Canal Lining

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Larry and I thought that some musings about canal lining might be of some interest for some of you USCID newsletter readers. As you know, there are many canal lining techniques – especially if one considers the wide assortment of internationally used lining methods.

Why line canals?
The answer to this question is fundamental, because typical concrete lining can often exceed $1 million per mile, when all costs are considered. Typical justifications are:

1. Stabilization of canal banks. This is a common justification in international projects where there is a tendency for canals to get a bit wider every year, narrowing canal bank roads and infringing on fields. Often, destabilizing factors such as improper canal bank construction, maintenance that constantly extracts from the canal banks, silty soils, animal and human damage to canal banks, and greatly fluctuating water levels (causing slumping of the canal banks) all appear simultaneously in the same canal. Lining with something sturdy is a simple solution to stabilization...assuming that the lining is indeed sturdy.
2. Reduced maintenance. While there is considerable truth to the statement that lining reduces maintenance, especially in regards to eliminating side vegetation, a serious maintenance program is still needed. Canal lining does eliminate algae growth or pondweed, but sediment still accumulates.
3. Reduced seepage. There is no doubt that a new concrete lining will reduce seepage, but sustaining long-term seepage reduction is highly dependent upon the quality of initial construction, as well as factors such as freeze-thaw cycles and soil subsidence. Various studies over the years have shown that cracked concrete can have about the same seepage rates as unlined canals.

The big question posed by the third point above must always be: Is the push to reduce seepage justified? Canal lining is listed as a water conservation best management practice in numerous publications and water conservation plans. However, if the canal is in a conjunctive use (well pumping plus surface water) region (which depends on groundwater recharge), the seepage may be necessary to recharge the groundwater during wet years. This is a fairly complex question because it often deals with water rights, equity of surface water distribution, and power consumption. Knee-jerk canal lining, without understanding the complete water balance picture, may be supported by water conservation funds but actually result in no true water conservation.

On the other hand, seepage often creates a localized high water table that damages crops in adjacent fields. This is a clear problem, and irrigation districts often selectively line such canal sections. Interestingly enough, these problems often appear in heavier texture soils, in which the seepage rates are low but the seepage water moves laterally. In sandy soils with unrestricted drainage, high seepage rates may not be noticed by the farmers.

Of course, for the case of localized seepage, there are alternatives to lining such as the installation of parallel interceptor tile lines. The water can be pumped back into the canal, and the drain can protect the adjacent fields.

What size of new canal?

A clean and smooth concrete cross section can pass a higher flow rate than an irregular earth cross section with weeds. Therefore, there is a natural tendency to use a new lined canal of a smaller cross section than the canal it replaces. It's simple – a small amount of lining costs less than a large amount of lining. However, there are some necessary considerations:

1. In some projects, it is difficult to find the fill dirt to fill in the old, larger cross section.
2. The assumption is that the new concrete lining will be maintained in a clean and smooth condition. This is a huge, incorrect assumption in some projects. I remember a project in Mali that was efficiently designed with that assumption, and the water didn't even make it a third of the way down the canal.
3. The old, wide canals provide the operators with a big advantage: they provide a fair amount of operational storage. Now, I know that the canal water levels are supposed to be kept constant for good service to the turnouts and for good bank stability, but the reality is that canal operators are often given instructions to make the prevention of tailend spill their top priority. The only way they can do that is to juggle with canal pool storage. The bottom line is that there needs to be storage or recovered spill if we want to provide equity, reliability, and flexibility in water delivery to turnouts. So...let's just say that it's a good idea if, before designing a new lined canal cross section, you consider the operational objectives and instructions to the ditchriders/zanjeros/operators of the canal system. Those guys way down on the totem pole have to live with our fantastic improved designs.

What are material and construction options?

I think everyone has their own preference for materials. In part, it will depend upon local costs, availability of installation equipment, and employee manpower. Here are a few points that I like to make:

1. If the objective is simply seepage reduction and the soils are "medium" textured, you might consider vibratory compaction of the canal banks and sides. The cost is in the neighborhood of $1.50 - $2.00 of canal length over a variety of canal sizes. See ITRC Paper No. P 09-001 (http://www.itrc.org/papers/canalseepage.htm) for more information. We don't know how long the benefits will last, but it seems to be pretty good.
2. It is essential to have excellent soil compaction and bed preparation for any rigid canal lining such as concrete, masonry, etc. I don't know how many concrete and masonry lining projects I've seen that have failed because of lack of attention to this simple detail. Yes, it costs money to over-excavate and properly prepare the soil, but it saves money in the long term.
3. Be careful with being the guinea pig for large projects involving new materials. Many of us can tell stories of sections of synthetic lining breaking off and floating downstream and lodging against bridges (oops!), stories of geomembrane cracking, etc.
4. The details of the height of the lining and tying in to the soil, especially with geomembranes, are very important.
5. If you want to use geomembrane by itself, get references and check up on them.

If you want both physical durability and seepage reduction, consider combinations of a geomembrane covered with hard material. I have to admit that I am partial to the few geomembranes that enable shotcrete to "stick" to their outer surface. The shotcrete can be smoothed fairly easily. About 15 years ago, the USBR published a report on canal lining adventures that gave a high rating to this approach (http://www.usbr.gov/pn/programs/wat/canal.html).

In some areas, especially with high freeze/thaw problems, engineers prefer to cover the geomembrane with rocks. The geomembrane must be strong enough to not puncture.

Karimov, Leigh, and Fipps of the Texas Agrilife Extension Service (Texas A&M, College Station) recently published an excellent report on experiences in Texas (Evaluation of Canal Lining Projects in the Lower Rio Grande Valley of Texas. June 29, 2009, Publication TR 353, http://twri.tamu.edu/reports/2009/tr353.pdf). It includes various types of geomembrane/concrete combinations.