

Florida Department of Transportation Bridge Scour Evaluation Program

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Following the catastrophic failure of the Schoharie Creek bridge in April 1987 FHWA established a national bridge scour evaluation program under the National Bridge Inspection Standards to be implemented by state highway and transportation departments. Initial scour susceptibility screening was completed for the most part by October 1992, and FHWA has established January 1997 as the completion date for scour evaluations of all existing bridges identified as scour susceptible. The procedures that were developed and the results to date of scour evaluation of bridges in Florida are highlighted. The Florida Department of Transportation guidelines contain a four-phase approach to scour evaluations: Phase I is data collection and qualitative analysis, Phase II is hydrologic and hydraulic assessment for scour analysis, Phase III is geotechnical and structural scour assessment, and Phase IV is a recommended plan of action. The checklists and field procedures developed to complete Phases I and II of the evaluation are presented, and the results of the scour evaluations to date are summarized.

Following the catastrophic failure of the Schoharie Creek bridge in April 1987 FHWA established a national bridge scour evaluation program to be implemented by state highway and transportation departments. Initial scour susceptibility screening was completed for the most part by October 1992, and

FHWA has established January 1997 as the completion date for scour evaluations of all existing bridges identified as scour susceptible. With almost 8,000 bridges under the National Bridge Inspection Standards (NBIS), Florida is facing a formidable task. The procedures that were developed and the results to date from scour evaluation of bridges in Florida by the Florida Department of Transportation (FDOT) are highlighted. The checklists and field procedures developed to complete the initial phases of the evaluation are presented and discussed. This paper expands on and updates a description of the scour evaluation program developed initially for a single district of FDOT (1).

FDOT GUIDELINES

Technical Advisory 5140.23, *Evaluating Scour at Bridges* (2), issued by FHWA in 1991 to supersede Technical Advisory 5140.20, provides guidance on the development and implementation of procedures for evaluating bridge scour. The technical advisory indicates that every bridge over a waterway, whether existing or under design, should be evaluated for scour to determine prudent measures to be taken for its protection. The evaluations are to be conducted by an interdisciplinary team (hydraulic, geotechnical, and struc-

tural engineers) and are to include hydraulic studies and scour evaluation.

The scour evaluation procedures implemented in Florida are based on FDOT guidelines for scour evaluation studies (3), which are supported by FHWA guidance in Technical Advisory 5140.23 and FHWA's Hydraulic Engineering Circulars 18 (HEC-18) (4) and 20 (HEC-20) (5). FDOT guidelines contain a four-phase approach to scour evaluations:

- Phase I: data collection and qualitative analysis,
- Phase II: hydrologic and hydraulic assessment for scour analysis,
- Phase III: geotechnical and structural scour assessment, and
- Phase IV: recommended plan of action.

The site data analysis for Phase I is qualitative. It involves preliminary conclusions and findings based on the application of simple geomorphic concepts and reconnaissance-level evaluation of office data, field data, and site conditions. This phase relies heavily on the stepwise procedure and techniques presented in HEC-20 (5). Phase II involves basic engineering analysis techniques and development of quantitative information for bridge scour assessment. Guidance in specific areas of the evaluation and the level of detail required are based on the results of Phase I. Again, a stepwise analysis procedure presented in HEC-20 (5) provides guidance for the Phase II effort, and scour analyses are completed in accordance with the detailed procedures presented in HEC-18 (4).

Phases III and IV of the FDOT procedure, which will not be discussed further, involve the structural and geotechnical disciplines represented on the scour evaluation team (Phase III) and the development of a conceptual plan for scour countermeasures for protecting structural elements considered at risk as a result of scour (Phase IV). Phase IV involves the entire multidisciplinary evaluation team and relies on the countermeasure guidance contained in HEC-18 (4) and HEC-20 (5).

EVALUATION CRITERIA

In HEC-18 (4) the recommendation is made that states screen their bridges and place them into three categories: low risk, scour susceptible, and unknown foundations. If the evaluation team detects an immediate scour threat to a bridge during Phase I, the responsible department of transportation district should be notified. Consequently, the Phase I procedure developed for FDOT includes an additional scour-critical category. The following guidelines are provided to assist the evaluation team in making consistent ratings. A high, me-

dium, and low priority is also included to assist the FDOT district in prioritizing Phase II and follow-on activities.

<i>Category</i>	<i>Rating</i>
Scour critical	Yes or no
Scour susceptible	High, medium, low
Low risk	High, medium, low
Foundations	Known or unknown

Scour critical

- Evidence of structural damage due to scour,
- Aggressive stream or tidal waterway (high velocity, steep slope, deep flow),
- Exposed footing in erodible material,
- Exposed piles with unknown or insufficient embedment,
- Countermeasures needed immediately, and
- Actively degrading channel.

Scour susceptible (high priority)

- Aggressive stream or tidal waterway,
- Foundations are spread footings on erodible soil, shallow piles, or embedment unknown,
- Tidal flows have high velocities (surface velocity, >0.9 m/sec) and large tidal amplitudes (>0.6 m),
- Bed material is easily eroded,
- Evidence of scour or degradation,
- Scour is below top of footing,
- Large angle of attack (>10 degrees),
- No countermeasures or countermeasures in poor condition,
- Clear water scour mode (e.g., relief bridge on floodplain),
- Significant flow over the bank (potential for contraction scour), and
- Possibility of bridge overtopping (potential for pressure flow).

Scour susceptible (medium priority)

- Characteristics fall between high and low.

Scour susceptible (low priority)

- Stream is not aggressive (low velocities) or other factors mitigate the high velocities,
- Foundations are on piles but of unknown embedment,
- Tidal flows have low velocities and tidal amplitudes,
- Bed material is erodible,

- Some evidence of scour or degradation,
- Scour is not below top of spread footings,
- Stream is degrading but foundations are known, and
- Countermeasures are in fair to good condition.

Low risk (high priority)

- Stream is not aggressive (low velocity), or other factors mitigate the high velocity,
- Foundations on piles of known embedment,
- Stream is aggressive or the tidal range is large, but foundations are known and cross section is stable,
- Stream is aggrading or stable, and
- Countermeasures are in fair condition.

Low risk (medium priority)

- Characteristics fall between high and low.

Low risk (low priority)

- Stream is not aggressive or other factors mitigate high velocity,
- Foundation is in bedrock,
- Stream is aggrading or stable,
- Pile foundations are deep,
- Cross section is stable,
- No evidence of scour,
- Tidal flows have low velocities and ranges,
- Countermeasures are in good condition,
- No possibility of overtopping bridge,
- Foundations are designed using current technology,
- Channel is heavily vegetated, and
- No flow over the bank.

Unknown foundations

- No record of foundation type (i.e., spread footing versus piles) or condition of foundation or pile embedment is unknown (generally rated a minimum of scour susceptible, low priority, unless there are significant mitigating factors, e.g., a long history of significant aggradation).

These criteria are intended to serve as guidelines in the Phase I scour evaluation. Although a numerical rating scheme could be developed, Phase I is intended to be a qualitative evaluation based heavily on experience and engineering judgment. It is not necessary that all factors in a given category be present to justify a specific rating, but the observance of several factors in a given category would guide the rating toward that category, considering all other office review and field reconnaissance data available. As noted in FDOT guidelines (3),

the engineer must use good judgment in the evaluation process and is encouraged to use ingenuity in applying the recommended concepts and procedures.

STANDARDIZED FORMS


Phase I: Qualitative Analysis

To support the Phase I office and field evaluation, a set of standardized forms was developed (Figure 1). The form consists of 11 categories that systematically address structural components affected by scour, abutments and piers, lateral and vertical channel stability, geomorphology, other considerations (watershed, tidal, and tributary factors), and additional comments (such as unique characteristics and a standard set of photographs), which can be evaluated on a qualitative basis during office and field inspections. The appropriate data collected in the office for Sections 4 through 11 (Figure 1) are considered during the Phase I field evaluation and review. Each of these categories is tied closely to the FHWA guidelines and procedures presented in HEC-18 (4) and HEC-20 (5). Initially, field site visits were scheduled before the office review, but experience has shown that many questions in the field can be avoided if adequate time has been taken to assemble and review all available file information first.

The specific conclusions reached following the office and field review are summarized in Sections 1 through 3, which outline the Scour Vulnerability Rating (rating and reasons for rating), FDOT Scour Index (based on a preliminary screening by FDOT), and recommendations (including countermeasures and the need for a Phase II analysis). A standard cover sheet (Figure 1) identifies the bridge by number and location, provides a scour vulnerability summary (scour mode and rating), and provides a recommendation regarding the need for a Phase II quantitative analysis.

The forms are arranged to guide the inspector or reviewer through a standard evaluation process. Several areas of the form allow alternative choices in each of the categories. These areas are intended to be appropriately marked or circled in the field for further evaluation in the office. The scope of Phase I qualitative analysis is designed to develop an informed opinion of scour susceptibility based on available site-specific data and good engineering judgment.

The countermeasures identified on the form represent recommendations of the inspector or reviewer. If scour monitoring is specified as a countermeasure, this would require installation on the bridge of a device designed to continuously or periodically measure scour. If inspections are recommended as a countermeasure, the frequency is specified (i.e., during routine bridge inspec-

Prepared For: 	SCOUR EVALUATION REPORT	Prepared By: AVRES ASSOCIATES 3901 Coconut Palm Drive Suite 100 Tampa Florida (813) 628-0742		
REPORT IDENTIFICATION				
<input checked="" type="checkbox"/> PHASE 1 Qualitative Evaluation/ Assessment Date: _____	<input type="checkbox"/> PHASE 2 Hydraulic/Hydrologic Assessment Date: _____	<input type="checkbox"/> PHASE 3 Structural/Geotechnical Assessment Date: _____	<input type="checkbox"/> PHASE 4 Plan of Action Date: _____	
Bridge Number: _____		Name: _____		
Location: _____		County: _____		
SCOUR VULNERABILITY				
SCOUR MODE:		<input type="checkbox"/> Riverine	<input type="checkbox"/> Tidal	<input type="checkbox"/> Both
SCOUR RATING:		Scour Critical: <input type="checkbox"/> Yes <input type="checkbox"/> No		
		Scour Susceptible:		
		<input type="checkbox"/> High	<input type="checkbox"/> Medium	<input type="checkbox"/> Low
		Low Risk:		
		<input type="checkbox"/> High	<input type="checkbox"/> Medium	<input type="checkbox"/> Low
		Foundations: <input type="checkbox"/> Known <input type="checkbox"/> Unknown		
RECOMMENDATION:				
Name of Engineer	Initials	Engineering Registration Number	Discipline	
Reviewing Bridge Engineer/Supervisor		Confirming Registered Professional Engineer		
Name _____ P.E. No. _____		Name _____ P.E. No. _____		
Initials _____		Signature/Seal _____		

a

SCOUR EVALUATION - FIELD / OFFICE REVIEW REPORT			
Bridge #:	County:	Route:	Over:
1. SCOUR VULNERABILITY RATING (PER FHWA)			
a. Scour Critical:	<input type="checkbox"/> Yes	<input type="checkbox"/> No	
Scour Susceptible:	<input type="checkbox"/> High	<input type="checkbox"/> Medium	<input type="checkbox"/> Low
Low Risk:	<input type="checkbox"/> High	<input type="checkbox"/> Medium	<input type="checkbox"/> Low
Foundations:	<input type="checkbox"/> Known	<input type="checkbox"/> Unknown	
Structure Type:	<input type="checkbox"/> Bridge	<input type="checkbox"/> Bridge Culvert	
b. Reasons for Rating:			
2. FLORIDA DOT SCOUR INDEX NUMBER			Initial _____ Secondary _____
3. RECOMMENDATIONS			
a. Countermeasures:			
<input type="checkbox"/> Riprap			
<input type="checkbox"/> Scour Monitor			
<input type="checkbox"/> Inspection			
<input type="checkbox"/> Other			
b. Phase Two Analysis Recommended:		<input type="checkbox"/> Yes	<input type="checkbox"/> No
c. Phase Two Priority:		<input type="checkbox"/> High	<input type="checkbox"/> Medium <input type="checkbox"/> Low <input type="checkbox"/> None
d. Remarks:			

b

FIGURE 1 Scour Evaluation Report cover sheet and Phase I qualitative evaluation Field/Office Review Report forms.

SCOUR EVALUATION - FIELD / OFFICE REVIEW REPORT			
4. SITE FIELD REVIEW			
a. Evidence of Scour at Structure			
1) Abutment Tilt / Moving In:	<input type="checkbox"/> Yes	<input type="checkbox"/> No	
2) Slopes Washing In / Sloughing:	<input type="checkbox"/> Yes	<input type="checkbox"/> No	
3) Scour Holes Near Abutments / Bents:	<input type="checkbox"/> Yes	<input type="checkbox"/> No	
4) Bed Deposits Downstream:	<input type="checkbox"/> Yes	<input type="checkbox"/> No	
5) Bridge Railing Sagging:	<input type="checkbox"/> Yes	<input type="checkbox"/> No	
6) Debris:	<input type="checkbox"/> Yes	<input type="checkbox"/> No	
7) Highwater Mark:	<input type="checkbox"/> Yes	<input type="checkbox"/> No	
b. Feasibility of Monitoring During High Flow			
1) Rod / Pole / Weight from Deck:	<input type="checkbox"/> Yes	<input type="checkbox"/> No	
2) Fixed Monitoring Device:	<input type="checkbox"/> Yes	<input type="checkbox"/> No	
c. Feasibility of Adding Riprap or Other Scour Countermeasures: <input type="checkbox"/> Yes <input type="checkbox"/> No			
6. ABUTMENTS			
a. Type:			
<input type="checkbox"/> Split Through Bridge	<input type="checkbox"/> Vertical Wall	<input type="checkbox"/> Wing Walls	
	<input type="checkbox"/> Concrete Box Culvert	<input type="checkbox"/> Seawalls	
b. Foundation:	Dimensions (L,W,D.) (ft)	Embedment (ft)	Scour Exposure (ft)
<input type="checkbox"/> Spread Footings			
<input type="checkbox"/> Pile Caps			
<input type="checkbox"/> Piles			
<input type="checkbox"/> Drilled Shaft			
Source of Data: <input type="checkbox"/> Field Review <input type="checkbox"/> Design Plans <input type="checkbox"/> As-built Drawings <input type="checkbox"/> Pile Driving Records <input type="checkbox"/> Inspection Reports <input type="checkbox"/> Other			
c. Location from Bank:	Left (ft)	Right (ft)	
<input type="checkbox"/> Set back			
<input type="checkbox"/> In Channel			
<input type="checkbox"/> At Bank			
d. Protection			
1) Riprap:	<input type="checkbox"/> Sand Cement	<input type="checkbox"/> Rubble	<input type="checkbox"/> Commercial Block
	<input type="checkbox"/> Seawall	<input type="checkbox"/> None	<input type="checkbox"/> Other
2) Condition:	Good	Fair	Poor
Left	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Right	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>

c

SCOUR EVALUATION - FIELD / OFFICE REVIEW REPORT			
6. PIER			
a. Type:			
<input type="checkbox"/> Concrete Wall	<input type="checkbox"/> Pile Bent	<input type="checkbox"/> Column Type	
b. Shape: <input type="checkbox"/> Square <input type="checkbox"/> Rounded <input type="checkbox"/> Sharp Nose			
c. Width: ft.		Length: ft.	
d. Foundation (worst pier)	Dimensions (L,W,D.) (ft)	Embedment (ft)	Scour Exposure (ft)
<input type="checkbox"/> Spread Footing			
<input type="checkbox"/> Pile Cap			
<input type="checkbox"/> Piles			
<input type="checkbox"/> Drilled Shaft			
Source of Data: <input type="checkbox"/> Field Review <input type="checkbox"/> Design Plans <input type="checkbox"/> As-built Drawings <input type="checkbox"/> Pile Driving Records <input type="checkbox"/> Inspection Reports <input type="checkbox"/> Other			
e. Protection			
1) Riprap:	<input type="checkbox"/> Sand Cement	<input type="checkbox"/> Rubble	<input type="checkbox"/> Commercial Block
	<input type="checkbox"/> Seawall	<input type="checkbox"/> None	<input type="checkbox"/> None Apparent
			<input type="checkbox"/> Grouted
			<input type="checkbox"/> Other
2) Condition:	<input type="checkbox"/> Good	<input type="checkbox"/> Fair	<input type="checkbox"/> Poor
7. CHANNEL LATERAL STABILITY			
a. Bends			
1) Bridge Location:	<input type="checkbox"/> Upstream of Bend	<input type="checkbox"/> Downstream of Bend	<input type="checkbox"/> In Bend
2) Migration:	<input type="checkbox"/> Yes	<input type="checkbox"/> No	
3) Countermeasures:	<input type="checkbox"/> Yes	<input type="checkbox"/> No	Type:
b. Bank Condition: Upstream Downstream			
1) Eroding	<input type="checkbox"/>	<input type="checkbox"/>	
2) Stable	<input type="checkbox"/>	<input type="checkbox"/>	
3) Vegetated	<input type="checkbox"/>	<input type="checkbox"/>	
4) Seawall	<input type="checkbox"/>	<input type="checkbox"/>	
5) Countermeasures:	<input type="checkbox"/> Yes	<input type="checkbox"/> No	Type:
c. Angle of Attack: Flood Flow Normal Flow			
d. Point Bar Under Bridge: <input type="checkbox"/> Yes <input type="checkbox"/> No			
e. Islands or Bars			
1) Upstream:	<input type="checkbox"/> Yes	<input type="checkbox"/> No	
2) Downstream:	<input type="checkbox"/> Yes	<input type="checkbox"/> No	

d

FIGURE 1 (continued)

tions, frequent seasonal inspections, or inspections made following storm events or tidal surges).

The basic forms are combined with a single page of text and selected bridge sketches to provide a standardized Phase I report on each bridge. The one-page report summary includes a summary of findings (and recommendations), the basis for the evaluation (discussion), and a listing of the materials and documentation used to develop the report. A bridge location map and plan, profile, and boring logs are also included when they are available. The bridge profile (elevation) includes an as-built streambed cross section (profile) at the bridge and, when they are available, successive cross sections taken by bridge inspectors during the standard biennial bridge inspection under the FHWA NBIS. These successive cross sections are compared with point soundings taken by lead line, pole, or sonic sounder during the Phase I field site visit and constitute a critical component of the Phase I qualitative evaluation. Both long-term aggradation or degradation trends and any recent local scour problems are generally readily apparent from this time-sequenced cross section comparison.

Phase II: Hydrologic and Hydraulic Assessment for Scour

Phase II of the FDOT program is somewhat less structured than Phase I, but it follows the recommended procedures of HEC-20 (4) and HEC-18 (5). In Florida the selection of the hydraulic analysis approach requires consideration of both riverine and tidal flow conditions. Phase II analysis has three basic components: hydrology, hydraulics, and scour computations. The majority of the effort in Phase II is in quantifying the discharge conditions (hydrology) and modeling the corresponding flow conditions at the bridge (hydraulic analysis). Given the hydraulic variables, the scour computations are relatively simple and straightforward. If the hydrologic and hydraulic analyses can be simplified without a significant loss in the accuracy of the scour results, a major cost savings will be realized.

In the interests of economy, then, a simplified riverine or tidal analysis generally is considered first. For riverine flow conditions use of a very conservative estimate of discharge and a simple FHWA WSPRO (6) water surface profile model obtained by using a limited number of cross sections of the stream usually represents the simplest approach to the problem. If these prove inadequate for the complexities of the bridge reach (e.g., complex cross sections, flow bifurcation, multiple openings, or multiple bridge crossings in the reach), then a more complex (detailed) WSPRO model with more refined discharge estimates must be developed or, perhaps,

a two-dimensional hydrodynamic model must be applied.

Similarly, for tidal conditions the simplified procedures presented in HEC-18 (4) (e.g., a tidal prism or constricted waterway approach) are considered first. If these simplified techniques prove inadequate, then more complex (detailed) one- or two-dimensional unsteady flow modeling approaches are used. Regardless of the approach used to develop hydraulic parameters for the bridge reach, the equations presented in HEC-18 (4) are applied to evaluate potential scour conditions. For scour evaluations very conservative assumptions are made to support the simplified analysis techniques for both riverine and tidal conditions. Thus, if a bridge can be shown to be at low risk for scour by the simplified approaches, more complex techniques should not be required. However, if a bridge is rated marginally susceptible for scour by simplified techniques, more complex techniques with less conservative assumptions could refine the evaluation and could possibly result in a lower risk rating. This approach ensures that an appropriate level of effort is applied to support a quantitative scour evaluation, resulting in overall program economy. For both riverine and tidal conditions, the results of a simplified analysis provide a point of departure for a more detailed analysis if one is necessary.

To support the simplified or detailed Phase II quantitative analysis, a standard format has been developed. The Phase II Field/Office Review Report is shown in Figure 2. A standard cover sheet (Figure 1) is used to summarize the scour evaluation and update the analysis from the Phase I rating. This is followed by several pages of text with the following sections:

- 1.0 Summary of Findings
- 2.0 Hydrologic Analysis
- 3.0 Hydraulic Analysis
- 4.0 Scour Analysis
- 5.0 Materials and Documentation

Typically, two figures are included in the summary section: a bridge location map and bridge profile (elevation) showing the 100-year and 500-year scour prism or the scour prism from the overtopping flood, if that puts the most stress on the bridge. Several attachments complete the report:

- Attachment A: Phase II Field/Office Review Report (Figure 2).
- Attachment B: hydrologic calculations,
- Attachment C: WSPRO (or other computer model) input and output files,
- Attachment D: scour calculations, and
- Attachment E: original Phase I Scour Evaluation Report.

SCOUR EVALUATION – PHASE 2 FIELD / OFFICE REVIEW REPORT			
Bridge #:	County:	Route:	Over:
1. SCOUR VULNERABILITY RATING (PER FHWA)			
a. Scour Critical			
Scour Susceptible	<input type="checkbox"/> High	<input type="checkbox"/> Medium	<input type="checkbox"/> Low
Low Risk	<input type="checkbox"/> High	<input type="checkbox"/> Medium	<input type="checkbox"/> Low
Foundations	<input type="checkbox"/> Known	<input type="checkbox"/> Unknown	
b. Method of Analysis	<input type="checkbox"/> Simplified	<input type="checkbox"/> Detailed	
c. Reasons for Rating:			
2. PHASE 1 RATING			
3. FLORIDA DOT SCOUR INDEX NUMBER Initial _____ Secondary _____			
4. RECOMMENDATIONS			
a. Countermeasures			
<input type="checkbox"/> Riprap			
<input type="checkbox"/> Scour Monitor			
<input type="checkbox"/> Inspection			
<input type="checkbox"/> Other			
b. Phase 3 Analysis	<input type="checkbox"/> Required	<input type="checkbox"/> Not Required	
c. Phase 4 Analysis	<input type="checkbox"/> Required	<input type="checkbox"/> Not Required	

a

5. SCOUR IMPACT ASSESSMENT FOR DESIGN FLOOD EVENT	
a.* Reported Design / Constructed Embedment	_____
b.* Current Remaining Embedment	_____
c. Estimated Embedment Remaining After Scour	_____
* Based on 19__ Pile Driving Records	
6. EVALUATION OF METHODS	
a. Method of Analysis	
<input type="checkbox"/> Simplified	<input type="checkbox"/> Detailed
b. Do results of analysis provide reasonable prediction of scour depths for this structure?	
<input type="checkbox"/> Yes	<input type="checkbox"/> No
c. If 6b is NO, perform Detailed Analysis.	
d. If 6b is YES, does the predicted scour suggest instability of structure, based on existing knowledge of the bridge?	
<input type="checkbox"/> Yes (Phase 3 or Phase 4 is recommended)	<input type="checkbox"/> No (No further action required)

b

FIGURE 2 Phase II Field/Office Review Report forms.

7. FLOOD HISTORY

a. Drainage Area _____ sq. mi.

b. Scour Mode: Riverine Tidal Both

c. Riverine Flow

Q₁₀₀ Discharge From:

Gage Analysis Regression Analysis Rational Method Other _____

Q_{OVERTOPPING} Discharge From (____ Yr):

Gage Analysis Regression Analysis Rational Method Other _____

Q₃₀₀ Discharge From:

Gage Analysis Regression Analysis Rational Method Other _____

Q₁₀₀ = _____ cfs Q_{OVERTOPPING} = _____ cfs Q₃₀₀ = _____ cfs

d. Tidal Flow:

Q_{DAILY} Discharge (Tidal Flow) _____ cfs Tide Table HEC 18 Procedure

Q₁₀₀ Discharge (Surge) _____ cfs Historic Data HEC 18 Procedure

Q₃₀₀ Discharge (Surge) _____ cfs Historic Data HEC 18 Procedure

8. CHANNEL STABILITY CONSIDERATIONS

a. Natural Channel Aggradation/Degradation Expected Over Remaining Life of Structure _____ ft

b. Channel Migration Anticipated During Life of Structure Left _____ ft
 Right _____ ft

c. Armoring Potential Yes No

d. Depth to Armoring for Q _____ of cfs _____ ft

e. Discussion:

c

9. DESIGN FLOOD - SCOUR EVENT

a. Worst Case Flood Event (≤ 100 yr): Discharge _____ CFS
 100 yr overtopping Frequency _____ YR

b. Contraction Scour: Left Over Bank _____ FT
Main Channel _____ FT
Right Over Bank _____ FT

c. Maximum Pier Scour Location at: Scour Depth _____ FT
Minimum Remaining Pile Tip / Pier Footing Embedment _____ FT

Worst Pier Typical Pier Maximum Approach Velocity _____ FPS
Pier No: _____ Bent No: _____ Approach Froude Number _____

d. Abutment Scour: Left Abutment _____ FT
Right Abutment _____ FT

e. Maximum Total Scour: (8a + 9b + (9c or 9d)) Left Abutment _____ FT
Main Channel Pier _____ FT
Flood Plain Pier _____ FT
Right Abutment _____ FT

10. CHECK FLOOD - SCOUR EVENT

a. Worst Case Flood Event (\leq yr): Discharge _____ CFS
 500 yr overtopping Frequency _____ YR

b. Contraction Scour: Left Over Bank _____ FT
Main Channel _____ FT
Right Over Bank _____ FT

c. Maximum Pier Scour Location: Scour Depth _____ FT
Minimum Remaining Pile Tip / Pier Footing Embedment _____ FT

Worst Pier Typical Pier Maximum Approach Velocity _____ FPS
Pier No: _____ Bent No: _____ Approach Froude Number _____

d. Abutment Scour: Left Abutment _____ FT
Channel _____ FT
Right Abutment _____ FT

e. Maximum Total Scour: (8a + 10b + (10c or 10d)) Left Abutment _____ FT
Main Channel Pier _____ FT
Flood Plain Pier _____ FT
Right Abutment _____ FT

d

FIGURE 2 (continued)

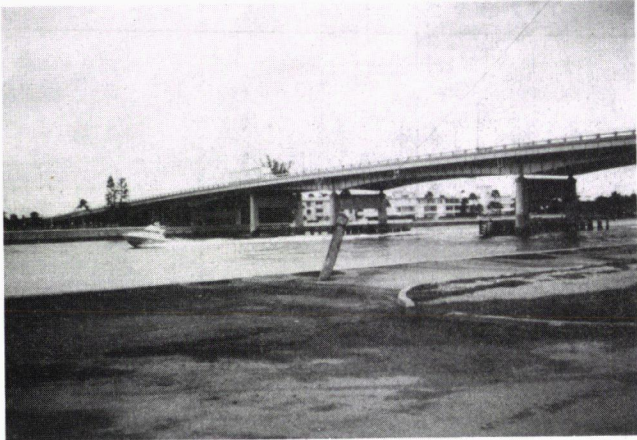


FIGURE 3 Bridge over Baker's Haulover inlet, Biscayne Bay, District 6, FDOT.

The standardized approach to scour evaluations adopted by FDOT for both Phase I and Phase II evaluations will lend itself to development of a statewide database on bridge scour vulnerability.

RESULTS

The Phase I and Phase II procedures outlined above have been applied to scour evaluations of a wide variety of bridges in Florida. These range from large bridges over aggressive tidal inlets (Figure 3) and bascule bridges over the Intracoastal Waterway (Figure 4) or small tidal waterway bridges (Figure 5) to small riverine bridges in rural northeastern Florida (see Figure 6).

FDOT has 7,948 bridges in the inventory, with 4,395 bridges in the federal aid program and 3,553 not in the

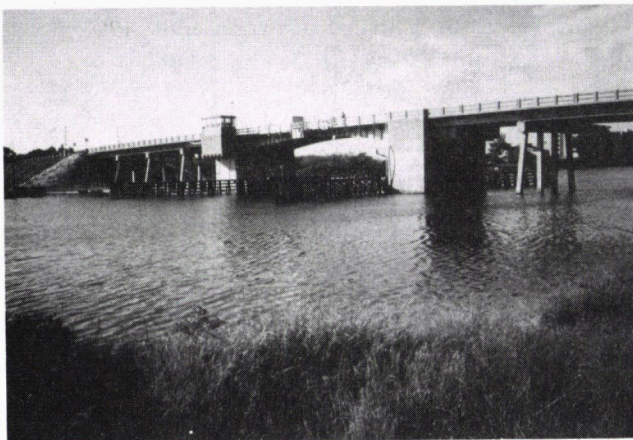


FIGURE 4 Bascule bridge over Intracoastal Waterway, Indian Rocks, District 7, FDOT.

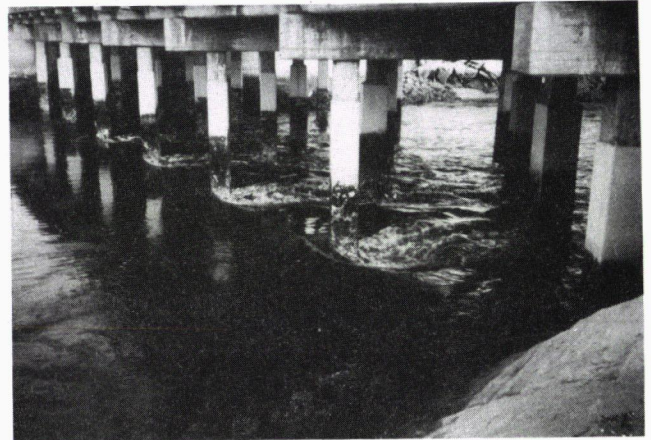


FIGURE 5 Bridge over Shad Creek, just above confluence with St. John's River, Jacksonville, District 2, FDOT.

federal aid program. As of March 1994 preliminary scour screening resulted in the ratings shown in Table 1. Table 2 provides a more detailed summary of results of Phase I scour evaluations for a small population of bridges in District 2 (Lake City/Jacksonville), District 6 (Miami/Florida Keys), and District 7 (Tampa Bay). Thus, a wide range of tidal, riverine, urban, and rural conditions are represented by the bridges in this sample (Figures 3 to 6). It should be noted that these bridges do not represent a random sample. Most districts in FDOT have chosen to focus on bridges that were considered potentially scour susceptible on the basis of a very preliminary screening by FDOT that primarily used office records (Table 1). As would be expected in

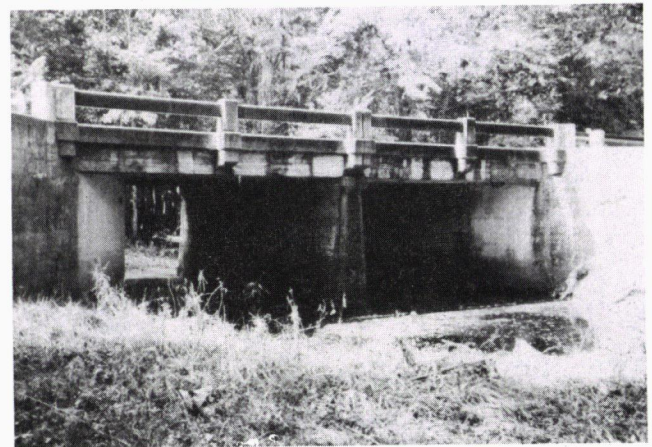


FIGURE 6 U.S. Highway 17 Bridge over Unnamed Tributary to Lofton Creek, Nassau County, District 2, FDOT.

TABLE 1 FDOT Preliminary Bridge Scour Screening

Category	Federal Aid	Non-Federal Aid	Total
Scour-Susceptible	2,377	2,006	4,383
Low Risk	1,539	726	2,265

Florida many of the bridges are tidal or tidally influenced (Table 2). Although no bridges in this small population were scour critical, 61 percent were considered scour susceptible with either a high, a medium, or a low priority, and a Phase II quantitative analysis was recommended for almost all of these bridges. Exceptions were bridges on which remedial actions or replacement planning was under way.

It is significant that 49 percent of the bridges in this group were found to have unknown foundations; that is, after the office and field reviews it was uncertain what the structural foundation condition was or what the pile lengths were for pile-supported foundations. This is not a problem unique to Florida. As of February 1995, of the 481,708 bridges over water in the NBIS, 22 percent had unknown foundations. Consequently, FHWA has removed the requirement for in-depth scour evaluations to be completed by January 1997 for structures except Interstate bridges with unknown foundations (unknown pile tips). The bridges to which this exemption applies are to be monitored until such time as technology becomes available to determine foundation conditions in situ.

CONCLUSIONS

To meet the requirements of FHWA Technical Advisory 5140.23 for bridge scour evaluations, FDOT has adopted a four-phase approach. Although a numerical rating scheme could be developed, Phase I of the FDOT procedure is intended to be a qualitative evaluation based heavily on experience and engineering judgment.

The approach is consistent with FHWA procedures presented in HEC-18 (4) and HEC-20 (5) and provides meaningful results on which to base decisions for monitoring, the use of countermeasures, or replacement for scour-susceptible bridges. Since all FDOT bridges will be evaluated by the procedures highlighted here, a consistent database on bridge scour vulnerability will be developed for all bridges in Florida.

The Phase I forms ensure that numerous qualitative geomorphic factors, related primarily to stream instability concerns, are considered in the evaluation. The Phase I evaluations, including office and field review for each bridge, were estimated to require a level of effort of about 40 hr for an average bridge, and the results of the first group of Phase I evaluations support this estimate.

The approach to Phase II evaluations adopted by FDOT, which considers, first, a simplified tidal or riverine scour analysis before proceeding to more detailed or complex computational techniques, should result in significant cost savings for the statewide scour evaluation program. As of this writing, simplified techniques have been satisfactory for most of the bridges requiring a Phase II scour analysis.

REFERENCES

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TABLE 2 Phase I Scour Evaluation Results for 330 Bridges in Florida

	Riverine	Tidal	Riverine/ Tidal	Total	Scour Critical	Scour Susceptible	Low Risk	Known Foundation	Unknown Foundation	Phase II Recommended
District 2 (Lake City/ Jacksonville)	76	34	14	124	0	70	54	72	52	70
District 6 (Miami/ Florida Keys)	0	27	4	31	0	28	3	4	27	28
District 7 (Tampa Bay)	73	71	31	175	0	102	73	92	83	102
Total	149	132	49	330	0	200	130	168	162	200
Percent (%)	45	40	15			61	39	51	49	61

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