Valuable Agricultural Water Saved in Federal Drought Area of Northern California

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Abstract

The Tulelake Irrigation District (TID) is one of 18 districts in the U.S. Bureau of Reclamation Klamath Project which is one of the oldest irrigation projects in the Western United States. The irrigation district supplies valuable agricultural water to otherwise dry but fertile lands in northern California and southern Oregon.

Historically, the TID has faced loss of deliverable water due to high seepage rates in unlined canals and laterals, approaching 50 percent in some cases. This, in addition to the drought conditions here and in other western and southwestern irrigation districts, has prompted the federal government to initiate a program for the selection and installation of low cost, low tech synthetic canal lining systems.

This paper will focus on the selection, cost, installation methods and effectiveness of EPDM rubber canal lining systems as used in the TID emergency seepage control program and as approved by the Federal Government.

Introduction

Historically, one of the major uses for flexible membrane liners or geomembranes has been in the waterproofing of canals and laterals used in water distribution for agricultural irrigation and their use has been documented as early as the 1940's. Early lining systems included bitumen coated burlap and eventually thermoset elastomeric liners such as Butyl Rubber (IR) and Ethylene Propylene Diene Monomer (EPDM). According to Staff (1984), rubber linings were even used prior to the 1930's for the containment of water and Polyvinyl Chloride (PVC) was used in the 1950's. In the 1960's, both thin PVC and Low Density Polyethylene (LDPE) sheeting found their way into lower cost canal lining applications replacing spray applied bitumen, bentonite and thin concrete. However, the thin 0.2 to 0.25 mm (8 to 10 mil) plastic materials were easily damaged during installation and required a minimum of 300 mm (12 in.) of soil cover for protection from UV exposure and mechanical damage.

The agricultural industry in the United States and other countries have historically been faced with the efficient storage and conveyance of water, especially in the arid lands such as the western United States. Government agencies and national committees in many countries were formed to investigate and implement improved canal lining materials. The Department of Agriculture and the U.S. Bureau of Reclamation were pioneers in the development of early research into materials and methods used in the waterproofing of water distribution systems and in the development of specifications and guidelines for the lining of canals (Comer, et.al., 1999).

There are over 26,000 km (16,000 miles) of main canals and over 43,000 km (27,000 miles) of secondary's or laterals in the arid western United States alone (Comer, et.al., 1999). Many of these original water distribution structures were simply excavated in the native soils (or rock) to provide water distribution. The U.S. Bureau of Reclamation began investigating plastic and other "alternative" lining materials for seepage control in the 1940's. to reduce known seepage in many of the canals and laterals under their control. An "alternative" lining material is a material other than conventional concrete or compacted earth linings for use in areas of limited right of way (steep side slopes), northern climates (freeze/thaw) and areas where clay materials were not available. Early work with various canal lining materials is summarized in Bureau of Reclamation (1963), Hickey (1969) and Morrison and Starbuck (1984).

In response to the growing need to reduce seepage and conserve dwindling water supplies in drought areas, the U.S. Bureau of Reclamation has recently completed a canal lining demonstration project where 27 "alternative" canal lining test sections have been constructed. These test sections are being used to assess durability, installation costs, benefit/cost (B/C) ratios, maintenance costs and seepage control effectiveness over severe rocky and highly porous soils. The test sections are predominately located in Oregon, Montana and Oklahoma and are described in Swihart et.al. (1994). Installation of additional test sections and a 7 year durability report was published by Swihart and Haynes (1999) with an updated 10 year report due out in 2002. Based on this and other work, the U.S. Bureau of Reclamation is assisting western irrigation districts in the design and installation of geomembranes for use in saving valuable and increasingly limited agricultural water.

The Tulelake Irrigation District Project

The U.S. Bureau of Reclamation Klamath Project is one of the oldest irrigation projects in the Western United States. As one of the original 18 irrigation districts, the Tulelake Irrigation District (TID) supplies valuable agricultural water to the over 25,500 hectares (63,000 acres) of otherwise dry but fertile lands of the northern California counties of Siskiyou and Modoc as well as Klamath County, Oregon. Irrigation water has always flowed to the approximately 800 farms using a vast network of over 390 km (242 miles) of main canals, laterals and ditches, some of which date back to the turn of the century.

In April, 2001, the U.S. Bureau of Reclamation drastically reduced the flow of irrigation water to the Klamath and Tulelake irrigation districts of northern California and southern Oregon citing environmental considerations in the already drought-affected area. This action caused many farms to go out of business due to lack of irrigation water. The area has been designated a federal drought area eligible for federal aid and funds have been made available for implementing emergency drought relief measures which include the rehabilitation of old earth lined delivery channels.

Historically, the irrigation district has also faced loss of deliverable water due to high seepage rates in unlined canals and laterals of over 30 percent and approaching 50 percent in rocky reaches. The high seepage rates in unlined canals and laterals as well as the drought conditions here and in other irrigation districts, has prompted the federal government to initiate a program for the lining of distribution channels. Part of this program includes the selection and installation of low cost, low tech lining systems that can be 100 percent installed and maintained by the irrigation district personnel without the need for specialized installers or contractors. Materials must be capable of being installed in harsh, rough soil or rocky conditions, resist animal

traffic, be repairable by the irrigation district and must be designed for being left exposed in excess of 20 years.

Federal Government Requests Proposals for Lining Systems

In June of 2001, the U.S. Bureau of Reclamation, Mid Pacific Region, issued a Request for Proposals (RFP) to supply a geomembrane system and associated geotextiles (where required) to line the M-2 lateral of the Tulelake Irrigation District from sta 0 + 00 to sta 121 + 92 or approximately 3.7 km (2.3 miles). The request specified an exposed geomembrane system that could be installed, seamed, repaired and maintained by irrigation district personnel. The maximum panel size was limited to 9.14 m x 61 m (30 ft x 200 ft) with a minimum thickness of 1.14 mm (45 mils). The geotextile required for extreme rocky outcroppings was a minimum 340 gm/sq m (10 oz/sq yd) nonwoven protection fabric. The government required that a review panel select the geomembrane system based on the following evaluation criteria:

1. Technical Capability
   a. Ease of Installation (Delivery, Placement, Seaming by TID)
   b. Damage Resistance (During Placement and Operation)
   c. Ease of Repair (Repair by TID over life of the lining)
   d. Expected Life (Manufacturer warranty for exposed conditions)
   e. Seepage control (Effective barrier material)
   f. Descriptive Literature addressing the above

2. Past History and Performance

3. Price

The final selection of a supplier was based primarily on technical merit, installation by TID personnel using their equipment and characteristics of the geomembrane material as well as cost considerations. Thus, the lowest bid price was not the principal determining factor in the final selection of the system.

The canal section to be lined was an original earth-lined canal built in 1942 with some rocky reaches and known high seepage loss in excess of 30 percent. The original section and right of way necessitated use of an exposed geomembrane material due to excessively steep slopes (no soil cover could be placed due to stability considerations). Technical characteristics included the following:

Q = 2 cms (72 cfs)
V = 0.4 m/s (1.32 fps)
D = 1.22 m (4.0 ft)
S = .00015

Side slopes were an average of 1.5H : 1V and base width varied between 1.8 m and 2.4 m (6 - 8 ft). Total width of the section including flat runout anchors at top of slope was 9.14 m (30 ft). Thus, geomembrane panels delivered to the site were required to have a 9.14 m (30 ft) width with no longitudinal seams. Seaming in the field was to be at panel ends only and across the width of the canal section with no horizontal seams on slopes or longitudinal seams on the invert of the canal.

EPDM Chosen for Superior Technical Characteristics and Low Cost

The U.S. Bureau of Reclamation, Mid Pacific Region awarded the project to a material supplier of 1.14 mm (45 mil) thick Ethylene-Propylene-Diene-Monomer (EPDM) rubber geomembrane based on the above technical evaluation factors and low cost. EPDM geomembranes have been in use worldwide for over 40 years in a wide variety of containment applications including large and small irrigation canals. Most recently, EPDM was chosen for the Ochoco and Talent Irrigation Districts in Oregon to line canal sections with extreme water seepage. Both of these projects utilized the irrigation district crews for soils preparation, EPDM installation, seaming and connections to structures.

EPDM rubber geomembranes are considered a superior choice for use in the rehabilitation of old canals and laterals of western irrigation districts for the following reasons:

- Minimal preparation of the channel section using district equipment and personnel
- User friendly ease of panel installation with district equipment and personnel
- User friendly low tech seaming and repair methods by district personnel
- Mechanical properties to resist installation and operation stress in an exposed environment (puncture/impact resistance, working strain to over 500 percent)
- Attachment to concrete and steel structures (gates, turnouts, pipes, etc.) using special waterproof adhesive systems
- Lay flat (soil friction and unit weight) characteristics to resist wind uplift/displacement
- High UV and weathering resistance backed by decades of exposed installations
- Repair and maintenance by irrigation district using simple low tech seaming techniques and repair kits
- Custom panel sizes for differing channel sections
- Installation and seaming in cold winter weather conditions (usually off-season October to March)
- Resistant to animal traffic including deer and elk in remote areas

EPDM Geomembrane Placement by the Tulelake Irrigation District

EPDM factory panels were manufactured and custom-sized for the TID by Firestone Building Products Company. The panels were sized to 9.14 m (30 ft.) in width by 61 m (200 ft.) in length, folded along the length and then rolled for delivery and handling on site. Once the rolls of panels were delivered to the site, the TID deployed the panels using their own equipment and 8 person crew. District personnel fabricated a custom lifting bar which was suspended by cable from the bucket of an XL4100 Gradall. The rolls of EPDM were lifted from a flatbed truck, positioned in the channel bottom and unrolled along the channel by advancing the XL4100 Gradall along the channel access road.

Once the panels were unrolled and unfolded up the side slopes, they were positioned and placed into the anchor benches on both sides of the channel section. The ends of the panels were then overlapped a minimum of 150 mm (6 in.) and the overlap area was cleaned and primed with Firestone QuickPrime Plus. The overlap area was then tacked without wrinkles and Firestone QuickSeam tape, an adhesive tape seam system, was applied by the TID crew. The field fabricated seams were composed of prefabricated 150 mm (6 in.) wide rolls of partially vulcanized Firestone cover strips with adhesive backing. Once the strip was

placed and centered on the overlap, it was pressed down onto the two adjacent panels with constant hand roller pressure to ensure complete adhesion. Advantages of using the patented tape seam system include the following:

- Designed for remote areas and can be installed in cold temperatures.
- No specialized welding equipment, hot air guns or supporting electric generator equipment is required.
- Components are simple and can be stored at irrigation district shops for future use.
- Seaming requires no specialized training (TID crew received 15 minutes of instruction).
- Resultant seam is a continuous 75 mm (3 in.) bond to panel edge with high peel and shear strength. Seam area will resist movement under load to over 300 percent strain without affecting the waterproof integrity.
- The same seam methods are used for repair patches by TID maintenance crews.

During the placement of panels, it was noted that the EPDM sheet material was not susceptible to wind uplift even by high winds which are a frequent occurance at this site. The EPDM rubber sheet conforms readily to the subgrade, lays flat and adheres to the soil due to surface friction, unit weight and flexibility (conformance to subgrade).

Once the panels were in place and seamed, the TID crew placed soil cover on the anchor benches and compacted the material at top of slope with dozer or motor grader wheel loading. It was noted that during soil placement and grading on the top of the channel that some large angular rocks in excess of 34 kg (75 lbs) were displaced and rolled down the EPDM slopes. No puncture damage or marks were noted on the EPDM due to rock fall. Although there is no requirement for soil cover on the bottom of the channel, sediment, upper slope soils and wind blown soils will accumulate over time providing a deposited soil cover.

Summary

The TID successfully installed an exposed EPDM geomembrane system using custom manufactured panels, TID personnel for installation and seaming and TID equipment for the soils preparation and backfilling. The combination of low cost and user friendly materials that can be installed by irrigation district personnel with minimal training and no specialized equipment is an outstanding low cost alternative to other systems.

The installed cost of the exposed EPDM system at Tulelake was approximately $0.40 per square foot including preparation of the channel section, material and installation/seaming. As a comparison, the U.S. Bureau of Reclamation estimates of installed costs for lining systems range from a low of $0.76 to a high of $4.33 per square foot (Swihart et.al., 2000).

Since the initial installation and success through the first irrigation season, the TID has purchased additional EPDM panels for installation in 2.2 km (1.3 miles) of additional channel rehabilitation starting in October of 2002.

The TID is typical of many irrigation districts in the western United States where conveyance channels are unlined with many losing between 30 and 50 percent of the deliverable water to seepage during the irrigation season (April - October). With water costs increasing and available water in short supply (especially during dry years or federally mandated allocation restrictions), irrigation canals and laterals are being evaluated for lining with exposed

geomembrane systems. There are over 26,000 km (16,000 miles) of main canals and over 43,500 km (27,000 miles) of laterals in the western United States alone. Of these, only approximately 15 percent are lined. Although all reaches of canals or laterals do not need lining, the potential of those that will need lining to save valuable irrigation water is indeed large.

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