



## Definition and Purpose

Locked Logs are entire trees, large or small, with root wads attached, anchored under, or within, in-stream structures such as Bendway Weirs, Longitudinal Peaked Stone Toe Protection (LPSTP), or Longitudinal Fill Stone Toe Protection (LFSTP). The Locked Log is placed on the bed and the structure stone is placed on the locked Log, holding (or locking) it in place. The Locked Logs should be underwater at all times (if possible), angled downstream relative to the bank, and angled downhill while also protruding into deeper scoured areas. Locked Logs provide horizontal and vertical structure, hydraulic roughness, and areas of refugia for fish.

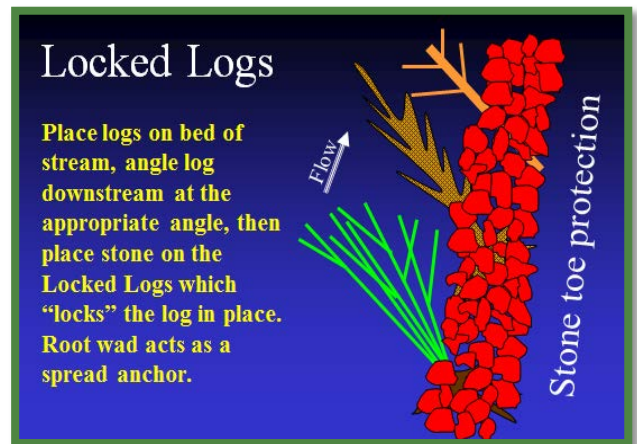


Figure 1: Locked Log Installation. Drawing by Dave Derrick.

***Locked logs can be placed with staggered heights to better slow water down at various flood stages. Proper hydrologic studies during planning are important in determining these levels.***



Image 1: Ice buildup around Locked Logs in Missouri River. Dave Derrick

These structures serve to partially realign the thalweg away from the eroding bank, reducing pressure from the stream's flow. This ultimately helps reduce bank erosion. An example of thalweg realignment can be seen during initial ice formation in some stabilization and/or restoration projects. Ice will form first in slower water and will become thicker than other areas. The thick ice near the bank will stay put after the "ice out" and will melt in place so that the plants are not sheared and smaller stones are not removed (plucked).

## Practice Applicability

The following are functions of Locked Logs/Locked Limbs:

- Provide turbulence, return currents, eddy fences, internal distortion, pressure zones, and flow complexity.
- Establishes diversity and complexity of velocities.
- Creates within channel refugia during high flow events.
- Provides in-stream overhead cover, and horizontal and vertical structure for fish.
- Creates feeding lanes for fish
- Provides solid substrate for benthics.
- Hydraulic roughness dissipates stream energy.



Image 2: Locked Log selection at Camp Miakonda in Sylvania, OH. Kyle Spicer

***Locked Logs, like all redirective methods, will usually reduce, but do not eliminate, bank erosion because the primary function is thalweg management and energy dissipation.***



Image 3: Thalweg realignment Locked Log in Ottawa River at Camp Miakonda, Sylvania, OH. Kyle Spicer

Locked Logs have been implemented all over the U.S.A. Several restoration projects in the Maumee River Area of Concern (AOC) are among those success stories. The Ottawa River bordering Camp Miakonda in Sylvania, Ohio, has multiple locked logs positioned within LPSTP and under Bendway Weirs, helping to reduce the scouring impact of the river on its eroding outer banks. By utilizing this redirective method, the quality and amount of in-stream habitat has increased, erosion to the bank was minimized, and the stream thalweg has been realigned. Other local restoration projects with LL include the Ottawa River on the University of Toledo campus and at Hill Ditch within The Toledo Botanical Gardens.

Methods typically combined with, or connected to, Locked Logs:

- Longitudinal Peaked Stone Toe Protection (LPSTP)
- Longitudinal Fill Stone Toe Protection (LFSTP)
- Bendway Weirs
- Project Bioengineering



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### Preparing for Locked Logs

Three questions should be deliberated in the preparation of or consideration in deciding to use Locked Logs or other wood structures in any configuration.

1. *If it stays, what will happen?*

Like any in-stream structure, keep in mind the structures can capture more debris than anyone might think. It's almost impossible to plan for everything that could flow through and potentially impact your structure, but you can identify the necessary precautions depending on your stream size and/or bend radii. Objects angled downstream and downhill typically collect very little debris.

2. *If it gets loose, or removed by the flow, what happens?*

No matter how much we plan, sometimes nature decides to have a little too much fun. It's important to consider where wood structures might end up and what infrastructure could be impacted.

3. *If it works, how long will it last?*

Keep in mind the project life expectancy. Locked Logs will last longer if they are completely submerged at all times. Slow growing hardwoods, or species of trees that farmers use for fence posts last the longest!

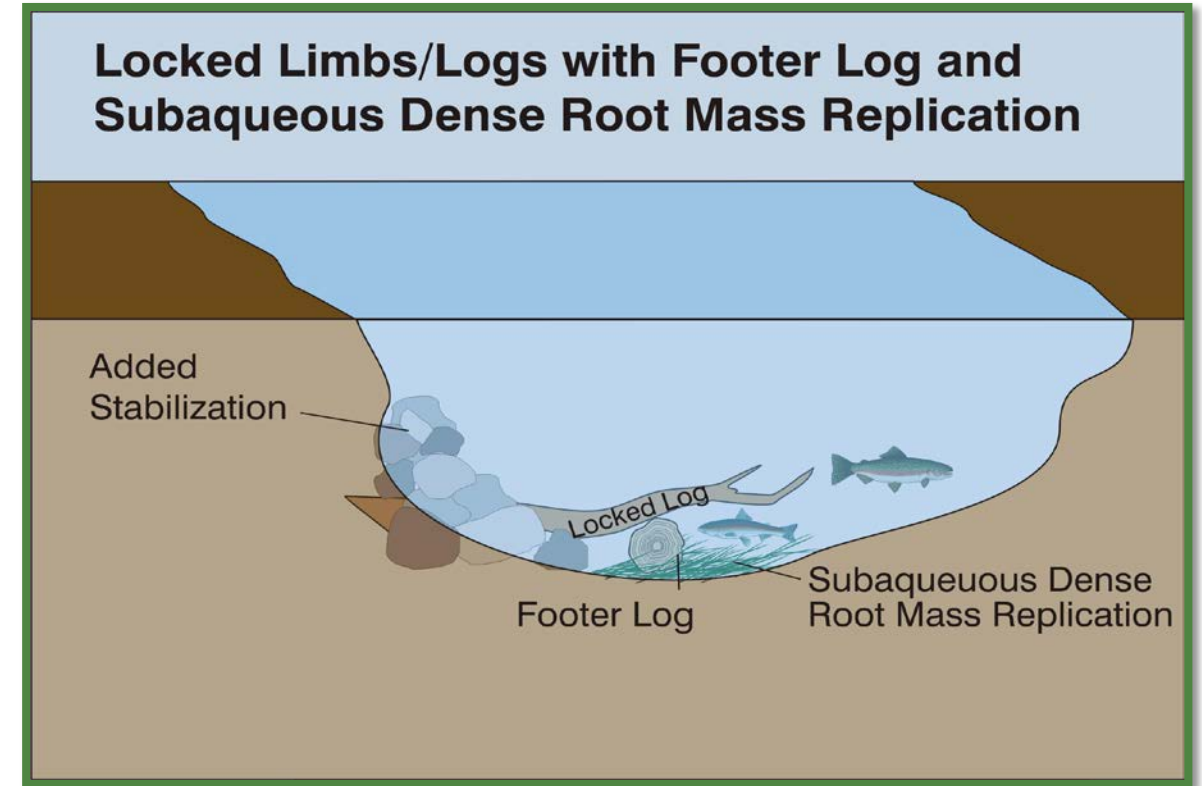


Figure 2: Locked Log design. Courtesy of Ecology and Environment, Inc.

### Limitations

- Sufficient depth is needed so that the Locked Logs are mostly underwater, even during base flow.
- Locked Logs are best used in medium to large streams, and up to the largest of rivers.
- Locked Logs can be used in medium to large radius bends, gentle curves, or straight stretches.
- Narrow, tight bends should be avoided.
- Locked Logs should not block more than 15-20% of the width of the stream or 15-20% of the channel cross-sectional area.
- In narrow stream applications, Locked Logs should not aim flow into the opposite bank (small angle relative to the bank).

### General Guidelines for Construction

- Locked Logs should always be angled downstream relative to the bank. To determine this range of angles, study patterns of downed trees moved by flow prevalent in local streams should be undertaken.
- Typical angles observed for medium-sized streams are 10 to 35 degrees downstream, relative to the bank. On the Missouri River near Vermillion, S.D., angles varied from 30 to 70 degrees downstream, so do your homework!!
- The spacing of Locked Logs is not critical, can vary, be random, follow observed spacing patterns, replicate natural wood deposition areas, or they can be placed in groups with "bare" areas in between.
- Denser placement will better realign the thalweg, further reduce near-bank velocities, and reduce damage from collisions between Locked Logs and floating Large Woody Debris.

Example Construction Sequence



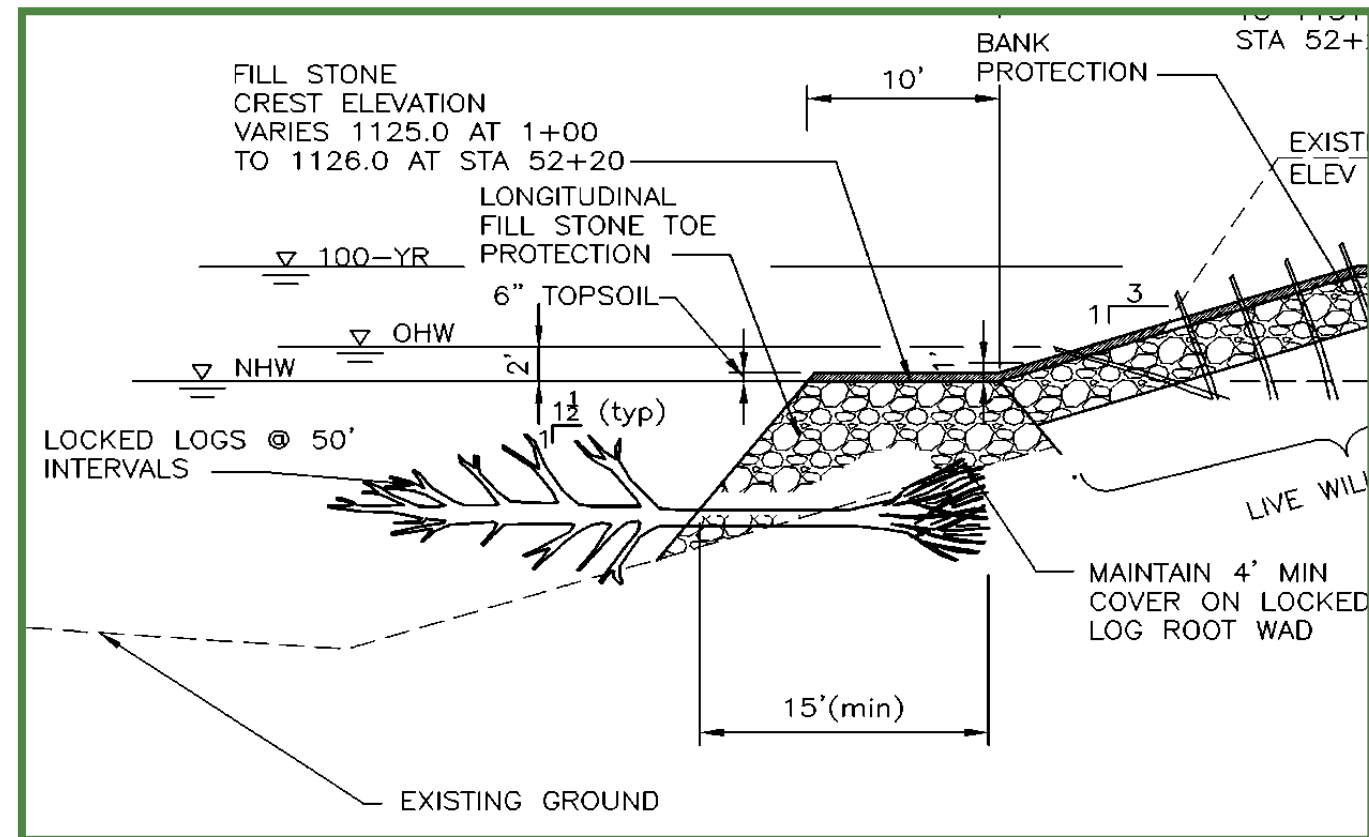
After securing the appropriate log (note branches and root wad intact), the contractor uses an excavator to position the Locked Log.

The Locked Log is placed root wad towards bank, with trunk into the stream and angled downstream. The LPSTP will cover and "lock" the root wad in place.

After the root wad is locked into place within the LPSTP, 3-4 ft of stone is placed over the root wad and lower tree trunk for further stabilization.

The completed structure. Upstream logs are actually naturally eroded trees that fell into the river, angled downstream by flow. Appear strikingly similar to the downstream placed Locked Logs!

Example Plan Drawing



Estimating Time and Materials

Typical locked log installations can benefit from usable materials existing within the project's proposed boundaries. Otherwise, obtaining entire hardwood trees (including root wad) can be somewhat difficult. Contacting local landowners, tree removal services, state departments of transportation, or environmental organizations might be necessary. Many times local landowners will be willing to work with you, especially if a tree presents itself as a current or future hazard.

Maintenance and Monitoring

Locked Logs require little maintenance; however it is important to monitor their condition within a year after implementation, especially during and after high flow events. Due to the nature of the structure, debris could be caught by the Locked Logs. It may become a concern over time, and action should be taken to remove any excess buildup. Like any wood structure, Locked Logs could become dislodged, and impact downstream. These should be removed immediately and work should likely be done to repair and/or replace the Locked Log.