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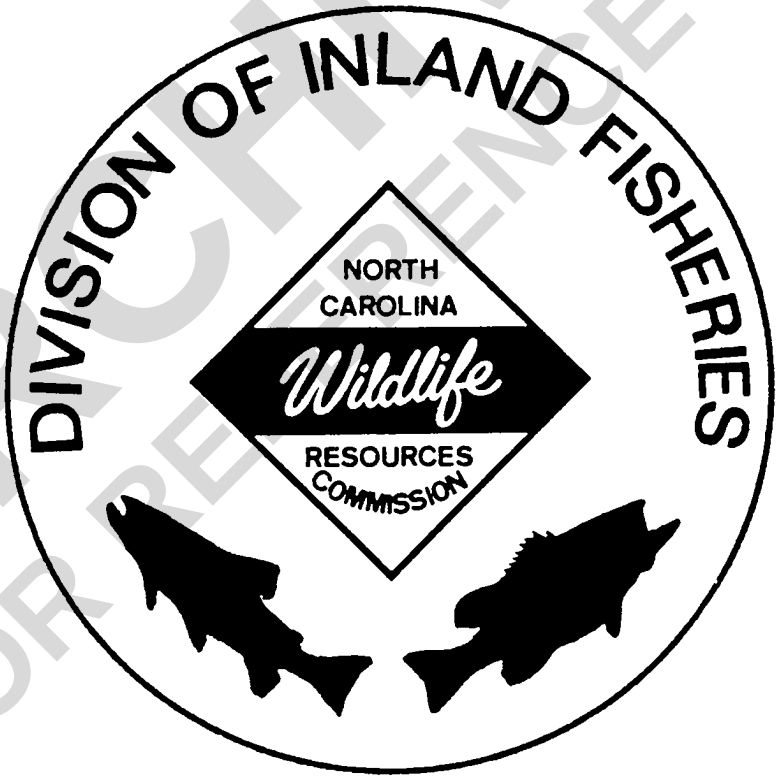

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GUIDELINES FOR MOUNTAIN STREAM RELOCATIONS IN NORTH CAROLINA

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INTRODUCTION

Relocations of North Carolina's mountain trout streams traditionally have been a routine practice during road construction. This practice has been extremely destructive to the state's fishery, wildlife and recreational sources, because proper environmental consideration was not given to these values during project designs. These values, however, must be included in future stream location decisions. It is recognized that some stream relocation is unavoidable, but damage to the abeam and its associated riparian vegetation can be mitigated with careful planning. Studies have shown that fish and wildlife resources can be maintained and even enhanced over those existing in the original channel, If careful planning and certain design criteria are utilized in relocating stream section.

The following criteria constitute the recommendations of the North Carolina Wildlife Resources Commission and are based on reviews of pertinent literature, field experience and consultation with representatives of appropriate stale and federal agencies. This report present standard guidelines for stream relocations which will facilitate road project reviews by the North Carolina Wildlife Resources Commission and assist engineers in designing projects.

These guidelines only cover normal relocation projects. Those projects which have unavoidable engineering problems, or involve highly productive or important trout waters will require special review and recommendations by trained fishery biologists. To identify the proper person for consultation, contact the Division of Inland Fisheries, North Carolina Wildlife Resources Commission, Raleigh, North Carolina 27611, phone 919-733-3633.

GUIDELINES FOR MOUNTAIN STREAM RELOCATIONS

1. Relocated channels should match original channel in length, slope and meanders unless topographic restraints preclude this construction.
2. Relocated channel width and depth may vary as did the old channel, but the new channel width (average) should be no more than 1 1/3 times the old channel width (average).
3. Banks of the relocated stream should have a slope that varies between 1:1 and 2:1 unless impossible because of topographic restraints (vertical cute, exposed bedrock or unstable soil types).
4. Riprap, or other suitable materials, should be used to stabilize relocated stream banks to the ten year flood level, or the top, whichever is lower. The upper portion of the bank should be covered with topsoil suitable for growing grass.
5. Vegetation will be planted on both sides of the stream according to standard landscape procedures unless this is prevented by topographic problems (vertical cuts or exposed bedrock).

    a. Grasses and forba will be seeded on the upper portion of the riprapped bank and on a buffer strip beyond the bank for a distance of 7-15 m (25-50 ft.). Recommended plants are fescue [Kentucky 31), red fescue, sericea lespedeza, shrub lespedeza, timothy, crown-vetch, Reed canary grass or other acceptable plants.
    b. Shrubs will be planted on the abeam bank (in the riprap J and/or near the top edge of the bank. Recommended shrubs include rhododendron, autumn olive and tag alder.
    c. Trees should be planted adjacent to the upper edge of the stream bank. Trees to be utilized are purple osier willow, dogwood, river birch, sycamore, black or yellow locust, serviceberry, hemlock, maple, oak and hickory. Dogwood and/or willow should be planted, when feasible, in the same area as the shrubs.

6. State right-of-way should extend a minimum of five stream widths beyond the top of each stream bank or to a maximum of 15 m (50 ft.), in order to protect the abeam from bordering development.
7. Fences will be installed on the state's right-of-way line to prevent cattle from grazing on the trees and shrubs in places other than established livestock watering areas.

8. Fence crossings for fishermen access will be constructed where fences exist between the road and the abeam. These crossings should be a maximum of 275 m (300 yds.) apart.
9. Parking arena should be provided near the fence crossing to allow for angler access to the abeam sections.
10. Streambeds, of tributaries entering an altered section, will be contiguous with those of the main run and will be sloped so as not to impede the upstream movement of fish. This slope should not exceed five percent unless an exception is approved by the North Carolina Wildlife Resources Commission.
11. If gravel, rubble, or bedrock is not present in the new abeam channel, a suitable substrate will be provided. The following mixture of atone will serve as guidelines for this substrate and should be at least .5 m (1.5 ft.) deep.

    25% - Coarse rubble -15-30 cm diameter (8-12 in.)

    25% - Fine rubble - 7.5-15 cm diameter (3~ in.)

    25% ~ Coarse gravel - 2.5-7.5 cm diameter (1-3 in.)

    25% - Fine gravel - 0.3-2.5 cm diameter (0.12-1 in.)

12. Culverts or abeam crossings should be designed to facilitate passage of fish during normal water flows. Bridges are the preferred type of structures for abeam crossings followed by open-bottomed box culverts, countersunk corrugated pipe and countersunk box culverts (Lauman 1978). These types of structures should be located in a manner to insure that the following conditions are satisfied:

    a. No sudden change in stream velocity will occur above, below, or in the structure.
    b. No structure is to be located on a curve in the abeam.
    c. Structures must be designed to fit the abeam, not the abeam designed to fit the structure (Lauman 1978).

In culverts longer than 45 m (150 ft.), the average water velocity at normal flow should not exceed 0.6 m/sec (2 ft./sec.) (Lauman 1973). In all culverts containing an artificial substrate, the bottom should be as rough as possible. Culvert size should be large enough to prevent pooling at the upstream end. All culverts will

be designed so that the entrance and exit from them is even with or below the natural streambed. Countersunk structures should have their bases 0.5 hi (1.5 ft.) below the streambed. Regular maintenance may be needed to keep the culverts clean.

13. All work on a relocated abeam will be completed before water is diverted into it.
14. Any relocated abeam section less than 30 m (100 ft.) in length will contain only random boulder placement as an instream structure.
15. Instream structures will be used for environmental and habitat enhancement. Recommended structures for implementation are as follows:

a. Boulders:

1. Will be randomly placed in thalweg (main channel) Fig. 4.

2. Will be angular and oblong.

3. The long axis will be 1/3 of the stream width or 1.5 m (5 ft.1. whichever is smaller.

b. Low water rock dams:

1. Will be designed to have an upstream arch (Figure 1A).
2. Rocks .5-1 m (1.5-3 ft.) in diameter will be buried a minimum of 0.3 m (1 ft.) in the streambed.
3. Will be designed to have the top of the large rocks 0.3 0.8 m (1-2 ft.) above it normal water level and sloping down to a maximum height of 0.2~0.5 m (.5-1.5 ft.) at the center of the dam (Figure 1B).
4. Will utilize two or more rows of rocks to install this device with the upstream row consisting of smaller rocks (Figure 1C).
5. All rocks in the dam should be keyed (hand-placed) to each other to increase stability.
6. Each end of the dam should be contiguous with the bank riprap (Figure 1B).

c. Stone and rock deflectors:

1. Will be used in relocated stream sections greater than 30 m (100 ft.) in length.

2. Will be shaped in a 30 e0-80 degree triangle with the 30 degree angle to be upstream and against the Hank (Figure 2A). In cases where there is less than five abeam widths between the double wing and single wing deflectors, eliminate
the last single wing deflector.
3. Stone and rock will be a minimum of 0.5 m (1.5 ft.) in diameter, while in larger channels, rock up to 1.5 m (5 ft.) in diameter may be appropriate.
4. Stone and rock in the deflectors will be dug into the abeam bottom a minimum
of 0.3 m (1 ft.).
5. Top of rocks in the deflectors (near bank) will be approximately 0.3 m (1 ft.) above the normal abeam flow and sloped to 0.2 m (.5 ft.) at the apex of the deflectors. (Figure 2B).
6. Stone and rock in deflectors will be contiguous with the bank riprap. (Figure 2A).
7. Deflectors will be located five stream widths apart. All measurements will start at the downstream end of the relocated abeam.

8. Deflectors:

a. Single wing - The single wing deflector will extend one-half of the way across the abeam {Figure 2A).

b. Double Wing - The double wing deflector will extend one-quarter of the way across the stream, will be opposite each other and the narrowest point between the deflectors will be one-half of the stream width (Figure 3).

c. Deflector pattern - The first and last deflector in a relocated channel will be a double wing, with the general pattern to be double wing, single wing, single wing, double wing, single wing, etc. Placement of deflectors in a meandering stream will follow the pattern as depicted in Figure 4. (Note: Deflectors are not to be placed on outside cures.) The method of implementing these structures is shown in Table 1.

Table 1. Implementation of instream structures on relocated streams.

Low Gradient Streams (slope less than 1.5%) **Structure**	**Stream width in meters (approximate feet)** **Less than 5.0 (15)**	**5.0 – 9.0 (15 - 30)**	**9.0 – 15.0 (30 – 50)**	**Over 15.0 (50+)**
Boulders	3 boulders randomly placed in thalweg below deflector	6 boulders randomly placed in thalweg below deflector	9-12 clumps of 3 6 boulders randomly placed in thalweg below deflector	12-25 clumps of 3 boulders randomly placed every 30 m (100 ft.)
Deflectors	Single and double wing	Single and double wing	Single and double wing	---
Medium Gradient Streams (slope 1.5 – 6.0 %) Boulders	3 boulders randomly placed in thalweg below deflector	6 boulders randomly placed in thalweg below deflector	9-12 clumps of 3 boulders randomly placed in thalweg below deflector	12-25 clumps of 3 boulders randomly placed every 30 m (100 ft.)
Deflectors	---	Single and double wing	Single and double wing	---
High Gradient Streams (slope more than 6.0%) Boulders	Boulders randomly placed 7.5 – 15.0 m (25-50) apart	Clumps of 2 – 3 boulders randomly placed 7.5 – 15.0 m (25 – 50 ft.) apart	---	---
Deflectors	Located 25.0- 30.0 m (80 – 100 ft.) apart	---	---	---

See guidelines for mountain stream relocations, item 15 for details.

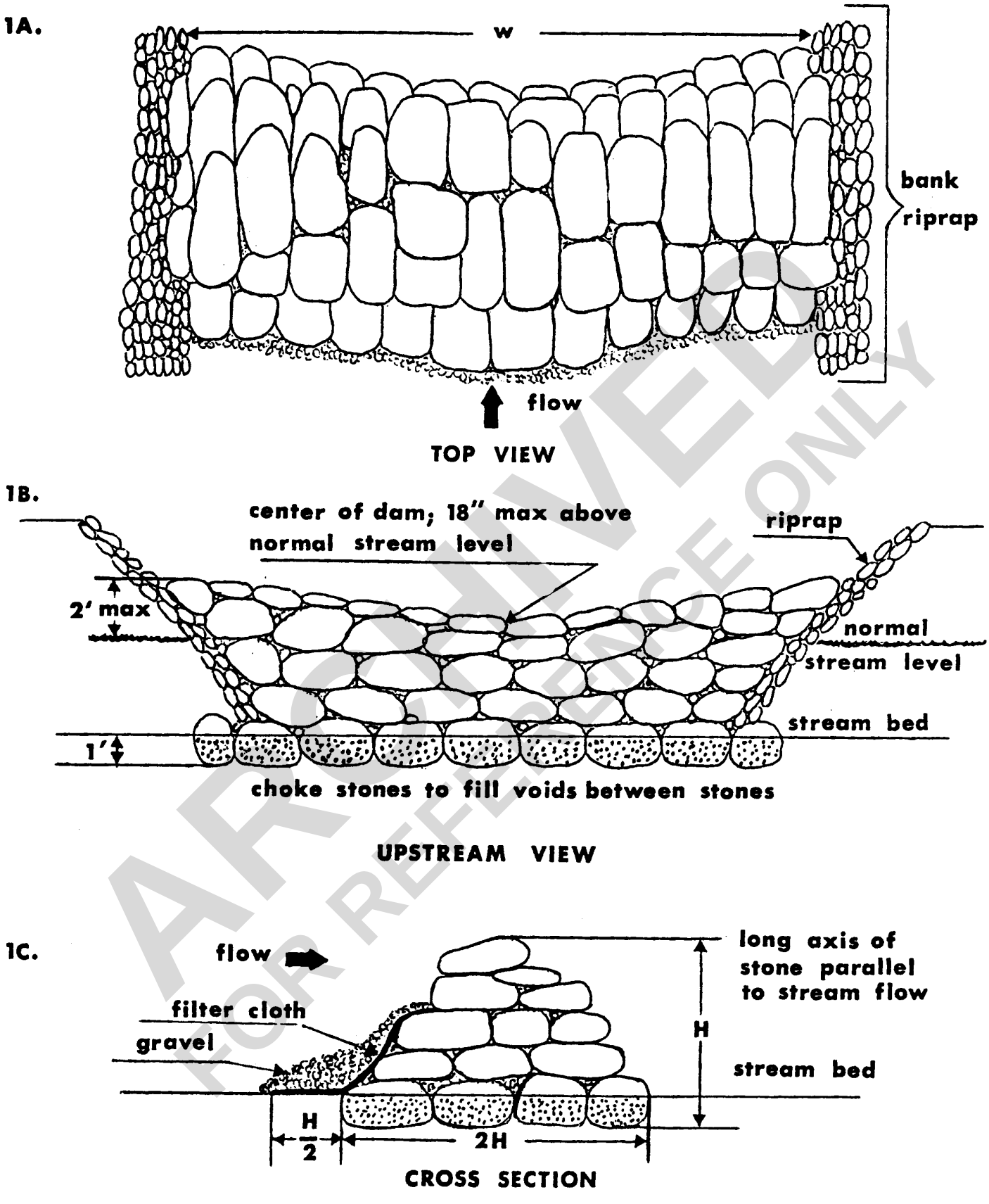

Figure 1. **ROCK DAM**

Figure 4. General deflector pattern. (Not to scale)

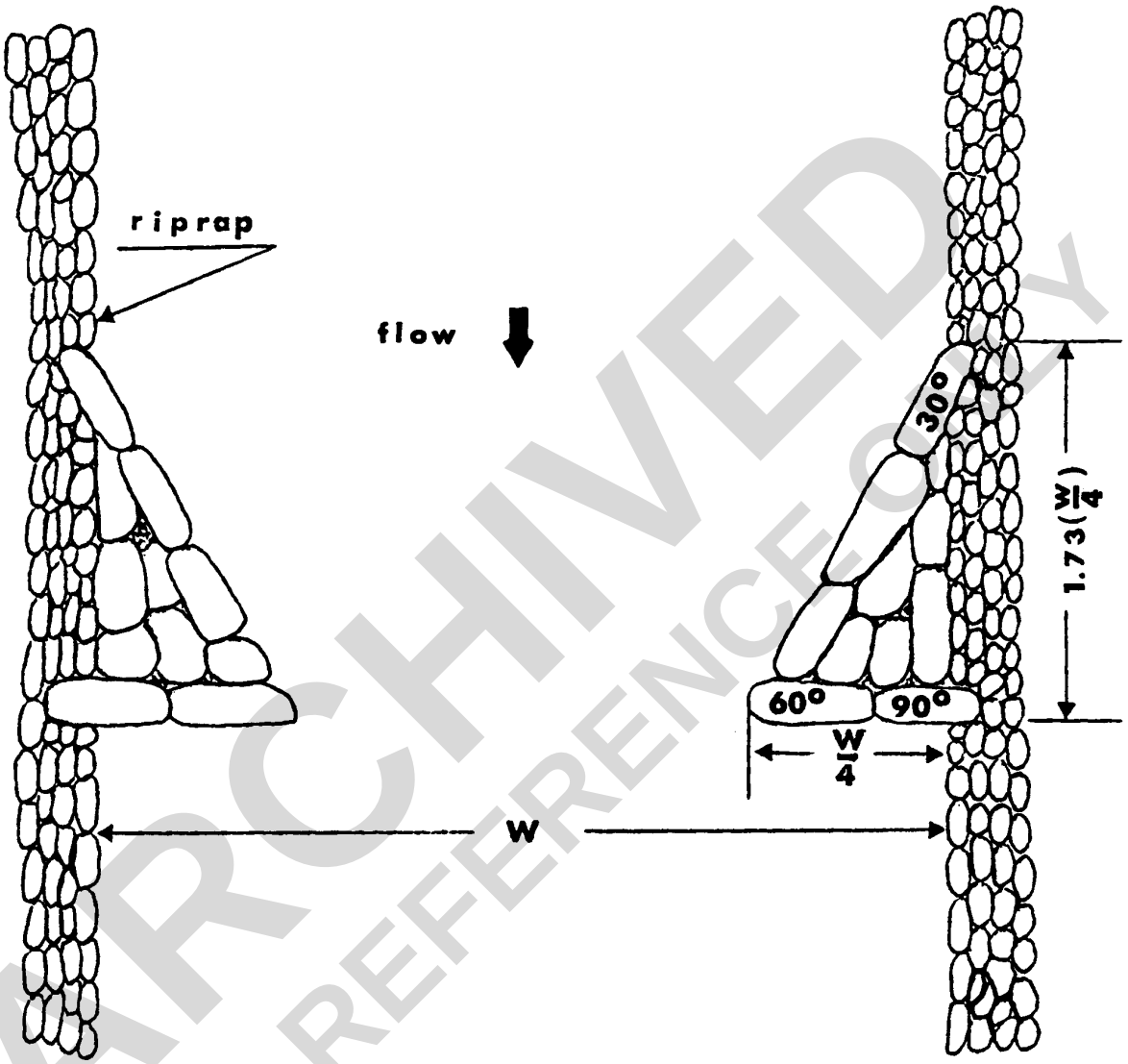

Figure 3. **DOUBLE WING DEFLECTOR**

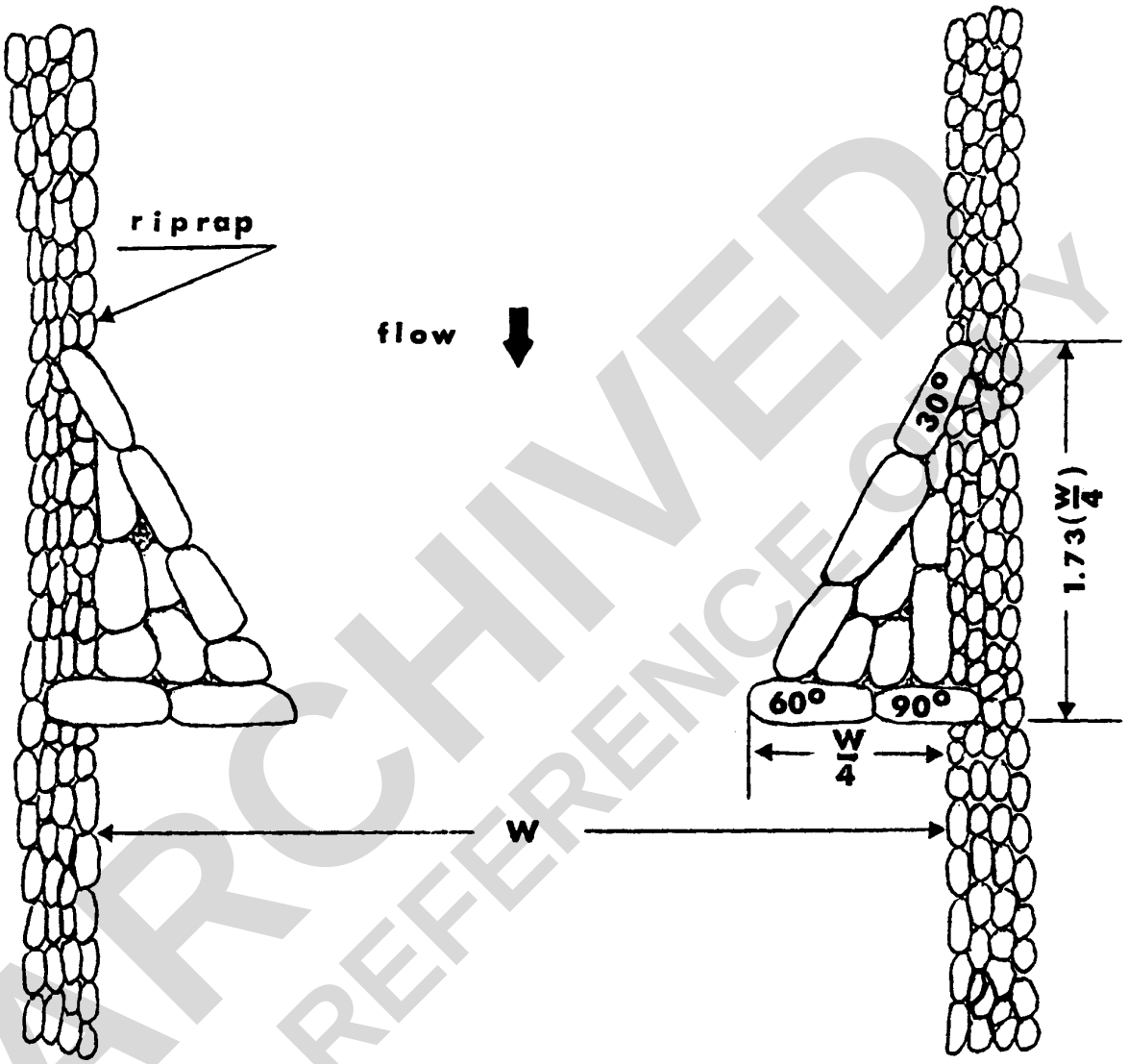

Figure 3. **DOUBLE WING DEFLECTOR**

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