DEVELOPMENT OF LOW-WATER CROSSING DESIGN GUIDELINES FOR VERY LOW ADT ROUTES IN ILLINOIS

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ILLINOIS

Department of Agricultural and Biological Engineering
COLLEGE OF ACES | ENGINEERING AT ILLINOIS

BACKGROUND

Low Water Crossings (LWCs)…

- Road-stream crossing structures designed to be overtopped by high flows or by debris or ice-laden flows (Clarkin et al. 2006)

- Economical alternative to bridges and culverts on low-volume roads where there is low number of floods

Clarkin, K., Keller, G., Warhol, T., Hixson, S., 2006. Low-water crossings: geomorphic, biological, and engineering design considerations. Washington, D.C.

BACKGROUND

Types of LWCs…

- 3 main types: unvented fords, vented fords, low water bridges

Unvented ford across Big Creek in Hamilton County, IL

Vented ford in Jackson County, IL

BACKGROUND

Types of LWCs…

Low water bridge at Montgomery County, NC

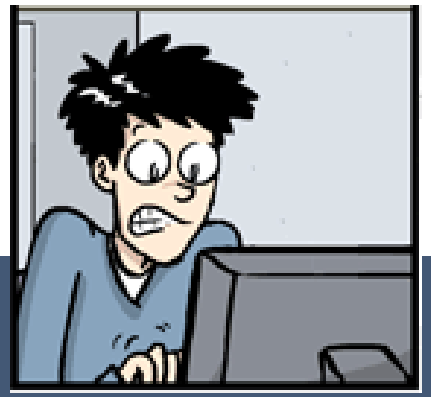
- LWCs suffer less damage during overtopping
- Less susceptible to fail during higher flows
- Good for storm proofing roads where large amounts of sediment and debris are expected

INTRODUCTION

LWC Design issues…

- Current IDOT bridge design requires 1 ft of vertical clearance above the design high-water elevation for roadways with an ADT < 250, where the minimum design flood is a 15-year event.

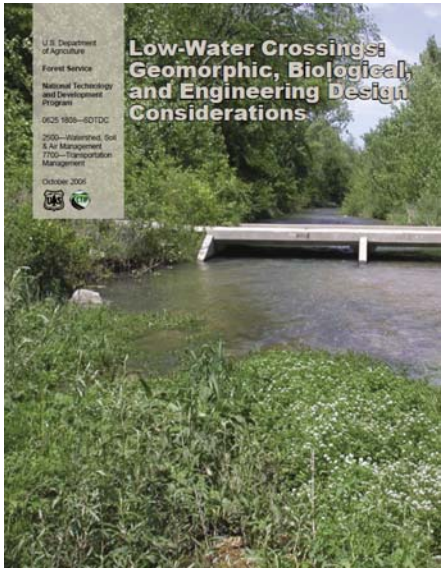
- Lack of lack of design guidance has posed difficulty for county engineers in Illinois in designing LWCs.



OBJECTIVES

Overall Objective…

Develop design guidelines that can be used to determine optimal, safe and cost-effective LWCs in Illinois



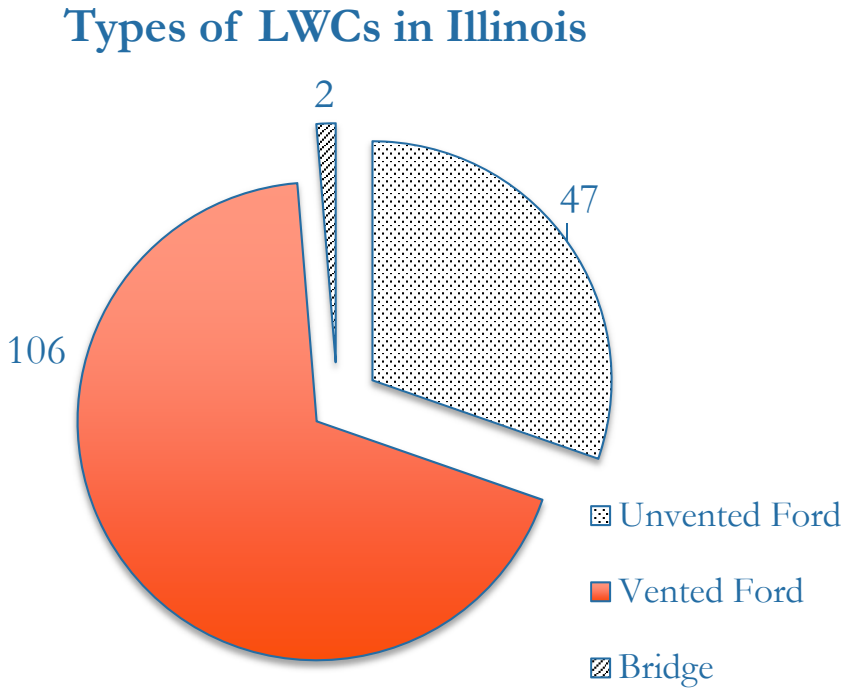
MATERIALS & METHODS

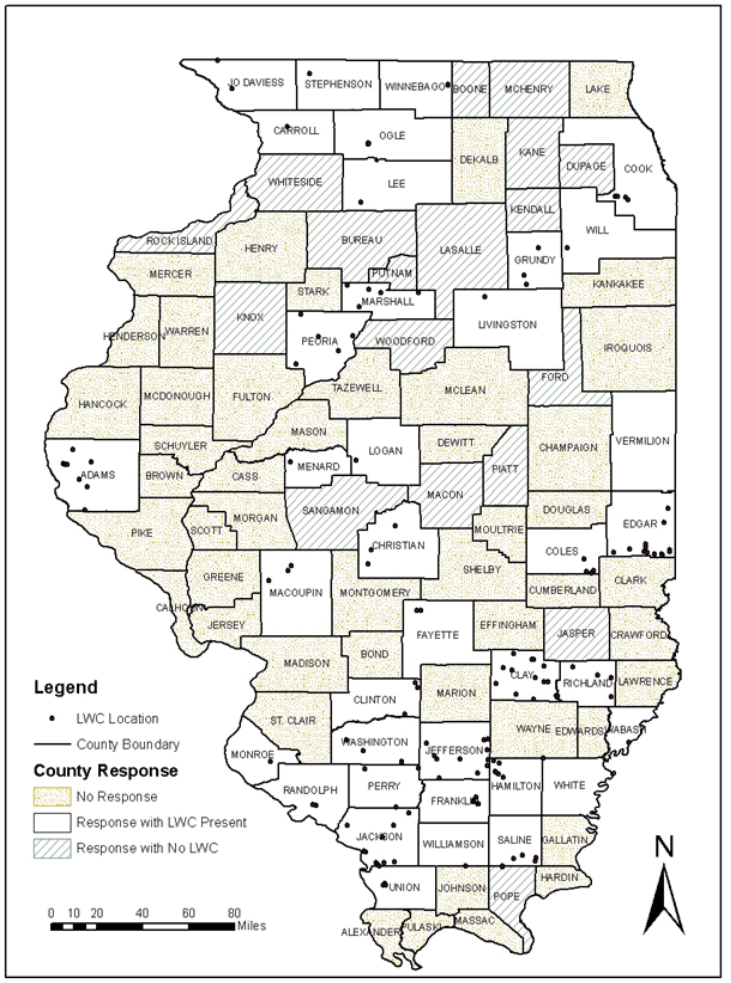
Illinois LWC Survey…

- Response from 55 counties, out of which 37 have LWCs
- A total of 155 LWCs were identified, and located in the map
- Most of them did not have information about design flow, and lacked warning signs.

MATERIALS & METHODS

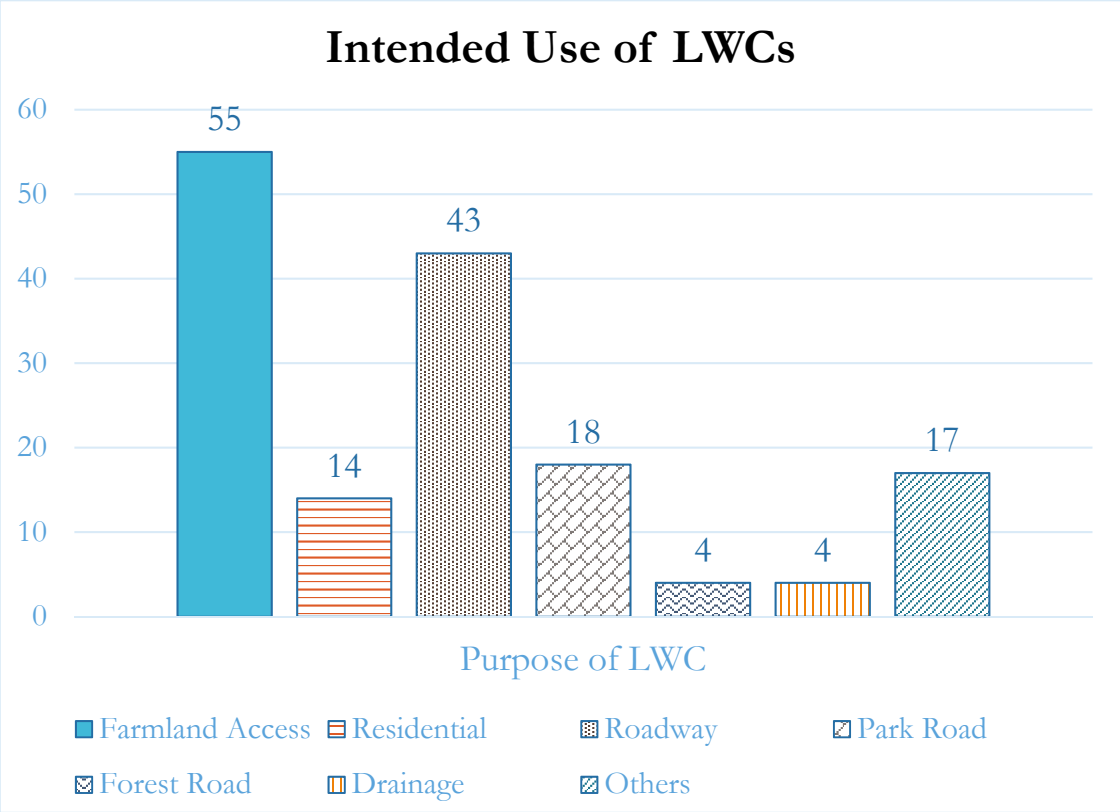
LWCs in Illinois…





MATERIALS & METHODS

LWCs in Illinois…



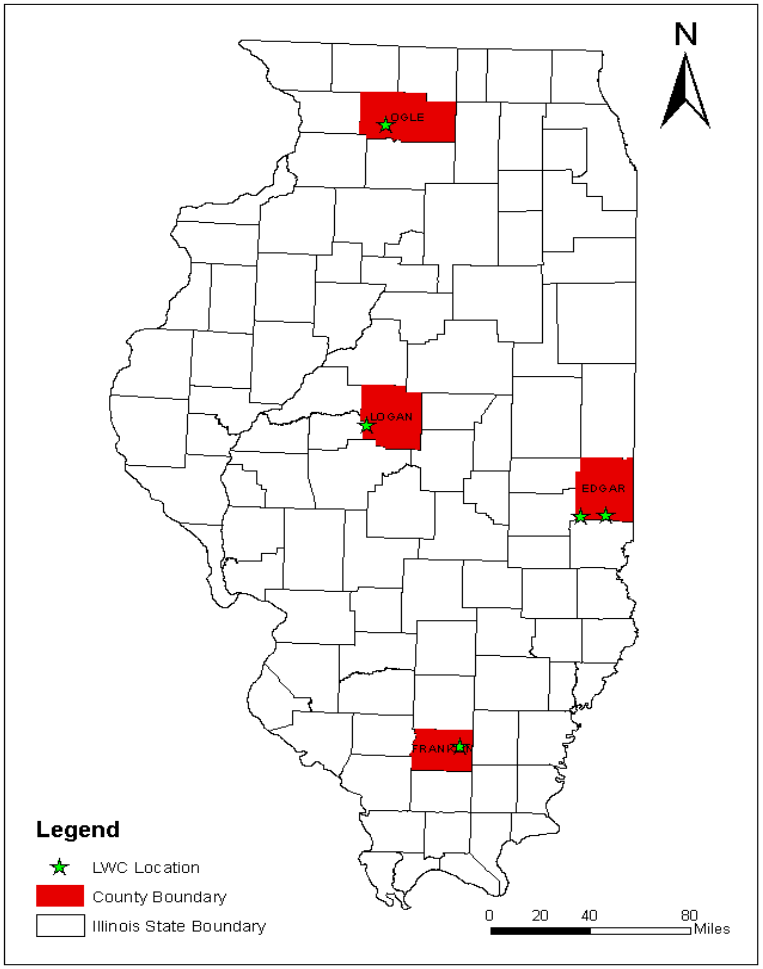
No. of Overtoppings per Year	No. of LWCs
250 or more	11
100 to 250	8
25 to 100	3
10 to 25	26
Less than 10	44
Unknown	63

MATERIALS & METHODS

Study Sites…

- 5 sites: 3 vented, 2 unvented

County	ID	Lat.	Long.	Str. Type	Stream
Edgar	Edgar#1	39.508	–87.923	Above-Grade Vented	North Fork
	Edgar#3	39.513	–87.729	At-Grade Vented	Fork Big Creek
Franklin	Franklin	38.017	–88.787	At-Grade Unvented	Tributary to Akin Creek
Logan	Logan	40.067	–89.545	At-Grade Vented	Tributary to Salt Creek
Ogle	Ogle	41.992	–89.470	At-Grade Unvented	Pine Creek



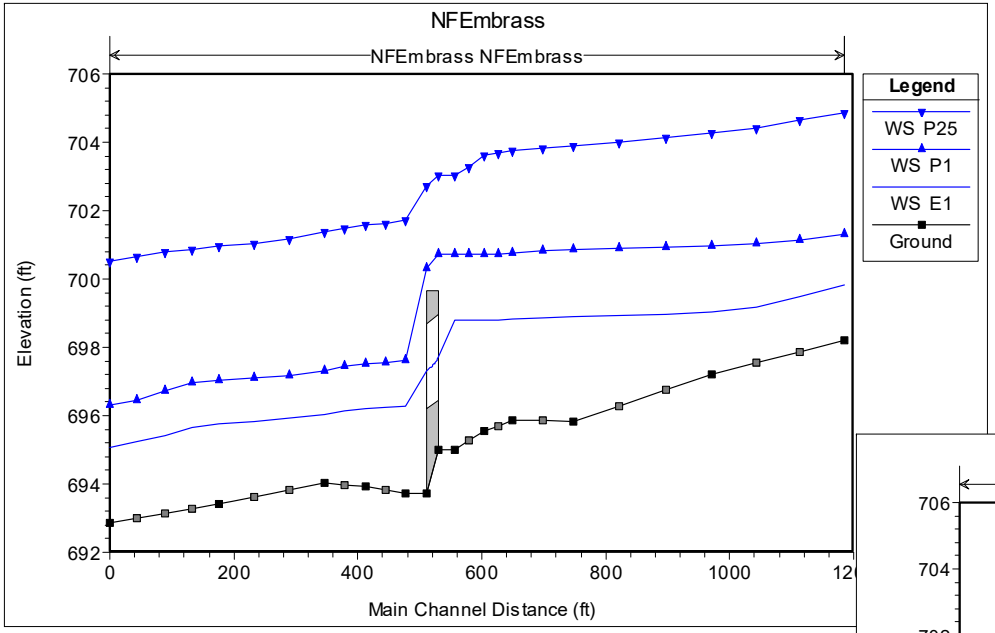
MATERIALS & METHODS

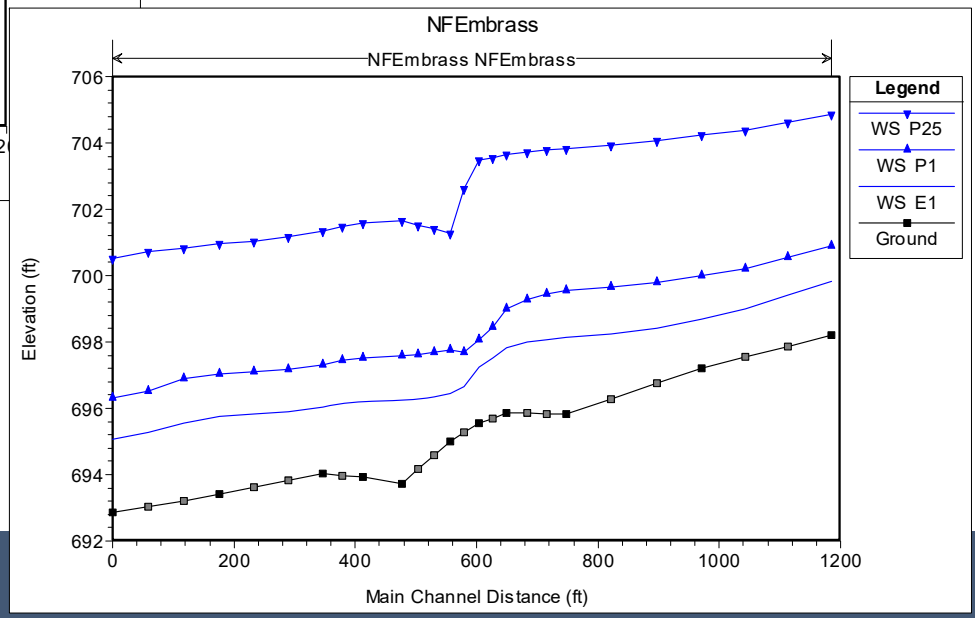
LWC Performance Evaluation…

- Adequacy of LWC: ability to pass 1% exceedance flow (E1), 1-yr flow (P1) flow, evaluation of culvert flow capacity
- Flood extent analysis: Hydraulic modeling results for 25-yr flow (P25) and its effect on floodplain
- Sediment Transport: Change in bed shear between present and LWC-free (baseline) condition for critical cross sections during normal flow
- AOP: Change in stream velocity between present and LWC-free (baseline) condition for critical cross sections during normal flow

RESULTS

Edgar#1 LWC…



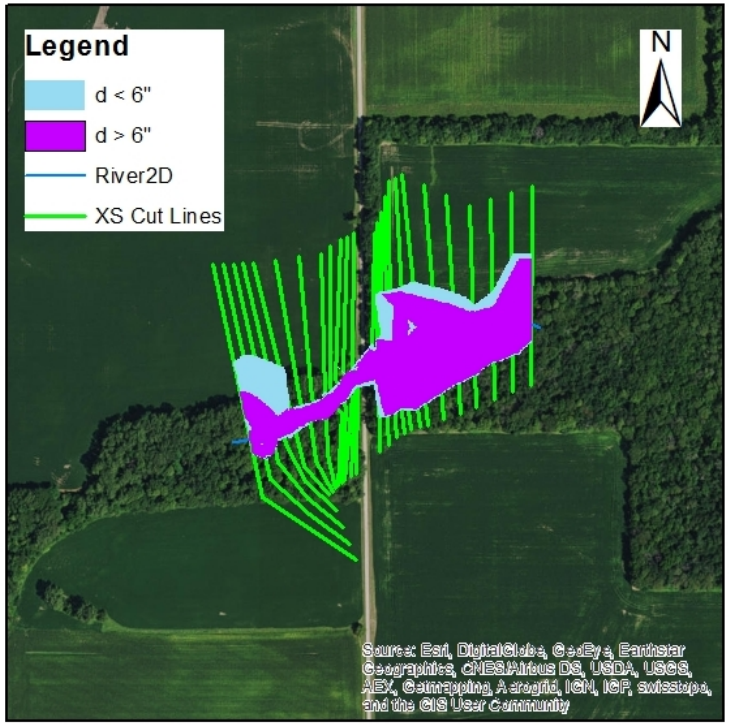


RESULTS

Edgar#1 LWC…

LWC	Scenario	Inundated area (acres)		Percent change
		Present Scenario	LWC free scenario	
Edgar#1	Total area	6.76	6.47	4.48
	Area with d > 6 in.	5.13	4.85	5.77

The area inundated by this flood includes the surrounding forested area and a small portion of farmland, which was found to be acceptable



RESULTS

Edgar#1 LWC…

Scenario	Shear Stress (lb/ ft^2)	
	U/S Section	D/S Section
LWC	0.02	0.11
LWC Free	0.42	0.11

Scenario	Velocity (ft/s)	
	U/S Section	D/S Section
LWC	0.82	1.71
LWC Free	3.08	1.71

- This vented LWC is a good choice for the site located in a small drainage watershed
- The crossing is functioning well, and there is very little effect in the environment
- The vented ford poses less restriction to the movement of aquatic species

LWC DESIGN CONSIDERATIONS

Considerations	Criteria
Channel cross section	Should not be altered
Overtopping flow depth	Less than or equal to 6 inches
Vertical curve at dip (approach grades)	Less than 10%
Stream bank height	Less than 12 ft
Orientation of Structure	Straight, avoid skew
Approach Distance	750 ft minimum sight distance for warning signs
Height of crossing above streambed	Less than 4 ft
Erosion from flows overtopping crossing	Elevation difference between crossing and streambed kept to minimum. LWSC surface material extended in both directions away from structure. Downstream slope 4:1 or milder.
Core material protection	Provide cutoff walls and sidewalls
Stream bank protection	Establish vegetation

LWC DESIGN GUIDELINES

- Recommendation on Economics
- Recommendation on Signage
- Permit requirements
  - IDNR
  - Army Corps of Engineers

SITE HYDROLOGY

Two approaches to get design flow used in design of the fords

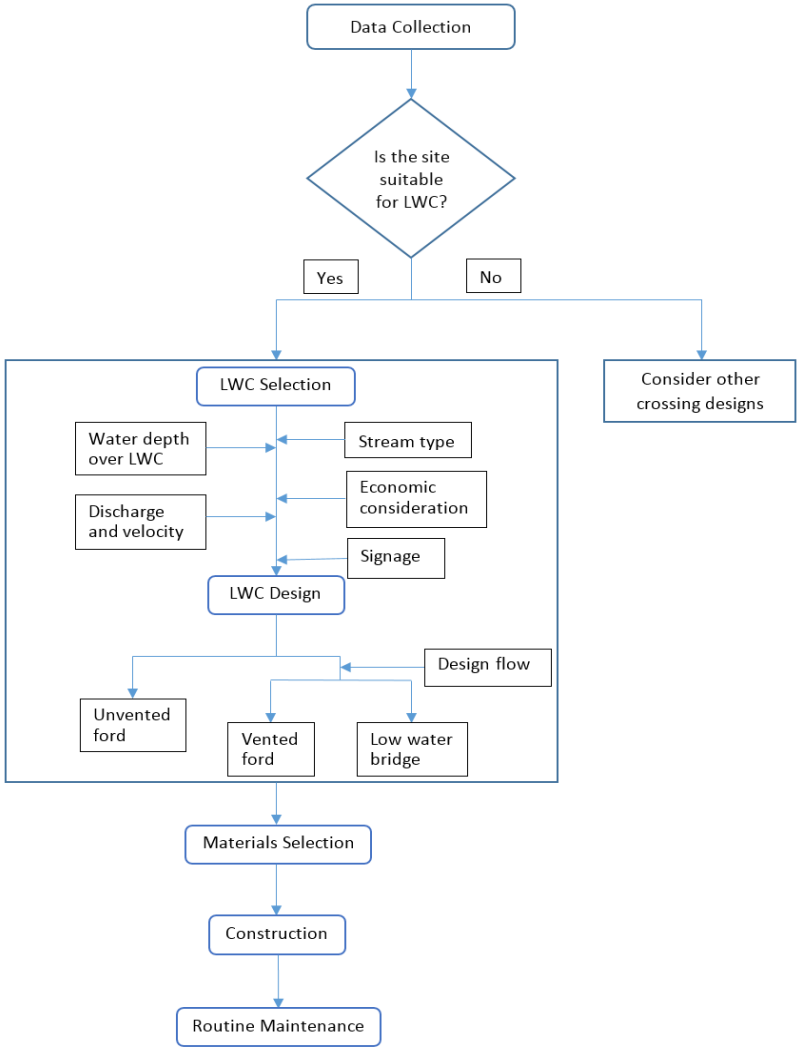
1. **Flow-Duration** data in the estimation of closure time of the LWC (number of days in a year during which the LWC may be closed to traffic) and the capacity of the LWC (pipes in case of a vented ford).

2. **Flood-Frequency** data in the estimation of high design flow for the design of the LWC structure full capacity and local knowledge on base flow in the stream in determining the type of LWC, and the size of pipe in the case of a vented ford.

LWC DESIGN GUIDELINES

- Design of unvented ford
  - Manning's equation and broad-crested weir
- Design of Vented ford
  - Similar to culvert
- Design of low-water bridge
  - Slab bridge
  - Precast concrete channel beam bridge

LWC DESIGN GUIDELINES



LWC Design guideline is available at:
https://apps.ict.illinois.edu/projects/getfile.asp?id=5066

Questions ??

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