Basic Engineering Design Process

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2008 ICE Training
What is an Engineering Design?

- An orderly process of collecting, recording, and analyzing all the facts and data needed to arrive at a satisfactory solution to a problem.
- NEM-VA501.09 through VA501.19 outlines the policy for performing engineering work for NRCS in Virginia.
- EFH, Chapter 5 – Preparation of Engineering Plans
Preparing an Engineering Design

- The following basic steps should be followed for all engineering designs (regardless of complexity):
  1. Identification of the problem and its scope.
  2. Site Investigation.
  3. Collection of basic design data.
  4. Assembly and analysis of data.
  5. Design.
  6. Preparation of plans and specifications.
  7. Review and approval of plan.
Basic Engineering Design

- What is an engineering design (the final product) made up of?
  - Drawings:
    - Coversheet
    - Plan View Sheet
    - Standard Detail Sheet
    - Cross-Section or Profile Sheet
  - Construction Specifications
  - O&M Plan
  - Miscellaneous
    - Bill of Materials
    - Cost Estimate
- The landowner (or cooperator) should be given a copy of all of this!!!
Construction Drawings

- Should be:
  - Clear
  - Concise
  - Neat
  - Legible
- CAD is a tool, not required.
- Goal is production...not a chance to be an artist.
Location map should provide sufficient information so that someone unfamiliar with the job can locate the site (not the same as the plan view).

### Table of Estimated Quantities

<table>
<thead>
<tr>
<th>Item</th>
<th>Unit</th>
<th>QTY</th>
</tr>
</thead>
</table>

### Notes

1. The landowner/operator is responsible for obtaining and complying with all permits and easements. This includes all federal, state and local permits.

2. The landowner/operator is responsible for checking and complying with all local ordinances that may affect the project.

3. The NURS (i.e., 1-800-255-7777 or 1-800-753-7051) must be contacted at least 3 working days before construction begins. The landowner/operator is responsible for ensuring that the excavator/contractor contacts the NURS (i.e., 1-800-255-7777 or 1-800-753-7051) to provide the NURS number within 24 hours upon request by the NURS representative.

4. The landowner/operator is responsible for locating any buried utilities (water lines, electric lines, telephone lines, gas lines, sewer lines, etc.) in the work area that are not covered by the NURS program.

5. Prior to beginning construction, the cover sheet must be signed by NURS, the landowner/operator, and the excavator/contractor. The landowner/operator is responsible for informing the excavator/contractor of their responsibilities by providing them a copy of the cover sheet. The excavator/contractor must verify the cover sheet ensuring that they understand their responsibilities and the landowner/operator must return the signed cover sheet to the NURS office or utility providing assistance. If requested by NURS, the landowner/operator shall arrange for a meeting between the contractor and NURS to review the construction drawings and specifications prior to construction.

6. NURS makes no representation of the existence or non-existence of utilities. The presence or absence of utilities on the construction drawings does not assure that there are or are not utilities in the work area.

7. The excavator/contractor is responsible for knowing and following the appropriate safety standards required by the Virginia Safety and Health Codes Board.

8. The landowner/operator shall notify the local NURS or SWCD representative at least one week prior to when construction is to start, and at the times specified in this construction plan and attached specifications. NURS or SWCD representative telephone number: ____________

9. Any deviation from these construction drawings and specifications without written approval from NURS may result in this practice not meeting NURS specifications and the withdrawal of technical assistance for this project.

### Acknowledgement Signatures

These construction drawings and attached specifications have been reviewed and are printed to the best of our knowledge and belief.

- **As Built Documentation**
  - Certified By and Date
  - Date Completed
  - Engineering Job Close
Plan view should show the detailed layout of the proposed practice, topographic features, dimensions, etc.
Use Standard Drawings Whenever Possible

Available designs include various types of watering troughs, livestock shade structures, temporary waste pads, stream crossings, spring developments, pole structures and waterways.
Cross sections are typically perpendicular to a baseline or centerline (road, stream, etc.).

Used for showing existing ground and design slopes, elevations, grade changes, structure details, etc.
Profiles are typically along or parallel to a baseline or centerline (road, stream, etc.)

Used for showing existing ground and design slopes, elevations, grade changes, structure details, etc.
Construction Specifications

CONSTRUCTION SPECIFICATION

VA-761. LOOSE ROCK RIPRAP

1. SCOPE

The work shall consist of the construction of loose rock riprap revetments and blankets, including filter layers or bedding where specified.

2. MATERIALS

Rock for loose rock riprap, filter layers or bedding shall come from sources approved by an NRCS representative and meet the size and gradation requirements shown on the design drawings. The rock shall be excavated, selected and handled as necessary to meet the quality and grading requirements of this specification and the construction drawings. Individual rock fragments shall be dense, sound and free from cracks, seams and other defects conducive to accelerated weathering. The rock fragments shall be angular to subrounded in shape. The least dimension of an individual rock fragment shall be not less than 1.3 the greatest dimension of the fragment unless otherwise specified on the construction drawings.

Except as provided below, the rock shall have the following properties:

a. Bulk specific gravity (saturated surface-dry basis) not less than 2.5.
b. Absorption not more than 2 percent.
c. Soundness: Weight loss in five cycles not more than 10 percent when sodium sulfate is used or 15 percent when magnesium is used.

Bulk specific gravity and absorption shall be determined according to ASTM C 127. The test for soundness shall be performed according to ASTM C 88.

Rock that fails to meet the requirements stated in a, b, and c above may be accepted only if similar rock from the same source has been demonstrated to be sound after 5 years or more of service under conditions of weather, wetting and drying, and erosive forces similar to those anticipated for the rock to be installed under this specification.

The rock shall conform to the grading limits, specified on the drawings, after it has been placed as the riprap.

3. SUBGRADE PREPARATION

The subgrade surfaces on which the riprap or bedding course is to be placed shall be cut or filled and graded to the lines and grades shown on the drawings. When fill to subgrade lines is required, it shall consist of approved materials and shall be compacted to a density equal to the adjacent existing soil material.

Rock materials shall not be placed until the foundation preparation is completed and the subgrade surfaces have been inspected and approved by the NRCS representative.

4. EQUIPMENT-PLACED ROCK RIPRAP

The rock shall be placed by equipment on the surfaces and to the depths specified. The riprap shall be constructed to the full course thickness in one operation and in such a manner as to avoid serious displacement of the underlying materials. The rock shall be delivered and placed in a manner that will insure that the riprap in place shall be reasonably homogeneous with the larger rocks uniformly distributed and firmly in contact, one to another with the smaller rocks and spalls filling the voids between the larger rocks.

Riprap shall not extend above grade on side slopes so that water is ponded outside the riprap.

Riprap shall be placed in a manner to prevent damage to structures. Hand placing will be required to the extent necessary to prevent damage to the permanent works.

5. HAND-PLACED RIPRAP

The rock shall be placed by hand on the surfaces and to the depths specified. It shall be securely bedded with the larger rocks firmly in contact, one to another. Spaces between the larger rocks shall be filled with smaller rocks and spalls. Smaller rocks shall not be grouped as a substitute for larger rock. Flat slab rock shall be laid on edge unless otherwise specified.

6. FILTER LAYERS OR BEDDING

When the drawings specify filter layers or bedding beneath riprap, the filter or bedding material shall be spread uniformly on the prepared subgrade surfaces to the depth specified. Compaction of filter layers or bedding will not be required, but the surface of such layers shall be finished reasonably free of mounds, dips or windrows.

Filter fabric may be used in lieu of filter gravel if approved by the NRCS representative. The fabric shall be manufactured to provide the necessary life and filtering action. The fabric and riprap shall be placed in accordance with the manufacturer’s recommendations.

7. TESTING

The contractor will furnish such test data as are required to verify that the riprap, filter, and bedding materials and the completed work meet the requirements of the specifications.
OPERATION AND MAINTENANCE ITEMS

A properly operated and maintained Watering Facility is an asset to the farm. This practice was designed and installed to provide storage and/or a facility to provide utilization of water by livestock. Estimated life span of this installation is at least 20 years. The life of the installation can be assured and usually increased by developing and carrying out a systematic operation and maintenance program.

This practice will require periodic maintenance and may also require operational items to maintain satisfactory performance. Your operation and maintenance program includes:

- Check periodically for debris, algae, sludge or other materials in the trough which may restrict the inflow or outflow. Check all above ground connections, valves, gates, rodent guards, inlets and outlets to make sure they are functioning properly.

- Check troughs and tanks for leaks or cracks. Check the automatic water level device, if installed, to ensure proper operation. Check to ensure the outlet pipe, if installed, is freely operating and not causing erosion problems. Repairs or replacements shall be made promptly.

- Prepare for winter weather. Maintain, where necessary, coverings and insulation to prevent damage by freezing. Consider adding material in the storage area to allow for ice expansion without damage.

- Maintain the 10' hardened surface radius around the trough. Protect with materials similar to those placed at the time of installation. Expect to add additional stone to the area periodically during the life span of the trough.

- Clean the entire system periodically and remove moss, algae growth, and/or sludge. Chemicals such as copper sulfate and chloride can be used to prevent moss and algae growth. Local rules and regulations are to be followed when using chemicals. Make sure they are safe for animals.

- If the trough use is seasonal, remove any algae growth, drain the trough, allow it to stand empty for a week or so, remove any remaining algae, and refill. The trough should be flushed at least once a year. Twice is recommended but it should be done any time algae becomes a problem. Control of algae growth in the trough is an important part of the maintenance.

NRCS, VA
June 2004
# Bill of Materials & Cost Estimate

## Spring #1

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<tr>
<th>Item #</th>
<th>Item</th>
<th>Quantity</th>
<th>Unit</th>
<th>Unit Price</th>
<th>Cost</th>
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Basic Engineering Design

What should be kept in the job folder?

- Copy of design (everything given to landowner or cooperator).
  - Coversheet should be signed by NRCS representative, landowner, and contractor prior to construction.
- Field notes, before and after construction.
- Design notes & computations.
  - See NEM VA501.16 *Technical Quality*.
- Photographs, before and after construction.
- As-built drawings and notations.
- See “Design Data” and “Check Data” under applicable practice standards for required data.
Why supply the information previously mentioned?

- To comply with Conservation Practice Standards.
- To maintain technical and professional quality.
- At the direction of the State Conservation Engineer.
  - Operating under his technical supervision and P.E. license.
In Review...

- What is the first step of any engineering design?
- Should the cooperator receive a copy of the final design?
- Is drafting the construction drawings in CAD a requirement?
Questions?