VERMONT STRATEGIC WOOD ADDITION HANDBOOK

Techniques and tactics for using large woody material to improve stream habitats

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Introduction

Large woody material has always been a natural and important component of stream habitats in the northeastern United States. Mature forests naturally contribute large woody material when streamside trees fall into streams. Two of the best things we can do for streams is to protect and restore streamside forests and to leave downed trees where they lie, but restoring mature streamside forests and natural wood recruitment rates is an extremely long process. Strategic wood addition is a method for restoring wood loading in the meantime.

The purpose of this strategic wood addition handbook is to help guide potential practitioners through the process of planning and implementing this method of stream habitat restoration. This handbook is not a replacement for training and experience. Most of the techniques and tactics included in this handbook were developed after years of studying both natural and constructed log jams. Field crews working for the US Forest Service, Trout Unlimited, and Vermont Fish and Wildlife Department have implemented these methods throughout Vermont and New Hampshire, and these methods have proven to be effective at improving habitat and increasing trout biomass. This is not a cookbook, nor a state regulation. While there are many consistencies in the methods used, there are as many unique approaches and techniques as there are field crews. This handbook outlines planning, permitting, implementation, and monitoring. It distills many of the techniques and tricks learned by some of the more experienced field crews in Vermont and should reduce the learning curve for new practitioners.

Like any forestry activity, strategic wood addition poses inherent risks to the crew, with added risks to public health and safety. Projects should be conducted by a crew that has received field-based training or has experience in completing instream wood addition projects. A list of consulting contractors with relevant training or experience is available from the Vermont Fish and Wildlife Department upon request.

What is strategic wood addition?

Strategic wood addition is strategic in that it addresses a stream function or habitat deficiency and is conducted in a stream reach where the added wood is likely to stay and have a lasting, beneficial impact. The trees that are felled into the stream are carefully selected and positioned to maximize benefits and stability.

Figure 1. The chop-and-grip technique utilizes a grip hoist to secure downed trees.

Strategic wood addition includes a variety of techniques that can be used to securely add large woody material to streams. In most cases, riparian trees are felled directly into the stream using a chainsaw, although trees could be transported to the stream from upland sites. Strategic wood addition includes, but is not limited to, chop-and-drop, which is a technique that can be used on streams where the riparian trees are large relative to the channel. In these small streams, manipulation of the downed trees is not necessary to stabilize them. Strategic wood addition in larger streams is often conducted with the method known as chop-and-grip, which involves the use of a grip hoist to position downed trees in secure locations so that they will be less likely to move during high flow events

(Figure 1). Both methods are described in more detail later. Strategic wood addition techniques are not appropriate for every stream, and they are generally not practical on rivers with bankfull widths exceeding approximately 40 feet. On these large rivers, the use of heavy machinery to construct engineered wood structures is typically more cost effective.

Why add wood to streams?

Historically, rivers in northeastern North America were characterized by abundant natural wood pieces, jams, and rafts that shaped the structure and function of rivers and resulted in high floodplain connectivity (Pike 1999, Wohl 2013, Wohl 2014). Extensive logging and log-drives denuded the landscape and severely degraded the rivers. To drive logs, numerous splash-dams were built along the rivers, long stretches were straightened, side channels were blocked, and boulders, bedrock, trees, and other instream obstructions were removed to prevent logjams. Even on small streams that were never used to drive logs, large wood loading has been reduced as a result of timber harvest in the streamside forest. Repeated cycles of clear-cutting ended in the 1980's, and since then, many watersheds have become reforested. But many rivers in the northeast have entered an alternative stable state of single-thread channels with substantially reduced overbank flow, sedimentation, and avulsions (Wohl 2014), and it will be decades before riparian trees reach sizes and ages capable of restoring wood recruitment and retention to historic, natural rates (Keeton et al. 2007). In addition, it could take millennia for these streams to replace large boulders that were removed to aid log drives.

Figure 2. A typical wide, shallow reach in a river that was once used to drive logs.

Many streams in Vermont have subsequently incised (cut downward) and become disconnected from their floodplains (Kline and Cahoon 2010; Kline 2016). Incised streams may, if allowed to adjust over enough time, eventually undergo an aggradation and floodplain rebuilding process. However, many streams in the foreseeable future appear to be "stuck" in a sediment transport mode as opposed to an equilibrium mode of sediment in equals sediment out. The long-term damage to these watersheds has resulted in rivers and streams that remain overly wide, shallow and straight with little cover for brook trout and other fish. In many areas, pools are lacking along the entire reach (Figure 2). Due to a lack of structure in the channels, degraded streams are transporting rather than retaining much of the organic material that is contributed by the riparian

Figure 3. Large woody material collects other organic material, which becomes food for invertebrates.

forest. This loss of organic material contributes to a loss of productivity in the aquatic community because decomposing leaves are the base of the food web in these streams, where leaves and associated microbiota are eaten by aquatic invertebrates, which are eaten by fish (Figure 3). In the formerly dammed areas, several feet of incision have resulted in a floodplain that is largely disconnected from the stream. Although some reaches are healing themselves, it will take decades or longer for these streams to repair themselves.

Vermont's forests are generally younger than 90 years old, with almost no old growth. Many of the streams and rivers in Vermont have low wood loadings, and riparian forests lack the large, old trees that would be stable in the channel if they fell in. Strategically adding in-stream wood can help jumpstart the healing process. Large wood in the active channel directs the flow of water and material and creates pools and cover that trout and other fish species use for feeding and for refuge from predators and high flows (Dolloff and Warren 2003). Kratzer and Warren (2013) found that the lack of in-stream wood is one of the main factors limiting brook trout biomass in northeastern Vermont. Large wood increases stream stability (Gurnell et al. 2002, 2016, Baillie et al. 2008, Camporeale et al. 2013, Beckman and Wohl 2014), channel roughness (Comiti et al. 2008), and floodplain access (Jeffries et al. 2003, Sear et al. 2010). Wood structures also help reduce nutrients downstream through sediment storage (Gurnell et al. 2002, Brooks et al. 2004, Cordova et al. 2007, Andreoli et al. 2007, Davidson and Eaton 2013) and nutrient processing (Roberts et al. 2007, Krause et al. 2014). In this age of increasing flood frequency and severity, restoring large wood loading to upland streams can benefit not only the aquatic organisms in the stream but also humans living downstream. Large wood can improve floodplain connection in upstream, undeveloped areas, thereby potentially reducing flood impacts downstream through flood flow storage and sediment retention. It can also help to reduce nutrient loading downstream.

Why strategic wood addition?

In the past, nearly all stream habitat restoration work was performed by using large machines to build engineered structures. This work was mostly done on larger streams, lower in the watershed. Heavy machinery is still the most effective, and sometimes lowest-cost, method for adding wood to some rivers and streams, but it can be disruptive to the riparian forest and the streambed. In some situations, strategic wood addition, which is defined in this handbook as the suite of techniques that utilizes chainsaw, grip hoist, pry bars, and muscle power to add large wood to streams, can be as cost-effective as using machinery on appropriately sized streams, with fewer negative effects. In Vermont, strategic wood addition has been used effectively on streams with bankfull widths up to 40 feet. This may approximate the upper stream size at which these techniques can be effectively applied.

More importantly, strategic wood addition has been proven effective in increasing fish populations when applied using appropriate techniques in appropriate situations. In a six-year study in the East Branch Nulhegan River watershed, the brook trout population tripled on average at sites where large wood was added using these techniques (Kratzer 2018). This study also showed that the large wood was not just concentrating the fish in areas of improved habitat, but that the wood contributed to an overall increase in brook trout abundance in the stream as a whole. The longevity of strategically added wood has yet to be determined, but as of fall 2019, there were 531 individually tagged large wood structures created by chop-and-grip methods that had been installed between 2012 and 2018 in northeastern Vermont. Of these, 481 were still performing at least one habitat or fluvial function in the location where they were originally constructed. MacCartney et al. (2014) found that large wood structures that remain in place through the first few high flow events are generally stable for years. Past experience in Vermont's Northeast Kingdom has also demonstrated that logs that are dislodged typically move less than 1,500 feet before being deposited on another structure, on a large boulder, on an outside bend, or in the floodplain, where they will continue to provide fluvial and habitat benefits. Wood is more likely to move, and to move a greater distance, on larger or more powerful streams.

Project Planning

Wood addition is not the answer to all of our stream habitat problems, and it is not appropriate for all streams. The following series of questions should help to determine whether strategic wood addition is appropriate for a proposed stream reach.

Will adding large wood improve aquatic habitat or stream functions?

Some data on the proposed stream reach are necessary to answer this question. These data include bankfull width, slope, and wood loading. Dominant substrate size can also be helpful. The Vermont Fish and Wildlife Department uses a datasheet (Appendix C) to guide the collection of these data using a simple procedure. Two individuals walk the entire stream reach in either the upstream or downstream direction. While making this first pass, the crew pays attention to transitions in major stream morphology (i.e., bankfull width and slope) and tries to mentally divide the reach into smaller segments that have relatively consistent width and slope and that are at least 0.25 miles long. On the second pass, the crew records GPS coordinates at the upstream and downstream ends of each of these segments and records data from at least three somewhat randomly selected locations within each segment. At each location, the crew measures slope using a clinometer, measures bankfull width, records the first and second most common substrate size, and counts the number of pieces of large wood (at least 4" in diameter and at least 3' long) within the bankfull area over a 100-foot length of stream.

These data can be used to determine how the existing wood loading compares to expected loading. The highest wood loading recorded by Kratzer and Warren (2013) in northeastern Vermont streams was 692 pieces per acre bankfull area, or 20 pieces per 100 ft. This is very similar to the maximum wood loading (19.2 pieces per 100 ft) reported by Warren et al. (2009) for streams in New Hampshire and New York, including some streams flowing through mature forests with pockets of old growth. Kratzer and Warren (2013) found that brook trout biomass increased with increasing wood when wood loading exceeded the minimum response level of 80 pieces per acre. For a stream with a 10-foot bankfull width, this minimum response level would equate to 2 pieces of wood per 100 ft, 4 pieces for a 20-foot wide stream, 6 pieces for a 30-foot wide stream, and so on. Target final wood loadings (existing plus added wood) should be at least double this minimum response level, but probably should not exceed 700 pieces per acre (Figure 4).

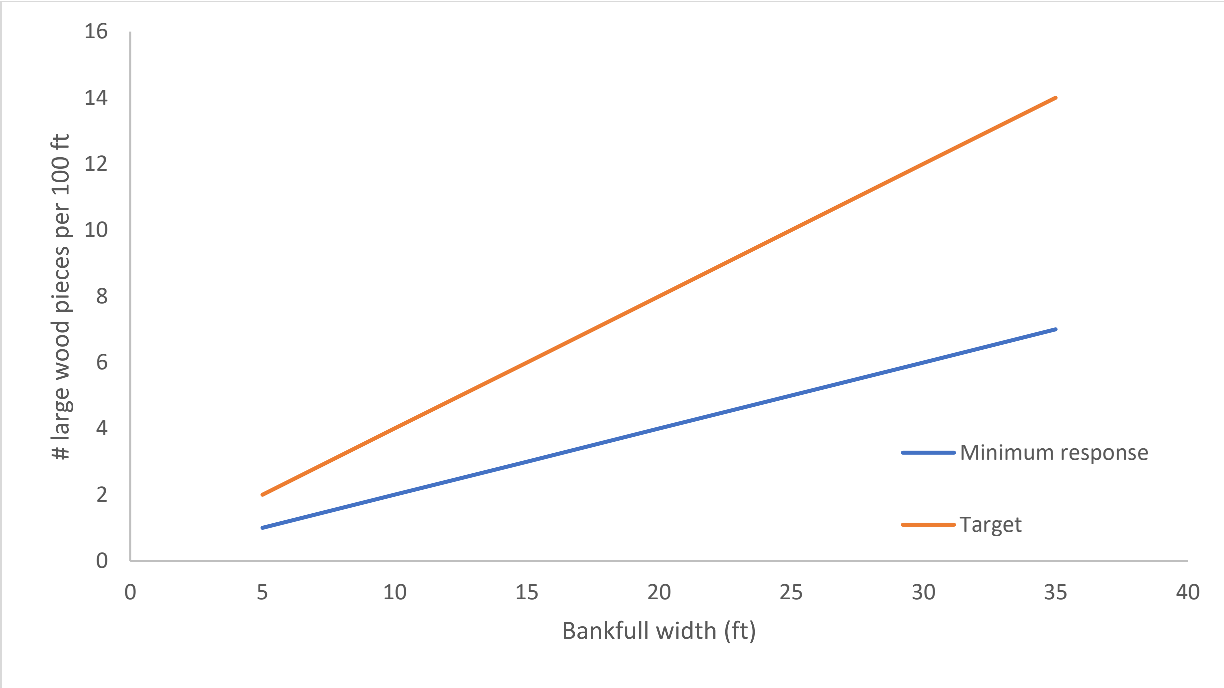

Figure 4. Minimum wood loading at which brook trout population response is expected (Kratzer and Warren 2013) and typical target final wood loading for streams in northeastern Vermont.

Slope and bankfull width data are needed to determine whether the stream channel would be likely to retain large woody material and whether the large wood could be expected to perform habitat and fluvial functions (Figure 5). A rough estimate of average tree height is also helpful in predicting the stability of added wood because downed trees that are long relative to bankfull width are less likely to move during high flows. If bankfull width is greater than 40 to 50 feet, the more effective technique for adding large wood may be to use machinery to build engineered structures. The following are some general guidelines for combinations of bankfull widths and slopes where adding large wood could be appropriate (Oregon 2010, Maine Forest Service 2012):

- Bankfull width 0-10 feet and stream slope of ≤ 15%
- Bankfull width 10-20 feet, and stream slope of ≤ 9%
- Bankfull width 20-32 feet, and stream slope of ≤ 5%
- Bankfull width 32-50 feet, and stream slope of ≤ 3%

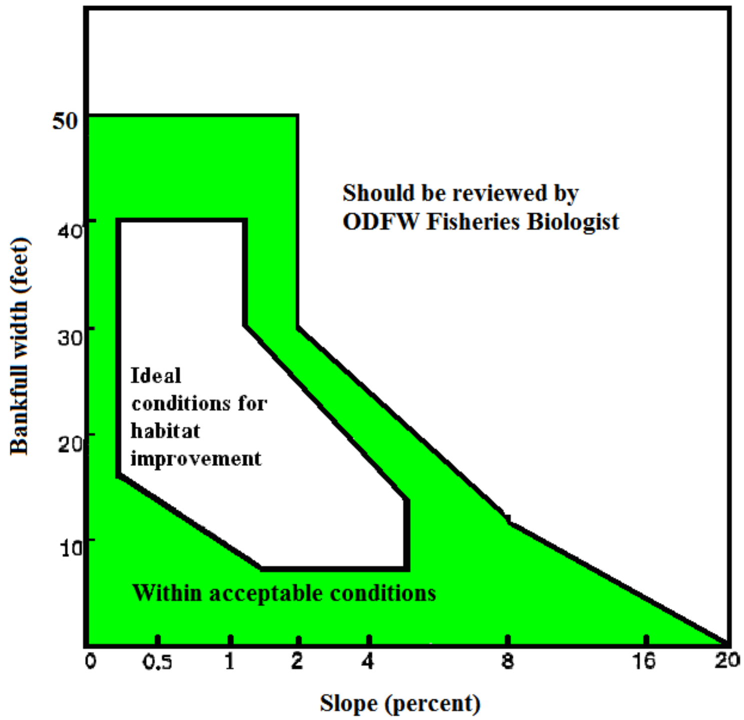

Figure 5. This figure is from Oregon (2010) and shows the stream slope and bankfull width combinations for stream reaches that are ideal or acceptable for habitat improvement efforts.

Substrate data can also be helpful in determining whether adding large wood is appropriate because the size of sediment that is present in a streambed is a function of bankfull width and slope. In general, streams with beds dominated by cobble and gravel are more likely to retain large wood than more powerful streams with boulder-dominated beds, and they are more likely to respond rapidly and dramatically to added wood than less powerful streams with sandy beds. Also, most streams have at least some large wood in them already. If this wood is stable and performing habitat and fluvial functions, adding additional wood may be appropriate if existing wood loading is low (Figure 6).

Figure 6. This stream reach has the right size and slope for wood addition, and existing wood is stable and functional.

It is important to consider whether stream habitat really needs large wood added. In certain stream channel types, large boulders may be a more important habitat feature than wood, and if they are present, adding wood might not be necessary (Figure 7). Some low gradient channels are naturally deep with overhead fish cover provided by undercut banks or overhanging vegetation. Adding wood to these types of streams may not significantly improve instream habitat, but these reaches could be opportunities for using large wood to improve floodplain connectivity.

In some projects, improving stream functions may be more important than improving instream habitat for aquatic organisms. For example, project objectives could include reversing the channel incision process to an aggradation process, restoring floodplain connectivity, or retaining sediments and nutrients. Consulting a trained river scientist or geomorphologist is valuable for identifying opportunities for stream function improvements.

Figure 7. In this reach, boulders appear to be more important than large wood. This reach would be a very low priority for strategic wood addition.

In a candidate strategic wood addition stream, the reasons for the existing lack of wood should be identified. Knowing the reasons for the current lack of wood is important for determining a long-term solution to the wood loading problem. For example, many streams in Vermont were manipulated in the past to aid the transport of logs. These manipulations include the removal of large boulders, channel straightening, and dredging. Also, most Vermont streams are currently flanked by young forests that lack trees that are large enough to remain stable in a stream if they fall in. Before implementing a strategic wood addition project, there should be a plan in place to restore natural wood recruitment to the system. The riparian area should be protected from harvest, and there should be minimal risk of people removing the added wood. Otherwise, adding wood is just a short-term band-aid.

While instream wood is important for fish habitat and stream functions, live streamside trees are also important for a healthy stream ecosystem. If streamside trees are going to be used to implement a strategic wood addition project, the riparian forest must be dense enough that the target wood loading can be achieved without significant negative impacts on riparian zone functions like wildlife habitat, shading, organic material input, and stream bank stabilization.

Stream reaches that have responded the most rapidly and dramatically to strategic wood additions in Vermont have had at least one of three characteristics: streambeds dominated by cobble or gravel substrates, high bed loads, and current or historic braiding (Figure 8). Streams with cobble or gravel substrates generally have enough stream power to generate bed scour under, over, or around large wood pieces but not so much power as to easily wash away large wood. Streams with high bed loads often respond quickly to added wood by depositing sediments upstream or downstream of added wood. Braided reaches are a natural component of stream systems and a natural

Figure 8. This reach responded rapidly and dramatically to strategic wood addition because of a high bed load and ideal combination of slope and width.

place for large wood to accumulate. In some cases, historically braided reaches were channelized to aid log drives or to protect property or infrastructure. In places where channel braiding can safely occur without risking infrastructure, added wood can encourage the dynamic processes of braided reaches. These braided reaches are important places for fish, amphibian, and invertebrate habitats; storage of fine sediments, nutrients, and organic materials; flood attenuation; and groundwater recharge (Wohl 2013).

Will large wood benefit fish populations?

If implemented in appropriate locations using appropriate techniques, a strategic wood addition project should have no adverse impacts to fish populations. The question of whether the added wood will benefit fish populations is only relevant for projects that specifically list improving fish habitat as a primary objective. Adding wood to benefit a fish population is not appropriate in streams that already have a robust population with little room for improvement. Furthermore, adding large wood will only benefit a fish population when large wood is a major limiting factor. For example, water temperature is the most important factor limiting brook trout presence and abundance in streams. Adding wood to streams that are too warm for brook trout, will probably not benefit that species. A strategic wood addition project aimed at improving brook trout habitat should be informed by water temperature data or fish sampling to ensure that large wood is added to stream reaches that are cold enough to support robust brook trout populations and where there are no other important factors that could limit the effectiveness of added wood. Consult the Vermont Fish and Wildlife Department for information about water temperatures and fish species present.

Whether or not the project objectives include improved fish habitat, the project proponent, manager, or implementor should be able to articulate how strategic wood addition will be likely to achieve the project objectives.

Can large wood be added safely and effectively?

This question encompasses several logistical concerns. Clearly, the project can legally occur only with landowner approval and the necessary permits. The field crew leader must be competent with adequate training and/or experience. The project should not risk downstream infrastructure or property. If the average tree height is at least two times the bankfull width and the streambanks are forested, there is very little risk of the added wood moving more than 100 feet. Still, large wood should not be added closer than approximately 500 feet upstream of a road crossing. Early in the planning process, the local Vermont Department of Environmental Conservation River Management Engineer should be consulted. The Engineer may advise a larger distance between the project and road crossings. If the average height of trees that are going to be felled into the stream is less than two times the bankfull width or if streambanks are not forested, there is higher risk of wood movement. Using chop-and-grip techniques, as described later, helps to minimize movement of wood in these situations, but they are not absolute safeguards against wood mobilization. There should be adequate distance for mobilized wood to settle in a stable location before reaching a road crossing or other infrastructure. The distance needed for mobilized wood to settle depends on the number and characteristics of locations where wood could be deposited. These locations include large instream boulders, existing instream wood, islands, and sharp meanders (Figure 9). These locations can often be identified by noting where naturally recruited wood has settled.

Figure 9. Low-gradient, sinuous reaches and large instream boulders are examples of good places for mobilized large wood to safely settle out.

Another safety aspect to consider is potential effects on recreational boating. A stream that is heavily used for canoeing, kayaking, or tubing may be a poor candidate for strategic wood addition, both because of potential threats to the boaters, and also for project longevity. Recreational boaters have been known to remove large woody material from streams, with or without permission.

Permitting

US Army Corps of Engineers

Most strategic wood addition projects in Vermont will require a permit from the US Army Corps of Engineers (USACE), which considers this work to be jurisdictional under Section 404 of the Clean Water Act because of the potential aggradation and degradation of substrate that can occur in association with added wood. The work may also be considered jurisdictional under Section 10 of the Rivers and Harbors Act of 1899, if occurring within navigable waters of the United States. Most strategic wood addition projects will be covered by the Vermont General Permits, but an application and project plans must be submitted to the USACE for review and consultation with federal and state resource agencies including the U.S. Fish and Wildlife Service (USFWS), Environmental Protection Agency, Vermont Department of Environmental Conservation, and Vermont Division for Historic Preservation. Since strategic wood addition projects require cutting trees ≥3” dbh, the USACE must consult with USFWS for potential effects to threatened and endangered species, including the Northern Long-eared Bat. The review process typically takes one to two months. Contact the USACE Vermont Project Office (Appendix A) for more information.

Stream Alteration

As a habitat improvement project, strategic wood addition is covered under the Vermont Stream Alteration General Permit. However, the regional Vermont Department of Environmental Conservation (DEC) River Management Engineer should be consulted early in the planning process (Appendix A).

Floodplains and River Corridors

Strategic wood addition should not be performed in areas where the added wood could contribute to increased risk of flooding property, buildings, or other infrastructure, and so it is mostly conducted in relatively remote, forested streams. However, the regional DEC Floodplain Manager should be consulted early in the planning process to confirm that a Floodplain Development Permit is not required (Appendix A). Most floodplain and river corridor projects in Vermont fall under municipal flood hazard regulations with the DEC Floodplain Manager providing a technical review to the town as part of the town approval process (24 V.S.A. §4424). Typically, towns do not require permits for strategic wood addition alone, but it is best to contact the town zoning or floodplain administrator. Projects on state-owned lands, agriculture, or silviculture may not be subject to municipal regulation but instead may require permitting by DEC under the Flood Hazard Area and River Corridor Rule. Projects that consist solely of strategic wood addition, when the project does not involve the placement of structures or other above ground improvements or earthwork that permanently alters ground elevations, are covered without a permit application (Non-reporting) under the Flood Hazard Area & River Corridor General Permit. If other restoration activities are planned beyond simply adding wood (such as culvert replacement or earthwork: berm removal, channel reconfiguration, or floodplain excavation), then a Flood Hazard Area & River Corridor permit application may be required.

Other Permits

This handbook is simply advisory and in no way negates existing statutes. It is incumbent on the strategic wood addition practitioner to be informed on the latest permitting requirements and processes. Most strategic wood addition projects will not require a consultation with a DEC Wetlands Specialist, but such a consultation would be prudent if the project has the potential to effect wetlands. The Vermont Fish and Wildlife Department (VTFW) does not administer any permits specifically related to strategic wood addition, but it should be consulted early in the planning process. The District Fisheries Biologist should be able to provide some insights on fish species present in the targeted stream reach and may be able to help evaluate the potential benefits of the proposed project on fish populations.

Estimating costs

Project costs depend on several factors including stream size, crew experience and quality, travel time to the project site, and whether the crew will be housed near the project site. There are also costs associated with planning and permitting before the project and monitoring and reporting, which could be required after the project. It is beyond the scope of this handbook to account for every possible project cost, but we provide some guidance that should be useful in roughly estimating project costs for the implementation phase of a strategic wood addition project on either a small stream, using chop-and-drop techniques, or on a larger stream, using chop-and-grip techniques.

Costs are lower on small streams. Chop-and-drop generally only requires a crew of two people, at least one of which must be skilled at directionally felling trees with a chain saw. A third crew member may be desirable for added safety and extra muscle for dragging trees and branches. If the project is occurring near a busy trail or road, additional crew may be necessary to ensure safety of passers-by. An experienced, motivated crew can complete approximately one mile of chop-and-drop with an average wood loading of about six pieces per 100 ft in approximately 30 hours. This figure does not include travel time to and from the site. Equipment needed by the chop-and-drop crew includes at least one chainsaw and associated tree felling equipment, fuel, oil, personal protective equipment, waterproof footwear, and first aid supplies.

Working on larger streams is slower work and requires more staff and equipment. A chop-and-grip crew can operate with as few as two people, but the work can be accomplished most efficiently with a crew size of four. An experienced and motivated crew of four can accomplish approximately one mile of chop-and-grip with an average wood loading of 4 pieces per 100 ft in approximately 50 hours, not including travel time. Less experienced crews or higher wood loadings may require significantly more time to cover the same length of stream. In addition to the equipment needed for chop-and-drop, chop-and-grip requires a grip hoist, cable(s), log chains, straps, pulley, and pry bars.

Target wood loading

A target wood loading should be established during the planning stages of the project. When establishing a target, the ideal and the practical must both be considered. The ideal target for most VTFW strategic wood addition projects is to have a final wood loading (including natural and added wood) of at least 160 pieces of large wood (>4" dbh) per bankfull acre of stream. This target was developed from Kratzer and Warren (2013), who found that brook trout populations increased with increasing wood loading when wood loading exceeded 80 pieces per acre. For the purposes of implementing this target in the field, it is best to convert the areal target to one that is based on stream length. For example, the target for a stream with a 10-foot bankfull width would be about 4 pieces of wood per 100 ft, 8 pieces for a 20-foot wide stream, and 12 pieces for a 30-foot wide stream (Figure 4).

These ideal targets are easy to reach on small streams, but increasingly difficult as stream size increases, both because the amount of wood increases substantially and because it becomes increasingly difficult to secure downed trees in the larger streams. Therefore, it is especially important to consider what is practical when establishing target wood loadings on the larger streams. Scouting the stream reach and visualizing the completed project can be very helpful in determining an attainable wood loading target. Visualizing includes asking questions about how many trees can practically be felled into secure locations in the stream and about how many trees can be cut without substantially affecting riparian forest functions.

The target wood loading should be compared with the actual wood loading as an average across the entire stream reach. Heterogeneity in stream morphologies and the streamside forest necessitate flexibility in localized wood loading. Some stream segments will receive much less than the target wood loading, while others will receive much more, but the average for the entire treated reach should meet the target.

Project Implementation

Tree selection

Strategic wood addition is usually implemented using streamside trees, so tree selection is already limited. It is further limited by three other considerations: shading, bank stabilization, and wildlife habitats. While it is difficult to implement strategic wood addition without at least some temporary effect on stream shading, it is possible to minimize the loss of shade with careful tree selection. It is preferable to use trees that are further from the edge of the stream and to minimize cutting of trees that directly shade the stream. Trees that are performing a bank stabilization function should not be cut because they are already providing benefits to stream habitat and function, and they are likely to fall into the stream naturally in the future. Finally, trees that provide significant habitats for wildlife should not be cut. Wildlife habitat trees provide cavities or other places for birds and mammals to nest, roost, or forage. These trees are especially important for bats, some of which are threatened or endangered. VTFW provides a brief training course that can help anyone to quickly and accurately identify potential bat roost trees. Depending on the location of the project, cutting trees between April 15 and October 31 has the potential to affect threatened or endangered bats. Consult VTFW to determine whether threatened or endangered bats are known to be present in the area and to schedule a roost tree identification training.

Figure 10. These spruce trees still have some branches after seven years.

Tree species differ in their utility and desirability for strategic wood addition. Hardwoods are usually preferred over softwoods because they are denser (less buoyant) and stronger than most softwoods. Spruce trees are more likely to float than hardwoods, but they have branches that are very effective at catching sticks and leaves, and these branches remain for several years after the tree is down (Figure 10). Hemlocks have branches that perform similarly to those of the spruce and are known for being rot-resistant. Cedars are also known for resisting rot, but they are very buoyant. Fir trees are one of the least desirable trees for strategic wood addition because they are buoyant and brittle, but it some cases, they are the only option. As beavers can attest, even alders can be used effectively on small or log-gradient streams. Alders and fir are often locally abundant, and both re-generate very quickly. While it is helpful to be aware of the different characteristics of different species, any tree species can be used for strategic wood addition, and the final selection often comes down to which tree is positioned in the best location where it can be efficiently felled into the stream in such a way as to benefit stream habitat and function.

Figure 11. Felling a tree from a high bank can add a lot of weight to a constructed logjam.

Size is another important consideration when selecting trees for strategic wood addition. Trees that are taller than twice the bankfull width are generally stable without additional manipulation and positioning, but smaller trees can be used if they are secured using techniques described under "chop-and-grip", or if a large tree is dropped on top of them. Large trees are especially valuable for strategic wood addition on large or high-power streams. High-power streams include those that are steep and/or incised. An incised channel will have a high bankfull depth, which increases stream power beyond what might be expected based on stream size and slope alone. One tactical advantage of working in streams with high banks is that the butts of the trees can often be left high up on the bank, thereby transferring more weight to the portion of the tree that is down in the stream channel (Figure 11). Felling a large tree from a high bank onto a constructed logjam can add a lot of weight, and therefore, stability. Large trees can also be helpful on stream reaches with wide floodplains or braiding. A tall tree can cover more of the floodplain and possibly more than one channel. Depending upon the landowner, the cutting of large, old trees could be controversial. It is advisable to discuss general tree selection concepts (i.e., species and size) with the landowner very early in the planning process.

Small streams: chop-and-drop

For strategic wood addition purposes, a "small stream" is one where the average tree height is at least twice the bankfull width. A downed, full-length tree in these small streams cannot float very far downstream before getting pinned against standing riparian trees, rocks, or other obstructions. In Vermont, streams with a bankfull width of 20 feet or less are generally considered small streams for the purposes of strategic wood addition. Small stream techniques can be used effectively on streams with a bankfull width of up to 25 feet or more, if stream power (i.e., bankfull depth and slope) is low or if some movement of downed trees is acceptable (e.g., no infrastructure at risk downstream).

Figure 12. A logjam created by felling several trees at one location on a small stream.

For the purpose of this handbook, chop-and-drop encompasses two main techniques. First, as the name implies, is simple directional felling of trees into the stream. Chop-and-drop is most effective when trees are dropped in clusters to create a logjam (Figure 12). Creating a logjam requires some forethought to decide the most strategic location and the best order for felling the trees.

Figure 13. A hand-placed log with a tree felled on top for ballast.

The second technique within the chop-and-drop category is hand placement of logs, which can be used to create step-pools. A small log, preferably a hardwood, is cut to length so that it will lay on the stream bed upstream of objects, such as boulders or stumps, that will prevent it from being pushed downstream by high flows. To prevent the log from floating away during high flows, at least one tree is usually dropped on top of the hand-placed log for ballast (Figure 13).

A great way to think about how and where to add wood to a stream is to consider what the natural wood looks like. Most small streams have at least some large wood in them already, and by observing that natural wood, practitioners can develop a sense for what added wood can accomplish in that stream and how to recreate those effects. The most dramatic examples of large wood in small streams

Figure 14. Intact logs at a former log drive dam site. These logs have been here for at least 100 years.

are often the step-pools that are created by logs that fell mostly perpendicular to flow and have retained enough sediment and organic material so that water now spills over the top of the log (Figure 6). Depending on the species of wood and how much of the log is submerged, these logs can remain in place for several decades or even centuries (Hyatt and Naiman 2001; Evans et al. 2011). In fact, VTFW and Trout Unlimited staff have found intact and sound pieces of wood from log drives nearly 100 years ago in northeastern Vermont streams (Figure 14). For this reason, it is important to get wood in direct contact with the streambed as much as is practicable. For example, a hand-placed log may remain functional in the streambed for decades after it becomes waterlogged and completely submerged, even if the ballast log rots away after a few years. Achieving at least partial water cover on downed wood can help to ensure that the wood becomes water-logged and, therefore, heavier and more rot resistant. Logs that are not in constant contact with water will cycle between wet and dry, thereby fostering fungal action and rot.

Moving logs into position can be a difficult task with a typical, two-person chop-and-drop crew. These small crews usually carry a few straps that can be used to wrap around a log to facilitate dragging it into position. A stout hardwood sapling can be cut and used as a pry-bar for rolling or sliding a log.

While it is easier to secure downed trees in small streams, the tight canopy can make it harder to get the trees down into the stream. Some smaller trees may need to be cut to make a path for a larger tree to come down. As always, minimize cutting so as to minimize impacts to riparian forest functions. The smaller trees can be added to the stream, where they can be pinned down by the larger tree.

The downstream end of the project should usually include a "strainer". A strainer is a large tree, ideally with plenty of stout limbs, that securely spans the stream channel from bank to bank (Figure 15). The strainer tree should be thick enough to avoid breaking during high flows, and both ends of the strainer should be securely upstream of a stump, boulder, or standing tree. The purpose of the strainer is to catch any wood that might be mobilized during high flows, thereby preventing that wood from reaching infrastructure or properties downstream.

Figure 15. A classic "strainer". Both ends of this large spruce are securely upstream of live trees.

Large streams: chop-and-grip

For strategic wood addition purposes, a "large stream" is one where average tree height is less than twice the bankfull width. In these streams, there is a much higher likelihood of large wood becoming mobilized during high flows. If the added wood is intended to stay where it was placed, additional steps are required to secure downed wood. For strategic wood addition purposes in Vermont, large streams typically have a bankfull width greater than 25 feet, but large stream techniques are sometimes warranted on smaller streams if stream power is high. Large stream techniques are sometimes used to construct the strainer at the downstream end of a chop-and-drop reach on smaller streams.

The techniques used on larger streams fall under the category of chop-and-grip, so named because it includes the use of a hand-operated, portable cable hoist (i.e., grip hoist) to position downed trees into configurations that will be secure during high flows. These techniques include wedging, spearing, bending, and rootwads (Figure 16). The wedging technique involves using the grip hoist to wedge downed trees between standing trees, stumps, or boulders. In spearing, downed trees or limbed logs are sharpened on one end and then speared into the bank by pulling with the grip hoist. In bending, the grip hoist is used to pull a tree over into the stream while leaving some of the roots attached. Before pulling the tree over, the roots on the front and back side of the tree are cut, leaving the side roots intact to help steer the tree and to secure it to the bank once it is down. This technique is more time consuming than using a chainsaw to fell the tree, but it may be useful when there are minimal options for securing downed trees by wedging or spearing. If all the roots are cut before the tree is pulled over, the entire tree, roots and all, can be freed from the ground and brought into the stream. This technique

a) Wedging

b) Spearing

c) Bending

d) Rootwads

Figure 16. Chop-and-grip techniques.

is even more time consuming than bending, but a whole tree is more stable in the stream than one that lacks the rootwad, and the rootwad can provide excellent and long-lasting cover for fish. If the project is permitted by USACE or if the grantors require it, digging around tree roots may require a consultation with the State Historic Preservation Office.

If the intention is to have downed trees stay in place on a large stream, randomly felling individual trees is not an option. Instead, clusters of two to ten trees are usually felled and manipulated to form structures, which are essentially constructed logjams. While these structures are not engineered, they do require some forethought to decide where and how to build them. There are two main schools of thought that can be used to guide structure placement and design: idealist and pragmatist. The idealist looks for locations where the stream habitat or morphology is the most in need of improvement and seeks to design structures for those locations that will most directly affect the needed improvement at that site. The pragmatist recognizes that wood is generally good for the stream wherever it is placed and is more concerned with how to get wood into the stream and secure it in place than with the ultimate function of the wood in the stream. The pragmatist often uses one of two approaches when designing structures. The top-down approach starts with identifying that one big tree that will go last on top of the structure and weigh everything down. The bottom-up approach starts by looking for a good place to secure a log on the streambed, such as a convenient place to spear a log into the bank. A spear is rarely left by itself, so the bottom-up approach also involves selecting other trees that can be felled on top of the spear for ballast. In practice, an experienced chop-and-grip practitioner is continually switching between idealist and pragmatist and considering both top-down and bottom-up approaches. To successfully place and design chop-and-grip structures, a practitioner must be flexible and adapt to the context of the specific site characteristics.

There are obvious similarities between chop-and-grip and chop-and-drop, and some considerations apply to both. A study of natural logjams occurring in the stream reach to be treated can help to inform optimal locations and designs for logjams constructed with either method. Also, the longevity and function of constructed logjams will be improved by including at least one log that can be pinned down on the streambed, where it can become waterlogged and integrated into the streambed. These logs may be placed by hand on small streams, but they are often speared into the bank on large streams. Of course, hand placement can also be used on large streams. In fact, one tactic that can be used to help the stream retain fine sediments and organics is to cut five to ten small softwoods (dbh less than 4") and lay them on the streambed before dropping much larger trees on top (Figure 17). These small trees often retain enough sediments to effectively bury themselves in just one year. In some situations, small trees and branches trapped or stuffed under larger trees can retain enough sediment to bring the stream bed and water up into contact with the larger, top log. Also, regardless of technique, a strong, secure strainer tree should be placed at the downstream end of the project area to catch any wood mobilized from upstream. A downstream strainer is not necessary if there is some other obvious place for mobilized wood to settle before reaching downstream infrastructure (Figure 18).

Figure 17. Softwood saplings, pinned under the top log, contributed to the formation of this sandbar over just two years.

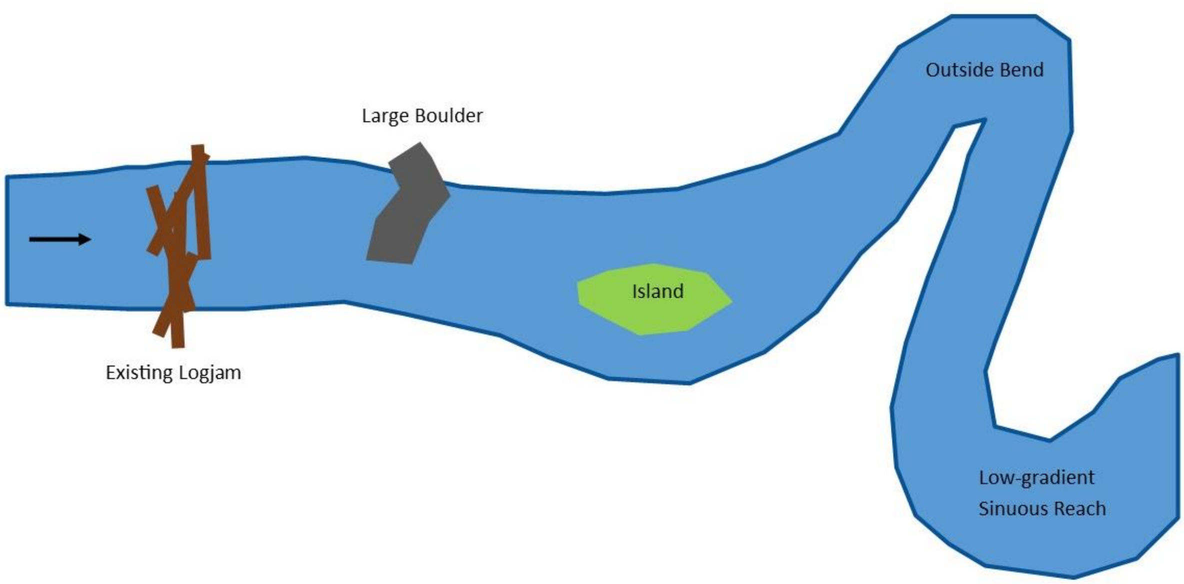

Figure 18. Typical locations for mobilized wood to settle.

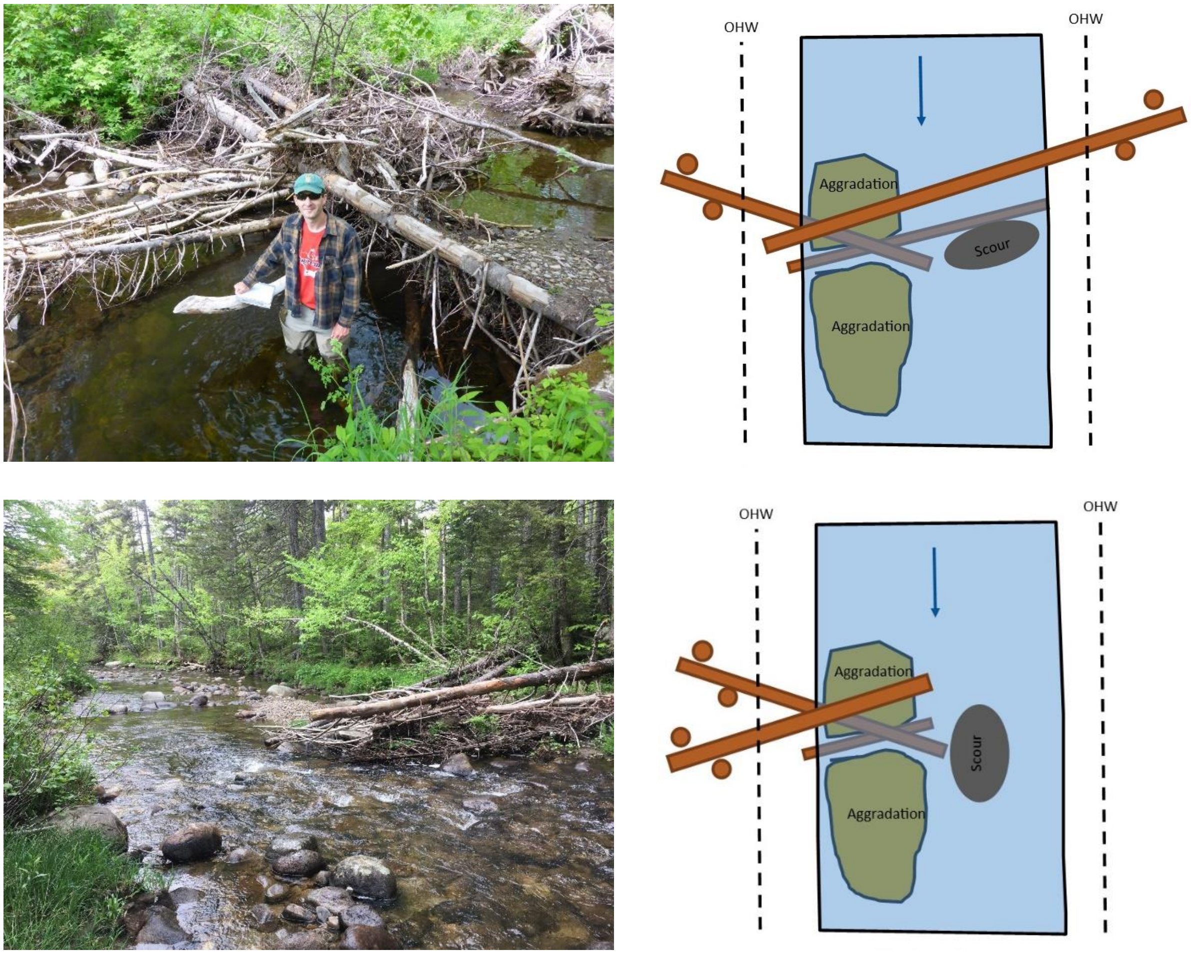

Figure 19. Examples of channel spanning and edge jam structures.

Logjams constructed using chop-and-grip techniques typically fall into one of two categories: channel spanning or edge jams (Figure 19). Channel spanning structures span the entire channel. It is only possible to build secure channel spanning structures when there are trees large enough to span the channel with enough girth to avoid breaking during high flows. Edge jams are constructed on just one side of the channel. Secure edge jams can be built on larger streams, even if trees are not long enough to span the channel. During the first winter after a structure is built, ice can build up on the branches of downed trees, thereby increasing risk that high spring flows will generate enough force to break the tree. This is especially likely with softwoods. Therefore, it is usually advisable to cut off the tops of edge jam trees to avoid having the tree break closer to the bank (Figure 20). With softwoods, it is usually best to cut the top at a diameter of four to six inches. Hardwoods can be cut at two to three inches. Ice can also help edge jams become more secure because it can help to lock several logs together, enabling them to brace one another against the first high flows of spring (Figure 21). There is strength in numbers.

Figure 20. The tops of these spruce trees were cut to prevent the river from snapping them.

Figure 21. Ice can help lock downed trees together in the winter.

The strength in numbers concept also applies at the reach scale. Spacing between structures is an important factor in the stability of individual structures. A logjam is much more secure if there are other logjams within 10 to 50 feet upstream and downstream. The upstream structure slows stream flow considerably before it hits the middle logjam. The downstream jam may also support the middle jam by essentially back-watering the middle jam, thereby reducing head at the middle structure. The more distance the stream has available to build up speed before hitting a logjam, the more rugged that logjam must be to endure. Therefore, maintaining tight spacing between successive logjams increases the overall stability of the project. This also means that the upstream most structure must be very rugged to withstand the brunt of high flows, including ice runs in the spring. Whenever possible, it is prudent to begin strategic wood additions in the headwaters and work downstream, thereby gradually slowing runoff from top to bottom. Placing the upstream end of the project at the downstream end of a bog or low-gradient reach can also increase the durability of the upstream-most logjams.

The grip hoist is a powerful tool for moving downed trees, but it is slow. It is usually best to fell trees as close to their final resting locations as possible to minimize the time it takes to drag the trees into position. Designing a structure and developing a plan for how to most efficiently build it come easier with experience. There is no substitute for time on the job to grow in these skill sets. One useful skill is to know when to use a pulley and how to rig it. If properly positioned, a pulley can double the force of the grip hoist. This is often necessary when driving a spear into the bank or when dragging an especially large tree (Figure 22).

Figure 22. A pulley can be used to increase force when driving a spear into the bank.

Post-implementation actions

A properly planned and implemented strategic wood addition project should not require maintenance. Added wood may move, but it usually does not move very far before being deposited on a natural logjam, constructed logjam, large boulder, outside bend, floodplain, or some other natural stream feature. Movement of large wood in streams is part of natural stream function. In the rare event that added wood manages to move to a place where it might threaten infrastructure or property, it should be removed from the channel or securely repositioned. It is sometimes beneficial to use the grip hoist to tweak the orientation or position of downed trees after the first high flow event has acted on a chop-and-grip structure.

The permitting agency and grantors may require a monitoring and evaluation plan, but even if they do not, some sort of monitoring is advised. The main benefit of monitoring is the opportunity to learn from the completed project: what worked and what did not. To maximize learning opportunities, VTFW marks each chop-and-grip structure with a numbered aluminum tag nailed into the top of one of the stumps. The GPS location of each structure is recorded along with the type of structure (channel spanning or edge jam) and the number of pieces of large wood in the structure. Each structure is photographed from upstream, downstream, and one stream bank. VTFW staff then revisit each structure the following summer and every one to two years thereafter to count the number of pieces of large wood present in each structure and qualitatively assess the functions performed by each structure. Potential functions include pool formation, retaining organic material, retaining sediments, providing cover, scouring streambed, narrowing the low-flow channel, and engaging the floodplain. If there are concerns about infrastructure, then monitoring may need to be more frequent, at least until the project site experiences a significant high flow event.

Logjams built using chop-and-drop methods are not monitored this closely because it is assumed that wood added on these small streams is very unlikely to move more than a few feet. Still, it is beneficial to walk treated reaches on small streams to critique the methods used and the apparent habitat and stream function benefits of the added wood.

Even if there is no time or funding to rigorously assess the performance of added wood, it is beneficial for strategic wood addition practitioners to periodically review their completed projects. It is most beneficial to visit the treated reach the following field season because most of the added wood that is going to move, moves during the first high flow event, which often occurs the first spring after project completion. The educational value of reviewing and critiquing one's own completed projects cannot be overstated. This is the best way to grow as a strategic wood addition practitioner.

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APPENDIX A: Contact Information as of June 2020

For more information on strategic wood addition or to contact a VTFW fisheries biologist:

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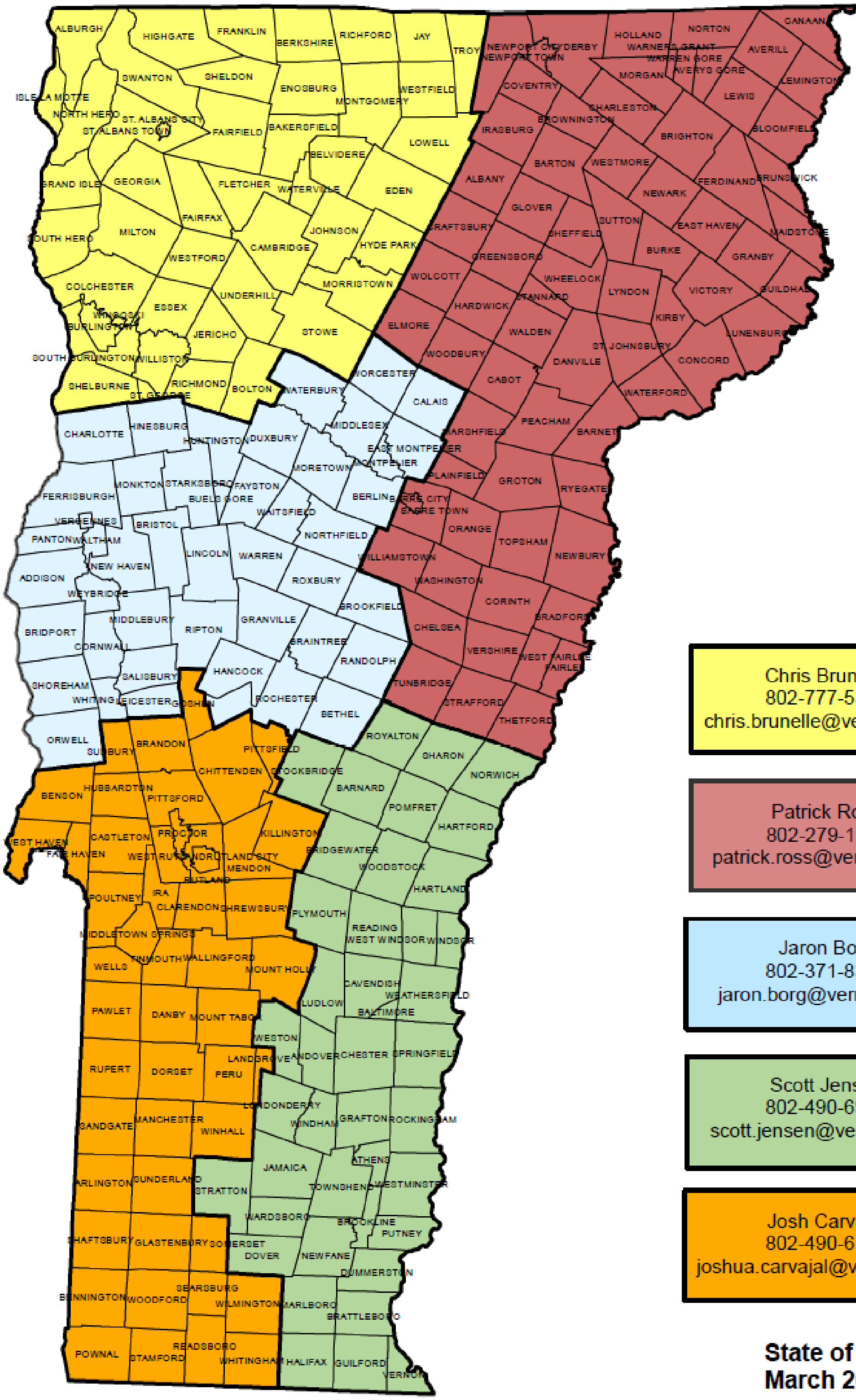
For relevant VT Department of Environmental Conservation staff, refer to the following maps:

ANR River Management Engineer Districts



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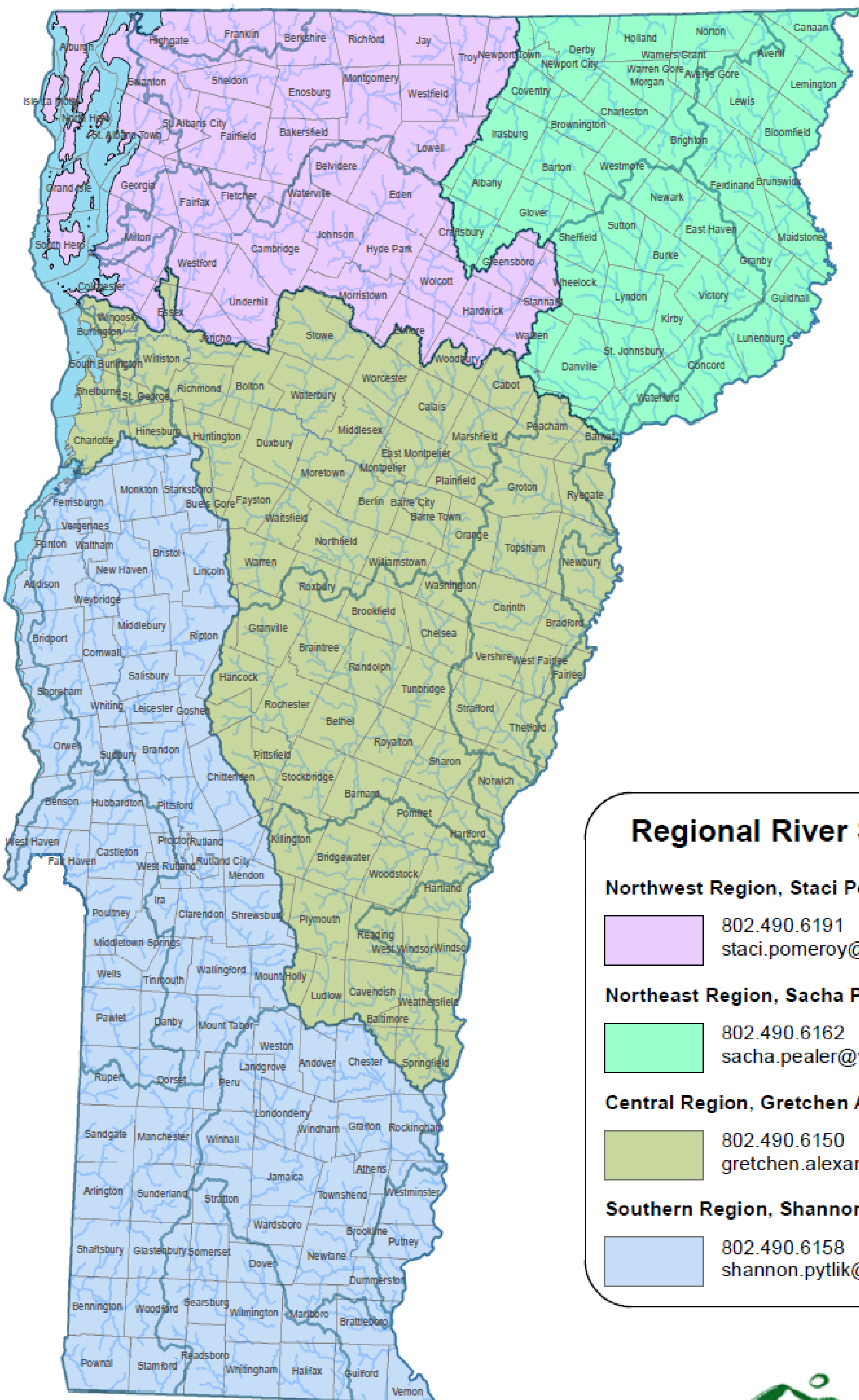
State of Vermont
March 2020

Vermont DEC River Scientist Regions



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Updated January 2016

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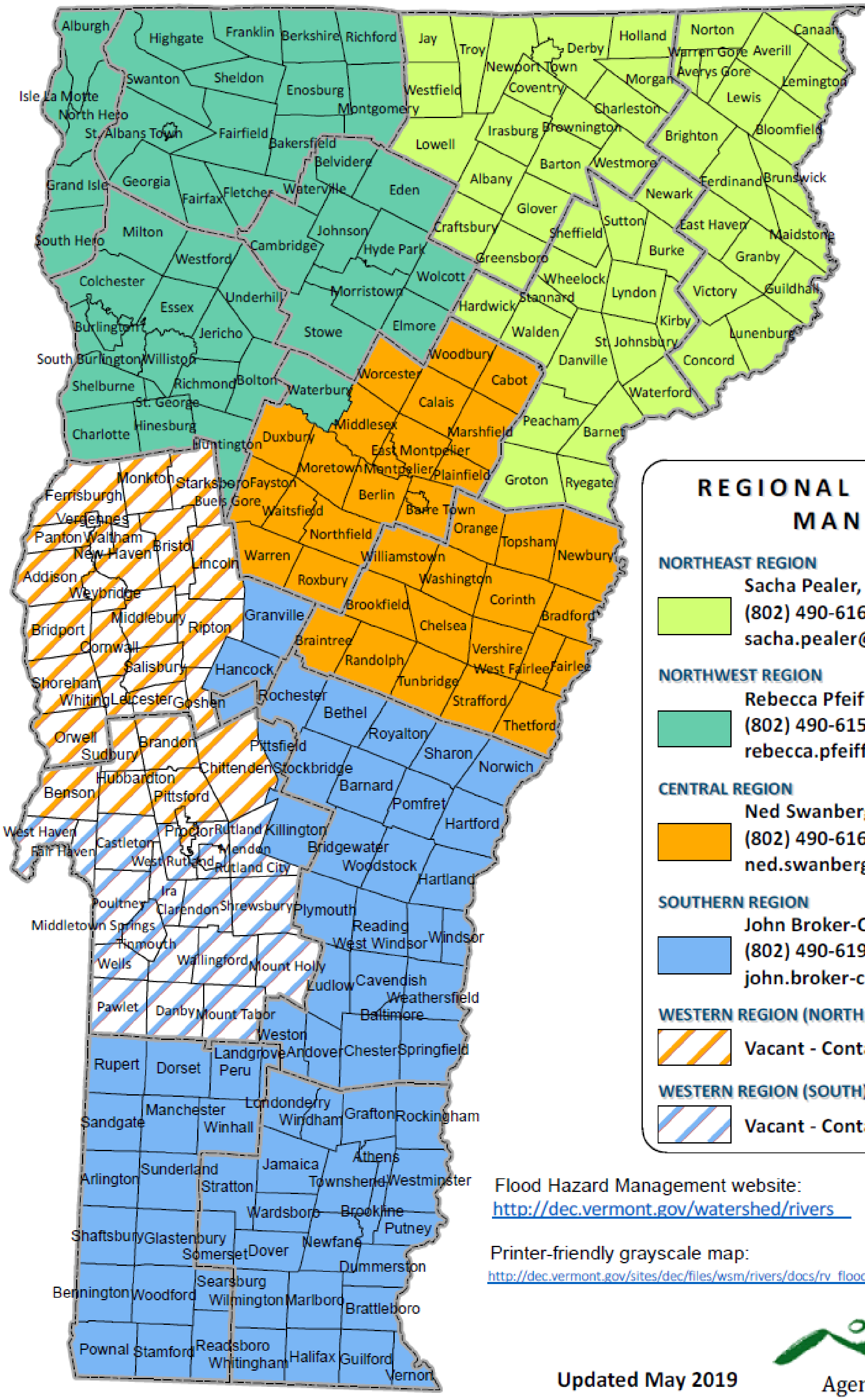
Agency of Natural Resources

Vermont DEC Floodplain Manager Regions



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WESTERN REGION (NORTH)

Vacant - Contact Ned Swanberg

WESTERN REGION (SOUTH)

Vacant - Contact John Broker-Campbell

Flood Hazard Management website:
http://dec.vermont.gov/watershed/rivers

Printer-friendly grayscale map:
http://dec.vermont.gov/sites/dec/files/wsm/rivers/docs/rv_floodplain_manager_regions_grayscale.pdf

Updated May 2019

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APPENDIX B: “Construction Typicals”

Strategic Wood Addition: East Branch and Southern Nulhegan River Watershed

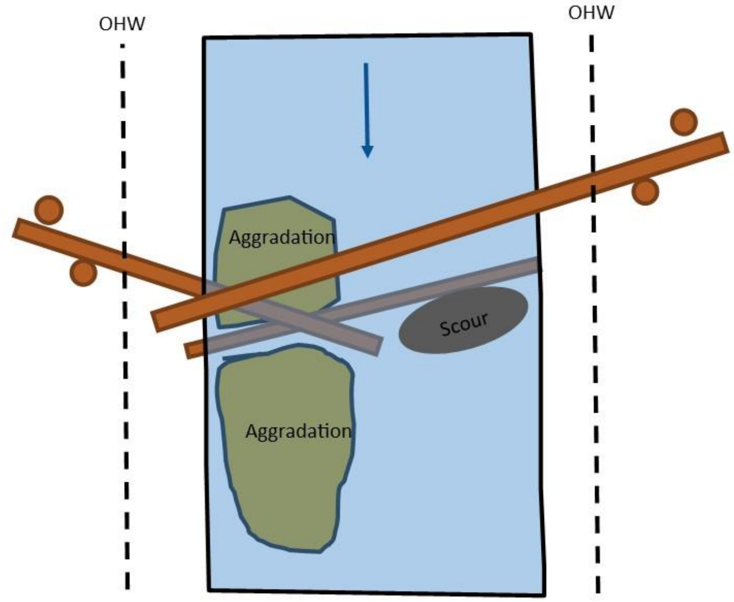
Jud Kratzer

Plan View and Cross-Section

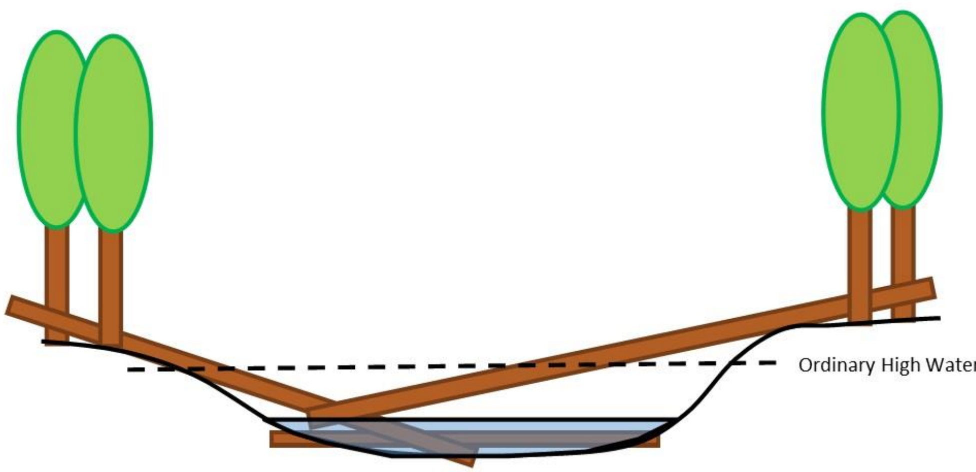
Figure 2: Typical strategic wood addition - “Channel Spanning Structure”

Drawn by Jud Kratzer, Vermont Fish and Wildlife Department

March 18, 2019



View from above



View from downstream

Strategic Wood Addition: East Branch and Southern Nulhegan River Watershed

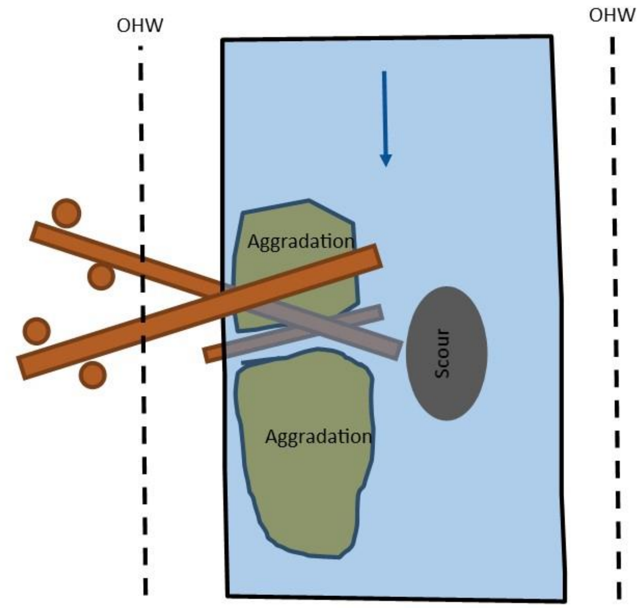
Jud Kratzer

Plan View and Cross-Section

Figure 3: Typical strategic wood addition - "Edge Structure"

Drawn by Jud Kratzer, Vermont Fish and Wildlife Department

March 18, 2019



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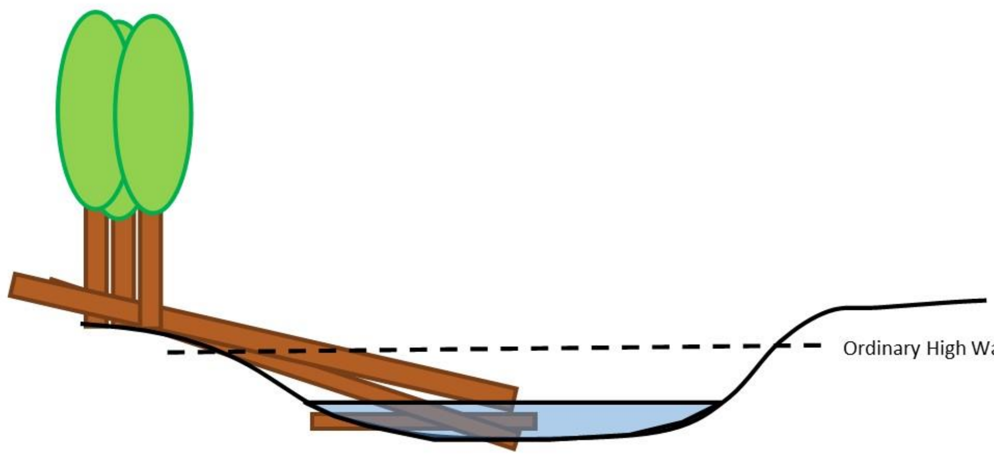


View from downstream

Strategic Wood Addition: East Branch and Southern Nulhegan River Watershed

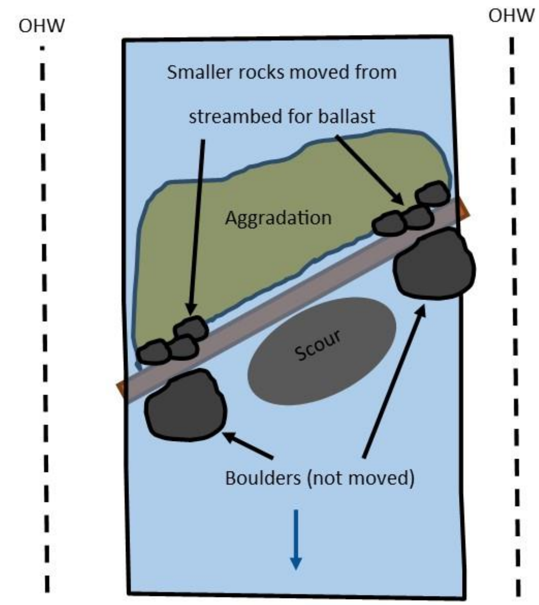
Jud Kratzer

Plan View and Cross-Section

Figure 4: Typical strategic wood addition - "Log Vane"

Drawn by Jud Kratzer, Vermont Fish and Wildlife Department

March 18, 2019



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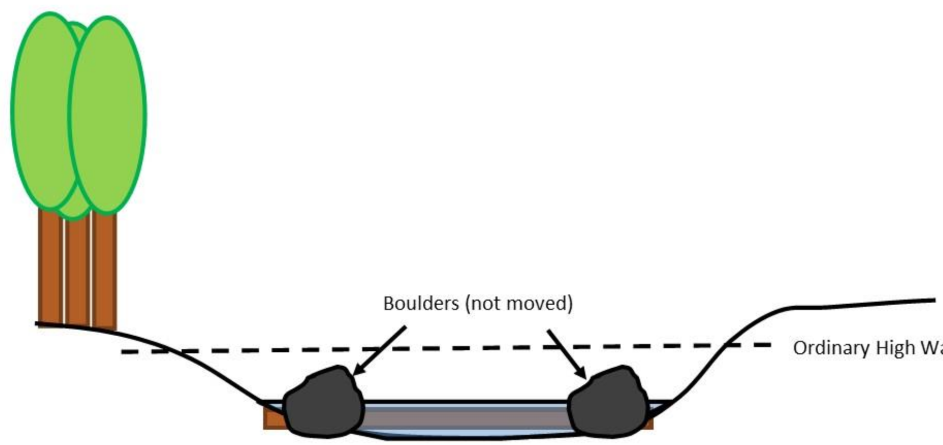

View from downstream

APPENDIX C: Datasheets

Trout Habitat Scouting Datasheet

Stream:		Date:	
		Crew:	

Segment #1 Photo numbers:

		Site #	Slope	BFW	Substrate*	Wood 100'	Notes:
Start Lat:							
Start Long:		1					
End Lat:		2					
End Long:		3					

Segment #2 Photo numbers:

		Site #	Slope	BFW	Substrate*	Wood 100'	Notes:
Start Lat:							
Start Long:		1					
End Lat:		2					
End Long:		3					

Segment #3 Photo numbers:

		Site #	Slope	BFW	Substrate	Wood 100'	Notes:
Start Lat:							
Start Long:		1					
End Lat:		2					
End Long:		3					

Segment #4 Photo numbers:

		Site #	Slope	BFW	Substrate*	Wood 100'	Notes:
Start Lat:							
Start Long:		1					
End Lat:		2					
End Long:		3					

*bedrock = bigger than car, boulder = basketball to car, cobble = baseball to basketball, gravel = pea to baseball

Strategic Wood Addition Recon Sheet Stream Reach: ______________________________ Page _____ of _____

Crew: ______________________________________ Date: ____________________________ Flows: ________________________________

Site #	Pool Forming	Catch Debris	Retain Sediment	Cover	Carve Streambed	Narrow Channel	Connect Floodplain	# Pieces	Notes