CULVERT ASSESSMENT AND DECISION-MAKING PROCEDURES MANUAL

For Federal Lands Highway

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CTIP

Federal Lands Highway
Commitment to Excellence

Central Federal Lands Highway Division
12300 West Dakota Avenue
Lakewood, CO 80228

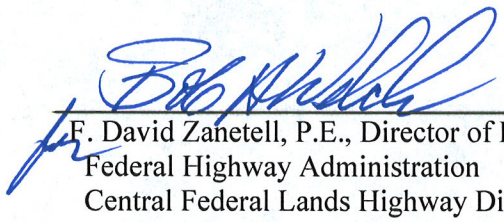
FOREWORD

The Federal Lands Highway (FLH) promotes development and deployment of applied research and technology applicable to solving transportation related issues on Federal Lands. The FLH provides technology delivery, innovative solutions, recommended best practices, and related information and knowledge sharing to Federal agencies, Tribal governments, and other offices within the FHWA.

The objective of this study was to produce project-level guidelines for assessing the condition and performance of existing roadway culverts, and when necessary, select corrective actions to be taken for any deficiencies found as part of specific project development activities.

The content, recommendations and examples provided in this manual are the result of the direct and indirect contribution of many years of combined experience in culvert design and evaluation by multiple agencies and industry consultants. Formulation of the procedure was also influenced by the existing work of others in the realm of culvert assessment and rehabilitation, as researched in the extensive literature review phase of its development.

The contributions and cooperation of the FLH personnel of the Eastern, Central and Western divisions are gratefully acknowledged, as well as interview participants at Caltrans, Minnesota DOT, Ohio DOT and Oregon DOT. Individuals from many other organizations around the country contributed valuable information and insight for this document. Although there are too many to mention by name, their contributions and cooperation are gratefully acknowledged.



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Notice

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16. Abstract

Federal Lands Highway (FLH) Division of FHWA works in cooperation with federal land management agencies to plan, design, construct and rehabilitate highways and bridges on federally owned lands. In support of this mission, FLH has developed project-level guidelines for assessing the condition and performance of existing roadway culverts, and when necessary, selecting corrective action for any deficiencies found as part of specific project development activities. The end-result of this effort is this procedure manual, which consists of a fully integrated culvert assessment tool and culvert decision-making tool that provides guidance for selecting replacement or rehabilitation alternatives.

Appendices A through G are included on the attached CD ROM.

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SI* (MODERN METRIC) CONVERSION FACTORS

APPROXIMATE CONVERSIONS TO SI UNITS

Symbol	When You Know	Multiply By	To Find	Symbol
		LENGTH		
in	inches	25.4	millimeters	mm
ft	feet	0.305	meters	m
yd	yards	0.914	meters	m
mi	miles	1.61	kilometers	km
		AREA		
in^2	square inches	645.2	square millimeters	mm^2
ft^2	square feet	0.093	square meters	m^2
yd^2	square yard	0.836	square meters	m^2
ac	acres	0.405	hectares	ha
mi^2	square miles	2.59	square kilometers	km^2
		VOLUME		
fl oz	fluid ounces	29.57	milliliters	mL
gal	gallons	3.785	liters	L
ft^3	cubic feet	0.028	cubic meters	m^3
yd^3	cubic yards	0.765	cubic meters	m^3
	NOTE: volumes greater than 1000 L shall be shown in m^3			
		MASS		
oz	ounces	28.35	grams	g
lb	pounds	0.454	kilograms	kg
T	short tons (2000 lb)	0.907	megagrams (or "metric ton")	Mg (or "t")
		TEMPERATURE (exact degrees)		
°F	Fahrenheit	5 (F-32)/9 or (F-32)/1.8	Celsius	°C
		ILLUMINATION		
fc	foot-candles	10.76	lux	lx
fl	foot-Lamberts	3.426	candela/m^2	cd/m^2
		FORCE and PRESSURE or STRESS		
lbf	poundforce	4.45	newtons	N
lbf/in^2	poundforce per square inch	6.89	kilopascals	kPa

APPROXIMATE CONVERSIONS FROM SI UNITS

Symbol	When You Know	Multiply By	To Find	Symbol
		LENGTH		
mm	millimeters	0.039	inches	in
m	meters	3.28	feet	ft
m	meters	1.09	yards	yd
km	kilometers	0.621	miles	mi
		AREA		
mm^2	square millimeters	0.0016	square inches	in^2
m^2	square meters	10.764	square feet	ft^2
m^2	square meters	1.195	square yards	yd^2
ha	hectares	2.47	acres	ac
km^2	square kilometers	0.386	square miles	mi^2
		VOLUME		
mL	milliliters	0.034	fluid ounces	fl oz
L	liters	0.264	gallons	gal
m^3	cubic meters	35.314	cubic feet	ft^3
m^3	cubic meters	1.307	cubic yards	yd^3
		MASS		
g	grams	0.035	ounces	oz
kg	kilograms	2.202	pounds	lb
Mg (or "t")	megagrams (or "metric ton")	1.103	short tons (2000 lb)	T
		TEMPERATURE (exact degrees)		
°C	Celsius	1.8C+32	Fahrenheit	°F
		ILLUMINATION		
lx	lux	0.0929	foot-candles	fc
cd/m^2	candela/m^2	0.2919	foot-Lamberts	fl
		FORCE and PRESSURE or STRESS		
N	newtons	0.225	poundforce	lbf
kPa	kilopascals	0.145	poundforce per square inch	lbf/in^2

*SI is the symbol for the International System of Units. Appropriate rounding should be made to comply with Section 4 of ASTM E380.
(Revised March 2003)

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LIST OF ABBREVIATIONS AND SYMBOLS

AASHTO	American Association of State Highway and Transportation Officials
C	Celsius
CA	California
Caltrans	California Department of Transportation
CFLHD	Central Federal Lands Highway Division
CIPP	cured-in-place pipe
CIPPL	cured-in-place pipe lining
cm	centimeter
CMP	corrugated metal pipe
DC	District of Columbia
DOT	departments of transportation
EFLHD	Eastern Federal Lands Highway Division
F	Fahrenheit
FHWA	Federal Highway Administration
FLH	Federal Lands Highway
ft	feet
GPS	Global Positioning System
HDPE	high-density polyethylene
in	inches
kPa	kilopascal
L1	Level 1 (investigation)
L2	Level 2 (investigation)
m	meter
MD	Maryland
MN	Minnesota
N/A	not available
NA	not applicable
NCHRP	National Cooperative Highway Research Program
NHI	National Highway Institute
NPS	National Park Service
OH	Ohio
OSHA	Occupational Safety and Health Administration
PE	polyethylene
PLF	price per linear foot
PSF	price per square foot
psig	pounds per square inch, gauge
PP	polypropylene
PVC	poly(vinyl chloride)
TRB	Transportation Research Board
USACE	U.S. Army Corps of Engineers
USFS	U.S. Forest Service
WFLHD	Western Federal Lands Highway Division
WI	Wisconsin
www	World Wide Web