

The Ohio Department of Transportation Office of Research & Development **RESEARCH** Executive Summary Report

A Study of Bankfull Culvert Design Effectiveness Problem

Start Date: August 23, 2009

Duration: 16 months

Completion Date: December 23, 2010

Report Date: May 16, 2011 (Revised Draft)

State Job Number: 134465

Report Number:

Funding: \$ 19,999.89

Principal Investigators: Dr. Mark A. Tumeo

ODOT Contacts:

Technical: William R. Cody

Administrative: Monique R. Evans, P.E. Administrator, R&D 614-728-6048

For copies of this final report go to http://www.dot.state.oh.us/divplan/research or call 614-644-8173.

> Ohio Department of Transportation Office of Research & Development 1980 West Broad Street Columbus, OH 43223

As part of the certification under the Clean Water Act 404 Nationwide Permit (NWP) in 2002. the Ohio Environmental Protection Agency (OEPA) mandated that the Ohio Department of Transportation (ODOT) install bankfull culverts in all new culvert installations subject to the permit. In addition, by embedding the culvert, the bottom of the culvert is to take on the characteristics of the natural streambed and promote the passage of fish and other aquatic organisms. Throughout this report, we use the term "embedded bankfull culvert" or EBC to refer to culverts designed using bankfull discharge design and depressed culvert inverts in accordance with the L&D Manual V2.

The OEPA's requirement to install bankfull culverts has resulted in increased design and construction costs. Preliminary investigations conducted at Cleveland State University indicated that the increased cost may be as much as 34% over a standard culvert design.

Despite this increased cost, a search of the literature reveals that there has been no published research conducted to determine under what physical conditions bankfull culverts are effective in establishing a natural channel bottom or in allowing for the passage of migratory aquatic species present in Ohio waterways.

Currently, the OEPA's general conditions for the new NWP program would require that bankfull culverts with depressed inverts on all new culverts installed at a slope of less than 3% despite the lack of scientific evidence indicating when these culvert design techniques are appropriate and effective. This project is focused on determining the effectiveness of these culvert design techniques in delivering the environmental benefits alleged and to assure that future regulations are developed based on sound science.

Objectives The objectives of the study were to examine the parameters which control the benefits of bankfull culverts when installed, including how the benefits alleged are affected by culvert diameter, slope and length, and the size of the stream in which the culvert is placed. Ultimately, the research was designed to determine if bankfull culverts, as currently installed, provide the benefit of allowing movement of aquatic biota better than traditional culverts, if there is any impact on flood attenuation, and if the bankfull culverts installed in Ohio have caused quantitative environmental changes or cumulative impacts (as measured by the QHEI).

Description

The research took 16 months and involved four specific activities: (a) a detailed literature review; (b) a survey of 61 existing bankfull culverts installed in Ohio to collect data; (c) an analysis of the effectiveness of the installed culverts as determined by the effect on sediment transport and the QHEI where available; and (d) a computer model analyses of the hydrologic impacts of bankfull culverts on velocity in the culvert and flood attenuation (using HydroCad[®]) and fish passage (using FishXing[®])

Conclusions & Recommendations

The physical survey of the culverts revealed that of the 61 culverts identified by ODOT as being designed as embedded bankfull culverts (EBCs), there are only 12 that are actually embedded. ODOT should develop and implement a system of inspecting and verifying that culverts specified to be embedded bankfull culverts are actually installed as such. Of the 12 embedded culverts, only two were found to be effectively allowing for the continuity of sedimentation patterns through the reach of a culvert. Because of the low numbers, *the results found are not statistically significant*. Therefore trends were identified and an attempt to define functionality and identify similarities in the physical parameters of the functioning culverts.

An important finding is that many of the culverts with greater than 1% slope had no sediment present inside of the culvert. The results of the survey indicate that, at the 90% confidence interval, sediments are being washed through culverts with a slope 1% or greater. *Therefore it is recommended that EBCs should not be installed at slopes greater than 1%*

To better understand the functionality of culverts and the trends presented, more research is needed. ODOT should consider funding additional research in this area to confirm preliminary trends and provide more guidance in the design of embedded bankfull culverts.

Implementation Potential

ODOT should immediately develop and implement a system of inspecting and verifying that culverts specified to be EBCs are actually installed as such. Because this would be an internal ODOT requirement, the steps to implementation are moderately straightforward. Initial efforts should include discussions with ODOT contractors to explore the reasons that culverts, when installed, are not being installed according to the design requirements of embedded bankfull culverts.

The remaining recommendations are not sufficiently supported by the data to be implemented at this time. Before ODOT begins the process of changing the design criteria for Embedded Bankfull Culverts, they should ensure that the trends identified in this research are verified by sufficient sample in the field. This may require sampling embedded bankfull culverts outside the State of Ohio to ensure sufficient EBCs are available for the study.