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LOCKHEED MARTIN

November 14, 2022

**VIA EMAIL AND PRIVATE CARRIER**

Anuradha Mohanty
Land and Materials Administration
Maryland Department of the Environment
1800 Washington Boulevard, Suite: 625
Baltimore, Maryland 21230

Subject: Transmittal Cow Pen Creek and Dark Head Cove Sav Restoration and Monitoring Report
Lockheed Martin Corporation – Middle River Complex
2323 Eastern Boulevard, Middle River, Baltimore County, Maryland

Dear Ms. Mohanty,

For your information, please find enclosed two hard copies with a CD of the above-referenced document. This document describes 2022 site monitoring of submerged aquatic vegetation via diver survey per the methods outlined in *Cow Pen Creek and Dark Head Cove SAV Restoration and Monitoring Work Plan* Lockheed Martin Middle River Complex in Middle River, Maryland.

Please let me know if you have any questions. My phone number is (240) 460-7508 (cell).

Sincerely,

Thomas D. Blackman
Project Lead, Environmental Remediation

cc: (via email without enclosure)
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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

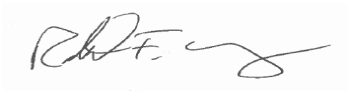
Prepared by:
Tetra Tech, Inc.

November 2022

Approved by:
Lockheed Martin, Inc.

Revision: 0

Michael Martin, P.G.
Regional Manager



Robert Murphy
Project Manager

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# ATTACHMENTS

# ACRONYMS AND ABBREVIATIONS

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

# SECTION 1
# INTRODUCTION

This report describes 2022 site monitoring of submerged aquatic vegetation (SAV) via diver survey per the methods outlined in *Cow Pen Creek and Dark Head Cove SAV Restoration and Monitoring Work Plan* (Tetra Tech, 2017). A qualitative assessment of the current condition of the donor beds used for seed harvests in 2017 and 2021 is also provided. A second assessment was conducted in September 2022 using additional transects to detect greater resolution of SAV distribution and percent cover. This report also provides an assessment of restoration progress, and, as part of an adaptive management strategy, recommendations for future efforts.

## 1.1 BACKGROUND

The Lockheed Martin Corporation (Lockheed Martin) Middle River Complex (MRC) is part of the Chesapeake Industrial Park, 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 that had been 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 SAV were damaged or removed. SAV serves as critical habitat for a variety of aquatic organisms, including ecologically important fish and invertebrates (Smart *et al*., 1996). In addition, it 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). SAV 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 Conservation and Management Act (amended 2007), legislation that regulates impacts to essential fish habitat. To mitigate impacts to SAV, and in accordance with Maryland Department of the Environment (MDE) Tidal Wetlands License No. 15-1119 and United States Army Corps of Engineers (USACE) Authorization No. 2016-61958-M02, the 6.5-acre impact area was to be re-seeded with native SAV and monitored for a period of five years. The actual area re-seeded deviated from the original estimated area because approximately two acres were too deep for plant survival. In response to the temporary loss of these ecosystem services, and in compliance with the USACE permit and MDE Tidal Wetlands License, Lockheed Martin implemented a large-scale SAV restoration project in 2017-2018.

As part of the sediment remediation effort, a series of steps were taken to document existing SAV conditions, restoration, and monitoring of impacted SAV habitat.

***Baseline Survey (2015)—*** Tetra Tech, Inc. (Tetra Tech) conducted a survey of SAV 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*). Eurasian milfoil is a non-native species, and actively restoring the population of this species is inappropriate; however, Eurasian milfoil is likely to re-establish in Dark Head Cove and Cow Pen Creek due to high densities in surrounding waterways. Coontail, a native species, is problematic for use in restoration because its seed is difficult to harvest. Furthermore, coontail is a rootless plant that would likely recolonize impacted areas via floating plants originating elsewhere in Middle River. Wild celery (*Vallisneria americana*) is an excellent plant for waterfowl and provides habitat for a variety of finfish and other aquatic organisms. Additionally, wild celery is a native plant that produces a readily harvestable seed pod that can be collected in large numbers for use in restoration (Moore and Jarvis, 2007). Therefore, the planting and monitoring plan 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 SAV was not generally present adjacent to the cove bulkhead (Figure 2) because water in that location exceeds suitable depths (2 meters [m]) for SAV growth (Batiuk, *et al*. 2000).

***SAV restoration activities (2017–2018)*** **–** Starting in August 2017, several existing wild celery beds in Middle River and its tributaries were monitored to assess the maturation of the seedpods. Reproductive shoots showed evidence of maturity by mid-August, at which point teams conducted multiple days of hand-harvesting. After collection, seedpods were transferred to a cooler filled with river water where they were kept until the conclusion of each collection day. Seed pods were transported to Tetra Tech's Biological Resources Facility (BRF) in Owings Mills, Maryland and stored at ≤4º Celsius. Approximately 4,000,000–4,500,000 seeds were collected. Viability tests (using tetrazolium oxide [per Moore and Jarvis, 2007]) were conducted on a subset of seeds, which determined that only 10% (i.e., only 400,000-450,000) of the seeds were viable. Prior to seed dispersal, exclosures were erected in portions of the restoration site 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.

All viable seeds were dispersed throughout Cow Pen Creek and along the shoreline of Dark Head Cove in spring 2018. 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. As noted above, approximately 400,000-450,000 viable seeds were spread over the area, including within the exclosures, with an estimated density of approximately 90,500-102,000 viable seeds per acre. In consultation with the Maryland Department of Natural Resources (DNR), Tetra Tech made an in-field decision to spread seed over a reduced area (4.42 acres instead of 6.5 acres) because greater than anticipated water depths were present within some regions of Dark Head Cove. These dredged regions were associated with water depths greater than 3 m, thereby precluding adequate survival of any seed spread in this environment (as indicated in Batiuk, *et al*., 2000). Rather than distribute seed in these areas, seed dispersal was concentrated in areas that would sustain wild celery habitat.

***2018 Monitoring*** **–** The first monitoring event was conducted in August 2018, by Tetra Tech scientific divers, using self-contained underwater breathing apparatus (SCUBA) gear to inspect 13 fixed transects and count plants within 0.25 square-meter ($m^2$) quadrats along each transect

(Tetra Tech, 2018). Eight transects were established in Dark Head Cove, extending up to 5 m out from the bank. Three measurements were made along each transect, at distances of 2 m, 3 m, and 5 m from the bank. The depth or type of substrate (i.e., gravel and cobble) was not conducive to SAV growth at any of the assessed quadrat locations. Depth ranged from 2 m at the bulkhead on Dark Head Cove to approximately 4 m at the five-meter survey point along the same transect. Results indicate that SAV was not well established within the transects in Dark Head Cove, likely due to unsuitable habitat associated with greater depths.

Five transects were surveyed in Cow Pen Creek, extending from bank to bank, and consisting of 10 equidistant survey points across each transect per the work plan. The shallower depths and substrate in Cow Pen Creek were more conducive to SAV establishment, as compared to Dark Head Cove. Plant counts (the number of plants per square meter) are shown in Table 2. SAV in Cow Pen Creek was more established. Higher numbers of plants 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, Eurasian milfoil, and sago pondweed (*Stuckenia pectinata*). This demonstrated that, in addition to plants growing from planted seed, natural recruitment of other SAV species was occurring in Cow Pen Creek. Overall, densities ranged from zero to 42 plants per square meter (Table 2). This wide range demonstrates natural variability, as plants respond to the conditions within the system, and multiple species compete for available habitat.

***2019 Monitoring*** - The second monitoring event was conducted on August 8, 2019, by Tetra Tech scientific divers, using SCUBA gear to inspect 13 transects and count plants within 0.25 $m^2$ quadrats along each transect in areas where seed was dispersed (Figures 3 and 4). Water clarity in both Cow Pen Creek and Dark Head Cove was better than when monitoring was conducted in 2018. Visibility was greater than 50 centimeters (cm) at the surface, but was 10-15 cm at depths of up to 3.2 m.

The same fixed transects that were established in 2018 (eight in Dark Head Cove and five in Cow Pen Creek) were monitored in 2019 per the work plan. The observed depth and type of substrate (i.e., gravel and cobble) in Dark Head Cove was not conducive to SAV growth at any of the

assessed quadrat locations. Depths in DHC and CPC were the same as noted in the 2018 survey (see above). Plant counts per square meter in this location are shown in Table 3.

Although previous survey results indicated that SAV was growing in Dark Head Cove areas outside of those studied in 2018, the 2019 survey indicated that it was no longer established outside the studied transects in Dark Head Cove.

SAV in Cow Pen Creek had also substantially reduced in 2019 as compared to 2018. Higher numbers of plants were present in 2018; as stated above, these plants were established near the banks as compared to the middle of the creek and had likely survived due in part to the shallower water depths near the banks. Overall Cow Pen Creek plant densities in 2019 (0-2.8 plants per $m^2$) had substantially decreased as compared to 2018 (0-42.4 plants per $m^2$). The two transects with the highest plant counts in 2018 (CPC-9 and CPC-10) were the only transects in which SAV was observed in 2019. As stated above, three plant species were present in 2018, while only wild celery (*V. americana*) and horned pondweed (*Z. palustris*) were found in 2019.

***2020 Monitoring*** - The third monitoring event was conducted on August 5, 2020. Tetra Tech scientific divers using SCUBA gear inspected 13 fixed transects and counted plants within 0.25 $m^2$ quadrats along each transect in the seed dispersal area (Figures 3 and 4). Water clarity in both Cow Pen Creek and Dark Head Cove was poorer than that observed while monitoring in 2019. Similar to 2019, visibility was under 50 cm throughout the water column

The same transects that were established 2018 (eight in Dark Head Cove and five in Cow Pen Creek) were monitored in 2020 per the work plan. Unsuitable habitat (greater water depths) was again observed at the Dark Head Cove transects, and little to no SAV was found. Depths there generally ranged from 1 m at the bulkhead to approximately 4 meters at the transect endpoint. The shallower depths and substrate in Cow Pen Creek continued to be much more conducive to SAV establishment as compared to Dark Head Cove. Plant counts per square meter in this location are shown in Table 4.

Although previous survey results indicated that SAV was growing in Dark Head Cove areas outside of those studied in 2018, results in 2020 (like those in 2019) indicated that SAV was not well established outside the Dark Head Cove transects. Survey results of SAV in Cow Pen Creek

in 2020 were similar to 2019 results. No plants were observed in the 13 fixed transects during the 2020 survey.

***2021 Monitoring-*** Tetra Tech scientific divers conducted the fourth monitoring event on August 5, 2021; SAV was surveyed along each fixed transect in the seed dispersal area (see Figures 3 and 4). Water clarity in both Cow Pen Creek and Dark Head Cove was similar to that observed in 2020, with visibility under 50 cm

Water depth ranged from 1 m at the bulkhead to approximately 4 m at the endpoint. The same five transects that were surveyed in Cow Pen Creek in 2018, 2019, and 2020 (Tables 2 through 4) were monitored again in 2021. Plant counts per square meter are shown in Table 5. Overall, fewer plants remained, with very little SAV surviving from the original planting in 2017-2018, and from previous years of monitoring.

Survey results from 2021 indicated that SAV had not established within the transects in Dark Head Cove, and only limited SAV had been established in Cow Pen Creek (Table 5). In 2018, SAV was becoming established in areas of Dark Head Cove outside of sampled transect locations, and a large SAV bed had been established along the bulkhead in the area between transects DHC-4 and DHC-5. However, monitoring events from 2019 to 2021 indicated that SAV had not been present in Dark Head Cove since 2018 (Table 6). Observations from other areas of Dark Head Cove and the lower reaches of Middle River, outside the project area, indicated that a large die-off of SAV occurred between 2019 and 2020 (see Section 3). Table 6 presents a summary of plant density observed during diver monitoring between 2018 and 2022.

## 1.2 2022 OBJECTIVES

Per the work plan and 2020 work plan addendum (Tetra Tech, 2017; 2020), the specific objectives for the SAV restoration and monitoring include the following:

- locating and collecting native wild celery seed from local (within 30 miles) populations, to provide a minimum of 100,000 viable seeds per acre (completed in 2017; the second seeding occurred within this [2022] monitoring period)
- providing viable seed that demonstrates at least 80% germination during testing (did not meet objective in 2017/2018, but met in 2022)

- dispersing seeds over the area to be restored, so that they are distributed at a minimum of 100,000 viable seeds per acre (completed and met objective in 2018; with a second reseeding completed[and objective met] in May 2022)

- installing and successfully maintaining grazing exclosures (completed in 2018 and removed in 2019)

- 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 the 2018, 2019, 2020, or 2021 monitoring event) by 2022 (equivalency met in 2022 by diver survey, not rake survey)

- implementing a robust post-seeding monitoring program using divers (conducted 2018 - 2022)

- conducting a survey of SAV throughout Dark Head Cove in areas outside the remediation project limits, for comparison (completed in 2020)

- conducting a qualitative assessment of seed donor beds (completed in 2020, 2021, and 2022)

# SECTION 2
# DONOR BED ASSESSMENT

Per the 2020 work plan addendum, Tetra Tech scientists conducted a qualitative assessment in 2021 of the submerged aquatic vegetation (SAV) beds used to source seeds in 2017. Ten beds were originally identified as potential seed donors throughout the Middle River, although seeds were eventually harvested from only five beds. Tetra Tech scientists visited the beds in June 2021 (at the beginning of the annual growing season) to observe the health and vitality of the donor beds. Two of the beds near the mouth of the Middle River, previously used in the 2017 harvest, were of adequate size and density to consider harvesting in 2021. One bed in Stansbury Creek, identified in 2017 but not harvested, was fairly extensive and robust enough to use for harvesting. Two beds in Sue Creek (neither used for 2017 seed harvest) were fairly robust and were suitable for seed harvest. Therefore, in late summer 2021, Tetra Tech scientists concluded that the Sue Creek beds were healthy enough to harvest seed pods, and pods were harvested in autumn 2021 (see Section 3 for more details).

Tetra Tech scientists returned to the donor beds in late summer 2022, approximately one year after the second seed harvest in autumn 2021 (see Section 3), to qualitatively assess bed health. Several of the beds used for seed collection had expanded and were very densely covered with wild celery and several other native species.

# SECTION 3
# SECOND SEEDING

Based on four years of monitoring data, and in consultation with agency staff (DNR, the National Oceanic and Atmospheric Administration, and MDE), Lockheed Martin opted to conduct a second round of seeding, focusing on the shallower areas of the impacted creek/cove. Tetra Tech scientists assessed the condition of several of the original seed donor beds in Middle River and hand-harvested seed pods on September 8-10, 2021. Following the same protocols established for the first seeding (Tetra Tech, 2017), pods were transported in a cooler filled with river water back to Tetra Tech's Biological Research Facility (BRF) in Owings Mills, MD for over-winter storage at 4$^{o}$ Celsius. Seeds and pods were periodically agitated to facilitate vegetative breakdown of the pods, releasing seeds to the bottom of the storage containers. All seeds were free from vegetative material by February 2022. Seeds were then tested for viability and germination rate. Viability is a measure of the seed health (alive or dead) while germination is a test of whether the seed is robust enough to emerge as a seedling. Germination tests done at the BRF were low (<30%), although viability testing over a 30-day period was greater than 75%. This suggests that germination testing may be flawed due to a variety of reasons not fully evaluated (e.g., less than ideal light or temperature), but suggests the seeds were robust for the re-seeding phase.

Tetra Tech scientists hand-seeded Cow Pen Creek and small parts of Dark Head Cove via boat in May 2022 (Figure 4). Areas that were less than 2 meters (m) deep were targeted to provide optimal conditions for seedling establishment. Deeper areas within Dark Head Cove, including the fixed monitoring transects which extend out to depths of 4-5 m, were avoided during seeding. An estimated 250,000 to 275,000 wild celery seeds were dispersed in total, with the vast majority planted in Cow Pen Creek.

# SECTION 4
# 2022 MONITORING RESULTS

Tetra Tech scientific divers conducted the year-five scheduled monitoring event in August 2022, using the established transects in Dark Head Cove (8 transects) and Cow Pen Creek (5 transects). As noted previously, the fixed transects extending into Dark Head Cove are at depths more than 2 meters (m). No submerged aquatic vegetation (SAV) had been noted in those transects in Dark Head Cove since pre-dredging in 2015 (Table 6). Divers failed to locate any SAV at these depths in August 2022; however, these areas were not directly re-seeded in spring 2022. Qualitative observations in the field indicated a resurgence of SAV along the shallower portion of Dark Head Cove in areas not covered by the fixed transects. Similarly, SAV was observed in the fixed transects in Cow Pen Creek, and was also noted as present and even fairly dense in several other areas. The 2022 shoot count results are found in Tables 6 and 7.

Field observations throughout Cow Pen Creek and Dark Head Cove in 2022 suggested that the fixed transect locations originally selected in the work plan were consistently misrepresenting SAV extent, so Tetra Tech modified the survey methodology to increase the number of surveyed transects and to improve spatial resolution throughout the project area. By adding several new transects, field scientists were able to better capture SAV extent and coverage (Figure 6). A second monitoring event was conducted on September 1, 2022, using these transects in addition to the fixed transects. Furthermore, although the fixed transects that extended into deeper water in Dark Head Cove were included in the 2022 second survey, quadrats in the middle of Cow Pen Creek that were deemed too deep for SAV growth were eliminated from the monitoring plan. This exclusion of mid-channel quadrats in Cow Pen Creek was done only for the second monitoring event of 2022; Tetra Tech opted to collect percent cover data during this second assessment in order to align with the outcomes described in the objectives, rather than limiting the data to shoot counts (Table 8). Divers dropped fixed survey points using 0.25-square-meter ($m^2$) polyvinyl chloride (PVC) quadrats along the identified transects (see Figure 6), and SAV coverage (percent cover, 0-100%) within each quadrat was estimated. Mean percent cover for Dark Head Cove and

Cow Pen Creek were estimated as 17.0% (number of observations [n]=37) and 22.3 % (n=44), respectively.

# SECTION 5
# CONCLUSIONS AND RECOMMENDATIONS

During initial project planning in 2017, estimation of submerged aquatic vegetation (SAV) percent cover was to be conducted via rake surveys. Plant density objectives were established for the rake surveys (Section 1.2) but rake surveys were never implemented because of concerns about damaging SAV during the surveys. To preserve existing plants, diver surveys used as an alternative to rake surveys. No objectives for plant density were established for the diver-based surveys (conducted from 2018 to 2022). However, the diver surveys do provide data relevant to the number of seedlings established after the dredging.

SAV observed in Cow Pen Creek in 2022 is still somewhat sparse (Figure 6) as compared to observed baseline conditions (Figure 2). As previously observed during annual monitoring at Cow Pen Creek and Dark Head Cove, water depths and substrate in Dark Head Cove appear non-conducive to SAV growth and establishment. Figure 7 shows SAV maps for the Middle River area from 2015 through 2021, courtesy of Virginia Institute of Marine Science (VIMS) annual surveys. Regional trends in SAV coverage for the Middle River (and Chesapeake Bay) follow the observations from Dark Head Cove and Cow Pen Creek. The baywide survey noted a decline of more than 30% between 2018 and 2019, the same time period where the project had poor success in the restoration area. Areal coverage has improved, and that has also been noted in the region of study.

The second round of diver-based monitoring in 2022 assessed the percent covered by SAV instead of counting SAV shoots. Observed mean cover percentage for each system indicates that the original percent coverage objectives of 10-15% for Cow Pen Creek (with 22.3% observed in 2022), and of 5-10% for Dark Head Cove (with 17% observed in 2022), were met. Having met these percent cover objectives, Lockheed Martin Corporation proposes it has fulfilled the requirements of the permit and proposes to no longer monitor the restored SAV.

# SECTION 6
# REFERENCES


Batiuk, R.A., P.W. Bergstrom, W.M. Kemp, E.W. Koch, L. Murray, J.C. Stevenson, R. Bartleson, et al. (2000). “Chesapeake Bay submerged aquatic vegetation water quality and habitat-based requirements and restoration targets: A second technical synthesis.” 130pp. Edgewater, MD: Chesapeake Research Consortium.

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Moore, K.A., and J.C. Jarvis. 2007. Using seed to propagate and restore *Vallisneria americana* (wild celery) in the Chesapeake Bay, 10. Vicksburg, MS: U.S. Army Engineer Research and Development Center.

Smart, R. M., R. D. Doyle, et al. (1996). "Establishing native submersed aquatic plant communities for fish habitat." American Fisheries Society Symposium 16: 347-356.

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Tetra Tech, Inc. (Tetra Tech), 2020. *Transmittal of Expanded SAV Survey for Cow Pen Creek and Dark Head Cove.* Lockheed Martin Middle River Complex, 2323 Eastern Boulevard, Middle River, Maryland.

# FIGURES

**Figure 1: Middle River Complex Location, Bordered by Cow Pen Creek to the West and Dark Head Cove to the South**

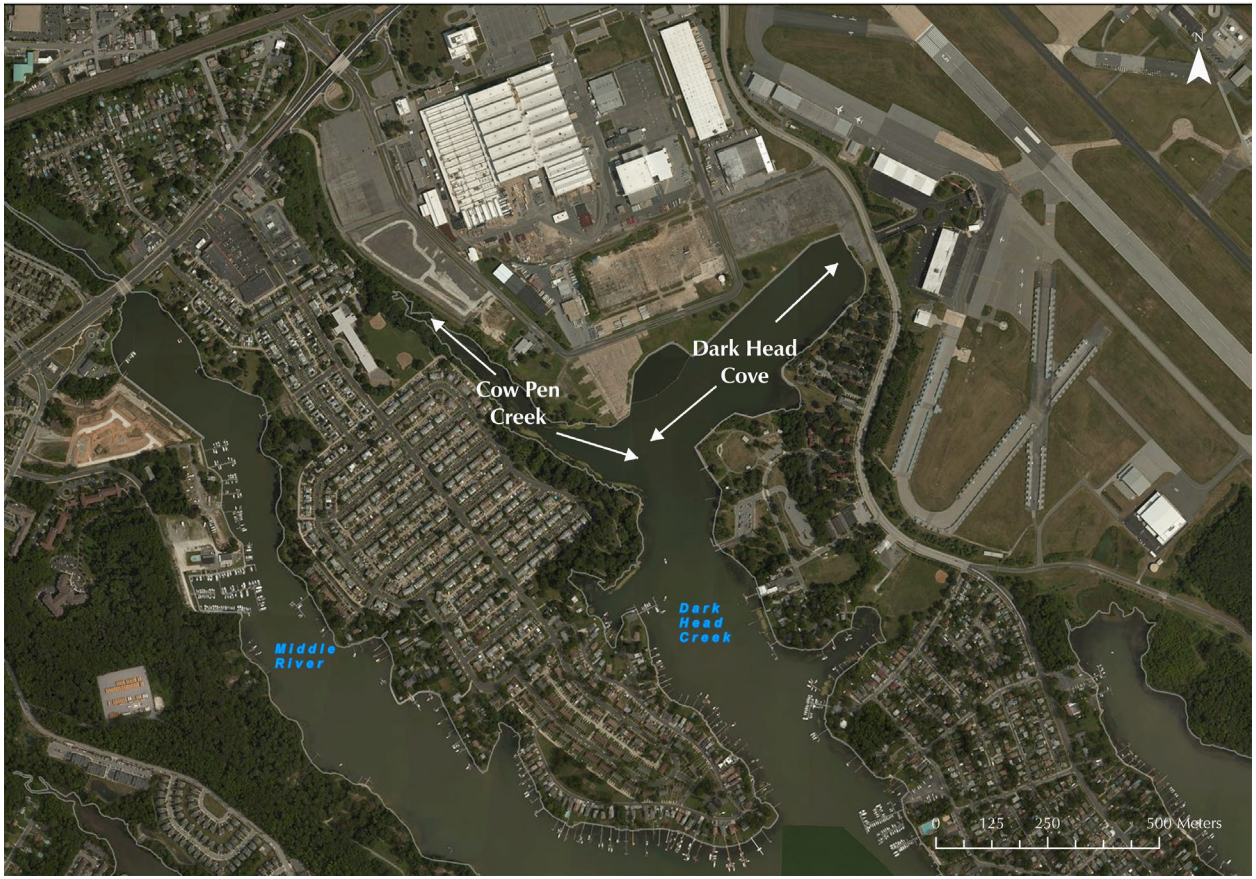


**Figure 2: SAV Density (via rake survey) in Dark Head Cove and Cow Pen Creek (2015 survey), Prior to Dredging (Note sparse to non-existent beds off bulkhead where water depths will not support growth)**

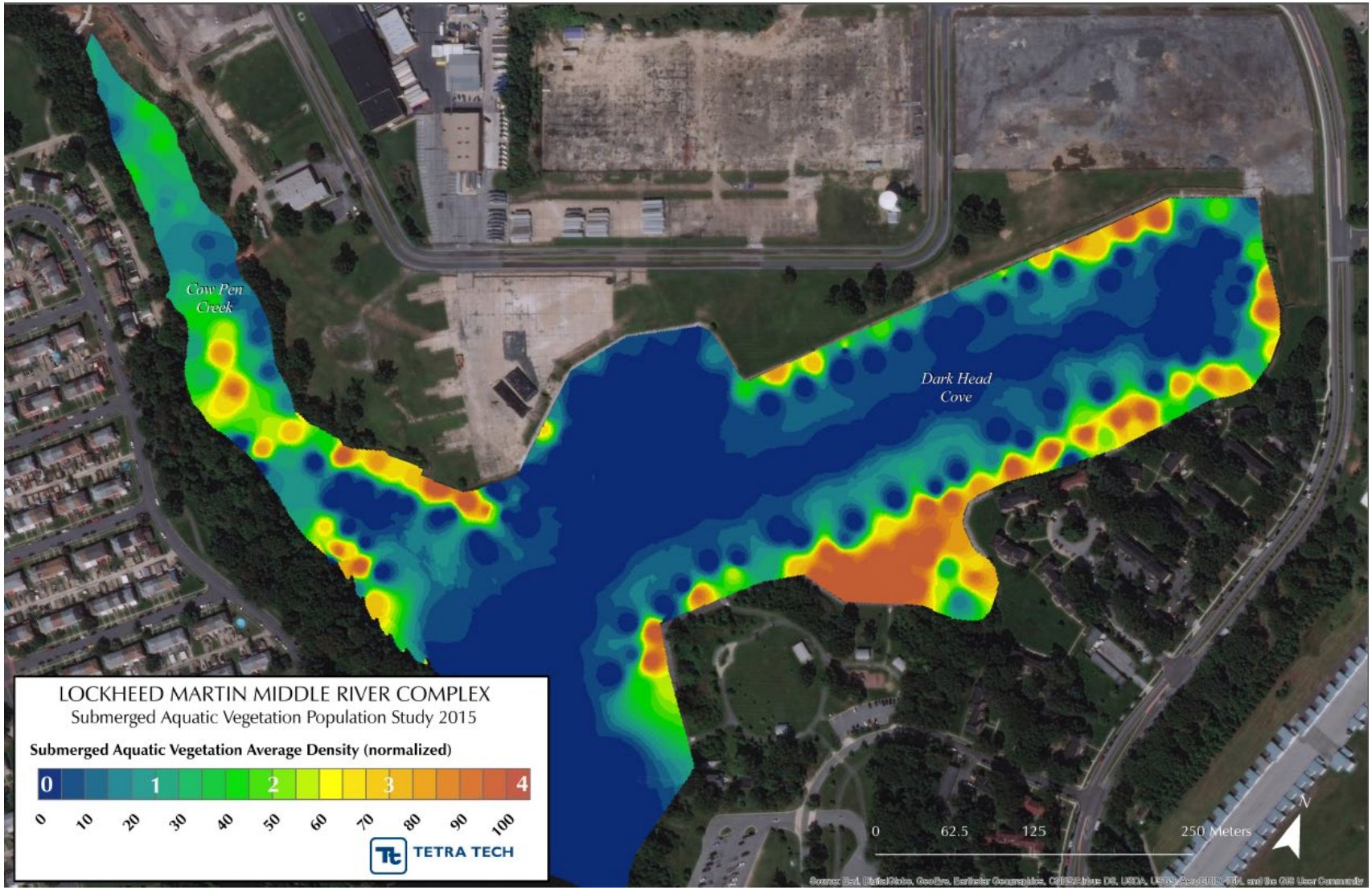


**Figure 3: Location of Fixed Monitoring Transects within Cow Pen Creek and Dark Head Cove, 2018–2022**

## Figure 4: Location of Seed Distribution in April 2018 and May 2022

**Figure 5: SAV Density in Dark Head Cove (2020 survey)**

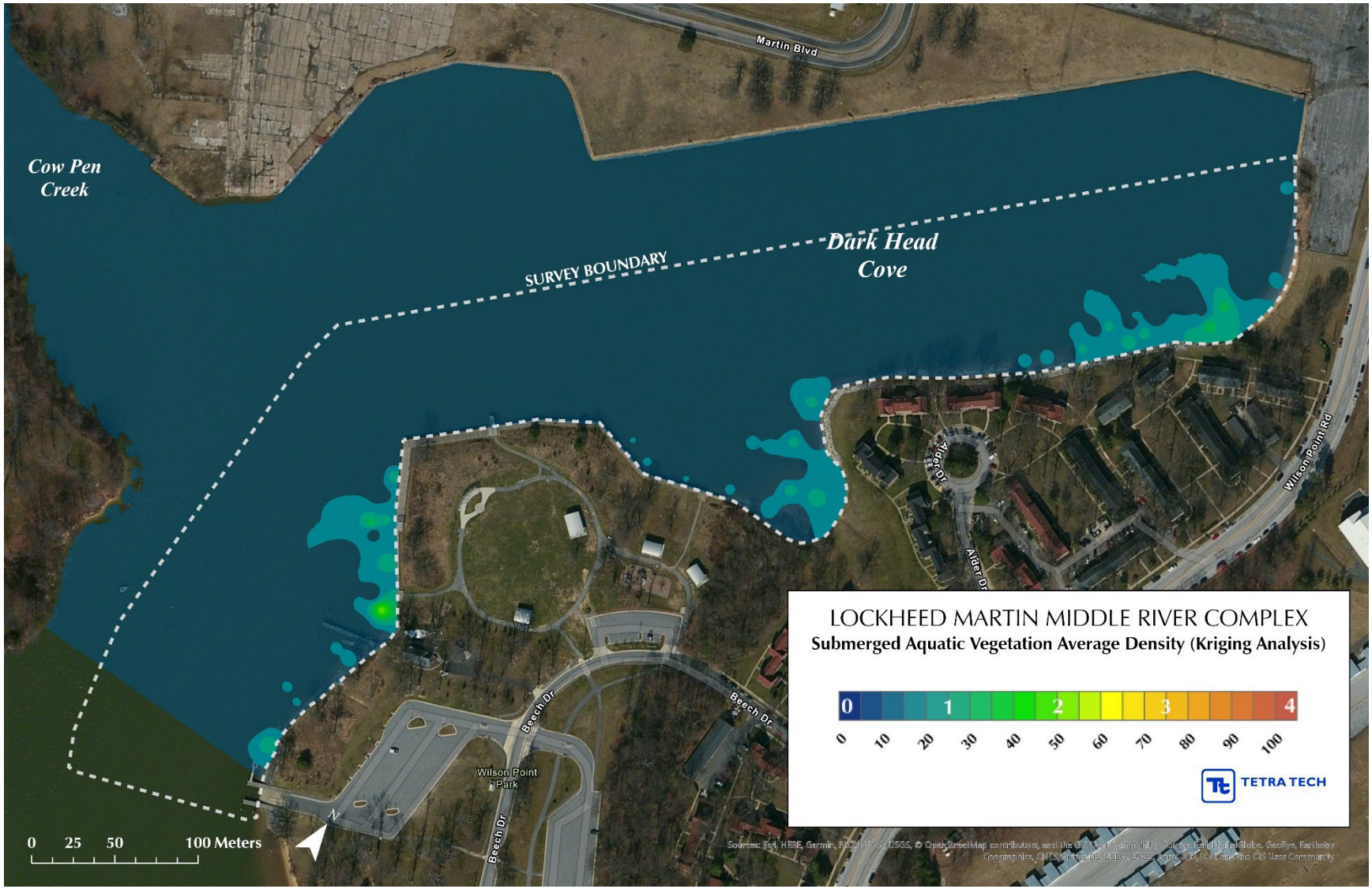


**Figure 6: Results of 2022 Monitoring**

(Note the additional transects added [in red])

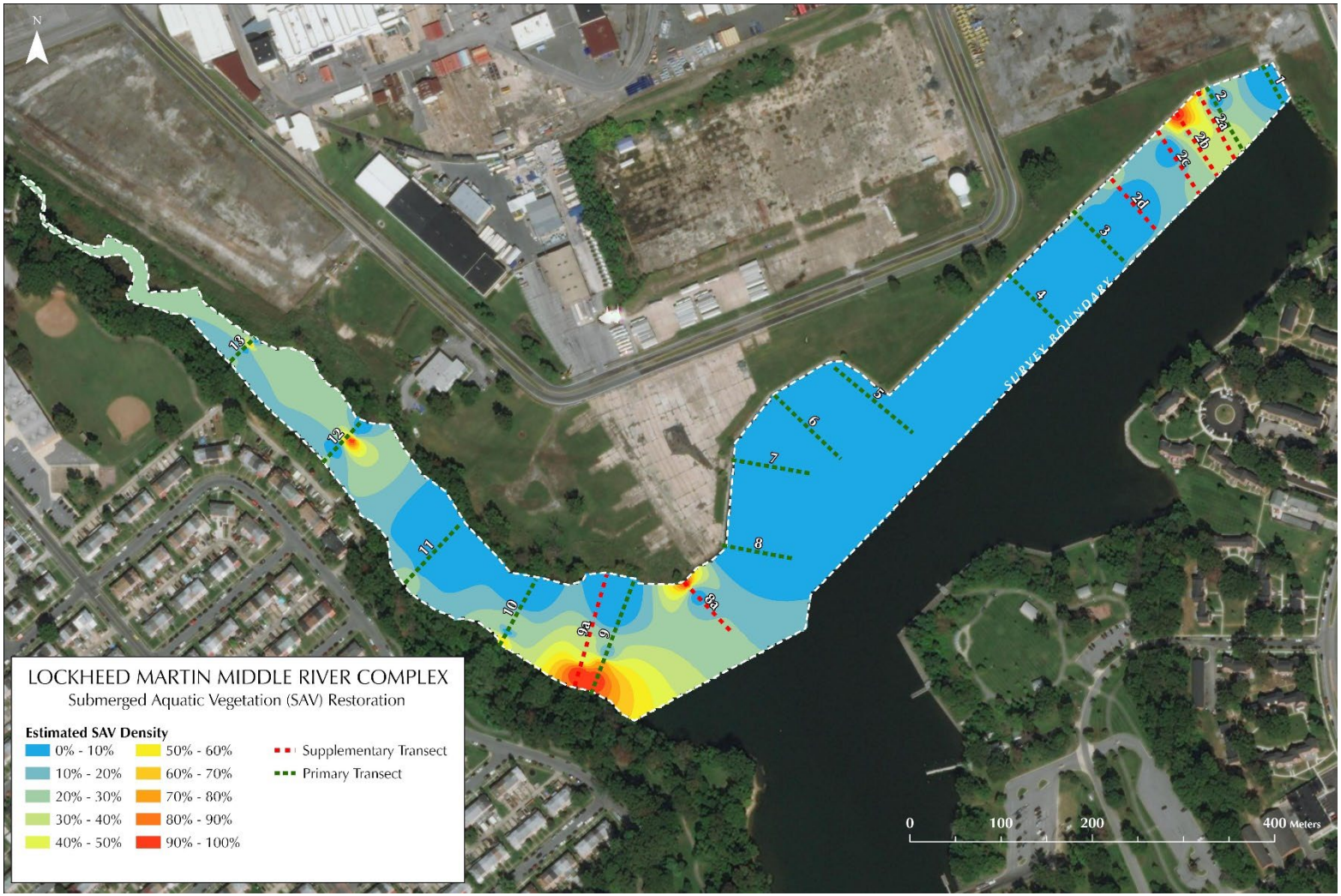
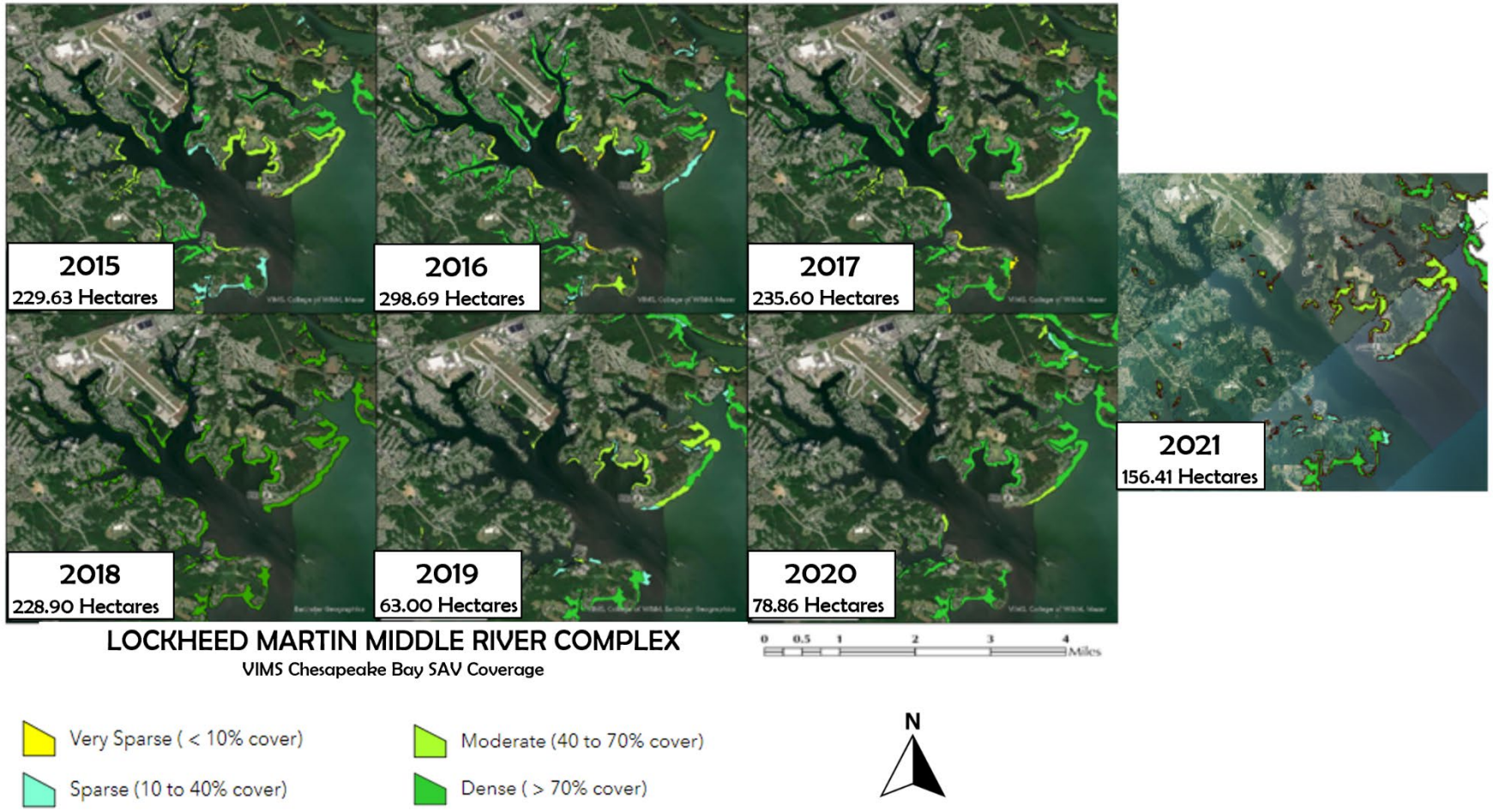


**Figure 7: SAV Coverage Maps for Middle River, Courtesy of VIMS Annual Survey (2015-2021)**



# TABLES

**Table 1.**
**Species Composition from 2015 and 2020 surveys of Dark Head Cove**

| SPECIES | % COMPOSITION | |
|---|---|---|
| | 2015 | 2020 |
| *Ceratophyllum demersum* (coontail) | 44 | 24 |
| *Myriophyllum spicatum* (Eurasian milfoil) | 41 | 0 |
| *Vallisneria americana* (wild celery) | 7 | 39 |
| *Stuckenia pectinata* (sago pondweed) | 3 | 0 |
| *Potamogeton crispis* (curly pondweed) | 2 | 3 |
| *Potamogeton perfoliatus* (redhead grass) | 1 | 0 |
| *Zannichellia palustris* (horned pondweed) | 1 | 0 |
| *Ruppia maritima* (widgeongrass) | 0 | 17 |
| *Potamogeton pusillis* (slender pondweed) | 1 | 5 |
| *Najas minor* (spiny naiad) | 0 | 8 |
| *Elodea sp.* (waterweed) | 0 | 2 |

**Table 2.**
**Plant Counts in Dark Head Cove and Cow Pen Creek, August 2018**
**(up to ten quadrats measured per transect)**

| Transect | Number of plants per quadrat ⇦ Shoreward | | | | | | | | | | Mean number of plants (per $m^2$) | Number of species present* |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | | |
| 1-DHC | 0 | 0 | 0 | - | - | - | - | - | - | - | 0 | 0 |
| 2-DHC | 0 | 0 | 0 | - | - | - | - | - | - | - | 0 | 0 |
| 3-DHC | 0 | 0 | 0 | - | - | - | - | - | - | - | 0 | 0 |
| 4-DHC | 0 | 0 | 0 | - | - | - | - | - | - | - | 0 | 0 |
| 5-DHC | 0 | 0 | 0 | - | - | - | - | - | - | - | 0 | 0 |
| 6-DHC | 0 | 0 | 0 | - | - | - | - | - | - | - | 0 | 0 |
| 7-DHC | 0 | 0 | 0 | - | - | - | - | - | - | - | 0 | 0 |
| 8-DHC | 0 | 0 | 1 | - | - | - | - | - | - | - | 1.3 | 1 |
| 9-CPC | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 75 | 30 | 42.4 | 3 |
| 10-CPC | 4 | 20 | 0 | 0 | 1 | 0 | 2 | 0 | 0 | 10 | 14.8 | 1 |
| 11-CPC | 2 | 0 | 0 | 0 | 0 | 0 | 0 | 12 | 14 | 1 | 11.6 | 1 |
| 12-CPC | 2 | 2 | 1 | 1 | 2 | 3 | 0 | 2 | 0 | 0 | 5.2 | 1 |
| 13-CPC | 0 | 1 | 1 | 2 | 0 | 0 | 0 | 0 | 15 | 2 | 8.4 | 1 |

* – Transects 8-CPC- 10-CPC, 11-CPC, 12-CPC, and 13-CPC only had *Vallisneria americana*; Transect 9-CPC had three species including wild celery (*Vallisneria americana*), Eurasian milfoil (*Myriophyllum spicatum*), and sago pondweed (*Stuckenia pectinata*).
CPC – Cow Pen Creek
DHC – Dark Head Cove
$m^2$ – square meter(s)

**Table 3.**
**Plant Counts in Dark Head Cove and Cow Pen Creek, August 2019**
**(up to ten quadrats measured per transect)**

| Transect | Number of plants per quadrat ⇦ Shoreward | | | | | | | | | | Mean number of plants per $m^2$ | Number of species present* |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | | |
| 1-DHC | 0 | 0 | 0 | - | - | - | - | - | - | - | 0 | 0 |
| 2-DHC | 0 | 0 | 0 | - | - | - | - | - | - | - | 0 | 0 |
| 3-DHC | 0 | 0 | 0 | - | - | - | - | - | - | - | 0 | 0 |
| 4-DHC | 0 | 0 | 0 | - | - | - | - | - | - | - | 0 | 0 |
| 5-DHC | 0 | 0 | 0 | - | - | - | - | - | - | - | 0 | 0 |
| 6-DHC | 0 | 0 | 0 | - | - | - | - | - | - | - | 0 | 0 |
| 7-DHC | 0 | 0 | 0 | - | - | - | - | - | - | - | 0 | 0 |
| 8-DHC | 0 | 0 | 0 | - | - | - | - | - | - | - | 0 | 0 |
| 9-CPC | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 7 | 2.8 | 2 |
| 10-CPC | 2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 4 | 2.4 | 1 |
| 11-CPC | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 12-CPC | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 13-CPC | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |

*Transect 9-CPC had two species including wild celery (*Vallisneria americana*) and horned pondweed (*Zannichellia palustris*); Transect CPC-10 only had wild celery (*V. americana*).
CPC – Cow Pen Creek
DHC – Dark Head Cove
$m^2$ – square meter(s)

**Table 4.**
**Plant Counts in Dark Head Cove and Cow Pen Creek, August 2020**
**(up to ten quadrats measured per transect)**

| Transect | Number of plants per quadrat ⇦ Shoreward | | | | | | | | | | Mean number of plants per $m^2$ | Number of species present [a] |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | | |
| 1-DHC | 0 | 0 | 0 | - | - | - | - | - | - | - | 0 | 0 |
| 2-DHC | 0 | 0 | 0 | - | - | - | - | - | - | - | 0 | 0 |
| 3-DHC | 0 | 0 | 0 | - | - | - | - | - | - | - | 0 | 0 |
| 4-DHC | 0 | 0 | 0 | - | - | - | - | - | - | - | 0 | 0 |
| 5-DHC | 0 | 0 | 0 | - | - | - | - | - | - | - | 0 | 0 |
| 6-DHC | 0 | 0 | 0 | - | - | - | - | - | - | - | 0 | 0 |
| 7-DHC | 0 | 0 | 0 | - | - | - | - | - | - | - | 0 | 0 |
| 8-DHC | 0 | 0 | 0 | - | - | - | - | - | - | - | 0 | 0 |
| 9-CPC | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 10-CPC | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 11-CPC | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 12-CPC | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 13-CPC | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |

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

**Table 5.**
**Plant Counts in Dark Head Cove and Cow Pen Creek, August 2021**
**(up to ten quadrats measured per transect)**

| Transect | Number of plants per quadrat ⇦ Shoreward | | | | | | | | | | Mean number of plants per $m^2$ | Number of species present* |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | | |
| 1-DHC | 0 | 0 | 0 | - | - | - | - | - | - | - | 0 | 0 |
| 2-DHC | 0 | 0 | 0 | - | - | - | - | - | - | - | 0 | 0 |
| 3-DHC | 0 | 0 | 0 | - | - | - | - | - | - | - | 0 | 0 |
| 4-DHC | 0 | 0 | 0 | - | - | - | - | - | - | - | 0 | 0 |
| 5-DHC | 0 | 0 | 0 | - | - | - | - | - | - | - | 0 | 0 |
| 6-DHC | 1 | 0 | 0 | - | - | - | - | - | - | - | 0.4 | 1 |
| 7-DHC | 0 | 0 | 0 | - | - | - | - | - | - | - | 0 | 0 |
| 8-DHC | 0 | 0 | 0 | - | - | - | - | - | - | - | 0 | 0 |
| 9-CPC | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 10-CPC | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 25 | 50 | 30.0 | 1 |
| 11-CPC | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 12-CPC | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0.4 | 1 |
| 13-CPC | 0 | 0 | 0 | 0 | 2 | 0 | 0 | 0 | 3 | 0 | 2.0 | 1 |

* Transect 6-DHC, 10-CPC, 13-CPC only had wild celery (*V. americana*); Transect 12-CPC only had curly pondweed (*Potamogeton crispis*).
CPC – Cow Pen Creek
DHC – Dark Head Cove
$m^2$ – square meter(s)

**Table 6**
**Summary of Plant Densities Observed at Fixed Transects during Diver Monitoring (2018-2022)**

| Transect | Mean number of plants (per $m^2$) | | | | |
|---|---|---|---|---|---|
| | 2018 | 2019 | 2020 | 2021 | 2022 |
| 1-DHC | 0 | 0 | 0 | 0 | 0 |
| 2-DHC | 0 | 0 | 0 | 0 | 0 |
| 3-DHC | 0 | 0 | 0 | 0 | 0.25 |
| 4-DHC | 0 | 0 | 0 | 0 | 0 |
| 5-DHC | 0 | 0 | 0 | 0 | 0 |
| 6-DHC | 0 | 0 | 0 | 0.4 | 0 |
| 7-DHC | 0 | 0 | 0 | 0 | 0 |
| 8-DHC | 1.3 | 0 | 0 | 0 | 0 |
| 9-CPC | 42.4 | 2.8 | 0 | 0 | 42 |
| 10-CPC | 14.8 | 2.4 | 0 | 30.0 | 1.2 |
| 11-CPC | 11.6 | 0 | 0 | 0 | 8.4 |
| 12-CPC | 5.2 | 0 | 0 | 0.4 | 13.2 |
| 13-CPC | 8.4 | 0 | 0 | 2.0 | 8.4 |

CPC – Cow Pen Creek
DHC – Dark Head Cove
$m^2$ – square meters

**Table 7.**
**Plant Counts in Dark Head Cove and Cow Pen Creek, August 2022**
**(up to ten quadrats measured per transect)**

| Transect | Number of plants per quadrat | | | | | | | | | | Mean number of plants per $m^2$ | Number of species present* |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | | |
| 1-DHC | 0 | 0 | 0 | - | - | - | - | - | - | - | 0 | 0 |
| 2-DHC | 0 | 0 | 0 | - | - | - | - | - | - | - | 0 | 0 |
| 3-DHC | 0 | 1 | 0 | - | - | - | - | - | - | - | 1.33 | 1 |
| 4-DHC | 0 | 0 | 0 | - | - | - | - | - | - | - | 0 | 0 |
| 5-DHC | 0 | 0 | 0 | - | - | - | - | - | - | - | 0 | 0 |
| 6-DHC | 0 | 0 | 0 | - | - | - | - | - | - | - | 0 | 0 |
| 7-DHC | 0 | 0 | 0 | - | - | - | - | - | - | - | 0 | 0 |
| 8-DHC | 0 | 0 | 0 | - | - | - | - | - | - | - | 0 | 0 |
| 9-CPC | 5 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 100 | 42.0 | 2 |
| 10-CPC | 2 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1.2 | 1 |
| 11-CPC | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 4 | 16 | 8.0 | 1 |
| 12-CPC | 0 | 1 | 1 | 4 | 1 | 0 | 0 | 6 | 0 | 20 | 13.2 | 2 |
| 13-CPC | 0 | 1 | 3 | 0 | 0 | 4 | 6 | 3 | 0 | 4 | 8.4 | 1 |

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

**Table 8.**
**Estimated Percent Cover Within Transects Surveyed in September 2022**

| Transect | Estimated Percent Cover |
|---|---|
| 1-DHC | |
| 2-DHC | |
| 2a-DHC | |
| 2b-DHC | |
| 2c-DHC | |
| 2d-DHC | |
| 3-DHC | |
| 4-DHC | |
| 5-DHC | |
| 6-DHC | |
| 7-DHC | |
| 8-DHC | |
| 8a-DHC | |
| *Average for DHC* | 17 |
| 9-CPC | |
| 9a-CPC | |
| 10-CPC | |
| 11-CPC | |
| 12-CPC | |
| 13-CPC | |
| *Average for CPC* | 22.3 |

CPC – Cow Pen Creek
DHC – Dark Head Cove

# ATTACHMENTS

# Attachment 1 – 2020 SAV Work Plan Addendum

**Lockheed Martin Corporation6801**
**Rockledge Drive MP: CCT-246**
**Bethesda, MD 20817**
**Telephone 301-548-2209**

LOCKHEED MARTIN

April 28, 2020

**VIA PRIVATE CARRIER**

Matthew Wallach
Tidal Wetlands Division
Wetlands & Waterways Program
Maryland Dept. of the Environment
1800 Washington Blvd, Suite 430
Baltimore, MD 21230

Subject: Transmittal of Expanded SAV Survey for Cow Pen Creek and Dark Head Cove
Lockheed Martin Corporation; Middle River Complex
2323 Eastern Boulevard, Middle River, Baltimore County, Maryland

Dear Mr. Wallach:

This submittal describes an expanded submerged aquatic vegetation (SAV) survey to be conducted in Dark Head Cove off the Lockheed Martin Middle River Complex. The actions described herein are an addendum to those described in the Cow Pen Creek and Dark Head Cove SAV Restoration and Monitoring Work Plan (Tetra Tech, 2017).

*Introduction*

In summer 2020, Tetra Tech will conduct a survey of the naturally occurring submerged aquatic vegetation (SAV) bed(s) along the southeastern shoreline of Dark Head Cove. The purpose of this survey is to characterize the natural conditions of SAV bed growth, including decline or other changes, to compare it to the current status of SAV that was planted during site restoration. Survival of the restored beds has been limited, but SAV throughout the Middle River area has also declined over the past several years. Surveying naturally occurring SAV will enable us to compare it to the current conditions existing in the restored areas. Survey results will also be qualitatively compared to the results of the previous baseline SAV survey conducted in 2015. The survey described in this document will help determine SAV presence and species composition in the survey area, the amount and relative density of the SAV bed(s) and habitat; and, will provide spatially-relevant information about survey-area resources. Because SAV beds can gradually shift in both location and density over time, obtaining current survey data is necessary to evaluate the natural conditions compared to the restored beds in Dark Head Cove and Cow Pen Creek.

*Approach*

SAV samples, collected via boat operated by Tetra Tech staff, will be collected to evaluate the density and species composition of the bed(s). Sampling locations will be pre-programmed into a global positioning system (GPS) unit (Trimble or equivalent). Samples will be collected along the southern shore of Dark Head Cove out to the 10-foot bathymetric contour interval. SAV generally does not grow at depths greater than two meters in the Chesapeake Bay region (Batiuk et al., 2000), so sampling beyond this depth is not warranted. Sampling locations will be spaced at five-meter intervals in each direction, in the area shown on Figure 1.

The primary modification to the survey methods used previously (in 2015) will be that the survey area will not include the area on the northern shoreline of Dark Head Cove or areas within Cow Pen Creek where SAV has successfully been restored. This area was originally surveyed in 2015 to establish baseline conditions of SAV bed distribution prior to restoration; however, it is not necessary to survey in 2020, the primary purpose being to establish conditions *outside* the restored area. For the restored areas, a diver survey will be used in 2020 to evaluate the SAV in the restored areas of Cow Pen Creek and Dark Head Cove.

**Lockheed Martin Corporation6801**
**Rockledge Drive MP: CCT-246**
**Bethesda, MD 20817**
**Telephone 301-548-2209**

*Field methodology*

Field scientists (including an SAV taxonomic expert) will access the sampling locations with naturally occurring SAV via a shallow draft boat. The team will start the survey at one corner of the survey area and will move on top of the collection site to collect the samples. The collection sites will be pre-selected before mobilization, and global positioning system (GPS) coordinates of these sampled naturally occurring SAV sites will be recorded for future reference. Two (2) metal leaf rakes bolted back-to-back, with handles removed and attached to a rope, will be used from the boat to collect SAV (see Figure 2). The rake will be thrown into the water, dragged across the creek bottom, and brought to the surface. This will be repeated twice, for a total of three throws. Vegetation, when present, will be taken on board where it will be identified to the species level using Bergstrom et al. (2006) and other manuals for identification. The density of the vegetation will also be noted. Density estimates, as well as species composition, will be recorded in a field data notebook, and subsequently transcribed to a spreadsheet. SAV density measurements will be based on a modified Braun-Blanquet scale (Braun-Blanquet, 1932) using density values ranging from 0 (no plants present) to 4 (representing a 70-100% cover), as shown on Figure 3. All values will be recorded in a field notebook and transcribed to a spreadsheet upon return to the office. Water depth measurements will also be collected at each naturally occurring SAV sampling location.

The density values will be incorporated into an ArcGIS kriging program; this software will analyze the data and generate a map that represents the spatial extent and relative density of the SAV beds. Figure 4 is the ArcGIS map produced for the 2015 baseline survey as an example. In addition, the species data obtained during the survey will be used to determine the observed species frequency of occurrence. These results, including all maps produced by ArcGIS software and the summary data used to produce the maps, will be provided for review via a technical memorandum and be included in the 2020 annual monitoring report.

If you have any comments, we respectfully request to receive them by May 22, 2020.

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

Sincerely,

Thomas D. Blackman
Project Lead, Environmental Remediation

cc: via email (without enclosure)
Gary Schold, MDE
Mark Mank, MDE
Cheryl Kerr, MDE
Christine Kline, Lockheed Martin
Norman Varney, Lockheed Martin
Michael Martin, Tetra Tech
Cannon Silver, CDM Smith

cc: (via Secure Information Exchange)
Jann Richardson, Lockheed Martin
Scott Heinlein, LMCPI
Christopher Keller, LMCPI
Glen Harriel, LMCPI

cc: (via mail with enclosure)
Brian Dietz, MDE
Becky Golden, DNR
Greg Golden, DNR
Kristy Beard, NOAA
Tom Green, LMCPI

# REFERENCES

*Literature cited*

Batiuk, R.A., P.W. Bergstrom, W.M. Kemp, E.W. Koch, L. Murray, J.C. Stevenson, R. Bartleson, V. Carter, N.B. Rybicki, J.M. Landwehr, C. Gallegos, L. Karrh, M. Naylor, D.J. Wilcox, K.A. Moore, S. Ailstock, and M. Teichberg. 2000. Chesapeake Bay submerged aquatic vegetation water quality and habitat-based requirements and restoration targets: A second technical synthesis, 130. Edgewater, MD: Chespeake Research Consortium.

Bergstrom, P.W., R.F. Murphy, M. Naylor, R.C. Davis, and J.T. Reel. 2006. Underwater grasses in Chesapeake Bay & Mid-Atlantic coastal waters: Guide to identifying submerged aquatic vegetation, 80. College Park, MD: Maryland Sea Grant College.

Braun-Blanquet, J. 1932. Plant Sociology (Transl. G. D. Fuller and H. S. Conrad), 539. New York: McGraw-Hill.

Tetra Tech. 2017. *Cow Pen Creek and Dark Head Cove SAV Restoration and Monitoring Work Plan, Lockheed Martin Middle River Complex*. Lockheed Martin Middle River Complex, Middle River, Maryland. December.

# FIGURES


*Figure 1: SAV survey area denoted by green hashed area*

*Figure 2. Modified rake used for conducting SAV surveys.*

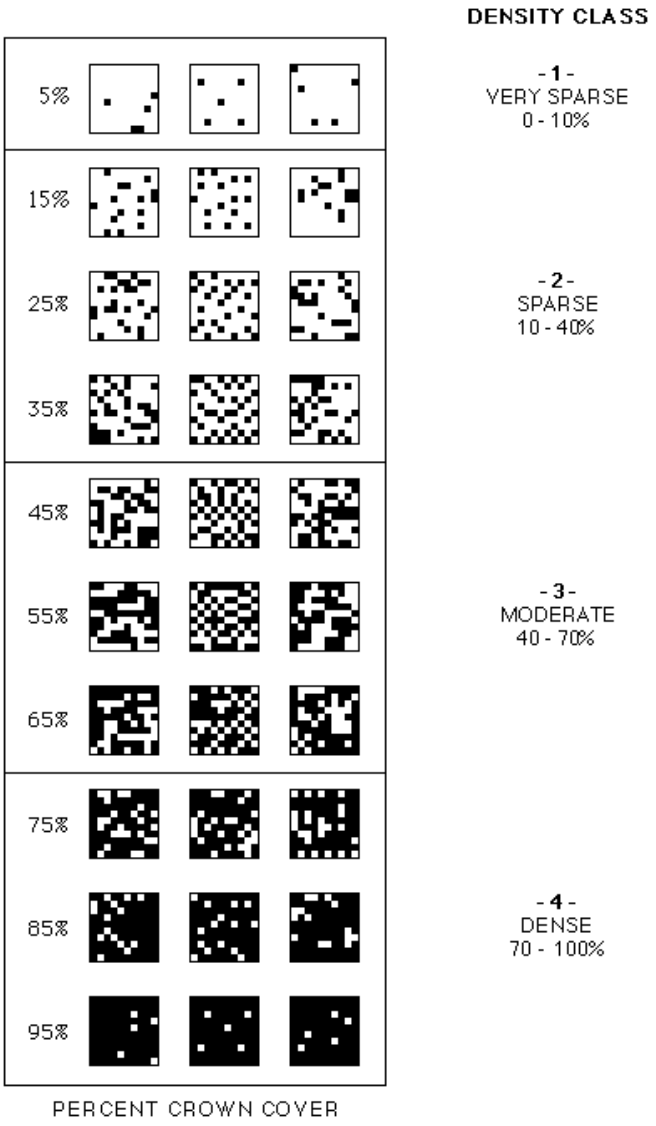



*Figure 3. Scale used to measure the density of SAV rake survey grabs. The scale is based on a modified Braun-Blanquet (1932) scale with values ranging from 0 (no plants present) to 4 (70-100% cover).*

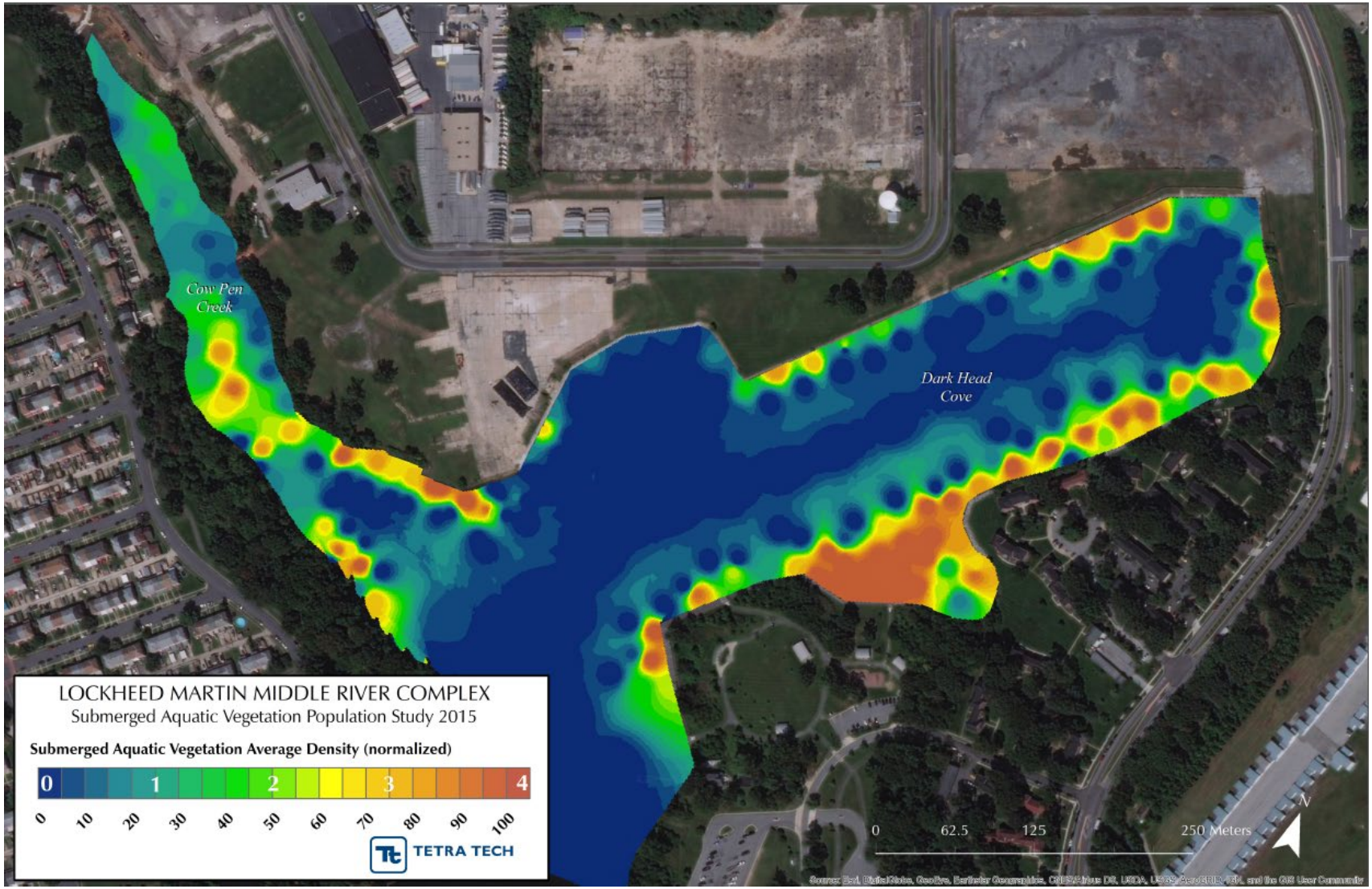



*Figure 4. Map of SAV density developed from 2015 baseline survey data.*