General

Require that inspectors do more than just test fill compaction, i.e., observe foundation preparation, pipe installation, riser construction, filter installation, etc. See checklists in NRCS Pond Standards (MD-378) The latest MD-378 is January 2000, and can be downloaded from NRCS web site.

Entire dam site must be cleared of trees, roots and other organic or deleterious materials to area at least 25 feet beyond limits of the embankment. Old stream channels and pockets of sand or gravel should be excavated and backfilled with compacted fill. Site should then be proof-rolled under direction of geotechnical engineer (or his inspector). Any soft or excessively wet areas should be undercut and backfilled with compacted soil, not gravel. Avoid the use of "bridge lifts".

Where possible, avoid using road embankments as dams or stormwater management structures. This helps to minimize future problems with ownership, maintenance and repair. This also minimizes problems with utilities in dams, since the utilities are usually located along the roadways.

Pipe Spillways

Many pond failures occur along the principal spillway because of the difficulty in compacting soil along a pipe. Consider use of alternative spillway structures, such as weirs and drop boxes.

Don't EVER allow pipe placement in a vertical trench excavated through the embankment or foundation.

Don't use gravel under pipe, riser or outlet structure. Do use a working slab or mud-mat (4 to 6 inches thick) of concrete or flowable fill in bottom of riser excavation and pipe trench. If water is a problem, contractor should use pumps and sumps to keep excavation dry. Undercut areas should be backfilled with compacted fill, concrete, or flowable fill, depending on type structure.

Do require that the inspector be educated in pipe standards. For example, does inspector know why reinforced concrete pipe (RCP) conduit labeled "ASTM C-76, Class V" is not acceptable for pond construction?

All spillway joints must be watertight to prevent infiltration of embankment soil into the conduit. All joints must be constructed as designed by pipe manufacturer. "Field joints", where the ends of the pipes are cut off in the field are not acceptable.

Gaskets for concrete pipe (ASTM C-361) should be o-rings (with circular cross section) seated in a groove. Alternative joint design (shoulders and "profile gaskets") should not be installed without prior approval of the design engineer *and the owner.*

Do require that pipe manufacturer submit certification that pipe meets plan requirements for design load, pipe thickness, joint design, etc. to the design engineer for approval prior to installation.

All pipe gaskets must be properly lubricated with the material (vegetable grease or soap) provided by pipe manufacturer. Use of incorrect lubricant may cause deterioration of gasket material. The gasket should be properly "tensioned". Failure to do this may result in improper joints that are not watertight, or may cause pipe failure.

Use concrete cradle under RCP up to springline. Cradles should be poured against undisturbed earth. Or, they can be formed if there is enough room along on outside of forms for proper compaction.

Corrugated metal pipe (CMP) spillways must meet or exceed the minimum requirements in NRCS MD-378. Check for metal thickness (compare manufacturer's certification that should accompany pipe shipment with plans), corrugation size, number of re-rolled end corrugations, proper connecting bands,

and gasket type. Note that the engineer may specify a heavier gage than MD-378 for increased design life.

Do ask that pipe manufacturers properly label and "match mark" their pipe sections. CMP is typically custom fabricated for each job as one long piece and then cut into shipping lengths. By consecutively labeling each piece, the pipe can be re-assembled in the same order as it was manufactured. (Also, have the manufacturer ship the longest sections possible--the fewer joints the better. Avoid use of short sections with anti-seep collars in the middle, as this increases the number of joints.)

Six-inch hugger bands and "dimple bands" are not acceptable for CMP conduits. Thirteen-inch bands with either o-ring or flat neoprene gaskets are allowed for pipes less than 24-inches in diameter. Larger pipes require 24-inch wide bands with 24-inch wide flat gaskets and four "rod and lug" type connectors. Note that flanged pipe ends with gaskets are also permitted.

Maximum allowable deflection of CMP conduits is 5 percent of pipe diameter. However, with the larger pipe sizes, it may be difficult to get acceptable joints even if deflection is less than this amount. No more than 1-inch difference in diameter is allowable between adjacent sections.

Flat gaskets for CMP must be factory welded or solvent glued into circular ring, with no overlaps or gaps in gasket allowed.

Use "flowable fill" under CMP up to springline. Caution: pipe will float, so must be held down. Also, flowable fill shrinks, so make at least 2 separate pours. Second pour on top of first fills voids.

The first pipe joint should occur within two feet of riser in order to accommodate differential movements of riser and pipe yet maintain a watertight connection.

Precast risers cannot be substituted if plans call for cast-in-place structure, unless reviewed by design engineer and approved by SCD or WMA before construction. Sections of precast structures must be anchored together for stability and flotation requirements. Watertight joints between the riser sections and the barrel are required.

Structural engineer must evaluate shop drawings for pipe, precast structures, or other fabricated appurtenances before fabrication or installation.

Cinder block and masonry riser structures are not allowed.

Precast box culverts are not approved, as they do not have watertight joints.

Embankment Construction

Do perform frequent tests of compaction effort. Typically, plan to conduct at least one test per 5000 square feet on each layer of fill. Test frequency may be reduced on large projects where the material is uniform after the contractor proves that a certain compactive effort will consistently achieve specified density.

Use Standard Proctor (ASTM D-698) for compaction criterion, not Modified Proctor (ASTM D-1557). Standard Proctor results in slightly wetter, more flexible, fill that can better settle without formation of cracks.

A new Proctor test is required if material changes from that previously tested.

Don't rely on nuclear density gage without correlation with traditional methods like sand cone and oven-dry moisture content. Otherwise, dry density and moisture content may not match those obtained in the lab.

Use sheepsfoot type roller for cohesive soils like clay, silt, clayey sands.

Use smooth drum vibratory roller on clean sands and gravels.

Filters and Drainage layers

Filters are critical for control of seepage. Aggregate size for filter is dependent on embankment soil. If contractor proposes different borrow source than used for filter design, then filter must be re-designed for new soil.

Clean sands cannot be adequately compacted by tamping alone, because water sets up surface tension between particles that may prevent achieving maximum density. Must flood filter with clean (potable) water, and vibrate just after water drops below sand surface.

Filter material should be placed in layers no more than a foot thick.

It is permissible to place up to four feet of dam embankment on top of lower portion of the filter and then excavate down with backhoe to expose previous layers. After removing any unsuitable materials, trench is then filled in one foot layers, flooded and vibrated as above, until top of adjacent fill is reached.

Filter fabric (geotextiles) should not be used in lieu of sands and gravel layers within the dam embankment.

Do not wrap filter fabric tightly around perforated pipes used to collect seepage. Because the area of water flow through the fabric is effectively reduced to the area of the perforations, it will clog rapidly. Fabric should be held away from the pipe surface by a layer of gravel or three dimensional geotextile (like EnkaDrain)

Utilities

Utilities that run through dam or foundation from upstream to downstream should be avoided. If they cannot be moved, then the conduit must meet the requirements for spillways, i.e., water tight joints, no gravel bedding, encasement in concrete or flowable fill, and restrained to prevent joint separation due to settlement.

Utilities that run along the axis of the dam (such as water and sewer under a roadway) should also be avoided. No gravel backfill should be allowed, as this may allow groundwater to flow into dam embankment from abutments, resulting in seepage and stability problems with the slopes.

No manholes allowed in dam embankments, unless carefully designed and constructed to be watertight.

Utility repairs in dam embankment require WMA dam repair permit or approval by SCD.

As-Built Drawings and Records

Use WMA checklist, guidelines in NRCS-MD-378, or other suitable outline to ensure that all items are verified.

The Dam Completion Report should document construction problems and include the results of all field and laboratory tests, manufacturers' certifications for materials, pipes, gaskets, etc., and the inspector's daily logs.

Useful web sites with design references

Site	url
Maryland Department of the Environment	www.mde.state.md.us
Association of State Dam Safety Officials	www.damsafety.org
NRCS Maryland	www.md.nrcs.usda.gov
NRCS Technical references	www.ftw.nrcs.usda.gov/tech_ref.html
NRCS H&H software	www.wcc.nrcs.usda.gov/water/quality/text/hydrolog.html
Corps of Engineers H&H software	www.hec.usace.army.mil
Corps of Engineers Technical manuals	www.usace.army.mil/inet/information/usace-docs/eng-manuals