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CANAL-LINING DEMONSTRATION PROJECT YEAR 10 FINAL REPORT

November 2002

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Pacific Northwest Region
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The Deschutes Canal-Lining demonstration Project is a cooperative effort among the Bureau of Reclamation, several irrigation districts, and several geosynthetic lining manufactures. The purpose of this study is to develop low-cost canal-lining technologies to reduce seepage over severe rocky subgrade conditions. The 34 test sections include combinations of geosynthetics, soil, concrete grout, Shotcrete, roller compacted concrete, elastomeric coatings, and sprayed-in-place foam. This report assesses the performance of test sections after 1 to 10 years of service. This report also documents the construction of five of the newest tests sections .

At this time, seven of the test sections have failed, while the remaining test sections are in fair to excellent conditions. Each test section covers about 30,000 square feet, and unit construction costs ranged from less than $1.00 to more than $4.00 per ft^2. The test sections are divided into four generic types: exposed geomembranes, fluid-applied membranes, geomembranes with concrete cover, and concrete alone. Preconstruction and postconstruction ponding test have shown effectiveness at reducing seepage between 70 and 95 percent. The most promising lining alternative demonstrate benefit/cost ratios between 3 and 4.

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Mission Statements

U.S. Department of the Interior

The mission of the Department of the Interior is to protect and provide access to our Nation's natural and cultural heritage and honor our trust responsibilities to Indian tribes and our commitments to island communities.

Bureau of Reclamation

The mission of the Bureau of Reclamation is to manage, develop, and protect water and related resources in an environmentally and economically sound manner in the interest of the American public.

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The authors wish to acknowledge the various material suppliers and contractors who were willing to participate in the project. In addition to making financial contributions, the participating companies provided invaluable technical support. These companies have also assumed risks by placing their products adjacent to those of their competitors under adverse conditions and often in new applications.

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GLOSSARY

CSPE	=	Chlorosulfanated polyethylene
CSPE-R	=	Reinforced chlorosulfanated polyethylene
EPDM	=	Ethylene Propylene Diene Monomer
EVA	=	Ethylene vinyl acetate
GCL	=	Geosynthetic clay liner
HDPE	=	High density polyethylene
LLDPE	=	Linear low density polyethylene
mPE	=	metallized polyethylene
PE	=	Polyethylene
PP	=	Polypropylene
PVC	=	Polyvinyl chloride
RCC	=	Roller compacted concrete
UV	=	Ultraviolet
VLDPE	=	Very low density polyethylene

EXECUTIVE SUMMARY

Reclamation has constructed 34 canal-lining test sections in 11 irrigation districts in four States to assess durability and effectiveness (seepage reduction) over severe rocky subgrades. The lining materials include combinations of geosynthetics, shotcrete, roller compacted concrete, grout mattresses, soil, elastomeric coatings, and sprayed-in-place foam. Twenty-eight test sections are located in central Oregon, three are in Montana, two are in Idaho, and one is in Oklahoma. Each test section typically covers 15,000 to 30,000 square feet. The test sections now range in age from 1 to 10 years. Preliminary benefit/cost (B/C) ratios have been calculated based on initial construction costs, maintenance costs, durability (service life), and effectiveness (determined by preconstruction and postconstruction ponding tests). The 34 test sections are divided into 4 generic categories as shown in the table below.

Table ES-1.—Test results for the 34 test sections

Type of Lining	Construction Cost ($/ft^2)	Durability (years)	Maintenance Cost ($/ft^2-yr)	Effectiveness at Seepage Reduction (percent)	B/C Ratio
Fluid-applied Membrane	$1.40 - $4.33	10 - 15 yrs	$0.010	90 %	0.2 - 1.5
Concrete alone	$1.92 - $2.33	40 - 60 yrs	$0.005	70 %	3.0 - 3.5
Exposed Geomembrane	$0.78 - $1.53	10 - 25 yrs	$0.010	90 %	1.9 - 3.2
Geomembrane with Concrete Cover	$2.43 - $2.54	40 - 60 yrs	$0.005	95 %	3.5 - 3.7

Each of the lining alternatives offers advantages and disadvantages. The geomembrane with concrete cover seems to offer the best long-term performance.

Fluid-applied membrane – Many of these test sections have failed and have been removed from the study. Most of the problems were related to poor quality control because of adverse weather common to field construction in late fall and early spring. These types of linings may have potential for special niche applications such as lining existing steel flumes or existing concrete channels.

Concrete – Excellent durability, but long-term effectiveness was only 70 percent because of random cracking. Irrigation districts are familiar with concrete, and they can easily perform required maintenance.

Exposed Geomembrane – The effectiveness is excellent (90 percent), but exposed geomembranes are susceptible to mechanical damage from animal traffic, construction equipment, and vandalism. Although exposed geomembranes have the lowest initial construction costs, they have a limited service life (typically 15 to 20 years). Also, exposed geomembranes are often poorly maintained because irrigation districts are unfamiliar with the geomembrane material, and sometimes need special equipment and training to perform even minor repairs.

Concrete with Geomembrane Underliner – The geomembrane underliner provides the water barrier, and the concrete cover protects the geomembrane from mechanical damage and weathering. System effectiveness is estimated at 95 percent. Districts can readily maintain the concrete cover, but they do not have to maintain the geomembrane underliner.

Effectiveness – Ponding tests showed a typical preconstruction seepage rate of about 1.0 foot per day. Postconstruction ponding tests showed effectiveness of 70 to 95 percent for the various lining alternatives.

Maintenance – Over the course of 10 years, maintenance costs have been relatively low for all the lining alternatives. Generally, exposed geomembranes require about twice the maintenance of concrete linings. For all lining alternatives, benefit/cost analysis shows that every $1 spent on maintenance returns $10 in conserved water by increasing effectiveness and design life. Therefore, more emphasis should be placed on maintenance, especially for exposed geomembrane linings.

New Test Sections

The newest test sections have been in service for only 1 to 2 years. While some of these test sections look promising, more time is needed to evaluate them before estimating service lives and benefit-cost ratios. These test sections include:

Wet-applied polyurethane geocomposite
Exposed reinforced metallized polyethylene
Exposed bituminous geomembrane
Exposed white textured HDPE
Exposed EVA geocomposite

Coupon Testing

Six of the exposed geomembrane test sections were sampled for laboratory evaluation. Although many of the exposed geomembranes visually appear to be in excellent condition, the changes in physical properties suggest that many are beginning to degrade. Service life predictions are included in table ES-2.

Table ES-2—Coupon Testing of Exposed Geomembrane test sections

Test Section	Material	Age	Visual Assessment	Physical Property Testing	Service Life Prediction
A-3	80-mil Textured HDPE	10 years	Excellent	Elongation down 90% OIT down 30%	20-25 years
A-4	30-mil PVC with Bonded Geotextile	10 years	Very Good	Tensile up 30% Modulus up 140% Elongation down 70%	10-15 years
A-5	45-mil Hypalon	10 years	Fair to Poor	Tear strength down 60%	10-15 years
A-6	36-mil Hypalon	10 years	Fair	Tear strength down 60%	10-15 years
O-3	45-mil EPDM	2 years	Excellent	Elongation down 30% Tear strength down 50%	15-20 years
O-4	30-mil LLDPE	2 years	Excellent	Tensile down 10% Tear Strength down 10%	10-15 years