Attachment L-17

Sediment Transport Estimation Method

ENSR
1601 Prospect Parkway, Fort Collins, CO 80525-9769
T **970.493.8878** F **970.493.0213** www.ensr.aecom.com

Memorandum

Date: May 6, 2008

To: Gabrielle Borin, Jessica Rubado

From: Jim Burrell

Subject: Sediment transport distances at selected NiSource pipeline crossing locations; re: potential impacts to mussel species

Distribution:

The attached table indicates estimated sediment deposition distances at selected wet open-cut watercourse crossings for the NiSource pipeline project (ENSR Project 01776-034). The following summary is a brief discussion of the estimation approach, site selection, and the interpretation of results. Further documentation is planned.

A. Estimation Approach. Guidance from the management team indicated that a rapid approach to estimating sediment yield, transport, and deposition for wet open-cut pipeline crossings was required. Since the potential existed for applying the technique to many (e.g., 50 or more) project locations on an accelerated schedule, the approach needed to be relatively simple and formulated on available data and GIS applications. On that basis, a simplified procedure was developed to formulate and quantify the three processes of 1) suspended sediment supply to a stream from site disturbance, 2) instream transport and dispersion of the sediment by representative size fractions, and 3) sediment deposition on the streambed. From this, the likely zones of impacts to mussel species can be further approximated. A general chart of the sediment approximation approach is depicted in the attached figure.

1) Sediment Supply. Sediment supply from bank excavations was estimated by applying the Universal Soil Loss Equation (USLE) to soils information retrieved from the NRCS STATSGO database for the crossing locations. Soil associations on the floodplains were characterized by their grain-size distributions (cobble and gravel, sand, silt and clay) and erodibility factors. A typical working excavation site geometry of 75 feet long by 75 feet wide was used for each streambank. Appropriate Best Management Practices (BMPs) to control erosion and sediment yield were assumed to be successfully employed outside this working area. Sediment that could be eroded or tracked into the flow was generated in the USLE application by a rainfall factor representing a one-year storm event. This is smaller than a mean annual thunderstorm. Due to the proximity of the bank excavation to the streams, one hundred percent sediment yield was employed.

Average sediment supply from instream trenching was calculated by an empirical equation developed for the Interstate Natural Gas Association of America (INGAA) and the Gas Research Institute (GRI) (Golder Associates 1998). The equation was adapted to site conditions on the basis of testing and comparison to other published equations (Reid, et. al. 2004). Equations from both references were reasonably correlated to sets of field measurements at wet open-cut pipeline crossings. Streambed sediment characteristics for input were determined from available data at U.S. Geological Survey (USGS) locations for similar settings within the crossing regions.

2) Instream Transport. Transport of suspended sediment was determined by stream hydraulic factors determined from field measurements at USGS stream gages. Each of the selected watercourse crossing locations is reasonably close to a USGS gage where measurements of flow

ENSR
1601 Prospect Parkway, Fort Collins, CO 80525-9769
T **970.493.8878** F **970.493.0213** www.ensr.aecom.com

rates, velocities, and flow geometries have been recorded by the agency. Rectangular cross sections were assumed, and were reasonably supported by geometric data. Average cross-sectional velocities were used.

Dispersion of the fine suspended particles (silts and clays) in the flow was determined using longitudinal (“X”) and lateral (“Y”) dispersion coefficients and related equations presented in a number of USGS open-channel hydraulics publications. Distances for complete vertical (“Z”) mixing of suspended silts and clays were determined to be well within the upstream portion of the dispersion fields.

3) Deposition. Sediment deposition downstream of the open-cut crossings was determined by calculating the fall velocities of representative grain diameters for the various sediment size classes (cobbles and gravels, sands, silts and clays) at each selected crossing location. Recent research (Wu and Wang, 2004) developed a well-correlated fall velocity approach for a range of sediment diameters. It is presented as being in line with, but more broadly applicable than, results from previous investigators. This was used for representative grain diameters greater than 0.2 millimeters. Fall velocities for silts and clays were based on suspended concentrations, using an averaging equation from the U.S. Bureau of Reclamation (US BurRec 2006). Turbulence effects on the settling of silts and clays were generally incorporated through the dispersion results.

The extent of deposition was based on the distance required for a vertically well-mixed suspended sediment load to fall through the water column as represented by the streamflow depth. The deposition distances were derived by a simple linear relationship based on the fall velocities of sediment size fractions and the downstream flow velocities. Although general in nature, this approach is supported in literature (Einstein 1967, Golder Associates 1998, and others). As footnoted, final deposition values indicated in the attached table represent the distances within which two criteria for mussel mortality were satisfied: 1) a burial depth of 0.6 centimeters or more, and 2) a suspended sediment concentration of 600 milligrams per liter or more. These criteria were obtained from related research into mussel mortality from siltation (Ellis 1936). Suspended silts and clays at lower concentrations would pass further downstream.

B. Site Selection and Flow Conditions. Three sites (the Duck River in Tennessee, the Elk River in West Virginia, and the James River in Virginia) were selected for application of the estimation procedure. Site selection was based on 1) a list of “may-affect” stream crossings for the NiSource project, 2) the availability of nearby USGS streamgaging data and related measurements, and 3) a likelihood of moderate flow conditions (discharge, depth and width, velocity) during the anticipated construction season (July through December). The anticipated crossing construction season is based on communications with the ENSR project staff regarding other wildlife considerations (e.g., bird nesting) that may affect the timing of construction near watercourses.

Moderate flow conditions may be the most significant in terms of potential effects of sediment deposition on mussel beds. Under the procedure, small discharges and slower flow velocities or shallow depths generally will not result in the calculation of sediment transport and deposition at distances as great as in the larger streams. Very large rivers, such as the Ohio and Tennessee rivers, absorb sediment inputs within their background conditions and disperse them fairly quickly within the cross-section to levels below the criteria.

Flow conditions used in the calculations represent the lower flow conditions late in the season. Average monthly flows were further averaged to obtain a seasonal average flow rate at each location, based on USGS gaging and watershed area. These flow conditions represent a narrower and shallower hydraulic geometry than “bankfull flows”. The latter are much more likely to occur in springtime, outside the construction timing window.

ENSR
1601 Prospect Parkway, Fort Collins, CO 80525-9769
T **970.493.8878** F **970.493.0213** www.ensr.aecom.com

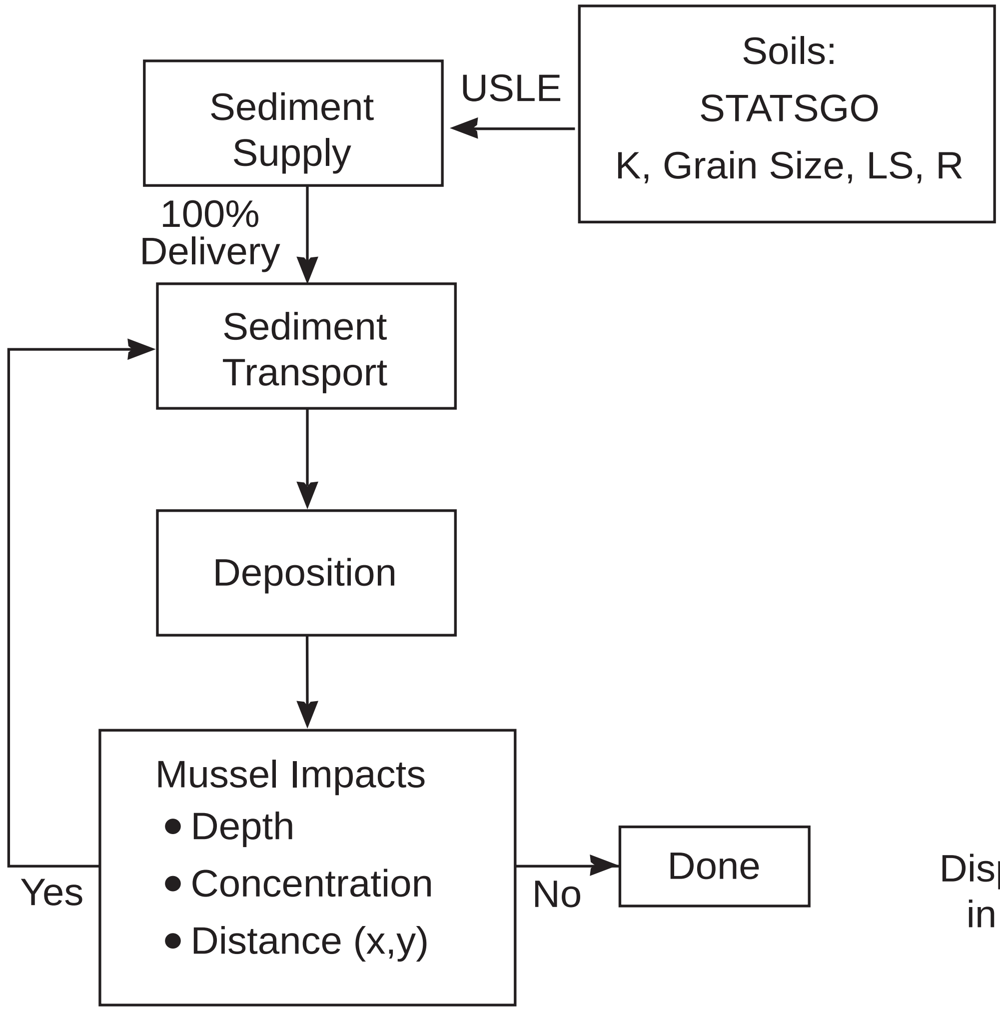
C. Interpretation of Results. The results of the estimation approach for the three streams are shown in the attached table. Of the sites selected, the Duck River is a relatively deep and fast-flowing stream with fine-grained materials in the banks and bed. Correspondingly, its transport and deposition distances are the longest. This is also due to the portion of silt and clay in suspension. In contrast, the Elk River is much deeper and slower. The overall grain size fractions along the Elk River are coarser, and its transport and deposition distances are the shortest. In addition to stream hydraulics, the silt and clay fraction never exceeds the concentration criterion or provides enough settleable mass in the water column to exceed the burial criterion. Therefore, the deposition distance for the criteria is governed by the faster settling rates of the sand fraction. The James River is in between the other two. While slower, it is also shallower, and has somewhat finer banks and bed than the Elk River. As a result, the silt and clay fraction exceeds the concentration criterion to the distance indicated in the table. However, for the same reason as on the Elk River (lack of settleable mass), the burial criterion is not exceeded by silt and clay on the James River. The deposition distance for the burial criterion is governed by the faster settling rates of the sand fraction.

It should be noted that the distances tabulated for the sediment supply from the bank (Part 1: USLE-derived sediment supply) relate to a portion of the flow field that extends out a distance of about 20 feet from the late summer and autumn seasonal shoreline on the James River, and out about 35 feet for the Duck River. A similar “wedge” of deposition occurs for fine sands on the Elk River. This is due to the transport mechanics, and the dispersion calculations, for a point source at each bank. This phenomenon is depicted on the attached figure, as well. For the trench calculations shown in Part 2, the distances pertain across the entire stream width.

The actual occurrence of mussel beds within these areas is subject to further analysis or data-gathering.

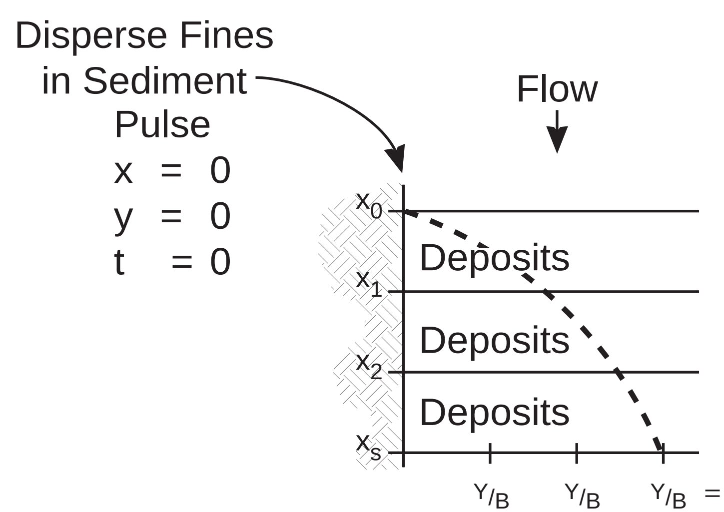
Sincerely yours,

Jim Burrell, EIT, MSCE
Senior Hydrologist
ENSR – Fort Collins, CO



Inputs

- Soils Data
- Watershed Areas
- Hydraulic Geometries, Velocities
- Fall Velocities, Dispersion
- Stream Slopes
- Background Conditions
  - Suspended Sediment
  - Seasonal Flows



- Depth of deposit 0.6 cm
- Concentration > 600 mg/l
- Distance (xy) = whatever it is

SEDIMENT TRANSPORT DISTANCES FROM WET OPEN-CUT CROSSINGS

1. From Bank Excavations, from USLE sediment supply approach

River	Location	TRANSECT ID	Flow Depth D, ft	Velocity, Vmean, ft/s	Representative Gravel Size, mm	Downstream Transport Distance, ft	Representative Sand Size, mm	Downstream Transport Distance, ft	Representative Silt & Clay Size, mm	% Silt & Clay	Downstream Transport Distance, ft *	Downstream Burial Distance, ft **
Duck	Maury County TN	1	5.32	2.45	12.44	7	0.30	94	< 0.05	80.2	3,700	1,060
Elk	Kanawha County WV	2	7.42	1.48	33.26	4	0.20	167	< 0.05	41.6	NA	167
James	Botetourt County VA	3	4.43	1.30	26.81	2	0.22	70	< 0.05	45.6	2,640	70

* Settling distance downstream for which suspended sediment concentration exceeds 600 mg/L
** Distance over which sediment settling forms deposits 0.6 cm thick or more
NA: neither criterion above was exceeded by the silt & clay fraction on the Elk River.

2. From Bed Trenching, per Gas Research Institute 1998 approach

River	Location	TRANSECT ID	Flow Depth D, ft	Vmean, ft/s	Representative Grain Size, d50, mm	Downstream Transport Distance, ft
Duck	Maury County TN	1	5.32	2.45	0.4231	65
Elk	Kanawha County WV	2	7.42	1.48	0.4420	53
James	Botetourt County VA	3	4.43	1.30	0.4420	28

Attachment L-18

Disinfection Techniques

Disinfection Techniques/ Options:
Preventing Spread of Pathogens, Bacteria and Invasives

Boats, Motors, Trailers, Equipment
U.S. Fish and Wildlife Service-Region 3
Develop and Implement a HACCP Plan! Comply with Federal and State Mandates

Methods below are only effective after proper preparation of infected equipment. After loading and securing boat and equipment on trailer at boat landing, boat, motor, trailer, and gear must have all aquatic vegetation, visible organisms/animals, soil, and water drained and removed BEFORE TRANSPORT. Upon leaving a worksite possibly infected with pathogens or invasive species, a proper disinfection must be completed before re-use of boat, motor, trailer, and any exposed gear in another waterway. Contact time is crucial for complete disinfection. Contact time reflects exposure of air, water, or disinfectant to a specific area, and not the total amount of time spent disinfecting. For example, if you are using 70^{o} C water to disinfect your boat, you must apply 70^{o} C water to each area for one minute or longer (see options and procedures below). Disinfection is MANDATORY for all exposed equipment and gear!

Methods	Procedures	Positives	Negatives
Heat + Air (Drying in hot sun/air)	**30C (86 F)** 24 hours minimum (time at temp contact period crucial) (exposure to hot sun/ air while dry)	Chemical free Effective, but only if properly done under ideal conditions	Time consuming Weather/Temperature criteria critical to reliable results
Heat + Water Spray &/or immerse	**50C (122 F)** contact time 10 minutes (time and temp contact crucial) (source of very hot water needed)	Chemical free Same as above	Must maintain high water temp/contact; hotter than normal tap or carwash
Heat + Water Spray &/or immerse	**70C (158 F)** contact time 1 minute (time and temp contact crucial) (source of super hot water needed)	Chemical free Same as above	Must maintain very high water temp/contact; hotter than normal tap or carwash. Risk of burns
Virkon Aquatic	**Follow product directions for proper mixture and minimum contact time.** (immerse in solution, apply directly, or spray-on with pressure washer & rinse)	Environmentally friendly Designed for aquatic use Quick inactivation time Sewer compatible	Follow MSDS directions for health risks and use personal protective gear ppg. when mixing Corrosive in concentrate form Chemical based
Quarternary Ammonium+Water ***(family of products)**	**Follow product directions for proper mixture and minimum contact time.** (immerse in solution, apply directly, or spray-on with pressure washer & rinse)	Effective, user friendly Low health risks Sewer compatible	Chemical based Follow MSDS directions for health risks and use ppg.
Chlorine + Water	**Min. 200 mg/liter** water for 20 minutes (immerse in solution, apply directly, or spray-on with pressure washer and rinse/neutralize thoroughly)	Widely available Effective	Follow MSDS directions for health risks and use personal protective gear ppg. Highly Corrosive

This is a partial list; research, choose, & use the most effective option available for you. Feel free to print, laminate, and post this page.
USFWS Contacts are: Corey Puzach, La Crosse Fish Health Center-608 783-8445, or Dave Wedan R3 Watercraft Safety Coordinator-608 783-8435. HACCP Webpage http://www.haccp-nrm.org/

Attachment L-19

Riparian Restoration Standard

Appendix L-19

Riparian Buffer Mitigation Monitoring Protocol

Mitigation for all aquatic HCP species includes the establishment or protection of riparian buffers. A requirement of Chapter 7 is to monitor the riparian buffer mitigation sites both for effectiveness and Chapter 10 requires assessment if a mitigation site is impacted by a changed circumstance (e.g., flood, fire, disease). The following outlines the general provisions required to monitor these sites. Specific additional measures may be required as monitoring is implemented to ensure effectiveness of the monitoring protocols.

NiSource will record the lat long coordinates to accurately delimit the easement polygon boundary and will clearly and permanently mark the boundaries of the easement on the ground (typically metal fence posts) within six months of the easement being recorded or as otherwise specified.

Once the easement vegetation is established, NiSource will examine updated aerial photos every five years to determine the general condition of the easement (e.g., presence of significant erosion, evidence of fire or disease, and clearing, trails, dumping, or other human impacts) and to ensure that the structure and percent cover of the mitigation vegetation (trees or grasses) meet minimum requirements established in Chapter 6 and Appendix XX. At least once every 10 years NiSource will do an on-the-ground verification of the remotely sensed data (i.e., structure and percent cover of mitigation vegetation) and to more effectively assess the easement site for indications of invasive species, disease, significant erosion that threatens site integrity and other potential threats to the functioning of the easement as designed. Additional assessment using both remotely sensed data and on-the-ground verification may be required to determine the impacts of changed circumstances should a changed circumstance (e.g., flood, fire, invasive species) affect a mitigation site. NiSource will coordinate with the Service, which will determine whether remotely sensed data are sufficient or whether on-the-ground assessment is required in the case of changed circumstances.

Google Map Photos (or other aerial photo data) are acceptable data for remote assessment if they meet the following requirements: a) they provide data acquired in the appropriate year and season necessary to determine the structure and percent cover of the mitigation site (or to evaluate a changed circumstance); b) the aerial photos are of sufficient quality and resolution to determine the structure and percent cover of the mitigation site and provide information on possible threats to its integrity. The attached GoogleMap image of Big Darby Creek in Ohio (Photo 1) represents information that may be sufficient to determine structure (i.e., trees versus crop field) but not of sufficient resolution to make a determination on percent cover or other impacts. Photo 2, another Google image of the White River in Indiana may represent an image of sufficient quality to determine both structure and percent cover.

NiSource will employ accepted guidelines for evaluating remotely sensed data and for conducting on-the-ground assessment of percent cover and structure. To the extent feasible, the methods will be quantitative and will allow comparison of the assessments among years. NiSource will provide the specific protocols for both remote sensing and on-the-ground surveys in writing to the Service for approval before the first assessment using either method. With respect to threats to mitigation site integrity, at minimum, NiSource will assess the entire shoreline for erosion, and the entire mitigation site for other impacts (e.g., trails, erosion, clearing, dumping) that might affect the integrity of the mitigation.

Photo 1 – Fictional Riparian Buffer Boundary on Big Darby Creek in Ohio (Google 2010 Image)

Photo 2 – Fictional Riparian Buffer Boundary on the White River in Indiana (Google 2010 Image)

APPENDIX L-19

RIPARIAN RESTORATION STANDARD

Mitigation Option B) There is uncertainty associated with the survival of vegetation planted to restore riparian corridors.

The hypothesis relevant to riparian corridor restoration planting survival is:

A minimum of 75 percent of trees and grasses will survive after three years.

Adaptive management will be employed to ensure that the minimum survival rate of 75 percent is achieved. A person with qualifications and expertise in evaluating tree planting survival will survey all riparian restoration sites during the growing season of the third year after planting to determine the survival rate.

The threshold for adaptive management will be less than 75 percent survival of trees at three years after planting. In addition, if fewer than 50% of the planted trees and shrubs or less than 50% of the area of planted grasses is alive after the first year, the mitigation will be determined a failure and corrective will be required during the next growing season. If by the third growing season, greater than 75% of the trees and shrubs survive or 75% of the area of grasses survive, but it is determined as above that the greater than 50% will be permanently impaired (e.g., inordinately subject to disease, blow-down, etc.) then corrective action will be required

Alternatives to evaluate if the threshold is reached:

A) Replant the original tree species back to 100 percent of the original planting density.

B) Replant a different suite of native species back to the 100 percent of the original planting density.

C) Modify the site to facilitate better survival of planted trees and implement A or B above.

D) Plant a different type of native vegetation that provides the same suite of benefits to mussels.

E) Re-establish the original level of mitigation at a new site where the mitigation would provide compensatory mitigation for Nashville crayfish.

SPECIFICATION GUIDE SHEET
for Riparian Forest Buffer (391)

SCOPE:

This work will consist of establishing adapted and compatible native trees and shrubs adjacent to and up gradient from watercourses or waterbodies. The purpose for this practice may include creating shade to improve aquatic habitat, provide riparian habitat, provide for a source of detritus and large woody debris, reduce excess sediment and other pollutants in surface and shallow groundwater, reduce pesticide drift, restore riparian plant communities, and increase carbon storage.

GENERAL SPECIFICATIONS APPLICABLE TO ALL PURPOSES

To be able to plan for the restoration of a riparian area one must understand what its functions are and where it lies in the landscape. A good definition defines the **riparian area** as "the aquatic ecosystem and the portions of the adjacent terrestrial ecosystem that directly affect or are affected by the aquatic environment. This includes streams, rivers, lakes, and bays and their adjacent side channels, flood plain, and wetlands. In specific cases, the riparian area may also include a portion of the hillslope that directly serves as streamside habitats for wildlife."

The Three Zone System

A three-zone system has been developed to help plan riparian forest buffers. This three-zone concept is intended to be flexible in order to achieve both resource protection and landowner objectives.

All buffers, as a minimum, will consist of Management Zones 1and 2. The minimum width of these combined 2 zones, for all purposes, is 35 feet. Wider buffers are encouraged and may be required depending on the purpose. Wider buffers will provide more functions and values than narrow strips. Forested buffers that will connect two or more forested patches are considered corridors for wildlife. Minimum widths for travel corridors for wildlife are 50 feet where it is an identified objective of the practice.

Zone 1

This zone begins at top of bank and will contain trees and shrubs needed to provide aquatic shade, bank stability, detritus, large woody debris, and retain nutrients bound to soils. Large woody debris and tree roots in the water create habitat complexity and niches for invertebrates and aquatic organisms. Detritus such as leaves, twigs and fruit seeds entering the water and held by woody debris provide a base to the aquatic food chain.

Zone 1 is most subject to inundation. Species with the greatest tolerance to these conditions are listed in VT Forestry Technical Note 2 – VT Tree and Shrubs for Conservation. Silver maple, black willow, boxelder, alder, dogwood, and eastern cottonwood have evolved in and are best suited for these conditions in most locations throughout Vermont floodplains. Silver maple floodplain forests and alluvial shrub swamps are two natural community types that are commonly the target for restoration with this practice. The fast growth rate and brittle habit of these species withstand the periodic trauma of heavy floods. Instead of washing away and exposing unstabilized banks, these species shed branches, regrowing from the remaining trunk. Because of their fast growth rate, they are established relatively easily and rapidly reach canopy closure. These species facilitate the important goal of stream shading and promote establishment of the riparian forest buffer.

The minimum width for this zone for all purposes is 15 feet from top of bank.

Zone 2

This zone is landward of Zone 1 and will contain the trees and shrubs and other vegetation needed to filter runoff and provide uptake of nutrients and pollutants. Together, Zone 1 and 2 will provide a travel corridor and habitat for wildlife in addition to providing shade and a source of woody debris.

Zone 2 can include commercially viable canopy species such as red oak and sugar maple where site conditions permit; areas with high terraces and drier conditions. More flood and wet soil tolerant species, similar to Zone 1, will likely be necessary in Zone 2 depending on the natural community and soil moisture. Generally, for most buffers being planned and implemented in Vermont, Zone 2 is functionally an extension of Zone 1. Except in very wide buffers or near abrupt slope breaks, the species used for both zones will be essentially the same. An understory of shrubs will provide additional shade and structure to Zone 2. Where shading needs for the water body are met, the transition from Zone 2 to 3 can be planted with early successional species such as elderberry, dogwoods, and viburnums to limit the encroachment of invasive plants into Zone 2 and to provide a soft edge between the grass and forest habitats. **The minimum width for this zone for all purposes is 20 feet.**

Zone 3

This zone is landward of Zone 2 and consists of a strip of grass or herbaceous cover to spread, slow and filter runoff which may be transporting sediment, nutrients, and pesticides off cropland or other erosive areas. **The minimum width for this zone, where necessary, is 15 feet.**

Additional Specifications to Reduce Excess Amounts of Sediment, Organic Material, Nutrients and Pesticides in Surface Runoff and Reduce Excess Nutrients and Other Chemicals in Shallow Ground Water Flow

The riparian forest buffer will consist of Zones 1, 2 and, in some cases, Zone 3. Establishment of Zone 3 filter area will be required where there is sheet flow from cropland toward the forest buffer and stream. A hundred foot buffer has been shown to provide even greater water quality benefits and may be necessary depending on site conditions.

Fast growing species with high nutrient uptake potential should be favored for Zone 2. Zone 2 width will be expanded beyond the 20 foot minimum where necessary to capture excess nutrients, accommodate topography (slope) of the site and or accommodate stream adjustment processes (see Unstable River Channels section).

Where Zone 3 is required, the total combined buffer width shall be no less than 50 feet. Zone 3 will be established and managed according to the Filter Strip Specification Sheet 393.

Unstable River Channels

Planning buffers on unstable river channels requires a greater level of analysis. Many rivers in Vermont are undergoing adjustments due to past and current alterations and managements. Establishing a riparian forest buffer must account for the nature of these systems and for the extent of adjustment and change that could be expected. This will require using geomorphic assessment data and consultations with river scientists or other resource professionals. This consultation will help verify the form and extent of the instability.

Where an unstable channel exists on a project area and where Phase 1 assessments have been completed, use the defined river corridor from the internet based **River Management Stream Geomorphic Assessment Data Viewer** (Mapserve) as the potential foot print of the buffer area which may be refined with site visits. The corridor is intended to include the area that will allow for stream equilibrium condition to develop and stabilize over the long term.

Where there is no phase 1 data, a river corridor can be defined using the belt-width approach. See the DEC River Management 'Defining River Corridors Fact Sheet.' Adding an additional channel width on each side of the stream belt-width will approximate the river corridor for planning purposes.

Plantings should be set back from the top of bank and eroding channel commensurate with the rate of erosion. Bioengineering using stakes and wattles may help to slow the rate of erosion and aid in woody establishment on the buffer.

Additional Specifications to Maintain or Restore Water Temperatures and Provide Large Woody Debris

The riparian forest buffer will consist of Zones 1 and 2 and the total combined width will be a minimum of 35 feet. Zone 1 will be planted to fast growing, tall species that will quickly address the lack of shading and provide large woody debris. Canopy density should be kept at least at 80 percent coverage. Maximum shading ability is reached within a width of 80 feet, with 90 percent of the maximum reached within 55 feet.

Large woody debris (>4 inch diameter) usually originates within 60 feet of the stream. Ideally, streams supporting fish should have 75 to 200 pieces of large woody debris per stream mile.

Additional Specifications to Provide Fish and Wildlife Habitat

The riparian forest buffer will consist of Zones 1 and 2 and the total combined buffer width shall be no less than 50 feet. This will require that Zone two be expanded beyond the minimum to 35 feet. Zone 3 will be used in addition to Zones 1 and 2 where excess nutrients, sediments, etc. are also a concern. Buffers more 100 feet wide or more are recommended as they provide the most fish and wildlife habitat value. See Table 1 for more information about species or groups and buffer requirements. Design buffers to meet or exceed the minimum requirements of local species of concern.

Design buffers to connect upland habitats and wetlands if possible. Numerous species that use aquatic and riparian/wetland habitats will also use upland habitats at some point of their life cycle (e.g. wood turtle).

Planting Plan

The planting plan will be recorded on the approved VT NRCS 391 Job Sheet and will include the natural community type, species and sizes, numbers to be planted for the restoration, spacing, specifications for protection if applicable, and any associated bioengineering that will compliment the tree and shrub establishment. A pre-planting meeting will be held on site with the planters to ensure that the planting plan is properly followed based upon the site conditions.

Riparian forest buffers will be designed to meet the intended purpose of the practice and will also mimic natural plant communities native to the site. Locally developed, native Vermont plant materials or seeds should be considered for planting. See VT Forestry Technical Note 2 – VT Trees and Shrubs for Conservation for more information. Do not order or plant species developed outside of Vermont which are uncommon or rare in the State. This will maintain the genetic integrity of this species in Vermont. Plant a minimum of 5 species of trees and or shrubs for each site. For specifications on tree and shrub planting see Tree and Shrub Establishment (612) Specification Guide Sheet.

Determining Natural Plant Community

Various tools are available to assist in determining the natural community type and species typical of a specific site. The primary reference for determining natural community and species composition is Wetland Woodland Wildland – A Guide to the Natural Communities of Vermont. The companion reference is the Vermont NRCS Soil Series of Vermont and their associated Natural Communities found within section IIA of the electronic Field Office Technical Guide (eFOTG).

Steps: For a given site, the planner may determine the soil series from the County Soil Survey or onsite review. Next, refer to the Soil Series Natural Community guide and find the soil series; read across the table to find the natural community typical of that soil series. Refer to Wetlands Woodlands Wildland for more information about the natural communities including tree and shrub species.

It is also important for the planner to evaluate nearby plant communities on similar site conditions to determine what is appropriate or typical for the specific site. There may be inclusions of other non-forested communities such as emergent shallow marsh or sedge meadows which may provide good habitat diversity in concert with the forested areas. These naturally open communities should not be planted to trees without consideration.

Finally, the planting plan will also need to account for the availability of plant materials. Some species are difficult to grow locally and may be better established through natural regeneration on site.

Note: Be aware of local potential pathogens or pests known to be associated with plant materials that may be ordered from outside Vermont. For example, hemlock should generally not be imported due to wooly adelgid concerns.

Site Planning

Once the appropriate natural community and species are determined for the site, it is important to have a planting plan that specifies how and where different species will be planted based upon site conditions. It is not a good practice to indiscriminately plant species, regardless of habit, across the entire buffer area unless site conditions are uniform. There may be a good amount of variability in soil moisture, herbaceous vegetation height, and topography across this buffer area that should be planned for in the planting plan. For example, if there is a low floodplain or depressions within the buffer area, the planner will need to specify that species adapted to wet soils and inundation be planted in these locations and more upland species at the higher sites. Live stakes and wattles may be a good alternative to tree planting in very wet sites that are frequently flooded. This specific planting information should be made clear to the contracted planters at the pre-planting meeting on site. For information about tree species habits and characteristics and species suitable for bioengineering refer to VT Forestry Technical Note 2 – VT Trees and Shrubs for Conservation and the Tree and Shrub Establishment (612) Specification Guide Sheet.

Natural Regeneration

Natural regeneration can be a cost effective way to allow riparian forest buffer establishment and plant succession to occur on site. It is a slower process than planting but it is one that will select the most suitable species for the site and there is no concern about origins of the growing stock. However, it may not provide uniform stem density and closed canopy coverage for the site in as short a period of time as planting.

Determine if natural regeneration can successfully meet the purpose of the riparian forest buffer. If closed canopy conditions throughout the entire buffer area are required in a short period of time; then natural regeneration may not be the best choice. Recognize that natural regeneration has limitations and that certain buffer functions such as shading, nutrient uptake, habitat corridors, natural communities may need to be met with a planted buffer.

The first step in determining if natural regeneration will meet the purpose of the buffer is to determine how many stems per acre and what species are currently present. This can be done by using the Systematic Line Plot Cruise developed by the Maryland Department of Natural Resources Forest Service or other methods. For detailed description of this process see VT Forestry Technical 1 – Stems per Acre Line Plot.

Natural Regeneration Specifications

Where other buffer functions have been accounted for within the zones, then 150 existing woody stems per acre on site will be considered an established riparian forest buffer. Invasive plants will not be included in this count. This number of stems will approximate the number of stems that are expected to survive from a minimum planting of 200 stems per acre (see Plant Spacing and Density). Generally 75% survival is expected for a planted riparian forest buffer.

Once woody stems have been established it should lead to further regeneration through changes in the site condition (shading favoring trees and shrubs), seed dispersal by birds and mammals and root suckering. This additional regeneration will meet or exceed stems/acre on many planted buffers in Vermont.

Pay careful attention to Zone 1 of the Buffer when considering using natural regeneration instead of planting. This is a critical zone for development of favorable aquatic habitat and conditions. There should be very good evidence of natural regeneration in this Zone. Where there is not, plant accordingly even if the minimum numbers of stems per acre are present.

When considering potential establishment through natural regeneration, consider the site conditions and potential for establishment. Dense sod will likely need to be harrowed while idle crop fields or pastures may be well suited. Often pastures have some woody component that has been suppressed.

Consider the surrounding riparian areas or forest areas for seed sources. Natural regeneration is not a good option if the buffer area is surrounded by agricultural land with no favorable seed sources or potential for vegetative reproduction. Where there are perches for birds (e.g. fence posts, trees on site, etc.) there is a better likelihood of colonization for some woody species; in particular, shrubs whose fruits are fed upon by birds will be seeded into these areas.

When planning for natural regeneration to occur in the buffer, consider mode of dispersal, distance between seed source and target area, seed source strength (number and size of mature seed bearing specimens) and seed size. Generally, heavy seeded species will disperse short distances (one study found 150 feet or less) while wind and bird dispersed seeds may travel greater distances (same study found 450 feet or less). Obviously all seeds can travel greater distances but the probabilities are less. See Tree and Shrub Establishment Specification Sheet 612 (Table 1) for examples of seed sizes and dispersal mechanisms for various trees and shrubs.

Wind and bird dispersed seeds will be most likely to colonize a site with some stems present. Where there are no perching sites in a buffer, wind dispersed seeds will be the primary form of regeneration. Heavy seeded species such as oak and hickory will take longer to naturally establish; particularly over longer distances. Consider planting species such as oak and hickory in regenerating buffers to aid in establishment where they are a component of the targeted natural community.

Buffers that are not planted may persist in an early successional state for decades. This may provide good habitat for certain species of concern in the Northeast (e.g. shrubland birds) but it can also provide favorable conditions for invasive plants such as buckthorn and honeysuckle. Monitoring is important to prevent their initial establishment.

Plant Spacing and Density

In mature riparian floodplain forests, canopy tree stem density is roughly 150 stems per acre, indicating a tree spacing of 16 to 18 feet. Conversely, in an alluvial shrub swamp there may be thousands of stems per acre. Determine what plant spacing and density best meets the purpose of the buffer and best matches the natural community. It is likely that in many cases it is not feasible to plant to meet the natural condition stems per acre in some shrub natural communities so the goal should be to plant in a manner that will allow for succession to this natural community condition.

Initial plant to plant densities for trees and shrubs will depend on their potential height at 20 years of age. Riparian forest buffers are expected to reach crown closure at 10-20 years when stocked at the minimal level of 200 tall trees an acre (greater than 25 feet). Heights may be estimated based on:

- Performance of the individual species (or comparable species) in nearby areas on similar sites.
- Predetermined and documented heights from VT Forestry Technical Note 1 – VT Trees and Shrubs for Conservation.

When establishing a new planted buffer, a minimum of two staggered rows of trees and or shrubs will be established along the water body. Generally this will be within Zone 1. Favor species that will provide shading in a short amount of time. See VT Forestry Technical Note 2 – VT Trees and Shrubs for Conservation.

Planting density should be higher than the final stem density desired, to allow for losses due to competition, stress, and animal damage. Generally, 75% is the expected survival rate for planted buffers. For a floodplain forest, a minimum of 200 plants are needed to be planted per acre to ensure 150 stems per acre. Natural regeneration is also expected to contribute trees and shrubs. In a study in Maryland of 130 buffer sites, 36% of total stocking of woody species was from natural regeneration.

Plant Types/ Community	Plants per Acre	Plant-to-Plant Spacing (Feet)
Shrub Community – shrub dominated, mostly shrubs	450 to 300	10 to 12
Forest Community – tree dominated, mix of trees and shrubs	300 to 200	12 to 15

Plant a mix of trees and shrubs to add habitat value; even when planting the minimum 200 stems per acre. When planting the minimum number of trees and shrubs together in a forest community, do not exceed 25% shrubs in the planting plan. Except in narrow buffers (35-50 feet), it is unlikely necessary to have tall trees for shading on the entire buffer. Adding shrubs to the planting will provide a successional component and important habitat value for wildlife. Adding vertical strata (shrub layer) to the vegetative community will increase the available niches to be used by more species of wildlife. For buffers greater than 50 feet, up to 25% of the buffer area may be left open and intermixed with planting areas. This approach would work well with planting clumps of shrubs. Individual open areas should not exceed 1/10 acre in size. Species of concern such as wood turtles will use open areas for foraging or basking; particularly in or near alluvial shrub swamps.

Establishment Period

The riparian forest buffer will be considered established when 75% of the planted trees and shrubs are alive after 2 growing seasons. If, after 2 growing seasons, there are less than 75% live planted trees on site and natural regeneration has not made up the loss of stems, then re-planting will be necessary.

For Natural Regeneration, assuming other buffer purposes have been accounted for, then 150 existing woody stems per acre on site will be considered an established riparian forest buffer. No additional planting will be necessary unless specified by the planner.

Planting trees and shrubs is not required in all cases where existing stem density is less than 150 per acre. Sites that have evidence of regeneration, where there is a high likelihood of attaining the minimum 150 stems per acre in two growing seasons do not require planting. For instance, a crop field that has initial establishment of silver maple seedlings (not required density) adjacent to mature silver maples will likely exceed the minimum 150 stems per acre through natural regeneration in two growing seasons simply by stopping tillage and herbicide application. Also, a heavily grazed pasture with a 100 native woody stems per acre may easily reach 150 stems per acre in two growing seasons simply by removing livestock. If, after 2 growing seasons, there are less than 150 live native woody stems per acre on site then planting will be necessary.

Direct Seeding Guidelines

Refer to Tree and Shrub Establishment (612) Specification Guide Sheet for information regarding direct seeding. Plant enough seeds to reach the desired stems per acre. Be aware that mortality is generally much higher when direct seeding.

Site Preparation/Weed Control for Buffer Establishment

Refer to Tree and Shrub Establishment (612) Specification Guide Sheet for information regarding site preparation and weed control.

Planting Dates

Refer to Tree and Shrub Establishment (612) Specification Guide Sheet for information regarding planting dates for seeds, seedlings, cuttings and larger planting stock.

Planting Requirements/Techniques

Refer to Tree and Shrub Establishment (612) Specification Guide Sheet for information regarding planting requirements and techniques.

Plant Protection

Refer to Tree and Shrub Establishment (612) Specification Guide Sheet for information regarding protection for planting stock.

REFERENCES:

Buffers for Habitat - Riparian Buffers for the Connecticut River Watershed Fact Sheet Number 4 1998. Connecticut River Joint Commission (CRJC). http://www.crjc.org/riparianbuffers.htm

Buffer Maintenance and Monitoring. 2004. Alliance for the Chesapeake Bay. http://www.acb-online.org/pubs.cfm

Chesapeake Bay riparian handbook: a guide for establishing and maintaining riparian forest buffers. 1997. Palone, R.S. and A.H. Todd (editors.) USDA Forest Service. NA-TP-02-97. Radnor, PA.

Riparian Buffers and Corridors – Technical Papers. 2005. VT Agency of Natural Resources.

Riparian Forest Buffers - Function and Design for Protection and Enhancement of Water Resources, NA-PR-07-91. 1991 David J. Welsch. USDA Forest Service, Northeastern Area State and Private Forestry, St. Paul,MN. http://www.na.fs.fed.us/spfo/pubs/n_resource/buffer/cover.htm

Riparian Forest Buffer Success and Survival in Maryland. 2001. Maryland DNR Forest Service. Research Report DNR/FS-01-01.

Tree dispersal among forest fragments: II – Dispersal abilities and biogeographical controls. 2002. Nina Hewitt and Martin Kellman. Journal of Biogeography, 29:351-363.

Table 1. Riparian Forest Buffer Widths for Fish and Wildlife

SPECIES	DESIRED WIDTH (in feet)
Wildlife dependent on wetlands or watercourses	**30-600'**
Bald eagle, nesting heron, cavity nesting ducks	600
Pileated woodpecker	450
Beaver, dabbling ducks, mink	300
Bobcat, red fox, fisher, otter, muskrat	330
Amphibians and reptiles	100-330
Belted kingfisher	100-200
Songbirds	**40-660**
Scarlet tanager, American redstart, rufous-sided towhee	660
Brown thrasher, hairy woodpecker, red-eyed vireo	130
Blue jay, black capped chickadee, downy woodpecker	50
Cardinal	40
Cold water fisheries	**100-300**

Source - Connecticut River Joint Commission (CRJC) Buffers for Habitat - in the series *Riparian Buffers for the Connecticut River Watershed*

Table 2. Natural Community types associated with rivers and lakes.

Open Upland Shores	Open Wet Shores	Marshes and Sedge Meadows	Shrub Swamps	Floodplain Forests and Swamps
Riverside Outcrop	Outwash Plain Pondshore	Shallow Emergent Marsh	Alluvial Shrub Swamp	Lakeside Floodplain Forest
Erosional River Bluff	River Mud Shore	Sedge Meadow	Sweet Gale Shoreline Swamp	Red or Silver Maple-Green Ash Swamp
Lake Shale or Cobble Beach	River Sand or Gravel Shore	Cattail Marsh		Red Maple-Northern White Cedar Swamp
Lake Sand Beach	River Cobble Shore	Deep Broadleaf Marsh		Silver Maple-Ostrich Fern Riverine Floodplain Forest
Sand Dune	Calcareous Riverside Seep	Wild Rice Marsh		Silver Maple-Sensitive Fern Riverine Floodplain Forest
	Rivershore Grassland	Deep Bulrush Marsh		Sugar Maple-Ostrich Fern Riverine Floodplain Forest
	Lakeshore Grassland			

Source – Riparian Buffers and Corridors – VTANR

Table 3.

Number of Trees per Acre by Various Methods of Spacing

Spacing (feet)	Trees (number)	Spacing (feet)	Trees (number)	Spacing (feet)	Trees (number)
2x2	10,890	7x9	691	12x15	242
3x3	4,840	7x10	622	12x18	202
4x4	2,722	7x12	519	12x20	182
4x5	2,178	7x15	415	12x25	145
4x6	1,815	8x8	681	13x13	258
4x7	1,556	8x9	605	13x15	223
4x8	1,361	8x10	544	13x20	168
4x9	1,210	8x12	454	13x25	134
4x10	1,089	8x15	363	14x14	222
5x5	1,742	8x25	218	14x15	207
5x6	1,452	9x9	538	14x20	156
5x7	1,245	9x10	484	14x25	124
5x8	1,089	9x12	403	15x15	194
5x9	968	9x15	323	15x20	145
5x10	871	10x10	436	15x25	116
6x6	1,210	10x12	363	16x16	170
6x7	1,037	10x15	290	16x20	136
6x8	908	10x18	242	16x25	109
6x9	807	11x11	360	18x18	134
6x10	726	11x12	330	18x20	121
6x12	605	11x15	264	18x25	97
6x15	484	11x20	198	20x20	109
7x7	889	11x25	158	20x25	87
7x8	778	12x12	302	25x25	70

Source - Chesapeake Bay riparian handbook