CULVERT TECHNOLOGIES

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AGENCY	DESCRIPTION OF TECHNOLOGY	AVAILABILITY OF TECHNOLOGY
Hydraulic Analysis & Design		
FHWA	HDS 5, Hydraulic Design of Highway Culverts	www.fhwa.dot.gov/engineering/hydraulics/library_arc.cfm?pub_number=7&id=13 ***Last revision: 05/2005***
	HDS 5 Appendix D Chart Calculator	www.fhwa.dot.gov/engineering/hydraulics/software.cfm
	HEC 9, Debris Control Structures Evaluation and Countermeasures	www.fhwa.dot.gov/engineering/hydraulics/pubs/04016/ ***Last revision: 09/2005***
	HEC 14, Hydraulic Design of Energy Dissipators for Culverts and Channel	www.fhwa.dot.gov/engineering/hydraulics/pubs/06086/ ***Last revision: 07/2006***
	FHWA-RD-01-077, Hydraulics of Iowa DOT Slope-Tapered Pipe Culverts	www.fhwa.dot.gov/engineering/hydraulics/pubs/01077/01077.pdf
	FHWA-HRT-02-078, Bottomless Culvert Scour Study, Phase I Laboratory Report	www.fhwa.dot.gov/engineering/hydraulics/pubs/02078/
	FHWA-HRT-07-026, Bottomless Culvert Scour Study, Phase II Laboratory Report	www.fhwa.dot.gov/engineering/hydraulics/pubs/07026/
	FHWA-HRT-06-138, Effects of Inlet Geometry on Hydraulic Performance of Box Culverts	www.fhwa.dot.gov/engineering/hydraulics/pubs/06138/ ***Note: document amended 11/2007***
	HY-8 Culvert Analysis Hydraulic Program, Version 7.1	www.fhwa.dot.gov/engineering/hydraulics/software/hy8/ ***Note: Version 7.1 was released on 07/01/2008***
	NHI Course 135056, Culvert Design	www.nhi.fhwa.dot.gov/training/brows_catalog.aspx
TRB	Consideration of Stream Morphology in Culvert and Bridge Design	http://trb.metapress.com/content/m428j0k71119263j/?p=77afa1ff2ffa4ec3aab5429a174077f9&pi=62
	Hydraulic Jumps in Broken-Back Culverts	http://trb.metapress.com/content/f12503k0u85x4512/?p=539768f031064d169f716acc4db036c3&pi=20
AASHTO	Highway Drainage Guidelines, 4th Edition: Volume 4 – Hydraulic Design of Culverts	https://bookstore.transportation.org/ ***Note: item code HDG-4-M***
	Model Drainage Manual, 3rd Edition (CD-Rom): Chapter 9 – Culverts	https://bookstore.transportation.org/ ***Note: item code MDM-3-CD***
U.S. Army Corps of Engineers	Hydrologic Engineering Center's River Analysis System (HEC-RAS), Version 4.0	www.hec.usace.army.mil/

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USGS	Measurement of Peak Discharge at Culverts by Indirect Methods	http://pubs.usgs.gov/twri/twri3-a3/
Ontario Ministry of Transportation	Gravity Pipe Design Guidelines – Circular Culverts and Storm Sewers	www.ontla.on.ca/library/repository/mon/13000/260761.pdf
Alaska DOT	Preliminary Study of Scour in Bottomless Culverts	www.dot.state.ak.us/stwddes/research/search_lib.shtml ***Note: perform library search on key words***
	Design of Depressed Invert Culverts	www.dot.state.ak.us/stwddes/research/search_lib.shtml ***Note: perform library search on key words***
Florida DOT	Culvert Design Handbook	www.dot.state.fl.us/rddesign/dr/Manualsandhandbooks.shtm
Kansas DOT	Sizing of Highway Culverts and Bridges: A Historical Review of Methods and Criteria	www.ksdot.org/burmatrres/kdotlib2.asp ***Note: perform library search on KU-05-4***
	Bend Losses in Rectangular Culverts	www.ksdot.org/burmatrres/kdotlib2.asp ***Note: perform library search on KU-05-5***
Nebraska DOT	Broken-back Culvert Analysis Program, Version 3.2	www.nebraskatransportation.org/roadway-design/downloads.htm#bcap
	Hydraulic Analysis of Broken-Back Culverts	http://ntl.bts.gov/lib/20000/20700/20745/PB98144884.pdf
Texas DOT	Hydraulics of Low-Headwater Box Culverts	www.utexas.edu/research/ctr/pdf_reports/0_2109_S.pdf
Structural Design		
FHWA	Structural Design Manual for Improved Inlets and Culverts	www.fhwa.dot.gov/engineering/hydraulics/library_arc.cfm?pub_number=32&id=58
NCHRP	NCHRP Report 473, Recommended Specifications for Large-Span Culverts	http://onlinepubs.trb.org/Onlinepubs/nchrp/nchrp_rpt_473-a.pdf
	NCHRP Web Document 44 (Project 12-45): Contractor's Final Report, Design Examples for Large-Span Culverts (Supporting Material for *NCHRP Report 473*)	http://onlinepubs.trb.org/Onlinepubs/nchrp/nchrp_webdoc_44.pdf
	CANDE-2007 (Culvert ANalysis and Design)	www.trb.org/TRBNet/ProjectDisplay.asp?ProjectID=408
Ontario Ministry of Transportation	Gravity Pipe Design Guidelines – Circular Culverts and Storm Sewers	www.ontla.on.ca/library/repository/mon/13000/260761.pdf
U.S. Army Corps of Engineers	Engineer Manual 1110-2-2902 – Engineering and Design: Conduits, Culverts, and Pipes	http://140.194.76.129/publications/eng-manuals/em1110-2-2902/toc.htm

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Arizona DOT	Final Report 621: High Density Polyethylene Pipe Fill Height Table in Arizona	www.azdot.gov/TPD/ATRC/publications/project_reports/PDF/AZ621.pdf
Texas DOT	CULV5-Concrete Box Culvert Analysis	www.dot.state.tx.us/services/technology_services/engineering_software.htm
ACPA	American Concrete Pipe Association – Concrete Pipe Design Manual	www.concrete-pipe.org/designmanual.htm
ADS	Advanced Drainage Systems, Inc. – Drainage Handbook (Polyethylene Pipe)	www.ads-pipe.com/en/documentlisting.asp?documenttypeID=682
NCSPA	National Corrugated Steel Pipe Association Design Data Sheets	www.ncspa.org/downloadable-publications.asp
NPCA	National Precast Concrete Association – Standards, Specifications, and Technical Documents for Precast Concrete	www.precast.org/technical/standards.htm#pipe
PPI	Plastic Pipe Institute – The Complete Corrugated Polyethylene Pipe Design Manual and Installation Guide	http://plasticpipe.org/drainage/design_manual.html
Fish/Aquatic Organism/Terrestrial Passage Design		
FHWA	2006 Fish Passage Summit presentations	www.fishpassage.wsu.edu/culvert/
	Design For Fish Passage at Roadway - Stream Crossings: Synthesis Report	www.fhwa.dot.gov/engineering/hydraulics/pubs/07033/
U.S. Forest Service	Stream Simulation: An Ecological Approach to Providing Passage for Aquatic Organisms at Road-Stream Crossings	www.fs.fed.us/eng/pubs/pdf/StreamSimulation/index.shtml
	FishXing software for the evaluation and design of culverts for fish passage	www.stream.fs.fed.us/fishxing/
B.C. Ministry of Environment	Watershed Restoration Technical Circular No. 11: Fish Passage – Culvert Inspection Procedures	www.for.gov.bc.ca/HFD/LIBRARY/FFIP/Parker_MA2000.pdf
B.C. Ministry of Forests	Fish-stream Crossing Guidebook	www.for.gov.bc.ca/tasb/legsregs/fpc/FPCGUIDE/Guidetoc.htm
Alaska DOT	Analysis of an Efficient Fish Barrier Assessment Protocol for Highway Culverts	www.dot.state.ak.us/stwddes/research/search_lib.shtml ***Note: perform library search on key words***
	FISHPASS fish passage evaluation software	www.dot.state.ak.us/stwddes/research/search_lib.shtml ***Note: perform library search on key words***
Caltrans	Fish Passage Design for Road Crossings	www.dot.ca.gov/hq/oppd/fishPassage/index.htm
Colorado DOT	Effectiveness of Ledges in Culverts for Small Mammal Passage	www.dot.state.co.us/Publications/PDFFiles/smallmammal.pdf

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Maine DOT	Fish Passage Policy and Design Guide	www.maine.gov/mdot/interagency-meetings/pdf/Fish%20Passage%20Policy/FP%20Design%20Guide%20Draft%2007-18-07.pdf
Montana DOT	The Effects of Highways on Fragmentation of Small Mammal Populations and Modifications of Crossing Structures to Mitigate Such Impacts	www.mdt.mt.gov/research/projects/env/animal_use.shtml
WSDOT	DOT's fish passage program information	www.wsdot.wa.gov/Environment/Biology/FP/fishpassage.htm
Washington Dept. of Fish and Wildlife	Design of Road Culverts for Fish Passage	wdfw.wa.gov/hab/engineer/cm/index.htm
Construction: Standard Specifications, Drawings, Details, and Practices		
Florida DOT	Standard Specification Section 430: Pipe Culverts and Storm Sewers	www.dot.state.fl.us/specificationsoffice/Implemented/WorkBooks/JanWorkBook2009/Files/SS4300000.pdf
LTRC	Louisiana Transportation Research Center: Alternative Methods to Trench Backfill	http://www.ltrc.lsu.edu/pdf/2005/fr_404.pdf
New York State DOT	Standard Specification Section 600: Incidental Construction Subsection 603-Culverts and Storm Drains	www.nysdot.gov/portal/page/portal/main/business-center/engineering/specifications/specs-repository/section600.pdf
Ohio DOT	Standard Specification Section 603: Pipe Culverts, Sewers, and Drains	www.dot.state.oh.us/Divisions/ConstructionMgt/Specifications/2008CMS/2008Specbook.aspx
South Carolina DOT	Supplemental Technical Specifications: Permanent Pipe Culverts	www.scdot.org/doing/sup_tech_specs.shtml
Utah DOT	Pipe Culvert Inspection Aids (for metal and plastic pipe)	www.udot.utah.gov/main/f?p=100:pg:4419176260588549843:::1:T,V:2013,
	Standard Specification Section 02610 – Pipe, Pipe-Arch, Structural Plate Pipe, and Structural Pipe Arch	www.udot.utah.gov/main/f?p=100:pg:4419176260588549843:::1:T,V:1925,
ADS	Advanced Drainage Systems, Inc. – Details and Drawings (Polyethylene Pipe)	www.ads-pipe.com/en/documentlisting.asp?documenttypeID=5
Materials		
FHWA	Memorandum – Culvert Material Selection Procedures	www.fhwa.dot.gov/engineering/hydraulics/policymemo/20070709.cfm
	Federal Lands Highway Division Project Development and Design Manual, Section 7.3.6 Alternative Pipe Materials	www.wfl.fhwa.dot.gov/design/manual/

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NCHRP	NCHRP Synthesis 254, Service Life of Drainage Pipe	www.trb.org/news/blurb_detail.asp?id=3303 ***Note: must order a paper copy***
NCSPA	Invert Abrasion Testing of CSP Coatings	www.ncspa.org/assets/08PInvertabrasionreport.pdf ***Note: also contains 2000 CSP Durability Guide***
	"The Real Deal on Steel" steel properties website and resources ***New***	www.realdealonsteel.com/
TRB	Behavior of High-Density Polyethylene Pipe with Shallow Cover (in Transportation Research Record 1624)	http://trb.metapress.com/content/w0x253545012p314/?p=c10f72cd076348ad932bafa31b304df3&pi=48
	Performance Evaluation of High-Density Polyethylene Culvert Pipe (in Transportation Research Record 1814)	http://trb.metapress.com/content/27702067j27528j2/?p=6720dbbb0b87497aa7ac77a8d6ffa135&pi=19
	Profile-Wall High-Density Polyethylene Pipes 1050 mm in Diameter Under Deep Soil Cover: Comparisons of Field Performance Data and Analytical Predictions (in Transportation Research Record 1814)	http://trb.metapress.com/content/jv9w21761370k5m5/?p=bc025cc41b45402d82556dac5453b634&pi=21
Caltrans	Evaluation of Abrasion Resistance of Pipe and Pipe Lining Materials	www.trb.org/news/blurb_detail.asp?id=8483
	Alternative Pipe Culvert Selection Website	http://dap1.dot.ca.gov/design/altpipe/
Colorado DOT	Effect of Corrosion/Abrasion on Service Life of Culvert Pipes ***New***	***Note: coming soon***
Florida DOT	Florida Culvert and Pipes Advisory Group	www.dot.state.fl.us/rddesign/dr/Advisory-Groups.shtm
	Culvert Service Life Estimator software	www.dot.state.fl.us/rddesign/dr/Manualsandhandbooks.shtm
	Drainage Handbook – Chapter 6, Optional Culvert Materials	www.dot.state.fl.us/rddesign/dr/Manualsandhandbooks.shtm
Missouri DOT	Installation and Initial Performance of 60"ADS N-12HC® HDPE Pipes	http://168.166.124.22/RDT/reports/Ri01037/RDT02007.htm
Management: Inventory, Inspection, and Assessment		
FHWA	Transportation Asset Management Case Study—Culvert Management Systems: Alabama, Maryland, Minnesota, and Shelby County	www.fhwa.dot.gov/infrastructure/asstmgmt/tamcs_cms.cfm
	Culvert Inspection Manual	www.fhwa.dot.gov/engineering/hydraulics/library_arc.cfm?pub_number=31&id=57
	Bridge Inspector's Reference Manual: Section 7.12 – Concrete Box Culverts; Section 12.3 – Concrete Pipe Culverts; Section 12.4 – Flexible Culverts; Section P.3 – Culvert Characteristics	www.nhi.fhwa.dot.gov/training/course_detail.aspx?num=FHWA-NHI-130055&num=130055

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FHWA	Culvert Management System User Manual	***Note: please contact Shyan-Yung Pan in the FHWA Office of Asset Management*** shyan.pan@dot.gov
	Culvert Management System software	
AASHTO	Highway Drainage Guidelines, 4th Edition: Chapter 14 – Culvert Inspection and Rehabilitation	https://bookstore.transportation.org/ ***Note: item code HDG-4-M***
MRUTC	Midwest Regional University Transportation Center: An Asset Management Approach for Drainage Infrastructure and Culverts ***New***	www.mrutc.org/research/0608/06-08_FR.pdf
NCHRP	NCHRP Synthesis 371, Managing Selected Transportation Assets: Signals, Lighting, Signs, Pavement Markings, Culverts, and Sidewalks	http://trb.org/news/blurb_detail.asp?id=8496
	NCHRP Synthesis 303, Assessment and Rehabilitation of Existing Culverts	www.trb.org/news/blurb_detail.asp?id=978
TRB	Factors for Rating Condition of Culverts for Repair or Replacement Needs (in Transportation Research Record 1814)	http://trb.metapress.com/content/t711231p13583875/?p=bc025cc41b45402d82556dac5453b634&pi=22
	Management of Utah Highway Culverts (in Transportation Research Record 1904)	http://trb.metapress.com/content/15t31186pj41538q/
TRB	Framework for Inspection, Maintenance, and Replacement of Corrugated Steel Culvert Pipes (in Transportation Research Record 1911)	http://trb.metapress.com/content/w488655468367l21/?p=06a468f606044c72995a846a950e25ab&pi=2
	Simple Rating System for Identification of Failure-Critical Culverts and Small Structures (in Transportation Research Record 1928)	http://trb.metapress.com/content/5653n20258803k41/?p=3914f3c62cb0414a8a502577e40843b1&pi=23
	New Inspection and Risk Assessment Methods for Highway Metal Culverts in Ohio	http://trb.metapress.com/content/k66n772148791561/?p=fd2351df1fae49c1a3ca91a09b989e3c&pi=3
	A Need for Culvert Asset Management	http://trb.metapress.com/content/1576w37742mv680k/?p=7770e0e774524b3b8fa5f85cb6e8a0e1&pi=9
Caltrans	Culvert condition rating system descriptions	www.dot.ca.gov/hq/oppd/culvert/
Minnesota DOT	*HYDINFRA* software to manage inventory, inspection, and maintenance activities	www.dot.state.mn.us/bridge/Hydraulics/HydInfra.html
Ohio DOT	DOT's culvert inventory and inspection training and other resources	http://www.dot.state.oh.us/Divisions/HighwayOps/Structures/Hydraulic/Pages/CulvertManagementTraining.aspx
	DOT's Culvert Management Manual	http://www.dot.state.oh.us/Divisions/HighwayOps/Structures/Hydraulic/Documents/CMM_12-2003[1].pdf

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Utah DOT	Condition Assessment of Highway Culverts and Determination of Performance Measures (Report No. UT-81FR0132)	www.sr.ex.state.ut.us/main/f?p=100:pg:4323270186552049231::::V,T:,195 ***Note: contact UDOT Research and Development Div.***
WSDOT	DOT's Culvert Inspection Program – with clips of robotic video inspections and inspection forms	www.wsdot.wa.gov/mapsdata/tdo/culvertinspectionprogram.htm
Management: Maintenance, Renewal and Replacement		
FHWA	Culvert Pipe Liner Guide and Specifications	www.cflhd.gov/techDevelopment/completed_projects/hydraulics/culvert-pipe-liner/
	Culvert Repair Practices Manual, Vol. 1	www.fhwa.dot.gov/engineering/hydraulics/library_arc.cfm?pub_number=36&id=94
	Culvert Repair Practices Manual, Vol. 2	www.fhwa.dot.gov/engineering/hydraulics/library_arc.cfm?pub_number=37&id=90
U.S. Forest Service	Summary of Trenchless Technology for Use With USDA Forest Service Culverts	www.fs.fed.us/eng/pubs/pdf/05771201.pdf
Caltrans	Design Information Bulletin No. 83-01, Caltrans Supplement to FHWA Culvert Repair Practices Manual	www.dot.ca.gov/hq/oppd/dib/dib83-01-5.htm
Missouri DOT	Horizontal Boring: Design, Construction, Inspection, and Utilities Issues (Course Manual)	***Note: contact MoDOT for more information***
MRUTC	Midwest Regional University Transportation Center: Use of Trenchless Technologies for a Comprehensive Asset Management of Culverts and Drainage Structures ***New***	www.mrutc.org/research/0715/
New York State DOT	Standard Specification Section 600: Incidental Construction Subsection 602-Rehabilitation of Culvert and Storm Drain Pipe	www.nysdot.gov/portal/page/portal/main/business-center/engineering/specifications/specs-repository/section600.pdf
Oregon DOT	Hydraulics Manual Part 2, Chapter 16, Trenchless Technology	www.oregon.gov/ODOT/HWY/GEOENVIRONMENTAL/hyd_manual_info.shtml
VTrans	Culvert and ditching program	www.aot.state.vt.us/techservices/envpermit/culvertditching.htm
VA Transport. Research Council	Understanding the Environmental Implications of Cured-in-Place Pipe Rehabilitation Technology	www.virginiadot.org/vtrc/main/online_reports/pdf/08-r16.pdf
Associations		
TRB	TRB Committee AFF70, Culverts and Hydraulic Structures	www.trb.org/directory/comm_detail.asp?c=AFF70
ACPA	American Concrete Pipe Association	www.concrete-pipe.org
MRUTC	Midwest Regional University Transportation Center	www.mrutc.org/

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NASSCO	National Association of Sewer Service Companies	www.nassco.org/index.html ***Note: inspection, assessment and repair of underground pipelines***
NCSPA	National Corrugated Steel Pipe Association	www.ncspa.org/
NPCA	National Precast Concrete Association	www.precast.org/
PPI	Plastic Pipe Institute	http://plasticpipe.org/index.html
Ongoing Initiatives		
FHWA	Development of Fish Passage Design Guidelines for Roadway Culverts (HEC 26)	***Note: FHWA point of contact is Bart Bergendahl*** bart.bergendahl@fhwa.dot.gov
	Development of Procedures Manual for Culvert Assessment and Decision Making ***New***	***Note: FHWA point of contact is Bart Bergendahl*** bart.bergendahl@fhwa.dot.gov
	Turner-Fairbank Highway Research Center – "Fish Passage in Large Culverts with Low Flows" ***New***	***Note: FHWA point of contact is Kornel Kerenyi*** kornel.kerenyi@fhwa.dot.gov
	HY-8 Culvert Analysis Hydraulic Program – Phase Three of Development Efforts ***New***	***Note: Pooled Fund Program solicitation*** www.pooledfund.org/projectdetails.asp?id=1222&status=1
NCHRP	NCHRP Project 14-19: Culvert Rehabilitation to Maximize Service Life While Minimizing Direct Costs and Traffic Disruption	www.trb.org/TRBNet/ProjectDisplay.asp?ProjectID=1634 ***Note: in progress***
	NCHRP Project 15-24: Hydraulic Loss Coefficients for Culverts	www.trb.org/TRBNet/ProjectDisplay.asp?ProjectID=404
	NCHRP Project 15-38: Design Requirements for Culvert Joints ***New***	www.trb.org/NotesDocs/NCHRP_Announcement.pdf ***Note: approved for start in FY09***
	NCHRP Project 20-07(264): Evaluation of Pipe Materials Selection Practices and Research, and Recommendations for Pipe Material Selection Criteria ***New***	***Note: in progress***
	NCHRP Project 21-06: Corrosion in the Soil Environment: Soil Resistivity and pH Measurements	www.trb.org/TRBNet/ProjectDisplay.asp?ProjectID=669 ***Note: the project final report will be published by NCHRP in mid-2009***

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