RESISTIVE (CONTINUOUS) VS. REDIRECTIVE (DISCONTINUOUS) STREAMBANK STABILIZATION METHODS

Special Topic

RESISTIVE METHODS

Riprap revetment is an example of a **resistive method** of bank stabilization. The practice is designed to resist the destabilizing forces of flowing water. Resistive methods are also called continuous methods because they are usually **placed continuously** along the entire reach. These methods are typically applied directly to the bank, and are thus classified as direct measures. Riprap revetment is a proven and very effective means to protect infrastructure (roadways, houses, etc.) from laterally unstable river systems.

Figure 1. Riprap Revetment, Sacramento River, California. A form of resistive bank protection.

Resistive erosion control structures are intended to be more or less stationary; and secondary flow patterns are often created that scour the channel bottom at the toe of the structure.

Ultimately, the thalweg of the stream will be located along the toe of the bank protected by the resistive structure. Velocities tend to be higher in this part of the cross section, and a long, continuous scour zone will occur along the toe of the bank.

The high velocities, lack of substrate diversity, and the usual lack of cover and streambank vegetation make continuous, resistive structures unattractive from an aquatic habitat perspective.

Some examples of resistive methods:

- Riprap Revetment
- Grouted Riprap
- Sack Revetments
- **Rootwad Revetments**
- Lunkers
- **Articulated Concrete Blocks**
- **Longitudinal Stone Toe**
- **Trenchfill and Windrow (Setback Revetments)**

REDIRECTIVE METHODS

Intermittent (discontinuous) bank protection usually provides higher levels of physical diversity, and therefore, higher levels of habitat quality than continuous methods (Shields et al., 1995). These techniques can increase backwater areas, increase edge or shoreline length, and can result in diversity and complexity of depth, velocity (both vertical and horizontal), substrate and flow patterns.

Rating the habitat value of the resulting changes will depend on what ecological goals were initially set (either species specific or ecosystem-based goals).

Examples of **Indirect**, usually discontinuous, techniques that **redirect the flow** and energy of the river or stream away from the area of the eroding bank:

- **Vanes**. Vanes are angled upstream at an angle 20 to 30 degrees from bankline).
- **Bendway Weirs**. Bendway weirs are slightly upstream angled (10 – 15°), are designed to be overtopped by most flows, and are flat crested.
- **Cross Vanes** (vortex weirs)
- **Spur Dikes**
- **Rootwad Revetments**
- **Large Woody Debris Structures** (Abbe et al., 1997; Shields et al., 2001)

Figure 2. A stone bendway weir, an example of a redirective bank protection technique.

CHOOSING BETWEEN RESISTIVE (CONTINUOUS) AND REDIRECTIVE (DISCONTINUOUS) METHODS

If the resource the project is being designed to protect (highway, road, levee, pipeline, house, bridge, swallow habitat, etc) is in close physical proximity to the top of the streambank, then a continuous-type resistive bank protection method is necessary. Resistive methods that gain back some of the riparian area recently lost to bank migration, such as **Longitudinal Stone Toe** may be helpful. Properly positioned continuous bank protection should result in a smoothed bank alignment. As noted above, resistive techniques are generally less beneficial from an environmental standpoint, but environmental amenity may be added with the use of the following techniques:

- **Vegetation Alone**.
- **Live Staking**.
- **Live Fascines**.
- **Turf Reinforcement Mats**.
- **Vegetated Gabion Mattress**.
- **Cobble or Gravel Armor**.
- **Longitudinal Stone Toe with Spurs**.
- **Longitudinal Stone Toe**.

- **Erosion Control Blankets**.
- **Geocellular Containment Systems**.
- **Rootwad Revetments**.
- **Live Brush Mattresses**.
- **Vegetated Articulated Concrete Blocks**.
- **Vegetated Riprap**.
- **Soil & Grass Covered Riprap**.
- **Coconut Fiber Rolls**.
- **Vegetated Gabion Basket**.
- **Live Cribwalls**.
- **Vegetated Mechanically Stabilized Earth**.
- **Live Siltation**.
- **Live Brushlayering**.
- **Willow Posts and Poles**.
- **Trench Fill Revetment**.

If discontinuous-type, redirective protection methods (**Bendway Weirs**, **Vanes**, **Spur Dikes**, etc.) are used, then allowances must be made for some erosion between structures (also called bank scalloping), which leads to an uneven bankline. Biotechnical techniques, such as **Live Brushlayering**, **Vegetated Mechanically Stabilized Earth**, and **Live Siltation** can often be used to reduce or eliminate bank scalloping. Redirective techniques generally have more habitat value than resistive techniques (Shields et al., 1995).

WHERE DISCONTINUOUS AND REDIRECTIVE METHODS (INCLUDING BENDWAY WEIRS) ARE NOT VERY EFFECTIVE, OR ARE PRONE TO FAILURE

- Where the section of stream upstream of the proposed project is actively meandering.
- In small radius bends (radius to width ratios less than 4).
- In areas of impinging flow.
- Where continuous bank protection methods are needed (no luxury of space to allow bank scalloping) – however, in many cases, redirective methods can be effectively combined with continuous resistive methods (e.g. **Longitudinal Stone Toe with Spurs**).

WHERE BENDWAY WEIR USE COULD PROVE PROBLEMATIC

- In cobble or gravel bed streams, the redirective effects of **Bendway Weirs** are limited in the downstream direction due to the resistance of the bed materials. Resistive bed materials or substrate can prevent redirection of the thalweg (which is the objective of installing **Bendway Weirs**).
- In narrow streams (where base flow water width is less than about 15 m (50 ft)).
- Bendway weirs have not been tried in high velocity, steep sloped stream systems.

WHERE VANE USE COULD PROVE PROBLEMATIC

- Material requirements become excessive when vanes or other types of intermittent structures must be built in very deep waters (the volume of a structure with triangular cross section increases with the square of its height).

- In areas of impinging flow.
- In areas where rock is not economically attractive.
- In areas where rock is aesthetically undesirable.
- In areas where bank scalloping is unacceptable.

REFERENCES

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