Report No. CDOH-DTD-R-89-16

EVALUATION OF HIGH-DENSITY POLYETHYLENE PIPE

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Final Report
December, 1989

Prepared in cooperation with the
U.S. Department of Transportation
Federal Highway Administration

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Technical Report Documentation Page

1. Report No. CDOH-DTD-R-89-16	2. Government Accession No.	3. Recipient's Catalog No.
4. Title and Subtitle Evaluation of High-Density Polyethylene Pipe, SPIROLITE		5. Report Date December, 1989
		6. Performing Organization Code 1530A/105.08
7. Author(s) Dave Woodham		8. Performing Organization Report No. CDOH-DTD-R-89-16
9. Performing Organization Name and Address Colorado Department of Highways 4201 E. Arkansas Avenue Denver, Colorado 80222		10. Work Unit No. (TRAIS)
		11. Contract or Grant No. HPR B
12. Sponsoring Agency Name and Address Colorado Department of Highways 4201 E. Arkansas Avenue Denver, Colorado 80222		13. Type of Report and Period Covered Final Report, Four Years
		14. Sponsoring Agency Code 740.070

15. Supplementary Notes

Prepared in Cooperation with the U.S. Department of Transportation, Federal Highway Administration

16. Abstract

Six high-density polyethylene (HDPE) pipes were installed as rundowns in the Summer of 1985 on Interstate 70 west of Denver. The HDPE pipes were able to handle the corrosive and abrasive runoff and eliminated the need for heavy equipment during placement on the steep fill slopes. No problems were observed with the use of these pipes during four and one-half years of monitoring.

Implementation

Polyethylene and PVC plastic pipes are currently allowed by CDOH in all corrosive conditions. These pipes offer additional advantages due to their light weight and hydraulic efficiency.

17. Key Words Plastic Pipe, Polyethylene Pipe Spirolite, Culverts		18. Distribution Statement No Restrictions: This report is available to the public through the National Information Service, Springfield, Virginia 22161	
19. Security Classif. (of this report) Unclassified	20. Security Classif. (of this page) Unclassified	21. No. of Pages 24	22. Price

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APPENDICES

I. INTRODUCTION

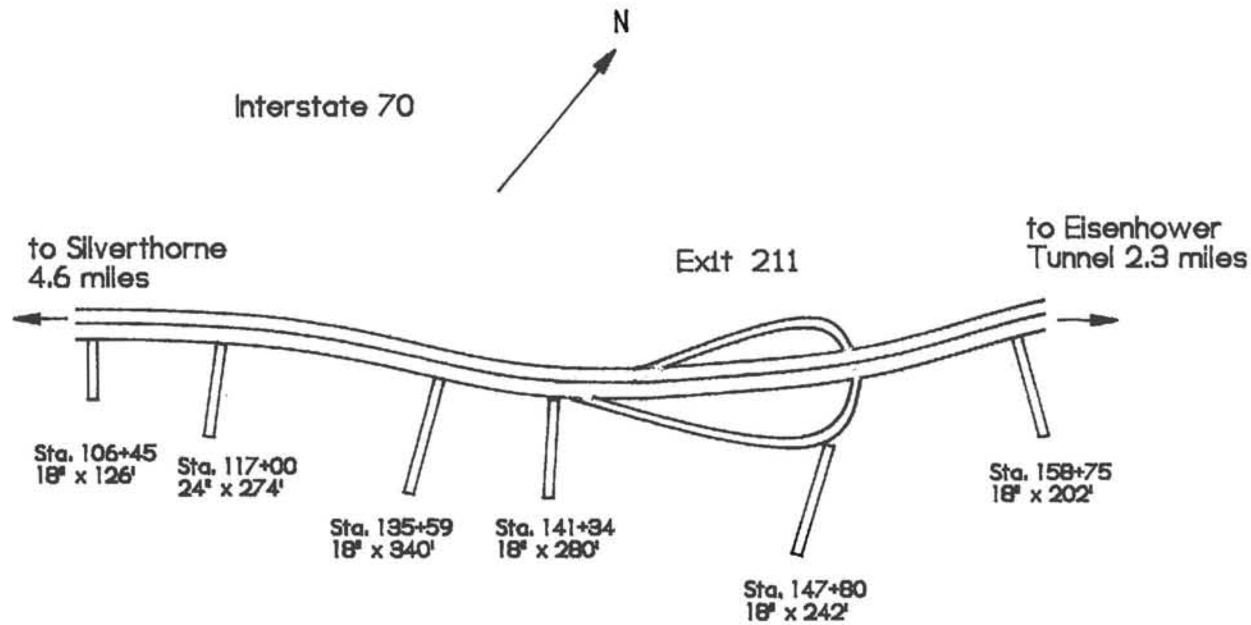
Plastic pipes are finding increased applications in highway construction because of their light weight and ability to handle corrosive runoff. The reduction in weight often eliminates the need for heavy equipment during pipe placement and speeds construction in rough terrain or tight quarters. In addition, the low roughness (Manning's n) of plastic materials may allow a smaller plastic pipe to be substituted for a larger corrugated metal pipe.

II. BACKGROUND

Construction on project I-IR 70-3(122) was completed during the Summer of 1985 and involved the repair and replacement of corrugated steel pipe (CSP) cross drains and the construction of downdrains in the Hamilton Gulch area of the Straight Creek drainage. The downdrains were needed to prevent erosion on the fill slopes below the I-70 roadway (please see Figure 1 on page 2). The previously installed CSP crossdrains and downdrains were showing severe results of corrosion.

The project area has high sulfate soils and, because of the elevation (approximately 10,000 ft.), large amounts of salt and sand are placed on the roadway during winter months. The Colorado Department of Highways tested water samples from the area and rated the runoff as "CR5" which designates a severe corrosive condition (see Appendix B). The corrosive and abrasive properties of the resulting runoff water had corroded through some of the CSP cross drains, allowing water to pass outside of the pipes leading to erosion and subsequent sedimentation problems in Straight Creek.

Figure 1.



Location and Dimensions of Plastic Pipe Rundowns

Project I IR 70-3(122)

Because of the steep fill slopes, the corrosive and abrasive runoff, it was decided to use a smooth interior-wall plastic pipe meeting ASTM F894 and ASTM F679. A high density polyethylene (HDPE) pipe called SPIROLITE met all the requirements and was selected for use on this project. The light weight of this product proved to be an advantage because of the difficulty with using heavy equipment on the steep sideslopes (approximately 1.5:1).

III. CONSTRUCTION

The SPIROLITE downdrains were installed in June and July of 1985. The construction procedure was as follows: a back hoe was lowered by winch down the fill slope to construct a four-foot wide by four-foot deep trench. The HDPE pipe was installed section by section starting at the bottom of the fill slope. Each section was anchored by driving a 36-inch rebar pin into the slope on each side of the pipe and passing a cable over the pipe and connecting the cable ends to the rebars (please see Photographs 1 through 5 in Appendix A). Because the corrugations in the pipe interlocked with both the cable and the soil, this method provided a good anchor for the pipes against slippage, creep and floating during backfill.

After several sections had been joined, backfill and compaction operations began. Backfill material was sent down an eight-inch pipe from the material stockpiles at the roadway shoulder. Small plywood vanes were used to direct the backfill material as needed. Initial compaction around the pipe was accomplished with a hand-held pneumatic tamper. Once the backfill was up near the top of the pipe, a larger, gas-powered compactor was lowered from above by use of a winch. The remaining cover (minimum one foot) was compacted with the larger compactor. Water was used as necessary to reach the required compaction.

Although few problems were encountered with this installation procedure the work progressed slowly because of the large volume of backfill used, the large amount of labor needed, and the difficulty of working at high elevations on steep side slopes.

The costs for the plastic pipes (completed in place) were bid as follows:

18 in. diameter SPIROLITE $36.00 / lin. ft.

24 in. diameter SPIROLITE $53.00 / lin. ft.

In order to make a more direct comparison of material costs and to eliminate the variations due to construction costs, price quotes for various types of pipe with the same corrosion resistance (CR 5) were obtained. The current (1989) prices for each pipe are:

Product	Size	
	18 in.	24 in.
SPIROLITE HDPE	$15.50	$22.50
Bituminous coated CSP	$14.50	$19.00
RCP, Type V Cement	$12.00	$18.00
JM Permaloc PVC	$ 8.00	$12.50
ADS N-12 HDPE	$ 9.00	$13.00

Prices are approximate for small quantities and are FOB Denver, CO.

IV. MONITORING

Once the HDPE pipes were installed, visual inspections were made at approximately six month intervals. The inspections consisted of looking at both ends of each of the HDPE rundowns and looking for surface indications of settlement, slippage, or joint failures. In addition, CSP rundowns installed on a 1979 project, I 70-3(99), were inspected as a control product. These downdrains are located just west of the plastic rundowns shown in Figure 1. Photographs were taken during each inspection for documentation purposes. Please see Photographs 6 through 12 in Appendix A.

V. CONCLUSIONS

In the four year period following construction, there have been no signs of any defects in the HDPE downdrains. No significant abrasion in the pipes has been observed, although large amounts of sediment have traveled through the downdrains. There is no indication that joints have opened up in the pipe (e.g. seepage or erosion above the pipe) nor that any mass displacement of the rundowns has occurred. The joints between the concrete inlets and the HDPE pipes have all performed well with no movement or leakage observed. The concrete inlet provides the connection between the CSP crossdrains and the HDPE rundowns and eliminated the need for a direct connection of the two different pipes.

The CSP rundowns installed in 1979, however, have begun to corrode in several places. In viewing the limited number of CSP pipes installed in the study area, it appears that the useful life of the CSP steel rundowns is 10 years in this environment.

The useful life of the HDPE rundowns is expected to be much longer for two reasons: high abrasion and corrosion resistance. Laboratory abrasion tests show the HDPE material to be approximately 4 to 10 times more wear resistant than steel when subjected to abrasive slurries at flow rates of 7 fps and 15 fps, respectively [1]. Other documentation also indicates the high abrasion resistance of this material as a pipe liner [2],[3]. In typical roadside applications, the HDPE material is essentially inert to the types of corrosive agents found. Finally, even though the pipe is buried, degredation due to ultraviolet (UV) light should not occur (e.g. on exposed ends) because of the carbon black added to the HDPE material.

VI. IMPLEMENTATION

The Colorado Department of Highways currently allows the use of plastic pipes in corrosive and noncorrosive environments. The use of an exterior-ribbed pipe should be considered on steep side slopes where the ribbed exterior provides an interlock with the surrounding soil. The light weight of the plastic pipes also appears to reduce construction costs on steep slopes. The decision on whether the interior of the pipe should be smooth or corrugated should be made on a case-by-case basis. In some instances, the energy dissipation provided by a corrugated interior will reduce the need for energy dissipation structures at the pipe's outlet. In other cases, the hydraulic efficiency of a smooth interior wall may be another consideration.

In general, HDPE and PVC pipes are competitive with steel and concrete equivalents in cost and have the additional benefits of high corrosion resistance and ease of construction. It is recommended to allow the contractor the choice between approved pipes of equivalent corrosion resistance provided all structural requirements are met.

References:

[1] Excerpts from: Haas, D. B. and Smith, L. G., Erosion Studies-- A report to DuPont of Canada, Ltd., Saskatchewan Research Council, E75-7, September, 1975.

[2] Bond, J. G. and Broad, B. A., Wear in Slurry Pipelines: Experiments with 38mm Diameter Specimens in a Closed-Loop Test Rig, Transport and Road Research Laboratory, UK, Supplementary Report 773, 1983.

[3] Johns, Henry, Erosion Studies of Pipe Lining Materials, US Bureau of Reclamation, REC-ERC-84-3, May, 1984.

Appendix A

Photographs of the SPIROLITE Rundowns

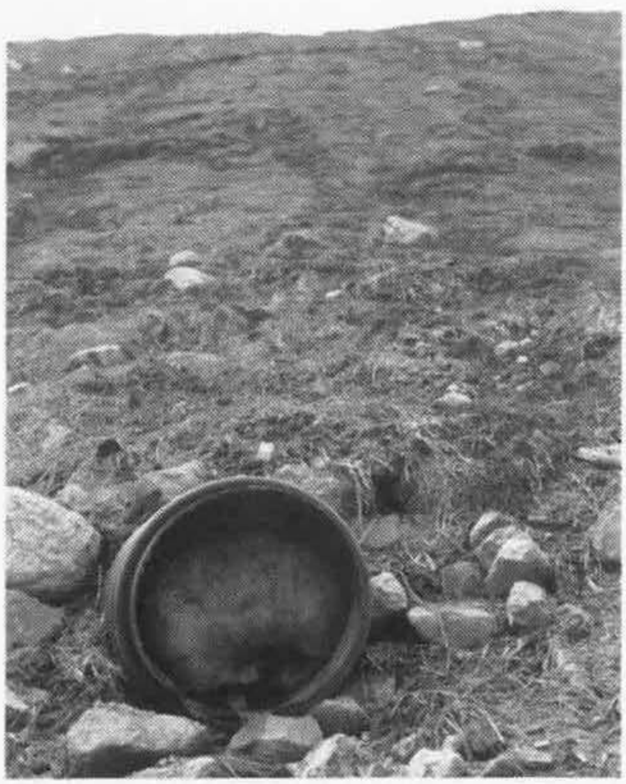
Photograph 1. Backfill material was transported down the slope in smaller plastic pipes. SPIROLITE pipes are shown in foreground.

Photograph 2. The backfill material was directed as needed with plywood vanes.

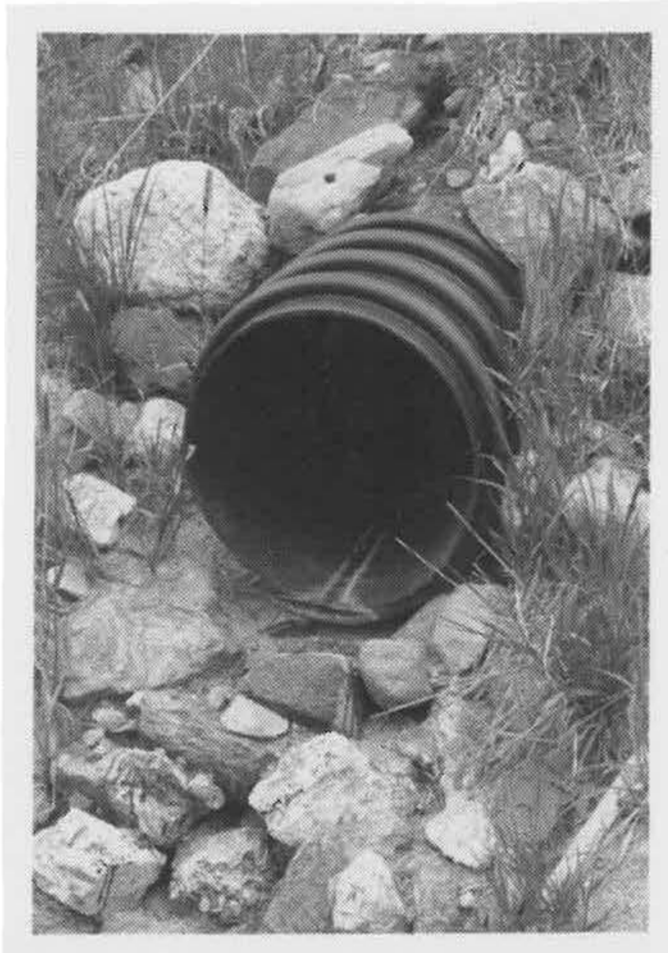
Photograph 3.
Compaction began at the bottom of the slope using a hand-help pneumatic tamper.

Photograph 4.
Compaction work progressing up the slope.

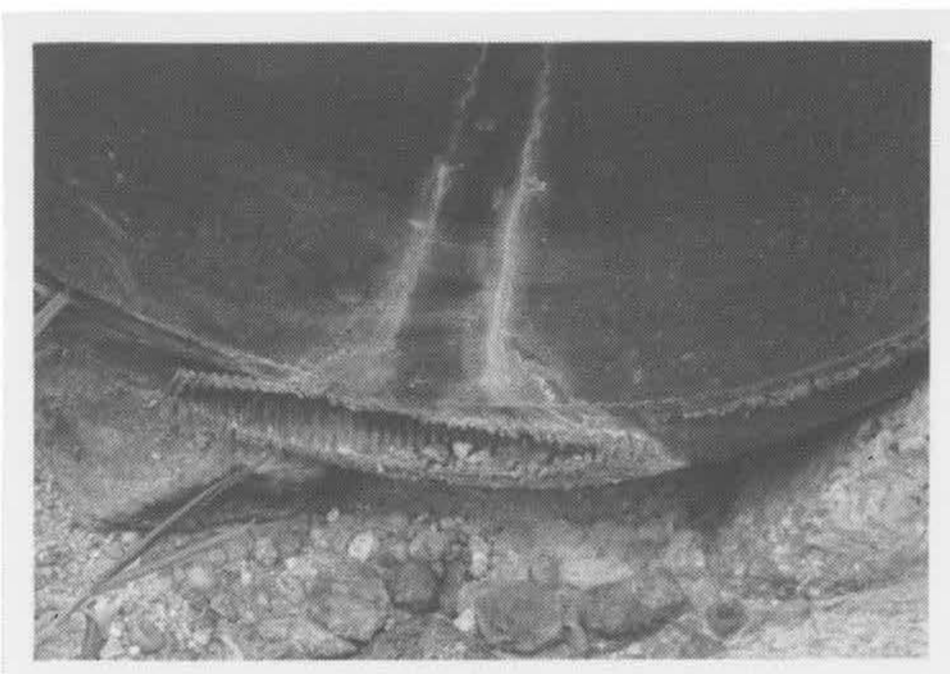
Photograph 5.
Larger tamper was used once the backfill was up to the level of the top of the pipe.



Photograph 6.
Vegetation began to take hold the first spring following construction.

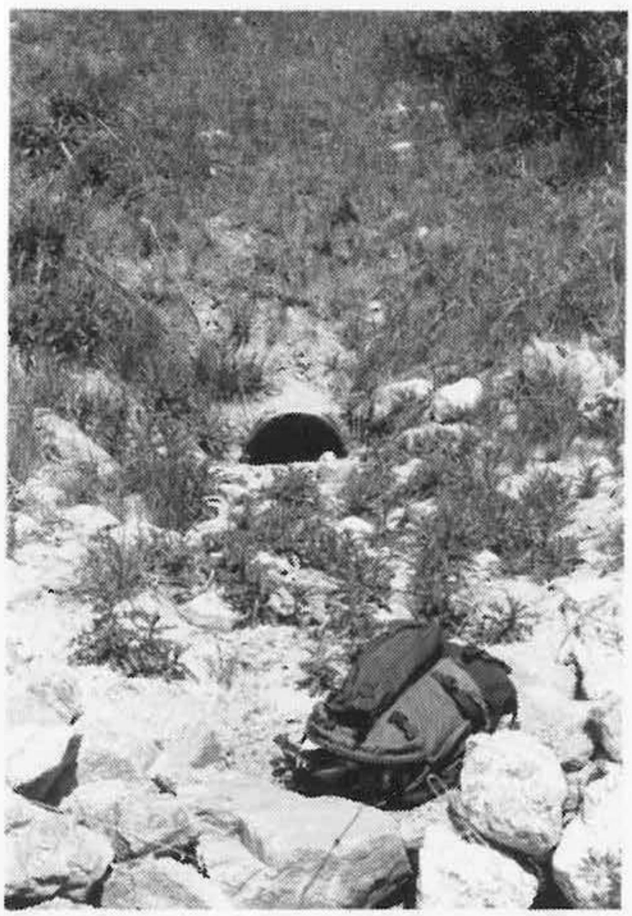


Photograph 7. End of pipe in Summer. Large quantities of roadside sand are transported down the rundowns in the Spring.

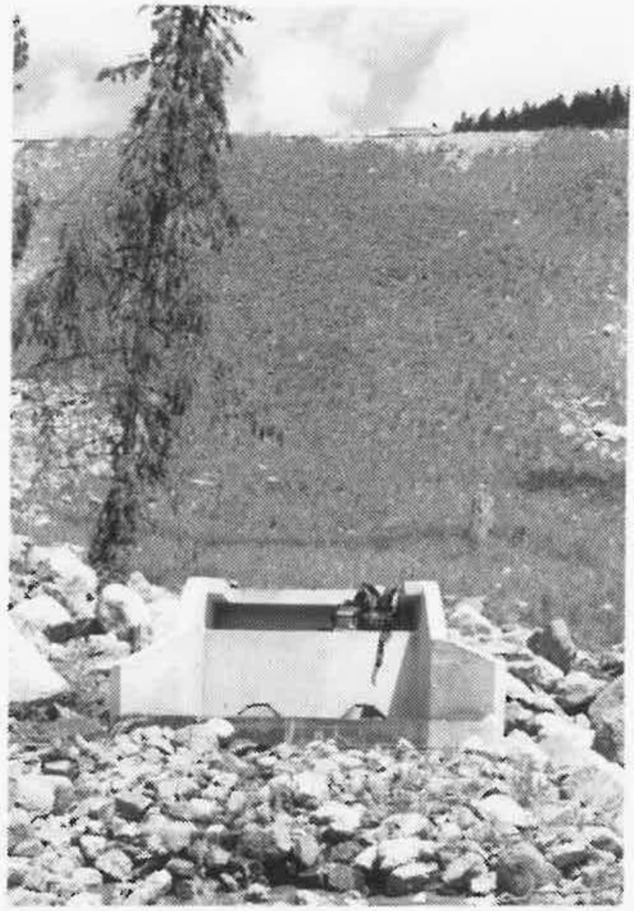


Photograph 8. Closeup of pipe end. There is no evidence of scouring.

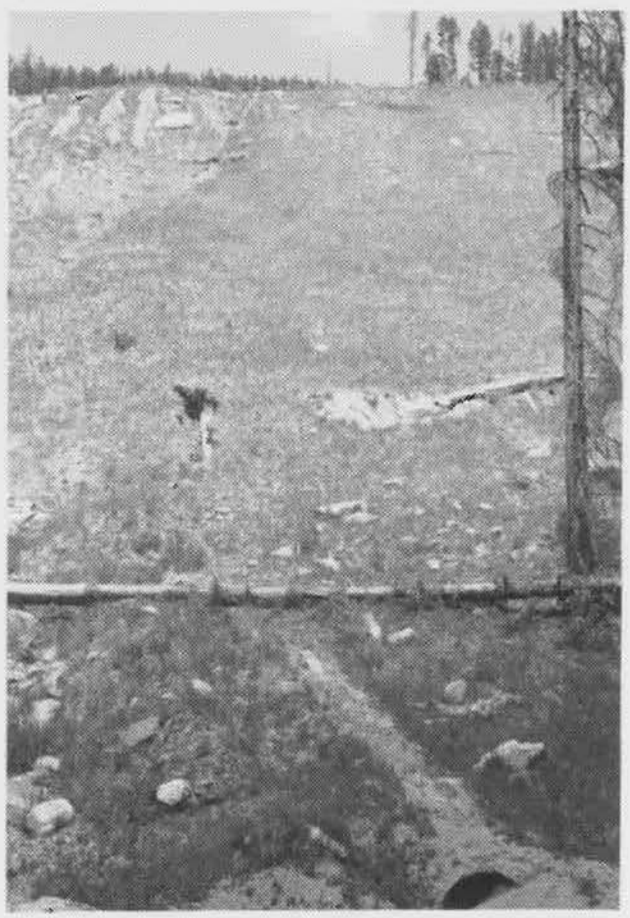
Photograph 9. The vegetation is well established by the Summer of 1989.



Photograph 10. Summer 1989. Note that settlement pond is nearly full.



Photograph 11. Stilling basin installed at the bottom of one of the rundowns.



Photograph 12. One of the corrugated steel pipes installed in 1979. Note washed out area in middle of slope where pipe has corroded through.

Appendix B

Information on Colorado Corrosion Resistance Levels

GUIDELINES FOR SELECTION OF CORROSION RESISTANCE LEVELS

	SOIL			WATER		
CR Level	Sulfate (SO_4) % max	Chloride (Cl) % max	pH	Sulfate (SO_4) ppm max	Chloride (Cl) ppm max	pH
*CR 0	0.05	0.05	6.0 - 8.5	250	250	6.0 - 8.5
CR 1	0.15	0.15	6.0 - 8.5	250	250	6.0 - 8.5
CR 2	0.05	0.05	6.0 - 8.5	500	500	6.0 - 8.5
CR 3	0.15	0.15	6.0 - 8.5	500	500	6.0 - 8.5
CR 4	0.50	1.00	5.0 - 9.0	1000	1000	5.0 - 9.0
CR 5	1.00	1.50	5.0 - 9.0	2000	2000	5.0 - 9.0
CR 6	>1.00	>1.50	<5 or >9	> 2000	> 2000	<5 or >9

* No special corrosion protection recommended when values are within these limits.

Concrete pipe used when the pH of either the soil or water is less than 5 should be coated in accordance with 706.10.

This chart is to be used as an aid in the selection of a CR level. Observations of field conditions should always be considered in making final decisions.

TABLE OF ALLOWABLE MATERIALS FOR VARIOUS CORROSION CONDITIONS

Corrosion Resistance Number*	CR 1	CR 2	CR 3	CR 4	CR 5	CR 6
Corrosion Condition Description	Mild	Mild	Mild	Moderate	Severe	Extreme
Corrosion Condition Inside or Outside Pipe	Outside Only	Inside Only	Both	Both	Both	Both
Type of Pipe						
CSP	NO	NO	NO	NO	NO	NO
Bituminous coated CSP	YES	NO	NO	NO	NO	NO
Aramid Fiber Bonded CSP	YES	YES	YES	YES	YES	YES
Corrugated Aluminum Pipe	YES	YES	YES	YES	YES	NO
Precoated CSP (both sides)	YES	YES	YES	NO	NO	NO
Precoated CSP (outside)	YES	NO	NO	NO	NO	NO
Precoated CSP (inside)	NO	YES	NO	NO	NO	NO
RCP or NRCP, Type I Cement	YES	YES	YES	NO	NO	NO
RCP or NRCP, Type II Cement	YES	YES	YES	YES	NO	NO
RCP or NRCP, Type V Cement	YES	YES	YES	YES	YES	YES
PVC	YES	YES	YES	YES	YES	YES
PE, Smooth int., ribbed ext.	YES	YES	YES	YES	YES	YES

* As determined by the Division of Highways.

RCP or NRCP made with Type II cement having maximums of 5% C_3A and 25% (C_4AF+2C_3A) may be used for all corrosion conditions except CR 6 if approved by the Central Laboratory.