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ENGINEERING TECHNICAL NOTE NO. NM-2

SUBJECT: ENG – Livestock Water Access and Ford Stream Crossings

Purpose: To distribute information to the field.

Effective Date: Effective when received.

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A livestock water access or ford stream crossing is a trail or travel way constructed across a stream or at a water access point that allows livestock to cross or to drink with minimal disturbance to the streambank and channel.

Livestock water access and ford stream crossings are used to:

- prevent or minimize water degradation from sediment, nutrient and organic loading.
- protect the watercourse from restricted capacity, degradation and adverse hydrological impacts.
- protect the land from streambank erosion.
- provide a means for livestock to cross a watercourse or provide a stable area to drink from the stream.

This practice may be used for all land uses where an intermittent or perennial stream exists and a crossing or access point for livestock is necessary.

A handwritten signature in blue ink that reads "Roger Ford".

ROGER FORD
State Conservation Engineer

Attachment



LIVESTOCK WATER ACCESS AND FORD STREAM CROSSINGS

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This practice may be used for all land uses where an intermittent or perennial stream exists and a crossing or access point for livestock is necessary.

Stream crossings (Figure 1) or access points (Figure 2) should be located in areas where the streambed is stable. Where practical, crossings should be located just upstream or downstream of any natural barrier such as a rock seam. Avoid sites where:

- channel grade or alignment changes abruptly
- the channel bed is unstable
- over falls exist
- large tributaries enter the stream
- there is a newly located or constructed channel, or
- immediately upstream or downstream of a culvert or bridge
- water velocity and depth are excessive.



Figure 1. Stream Crossing



Figure 2. Livestock Access Point

It is not recommended to install a crossing or access point if the product of the depth x velocity is greater than six. In this case, a bridge crossing should be considered.

Crossings or access points should be installed perpendicular to the direction of the flow of the stream, preferably at the midpoint between the stream meanders (riffle section). Special care should be taken to harden the width and depth of bank full stream channel dimensions in order to maintain long-term health and proper stream function. Bank full is based on the 1-1/2 year return interval. Do not disturb the stream channel upstream or downstream of the crossing during installation of a stream crossing. Avoid polluting streams during construction. Temporary diversions may need to be installed to avoid excess sediment transport.

Shaping of the entrance and exit approaches may be all that is necessary if bank and channel is comprised of .5 inch diameter or larger materials.

GENERAL DESIGN GUIDELINES

Establishing Grades

Sub grade and finished surface grade are critical factors in the design of a properly functioning crossing or access point. Materials should be placed in excavated sub grades, which are below potential scour lines.

Geotextile Filter Fabric

Geotextile should be installed on the excavated surface of the ford according to specifications. The geotextile should extend across the bottom of the stream including 20 feet of approach on each side of the stream. Geotextile may be omitted in streambeds with stable rock, gravel, or cobbles. All edges of the geotextile should be keyed as described under construction specifications and manufacturer's recommendations.

Geotextile filter fabric should be woven or non-woven, needle-punched, geotextile fabric with a minimum tensile strength of 180 pounds (minimum average roll value).

Longitudinal ends of the geotextile filter fabric should be lapped back over the top of the backfill toe trench a minimum of one foot beyond the edge of the trench. The ends should be anchored to the fabric using anchoring pins placed on five-foot centers. When more than one width of fabric is required, the downstream panel should be installed first. The next upstream panel should be installed with a minimum of 18 inches overlap over the first section. Anchoring pins should be installed on 3-foot centers, 6 inches from the downstream edge of the lap. Pins should penetrate both sections of fabric in the lap.

Every precaution should be taken to not tear the geotextile filter fabric. Tears should be repaired immediately by removing all surface material and soil from the tear, for a minimum distance of 18 inches, in all directions from the tear. Spread a new section of fabric over the cleared area and anchor with anchoring pins around all sides.

Where stream channels are composed of a stable coarse rocky material or solid bedrock, the requirement to extend filter fabric across the channel bottom may be waived upon the approval of the engineer.

Anchoring Pins for Geotextile

Anchoring pins should be fabricated using No. 3 reinforcing steel or material of equivalent or greater size and durability. All anchor pins should be installed with the top width lying perpendicular to the direction of flow in the stream. Pins should be driven vertically into undisturbed soil to provide maximum resistance to removal.

Anchoring pins should be installed through all overlapped filter cloth at all excavated trenches and across the channel bottom widths on approximately 3-foot centers. For crossings using only one width of fabric, plan to use a number of pins equal to 0.85 times the total length of the crossing from entrance to exit end. For crossings using two widths of fabric, use 1.3 times the total length

Example: Stream crossing 80 feet in total length using two adjacent strips of 15' wide fabric for a crossing width of 20 feet. Minimum number of pins is 1.3 times 80 feet for 104 pins. Recommend 110 anchor pins.

Care should be taken not to rip the fabric while installing anchor pins. Pins should be sharpened to permit easy penetration through the fabric. Also, the fabric will fit tightly around anchor pins with sharpened ends. If a pin must be removed, plug the opening with a wadded ball of fabric filter cloth.

Light weight wire staples such as used to anchor mulch netting may be used to hold filter cloth in place temporarily while construction is in progress. Such staples cannot substitute for anchor pins.

Elevation

The design sub grade and finished surface are determined by analysis of the stream channel profile upstream and downstream of the proposed crossing location. The finished (top) surface of the stream crossing in the channel should not be higher than the natural stable channel grade line. If the top surface is above the stable grade line, the surfacing material may wash off. It is recommended that the final finished surface should be approximately four inches below natural channel grade.

Width

Width is defined as the crossing surface and does not include the side slopes. "Livestock only" crossings may be as narrow as 6 feet wide. Multi-use crossings should be no less than 10 feet and no more than 20 feet wide in the upstream-downstream direction.

Side Slopes

All cuts and fills for the stream crossing should have side slopes that are stable for the soil or soil material involved. Side slopes of earth fills should be no steeper than 2.5:1. Rock fills should be no steeper than 1.5:1. Cut slopes should be no steeper than 2.5:1 unless in rock or hard shale, in which case they should be no steeper than .5:1.

Entrance and Exit Approaches

The entrance and exit approach is defined as the terrace elevation to the five-year rainfall event surface elevation, where it exists. Materials will be used which are equal to the channel bottom materials from the channel bottom to the five-year frequency storm or terrace elevation (whichever is less). Use surfacing material (minimum 6" thick) and geotextile fabric, where necessary, from the five-year to the terrace elevation (if exists).

Entrance and exit approaches to the crossing or access point should blend in with existing site conditions where possible, but should not be steeper than 5:1. The entrance and exit approaches should be underlain with geotextile filter fabric and covered with a minimum 6 inches of crushed gravel. The minimum width of the approaches to the structure should be equal to the width of the structure.

Where necessary, a surface flow diversion should be installed across the entrance and exit of the travel way to prevent sediment-laden runoff from entering the stream (See Figure 3).

Fencing

If necessary, stream channel areas above and below the stream crossing should be fenced to prevent livestock access to the stream except at the crossing or access point (Figure 2). Fence posts along each side of fords should be installed inside the area covered with geotextile filter cloth and stone. Fence posts with sharpened ends should be driven through the filter cloth, in the center of the toe trenches, along the side of the crossing.

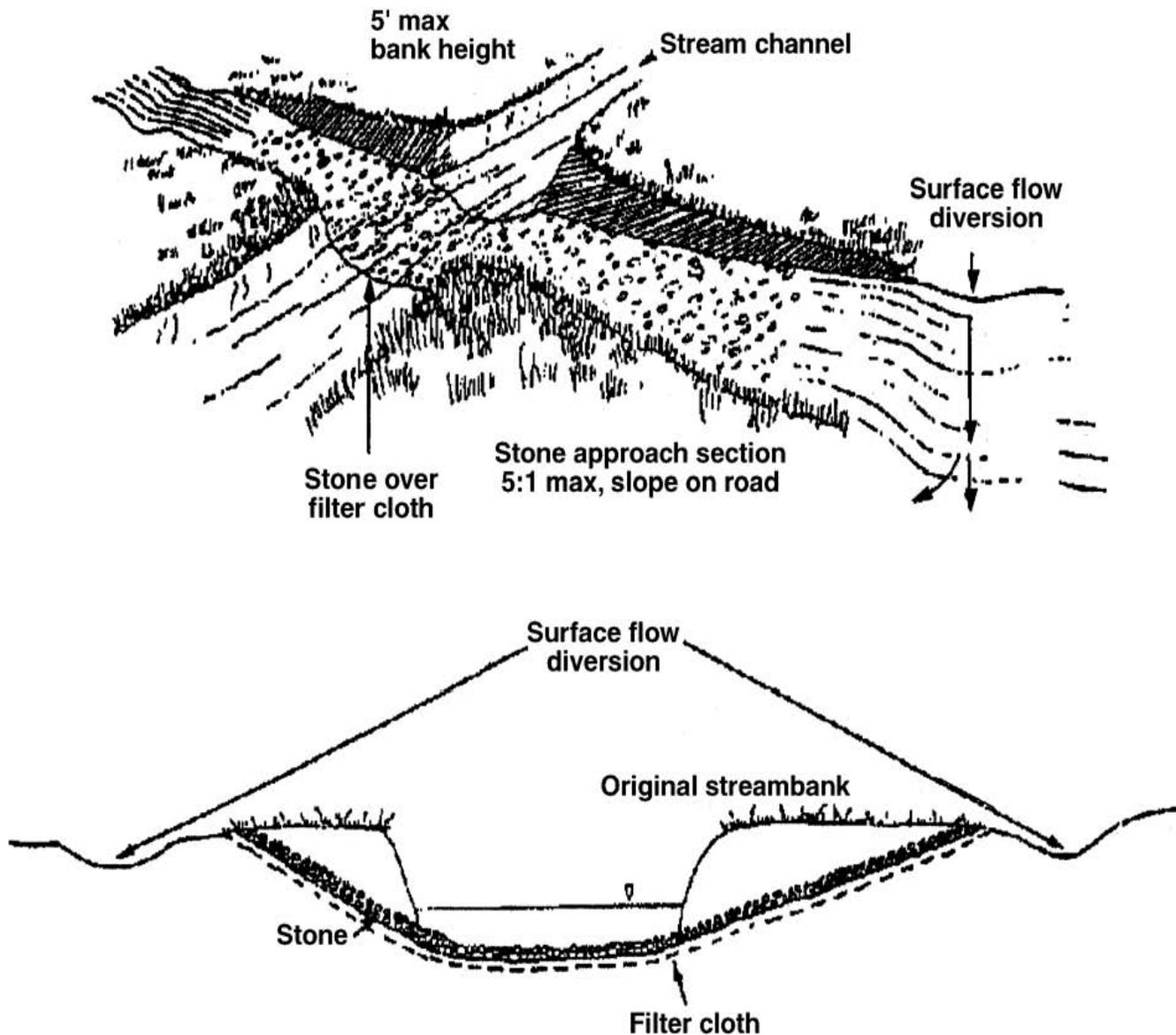
A "break-away" fence may be installed across streams where damage from runoff is likely to occur. The fencing wire should be placed on the downstream side of the posts on each fence line. Strands of wire should not be continuous across the crossing, but should be cut and secured lightly to the posts so a buildup of trash will pull the wire away from the post, allowing the trash to move downstream.

In lieu of "break-away" fences, other appropriate means of preventing livestock access to the stream, such as swinging gates, electrified chains, or other control measures may be used.

Safety

The specifications contained in this practice pertain primarily to flow capacity and resistance to washout of the structure. A gauging rod should be installed at ford crossings to determine depth of flow and safety for crossing. Crossing should not be installed where water velocity and depth are excessive.

Figure 3. Stream Crossing



Fords Using Stone

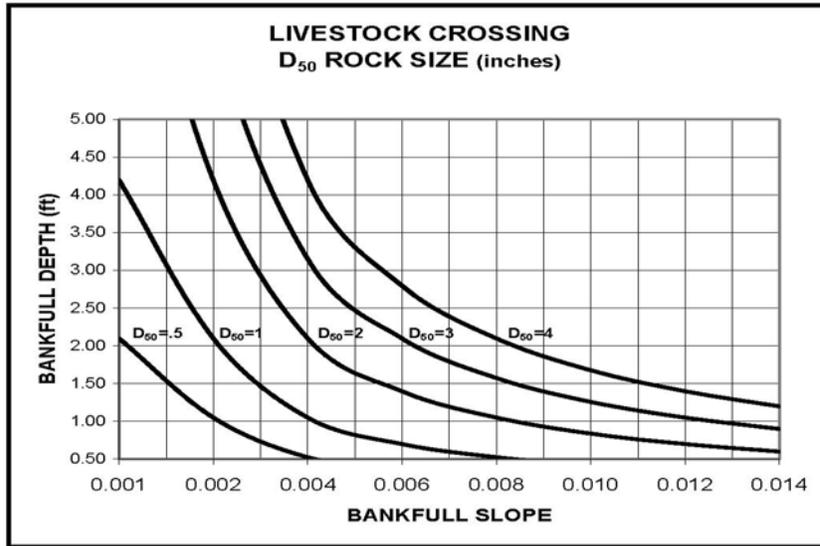
Figure 3 shows a typical layout for a well-constructed crossing (fence not shown). The stream crossing must be designed to remain stable during the bank full event. Bankfull flow and water surface slope or channel velocities should be computed or measured, and a stone size chosen from Figure 4 or Table 2. The surfacing material should consist of 1/2" to 2" rock with a minimum 2-3" thick layer, where the D_{50} of the crossing stone is >1 inch. The minimum thickness of rock protection should be the greater of 6 inches or twice the D_{50} rock size.

The final elevation of the surfacing stone in the bottom of the stream/watercourse should be no higher than the original stream bottom on both the upstream and downstream edges of the crossing or access point. This eliminates any overfall and possible scour problems.

Table 2. Livestock Crossing D_{50} Rock Size

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Figure 4. Livestock Crossing D_{50} Rock Size



D50 inches	V fps	Slope ft/ft	Bankfull Depth ft	D50 inches	V fps	Slope ft/ft	Bankfull Depth ft
0.5	2.96	0.001	2.10	2	4.03	0.01	0.84
0.5	2.63	0.002	1.05	2	3.91	0.012	0.70
0.5	2.35	0.004	0.52	2	3.81	0.014	0.60
0.5	2.20	0.006	0.35	3	6.45	0.002	6.29
0.5	2.09	0.008	0.26	3	5.75	0.004	3.15
1	4.18	0.001	4.20	3	5.38	0.006	2.10
1	3.73	0.002	2.10	3	5.13	0.008	1.57
1	3.32	0.004	1.05	3	4.94	0.01	1.26
1	3.10	0.006	0.70	3	4.79	0.012	1.05
1	2.96	0.008	0.52	3	4.67	0.014	0.90
1	2.85	0.01	0.42	4	7.45	0.002	8.39
1	2.77	0.012	0.35	4	6.64	0.004	4.20
1	2.70	0.014	0.30	4	6.21	0.006	2.80
2	5.27	0.002	4.20	4	5.92	0.008	2.10
2	4.70	0.004	2.10	4	5.70	0.01	1.68
2	4.39	0.006	1.40	4	5.53	0.012	1.40
2	4.19	0.008	1.05	4	5.39	0.014	1.20

Fords or Access Points Using Geocell and Stone

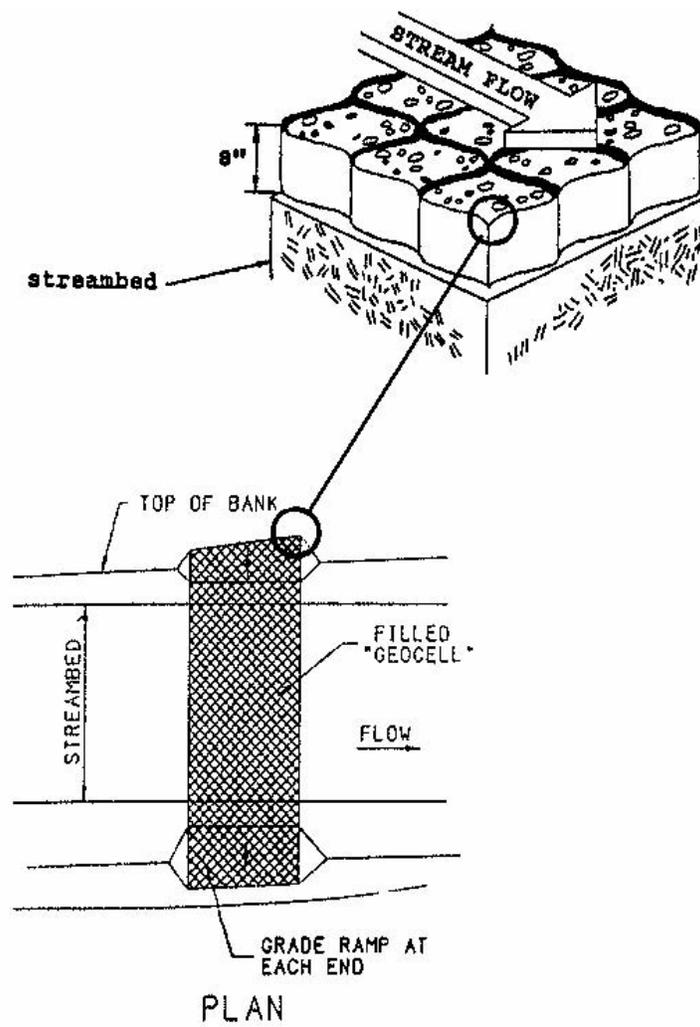
The minimum height of the geocell is 6 inches but an 8-inch geocell is recommended (See Figure 5).

The geocell material should not be used if velocities are expected to exceed 6 fps. In order to minimize velocities; locate the crossing where the stream is not steeply graded.

Install geotextile and geocell as shown in Figure 5. The geotextile and geocell should extend across the bottom and at least 20 feet up each approach section. Fill geocell with AASHTO No. 2 stone, (3/4 in. to 3 in.) and, add 2 inches (minimum) of stone above the geocell. Use staples, clips, anchor pins, or earth anchors as recommended by manufacturer.

The final surface of the stone in the bottom of the watercourse should be the same elevation as the original watercourse bottom in order to eliminate any overfall and possible scour problems.

Figure 5. Stream Crossing Using Geocell



(Hydraulic Flow diagram provided with permission from Presto Products, GEOSYSTEMS Division.)

Fords Using Concrete

Concrete may be used as a surface treatment for crossings. The finished surface of the concrete will be at or slightly below the natural stable channel grade. The subgrade for the concrete will be shaped and smoothed to provide a uniform 5 inch minimum thickness of concrete. The concrete slab and toewalls will be reinforced by placing #4 (1/2-inch diameter) steel reinforcing bars on 24 inch centers (both directions) at the slab thickness mid-point. The concrete will extend down into toe trenches, minimum 6 inches wide and 18 inches deep, on the upstream and downstream edge of the crossing. The toe trenches/walls will extend half way up the streambank approaches.

If the crossing has "soft" or compressible soil, the foundation will be excavated and backfilled with graded aggregate base (GAB) or crusher run stone to provide a dense subgrade for the concrete.

De-watering of the toe trenches and site should be needed during placement of the concrete to maintain the proper water/cement ratio. Flowing water will erode concrete that is not sufficiently hardened. The stream should be diverted or retained from flowing over the concrete for 12 hours after placement of the concrete.

A three-foot wide and 18 inch thick rock riprap apron should be installed along the downstream edge of the concrete. This riprap apron serves two purposes; 1) velocity dissipation, and 2) head cut protection should the stream channel degrade.

The concrete should meet the following minimum requirements:

- Minimum 28 day compressive strength of 3500 psi and maximum water/cement ratio of 0.5 (minimum of 5 1/2 bags of cement per cubic yard).
- Portland cement type I or II should be used.
- A slump of 1.5 to 3 inches - use a concrete super plasticizer admixture to improve workability during placement and reduce voids and honeycombs.
- The maximum size aggregate should be 1-1/2 inch.
- Air entrainment should be 3 to 6 percent by volume (air entrainment is critical for concrete subject to freezing and thawing).
- The concrete will be placed within 90 minutes after adding water to the cement/sand/gravel mix.

Construction Equipment

Experience has proved that certain types of construction equipment are more suitable for installation of crossings than others. Where crossings are on small drains with stable subsoil, equipment choice may not be critical. Where non-plastic silts and clays or unstable fine sands are anticipated in the subgrade material, the following observations should be noted:

- Tracked equipment is superior to rubber-tired equipment, when working in streams.
- Crawler tractors with angle dozer or bulldozer blades and fixed bucket front-end loaders should be avoided.
- Smaller, lighter dump trucks to deliver surfacing material will cause less damage to approaches than large trucks.
- Track-mounted hydraulic excavators with reaches of 25 feet or more provide the best and fastest installation.
- A tracked front-end loader with a 4 in 1 clamshell type bucket and a large rubber-tired backhoe provide the best installation if a hydraulic excavator is not available.
- A gasoline-powered pump and hose should be available for pumping excess water from trenches.

Landowners and contractors should be advised of the use of proper equipment. Improper equipment will result in construction difficulties and excessive construction costs.

Vegetation

Disturbed areas not covered or protected should be established to vegetation immediately after construction. Seed bed preparation, fertilizing, seeding, and mulching should be in accordance with NRCS Field Office Technical Guide, Section IV, Practice Standard 322, Channel Vegetation or Practice Standard 342, Critical Area Planting.

PLANNING CONSIDERATIONS

Avoid crossing streams when possible. Crossings can be a direct source of water pollution. They may create flooding and safety hazards and can be expensive to construct.

Evaluate each specific site carefully to determine if a crossing is most appropriate.

Crossings made of stabilizing material such as rock riprap are often used in steep areas subject to flash flooding, where normal flow is shallow or intermittent. Crossings have the least detrimental impact on water quality when crossing is infrequent. Crossings are especially adapted for crossing wide, shallow watercourses with firm streambeds. Generally, crossings should not be used where bank heights exceed 5 feet. Mud and other contaminants are brought into the stream by vehicular and animal traffic where crossings are used. Access to crossings will be prevented during high flows. It is recommended to shape cut slopes of a minimum of 3:1 or flatter to facilitate re-vegetation and ease of maintenance.

Livestock access points should be constructed as narrow as possible to allow drinking, but so as not to encourage loafing in or near the stream.

Where feasible, utilize and stabilize existing livestock crossing areas to ensure livestock are familiar with and will use the area.

Roads or trails leading to stream crossings will normally slope into the stream. Where necessary, water diversions should be installed to move sediment-laden runoff from the trail or road and to disperse the runoff onto an undisturbed area for filtering. Crossings should provide a way for normal passage of water and aquatic animals within the channel.

Consideration should be given to erosion and sedimentation, which will be caused by the installation of the crossing and any necessary stream diversion. Construction should be done during the driest part of the year.

Cultural resources should be considered when planning this practice. This practice has the potential to adversely affect cultural resources and requires compliance with General Manual 420, Part 401 during the planning process.

Measures planned shall not adversely affect threatened and endangered species or species of special concern. If threatened and endangered species or their critical habitats are present at this site, or downstream, or upstream, General Manual 190, Part 410.22 shall be followed.

Determine and secure necessary permits prior to construction. It may be necessary to obtain permits such as 310 Permits, 404 permits, etc.

OPERATION AND MAINTENANCE

The crossing or access point and associated fence should be inspected on a frequent basis, especially after major storm events. Any disturbed materials should be repaired or replaced as soon as possible to prevent further damage from occurring. Surfacing stone used for crossings or access points should be replaced as needed. Break-away type fences will need to be repaired after major runoff events.

During high flows, sediment and deposition may occur on approaches to crossings. This berm of soil and debris will need to be occasionally removed.

REFERENCES

United States Department of Agriculture, Natural Resources Conservation Service, Field Office Technical Guide, Section IV, Practice Standards and Specifications:

- Alabama Stream Crossing 728
- Access Road 560
- Fence 382
- Channel Vegetation 322
- Georgia Stream Crossing 728
- Montana LIVESTOCK WATER ACCESS AND FORD STREAM CROSSINGS Engineering tech note 13