WATER OPERATION AND MAINTENANCE

BULLETIN NO. 147

March 1989

IN THIS ISSUE

UNITED STATES DEPARTMENT OF THE INTERIOR
Bureau of Reclamation

The Water Operation and Maintenance Bulletin is published quarterly for the benefit of those operating water supply systems. Its principal purpose is to serve as a medium of exchanging information for use by Reclamation personnel and water user groups for operating and maintaining project facilities.

While every attempt is made to insure high quality and accurate information, Reclamation cannot warrant nor be responsible for the use or misuse of information that is furnished in this bulletin.

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Cover photograph:

Aerial view of Brantley Dam and Reservoir showing maximum section of dam.

UNITED STATES DEPARTMENT OF THE INTERIOR BUREAU OF RECLAMATION

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TEFLON PACKING WARNING

Do not use packing that contains asbestos or TFE
when packing expansion joints on steel outlet pipes.

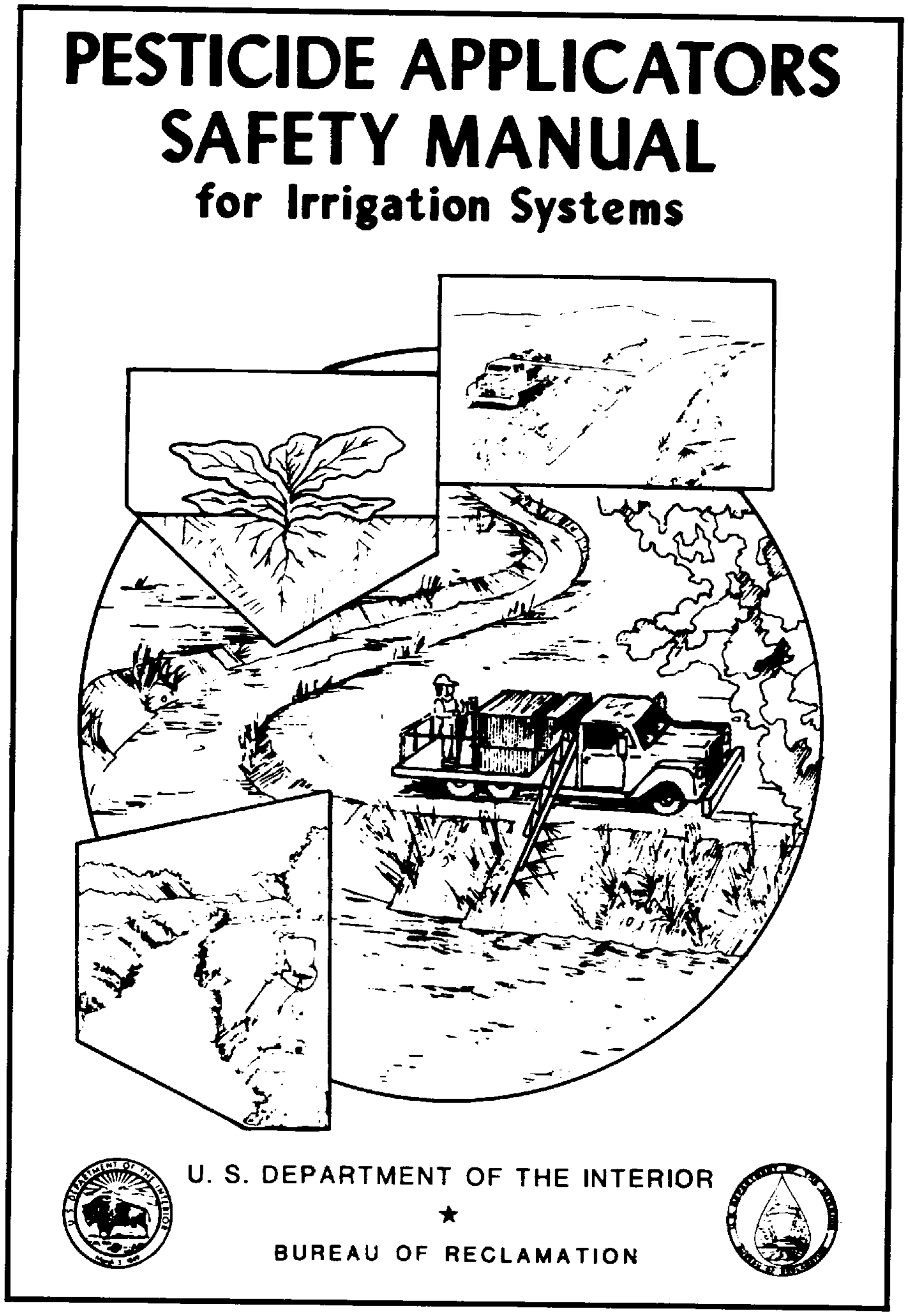
Asbestos fiber packing, which has traditionally been used in the past, is increasingly difficult to procure. Other types of fiber, which have been impregnated with TFE (teflon), have been used.

Heating the TFE material above 500 °F will release potentially hazardous fumes.

Field personnel occasionally heat expansion joints to free stuck or rusted glands.

If packing of this type has been used, a warning should be posted and included in the operation manual for the installation.

If any Bureau office desires assistance in selecting or locating the proper packing for the expansion joints, please contact the Mechanical Branch in the Denver Office.



JUST OFF THE PRESS

Pesticide Applicators Safety Manual

This publication is a guide for planning, applying, and practicing safety procedures in the application of pesticides.

This Manual is a 6- by 9-inch paperback and may be purchased for $5.75 a copy, which price includes postage and handling costs. Send your check or money order (no cash or stamps) payable to the Bureau of Reclamation, attention D-7923A, PO Box 25007, Denver, Colorado 80225-0007.

A SOUND MARRIAGE[1]

Sidewalk Blocks and Polyethylene Combine to Form a Unique Canal Liner

Marriages are made in heaven, so the saying goes, but this marriage between black polyethylene plastic sheeting and concrete sidewalk was contrived at the Lethbridge Research Centre. Originally the idea of Dr. Theron Sommerfeldt of Canada Agriculture and Larry Spiess of the Irrigation Branch, Alberta Agriculture, the trial lining was installed as one of four different types back in the spring of 1982 in a small farm lateral at the Centre. The search then, as it is still today, was to find the ultimate low-cost canal lining material. The 1982 Fall Edition of the Water Hauler's Bulletin reported on this unique combination.

With the concrete sidewalk block system, the channel is trimmed and graded to a smooth surface; a herbicide applied to prevent weed growth; the plastic sheeting laid down and keyed into the upper part of the sideslope; and finally, the 600- x 600- x 50-mm (24- x 24- x 2-inch) unreinforced concrete sidewalk blocks laid directly on top of the liner.

According to Dr. Sommerfeldt, the blocks have performed well since installation. The plastic appears to be in the same condition as when installed and this has been confirmed by recent laboratory tests done by the manufacturer, Canadian Industries Limited. A few weeds have grown between the joints. Their roots extend under the blocks between the plastic and the blocks themselves; however, no damage has occurred. The rigid blocks and flexible liner are not suffering any damage from frost heaving and normal problems associated with shifting soil.

Base requirements for installation are less demanding than for installation of the rigid linings, such as concrete. No earth pad is required. For simple farm delivery ditches, a l-l/2:1 sideslope is probably adequate; however, for larger ditch sections where more than one block is required along the sideslope, a 2:1 sideslope would be more stable. A smooth, flat, channel surface is necessary to obtain a relatively good fit between adjoining blocks.

"The ditch is on a steep 1 percent grade. Because of the rapid flow of water and turbulence, it is difficult to obtain accurate depths of flow for determining the coefficients of roughness," says Dr. Sommerfeldt. His measurements place the coefficient of roughness at 0.016.

The cost of materials converted to today's prices for the "Sommerfeldt/Spiess liner" is around $8 a square metre ($7 a square yard). For the small section of ditch used in this experiment, labor requirements were considerable during construction; but for a large project, much of the hand labor could be reduced by the use of machines.

Dr. Sommerfeldt feels the block system is unique in that the blocks can be removed should the plastic membrane ever become damaged. A new section of the liner can be installed and the blocks replaced with little disruption and no specialized machinery.

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[1] Reprinted with permission from the Editor, Water Hauler's Bulletin, Summer/88 issue, Alberta Agriculture, Agriculture Centre, Lethbridge, Alberta T1J 4C7.

The sidewalk blocks, because they are not joined at the butt, have not suffered any cracking or misalignment from frost action.

He contends that this marriage of two different types of lining materials has its place here in southern Alberta and will be economical and sufficiently durable to withstand the rigors of our often harsh climate. Both men wish to see a larger lateral requiring multiple adjoining blocks on sideslopes be lined with their unique system.

For further information, please contact Dr. Theron Sommerfeldt, Soil Science Section, Canada Agriculture, telephone (403) 327-4561 or Larry Spiess, P.Eng., Research, Planning and Monitoring Section, Irrigation Branch, Alberta Agriculture, telephone (403) 381-5152.

CONDENSED INTERIM REPORT ON CANAL LININGS USED BY THE BUREAU OF RECLAMATION[1]

by

Thomas R. Haider and Thomas E. Mitchell[2]

Introduction

Information on Bureau of Reclamation lining practices appears in a variety of publications and papers including the publication entitled "Linings for Irrigation Canals" [1][3] which is out of print. While most of the information in this publication is still applicable, there are areas where the technology should be updated. This is an interim report on Bureau of Reclamation practice related to canal lining selection and design while the aforementioned publication is being updated. Many of the areas that planners and designers need to be aware of prior to making a determination of lining type are discussed. Much of the information presented in this report may be used also to determine the type of lining for rehabilitations.

In addition to the above publication, information related to canal linings may be found in Design Standards No. 3 [2], Performance of Plastic Canal Linings [3], Performance of Granular Soil Covers on Canals [4], and Bureau of Reclamation Practices for Design and Construction of Concrete Lined Canals [5].

History

The following is a brief history of canal linings and canal lining studies that culminated with the "Linings for Irrigation Canals" publication. Also included is a statistical compilation of different types of linings expressed as a percentage of the total Bureau of Reclamation canals.

a. Lower cost canal lining program.–The "Linings for Irrigation Canals" publication is a direct result of the Bureau of Reclamation's lower cost canal lining program. The lower cost canal lining program was initiated in June 1946; and after 16 years of comparisons of various canal linings, the "Linings for Irrigation Canals" publication was issued.

During those 16 years, 2,570 miles of lower cost linings and 420 miles of reinforced concrete linings were installed on Bureau of Reclamation canals. The lower cost linings included unreinforced concrete, shotcrete, soil cement, asphaltic concrete, exposed asphaltic membranes, exposed plastic and synthetic rubber films, prefabricated concrete blocks, prefabricated buried asphaltic membranes, buried plastic and synthetic rubber films, bentonite membranes, thick compacted earth lining, thin compacted earth linings, and loosely placed (uncompacted) earth blankets. A summary of these linings is shown in table 1.

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[1] Condensed for the Bulletin (typical section sketches and design charts have been eliminated). The complete paper may be obtained by contacting one of the authors.

[2] Thomas R. Haider and Thomas E. Mitchell are Principal Designers in the Water Conveyance Branch, Civil Engineering Division, Bureau of Reclamation, D-3120, PO Box 25007, Denver CO 80225.

[3] Numbers in brackets refer to References at end of report.

Table 1. Quantities of canal linings placed on Bureau of Reclamation-constructed canals (1946-1962)

Type of lining	Square yards	Miles
Exposed Lining		
Asphaltic concrete (hot and cold mix)	276,000	42.0
Asphaltic macadams	11,000	0.8
Asphalt surface membranes (prefabricated and constructed in place)	81,000	10.3
Other exposed asphalt linings (mortars, blocks, and slabs)	8,000	0.7
Portland cement concrete (unreinforced)	23,690,000	1,077.5
Portland cement concrete (reinforced)	9,738,000	419.9
Shotcrete	1,919,000	167.6
Soil cement	37,000	3.7
Other exposed linings (concrete blocks, plastic, and rubber surface membranes, etc.)	8,000	6.8
Buried Membrane Linings		
Asphalt (hot-applied)	5,839,000	333.1
Asphalt (prefabricated)	24,000	2.1
Bentonite	300,000	19.6
Plastic	22,000	1.2
Earth Linings		
Thick compacted earth	12,152,000	566.2
Thin compacted earth	1,885,000	74.3
Loosely placed earth blankets	3,207,000	174.9
Bentonite-soil mixture	108,000	6.1
Soil sealants (chemical, petrochemical, and sediment)	535,000	41.2
Miscellaneous		
Includes resurfacing of existing linings, their undersealing and grouting, and the construction of cast-in-place concrete pipe in lieu of lining	144,000	45.8
Totals	59,984,000	2,993.8

b. Statistics on lining types.–The latest statistical compilation publication [6] dated September 30, 1986, indicates that since the early 1900's approximately 6,600 miles of Bureau of Reclamation canals have been completed or are under construction. The "Linings for Irrigation Canals" document compared lining types for 2,993.8 miles of canals built between 1946 and 1962 (see table 1). From the 1986 statistics publication, it is estimated that approximately 1,400 miles of canals were constructed between 1962 and 1986.

Table 2 shows, by percentage, an estimate of the types of linings used on canals constructed during these two periods and also for all Bureau of Reclamation canals constructed since the Bureau's inception in the early 1900's.

Table 2. - Percentages of types of linings on Reclamation-constructed canals

Type of lining	From 1963 publication (3,000 miles)	1963 to 1986 (1,400 miles)	Total USBR canals (6,600 miles)
Concrete (reinforced, unreinforced, shotcrete, etc.)	56 %	60 %	58 %
Buried membrane:			
Hot asphalt	11 %	—	5 %
Plastic	0.00004 %	7 %	2 %
Other	0.007 %	—	—
Compacted earth	19 %	33 %	27 %
Other	14 %	—	8 %

Selection of Type of Lining

Linings most prevalent at the present time are unreinforced concrete, thick compacted earth, and buried PVC (polyvinyl chloride) geomembrane. It is the policy of the Bureau of Reclamation to line open channels to conserve water and secure other benefits. There are many factors that influence the type of lining chosen, and no single type of lining can be recommended to satisfy all conditions. A full economic evaluation should be conducted which would include an evaluation of land and water values along with estimates of construction costs and operation and maintenance costs for the various lining options considered. In addition to economics, other factors such as location, climatic conditions, construction considerations, environmental concerns, operational and maintenance concerns, experience gained on existing systems, and general sound engineering judgment must be considered before a final choice is made. General Bureau of Reclamation criteria for each type of lining are discussed in the following sections.

Concrete Lining

Concrete lining has been successfully used on many Bureau of Reclamation projects built since the early 1900's. Concrete lining has certain hydraulic and structural characteristics that tend to make it a desirable alternative at many locations. Higher flow velocities, inherent with concrete lining, can hinder silt deposits and some kinds of aquatic growth. Furthermore, concrete lining has better hydraulic characteristics along with steeper allowable side slopes, usually 1-1/2:1, resulting in a smaller canal prism which will reduce right-of-way required for construction, which in turn may significantly reduce the land required. Concrete is also a common construction material and may be the most economically available lining in some locations. Contractors are generally familiar with construction methods and equipment used for concrete lining. If properly designed, constructed, and maintained, concrete lining provides a seepage rate comparable to compacted earth lining; presents a hard impenetrable barrier against burrowing animals; and significantly reduces weed growth in the canal prism. Finally, from a safety standpoint, reinforced concrete panels with waterstop joints may provide the required structural capability and seepage control in critical areas where a canal bank failure could result in loss of life and/or damage to improvements, such as farm and town buildings, railroads, highways, etc.; and this factor alone may preclude using other types of lining.

Many different methods have been used to provide an economical and watertight system of construction joints in concrete lining. Current Bureau policy is to place PVC strips during the lining installation or to place elastomeric sealant in preformed grooves after the lining has cured. If canals with elastomeric sealant are left unwatered for a long period of time before going into operation after construction, the sealant may deteriorate by exposure to the sunlight.

Higher velocities and steeper side slopes typical of concrete lined sections present a greater hazard to humans or animals that enter the canal when water is flowing. Safety ladders must be installed to allow exit by humans, and animal escapes may be required in areas of deer concentrations. Fencing required to restrict access by people, livestock, and/or deer can vary from 4-foot-high four-strand barbed-wire fence for livestock to an 8-foot-high deerproof fence.

The Bureau's Concrete Manual [7] has a further discussion on grooves, and finishing and curing for concrete lining.

A variety of foundation problems must be considered for concrete lining to perform satisfactorily. It should be pointed out that although these foundation problems are discussed under concrete lining, many of these problems would have to be addressed if compacted earth or plastic membrane lining is used. Following are the more common situations which may need consideration:

a. Expansive earth foundation material can damage concrete lining; therefore, special foundation preparation, such as overexcavation and replacement with suitable material or lime treatment of the inplace expansive material, may be required during construction.

b. Low density material that has historically never been wet usually has the potential for collapse upon saturation, as stated in the Bureau's Earth Manual [8]. These areas should be treated by removal and recompaction or by prewetting. The Bureau has some limited experience of treating low density loessial material by a method of silt injection to consolidate the loose material. Soil stabilization by silt injection, discussed in an ASCE paper [9], may be used after construction as problems develop in areas that were not identified prior to or during construction.

c. Special care should be taken when a canal is constructed on a silt material since an ice crystal formation adequate to damage thin unreinforced concrete lining may develop even with no free water surface present. A moisture content in silt of 2 percent greater than optimum can lead to damage to unreinforced concrete lining from frost action.

d. Cracks in the lining should be repaired as soon as practical to keep water from reaching potentially troublesome foundation material. The referenced article on sealing contraction joints and random cracks [10] may be helpful.

e. Thin concrete lining must have a smooth, uniform foundation. Small continuous foundation ridges as small as 1/2 inch in height can cause a crack in unreinforced concrete lining.

f. Hydrostatic pressure in the soil behind the concrete lining can cause the lining to uplift and crack. Improper ponding or runoff of storm drainage, or cracks in the lining, which allows water to enter behind the lining that could create a localized high ground water, or a naturally occurring ground water table, will cause this damage if the water surface in the canal drops faster than the pressure behind the lining can be reduced. If the back pressure potential appears to be imperative, damage due to this back pressure may be mitigated by restricting operational fluctuations and/or by installing a properly designed underdrainage system. Underdrain systems that drain by gravity to natural low areas along the canal, or to a pump sump if no natural low areas are available, is one way to protect the lining where hydrostatic back pressure or ground water exists. A flap valve weep drainage system may also be effective at reducing localized back-pressure problems. The flaps must be aligned with the direction of flow to minimize the adverse effect of trash and sediment on the operation of the flap. It is also recommended that flap valve weeps be placed only in the invert of the canal as the flaps tend to twist when open and at times do not close properly if installed on the canal side slope.

Exposure to varying weather conditions can present special problems for concrete lining. In areas where the frost line may be significantly below the ground surface, frost susceptible foundations must be investigated. Air-entrained concrete should be specified if freeze-thaw deterioration could be a problem. Other possible exposure problems could include heavy rains during construction which could affect the finish, prolonged freezing temperatures which preclude paving operations since it is impractical to protect the concrete, and high temperatures coupled with low humidity which will exaggerate plastic shrinkage cracking tendencies.

Compacted Earth Lining

Thick compacted earth linings of gravel and sand with clay binders or poorly graded gravel-sand-clay mixtures with a minimum thickness of 2 feet normal to the finished canal prism are excellent earth lining materials as they provide excellent seepage control and erosion protection. If suitable materials are locally available, then this type of lining should be considered because compacted earth produces an acceptable lining and will usually be economically competitive. Compacted earth lining can withstand colder temperatures with less damage than concrete lining as it has greater ability to tolerate frost heave, although a reduction in unit weight will occur due to frost action. No special equipment or technology is required for construction of compacted earth lined canals, which usually results in competitive bidding. Compacted earth can also tolerate greater water surface fluctuations with less damage than can concrete lining. It generally does not require as much foundation preparation as concrete lining and certain expansive materials may be tolerated near the prism. The problem of low density material should be addressed in a manner similar as with concrete lining. Since side slopes are flatter and velocities slower, compacted earth lined sections are less hazardous to people and animals that enter the canal.

Compacted earth lining has different design considerations than concrete lining for satisfactory performance. First, it must be designed for a slower flow velocity to prevent erosion. If the lining chosen tends to be erodible, gravel armoring of the side slopes or a beach belt in the operating zone may be required. Cleaning of the canal prism must be done with care to prevent removing lining material or disturbing the armoring or beach belt, and control of aquatic growth in the canal prism and weeds on the adjacent bank is more difficult. Finally, a sudden failure due to burrowing animals is a potential problem since the earth lining is not a barrier to these animals.

Buried Plastic Lining

Buried plastic PVC material is gaining more acceptance as a lining material. Tests on various buried membranes date back to the 1950's; however, use of this type of lining did not gain in popularity until the mid-1970's when manufacturing techniques provided for heavier plastic sheets at a more competitive price. Better quality control has also enhanced its acceptance.

In many ways the plastic lining covered with earth and/or sand and gravel is similar to compacted earth lined canals. The finished prism is similar to the compacted earth lined prism except the side slopes may be flatter. Cleaning of the canal and control of aquatic and weed growth also poses a problem similar to thick compacted earth lined canals. If weed growth is considered a possibility, an approved soil sterilant could be applied to the subgrade. Care should be taken to not apply sterilant outside the lined area if landscaping or grasses are to be established later.

Several characteristics make PVC lining desirable. Buried PVC lining can be placed during colder periods of weather, is especially adaptable for rehabilitating existing earth canals, and is the type of lining least affected by frost heave or expansive material in the proximity of the canal prism. Buried PVC lining can also tolerate greater water depth fluctuations than any other type of lining if the cover material over the plastic is specifically designed to accommodate this condition. Where these types of conditions exist, buried plastic lining should be considered.

Theoretically, properly installed and maintained PVC lining should provide for a near zero seepage rate; but, a number of factors related to the manufacture, fabrication, installation, and maintenance of the membrane could influence the long-term ability of the plastic to retain the near zero seepage rate. Although the data on long-term seepage control are limited, indications are that seepage control for PVC lining should surpass that of a quality compacted earth lining.

The subgrade should be relatively smooth and free of sharp rocks, roots, or other objects which may puncture the membrane. Dragging the subgrade with a heavy machine-type chain or an old tractor track may produce an acceptable foundation. If this method does not provide an acceptable foundation, a covering of 3 to 4 inches of sand or fine-textured soil may be placed on the subgrade prior to placing the membrane.

The cover material design is important for the success of buried plastic lining. The gradation of the cover material should fall within acceptable limits and should be angular to help give it stability on the canal side slopes. To make buried plastic lining viable, a sand and gravel source within an economical haul distance is required. Although a full cover of sand and gravel is preferred, an earth cover topped with sand and gravel may also be used if economics preclude using sand and gravel for the entire depth of the cover. Advantages to using sand and gravel for the cover material are a one-step construction process and a more stable finished product on the side slopes. The use of pit-run gravel that falls within the acceptable gradation limits and is located near the canal site can significantly reduce the cost of this type of lining. There also must be sufficient depth of cover to protect the membrane from punctures from cattle or deer crossing the empty canal. For stability of the cover material, it is recommended that the side slopes should be 2-1/2:1, or flatter. Slopes constructed on 2:1 may be stable under certain conditions, but frequent maintenance may be required to reestablish the slopes and protect any exposed plastic lining.

Operational Criteria

As a general guide for beginning canal operations, the water surface fluctuation limits given below are considered tolerable for the upper 2 feet of the designed normal water surface. However, uncertainties arising from variable operating conditions dictate that these limits be approached with caution. Canal operators should be alert to assure that the manner in which the canal is operated does not have adverse effects on operation of the turnouts, or cause distress in the canal lining or banks.

The water surface rise limitations are to prevent possible undesirable changes in turnout discharges.

The water surface drawdown limitations are to prevent undesirable changes in turnout discharges, to protect the concrete lining from damage by external hydrostatic pressures, and to prevent the earth lined sections from sloughing.

Water surface rise. - The rise in the canal water surface should not exceed 6 inches in any 1 hour. The 6-inch rise may occur in less than 1 hour, but the total vertical movement of the water surface must not exceed 6 inches in the 1-hour period. Experience shows that filling should not exceed 18 inches in any 24-hour period.

Water surface drawdown. - Drawdown shall not exceed 6 inches in any 1-hour period (may occur at any rate), 12 inches in any 2-hour period, and 18 inches in any 24-hour period.

Experimental Linings

The Bureau of Reclamation continues to investigate alternatives to traditional types of lining and methods of placing lining. Following is a summary of recent work and work that is being considered for the near future:

a. Bottom-only lining. - In some special situations, conditions are such that the soil permeability is primarily vertical with very little, if any, horizontal movement. Under such conditions, a bottom-only lining may be attractive. If a completely watertight lining is not necessary, and the seepage from the side slopes can be tolerated, bottom-only lining may be a cost effective way to reduce seepage. This is possible because of the higher bottom width to water depth ratio of earth sections. Soil conditions which exhibit the vertical seepage pattern are found in loessial soils in some areas of Nebraska and Kansas. Field studies were conducted at three locations by the Nebraska-Kansas Projects Office, Grand Island, Nebraska. For these studies, 10-mil PVC was installed only in the canal invert. Results of the field studies, included in the report on Special Membrane Canal Lining, Farwell Main and Lower Main Canals [11] and the OCCS Research Summary Report [12], are listed below.

Canal location	Q ft³/s	*b ft	Seepage loss ft³/ft²/day		Percent reduction
			Before lining	After lining	
Farwell Main Canal	290	18	0.56	0.27	52
Franklin Canal	230	14	1.01	0.45	55
Upper Meeker Canal	284	16	1.13	0.56	50

* b Denotes the bottom width of the canal.

b. Placing concrete lining on plastic membrane under water. - A test section on the Coachella Canal in southern California has been proposed for the underwater placement of concrete on a plastic membrane. Equipment will have to be developed that will prepare the subgrade, place a sheet of plastic, and extrude the concrete directly on top of the plastic membrane. If successful, this would provide for an economical method of lining existing canals that cannot be taken out of service.

c. Shotcrete on geocomposite membrane. - Consideration is being given to placing sections of shotcrete on a geocomposite membrane. A geotextile would be fused to a plastic membrane. The shotcrete would then be applied to the geotextile. The shotcrete would join with the geocomposite to provide a monolithic watertight system. The shotcrete would provide the cover protection (for both puncture resistance and ultraviolet) for the plastic membrane. This system would be beneficial in areas where an adequate source of granular cover material for conventional buried membrane lining is not available.

d. Exposed flexible membrane linings (side slopes only). - A study was initiated recently to evaluate the possible use of exposed flexible membrane linings as alternatives to concrete, compacted earth, and buried plastic linings in the Bureau's irrigation canals. Potential lining candidates include RCSPE (reinforced chlorosulfonated polyethylene), RCPE (reinforced chlorinated polyethylene), and HDPE (high density polyethylene).

The potential advantages of using exposed linings, particularly in comparison to buried plastic linings, include:

(1) Canal side slopes can be increased to 1.5:1, or even 1:1 in special cases, with subsequent cost savings in reduced excavation and right-of-way.

(2) Elimination of the need for protective earth cover on the canal side slopes.

(3) Undetected damage to the membrane is minimized.

(4) Replacement of lining, if required, is easier.

Disadvantages and potential problem areas are always present with any new system and should be studied thoroughly. Exposed membrane linings could be subject to the following adverse conditions:

(1) Damage and problems associated with wind and water forces

(2) Problems related to vandalism and animal damage

(3) Minor ultraviolet surface degradation over time

(4) Damage and associated problems related to abrasion

In May 1983, an 800-foot-long test section of 30-mil HDPE was installed in the Whiterock Extension Canal near Republic, Kansas. The canal is unlined and had experienced some embankment failures in sandy soil. The test section was inspected in September 1987 and is performing satisfactorily, even though several small holes due to puncture by deer traffic were found in the lining.

e. New plastic lining materials. - With the increased use of flexible membrane linings in landfills and hazardous waste containments, several new materials have been developed which may have an application in buried membrane canal lining work. The materials include VLDPE (very low density polyethylene) and a polyethylene/geotextile composite.

In April 1987, a 500-foot test section of 30-mil VLDPE was installed on the Belle Fourche Project near Newell, South Dakota, and will include an evaluation as a possible alternative to PVC. Laboratory studies are underway on the polyethylene/geotextile composite material.

Conclusion

All three major types of linings discussed provide acceptable and cost effective seepage control depending on which factors must be considered when performing an analysis to select the lining type. Factors that should be included, but not necessarily limited to, in the analysis are:

Economics
Project requirements
Temperature ranges
Hydraulic constraints
Right-of-way constraints

Degree of watertightness required
Foundation considerations
Ground water and drainage
Availability of material (for earth lining or cover for PVC lining)
Operation and maintenance concerns
Environmental concerns
Concerns of local entities

When these factors along with any other factors unique to the project are considered, the lining best suited for the project should become evident.

References

1. Linings for Irrigation Canals, Bureau of Reclamation, 1963 (out of print)

2. Design Standards No. 3 - Canals and Related Structures, Bureau of Reclamation, 1967

3. Performance of Plastic Canal Linings, Report No. REC-ERC-84-1, Bureau of Reclamation, 1984

4. Performance of Granular Soil Covers on Canals, Report No. REC-ERC-81-7, Bureau of Reclamation, 1981

5. Bureau of Reclamation Practices for Design and Construction of Concrete Lined Canals, ASCE conference paper, 1975

6. Statistical Compilation of Engineering Features on Bureau of Reclamation Projects, Bureau of Reclamation, September 30, 1986

7. Concrete Manual, Eighth Edition, Bureau of Reclamation, 1981

8. Earth Manual, Second Edition, Bureau of Reclamation, 1974

9. The Stabilization of Soil by the Silt Injection Method for Preventing Settlement of Hydraulic Structures and Leakage From Canals, paper prepared by George E. Johnson, Chief Engineer of The Central Nebraska Public Power and Irrigation District, Hastings, Nebraska, 1951

10. Sealing Contraction Joints and Random Cracks in Concrete-lined Canals, Water Operation and Maintenance Bulletin No. 142, Bureau of Reclamation, 1987

11. Special Membrane Canal Lining, Farwell Main and Lower Main Canals, study report prepared by Bureau of Reclamation's Nebraska-Kansas Projects Office in cooperation with the Loup Basin Reclamation District, 1982

12. Summary Report - Studies and Ponding Tests - OCCS Research, summary report prepared by Project Manager, Nebraska-Kansas Projects Office, September 6, 1986

BE ALERT TO THE SYMPTOMS OF INSECTICIDE EXPOSURE[1]

by Becky Ohlde, Field Editor

Organophosphates and carbamates,
which include rootworm insecticides,
are among the five most toxic pesticides.

Corn rootworm insecticides are the most widely used insecticides in Nebraska.

If not handled properly, however, they can also be the most deadly.

"Corn rootworm insecticides are more toxic than other insecticides because they are controlling an animal pest with a nervous system," explains Larry Schulze, NU's extension specialist in pesticide training.

Schulze adds that commonly used corn rootworm insecticides in Nebraska include Counter, diazinon, Dyfonate, Lorsban, Dursban, Moscap, Thimet, and Furadan. These insecticides, with the exception of Furadan, are classified as organophosphates. Furadan is a carbamate.

"Organophosphates and carbamates are among the top five classes of pesticides that pose the most significant health hazards," Schulze explains. "Most pesticide poisoning cases involve either organophosphates or carbamates."

You will see, by looking at the chart of insecticide chemical families on the following page, that both organophosphates and carbamates affect humans by inhibiting acetylcholinesterase - an enzyme needed for proper functioning of the nervous system.

Schulze says the effects of these materials, particularly organophosphates, are rapid. Symptoms will begin shortly after exposure and, in severe poisonings, during exposure. In milder exposures, symptoms can occur anytime up to 12 hours after, but usually within 4 hours of exposure, he says.

"Diagnosis of a suspected poisoning must also be rapid," he adds.

You also need to be aware of the three signal words on pesticide labels and labeling: Danger Poison, including a skull and crossbones symbol; Warning; and Caution.

These words relate to the toxicity level of each particular pesticide and also to the amount of each that could harm a human. For example, an insecticide, such as Counter, labeled "Danger Poison" means it is highly toxic. The lethal oral dose of Counter for a 160-pound man is a few drops to 1 teaspoon, Schulze says. The dose is less for a child under 160 pounds.

Symptoms of organophosphate or carbamate poisoning, similar to those of the flu, are sometimes referred to as the "spring flu."

"There is a greater likelihood of pesticide exposure during the spring, when farmers are planting crops and applying insecticides - especially if they are handling corn rootworm

[1] Reprinted with permission from the Editor, Nebraska Farmer, April 2, 1988, issue.

Chemical family	Action on human system	Internal exposure	External exposure	Chronic exposure	Trade name examples
Organo-phosphates	Inhibits acetyl-cholinesterase (an enzyme) in the tissues	Headache, dizziness, weakness, shaking, nausea, stomach cramps, diarrhea, sweating	Minimal rashes but readily absorbed through the skin	Loss of appetite, weakness, weight loss and general feeling of sickness	Amaze (isofenphos) Dyfonate (fonofos) Thimet (phorate) Lorsban (chlorpyrifos) Counter (terbufos)
Carbamates	Reversible changes in acetylcholinesterase enzyme of tissues	Headache, dizziness, weakness, shaking, nausea, stomach cramps, diarrhea, sweating	Minimal rashes but readily absorbed through the skin	Loss of appetite, weakness, weight loss and general feeling of sickness	Sevin (carbaryl) Furadan (carbofuran)
Pyrethrins and pyrethroids	Very low human toxicity	Slight toxic reaction	none	none	Ambush Pounce (permethrin) Pydrin (benzeneacetate)

TOXIC INSECTICIDES. This chart lists the signs and symptoms of internal, external and chronic (repeated) exposure to three of the most common chemical families used in insecticides. We have also included a few trade name examples of products for each family of chemicals. Their inclusion implies neither less nor greater risk than other products that could have been listed as examples.

insecticides," Schulze says. "Pesticide exposure is possible when farmers come in contact with the active ingredient and don't use protective equipment."

Because the insecticides have differing modes of action, there is no common first aid treatment for insecticide poisoning. Schulze suggests that people frequently using or coming in contact with insecticides know and be able to implement five steps:

- Recognize the signs and symptoms of poisoning for the insecticides you commonly use or to which you may be exposed.

- If you suspect an insecticide poisoning, get immediate help from a local hospital, physician, or the nearest poison control center.

- In a poisoning emergency, identify the insecticide to which the victim was exposed. Provide the information to medical authorities.

- Have a copy of the pesticide label present for medical personnel. The label provides the chemical and trade names of the insecticide, antidotes, and the manufacturer's emergency telephone number that will be useful in helping a poisoning victim.

- Know emergency measures you can take until help arrives or the victim can be taken to the hospital. First aid and medical treatment procedures are listed on the product label.

Emergency numbers:

Chemical Transportation Emergency Center (CHEMTREC)
1-800-424-9300

- NEBRASKA RESIDENTS ONLY -
Mid-Plains Poison Control Center
(Children's Memorial Hospital, Omaha, Nebraska)
1-800-642-9999

Non-Emergency numbers:

National Pesticide Telecommunications Network
1-800-858-7378

Chemical Manufacturers Association
1-800-262-8200 (Monday thru Friday, 7 a.m. - 8 p.m.)

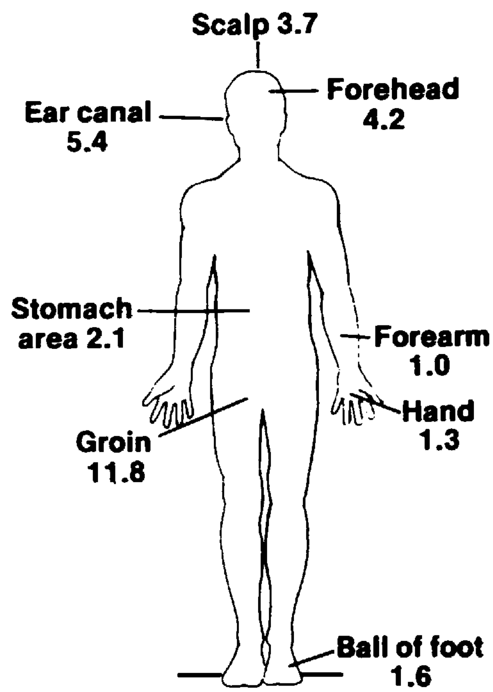
PESTICIDES[1]

Pesticide exposure or contamination can occur any time a pesticide is mixed, applied, or handled. One way pesticides can enter your body is through your skin.

The seriousness of dermal exposure depends on the material's dermal toxicity, the rate of absorption through the skin, the amount of skin area contaminated, and the amount of time the material is in contact with the skin, says Rollie Schnieder, NU's (Nebraska University) extension safety specialist.

Schnieder says there are eight places on your body where pesticides are readily absorbed into your system.

Pesticides can enter the body through these eight points:



INDEX OF ABSORPTION. - This drawing illustrates the eight points on the human body where pesticide absorption can occur. The rates on a scale of 1 to 12 are based on a comparison using the forearm (1) as a base.

The drawing is the Index of Skin Pesticide Absorption, which is labeled with the Skin Absorption Rates. The rates, ranging on a scale of 1 to 12, are based on a comparison using the forearm (1) as a base.

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[1] Reprinted with permission from the Editor, Nebraska Farmer, April 2, 1988, issue.

"Rates of absorption through the skin are different for different parts of the body," he explains. "For example, absorption is over 11 times faster in the lower groin area than on the forearm. Absorption through the skin in the scrotal area is rapid enough to approximate the effect of injecting the pesticide directly into the bloodstream. At this rate, the absorption of pesticide through the skin into the bloodstream is more dangerous than swallowing it."

You may notice that most of the points on the body, where pesticide absorption is most possible, are also sweat points.

"There is a relationship between the point of the body where pesticides can be absorbed in relation to increased blood flow in that body part or with increased perspiration levels which could absorb the pesticides," says Larry Schulze, NU's pesticide training specialist.

Schnieder says dermal or skin exposure can occur from splashing, mixing, spills, drift, field re-entry, or contaminated clothing.

"One example of contaminated clothing is caps with fabric sweatbands," Schulze adds. "If you happen to be wearing one of these types of caps when you are handling pesticides, the fabric sweatband can absorb some of that pesticide. Even if you take a shower or bath every day, if you still put on that same cap, without laundering it, you'll be re-exposed every time."

Schnieder explains that tractor cushions are another source for repeated exposure. He adds that cushion covers should be washed frequently.

Schnieder and Schulze point out that dermal exposure can be avoided by using protective equipment, such as goggles and filtered respirators, and wearing protective clothing.

SPOTLIGHT ON BRANTLEY PROJECT

New Mexico

History

In 1540, the first explorers into the area that was to become New Mexico were Spanish led by Francisco Coronado. There they found Pueblo Indians using primitive but effective irrigation systems to grow crops.

This earliest form of water resource development, irrigation, had been practiced centuries before Coronado's visit, making New Mexico the oldest irrigated area in the United States.

Legions of explorers, soldiers, and settlers followed the Spanish into the area. Political change accompanied development. From a Spanish possession, the area became a province of Mexico, then a United States' territory, and finally a State in 1912.

New Mexico has abundant sunshine, beauty, and many natural resources. But because the climate in most of New Mexico is arid and semiarid, the availability of water is most important.

The Pecos River Valley in southeastern New Mexico is no exception. In this area, the Reclamation Service (now the Bureau of Reclamation) was rehabilitating irrigation facilities of the Carlsbad Project even before New Mexico officially became a State.

Avalon and McMillan Dams were two of the old structures rehabilitated beginning in 1904. Sixty years later, a safety evaluation study showed a potential flood would exceed existing spillway capacity at McMillan Dam and cause the dam to be overtopped, which could cause failure of both dams.

The Brantley Project was authorized under Title II of Public Law 92-514 which was approved October 20, 1972. Title II reads in part as follows: "The Secretary of the Interior is authorized to construct, operate, and maintain the Brantley Project * * * for the purposes of irrigation, flood control, fish and wildlife and recreation, and for the elimination of the hazards of failure of McMillan and Avalon Dams * * * ."

Subsequent changes in design resulted in higher estimated construction costs; and in October 1980, Congress passed Public Law 96-375 to raise the cost ceiling.

The first major construction work on Brantley Project started in September 1983 with the relocation of a portion of U.S. Highway No. 285.

General Description

The Brantley Project is located in Eddy County in southeast New Mexico on the Pecos River about 15 miles upstream of the city of Carlsbad, New Mexico. The Pecos River, rising from the Sangre de Cristo Mountains, is a principal tributary of the Rio Grande.

Brantley Dam is located about 5.5 miles downstream of McMillan Dam and 10 miles upstream of Avalon Dam. The project area generally covers about 16.5 miles of the river.

Purpose of the Project

The primary purpose of the Brantley Project is for safety of dams. A failure of one or both of the present structures would result in potential loss of life and flood damage to the city of Carlsbad and Carlsbad Irrigation District facilities and irrigated agricultural lands.

Brantley Dam replaces McMillan Dam, which is considered unsafe; provides flood control storage not presently afforded by McMillan and Avalon Dams; provides protection to Avalon Dam by controlling upstream floods; provides replacement conservation storage for Lake McMillan where storage has been significantly reduced by sedimentation; provides additional irrigation water storage for Carlsbad Irrigation District; and provides fish and wildlife enhancement and recreation benefits.

Project Features

The dam is a combination concrete gravity center section and rolled earthfill structure. The earthfill dam has a crest at elevation 3308.5 feet and a height of about 110 feet. The concrete center section has a maximum height of about 113 feet and a length of 730 feet.

Earth embankments, each with a crest width of 24 feet, extend out on each side of the concrete section. Total length of the dam is about 4 miles. The total volume of rockfill and earthfill required for the dam is estimated to be 8.5 million cubic yards.

An overflow spillway through the concrete sections is controlled by six radial gates measuring 50 by 25.24 feet. The gates have a maximum discharge capacity of 350,000 ft^3/s. Routing the inflow design flood through the reservoir results in a maximum reservoir water surface at elevation 3303.5. The total controlled reservoir capacity will be 348,500 acre-feet with a surface area of about 12,150 acres at elevation 3271.

Brantley Dam outlet works is designed to release 1,400 ft^3/s at water surface elevation 3,255.3 through two 4- by 4-foot gates. The initial filling started in September 1988.

Recreation and Fish and Wildlife

The plans call for two recreational areas around Brantley Reservoir totaling 2,500 acres. Facilities will include 100 camp sites, 150 picnic sites, 3 boat ramps, 6 launch sites, 2 swimming beaches, 3 miles of trails, and 4.6 miles of access roads. Upon completion of construction of the recreation facilities, the New Mexico State Park and Recreation Commission will assume responsibility for the operation and maintenance.

An area of about 2,200 acres will be acquired for development as a waterfowl mitigation area. Some of the area will be developed for small waterfowl ponds, some will be available for raising crops for waterfowl food, while the remaining area will serve as a buffer zone. The New Mexico Department of Game and Fish will manage the area.

Cultural Resources

McMillan Dam, which has been declared unsafe, will be breached. Since McMillan Dam is a part of the original Carlsbad Reclamation Project and is listed on the National Register of Historic Places, an agreement has been signed with the Advisory Council on Historic Preservation to fully document the engineering and architectural features and history to mitigate the impact of breaching the dam.

Information

The Bureau of Reclamation's Pecos River/Brantley Projects Office, Carlsbad, New Mexico, is responsible for field activities associated with the design and construction of Brantley. That office also oversees water salvage work on the Pecos River, operation and maintenance of Sumner Dam, and the rehabilitation program for the Carlsbad Irrigation District.

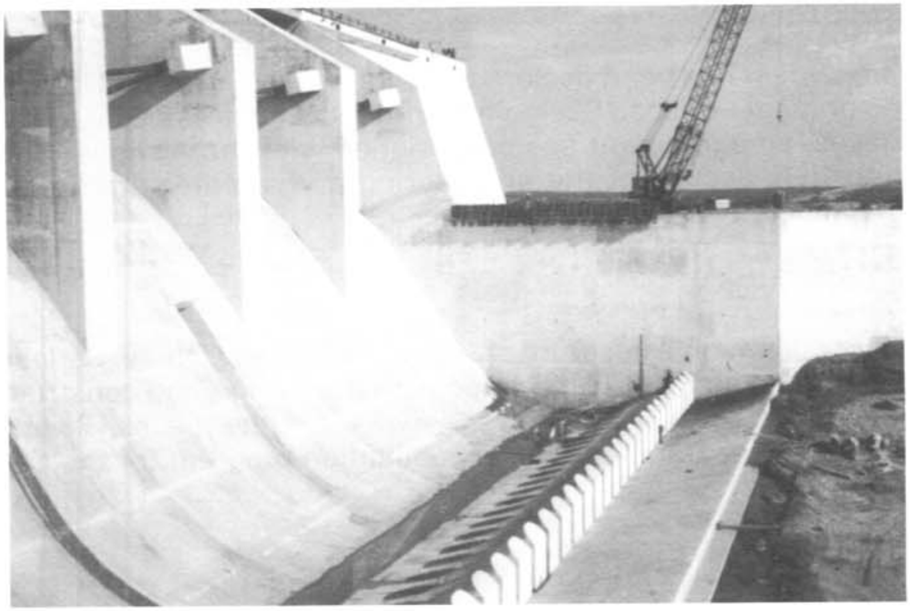

Figure 1. - Brantley Dam - Spillway chute and stilling basin. 10/4/87

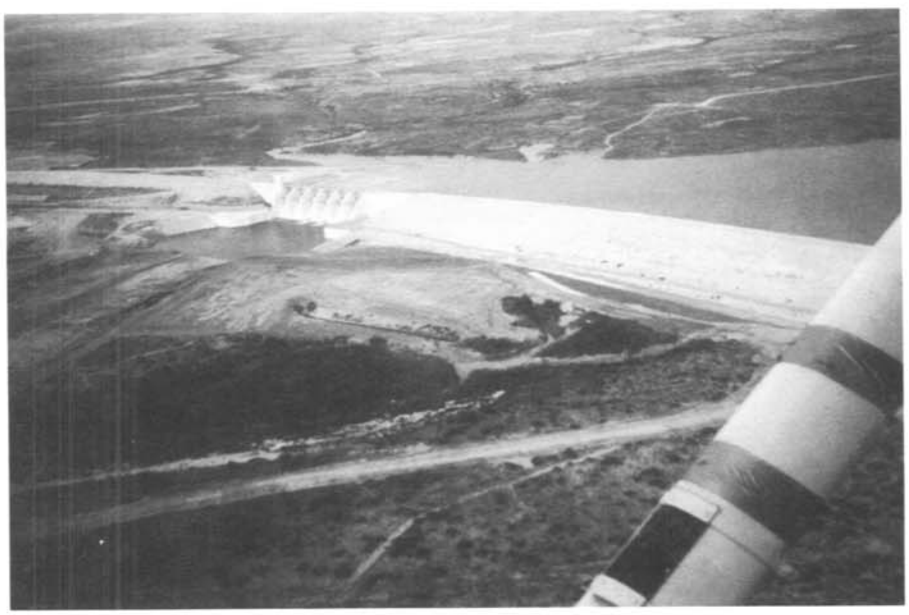

Figure 2. - Brantley Dam - Dam and Reservoir showing old Pecos River channel in foreground. 9/22/88

Figure 3. - Brantley Dam and Reservoir showing O&M complex in left foreground. 9/22/88

Figure 4. - Brantley Dam - Aerial view of the Reservoir and concrete structure. Note two safety buoys to which a safety float line will be connected between these buoys. 9/20/88

Figure 5. - Brantley Dam - Aerial view of concrete structure, stilling basin, left and right abutments, and Reservoir. 9/7/88

Figure 6. - Brantley Dam - Aerial view showing Dam and Reservoir. Lake McMillan can be seen in the background. Note curve of the earthen abutments. 9/29/88

Mission of the Bureau of Reclamation

The Bureau of Reclamation of the U.S. Department of the Interior is responsible for the development and conservation of the Nation's water resources in the Western United States.

The Bureau's original purpose "to provide for the reclamation of arid and semiarid lands in the West" today covers a wide range of interrelated functions. These include providing municipal and industrial water supplies; hydroelectric power generation; irrigation water for agriculture; water quality improvement; flood control; river navigation; river regulation and control; fish and wildlife enhancement; outdoor recreation; and research on water-related design, construction, materials, atmospheric management, and wind and solar power.

Bureau programs most frequently are the result of close cooperation with the U.S. Congress, other Federal agencies, States, local governments, academic institutions, water-user organizations, and other concerned groups.

A free pamphlet is available from the Bureau entitled "Publications for Sale." It describes some of the technical publications currently available, their cost, and how to order them. The pamphlet can be obtained upon request from the Bureau of Reclamation, Attn D-7923A, P O Box 25007, Denver Federal Center, Denver CO 80225-0007.