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AEN-101

Stream Crossings for Cattle

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Nutrients, sediments, and pathogens are the most common pollutants found in Kentucky streams. These pollutants can be partly attributed to cattle production practices that allow unlimited access to streams. Nutrients and pathogens are introduced to a stream through runoff contaminated with manure and urine deposits or through livestock defecating directly into the stream. Excessive levels of nutrients, particularly phosphorus in freshwater systems, can result in *eutrophication*, which is the excessive growth of plants such as algae. In some instances, algae such as cyanobacteria (blue-green algae) can produce toxins.

While there are no regulatory limits on phosphorus, levels of nitrogen in the form of nitrate-nitrogen and nitrite-nitrogen are set at 10 mg/L and 1 mg/L, respectively, for humans. Nitrates are of particular concern, as when too high a level is absorbed into the bloodstream, the nitrates can interfere with the body's ability to transport oxygen in blood. Manures may also contain pathogens such as *Escherichia coli* (*E. coli*), *Cryptosporidium* spp., and *Giardia* spp., which, once in streams, may become resuspended during subsequent rain events. Animal wastes have also been shown to contain hormones, antibiotics, and metals, which can impact the endocrine systems of both humans and animals.

Cattle activity in and along the stream's edge can also cause streambank and streambed erosion, which introduces sediment to the stream through hoof shear as well as through vegetation removal. Loss of vegetation weakens streambanks. The roots that once held the soil in place are no longer present, thus allowing stream flows to easily erode the banks. Sediment introduced into streams can interfere with aquatic life and may contain sediment-bound nutrients such as phosphorus. Fine sediments such as silts and clays in streambeds have also been shown to increase the survival of pathogenic organisms in streams. Loss of riparian vegetation can mean a loss of streamside shade. Removal of trees, shrubs, and tall grasses can increase water temperature by allowing more solar radiation into the water.

Limiting cattle access to riparian areas can decrease pollutant loads to streams, which is an important first step in improving water quality. Additionally, limiting access to riparian areas may encourage cattle to graze upland areas more frequently thereby promoting more uniform grazing.

This publication provides livestock producers with instructions on how to install a stream crossing that provides animal and vehicular access across streams. This best management practice (BMP) is intended for use with exclusion fencing that restricts cattle access to the stream. Implementation of a stream crossing with exclusion fencing will improve water quality, reducing nutrient, sediment, pathogen, and organic matter loads to streams. A stream crossing will also reduce streambank and streambed erosion. Stream crossings can provide cattle with easy access to pastures that are normally difficult thereby improving grazing distribution while reducing the likelihood that cattle will be injured while reaching these pastures. Stream crossings can be designed for use with farm equipment in addition to cattle. Stable stream crossings can help prevent farm equipment damage by providing a smooth entrance and exit.

Constructing a Stream Crossing

Please refer to design drawings at the end of this publication.

Permits

Stream crossings for agricultural and silvicultural activities require permits from federal and state agencies and potentially local agencies as well. The U.S. Army Corps of Engineers (USACE) regulates activities in and along-side streams under Section 404 of the Clean Water Act (CWA). If using a design from the NRCS to construct and maintain a stream crossing, obtaining the necessary USACE permit should be straightforward. Typically, the USACE will issue a Nationwide Permit (NWP) 14 for road culverts, bridges or other such crossings exceeding 300 linear feet of intermittent and perennial streams. For any length of stream impact within what are defined as Outstanding Resource Waters, Exceptional Waters, or Cold Water Aquatic Habitat Waters, an individual Section 401 Water Quality Certification (401 WQC) permits is required. For construction activities across or along a stream, a separate permit from the Kentucky Division of Water (KDOW) may be required. While Table 1 contains details about permitting requirements, it is strongly recommended that the office of your local USACE district and the KDOW be consulted regarding permit requirements for all stream crossing projects. For KDOW contact information, visit its website at http://water.ky.gov/Pages/ContactUs.aspx.

Table 1. Permit requirements for stream crossing construction. *These statutes specify possible permits that may be required and permitting agencies that may be involved.*
Stream Crossings: The Clean Water Act gives the U.S. Army Corps of Engineers (USACE) regulatory authority over activities in and alongside streams. Since stream crossing construction normally occurs in small streams, the USACE has issued NWP 14 to cover this activity. See pages 223-240 of the Kentucky Agriculture Water Quality Plan (July, 28, 2008) for further information. *[US Clean Water Act, 33 USC §1251 et seq., Section 404]*
Low Water Crossings: Low-water crossings installed as part of a larger streambank protection project may require a 401 Water Quality Certification from the Kentucky Division of Water. See pages 223-240 of the Kentucky Agriculture Water Quality Plan (July 8, 2008) for further information. *[US Clean Water Act, 33 USC §1251 et seq., Section 401]*
Construction in Floodplains: Construction activities (e.g., fills, channel relocations, streambank restoration, buildings, culverts, and bridges) in floodplains require a stream construction permit pursuant to KRS 151.250. An exemption exists for watersheds of less than one square mile (640 acres), except for impoundments and dams, which again fall under KRS 151.250 for a permit. *[KRS 151.250]*

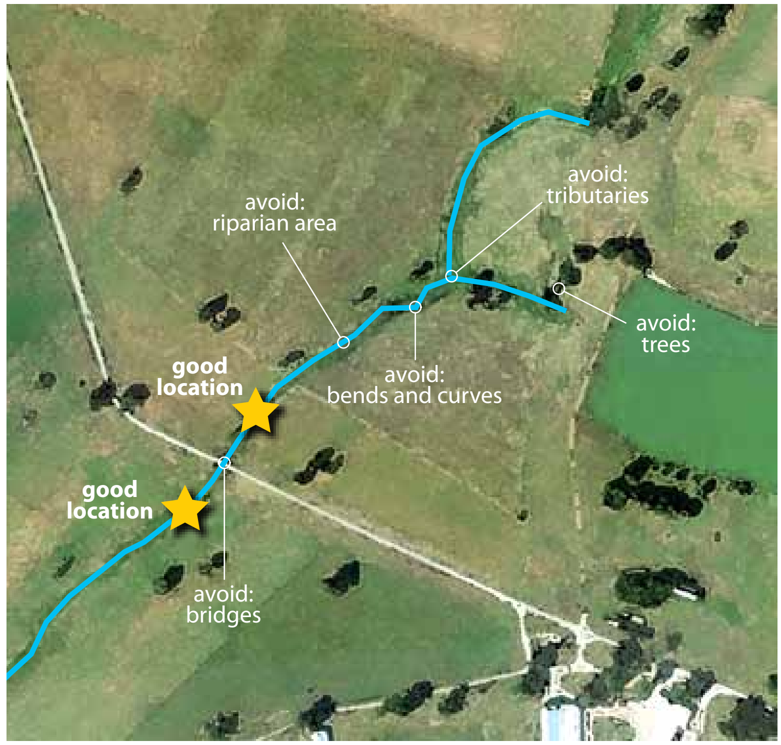


Figure 1. Where and where not to locate a stream crossing.

Time

Stream crossings should be constructed during the drier parts of the year, if possible, because earthwork activities ,such as excavating and compacting are very difficult in mud. Also, the potential of introducing sediment into the stream for construction activities is reduced.

Location

Stream crossings should be located in straight sections where the stream bed is stable or where grade control can be provided to create stability (Figure 1). Avoid locations such as bends, abrupt changes in channel grade, areas of excessive seepage, confluences of tributaries, or areas that are immediately upstream or downstream of a bridge or culvert. Also, avoid stream banks that are greater than 5 feet in height and areas where the product of velocity (feet per second) and depth (feet) is greater than 6. Knowing the product of velocity and depth helps to determine if the water is too fast and/or too deep to safely wade. An orange peel can be used to determine velocity (see insert) while a staff gauge, which is basically a long ruler placed permanently in a stream, can be used to determine depth. To discourage cattle loafing in the stream and protect tree root systems, locate stream crossings outside the tree dripline.

Width

Width is measured at the stream crossing in an upstream to downstream direction and does not include the side slopes. If the stream crossing will be used only for livestock, a 6-8 ft. width is sufficient. A multi-use stream crossing, however, should be 10-20 ft. wide.

Side Slopes

A critical design component of stream crossings is the establishment of grades, as lower side slopes result in a more stable stream crossing. The cut should be no steeper than 2.5:1 horizontal to vertical (H:V). The finished surface grade should have side slopes that are stable for the material involved. For earth fills, side slopes should not exceed 3:1 (H:V). For rock fills, side slopes should not exceed 2:1 (H:V). Please note that only clean fill material should be used for grading.

Entrance and Exit Approaches

Entrance and exit approaches should extend at least to the elevation of the five-year storm event. If this elevation is not known, blend the entrance and exit approaches for the stream crossing into the existing topography. It is recommended that the approaches be at least 20 feet in length, have slopes not exceeding 5:1 (H:V), and have a width at least the width of the stream crossing. To prevent excessive loitering at the approaches, avoid making them too wide. It may be necessary to install a flow diversion across the top of the entrance and exit approaches to prevent sediment- and nutrient-laden runoff from entering the stream. Use geotextile fabric covered with rock as a foundation for the entrance and exit approaches. Details are discussed in the following sections.

Site Preparation

For small stream crossings, a skid-loader can be used; however, for larger crossings a track loader may be required (Figure 2). When grading, remove rocks and debris from the stream crossing and the entrance and exit approaches, but

Figure 2. Use of a skid loader to grade the entrance and exit approaches of a stream crossing for a small stream. Grading provides a base for the geotextile fabric. Note the absence of rocks and debris on the approaches.

Table 2. Minimum requirements for non-woven, needle-punched geotextile fabric for stabilizing stream crossings

Property	Value[3]
Tensile strength (lb)[1]	180
Bursting strength (psi)[1]	320
Elongation at failure (%)[1]	>50
Puncture (lb)[1]	80
Ultraviolet light (% residual tensile strength)	70
Apparent opening size[2]	# 40
Permittivity (1/s)	0.70

Source: NRCS Conservation Practice Standard for Heavy Use Area Protection Code 561

[1] Minimum average roll value (weakest principal direction)

[2] U.S. standard sieve size

[3] All values are minimum except for apparent opening size, which is maximum, and elongation at failure.

do not remove rock until only bedrock remains, as this destroys aquatic habitat. Cut material should be removed from the floodplain to ensure that stream flows are not obstructed and to minimize permit requirements. If debris is deposited in the floodplain, a floodplain permit is required.

The stream bed elevations upstream and downstream of the crossing location will determine the elevations of the subgrade and finished surface of the streambed. To prevent placed materials such as aggregate from washing off, the finished grade should not be higher than the natural stable grade. If possible, the finished grade should be about 4 inches lower than the natural grade, but the stream should not be widened at the crossing.

Geotextile Fabric

Once grading is complete, the approaches and the crossing require stabilization. A non-woven, needle-punched geotextile fabric should be installed on the excavated surfaces of the approaches. If the stream has a bedrock bed, then stabilization will be required only on the approaches. Geotextile fabric may also be omitted from the streambeds if stable gravel or cobble is present. If such stable materials are not present, geotextile fabric will be required for small streams. The geotextile fabric should extend across the streambed and extend at least 20 feet up both the entrance and exit approaches. If the stream is large and has a soft bed, geoweb may be required over the top of the geotextile fabric. Geoweb is discussed in a later section.

Table 2 contains the minimum material requirements for the geotextile fabric. A fabric weight is usually not specified because the specific material features differ across manufacturers; however, the fabric should have at least a weight of 6 ounces per square yard. Consult a local extension agent, the local NRCS office, or an agricultural supply store for more information on purchasing geotextile fabric.

Geotextile fabric can be placed by rolling the material off the spool or precutting sections. For instances when more than one width of geotextile fabric is needed, start installing in a downstream direction and proceed upstream. Once the fabric has been positioned, remove any wrinkles and folds (Figure 3). The upstream section of fabric should be installed so it overlaps a minimum of 1.5 feet over the downstream section.

Anchoring Pins for Geotextile

After placing the geotextile fabric, install anchor pins on 3-foot centers. If multiple layers of geotextile fabric are used, install anchor pins 6 inches from the downstream edge of the overlap making sure that the pins penetrate both layers of fabric. Be sure not to rip the fabric when installing the anchor pins.

Figure 3. Once geotextile fabric is placed, it should be pulled tight, smoothed, and secured.

Anchor pins can be manufactured from No. 3 reinforced steel or an equivalent material (refer to design drawings). The ends of the pins can be sharpened to ease installation. Anchor pins should be long enough to drive them into undisturbed soil. Install the pins on 3-ft centers at overlaps and edges, including the streambed if geotextile fabric is required based on the type of stream bed material present. While lightweight staples can be used to hold the geotextile fabric in place, their use should be considered temporary, as staples are much harder to remove. To determine the number of anchor pins needed, measure the total length of the crossing covered in fabric. For one width, multiply the total length by 0.85. For two widths, multiply the total length by 1.3.

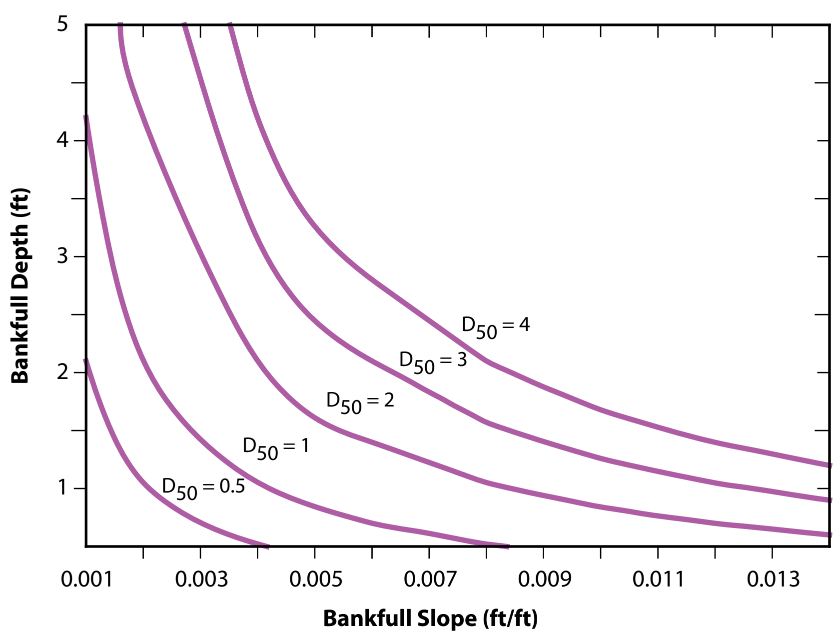
Rock Layers

A 6-inch base layer of large aggregate should be laid over the geotextile fabric and compacted (Figure 4). Select the aggregate size based upon the slope and depth of the stream at bankfull elevation (Figure 5), which is the point at which water begins to exit the stream and spread out onto the floodplain. For most stream crossings, a No. 2 or No. 4 aggregate will work well. Take care when spreading the base layer as not to disturb the geotextile fabric. Spread a 4-inch layer of dense grade aggregate (DGA) over the base layer. Compact the DGA layer by using a roller or by driving over the entire area multiple times until the finished surface is smooth (Figure 6). The finished surface will provide a solid, stable path for livestock, and if desired, vehicular traffic.

The use of concrete is not recommended for stream crossings. Poured concrete or grouted stone material restricts the stream's ability to flex and give during large flow events. Stream crossings that incorporate concrete will inevitably lose the bed material underneath the concrete, which will leave behind a hanging mass of untied concrete that will become a nuisance. This inability for a stream to adjust to large flow and substrate influx events can also create a number of additional problems, such as headcuts, an aggradation area where additional material may build up, and natural re-channellization, where the stream may completely abandon the restricted area and create a new channel around the crossing location. In addition, a general water quality plan will not be issued from KDOW for projects proposing to utilize concrete or grout materials for a stream crossing.

Figure 4. After anchoring the geotextile fabric, place and compact a 6-inch base layer of large aggregate.

Figure 5. Median particle size for stream crossing aggregate based on bankfull slope and bankfull depth. The D50 indicates that 50 percent of the particles in the base layer are of the specified size or smaller.



Geoweb

For large streams with soft bottoms, place geoweb over the geotextile to increase stability (Figure 7). Geoweb material should not be used if stream velocities will exceed 6 feet/second. If velocities are greater, consider a different location for the stream crossing. The minimum recommended height of the geoweb is six inches. The geoweb and geotextile should extend across the stream bottom and along the entrance and exit approaches for a minimum of 20 feet. Install the geoweb and place aggregate over the geoweb in accordance with the manufacturer's recommendations.

Product of velocity and depth

A simple way to measure velocity is by using a float such as an orange peel, a tape measure, and a stop watch.

- Use a tape measure to mark a section of stream at least 20 ft in length.
- Drop the orange peel about 5 ft above the start of the marked section. Try to drop the orange peel in the center of the stream.
- When the orange peel reaches the beginning of the marked section, start the stopwatch.
- When the orange peel reaches the end of the marked section, stop the stopwatch.

Repeat at least two more times.

Add all of the times and divide by the number of repetitions to obtain an average time.

Divide the length of the marked section by the average time to get an average surface velocity and then multiple by 0.8. The 0.8 correction accounts for the fact that the velocity of water at the surface is faster than water along the streambed.

Example:

A 50-foot distance is marked off along a stream. The times it takes for an orange peel to travel the marked distance are 12, 10, and 11 seconds, giving an average time of 11 seconds.

For a distance of 50 feet and an average time of 11 seconds using the 0.8 correction, the average velocity is 3.6 feet per second.

Vegetation

Following installation of the stream crossing, any remaining disturbed soil should be seeded and mulched with straw to protect against erosion. Soil tests can help determine an appropriate amount of fertilizer that will not negatively affect water quality or aquatic habitat.

Figure 6. A 4-inch layer of dense grade aggregate (DGA) is placed over the base layer and compacted to form a smooth surface.

Figure 7. Geoweb, when placed over geotextile, offers extra stability for streams with soft beds.

Fencing and Gates

Areas adjacent to the stream crossing should be fenced using either permanent or temporary means to exclude livestock from the riparian area. Fencing across the stream should consist of breakaway wire, swinging floodgates, hanging electrified chain or wire, or other such devices that allow the passage of debris during high flows (Figure 8).

If exclusion of cattle from the stream is desired, gates can be installed at the entrances to the stream crossing. The gates can be used to allow cattle limited access to the stream during parts of the year. The gates also can be used to completely exclude cattle from the stream by forcing them to stay in one pasture, such as with a rotational grazing scheme.

Figure 8. Swinging floodgates allow debris passage during high flows.

Safety

Stream crossings should not be used during periods of high flows when swift moving, deep waters pose a danger to livestock and people. A staff gauge can be installed at the stream crossing to determine when the water depth is too high to use the crossing. As a general rule, if the product of velocity (feet per second) and depth (feet) is greater than 6, stay out of the stream.

Maintenance

Inspect the stream crossing regularly, particularly after large storm events, to ensure the rock layers have not been eroded and fencing is not damaged. Conduct repairs as quickly as possible to prevent further damage to the stream crossing. If a flow diversion was built at the start of the approaches, inspect the diversion for sediment and debris deposition and remove as needed.

Cost-Share Eligibility

Producers interested in constructing a stream crossing should contact their local NRCS office regarding the potential for cost-share funds from the Environment Quality Incentives Program (EQIP) or other such state funds to implement this BMP.

References

Agriculture Water Quality Authority. 2008. Kentucky Agriculture Water Quality Plan. Available at: http://conservation.ky.gov/Pages/AgricultureWaterQuality.aspx.

Higgins, S.F., C.T. Agouridis, and A.A. Gumbert. 2008. ID-170, Drinking water quality guidelines for cattle. University of Kentucky Cooperative Extension Service.

Kentucky Administrative Regulations. 2011. 401 KAR 4:060. Stream construction criteria. Available at: http://www.lrc.ky.gov/kar/401/004/060.htm.

Kentucky Revised Statutes. 1982. KRS 151.250. Plans for dams, levees, etc. to be approved and permit issued by cabinet. Available at: http://www.lrc.ky.gov/KRS/151-00/250.pdf.

Kolodziej, E.P. and D.L. Sedlak. 2007. Rangeland grazing as a source of steroid hormones to surface waters. Environmental Science and Technology 41: 3514-3520.

Niemi, R.M. and J.S. Niemi. 1991. Bacterial pollution of waters in pristine and agricultural lands. Journal of Environmental Quality 20:620-627.

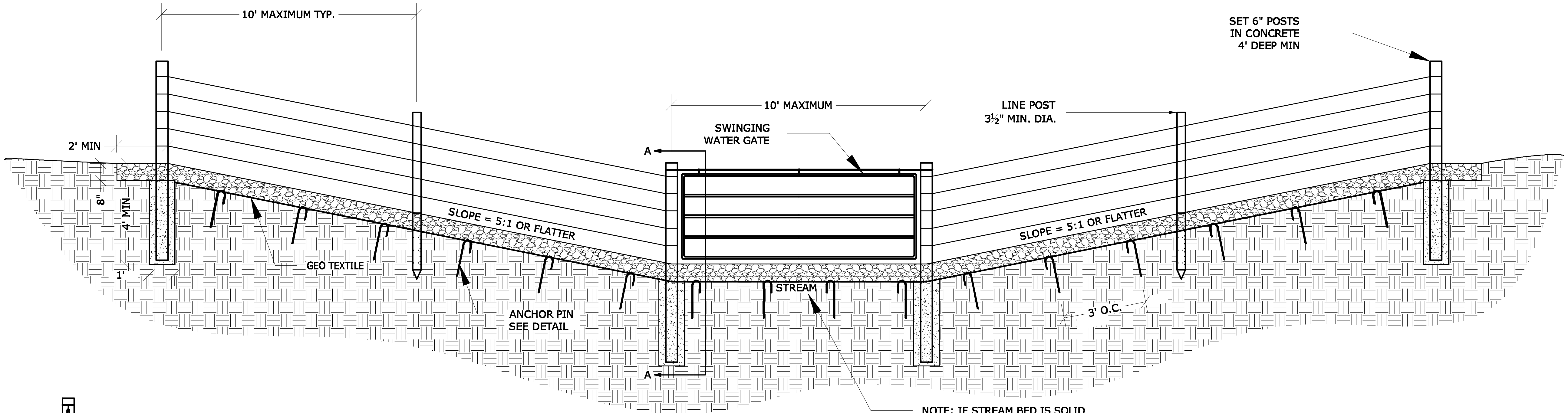
Stephenson, C.R. and R.C. Rychert. 1982. Bottom sediment: a reservoir of *Escherichia coli* in rangeland steams. Journal of Range Management 35:119-123.

Trimble, S.W. and A.C. Mendel. 1995. The cow as a geomorphic agent–a critical review. Geomorphology 13:233-253.

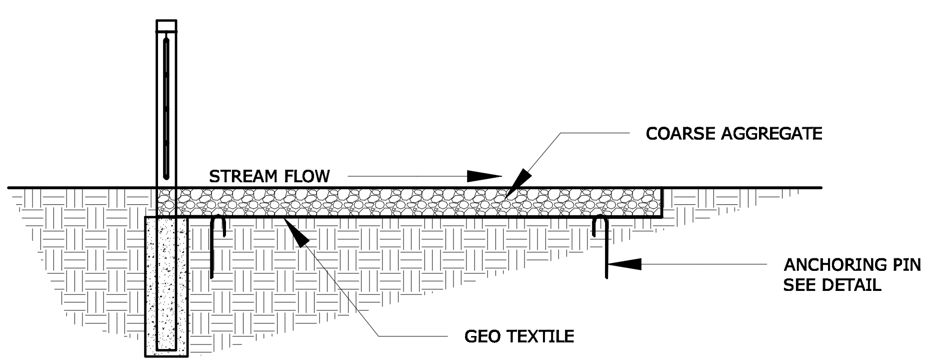
U.S. Clean Water Act. 1977. 33 USC §1251 *et seq.*, Section 404.

USDA-NRCS. 2001. Livestock water access and for stream crossings. Montana Engineering Technical Note No. 13. Available at: http://www.blm.gov/or/programs/nrst/files/tneng14%28rev1%29.pdf.

USDA-NRCS. 2010. Conservation Practice Standard, Stream Crossing, Code 578. Available at: ftp://ftp-fc.sc.egov.usda.gov/NHQ/practice-standards/standards/578.pdf.



CHANNEL SECTION @ CROSSING



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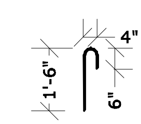

NOTE: ANCHORING PINS FABRICATED
FROM #3 REINFORCING STEEL OR
EQUIVALENT MATERIAL.

DETAIL - ANCHORING PIN

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REVISIONS	DATE	CHK

CHANNEL CROSSING
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DETAILS

DRWGS FOR:
☒ INFORMATION
☐ SUBMITTAL
☐ APPROVAL
☐ CONSTRUCTION
☐ OTHER

SCALE: DO NOT SCALE
DRAWN BY: J. A.
FILE: ChannelSection.dwg
DATE: FEB. 22, 2011

BIOSYSTEMS
AGRICULTURAL
ENGINEERING

BIOSYSTEMS AND AGRICULTURAL ENGINEERING

DESIGN:

SHEET NUMBER
1 OF 1