West Virginia
Mussel Survey Protocol

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Middle Island Creek mussels including federally endangered Snuffbox. Photo by Janet L. Clayton

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1.0 Introduction

The State owns all wildlife in West Virginia (§ 20-2-3), and may, by regulation, classify species into categories necessary for the purposes of control and protection (§ 20-1-7 (4)), and may prescribe the locality, manner and method by which various species of wildlife may be taken (§ 20-1-7 (5), § 20-2-5(26), § 20-2-27). All mussels are protected in the State of West Virginia pursuant to West Virginia §20-2-4 and CSR 58-60-5.15. In addition, federally listed threatened and endangered freshwater mussel species (FLS) are known to occur in the State. These species are protected by the Endangered Species Act (87 Stat. 884, as amended; 16 U.S.C. 1531 et seq.). Impacts to state and federally protected mussels and their habitats should be avoided or minimized to the maximum extent practicable.

To assist in ensuring compliance with state code, all streams that contain mussels must be reviewed and when applicable, surveyed prior to any proposed in-stream disturbance. The West Virginia Division of Natural Resources maintains and makes available a current mussel stream list via shapefile or kmz file on the West Virginia Division of Natural Resources' (WVDNR) website.

The protocols herein are designed to guide mussel surveyors in the proper procedures to document the presence or probable absence of mussel species and to provide standardized guidance on acceptable survey methods for different types of commonly encountered projects. This Protocol is not intended to guide research projects but to aid in the planning of surveys used to conduct environmental review regarding instream impacts. The current protocol and supporting materials are maintained on the WVDNR website mussel page.

The WVDNR also offers guidance and recommendations on stream and river related projects in a separate document titled "Mussel Stream Guidance" found on the WVDNR website. Topics include: justification and analysis of alternatives, alternative construction methods, horizontal directional drilling, alternative locations, and water withdrawals.

2.0 Stream Groups in WV

For ease of determining the appropriate survey type where state and federally protected mussels may occur, West Virginia mussel streams have been placed into four groups. An NHD shapefile of mussel streams is posted on the website and will assist in determining stream reaches requiring surveys. A kmz version is also provided on the website. Using the NHD mussel stream shapefile, locate the point of the anticipated stream impact. If it falls on a highlighted stream, mussel issues must be addressed. The metadata associated with the file also indicates to which group the stream reach belongs. This stream layer is applicable to direct effect areas only. If the impact area is upstream of a highlighted Group 2 stream reach the applicant may be required to address indirect effects with the US Fish and Wildlife Service (USFWS) (such as improved sediment and erosion control).

Group 1: High Quality Streams: which are state listed mussel streams, FLS not expected.
Group 2: Small to mid-sized streams with FLS expected.

- Group 2.5: These are typically small streams that join either a Group 2 or Group 4 stream which may potentially contain FLS, and thus, the lower ½ mile of the stream is considered Group 2.

Group 3: Large rivers where FLS are not expected. These include the Ohio River upstream (US) of Hannibal Locks and Dam and the Monongahela River.

Group 4: Large rivers where FLS are expected. These include the Ohio River downstream (DS) of Hannibal Locks and Dam, Little Kanawha River (slack-water section adjoining the Ohio River), and the Kanawha River downstream of Kanawha Falls.

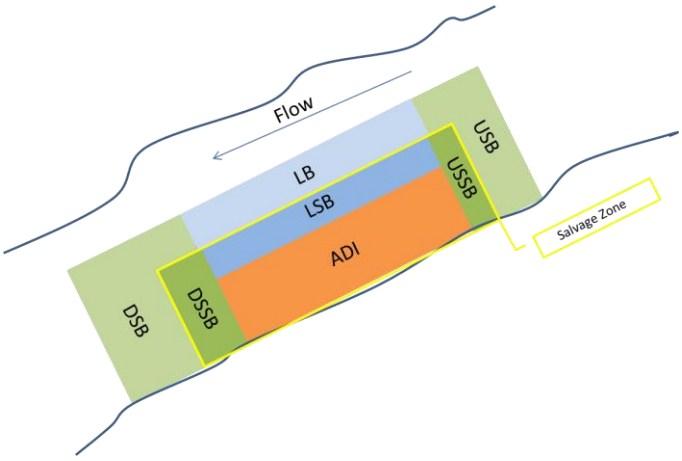
3.0 Surveyor Qualifications

To obtain a scientific collecting permit surveyors are required to be on the list of approved surveyors maintained by the WVDNR. Approval is a two part process. Once approved, the surveyor must meet specific standards to maintain certification. These criteria are established for those conducting surveys for environmental review purposes.

- WV mussel identification testing is required
  - Approved for FLS streams (Groups 2 and 4): overall score of 85% and score of 100% on the FLS species.
  - Mussel streams without FLS species (Groups 1 and 3): overall score of 85%.
  - The test is closed book and closed shell (simulating live condition).
- Must possess adequate experience and submit references.
  - Endangered species streams (Groups 2 and 4): at least three full field seasons (May-Oct) experience conducting surveys similar to the WV Mussel Survey Protocol. The surveyor must have conducted at least ten Group 2 surveys and ten Group 4 surveys. Alternatively three (Group 2/4) surveys within the previous five years), and submit two acceptable letters of reference.
  - Mussel streams without FLS species (Groups 1 and 3): at least one full field season (May-Oct) experience conducting surveys similar to the WV Mussel Survey Protocol, completed at least ten Group 1 and ten Group 3 surveys within the previous five years, and submit two acceptable letters of reference.
  - Within resume provide description of what tasks were personally undertaken for each project such as survey design, survey grid lay out, supervised staff components, surveyor, etc.
- To maintain certification the surveyor must:
  - Provide documentation that the surveyor is maintaining familiarity with WV's federally listed species through training or fieldwork. Minimum requirements based on a running two-year average: must handle five individuals (five each of males and females if applicable) of each species per year in the field; or 0.5 hours per species in a museum or with a reference collection. Specimens can be from outside WV.
  - Provide training hours, date, and location of reference collection with approximate number of each federally listed species, by sex, handled each year.
    - If a reference collection is not at a recognized museum such as Ohio State University, Carnegie, etc., approval from the WVDNR is required.
  - Provide approximate number of each federally listed species, by sex, handled each year in the field.
  - Provide a yearly tally of number of surveys conducted by Stream Group. These may include surveys in other states and placed into equivalent Stream Group.
  - Continuing education reporting (spreadsheet available on website) is due February 15 for the previous calendar year's efforts.

4.0 Establishing Areal Extent of the Project – Project Specific Guidance

Five distinct survey areas are to be defined for each project. These include the area of direct impact (ADI), upstream buffer (USB) with the salvage portion separated out (USSB), lateral buffer (LB) with the salvage portion separated out (LSB), and downstream buffer (DSB) with the salvage portion separated out (DSSB). In addition, if spudding (see Section 6.12) is to be conducted and the spudding area is not included in the other areas the spudding area should be designated. Table 3 (Section 12) summarizes the specific layout of buffer zones and survey areas organized by Stream Group and potential project type. Where a project does not span the width of the stream, the survey widths of the USB and the DSB shall be equal to the width of the ADI and include any associated LB applied to the ADI (example at right).



Special considerations are discussed in more detail below.

4.1 Commercial Sand and Gravel Dredging

Because of the potential for significant long-term adverse effects to wildlife resources, applications for Commercial Sand and Gravel Dredging will be handled on a case-by-case basis.

4.2 Maintenance Dredging

- Instream disposal of dredge material is not covered within project specific guidance and will require additional coordination with the WVDNR and with the USFWS for Group 4 streams.
- If less than five years have elapsed since the last dredging of the specific site, no additional surveys shall be required. If more than five years have elapsed or the previously dredged area is being expanded or moved, mussel surveys shall be required.
- Spudding areas must also be addressed. See Spudding, Section 6.12 (Example 1).
- Maintenance activities covered under NWP 3 may require an additional survey and may be subject to pre-construction notification (NWP General Condition 32).
- Group 4 dredging projects in general will have buffer distances based on the area of dredging that is to occur; however, confounding factors including but not limited to: dredge depth, side-casting, sediment contamination, change in use, and changes to hydrology may cause larger buffer levels to be applied. Early coordination with the WVDNR and USFWS is recommended.

4.3 Barge Loading Facilities (Non-Dredging Activities)

- If the activity is at an existing facility and includes installation of mooring cells, tri-ties, etc. within the current footprint of the facility, only the ADI and surrounding buffers must be surveyed using cells. For Group 4 streams, qualitative timed searches for species richness curve development are to be conducted around the cells. Transect surveys may be more appropriate for installation of three or more mooring cells (Examples 2-4).
- For Group 4 streams, if the proposed activity is a new facility or expansion of an active facility downstream, the survey extent shall include at a minimum 500m DSB and 150m USB of the ADI. The LB will be project specific. The survey shall include sufficient area so structures and barge activities can be placed within the area least likely to impact mussel communities or potential habitat. If the proposed activity includes an active facility and the expansion is upstream the survey extent shall include a 150m buffer surrounding the ADI. Transects should be placed to bisect mooring locations if known (see section 6.13 for definition of active facility).
- Spudding areas must also be addressed. See Spudding, Section 6.12 (Example 1).
- For Group 3 streams, if the proposed activity is a new facility or the expansion of an active facility downstream, the survey extent shall include at a minimum 150m DSB and 50m USB and 50m LB around the ADI. The survey shall include sufficient area so structures and barge activities can be placed within the area least likely to impact mussel communities or potential habitat. If the proposed activity includes an active facility and the expansion is upstream the survey extent shall include a 50m buffer surrounding the ADI. Transects should be placed to bisect mooring locations if known (see section 7.1.14 for definition of active facility). If the proposed activity is a new facility, the WVDNR must review the mussel survey results prior to the approval of mussel salvage.
- Variances in buffer distance due to the proximity of another active facility's ADI will be addressed on a case-by-case basis.

4.4 Large Scoping Projects (new barge loading facilities, determining alignment for bridges, or determining location for any instream construction such as intakes and discharges, when large-scale data can be used to help develop final project designs, and/or more detailed site-specific surveys)

- Transect spacing shall not exceed 100m in Group 3 and 4 streams. In Group 1 and 2 streams transect spacing shall not exceed 25m on average. The transects should be placed in the best available habitat but maintain an average 25m spacing. Such transect layouts are not designed to find FLS but to document mussel concentrations to aid in project design. Once the project design is drafted, a Phase 1 and potentially a Phase 2 survey would be required. This type of survey assists in the first step which is to avoid impacts.
- Transects should be placed throughout all potential alternative areas plus buffer zones.

4.5 Bridge Projects

- Hydraulic changes occur with causeway construction and shall be considered part of the ADI. If a causeway is deemed necessary, temporary bridges incorporated into the causeway design is preferred when practical.
- The ADI shall include any area that may be impacted by bridge construction, demolition, causeway, staging areas, etc. Any area that may be physically and hydraulically impacted shall be included in the survey extent.
- For new bridges, or complete removal and replacement of existing bridges, initial surveys should include areas that can be used for alternative construction sites.

4.6 Waterline/Pipeline and other Corridor Disturbances

- Discharge Outfalls, including those with diffusers, shall include the mixing zone (MZ) and appropriate buffer as described.
- If the pipe is not trenched (example: suspended on pillars), a 5m buffer is acceptable on the DS extent of the ADI. Depending on discharge composition of the outfall, relocation of mussels from the MZ may be required. State water quality standards are not necessarily protective of freshwater mussels; therefore, a review of the literature should be undertaken to determine this. For example, the state water quality standard for chloride is 230mg/L yet the level shown to affect freshwater mussels can be as low as 72mg/L. The MZ for the purposes of the mussel survey and/or relocation would include any area where the effluent concentration could be above the level that could affect mussels, which could be larger than the permitted MZ.
- Outflows with large potential volumes in relation to the receiving surface water may require the associated hydrologic changes caused by the outflow to be included in the ADI.

4.7 Shoreline Structures (example riprap, etc.)

- If the near-bank ADI is anticipated to be more impacted than further out, two survey cells should be appropriately sized to fit the areas. For example, an undulating shoreline will be riprapped. The keyway will definitely impact the first 3m but may or may not impact out to 10m. It is better to conduct a 3m wide cell and a 7m wide cell. If it is all covered in one cell, and mussels are found only in the outer portion of the cell, it could affect management decisions and require salvage when none is needed.
- If work is not from top of bank spudding must be addressed. See Spudding, Section 6.12.

4.8 Lake/Stream Drawdowns

This section pertains to the drop in water levels below normal levels not due to natural droughts. Examples include dropping of impoundment water levels below normal winter pool levels or causing stream drought conditions due to water withdrawals. In the case of planned activities such as dropping lake levels intentionally, impacts to mussel populations should be avoided through planning and coordination ahead of time and conducting salvage operations as warranted. Mussel stranding is to be avoided and various methods can be used to avoid and minimize impacts and will be addressed on a case-by-case basis. The second priority, after avoidance, should be to salvage mussels

prior to impact. Additional coordination may be necessary for emergency action, or drawdown outside the mussel survey period.

4.9 Non-Commercial Docks

Group 3 and 4 streams do not require a mussel survey for non-commercial docks if all the following criteria are met:

- Do not extend riverward more than 10m (33ft) from low water mark (water's edge).
- Do not contain any fill material other than pilings or posts, and any shoreline protection material such as riprap is placed only above the low water mark.
- Contain four or fewer pilings or posts that impact an area less than a combined total of $1m^2$.
- Are less than 10m (32.8ft) in length.

If the proposed dock is within 500m (1640ft) of an island, site specific clearance from USFWS must be obtained. All Group 4 Non-Commercial Docks must obtain concurrence from the USFWS.

5.0 Survey Application Requirements and Timelines

Even though standardized protocols are established for most types of projects, a scope of work must be provided to the WVDNR when applying for a scientific collecting permit (Section 5.1). This is to ensure that the appropriate level of effort is being applied for the given stream type and construction activity and to allow time for agency staff to review existing data from the proposed survey area and work with the applicant to design the appropriate survey extent as described below. State agencies shall be given at least 30 days to review survey results prior to the anticipated start of any construction activity. Contact information is provided in Table 1, Section 12.0. Attempts to request variances from established protocols have led to increased review times for all projects. These protocols have been developed to address most project types and thus variances should not be requested unless the project type is not included in the Protocol or extenuating circumstances exist. The scope of work should be submitted as it is believed the project should be surveyed and shall include a full description of the in-channel portion of the project. Once it has been assigned to a reviewer, it will either be accepted or revisions requested.

Non-FLS streams (Groups 1 and 3) require coordination with the WVDNR only. Activities to be conducted on streams with FLS (Groups 2 and 4) may require written concurrence from the USFWS prior to conducting any project activities including surveys, relocations, and/or construction activities. Surveyors are responsible for understanding their own responsibilities regarding compliance with applicable federal laws, including the Endangered Species Act. If the WVDNR is aware of potential regulatory issues not addressed in project documentation, it will advise applicants to review federal regulations and law as appropriate.
If a survey is not completed in the permitted year the WVDNR must be notified as such. Also, the full scope of work must be resubmitted during the calendar year of the rescheduled survey as it is a new permit year.

5.1 Survey Scope Checklist

The following criteria must be included in the Scope of Work

- Full description of the project including the work to be done. The survey is being conducted to provide aid in environmental review. If the company name, purpose of the project, etc. are not included an appropriate review cannot be conducted.
- Map showing project location sufficient to delineate all pertinent impact and buffer areas on recognizable landscape features (approximately 1:24,000).
- Survey methodology.
- Figure showing survey design overlaid on project diagram.
  - Show all areas as appropriate (ADI, salvage zone, USB, LB, DSB, MZ and spud areas). These areas are described in further detail in Section 6.1.
- Lead malacologist and collectors must be listed on the Protocol Form. The approved surveyor must be on site to ID mussels and qualifications of the collectors (including divers) must be provided along with a QA/QC plan.
- Protocol Form.

Clearance Surveys

6.0 Conducting the Survey

Definitions

6.1 **Survey Areas** include area of direct impact (ADI), upstream buffer (USB), upstream salvage buffer (USSB), downstream buffer (DSB), downstream salvage buffer (DSSB), lateral buffer (LB), and lateral salvage buffer (LSSB). The salvage zone (SZ) includes the ADI, USSB, LSB, and DSSB. The spud area includes any area in which the work barge may be spudded during the project (Section 6.12). Mixing zone (MZ) as defined by the level known to affect mussels must be addressed for all discharge type projects (example survey area in section 4.0).

6.2 **Timed Search** (qualitative) surveys consist of visually searching throughout a larger defined area (such as DSB, DSSB, ADI, LB, LSB, USB, USSB or mussel concentration) for a given period of time. Data must be provided separately for each of the areas listed above.

Timed searches can be applied to each Stream Group as follows:

- Group 1: No need to divide into cells, although it may be considered with respect to potential mussel salvage. Cover the whole ADI or buffer area within a time period defined by the size of the area to be surveyed (timed searches within each survey area) at a rate of 0.2 min/m^2 in areas of heterogeneous substrate, then an additional 0.3 min/m^2 if mussels are found (equaling 0.5 min/m^2). The areas may be divided into smaller units (cells – no size limit) if the area can be stratified by habitat. For example, the DSB has a large area that appears to be of poor habitat and mussels are not expected. Delineate the area and survey at rate of 0.2 min/m^2. The other sub area has higher potential for mussels and indeed a few were found. This area would then be required to be surveyed for an additional 0.3 min/m^2 (Example 5).

- Group 2: Timed searches are not required if using cells as each cell is its own timed search. If the stream width is greater than 20m and transects are used, timed searches are to be used to complete the species richness curve.
- Group 3: Conduct timed searches to delineate mussel concentrations as needed.
- Group 4: Conduct timed searches between transects with suitable habitat (if no mussels are found along the transect), and in mussel concentrations to increase the accuracy of the survey and to develop a species richness curve (Section 6.6).

6.3 **Cells** are more appropriate for surveying small to mid-sized Group 2 streams and are required on Group 2 streams 20m wide or less. Cells are encouraged for all surveys except in Group 3 and 4 streams that have extensive ADI and buffer areas. In these large areas the mussel concentrations are best delineated using transects. A cell survey is conducted by dividing each survey area into a series of cells in which each cell is surveyed, and data are recorded separately. Minimum search effort shall be 0.2 min/m^2. If any mussels are found, an additional 0.3 min/m^2 is required. If triggers are met the minimum search effort required is 1min/m^2. Cells are required for salvage unless using moving transects (Section 6.10). Cell size and effort for salvage are described in Section 10.

Use of cells further defined by Group:

- Group 1: Not required though may be used if needed to better apply search effort in areas with mussels and suitable habitat, no maximum size defined. Cells < 25m^2 or moving transects are required for salvage.
- Group 2: All streams <20m wide, preferred in all Group 2 streams. However, if surveying with transects (>20m wide), once a trigger is established, all triggered areas plus a 10m buffer surrounding the triggered area are to be surveyed using cells. Maximum cell size is 25m^2.
- Group 3 and 4: Small impact areas (e.g., boat ramp, mooring cell, tri-tie, water intake (near shore), or bridge pier). Maximum cell size 100m^2.

6.4 **Transect Surveys** are conducted by placing lines perpendicular to flow and subdivided into segments as noted below for each stream group. A transect survey must contain at least 500m of transect search area and consist of a minimum of five transects, three of which must be placed within the ADI. Along each transect, surveyors shall visually search (Section 6.8) an area 1m wide for mussels and record all data separately for each segment. The entire segment must be thoroughly covered and the minimum search effort for transects shall be 1min/m^2 in heterogeneous substrates. The maximum transect segment length is provided below, however this should be adjusted to a lesser length if a shorter distance better defines the impacts to freshwater mussels.

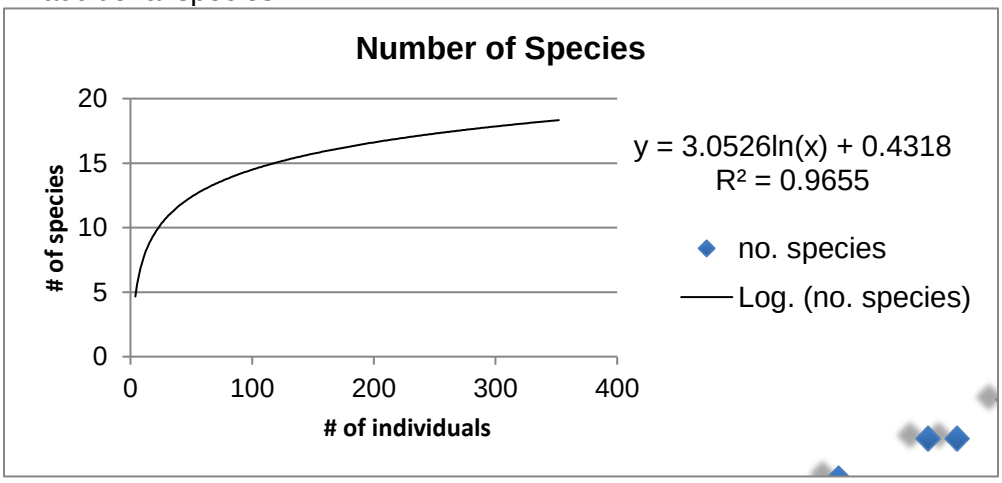
- Group 1: Transects (5m segments) may be used on large (>50m wide) Group 1 streams to delineate areas which require additional survey effort. Maximum 10m transect spacing.
- Group 2: Transects (5m segments) may be used for Group 2 streams (>20m wide) if it appears the reach may be stratified by habitat and some strata appear to have limited mussel resources. Transects could be used to delineate the habitats and mussel resources that require further survey effort by cells. If surveying with transects, if a trigger is established, all triggered

areas plus a 10m buffer surrounding the triggered area are to be surveyed using cells (see also 6.2).

- Group 3: Transects (maximum 10m segments) may be used for large impact areas such as proposed maintenance dredging.
- Group 4: Transects may be used for large impact areas such as proposed maintenance dredging. If using transects, a Phase 1 survey within a Group 4 stream must include qualitative timed search surveys for development of a species richness curve. Maximum transect spacing is 10m within the ADI, salvage zone (SZ), and buffers 100m downstream and 50m upstream of the ADI. The maximum transect spacing within additional lateral buffers shall be 20m and additional upstream and downstream buffers shall be 25m.

6.5 **Salvage Zone** is defined as the area within the ADI containing mussels connected by similar habitat plus associated buffer areas described in Table 3 from which mussels must be relocated prior to conducting instream activities.

6.6 **Species Richness Curve** shall be developed for Group 2 and 4 streams. It should demonstrate that an adequate number of animals have been surveyed to ensure that most species have been detected. Data from samples within mussel concentration areas should be used to develop the curve. Data collected from Group 2 cells do not need supplemented with timed searches. Data from Group 2 and 4 transects will need to be supplemented with timed searches conducted within the mussel concentration area (10min increments) until no new species are found in six consecutive samples. For example, if in bag six a new species is recorded another six samples are required assuming no new species was found during the samples. The Species Richness Curve is generated by plotting cumulative number of individuals (X axis) versus cumulative number of species (Y axis). Sufficient data should be collected to reach the plateau on this chart. For curve development, use data from all survey types with each transect segment being a sample, each cell being a sample, and each qualitative search effort of ten minutes a sample. Samples can be randomized to increase statistic power. A chart depicting the curve and associated logarithmic regression line shall be provided in the report. The number of individuals required to be collected for recovery of an additional species shall be calculated using the regression model. In the example below, a total 352 individuals were collected of 19 species. Using the regression formula, it would require 611 individuals to find one additional species.



6.7 Mussel Concentrations and Potential FLS areas (Groups 2 and 4): For determining the potential for FLS, the mussel concentration area is defined as an area encompassing all triggered areas connected by similar habitat plus a 10m buffer surrounding it. Not detecting an FLS during a Phase 1 survey does not confirm that it is not present. The presence of a diverse mussel concentration indicates FLS potential. The mussel concentration area may encompass multiple areas only if they are separated by more than 20m of dissimilar or unsuitable habitat, otherwise the entire area should be surveyed. Trigger criteria are as follows:

- Group 2: Two individual mussels within 5m of transect, otherwise two species not in Table 2 (Section 12) and/or density of 0.5/m^2 (all species combined).
- Group 4: Three species not in Table 2 along any one transect or combination of transects equal to 100m or within 100m^2 of cells, or within a timed search survey between transects and/or density of 0.5/m^2 (all species combined) within any area of the survey.

If a mussel concentration exceeds the trigger criteria FLS have a higher probability of occurrence. These areas should be avoided to the maximum extent practicable. If the area cannot be avoided a Phase 2 survey must be undertaken as described below. The species listed in Table 2 are not used in describing a mussel concentration with FLS potential due to their general habitat preferences are not typically associated with the current FLS found within West Virginia.

6.8 Visual or Surface Searches: A visual search includes moving cobble and woody debris; hand sweeping away silt, sand, and/or small detritus; and disturbing/probing the upper 5cm (2in) of substrate to better view the mussels which may be there. A minimum effort of 1.0 min/m^2 shall be expended in areas of heterogeneous substrate and 0.5 min/m^2 in areas of homogeneous substrate for transect surveys, 0.2 min/m^2 for cells without mussels, and 0.5 min/m^2 for cells with mussels. The minimum effort for timed searches in Group 1 streams is 0.2 min/m^2 for areas/cells without mussels and 0.5 min/m^2 for areas/cells with mussels. Waterscopes are typically not a good method for conducting the above searches as the substrate is to be disturbed and probed for mussels not visible at the substrate surface. Waterscopes should not be used in water depths over 40cm deep (16in).

6.9 Habitat: Appropriate information describing depth and habitat, based on the modified Wentworth scale, shall be recorded by cell or transect segment. Additional descriptions, such as depositional areas, detritus, scoured areas, etc., may be used for further clarification. Minimum search effort is based on the type of habitat present. A mixture of substrates such as sand and cobble are defined as heterogeneous. If there are rocks (>4in) present that require flipping and moving to look under and around them, this is heterogeneous substrate. Homogenous substrates are those that can be easily surveyed by running fingers through the substrate such as silt, loose sand and fine gravel, or uninhabitable (nonfunctional) substrate such as bedrock, large boulders, or debris.

6.10 Moving Transect is a method used for Group 1 surveys or mussel salvage whereby a defined segment along the transect is cleared, and the line is then moved to define a new area for clearing. For example, 1m along an established transect line is searched and mussels salvaged. Successive passes are to be made through the segment per salvage criteria (Section 10.0). Once the area is

cleared, the transect is moved to the adjoining area, and the new areas are cleared sequentially. The process is repeated until the entire salvage area is cleared of mussels. Number of mussels and effort per pass (by segment) are to be recorded.

Moving transects are the preferred method for conducting salvage efforts. The transect segments provide smaller search units ($5m^2$ or $10m^2$ rather than $25m^2$ or $100m^2$), thereby reducing the potential that the full cell needs to be salvaged at a greater effort when it may be only a small portion of that cell that needs the extra effort. Moving transects are more efficient and cost effective because it allows the surveyor to focus efforts in areas where mussels are found. See Example 10.

6.11 **Mussel Processing:** In each segment or cell, mussels observed (live and dead) are to be bagged and brought to the surface for further processing and positive identification. Mussel nomenclature shall follow that of the common and scientific names document posted to the Freshwater Mollusk Conservation Society (FMCS) website (molluskconservation.org). A list of WV mussels with current names will be maintained on the WVDNR website. Mussels shall be kept in water at all times, except for the brief period when they are measured or photographed (no longer than five minutes). Each mussel should have its location recorded (ie. Unique cell or transect segment).

All FLS are to be hand-placed into the substrate. For Group 3 and 4 streams, non-FLS mussels may be dropped from a boat into the delineated area from May 1 to September 1. In areas of high velocity such as the upper Kanawha River, Group 1 and 2 streams, or any work conducted after September 1 or prior May 1, mussels are to be hand-placed into the substrate.

6.12 **Spudding:** Work barges are typically held in place by spuds which are pipes or poles that can be driven into the river bottom to provide stability. Spuds vary in size. Project designs should include the associated impact expected by spudding if it is to occur outside of the ADI. Project impact minimization procedures can include reducing the number of times the work barges need to be moved during the operation. The project description should include size and number of spuds that will be used and the expected number of movements. The project diagram should depict the spud area if outside the ADI and data should be provided for this area separately. (Example 1)

https://en.wikipedia.org/wiki/File:New_Orleans_USACE_Flexifloat_DSC_0157.JPG

6.13 An **Active Facility** is a facility which has actively used structures (mooring cells, tri-ties, permanently spudded platform, etc.) within the wetted stream over the previous 5-year period. A facility

which consists only of land-based structures is not considered an active facility with regards to this protocol. Also not considered active are those facilities that have operated in the past by grounding barges nearshore which have not undergone environmental review since implementation of the WV Mussel Survey Protocol.

6.14 Ohio River Permitting Requirements: Any work within the Ohio River that is below normal pool elevation requires use of the WV Mussel Survey Protocol. If work is along the State of Ohio shoreline, it is recommended that the State of Ohio also be contacted to ensure compliance.

7.0 Survey Conditions, Constraints, and Data Required

7.1 Data Longevity:

Survey data collected at a specific site will be considered valid for five years from the date the survey was conducted. If mussel relocations are conducted, they should be done within the same field season as the expected instream activities. If the proposed instream activities are to be conducted before July 15, relocations may be conducted within the previous field season. After July 15, additional relocation efforts will be required just prior to construction activities depending on the results of earlier survey/relocation efforts (Section 7.6). If the area to be dredged increases in size and/or a new area is to be dredged additional surveys will be required.

7.2 Mussel Survey Period:

The survey period shall be from May 1 to October 1. Requests to conduct surveys outside of this time period will generally not be approved. The scope of work should be submitted to the appropriate agencies by September 1 for surveys that will be completed in the current calendar year. Any survey work approved outside this period will be done only under extenuating circumstances, with separate approval obtained from the appropriate state and federal agencies prior to conducting the work and may require a modified protocol.

7.3 Visibility Requirements:

Qualitative surface surveys must have a minimum visibility of one-half meter (50cm, or approximately 20in), with or without lights, at depth of survey. If suitable visibility is not present at the intended time of the survey, the survey must be re-scheduled, or a modified protocol must be employed in consultation with the appropriate state and federal agencies (e.g., more extensive quantitative surveys with excavations may be required). Turbidity meter measurements are not to be used as a substitution for visibility depth in centimeters. Secchi depth for Groups 3 and 4 surveys should also be included with reports.

7.4 Workable Stream Flow Requirements:

Surveys should be conducted under low to moderate flows to ensure safety of the surveyors and quality of the survey. If the area cannot be effectively surveyed under existing flow conditions the survey must be re-scheduled. Any variance must be approved by the appropriate state and federal agencies.

7.5 Minimum Data to be Recorded:

Standard WVDNR datasheets can be found on the WVDNR website mussel page. All datasheets are to be completed in their entirety and shall be incorporated as appendices in the final project report. Data shall be compiled and summarized separately at a minimum for all areas (Section 6.1), if applicable. A separate datasheet is required for qualitative search (es) within the potential relocation area(s). At a minimum, coordinates, in decimal degrees, shall be provided for the US and DS extent of the USB, ADI, DSB, and any relocation sites. A photographic voucher of all native species must be provided. Any questionable individuals should also be more extensively photo vouchered to provide a better reference for verification. The final report shall include a map of the surveyed area along with the proposed project activities, and a copy of the valid collecting permit. Note: stating "see attached report" on the data sheet is not acceptable.

7.6 Mussel Collection Efficiency:

Variability in the life histories of mussel species has yielded on average a 50% detection efficiency during the best survey efforts. Therefor, salvage efforts expire yearly. Salvage is used to mitigate impacts to mussels but does not eliminate impacts.

8.0 Extent of Areas to be Surveyed

8.1 **Minimum coverage** shall include the area of direct impact (ADI) and appropriate buffers, including any alternative locations. See also Spudding, Section 6.12. Table 3 summarizes buffer requirements by stream group and activity type. If the project may affect the local hydraulics of the stream, such as hydropower projects or installation of in-stream structures, the survey effort shall encompass the area that may be affected. Hydraulic modeling may be required to determine the extent of hydraulic changes. If modeling is not conducted prior to surveying, additional downstream surveys may be warranted.

8.2 The **mixing zone (MZ)** of an outfall shall be included within the survey area as shall the appropriate buffers around the mixing zone as described in Table 3. According to the WV Department of Environmental Protection (WVDEP) (https://dep.wv.gov/WWE/permit/individual/Documents/370_Mzguide.pdf), an outfall should not discharge within five river widths of certain areas, including sensitive areas, FLS, or tributary mouths. If they do, the initial downstream boundary estimations for the mixing zone should be at a distance preventing overlap. If not, the initial downstream boundary estimations should be a distance of five river widths. Some mussels, including endangered species, are more sensitive than the species used to develop WV water quality criteria, and in these cases the mixing zones should be developed based on review of the best available literature. The buffer zone should extend at least an additional 100m downstream of the mixing zone. Hydraulic and mixing zone model data shall be included with the proposed scope of work to define the survey area on Group 2 and 4 streams.

9 Stream Group Specific Guidance

9.1 **Group 1** are those small to mid-sized streams not suspected of containing FLS and timed search surveys are acceptable. These streams require coordination with only the WVDNR. If avoidance of instream impacts is not possible, a mussel survey and subsequent relocation is required. At a minimum, data are to be provided for each survey area separately. Each of the areas shall be searched for a minimum effort of 0.2 min/m^2. A minimum search effort of 0.5 min/m^2 shall be conducted in areas with mussels. If mussels are observed, the salvage zones shall be delineated as described in Table 3. Salvage shall be conducted as per Section 8.0. Group 1 streams require coordination with the WVDNR only unless an FLS is found, at which time all work shall cease and the WVDNR must be contacted immediately. All mussels are to be returned to the area from which they were collected.

9.2 **Group 2** are those small to mid-sized streams with FLS expected and require coordination with the WVDNR and appropriate federal agencies.

Phase 1 Survey: The objective is to determine if a mussel concentration is present and to delineate the area which could potentially contain FLS so that impacts to mussel concentrations can be avoided and minimized. Data are to be compiled separately for all areas (Section 6.1). Streams 20m wide or less must be surveyed using cells not to exceed 25m^2 in size. Each cell with heterogeneous habitat will be searched for 0.2 min/m^2 or 5 min/25m^2 cell. All cells in which any mussels are found are to be searched for an additional 0.3 min/m^2 (7.5 min/25 m^2 cell) minimum. Data (mussels, effort, and habitat) are to be recorded by cell position. For streams greater than 20m wide, the preferred survey method is cells; however, transects may be used to delineate mussel concentrations or areas that potentially support FLS. Transects, as defined, shall be surveyed 1m in width, spaced no more than 10m apart, and placed perpendicular to stream flow. Search effort shall be 1min/m^2 in heterogeneous substrates. Data (mussels, effort, and habitat) are to be recorded by 5m segment along the transect. When transects are used timed searches will need to be conducted (see 6.2).

If the triggers are met within any portion of the delineated area, that area should be avoided (direct and indirect impacts) during construction and operation of the project. If the area cannot be avoided a Phase 2 survey may be required.

If any of the following trigger criteria are met a Phase 2 survey is required:

- Mussel density of 0.5/m^2 (all species included) found within a cell.
- Two mussels of any species found within a 5m transect segment.
- Presence of at least two species not listed in Table 2 found within a cell.

Phase 2 Survey: The objective is to collect sufficient data to minimize impacts to mussel beds by adding additional effort to higher quality areas. If triggers are met using transects then the area shall be broken into cells not to exceed 25m^2. The search effort for each cell within the mussel concentration area shall be a minimum of 1min/m^2 in heterogeneous substrates. The initial search effort can be used to meet the 1min/m^2 level of effort. The mussel concentration area is defined as an area encompassing all triggered areas connected by similar habitat plus a 10m buffer surrounding it. The boundary of the Phase 2 area shall not exceed the Phase 1 area.

9.3 **Group 3** are large rivers where FLS are not expected. These include the Ohio River US of Hannibal Locks and Dam and the Monongahela River. Group 3 mussel streams

The objective of the survey is to determine if mussels are present, delineate the area of mussel concentration, and facilitate mussel salvage and relocation if advised by the state resource agency. The survey design shall consist of transects, 1m in width, placed perpendicular to stream flow or cells not to exceed $100m^2$ in size. Maximum transect spacing depends on project type (Table 3) but shall not exceed 25m unless a scoping project. If transect spacing is greater than 10m and no mussels are observed in two adjacent transects, with at least one of the transects containing apparent suitable mussel habitat, a timed search for a minimum of 10 minutes shall occur between the two transects in the area of suitable mussel habitat. If any live and/or fresh dead mussels are found between the two transects during the search, an additional transect shall be placed there and a search conducted as previously described. Cells may also be used and shall not exceed $100m^2$ in size. Data shall be compiled for each survey area separately and recorded by transect segment or by cell position. Cells are encouraged in those areas without an extensive ADI and buffer area. Cells allow better transition for moving into the salvage phase. In larger areas, such as maintenance dredging, long linear projects, or scoping projects, the targeted mussel areas are best delineated using transects. Delineate the distribution of mussels and/or suitable habitat using data obtained during sampling of cells or transects.

9.4 **Group 4** are large rivers where FLS are expected. These include the Ohio River DS of Hannibal Locks and Dam, Little Kanawha River (slack-water section adjoining the Ohio River), and the Kanawha River.

Phase 1 Survey: The objective is to determine if a mussel concentration is present and to delineate the area which could potentially contain FLS so that impacts to mussel concentrations can be avoided and minimized. The survey design shall consist of transects, 1m in width, placed perpendicular to stream flow or cells not to exceed $100m^2$ in size. Maximum transect spacing depends on project type (Table 3) but shall not exceed 25m unless a scoping project. If transect spacing is greater than 10m and no mussels are observed in two adjacent transects, with at least one of the transects containing apparent suitable mussel habitat, a timed search for a minimum of 10 minutes shall occur between the two transects in the area of suitable mussel habitat. If any live and/or fresh dead mussels are found between the two transects during the search, an additional transect shall be placed there and a search conducted as previously described. Data shall be compiled for each survey area separately and recorded by transect segment or by cell position. Additional timed search surveys shall be conducted within areas of mussel concentrations for species richness curve development (Section 6.6).

If the triggers are met within any portion of the delineated area, that area should be avoided (direct and indirect impacts) during construction and operation of the project. If the area cannot be avoided a Phase 2 survey may be required.

Survey results that trigger avoidance or a Phase 2 survey are:

- Mussel density of 0.5/m^2 (all species included) in any area of the survey
- Presence of at least three species not listed in Table 2 along any one transect (at least 100m in length) or a combination of adjacent transects (at least 100m combined length) or within a qualitative survey conducted between transects.

Phase 2 Survey: The objective is to collect sufficient data to minimize impacts to mussel beds by adding additional effort to higher quality areas. If transect spacing is greater than 10m, a Phase 2 survey shall consist of additional transects placed between the original surveyed transects within the mussel concentration area. The mussel concentration area is defined as an area encompassing all triggered areas connected by similar habitat plus a 10m buffer surrounding it. In other words, an additional transect shall be placed downstream of the most downstream transect that met the above criteria and upstream of the most upstream transect that met the above criteria. If the distance to the next transect upstream and downstream is greater than 10m, the additional transects shall be placed 10m upstream and downstream. The boundary of the Phase 2 area shall not exceed the Phase 1 area. Transect spacing of 10m or use of cells does not require a Phase 2 survey.

10.0 Conducting a Salvage and Relocation

All native mussels are protected within the state of WV (§20-2-4 and CSR 58-60-5.15) and if avoidance options have been exhausted, mussels must be relocated from the area of direct impact and appropriate buffer areas (salvage zone) as described in Table 3. No mussels are to be moved without prior authorization from appropriate state and federal authorities. On streams with potential FLS (Groups 2 and 4), coordination with the WVDNR must occur prior to any relocation efforts. Same day relocation approval should not be expected. Surveyors are responsible for understanding their own responsibilities under the Endangered Species Act. Because relocation of federally listed mussels constitutes “take”[1] under the Endangered Species Act, the WVDNR expects official consultation with the USFWS will occur where relocation of any federally listed mussels is proposed. *The WVDNR will not permit relocation of federally listed species without USFWS concurrence.*

10.1 For Group 1 and 3 streams, approval to relocate is granted by WVDNR solely. Depending on the type and extent of the project and potential for significant mussel resources to occur, some projects may receive approval to salvage mussels at the time of the initial survey. In some cases additional coordination with the State is conducted to determine if salvage is the best option.

10.2 For Group 2 and 4 streams, relocations shall not be conducted until survey results have been reviewed and approved by the WVDNR and written concurrence provided by the USFWS.

10.3 The salvage effort shall consist of disturbing and digging into the substrate 10 to 15cm (4 to 6in) if possible, moving large rocks, fanning, and systematically covering the salvage zone.

[1] *From Section 3(18) of the Federal Endangered Species Act: "The term 'take' means to harass, harm, pursue, hunt, shoot, wound, kill, trap, capture, or collect, or to attempt to engage in any such conduct."*

10.4 The salvage effort shall be systematically conducted by a "moving transect" or establishing cells not to exceed 100m^2 for Groups 3 and 4, and not exceed 25m^2 for Groups 1 and 2. For Groups 3 and 4, if the cell width exceeds 5m, salvage shall include the use of a moving guideline (transect) to aid in navigation through the cell.

10.4.1 Moving transects placed parallel to flow are the preferred method for salvage (see Section 6.10). Moving transects are the most efficient and cost-effective means by which to conduct salvage. This method also allows the surveyor to focus efforts in areas where mussels are present (see Example 9).

10.5 For Groups 1 and 3 where salvage is conducted concurrently with the survey, cells in which no mussels were found during the initial survey, and which are surrounded by cells in which no mussels were found during the initial survey, do not need to be further salvaged. Cells in which no mussels were found during the initial survey, but were adjacent to cells with mussels must have a salvage pass with a minimum effort of 1min/m^2. Additional passes maybe required (see Section 10.6).

10.6 When developing a salvage plan for Groups 2 and 4, areas found to be without mussels during the initial survey do not need to have a salvage effort conducted if the salvage is conducted within the same field season. Similar to defining mussel concentration areas (Section 6.7), the adjusted salvage area is defined as an area encompassing all observed mussels from the initial survey connected by similar habitat plus a 10m buffer surrounding it. The adjusted salvage area will not exceed the ADI plus a 10 meter salvage buffer. This adjusted salvage area is required to have a minimum salvage effort conducted. For example, Transects 5 – 10 had no mussels. Mussels were found on Transects 11 and above. Transect spacing was 10m. The area between Transect 10 and Transect 11 would need to be salvaged. If mussels are found in that outer 10m area, then the area would be expanded an additional 10m not to exceed the salvage area (see Example 10).

10.7 For all stream groups the minimum first pass salvage effort for heterogeneous substrates which require salvage shall be 1min/m^2. The minimum first pass salvage effort for homogeneous substrates is 0.5min/m^2. Minimum effort for subsequent passes in homogeneous substrates is half those defined below for heterogeneous substrates.

10.7.1 If no mussels are observed after a 1min/m^2 effort, that cell or segment salvage is complete.

10.7.2 If mussels (1-2 in 100m^2, or 1 in 1-25m^2) are found during the 1st pass, the minimum second pass effort shall be 1min/m^2.

10.7.2.●.1 Salvage is complete unless the number of mussels salvaged during the second pass is equal to or greater than the first pass. In this case, an additional pass is required at a minimum effort of 1min/m^2.

10.7.3 If mussels (3-29 in 100m^2, or 2 mussels to 0.3/m^2 in $\leq$25m^2) are found during the 1st pass, the minimum second pass effort shall be 2.5min/m^2.

10.7.4 If mussels ($\geq$0.3/m^2) are found during the 1st pass, the minimum second pass effort shall be 5min/m^2.

10.7.5 Third and additional passes at 1min/m^2 shall be conducted until no more than 5 percent of the original number collected is observed. Original number is defined as the number of mussels found in the 1st and 2nd pass combined.

- For Group 2 and 4 streams for which take authorization has been obtained, additional passes at 1min/m^2 shall be conducted until no FLS are found.

10.8 Salvage efforts shall meet the same standards as surveys (i.e., visibility requirements ($\geq$50cm), workable streamflow conditions, and mussel survey period).

10.9 Relocation sites shall be upstream (preferred) to an area of equal or better habitat which should include similar mussel diversity and densities, or to an approved

relocation site in a discrete area recommended by the WVDNR. For Group 1 streams, a 15min qualitative survey of the relocation site shall be conducted at a minimum. For all other stream groups, one hour of qualitative searches (six 10min searches) to delineate an area with similar species and equal or better density than the collection area shall be conducted. The relocation area is to be equal or larger in size to the collection area. All observations of resident mussels are to be reported including site coordinates (to be entered on the Protocol Form) in decimal degrees and mussels to be reported on a separate WVDNR datasheet. Effort noted above are the minimums. Be sure to conduct adequate effort to locate a good relocation area. Relocation site data shall be provided to the USFWS and WVDNR prior to salvage of Group 2 or 4 streams.

10.10 WVDNR or USFWS personnel will randomly conduct quality assurance checks on relocations. Failure to conduct an adequate salvage effort or to select an appropriate relocation area could result in revocation of approved surveyor status.

10.11 Monitoring of common species is rarely required. Monitoring of relocated FLS and areas of FLS habitat that were affected by project construction may be required.

10.12 For Group 3 and 4 streams, non-FLS mussels may be dropped from a boat into the delineated area May 1 to September 1. In areas of high velocity such as the upper Kanawha River, Group 1 and 2 streams, or any stream after September 1 or prior to May 1, mussels shall be hand-placed into the substrate. All FLS are to be hand-placed into the substrate from the area in which they were collected unless otherwise authorized.

10.13 If any FLS are found during relocation efforts for projects in any Stream Group where no FLS were found during previous survey efforts, and no incidental take authorization from the USFWS has been received, relocation efforts must cease and the WVDNR immediately contacted (see Table 1). If contact cannot be made by close of business of the day in question, all mussels, FLS and common species, are to be returned to the area from which they were collected. If some mussels have already been relocated, the surveyor will be directed how to proceed upon contact with the agencies.

10.14 Relocations should be conducted within the same year as the start of instream construction. If instream activities have not commenced prior to July 15 of the next year, additional relocation efforts will be required just prior to construction activities depending on the results of earlier salvage efforts.

10.15 **Group 2 & 4 Relocation Approval Checklist:** The information listed below are expected to be provided prior to relocation approval; this list was produced to standardize the relocation approval process when no federally listed species were found. This information often can be supplied in either a preliminary report or in a detailed email.

- Brief description of the Phase 1 / Phase 2 surveys, including a general overview of the habitat (any problems encountered etc.)
- Were any federally listed species or shells found?
- List of all animals found, denoting species and numbers within the salvage zone.
- Total effort for Phase 1 and Phase 2
- Coordinates of proposed relocation area with, search effort, and number of animals found with a brief habitat description of the relocation area.

11.0 Reporting Requirements and Deadlines

All data as per the scientific collecting permit are due by November 15, or 45 days post survey if an extension was granted. At a minimum, the WVDNR datasheets and an updated Protocol Form are to be submitted within this timeframe. If the project report is not available at that time, the surveyor must notify the permitting agency of the delay and establish a submittal deadline. If the survey was not conducted, the permittee must notify the permitting agency by November 15, though earlier is preferred.

Report Checklist: Below is a checklist of deliverables to be included in a mussel survey report. If supplying reports addressing multiple sites, please place all materials for each site together so each can be easily reviewed in its entirety. Incomplete data will delay project reviews and project concurrence will not be provided until complete data are provided. See Examples 6 to 8 for assistance in planning your data tables. This is not the required format, but data must be included. All text and tables should have font size such that they are legible (without a magnifying lens) when documents are printed. Scans of handwritten field sheets must also be legible. Excel spreadsheets are acceptable and preferred if data collection is extensive.

- Description of the project including any justification, alternative(s), minimization efforts, etc. included in the scope.
- Map showing project location sufficient to delineate all pertinent impact and buffer areas on recognizable landscape features (approximately 1:24,000).
- Survey methodology.
- Figure showing survey design overlaid on project diagram.
    - Show all areas as appropriate (ADI, USB, LB, DSB,SZ, MZ, and spud areas). These areas are described in further detail in Section 6.1
- Summary Data Table(s):
    - Number of each species by area (Section 6.1) by survey type.
    - Total salvaged (ADI plus salvage buffers) by species by method.

- If salvage was not completed, provide estimated number by species for ADI and salvage buffers required to be salvaged if project moves forward.
    - Mussel data by cell or transect segment (full data table or spreadsheet required). If extensive data, provide figure to summarize.
- Survey effort by cell or transect segment (full data table or spreadsheet required).
- Habitat data by cell or transect segment (full data table or spreadsheet required).
    - If extensive data, provide figure to summarize.
- Mussel data by pass for each salvaged segment or cell.
- Salvage effort by cell or transect and by pass (full data table or spreadsheet required).
- Group 2 and 4 – Species Richness Curve with calculations and calculate number of mussels needed to collect an additional species (see Section 6.6).
- Protocol Form (updated with actual survey information) for project and relocation area(s).
- Results of qualitative survey at relocation site.
    - Provide data on effort, number of each species found, and habitat.
- Photo vouchers of each species observed and photos of odd or questionably identified species.
- WVDNR Datasheets or electronic database submission (see WVDNR.gov/Mussels)

- Current Stream Weather Conditions (Required fields: Temperature in Celsius and Visibility in centimeters). Turbidity meter readings are NOT an acceptable alternative.
    - Form for survey area. If multiple days may include range and only submit one form.
    - Form for relocation area if site is greater than 300m from survey area.
- Mussel Survey Datasheet by species (summarize by area (6.1) with total for each species). Each survey methodology used requires a separate Summary Data Sheet.
- Mussel Survey Datasheet by species for relocation area

- Copy of state scientific collecting permit
- If consultation with the USFWS has occurred, a copy of the technical assistance letter or concurrence letter (USFWS concurrence required for FLS salvage)

Provide all required data. The management decision makers should be able to re-create all analyses conducted from the data provided.

Tables and Examples:

12.0 Tables

Table 1. Contact information for state and federal agencies.

West Virginia Division of Natural Resources Scientific Collecting Permits PO Box 67 Elkins, WV 26241 304-637-0245 DNRScientificCollectingPermit@wv.gov	U.S. Fish and Wildlife Service West Virginia Field Office - Ecological Services 6263 Appalachian Hwy Davis, WV 26260 304-866-3858 FW5_WVFO@fws.gov
West Virginia Division of Natural Resources Mussel Program Leader PO Box 67 Elkins, WV 26241 304-637-0245 kevin.m.eliason@wv.gov	https://wvdnr.gov/plants-animals/freshwater-mussels/ All required forms, current stream layers, current protocol, approved surveyors list, etc. can be found on the WVDNR website mussel page.

Table 2. Species that can be excluded in defining a diverse mussel concentration by stream group.

Species	Groups 1&2	Groups 3&4
Lampsilis siliquoidea	X	X
Lasmigona complanata		X
Leptodea fragilis		X
Obliquaria reflexa		X
Potamilus ohiensis		X
Potamilus alatus		X
Pyganodon grandis	X	X
Strophitus undulatus	X	X
Utterbackia imbecillis	X	X
Utterbackiana suborbiculata		X

Table 3. Summary of buffer requirements and maximum transect spacing for various types of stream disturbances. Units are in meters. Survey extent shall include all buffers and the area of direct impact (ADI). After demonstrating need and receiving approval, mussels may be relocated from area described (salvage zone).

	US Buffer	**DS Buffer**	**L Buffer**	**Salvage Zone (SZ) (ADI + Buffer Below)**		**Maximum Transect Spacing**
				US & L	DS	
Group 4	Phase 2 Surveys may be required if trigger met during Phase 1					
Dredging (Maintenance) or New Loading Facility ***Dredging Area*** <1000 m^2 1000 m^2 < 5000 m^2 >5000 m^2	 50 100 150	 150 250 500	 50 100 PS	10	10	ADI 10 0-50m USB 10, >50m USB 25 0-100m DSB 10 >100m DSB 25
Loading Facility (non-dredging activities: within active facility)	25	25	25	5	10	cells or 10
Scoping Projects		Project Specific				100
Bridge Projects	50	100	BB	5	10	10
Waterline/Pipeline Corridor Disturbances	50	100	BB	5	10	10
Water Intakes (at shoreline)	10	10	10	5	10	Cells
Shoreline Protection	10	10	10	5	10	Cells
Projecting Dike Structures	10	20	10	5	10	Cells
Outfalls	10	MZ+100	10	PS		PS
Group 4 and 3: Loading Facility (expanding US or DS, see Section 5.3 for required buffers)						
Group 3	Relocation at time of survey if pre-authorized					
Dredging (Maintenance)	50	150	50	10		10 SZ, 20 LB, 25 DSB and USB
Active Loading Facility (non-dredging activity)	25	25	25	5	10	cells or 10
Loading Facility (new or non-active)	50	150	50	10		10 SZ, 20 LB, 25 DSB and USB
Scoping Projects		Project Specific				100
Bridge Projects	10	25	BB[b]	5	10	cells
Waterline/Pipeline Corridor Disturbances	10	25	BB	5	10	cells
Water Intakes (at shoreline)	10	10	10	5	10	cells
Shoreline Protection	10	10	10	5	10	cells
Projecting Dike Structures	10	20	10	5	10	cells
Outfalls	10	MZ + 20	10	PS		cells
Group 2	Phase 2 surveys required if trigger met during Phase 1					
Scoping Projects		Project Specific				Average 25
Bridge Projects	50	100	BB	5	10	10
Waterline/Pipeline Corridor Disturbances	50	100	BB	5	10	10
Water Intakes at shoreline	10	10	10	5	10	cells
Shoreline Protection	10	10	10	5	10	cells
Outfalls	10	MZ + 20	10	PS		10
Group 1	Relocation at time of survey if pre-approved					
All Projects	10	25	10 or BB	5	10	TS

[b] pier only, 10m LB
TS Qualitative Timed Search
L Lateral
PS Project Specific
MZ Mixing Zone
DS Downstream
BB Bank to Bank
US Upstream
cells: not applicable, cells required

13.0 References:

Williams, J.D., A.E. Bogan, R.S Butler, K.S. Cummings, J.T. Garner, J. L. Harris, N.A. Johnson and G.T. Watters. 2017. A revised list of the freshwater mussel (Mollusca: Bivalvia: Unionida) of the United States and Canada. Freshwater Mollusk Biology and Conservation 20:33-58.

14.0 Acknowledgements

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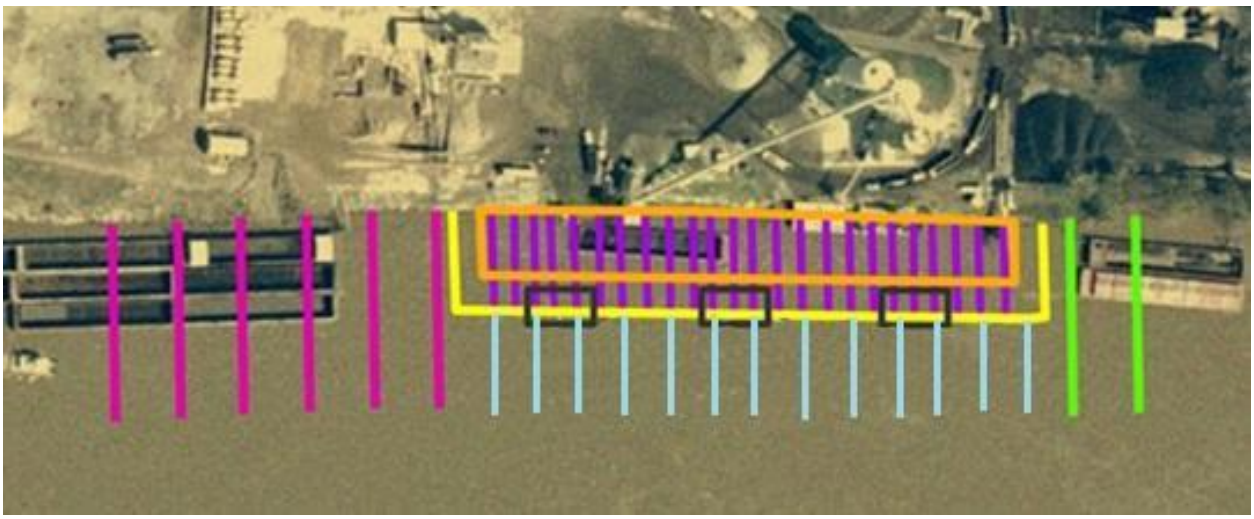
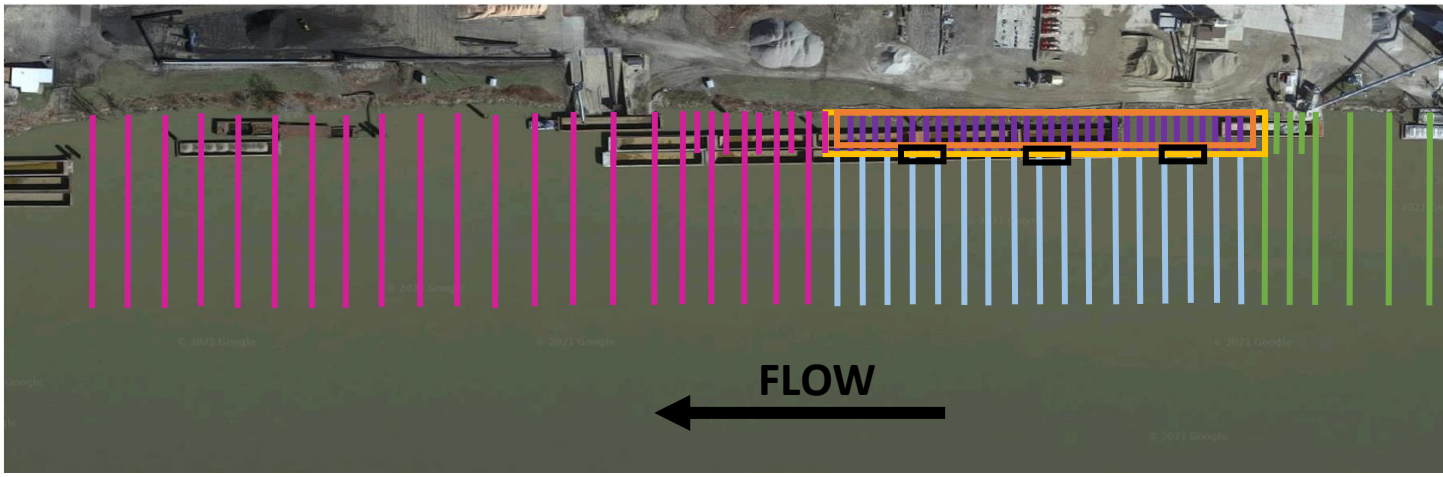
15. Examples

Example 1: Group 3 (top photo) and Group 4 (bottom photo) maintenance dredging of a 20m by 200m area is proposed (orange rectangle=ADI). Within the ADI and the salvage buffer (the ADI and a 10m salvage buffer around it, yellow outlined area) 1m wide transects are required at 10m spacing (purple lines). The mussels, effort and habitat data shall be provided by the ADI segments and the salvage buffer segments. Outside of the salvage zone, transects are spaced at 25m intervals. The USB of 50m includes two 70m transects (green). The remaining lateral buffer (minus the 10m salvage buffer) consists of 10 transects, 40m in length (blue) spaced at 20m intervals. The DSB (magenta) consists of six 70m transects at 25m intervals. If spudding is to occur outside the ADI, those areas should be indicated and data provided for each spud area (black rectangles). Group 4: LB transect length is 170m, ADI + SZ buffer transect lengths are alternated from 100m DSB through the ADI and proceed till 50m USB.





Example 2: If a new mooring cell or tri-tie (orange circle) is being placed within an active facility, the area may be best surveyed using cells to cover the 25m x 25m buffer surrounding the

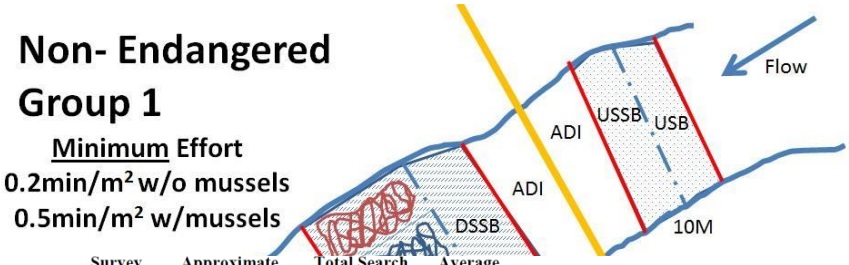
mooring cell. The mussels, effort, and habitat shall be recorded by cell for each of the areas being sure to delineate between the salvage zone and the additional buffer surrounding it. Green is USB, yellow is salvage buffer, blue is LB, and magenta is DSB. If the stream is Group 4, at least six 10min qualitative searches must be conducted around the cells (squiggly lines).

Example 3: If multiple moorings are to be installed within an active facility one can see that this scenario quickly becomes an underwater nightmare if using cells, thus transects may be more appropriate for Group 4 streams in which the mooring cells are in close proximity to each other and salvage is not being undertaken simultaneously.

Example 4: Therefore if 3 or more moorings are to be installed, within close proximity to each other, the area may be best surveyed using transects. Be sure to place a transect through each proposed mooring location. Remember that at least 500m of transects must be surveyed and transect spacing is 10m. In this scenario, twelve, 45m transects are being surveyed.

Example 5: Group 1 survey must record data separately for at least the 5 major areas. It may benefit the surveyor to stratify the areas based on habitat and the likelihood of finding mussels

in each area as shown here in the DSB. Mussels, effort and habitat by sub-area are then recorded.



Example 6: shows an acceptable data table for Phase 1 results. Note the buffer survey areas were broken into areas to be salvaged and those not. These abbreviations have been standardized in Section 6.1.

Cell #	Survey Area	Approximate Cell Size (m²)	Total Search Effort (min)	Average Depth	Dominant / SubDominant Substrate Types (%)
1	USB	50	15	2'	Sand / LWD
2	USB	50	15	7'	Sand (60) / Silt (40)
3	USB	50	15	10'	Cobble (70) / Silt (30)
4	USB SZ	50	15	2'	Sand / LWD
5	USB SZ	50	30	7'	Sand (60) / Silt (40)
6	USB SZ	25	20	9'	Cobble (70) / Silt (30)
7	USB	25	10	12'	Cobble (70) / Silt (30)
8	ADI	100	60	2'	Sand / LWD
9	ADI	100	60	6'	Sand / LWD
10	LB SZ	50	30	9'	Cobble (60) / Gravel (40)
11	LB	50	20	13'	Cobble (60) / Gravel (40)
12	DSB SZ	100	30	2'	Sand / LWD
13	DSB SZ	100	60	8'	Sand (40) / Cobble (40) / Silt (20)
14	DSB SZ	50	30	12'	Cobble (40) / Gravel (30) / Sand (30)
15	DSB	50	25	14'	Cobble (60) / Sand (20) / Gravel (20)

Example 7: provides further detail on mussels collected during salvage efforts. Data are supplied by cell by pass. The only thing missing is the effort used during each pass.

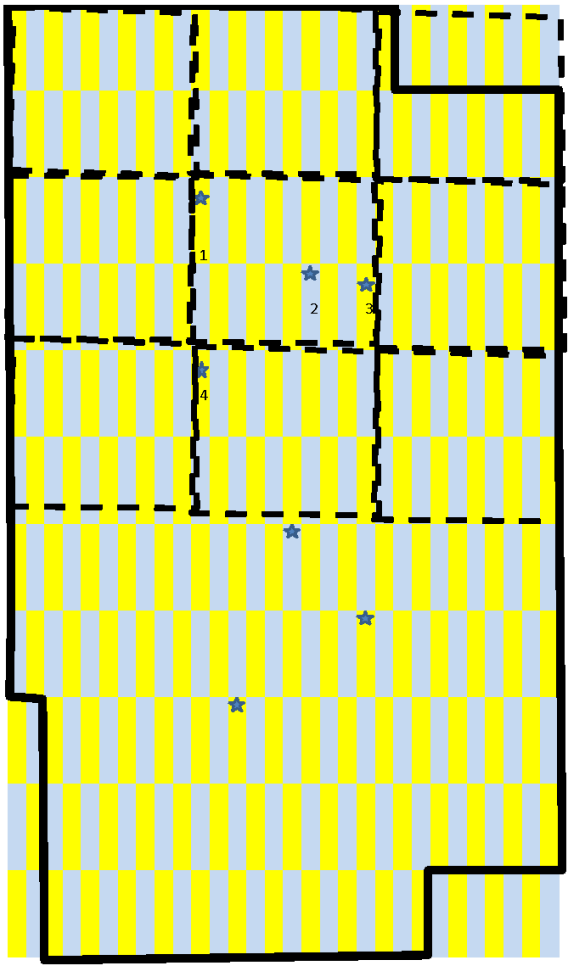
Cell #	Pass #	Species	# Collected	Abundance by Pass
1	1	*L. cardium*	2	.
1	1	*L. siliquoidea*	2	.
1	1	*L. complanata*	1	.
1	1	*L. costata*	3	.
1	1	*L. fragilis*	2	.
1	1	*P. alatus*	5	.
1	1	*P. grandis*	3	.
1	1	*S. undulatus*	2	.
1	1	*T. verrucosa*	1	21
1	2	*L. siliquoidea*	1	.
1	2	*L. fragilis*	1	.
1	2	*P. alatus*	2	.
1	2	*P. grandis*	1	5
1	3	*T. verrucosa*	1	1
2	1	*L. cardium*	5	.
2	1	*L. costata*	4	.

Example 8: provides a summary table of species collected by area. The only thing missing is a total by species column. Supply table for each method used and then a summary for all methods.

Species	ADI	LB	LB SZ	DSB	DSB SZ	USB	USB SZ
L. siliquoidea	2	0	1	0	1	0	0
P. alatus	0	0	1	2	3	0	2
TOTAL	**2**	**0**	**2**	**2**	**4**	**0**	**2**

Example 9: Moving transects are the preferred method for conducting salvages. Rather than conducting cell searches, a transect is cleared, moved, cleared, moved, and cleared until 10m past the last mussel has been cleared. In low density populations the smaller the transect segment the more cost effective the search. In the example below the yellow and grey areas are 5m segments. The thick black outline depicts the area needing salvaged based on the mussels observed (blue stars) during the initial survey. Assuming no other mussels are found, all areas within the thick black line need one salvage pass at a minimum effort of 1min/m^2. The entire cell containing segment numbers 1, 2, and 3 would need a second pass of 2.5min/m^2. If it was

salvaged via moving transect, only those segments (1, 2, and 3) within the cell would need to have 2 passes conducted at a minimum rate of 1min/m^2 for each pass. Salvage does not need to extend beyond the perimeter of the full salvage zone even if mussels were found within 10m of the edge.



Example 10: The figure below represents 10m spaced transects within a salvage area (blue and red 10m segment lines). The large black outlined area (without hash fill) surrounds the actual area that needs to be salvaged based on the survey results of where mussels were located. This area surrounds all mussels (blue stars) with similar or better habitat between and a 10m area surrounding them. Two mussels (red stars) were found during salvage cell searches on the outer edge; thus, requiring the establishment of four additional cells to be searched outside of the earlier defined salvage area but still within the full salvage area. If no mussels are found within these four new cells, salvage is complete. If additional mussels are found, additional salvage of cells surrounding those positive cells is required until 10m beyond the last mussel is established or the edge of the full salvage zone is reached.