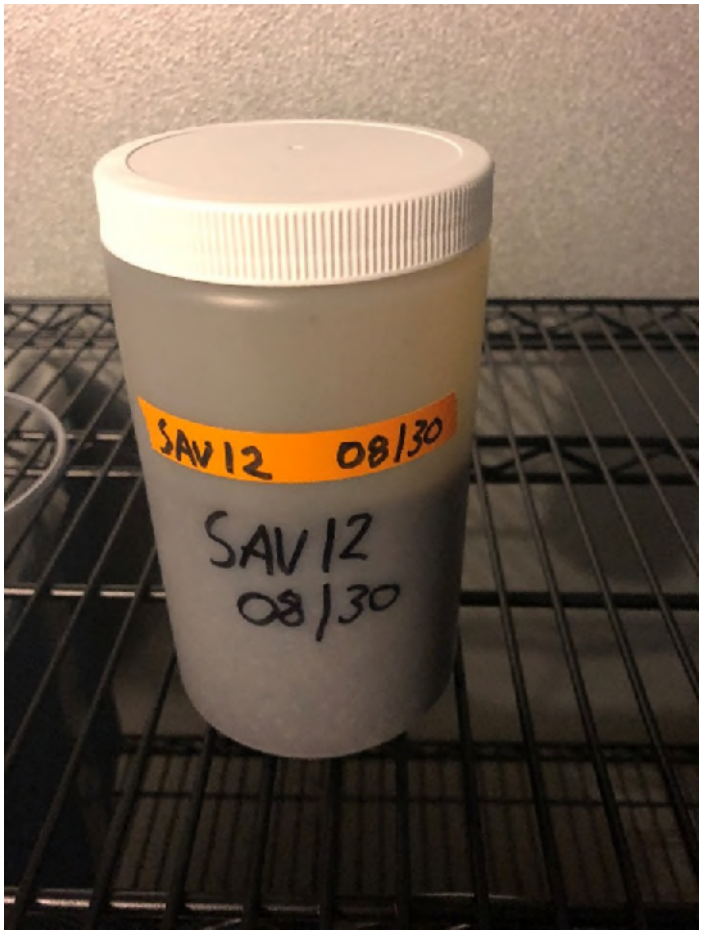

Figure 8 Constructing Exclosure in Cow Pen Creek

Figure 9 Location of Exclosures in Middle River Complex area

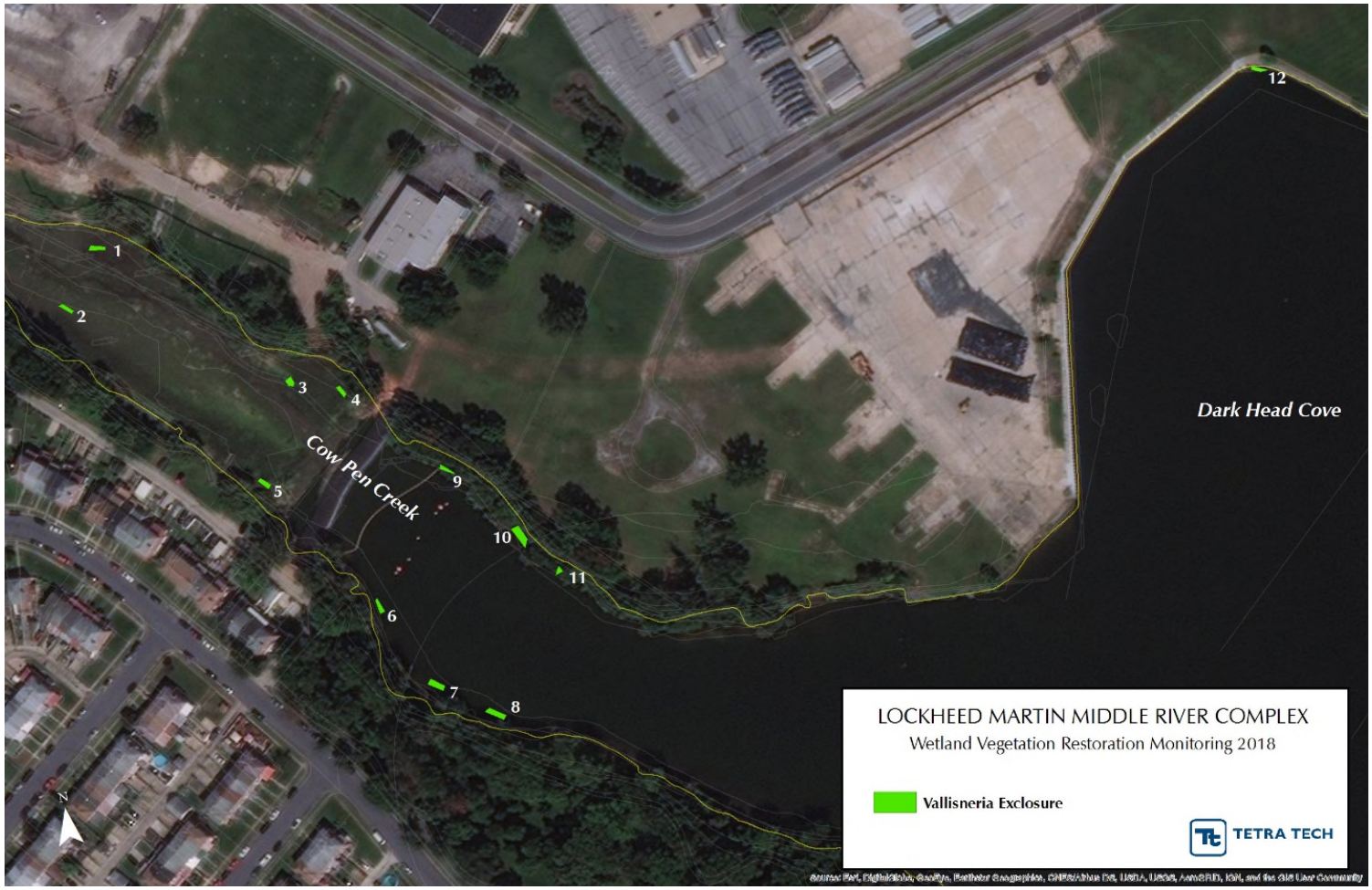

Figure 10 Seed dispersal within Exclosure in Dark Head Cove

Figure 11 Seeds, held in water, prior to dispersal

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TABLES

Table 1 Species composition from 2015 survey of Dark Head Cove and Cow Pen Creek

Table 2 Plant counts in Dark Head Cove and Cow Pen Creek during the August 2018 survey

Table 1

Species composition from 2015 survey of Dark Head Cove and Cow Pen Creek

SPECIES	% COMPOSITION
Ceratophyllum demersum (Coontail)	49%
Myriophyllum spicatum (Eurasian milfoil)	42%
Vallisneria americana (wild celery)	4%
Stuckenia pectinata (Sago pondweed)	2%
Potamogeton crispis (Curly pondweed)	2%
Potamogeton perfoliatus (Redhead grass)	0.5%
Zannichellia palustris (horned pondweed)	0.5%

Table 2
Plant counts in Dark Head Cove and Cow Pen Creek during the August 2018 survey.
(up to ten quadrats measured per transect)

Transect	Number of Plants per Quadrat										Mean number of plants
	1	2	3	4	5	6	7	8	9	10	per m^2
1-DHC	0	0	0	-	-	-	-	-	-	-	0
2-DHC	0	0	0	-	-	-	-	-	-	-	0
3-DHC	0	0	0	-	-	-	-	-	-	-	0
4-DHC	0	0	0	-	-	-	-	-	-	-	0
5-DHC	0	0	0	-	-	-	-	-	-	-	0
6-DHC	0	0	0	-	-	-	-	-	-	-	0
7-DHC	0	0	0	-	-	-	-	-	-	-	0
8-DHC	0	0	1	-	-	-	-	-	-	-	1.3
9-CPC	0	0	0	0	0	0	0	1	75	30	42.4
10-CPC	4	20	0	0	1	0	2	0	0	10	14.8
11-CPC	2	0	0	0	0	0	0	12	14	1	11.6
12-CPC	2	2	1	1	2	3	0	2	0	0	5.2
13-CPC	0	1	1	2	0	0	0	0	15	2	8.4

CPC – Cow Pen Creek
DHC – Dark Head Cove
m^2 – square meter(s)