San Jacinto River Waste Pits Superfund Site

Comments
of
International Paper Company
and
McGinnes Industrial Maintenance Corporation
on
Environmental Protection Agency Region 6
Proposed Remedial Action Plan

Appendix D

Examination of Selected Assertions by U.S. EPA in the Proposed Plan San Jacinto River Waste Pits Superfund Site
by
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1 Introduction

I have been engaged to provide comments on selected assertions within the Proposed Remedial Action Plan (PRAP, U.S. EPA 2016a) for the San Jacinto Waste Pits Superfund Site (Site). Site characteristics and history are described elsewhere (U.S. EPA 2016a, 2016b and Hayter et al. 2016). The PRAP assertions examined here deal with fluvial and coastal erosion processes along the reach of the San Jacinto River, in particular, the area containing the impoundments located north of Interstate 10 (Northern Impoundments) and the impoundment located on the peninsula south of Interstate 10 (South Impoundment). Figures are provided at the end of this document, and my resume of my qualifications is included as an appendix. Each of the selected assertions from the PRAP is set out below, followed by an evaluation of that assertion.

2 EPA Assertion #1. The San Jacinto River is a very dynamic system..... A series of aerial photographs illustrate this variability[1].

The photo sequence cited to support this assertion is presented without quantitative analysis. No mention is made of rectification or registration, and no allowance is made for varying water levels[2]. Standard techniques for analyzing aerial and satellite imagery involve georeferencing the images to obtain consistent frames of reference and remove distortions so that errors in measuring distances (and thus errors in measuring morphologic changes) are reduced. In a water body such as that surrounding the Site, water level variation can produce large changes in water surface area because of the extremely flat topography along some parts of the channel. Furthermore, there is no attempt made by Region 6 to disaggregate the effects of subsidence, erosion and dredging (which are discussed below) on channel morphology.

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[1] Text of the PRAP continues, "An aerial photograph taken in 1956 (Figure 3), before the waste pits were established, shows I-10 crossing the river and extensive islands and land to the north. The next photograph, from 1966 (Figure 4), shows the northern pits located just west of the I-10 Bridge (the pits were built and in operation in the mid–1960s); significant changes to the north can be seen compared to the 1956 photograph. Land erosion and subsidence is evident in the next photograph from 1973 (Figure 5); there is a new passage to the west of the Northern Impoundments since the 1966 photograph. Photographs in the 1990's and later (Figure 6) show continued loss of land."

[2] Normal tidal variation at the Site is about 1 to 2 feet (ft); stage changes associated with high flows are much greater. The range of stages observed over the last 20 years for the San Jacinto River at Sheldon (several miles upstream) is about 7 ft. Record stage at the Sheldon gage is about 33 ft above low stage.

By definition, the expression, "very dynamic," suggests that the river is "characterized by constant change or activity." My review of the aerial photo record and available topographic survey maps, summarized below, suggests that the main channel of the river channel is stable with respect to the fluvial processes[3] of lateral migration and avulsion and therefore cannot be characterized as “very dynamic.”

Lateral migration refers to the movement of meanders across a floodplain. This process usually involves erosion of the outside (concave bankline) of bends and deposition on the inside or opposite banks. Avulsion, an entirely different process, refers to the diversion of the entire river or a large fraction of the river through a newly eroded channel across the floodplain. Frequently, avulsions occur across the necks of meander bends. During a high flow, floodwaters follow a more direct route straight down the river valley than passing around a bend, triggering erosion of a new channel that captures flow and becomes the new river channel even after the flood recedes.

Lateral migration may be rapid or gradual, while avulsions are normally rapid, occurring during a single flood event. Meandering rivers may be classified as stable or actively meandering based on the rate and magnitude of change (Lagasse et al. 2004). Stable meandering channels do not migrate appreciably over many decades because they have insufficient stream power to erode their banks. These kinds of channels are also referred to as "moribund" (Thorne et al. 1996). An actively meandering channel has sufficient energy to deform its channel boundaries through bed scour, bank erosion and point bar growth. It is important to note that the term, “meandering,” as used here refers only to the river planform and not its dynamism, stability, rate of lateral migration or to the process of meander formation and migration. Rivers may be classified based on their planform as straight, meandering, braided or anastomosing (Thorne et al. 1997). Typically, any river with a single-thread channel and a sinuosity greater than about 1.5 is classified as meandering, although some writers set the threshold as low as 1.25.

Lagasse et al. (2004) present a classification scheme for rivers partially based on earlier work by Brice (1975), which is based on planform, width variation, and sandbar patterns. Meandering channels may be classified based on sinuosity, planform (single thread, braided, or anastomosed) and other morphologic characteristics. The Lagasse scheme was developed to assist engineers in evaluating the stability of river channels and assessing the risk posed to transportation infrastructure (roadways, railroads, bridges, etc.) by channel erosion processes such as lateral migration, avulsion and bank erosion.

In order to allow for the preliminary study of the San Jacinto River morphology and related processes required to prepare this report, a web-based GIS was produced using historical maps and aerial photographs as layers. All layers were georeferenced to a common coordinate

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[3] The term “fluvial processes” used herein refers to the transport of water and sediment by river currents, waves and tides. These processes have the potential to modify beds and banks of channels and estuaries. Fluvial processes are distinct from impacts of human activities such as mining, channel dredging and regional or global sea level rise.

system, and all aerial photo coverages were orthorectified. More in-depth analysis of this information would include assessing effects of water level variation, major hydrologic events and cultural activities between coverages, and quantitative measurement of areas and distances comprising key morphologic features.

Lake Houston was impounded in 1953, and major effects of subsidence and dredging were manifest at the Site after about 1960. Based on pre-1960 maps and aerial photographs, the San Jacinto River between the Lake Houston dam site and the Buffalo Bayou confluence (located about 2.3 miles down river from the I-10 crossing) may be classified using the Lagasse et al. (2004) scheme as a type B1, single-phase meandering equiwidth channel (sinuosity = 1.54, width nearly constant, bars almost absent, minimal braiding). This type of meandering channel is characterized by static or stable conditions and low rates of lateral migration in contrast to actively meandering channels. Figure 1 graphically depicts the stability of the entire reach, with almost no variation in channel planform, width or position between 1916 and 1955 (The 1920 USGS topographic map was based on 1916 survey data). The static position of concave banklines (outsides of bends) is particularly striking. Both maps show that floodplain land bordering the convex (insides of bends) are nearly level and low-lying. Aerial photos of the reach from 1944 and 1953 (Figure 2) and of the Site itself from 1953, 1964 and 1966 (Figure 3) suggest that these areas were lightly vegetated wetlands or tidal flats. The 1920 topographic map has contour intervals of 1 ft and shows the top of the bluff at Lynchburg on the Crosby Road has an elevation of 35-40 ft above mean sea level (MSL). The water surface elevation depicted on this map in the same vicinity appears to be about 2 ft above MSL. Although the datum for these two early maps is uncertain, it is worth noting that land surface elevations on the 1955 map are similar to the 1920 map.

By the mid-1960s, change is apparent in the water surface area of the reach of the San Jacinto River between Banana Bend Oxbow and the Northern Impoundments (Figure 4). At the Northern Impoundments themselves, the concave (eastern) side of the bend, normally the location of bank erosion in an actively migrating meander, remained in the same location as in 1916. However, the water area on the opposite (western) side of the channel expanded. The main channel position remained stable, but water area expanded due to dredging and subsidence. Although the overall natural form of the channel was masked by the effects of human activities (dredging and subsidence), the channel remained stable with respect to fluvial processes. The main channel has not changed course. The observed morphologic changes in the reach of the river containing the Northern Impoundments and Southern Impoundment were apparently not due to dynamic fluvial processes but to dredging and subsidence. For example, the location of the channel thalweg[4] and the relatively high elevation (shallow water) along the convex (western) side of the channel (point bar) are still obvious despite expansion of water width (Figure 5).

Despite the effects of land subsidence, in-channel and floodplain sand mining and other anthropogenic impacts, the overall stability of the San Jacinto River alignment over the last

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[4] Thalweg is defined as a curve connecting the lowest points of successive cross-sections along the course of a river.

century is remarkable. The 1920 USGS map, based on a 1916 survey, is shown along the 2014 National Agriculture Imagery Program coverage in Figure 6. A trace of the water's edge from the 2014 image is superimposed on the 1920 map in Figure 7. Although low-lying bar and tidal flat surfaces have been flooded due to land subsidence, the coincidence of the higher banklines is noteworthy. Similar overlay of banklines from 1953 aerial photography on the 2014 image is presented in Figure 8, and high banklines again coincide.

Dredging. Dredge cuts in this area are apparent in aerial photographs from the mid-1960s as arcuate shorelines (e.g., Figure 3). US EPA (2016b) notes, "Dredging and sand mining by others within the river and marsh to the west and northwest of the waste pits through the 1990s and early 2000s ….. Historical documents indicate that dredging actions also occurred in the river in the vicinity of the upland sand separation area located to the west of the Northern Impoundments (sand separation area)….."

Subsidence. A region of major subsidence is centered on the Site. Historical subsidence of up to 10 ft between 1906 and 1979 in the vicinity of the Site has been reported by the Harris Galveston Subsidence District, Bawden et al. (2012), Dellapenna (2016) and Al Mukaimi et al. (in preparation). Maps provided by the Harris Galveston Subsidence District show that both the Northern and Southern Impoundment areas subsided 8 to 9 ft between 1906 and 2000 (Figure 9). Subsidence at the Site is evident when the 1920 and 1967 topographic maps are compared, assuming the datums (given as MSL for both maps) are compatible. Examination of the 1920 and 1955 topographic survey maps indicate that the low lying lands that were submerged prior to the 1967 survey and the 1977 photo shown in Figure 2 were less than 10 ft above MSL, and thus subject to inundation due to this much subsidence. Data describing recent subsidence in the vicinity of the Site (e.g., Harris Galveston Subsidence District) show little subsidence since 2007, and about a foot of subsidence since 1973. Kearns et al. (2015) found that subsidence in the southeastern region of the Houston metropolitan area has nearly ceased, with rates < 3 mm/yr for 2005-2012. In fact, slight land rebound has been observed at some sites along the Houston Ship Channel since 2005. Subsidence has been arrested by institutional controls on groundwater extraction are in place at the regional scale and that are entirely independent of decisions or actions related to the Site. Typical charts of subsidence data for monitoring instruments in the vicinity of the Site are presented in Figure 10 and additional data are available at http://hgsubsidence.org/subsidence-data/.

In conclusion, the assertion that the aerial photograph record indicates that the river is "very dynamic" is flawed because it makes no distinction between morphologic effects due to land subsidence processes (which have virtually ceased), dredging and sand mining (now restricted in the river reach containing the Northern and Southern Impoundments (Coleman (2009)), and the effects of fluvial processes. With respect to fluvial processes, the evidence from maps and aerial photographs suggests a very stable type of river, and the historical behavior of the channel over the last century is consistent with the hypothesis that the San Jacinto River behaves in a very stable, near-static fashion as do other rivers with similar morphology.

3 EPA Assertion #2. The San Jacinto River is a very dynamic system, <u>subject to changes in size</u>

and flow paths as experienced during the 1994 storm[5].

Please note that the above response to Assertion # 1 addressed the comment that the aerial photograph record shows that the river is “very dynamic.” Below we address the assertion that the river in the vicinity of the Site is susceptible to changes such as those observed during the 1994 flood event. Assessment of river behavior for sites such as this one should be done using standard protocols and tools (e.g., Thorne et al. 1997, Hayter et al. 2014). The PRAP (EPA 2016a) extrapolation of rates of channel change from upstream reaches (i.e., Banana Bend and Banana Bend oxbow as described by National Transportation Safety Board (1996)) to the reach immediately adjacent to the Northern Impoundments is not supported by evidence or logic, as outlined below.

San Jacinto River reaches upstream from the Site are more fluvial and less subject to hydraulic control by sea level than the reach extending downstream from the Site to Galveston Bay. In general, the channel upstream from the Site is narrower and more sinuous than for the reach extending downstream from the Northern and Southern Impoundments. These upstream areas also have experienced different levels of impact due to operation of Lake Houston, floodplain sand mining, and subsidence. Downstream morphologic effects of dams and the reservoirs they create diminish with distance below the dam (Graf 2006). Floodplain sand mining impacts at the upstream sites were significant enough to produce erosion of high flow channels across meander necks, but similar channel activity did not occur in the meander bend adjacent to the Northern and Southern Impoundments. Observed historical subsidence also diminishes as one moves upstream from the Site (Figure 9). In short, the channel changes upstream from the Site during the 1994 flood that were described in the PRAP and by NTSB (1996) reflected different conditions than those at the Site. In the absence of these conditions (narrower, more sinuous channel; more fluvial conditions; less subsidence; more floodplain sand mining; closer to Lake Houston dam), we should not expect similar channel behavior in the river reach adjacent to the Northern and Southern Impoundments as was observed upstream in 1994.

The observed 1994 flood behavior at Banana Bend Oxbow and Banana Bend may be regarded as an avulsion in distinction to the more gradual process of lateral channel migration associated with erosion of the outsides of meander bends. However, it is more properly termed, “floodplain erosion,” or “erosion of high flow channels,” since the floodplain erosion was not extensive enough to capture river flow at stages lower than flood stage. The location of the Banana Bend

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[5] The text of the PRAP continues, “The 1994 flooding caused major soil erosion and created water channels outside of the San Jacinto River bed. This flooding caused…….new channels created in the flood plain outside of the San Jacinto River boundaries. The largest new channel was cut through the Banana Bend oxbow just west of the Rio Villa Park subdivision, about 2½ miles northwest of the Site. This new channel was approximately 510-feet wide and 15-feet deep. A second major channel cut through Banana Bend just north of the channel through the Oxbow. Both of these new channels were cut through areas where sand mining had been done before, as is the case in the vicinity of the Site.”

Oxbow floodplain erosion that occurred in the 1994 flood event (Figure 11) was coincident with the location of sand mining on a meander neck. The location of the sand mine was highly conducive to floodplain erosion during a flood because it presented floodwaters with a slope advantage of 8.8 (= 19,086 ft/2,168 ft = length of flow path around bend divided by distance across meander neck). Almost the entire path taken by the eroding floodwaters had been excavated prior to the flood. The area disturbed by sand mining on the 1989 Google Earth coverage of this site occupies 1,938 ft of the 2,168 ft-long-path eroded across the meander neck in 1994. In the case of Banana Bend (Figure 12), the location of the high flow channel that eroded through the floodplain just east of the River channel during the 1994 flood was also coincident with extensive floodplain sand mining. Institutional controls are available to restrict activities such as floodplain sand mining (US EPA 2016b). For example, the USACE 403(b) permitting process can be used to limit sand mining in the San Jacinto River,[6] and additional restrictions have been placed on permitted activities in the reach containing the Northern and Southern Impoundments under Clean Water Act Section 404 and Rivers and Harbors Act Section 10 (Coleman 2009).

Logically, fluvial erosion that might impact the Northern or Southern Impoundments or any specific area along any river could occur in three locations: distant from the area, adjacent to the area, and through the area.

- Erosion distant from the area (e.g., erosion of a high flow path or avulsion of the main channel that created an alternate route for the channel) would reduce hydraulic loading and erosion potential at the Site itself.
- Erosion alongside the area (e.g., river erosion immediately adjacent to one of the Impoundments) might pose a hazard of undermining protection structures such as an armored cap (Northern Impoundments) or existing industrial structures and soil overburden (Southern Impoundment). In the case of the Northern Impoundments this risk could be quantified using simulation models and addressed by cap design features such as more gradual side slopes or reinforced toe sections sized with appropriate factors of safety as proposed by Alternative 3aN of the PRAP. In the case of the Southern Impoundment, undermining of the Impoundment due to local scour along its margins would require realignment of river flow under the I-10 bridges and then removal by erosion of much of the peninsula containing the Southern Impoundment and structures now on the peninsula. This type of major flow realignment is unlikely in light of the fact that the channel alignment has been stable for the past century. Furthermore, undermining scour along the margins of the Southern Impoundment would undermine the considerable volume of soil overlying

[6] Hayter et al. (2016), notes: "A TxDOT Agreement was put into place during TCRA construction in which TxDOT is required to receive a three-day notice before commencement of construction activities, and requires TxDOT to be provided notice should any future construction disturb sediments in the San Jacinto River…"

the Southern Impoundment[7] and this material would then slump into the scour, retarding its progress.

- The risk of erosion through the Site has been assessed by simulation models (Hayter et al. 2016, AQEA 2012) and, in the case of the Northern Impoundments, may be addressed by protective measures (armored cap) sized with appropriate safety factors also as proposed by Alternative 3aN. The risk of erosion through the Southern Impoundment could be assessed by the same simulation studies.

4 EPA Assertion #3. Sonar tests in a 130-foot section south of the I-10 Bridge located adjacent to the Site found about 10 to 12-feet of erosion from the bottom of the river bed.

Channel scour downstream from bridges (such as that observed downstream of the I-10 bridge as a result of the 1994 flood) or other hard structures is not indicative of scour processes that will be operative at the Northern impoundments in the future, unless a bridge is built immediately upstream. Sonar examinations of the riverbed in the vicinity of the Interstate 10 crossing after the 1994 flood are described by NTSB (1996): "The Texas Department of Transportation evaluated the extent of scour around the substructure of critical sections of the two Interstate 10 bridges (east- and west-bound). The results of the sonar tests performed on October 21–22, 1994, documented 12 locations in the main channel for distances up to 130 feet south of the east-bound Interstate 10 bridge."

During this extreme event, scour was limited to a region in the main channel 130 ft south (downstream) from the east-bound bridge. Scour was not reported upstream from the crossing, between the bridges or outside the main channel. The Northern and Southern Impoundments were not scoured during the 1994 flood, despite the 10-12 ft of scour in the main channel downstream from the bridge and the fact that the Northern Impoundments were not capped at the time.

The peninsula containing the Southern Impoundment is immediately downstream from the Interstate 10 crossing, but it would be impacted by bridge scour only in the event of a major realignment of the San Jacinto River main channel. As noted above, that channel has been stable and nearly static for a century and exhibits characteristics similar to stable rivers found elsewhere. Such a major realignment would be highly unlikely.

5 EPA Assertion #4. These changes (i.e., loss of land at the waste pits site due to erosion and subsidence) will likely continue in the future.

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[7] Soil borings into the Southern Impoundment indicate dioxin and furans associated with paper mill wastes are buried by a layer of soils about 4 to 5 ft thick. One boring found TEQ above background within 1 ft of the surface. In other cases, the overburden had TEQ at or below background.

As noted above, the major driver of historical land loss at the Site was subsidence, which has been arrested by institutional controls such as those on groundwater extraction. Additional historical land loss was due to sand mining and in-channel dredging, which are now also restricted or banned in this area. It follows that land loss due to these factors should not continue in the future unless the driving factors are re-activated. At any rate, scientific data and tools are available to quantify risk regarding future morphologic changes impacting the Site (Hayter et al. 2014).

6 EPA Assertion #5. Corps (Hayter et al. 2016) models (and any existing sediment transport model) cannot simulate river channel changes due to bank erosion, shoreline breaches, etc. during a high flow event caused by a major flood or hurricane. Therefore, the model predictions should be considered as having a very limited long-term reliability.

Models are developed to evaluate specific situations or answer specific questions. Models themselves do not represent predictions; however, interpretations of model output can be used to predict future outcomes. Models can also be used to simulate a hypothetical scenario in order to evaluate a possible future state. Model uncertainty can be evaluated and quantified.

As noted in the PRAP, the Corps' hydrodynamic simulation model (Hayter et al. 2016) does not predict lateral movement or avulsion of the channel. Accordingly, the 2D hydrodynamic models (Hayter et al. 2016, AQEA 2012) have not been used to evaluate potential larger scale river processes such as localized bank erosion, channel migration, or avulsion. To date, the models have been used to answer specific questions related to conditions directly adjacent to the cap.

However, notwithstanding their limitations, these and similar models can quantify shear stresses impinging on the Northern and Southern Impoundments under "worst-case" extreme events (or more frequent) events. Evaluation of these stresses in light of critical stresses needed to erode the channel boundaries and floodplains can give an indication of the potential for channel migration or avulsion to initiate. Such an evaluation should consider reaches up- and downstream from the Site. In fact, models developed by Hayter et al. (2016) in support of the PRAP might have been used to perform such an analysis if they captured stresses on the floodplain during overbank flow conditions. However, the work plan presented by Hayter et al. (2016), requested by the EPA, did not include this task.

The current version of HEC RAS 5.0 includes the USDA-ARS Bank Stability and Toe Erosion Model (BSTEM). Although it cannot simulate large-scale channel change, it can simulate bank erosion. This model could have been used to examine bank erosion rates and erosion potential under various scenarios. Recently-developed, "morphodynamic" simulation models (e.g., Langendoen et al. 2015 and 2016) simulate lateral channel migration and predict future channel alignments. Thus, contrary to EPA's assertion, simulation of avulsions (cutoffs) and subsequent channel response would have been possible.

7 EPA Assertion #6. Future storm intensity and flooding may be even more intense due to climate change, sea level rise, and continued urban development.

Greater submergence due to sea level rise may further reduce hydraulic loads during the most extreme events. The Northern Impoundments' location just upstream of the I-10 crossing and rising sea level will place it under backwater conditions and in a depositional rather than erosional environment for the most extreme events. In fact, considering a wide range of events, the Site is already depositional. Hayter et al. (2016) found that net average long-term sedimentation rate averaged over the area of the existing cap is 1.3 cm/yr. ± 0.8 cm/yr. Similar findings were reported by AQEA (2012).

It is assumed that as additional information becomes available about storm intensity and hydraulic loadings under future climate and sea level scenarios, these data could provide a basis for quantitative analysis. If appropriate engineering analyses indicate potential for unacceptable hydraulic loading on the Impoundments or river channel movement over the period of interest, there are structural measures (river training structures such as groins, spurs, jetties, revetments or bank protection structures) that could be designed, in accordance with standard guidance and with appropriate factors of safety, to address such conditions.

8 References

Al Mukaimi, M.E., Dellapenna, T.M. and Williams, J.R. 2016. Impacts of enhanced land subsidence on Galveston Bay, Texas: Has sedimentation kept pace and what are the future implications under a regime of elevated sea level rise? Texas A & M University Department of Oceanography. Draft manuscript.

AQEA, 2012. Chemical Fate and Transport Modeling Report, San Jacinto Waste Pits Superfund Site. Prepared for U.S. Environmental Protection Agency, Region 6, on behalf of McGinnes Industrial Maintenance Corporation and International Paper Company. Anchor QEA, Ocean Springs, MS.

Bawden, G.W., Johnson, M.R., Kasmarek, M.C., Brandt, Justin, and Middleton, C.S. 2012. Investigation of land subsidence in the Houston-Galveston region of Texas by using the Global Positioning System and interferometric synthetic aperture radar, 1993–2000: U.S. Geological Survey Scientific Investigations Report 2012–5211.

Brice, J.C. 1975. Air Photo Interpretation of the Form and Behavior of Alluvial Rivers, final report to the U.S. Army Research Office, Washington, DC.

Coleman, S. 2009. San Jacinto River Waste Pits Superfund Site, Harris County, Texas. Letter to Colonel David C. Weston, District Engineer, U.S. Army Corps of Engineers, Galveston. Director, Superfund Division, U.S. Environmental Protection Agency, Region 6, Dallas, Texas.

Dellapenna, T. 2016. Elevated anthropogenically driven subsidence rates within Galveston Bay provides an opportunity to determine if sedimentation within a coastal plain estuary keeps pace with rapid subsidence. Abstract from Geological Society of America Abstracts with Programs 48, 1.

Graf, W. L. 2006. Downstream Hydrologic and Geomorphic Effects of Large Dams on American Rivers. Geomorphology 79(3-4), 336-360.

Hayter, E., Gustavson, K., Ells, S., Gailani, J., Wolfe, J., Dekker, T. and Redder, T. 2014. Technical Guidelines on Performing a Sediment Erosion and Deposition Assessment (SEDA) at Superfund Sites. ERDC TR-14-9. Prepared for the U.S. Army Corps of Engineers. Washington, D.C.

Hayter, E., Schroeder, P., Rogers, N., Baily, S., Channell, M. and Lin, L. 2016. Evaluation of the San Jacinto Waste Pits Feasibility Study Remediation Alternatives. ERDC Letter Report. U.S. Army Corps of Engineers. Engineer Research and Development Center. Vicksburg, MS.

Kearns, T.J., Wang, G., Bao, Y., Jiang, J. and Lee, D. 2015. Current Land Subsidence and Groundwater Level Changes in Houston Metropolitan Area (2005-2012). Journal of Surveying Engineering. Published online.

Kunkel, K.E, L.E. Stevens, S.E. Stevens, L. Sun, E. Janssen, D. Wuebbles, M.C. Kruk, D.P. Thomas,

Lagasse, P.F., Zevenbergen, L.W., Spitz, W.J. and Thorne, C.R. 2004. Methodology for

Predicting Channel Migration. NCHRP Report 533. Prepared for National Cooperative Highway Research Program. Transportation Research Board of National Academies. Washington, D.C.

Langendoen, E.J., Mendoza, A., Abad, J.D., Tassi, P., Wang, D., Ata, R., Abderrezzak, K.E. K. and Hervouet, J.M. 2016. Improved numerical modeling of morphodynamics of rivers with steep banks. Advances in Water Resources 93, 4-14.

Langendoen, E.J., Motta, D., Abad, J.D., Garcia, M.H., Fernandez, R., Oberg, N. 2015. RVR meander - a toolbox for river meander planform design and evaluation. 3rd Joint Federal Interagency Sedimentation Conference Proceedings. April 19-23, 2015, Reno, NV, pp. 1823-1830.

National Transportation Safety Board. 1996. Evaluation of Pipeline Failures During Flooding and of Spill Response Actions, San Jacinto River near Houston, Texas, October 1994. Notation 6734. National Transportation Safety Board. Washington, D.C.

Thorne, C. R., R. G. Allen, and A. Simon. 1996. Geomorphological River Channel Reconnaissance for River Analysis, Engineering and Management. Transactions of the Institute of British Geographers, 469-483.

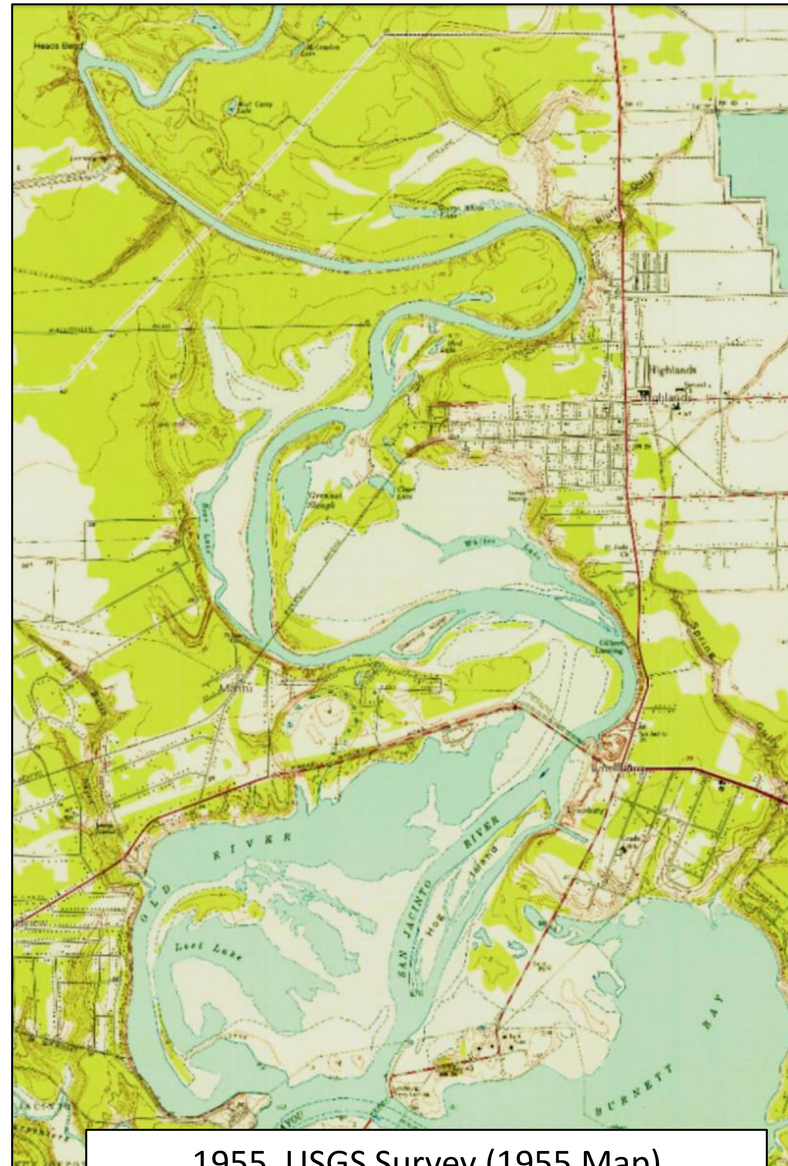
Thorne, C.R., Hey, R.D. and Newson, M.D. 1997. Applied Fluvial Geomorphology for River Engineering and Management. John Wiley and Sons. West Sussex, England.

U.S. EPA. 2016a. Environmental Protection Agency Region 6 Announces Proposed Plan. San Jacinto River Waste Pits Site, Harris County, Texas, September 2016. Washington, D.C.

U.S. EPA. 2016b. Final Interim Feasibility Study Report. San Jacinto River Waste Pits Superfund Site. United States Environmental Protection Agency. Washington, D.C.

Figure 1. Side-by-side comparison of 1916 and 1955 topography surrounding San Jacinto River, Texas.

1916 USGS Survey (1920 Map)



1955 USGS Survey (1955 Map)

Figure 2. Side-by-side comparison of Google Earth aerial photo coverage of San Jacinto River, Texas between Lake Houston Dam site and Burnett Bay (a) dated December 31, 1943 (listed as 1944), and (b) December 31, 1952 (listed as 1953). Red curve on photos is channel centerline from 1995 USGS topographic map.

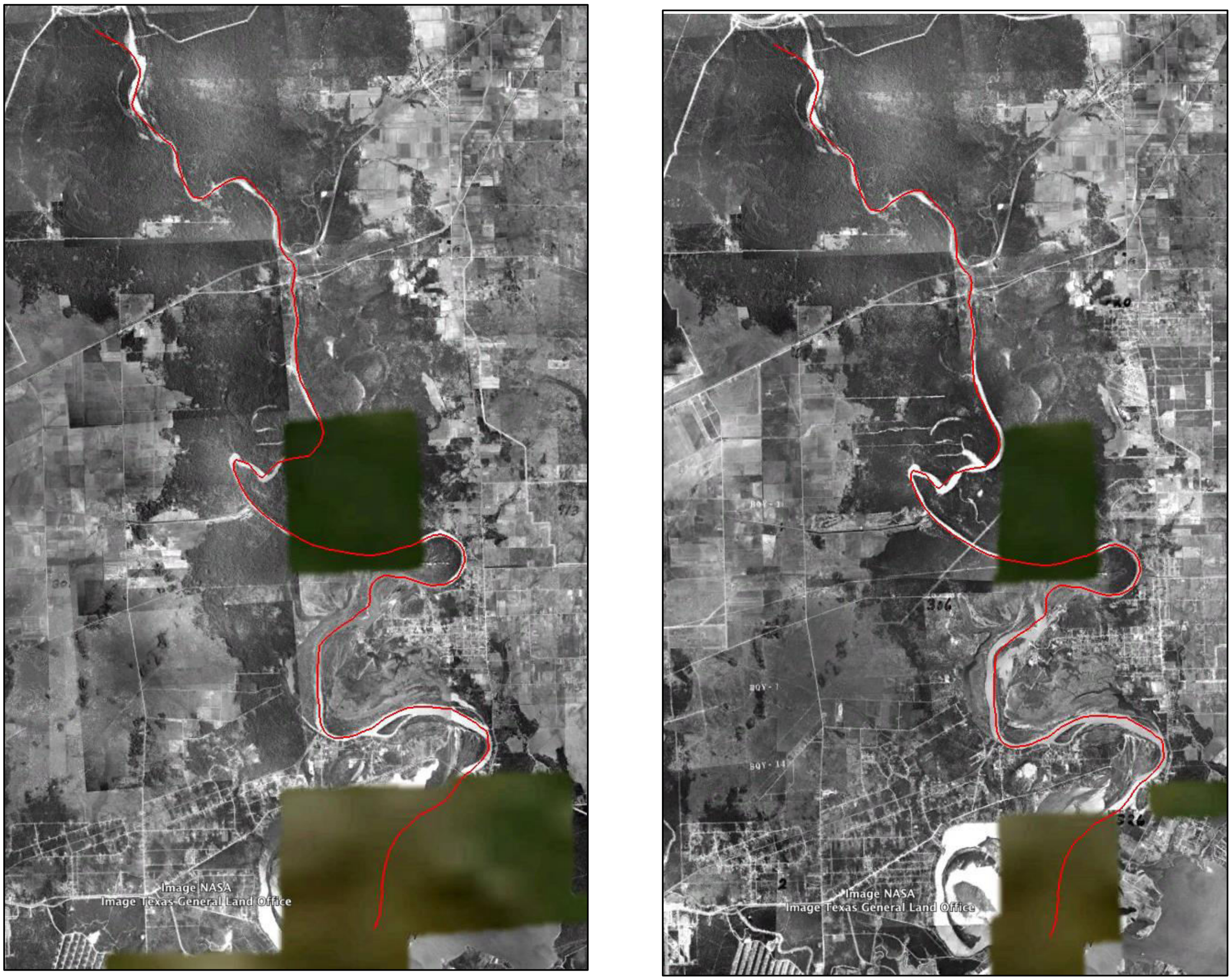


Figure 3. Aerial photograph of waste pits site dated (a)dated October 10-28, 1953, (b) October 7-15, 1964, and (c) October 16, 1966. Photos a and b from National Environmental Title Research, historicaerials.com. Photo c from Figure 4 of PRAP (US EPA 2016a).

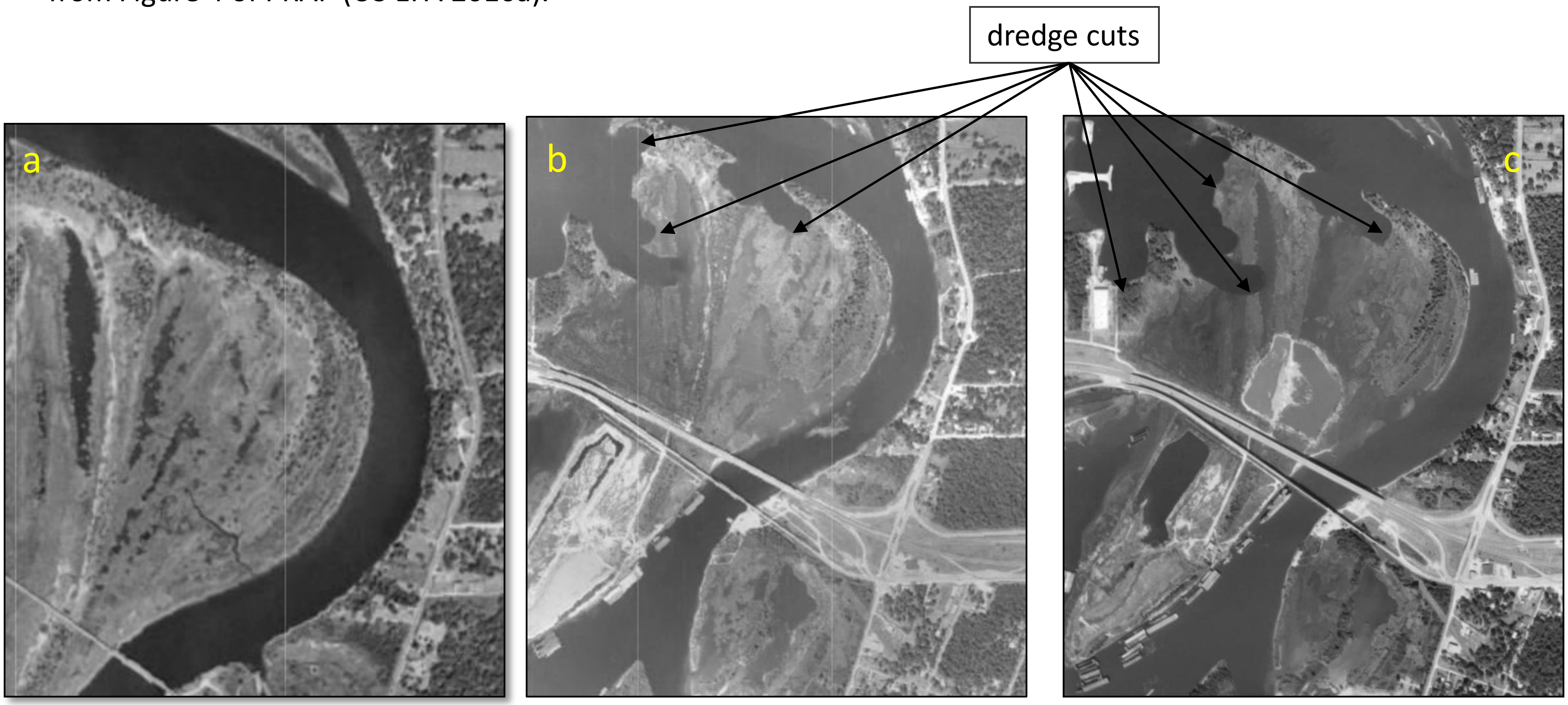
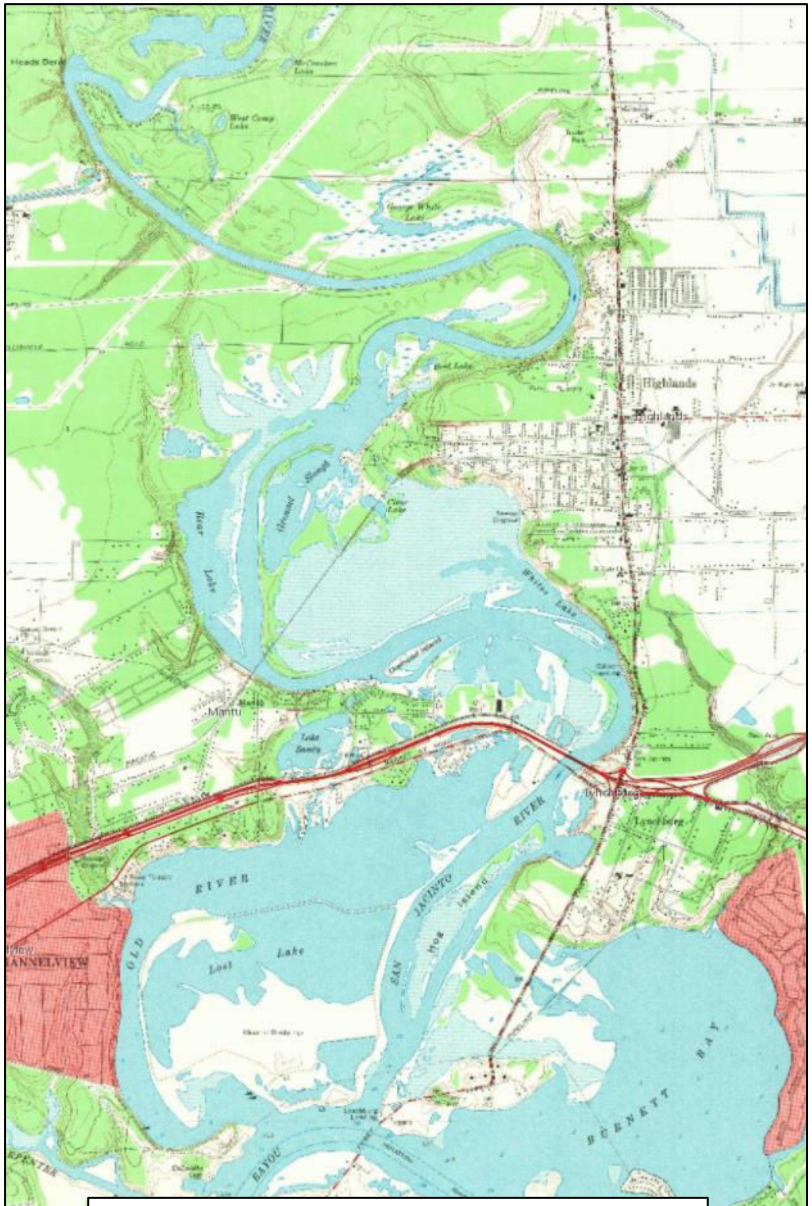
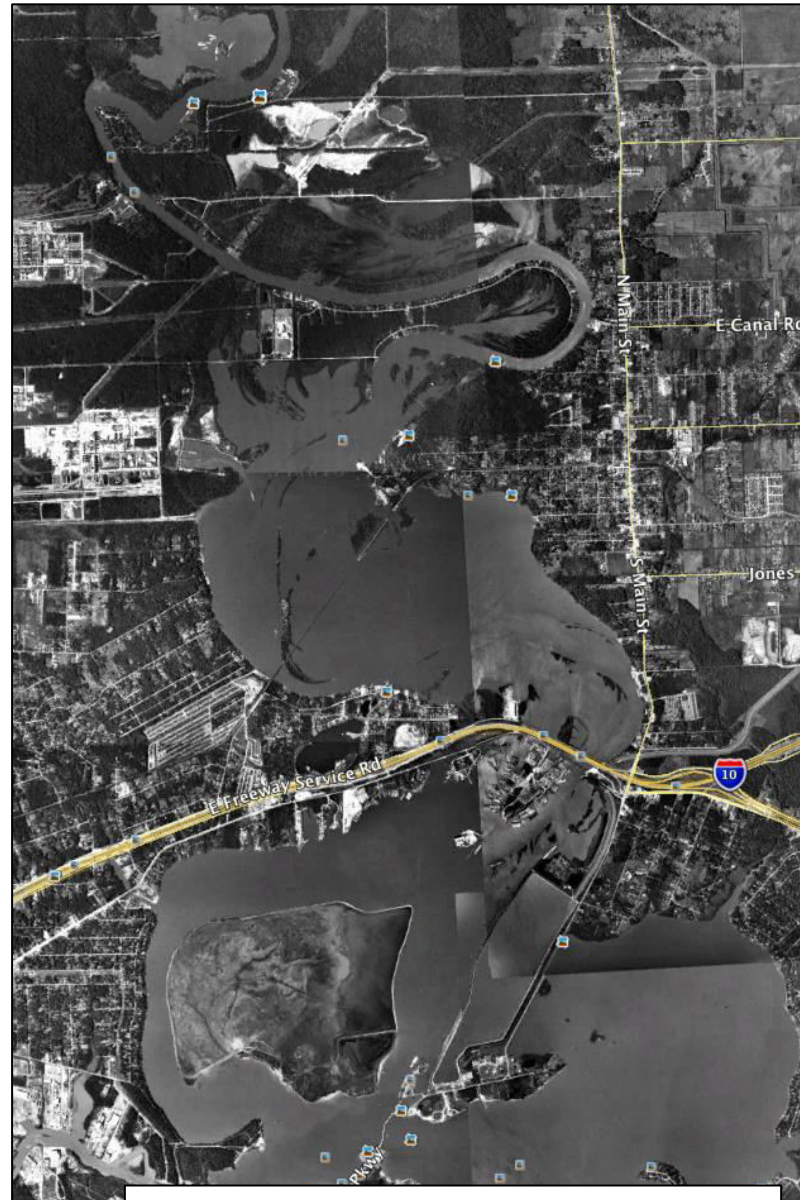


Figure 4. Side-by-side comparison of 1967 map and 1977 aerial photography of San Jacinto River, Texas.



1966-67 USGS Survey (1967 Map)



1977 Aerial photography (Google Earth)

Figure 5. (a) Transparency of October 16, 2014 aerial photo (NAIP) of Site overlaying 1920 USGS topographic map. Note tow moving downstream along 1916 thalweg in 2014 photo while just to the south barges are parked in shallows above the 1916 bar (black box).(b) Interpolated surface map of combined 2009 and 2010 bathymetric surveys inside the USEPA Preliminary Site Perimeter (from AQEA 2012).

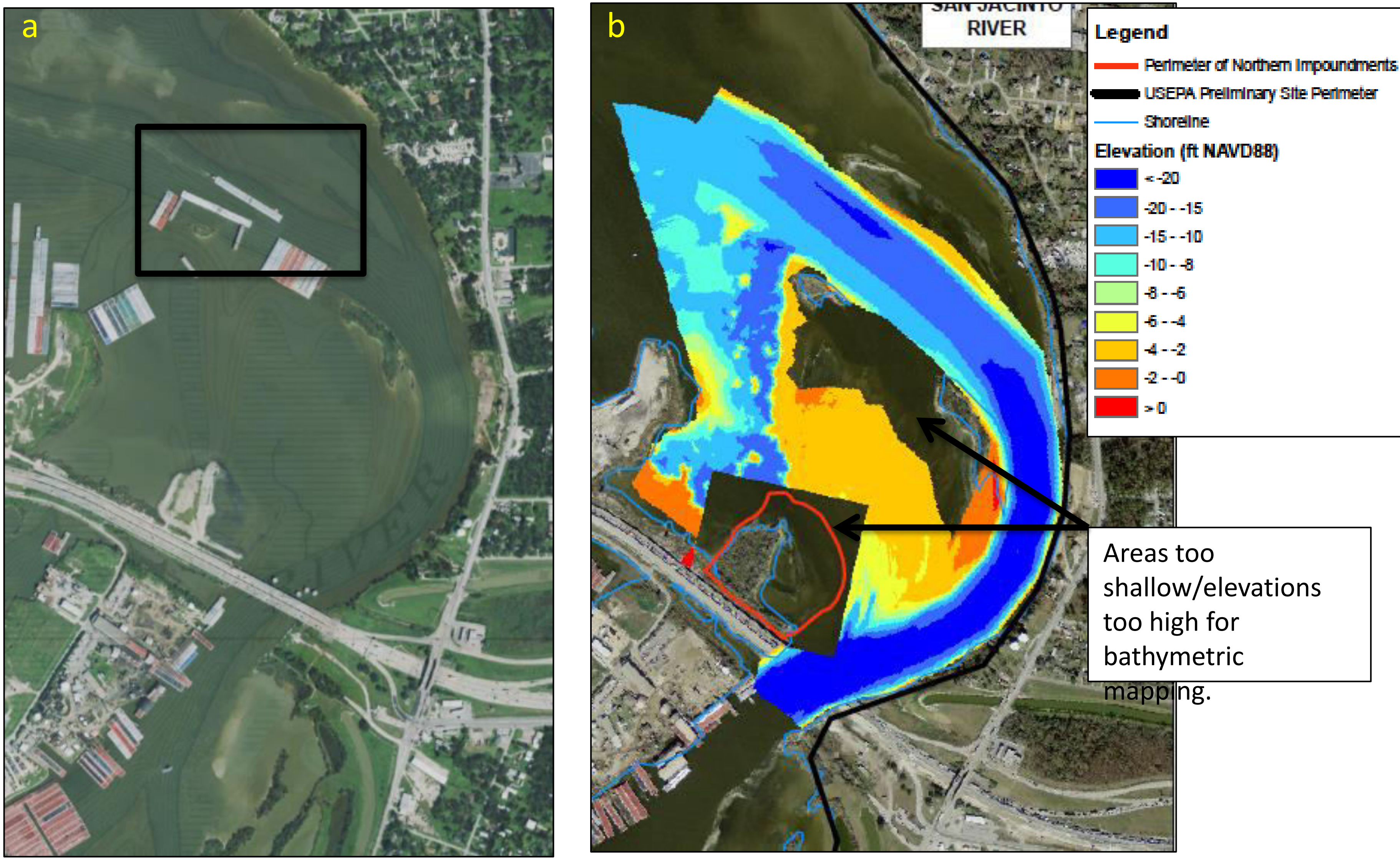
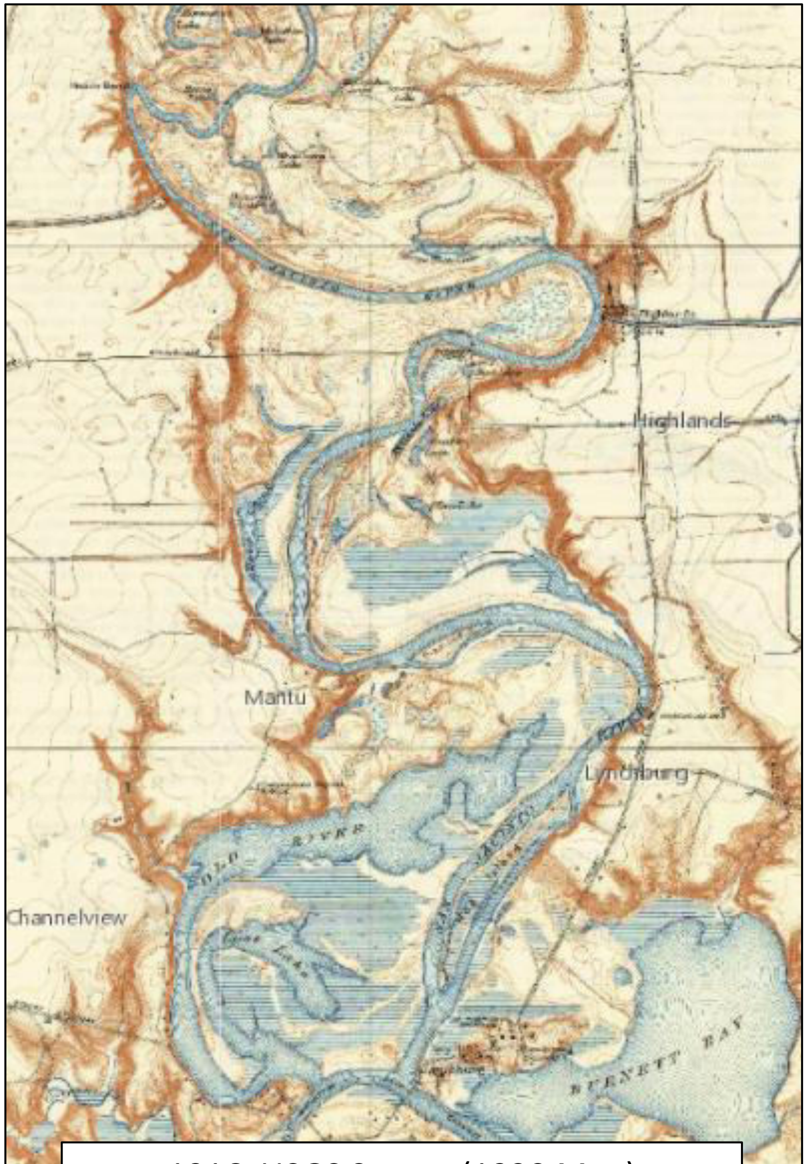
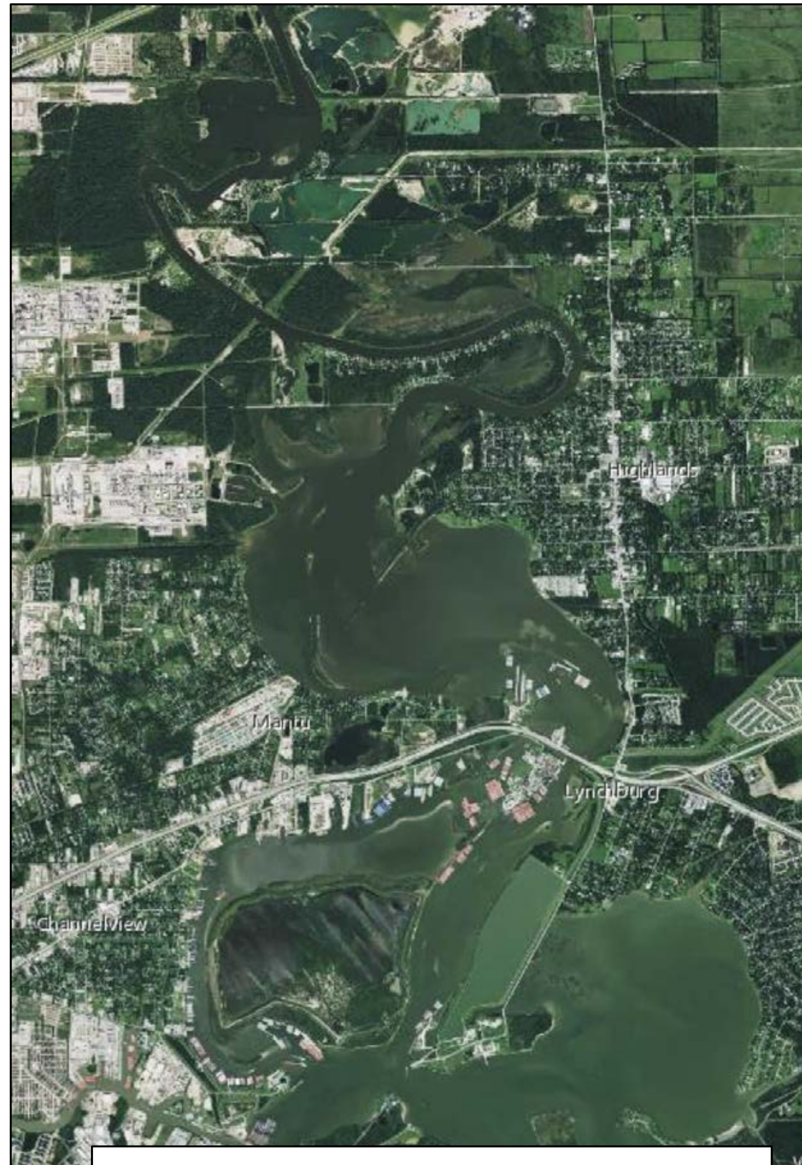


Figure 6. Side-by-side comparison of 1916 topography and 2014 aerial photo of lower San Jacinto River, Texas.



1916 USGS Survey (1920 Map)



2014 NAIP

Figure 7. USGS 1920 topographic map based on 1916 survey with overlay of water boundary from 2014 NAIP aerial photo coverage. Although low lying areas flanking the 1916 channel have been flooded due to land subsidence by 2014, note the stability of the higher banks (arrows).

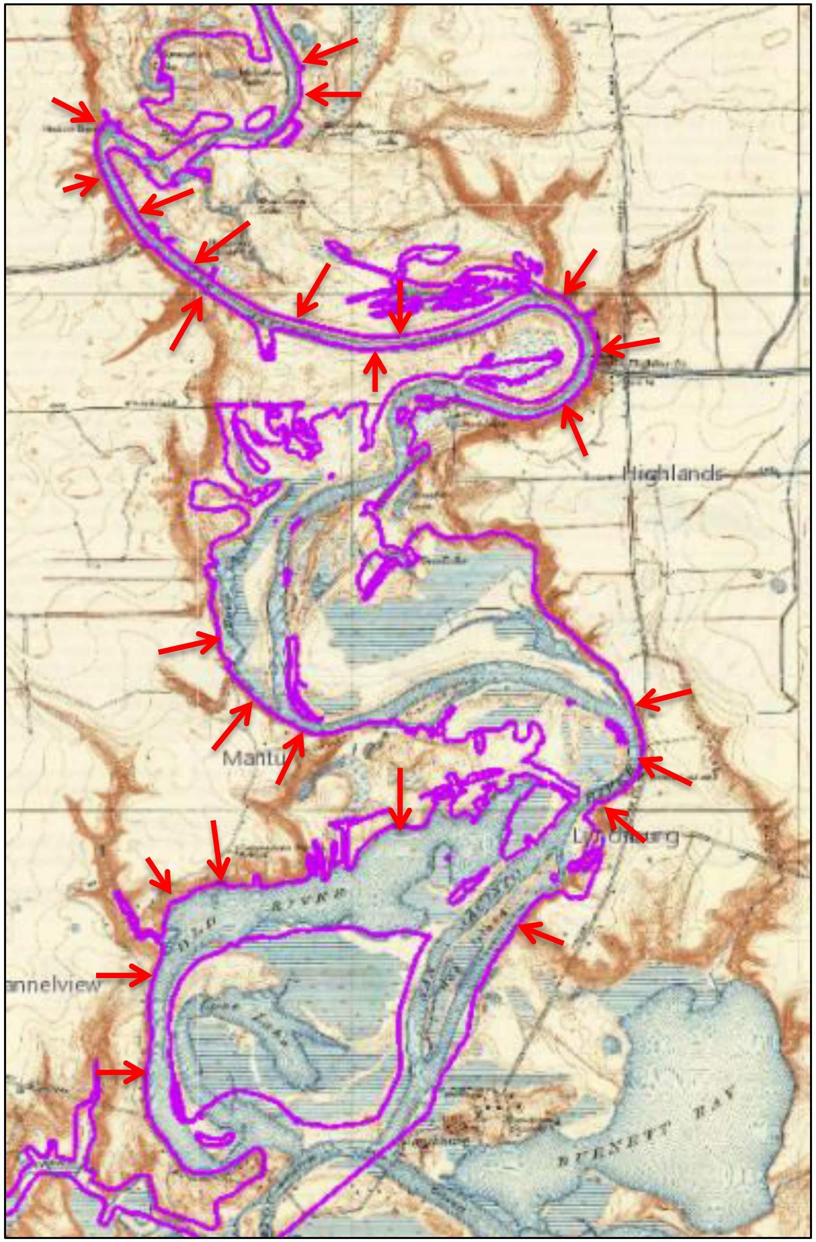


Figure 8. 2014 NAIP aerial photo coverage with overlays of water boundaries from 1953 aerial photo coverage (red) and 2014 NAIP aerial photo coverage (magenta). Although low lying areas flanking the 1953 channel have been flooded due to land subsidence by 2014, note the stability of the higher banks as in Figure 7 (arrows).

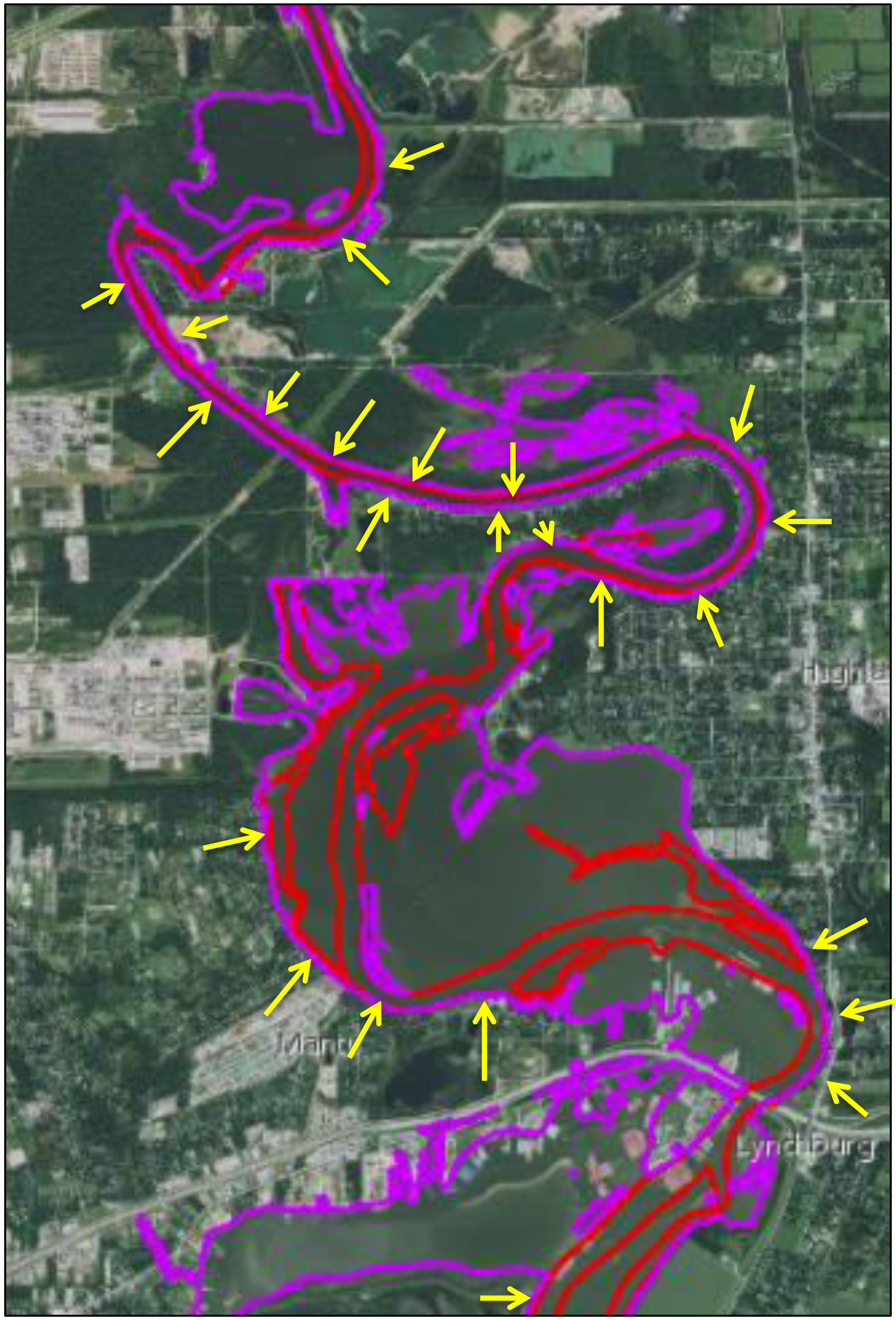


Figure 9. Subsidence map of region surrounding Site. Inset is enlargement of area around I-10 crossing (yellow curve) of the San Jacinto River. From Harris Galveston Subsidence District (http://hgsubsidence.org/).

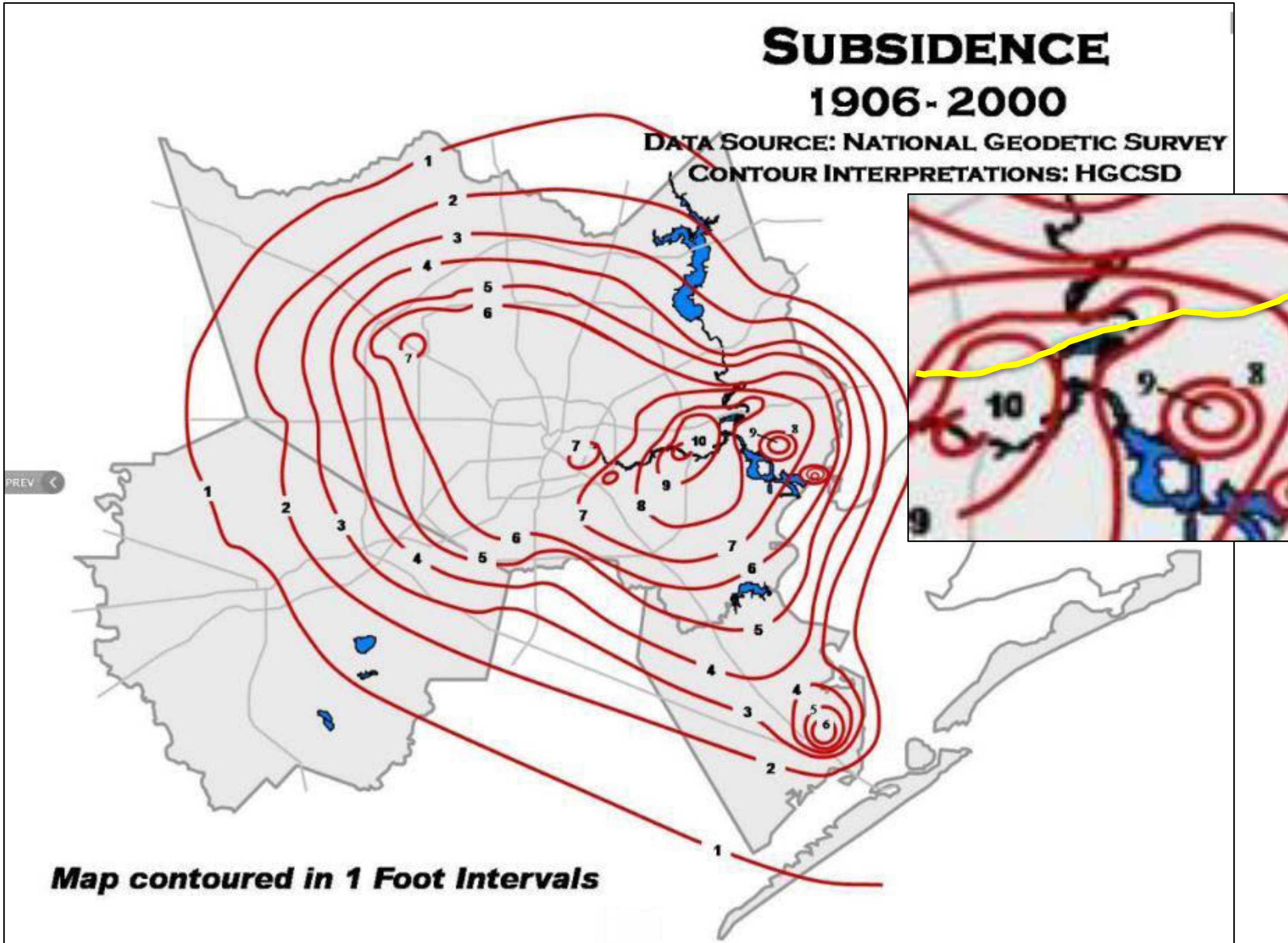


Figure 10. Typical subsidence data for instruments in vicinity of Site (yellow rectangle). From Harris Galveston Subsidence District. http://hgsubsidence.org/subsidence-data/

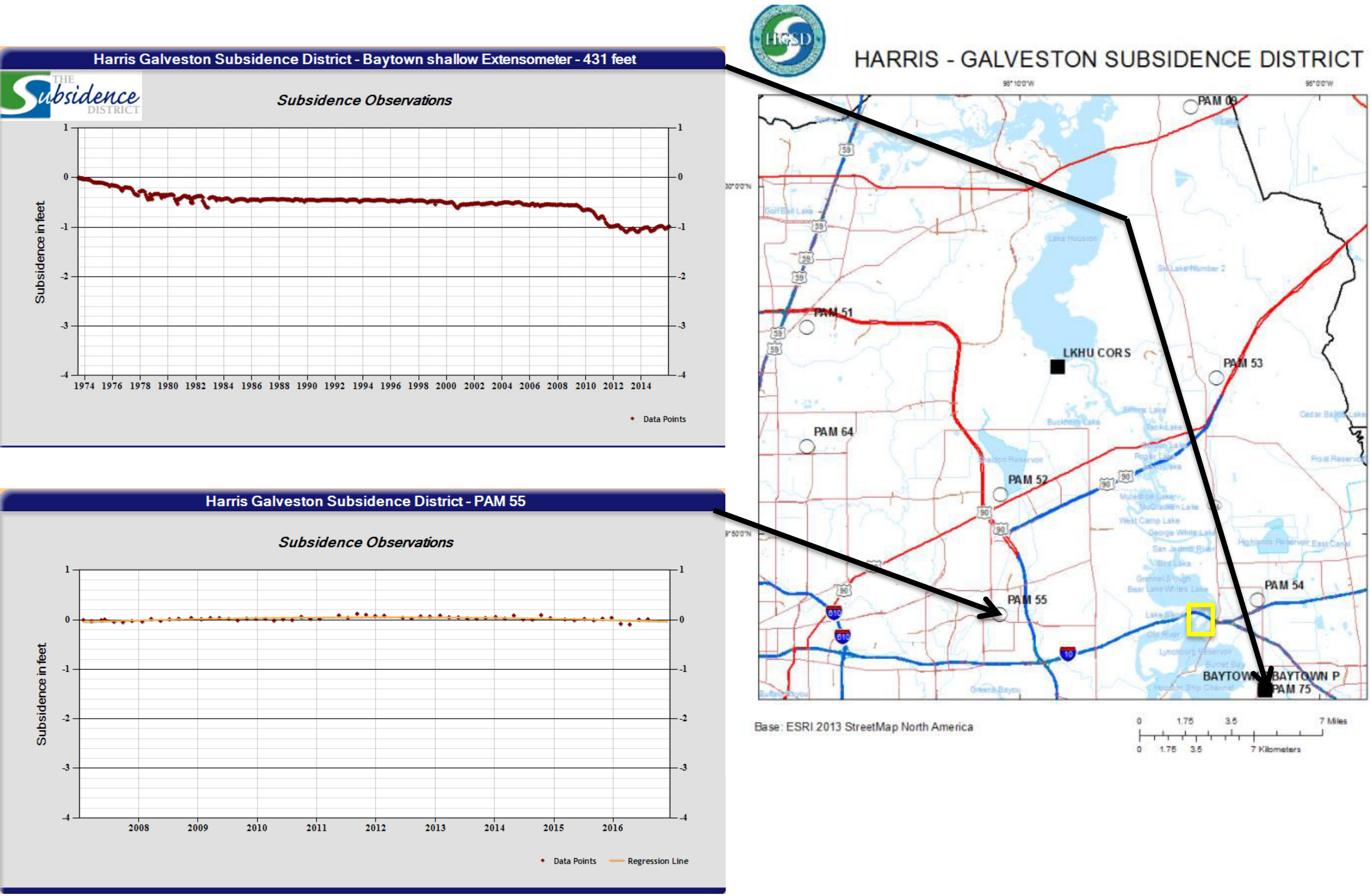


Figure 11. Aerial photographs of Banana Bend Oxbow before and after 1994 flood.

Banana Bend Oxbow in 1978 before 1994 flood. Note sand mines on left side of photo. From Google Earth.

Banana Bend Oxbow in 1995 after 1994 flood. Erosion during overbank flow created a high flow channel across neck coincident with sand mines. From Google Earth.

Figure 12. Aerial photographs of Banana Bend before and after 1994 flood.

Banana Bend in 1989 before erosion of high flow channel in 1994 flood. Note sand mines in center of photo. From Google Earth.

Banana Bend in 1995 after 1994 floodplain erosion. Evidently the flooded mine complex to the north of Highland Shores Dr connected with the channel to the south to provide a path for high flows across the floodplain. From Google Earth.

Appendix
Resume of Doug Shields, Jr.

F. Douglas Shields, Jr., Ph.D., P. E., D.WRE
CONSULTING HYDRAULIC ENGINEER

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Doug Shields has 40 years of experience in water resources and environmental engineering, including 12 years for the U.S. Army Corps of Engineers and 22 years as a Research Hydraulic Engineer at the National Sedimentation Laboratory in Oxford, Mississippi. Dr. Shields' research focuses on response of fluvial systems to human influences and development of environmental design criteria for all types of channel stabilization and modification projects, including stream bank erosion controls and management of riverine backwaters. He is a leading authority on stream and river restoration. Doug has authored or co-authored more than 300 technical publications and has completed consulting projects dealing with stream restoration, erosion protection of riparian cultural resources sites, stream bank erosion, geomorphic assessment, and local flooding.

Current position

Principal and Hydraulic Engineer, Shields Engineering, LLC

Hydraulic Engineer, cbec eco engineering, Sacramento, California (part time)

Education

1983-87 Colorado State University; Hydraulics; Ph.D. 1987, 4.0/4.0

1975-77 Vanderbilt University; Environmental and Water Resources Engineering; M.S., 1977, 4.0/4.0

1971-75 Harding University; major, mathematics, minor, physics; B.S summa cum laude, 1975 3.9/4.0

Certification

Registered professional engineer in the State of Mississippi since 1981, number 08360.

Career

1977-78	Instructor and Research Associate, Department of Civil Engineering, Tennessee State University, Nashville, Tennessee.
1978-80	Hydraulic Engineer, Nashville District, U.S. Corps of Engineers
1980-90	Research Civil Engineer, U.S. Army Engineer Waterways Experiment Station (WES).
1986-87	Supervisory Research Civil Engineer, Acting Chief, Water Resources Engineering Group, WES

1990-2012 Research Hydraulic Engineer, USDA, ARS, National Sedimentation Laboratory, Oxford, Miss.

1994-pres Adjunct professor, Department of Civil Engineering, University of Mississippi

2012-pres Principal, Shields Engineering, LLC, Oxford, MS

2012-pres Hydraulic Engineer, cbec eco-engineering (part time)

Stream and River Restoration Experience

1991-1993 Responsible for site selection, real estate, planning, design and direction of construction for three stream restoration projects in incised channels in northwestern Mississippi. Treatments included instream weirs, riprap toe protection, spur (wing) dikes, and willow planting on a total 10,000 linear ft of channels. Monitoring continued for up to 11 years, including collections from degraded and pristine reference sites. All research findings have been published in refereed literature.

1998-2006 Responsible for site selection, real estate, planning, design and direction of construction for a 6000 ft stream restoration project in central Mississippi. Channel treatments were limited to plant materials (large wood, willow cuttings, switchgrass plantings). Monitoring continued through 2004. Research was interdisciplinary and involved scientists from several universities and government agencies. Research findings have been published in refereed literature.

2000-2001 Identification of environmental enhancement opportunities for an urban river corridor, Menominee River Watershed Assessment, Milwaukee, WI. Subconsultant to Interfluve, Inc.

2001-2003 Developed software to advise users on selecting appropriate environmentally sensitive channel- and bank protection measures for a given site. Subconsultant to Salix Applied Earthcare on contract with National Cooperative Highway Research Program.

2004-2005 Development of channel stabilization plan for Kinishba Wash at Kinishba Ruins, Arizona, Subconsultant to Nickens and Associates.

2006 Assessment of performance of biotechnical stabilization of Hasotino cultural resources site, Snake River, Washington. Subconsultant to Nickens and Associates.

2006 Design of Miller Creek restoration project, Mobile, Alabama. Subconsultant to Volkert and Associates. Project intended to rehabilitate stream from damages produced by illegal modifications and featured extensive use of large wood.

2007-2008 Geomorphic analysis to support planning for Amite River restoration project, Louisiana. Subconsultant to Taylor Engineering. Lead author on literature review and field assessment of geomorphic status of major river system.

2008-pres Expert review panel, Sacramento Area Flood Control Agency and California Levee Vegetation Science Team. Review of comprehensive effort to assess effects of trees and tree removal on earthen flood control levees.

2009 Headwaters Corporation, Kearney, Nebraska. Expert review of Platte River Recovery Implementation Program Monitoring Protocol for Channel Geomorphology and In-Channel Vegetation.

2011 – 2012 Subconsultant to cbec, inc. eco engineers, West Sacramento, California. Swift Slough restoration feasibility and design alternative analysis. Assist team with development of design alternatives to enhance the hydrologic connectivity of Swift Slough, a major backwater on the Apalachicola River, Florida.

2012-2015 Subconsultant to ICF International. Preparation of national guidelines for placement of large wood in streams. Team project.

2012-2016 Member of Russian River Independent Science Review Panel, California Land Stewardship Institute. Holistic assessment of water use and ecological impacts in Russian River watershed, northern California.

2012-pres Hydraulic engineer, cbec, inc. eco engineers, West Sacramento, California. (part time). Senior level review and advisory activities on Southport Early Implementation Project levee setback, development of guidance for Rapid Stream Stability Assessment for use by Caltrans, and other projects.

2013-pres Subconsultant to Ayres and Associates, Fort Collins, Colorado. Evaluation and Assessment of Environmentally Sensitive Stream Bank Protection Measures. Project funded by Transportation Research Board, National Cooperative Highway Research Program (NCHRP Project 24-39). Work with interdisciplinary team to develop quantitative design guidance for biotechnical bank protection measures.

Experience as an Expert Witness

1993 Retained as expert witness by Mr. Dana Swan, partner, Chapman, Lewis & Swan, Clarksdale, MS. Case involved erosion of a stream channel bank and attendant damage to client's property following work on the channel by a real estate developer. Following my deposition, developer settled outside of court.

2006 Consultant to Village of Taylor, MS. Provided an examination of runoff, storm drainage, erosion and sedimentation issues surrounding design of the Main Street Taylor Development. Acted as consultant at request of Freeland and Freeland law firm, Oxford, MS.

2008 Retained as an expert consultant and potential expert witness by Orrick, Herrington & Sutcliffe LLP Sacramento, California, counsel to Robert Mori and Robert Mori II in the case of Mori II v. Baroni, et al. I was never called upon to serve.

2010 Retained as an expert witness by Daniel, Coker, Horton & Bell, Oxford, MS. Case (Crockett et al. v. City of Saltillo, MS) involved flooding of a subdivision. I prepared a preliminary report and a work plan for more detailed analysis. Case was settled out of court.

2013 Retained as an expert witness by Daniel, Coker, Horton & Bell, P. A, Oxford, MS. Case (Kmart Corporation v. City of Corinth, MS. et al.) involved flooding of a retail shopping center. I assessed the evidence in the case and critiqued analysis and report by plaintiff's expert. Case was settled out of court.

2014 Retained as an expert by Wheeler and Howorth, landowners adjacent to Shaw Place, an antebellum home surrounded by 5 acres inside the City of Oxford, MS. Provided a written report and testimony before the City Planning Commission regarding effects of development on runoff and erosion. Case settled prior to litigation.

2015 Retained as an expert by Lafayette Civic Center in pre-litigation examination of erosion and sedimentation impacts on small lake related to adjacent earthmoving activities. Matter is pending.

2015 Retained as an expert by Willoughby and Hoefer, P. A., Columbia, SC. Case (Snyder et al. v. SCE&G) involves assignment of responsibility for extensive flooding of residential areas during high flow events associated with Hurricane Joaquin in October 2015. Matter is pending.

Direction of Graduate Research

1997. Martin W. Doyle. Bed material size trends in incised channels. M.S. Thesis, University of Mississippi.

2001. Nathalie Morin. Specific gravity of naturally occurring large woody debris in the river environment. Internship report, L'INRS-Eau, Terre et Environment (in French).

2005. John M. Stofleth. Hyporheic and Total Storage Exchange in Small Sand-Bed Streams. M.S. Thesis, University of Mississippi.

2012. Mary A. McCaskill. Bacterial and sediment transport in an artificial sand bed stream during unsteady flow. M. S. Thesis, University of Mississippi.

Membership in Professional Societies

- Fellow, American Society of Civil Engineers
- Fellow, Environmental and Water Resources Institute
- Diplomate, American Academy of Water Resources Engineers

- Order of the Engineer
- American Geophysical Union

Awards

2008	Diplomate, American Academy of Water Resources Engineers
1999	Bronze Award, U.S. Environmental Protection Agency Office of Water
1997	American Society of Civil Engineers Hydraulic Engineering Achievement Award, Mississippi Section
1984	American Society of Civil Engineers (ASCE) Zone II Young Government Civil Engineer of the Year
1983-1984	U.S. Army Corps of Engineers Civil Works Fellowship
1975-1976	Energy Research and Development Agency trainee fellowship, Vanderbilt University

Offices and Committee Assignments Held in Professional and Honorary Societies

1986 –1990	Control member of American Society of Civil Engineers Task Committee on Aquatic Habitat and Sedimentation
1991-1995	Corresponding member of American Society of Civil Engineers Task Committee to update *Sedimentation Engineering* Manual and Report on Engineering Practice No. 54
1994 –2005	Board of Governors, Order of the Engineer, The University of Mississippi, Link No. 149
1996-2007	Control member of American Society of Civil Engineers Task Committee on Sedimentation Engineering for River Restoration
2007-2009	Chair of American Society of Civil Engineers Hydraulics and Waterways Committee
2012-2013	Vice Chair, American Society of Civil Engineers River Restoration Technical Committee
2013	Chair, American Society of Civil Engineers River Restoration Technical Committee
2016	Chair, American Society of Civil Engineers Task Committee on Representation of Vegetation in Two-Dimensional Hydrodynamic Models

Selected Invitations

Invited to present, "Evaluating Impacts of Channel Stabilization Structures on Riverine Habitats," to the meeting of the Environmental Advisory Board of the Chief of Engineers, U.S. Army Corps of Engineers, Denver, Colorado, October 7, 1987.

Invited by the Southern Division, American Fisheries Society to co-author chapter, "Dikes and levees," for book, Impacts on Warmwater Streams: Guidelines for Evaluation, with C. H. Pennington, 1989.

Invited to present, "Engineering Constraints on Riverine Habitat Restoration," Missouri River Mitigation Workshop, Desoto National Wildlife Refuge, Iowa, June 27-28, 1990, U. S. Fish and Wildlife Service. Interagency workshop laid foundation for major mitigation project.

Invited by the Korean Institute of Construction Technology to visit South Korea and present seminar, "Instream Flow Methods to Meet Recreational and Aesthetic Objectives," and discuss current research activities. In concert with this invitation, also invited to deliver keynote address, "Rehabilitation of Watersheds with Incising Channels in Mississippi, USA," to the annual meeting of the Korean Society of Civil Engineers, October 17-23, 1994.

Invited by USDA-Natural Resources Conservation Service to chair interagency team of experts requested to visit North River Watershed in Missouri and to provide transfer of technology developed by the Demonstration Erosion Control Program to landowners, US Fish and Wildlife Service, and State agencies, October 23-25, 1995.

Invited by a consortium of the Environmental Defense Fund, the Bay Institute, and Philip Williams and Associates, all of San Francisco, to serve on an expert review panel for a study preparing a framework Restoration of the San Francisco Bay-Delta-River ecosystem, October 30, 1995—October 1997.

Invited by Ontario Ministry of Ministry of Natural Resources (Canada) to participate in the Temperate Wetland Restoration Workshop in Barrie, Ontario and present, "Physical perturbations on temperate riverine wetlands." The workshop was sponsored by Environment Canada, Ontario Ministry of Ministry of Natural Resources, Ontario Ministry of Environment and Energy, Trent University, and Ducks Unlimited Canada, November 27 - December 1, 1995.

By invitation of the USDA-NRCS International Conservation Division, worked as part of an interdisciplinary, interagency team to review forested riparian buffer strip research and management practices in Taiwan. The assignment included presenting a lecture on the state of science and ongoing research, touring field research sites on Taiwan with Taiwanese scientists and officials, and co-authoring a memorandum detailing recommendations, June 14-21, 1996.

Invited by the Comite Intergubernamental de la Hidrovia Parana-Paraguay (CIH), Buenos Aires, Argentina to serve on a five-person expert panel to review hydrologic studies conducted to assess technical and economic feasibility and environmental impacts of construction of the Hidrovia project—a collaborative effort among five South American countries to improve navigation conditions along 3,442 km of river using dredging and other channel modifications. The project holds potential for impacting the Patanal, the world's largest freshwater wetland. Due to recommendations of the incumbent and other panelists, governments of the countries involved initiated reconsideration of the project's impacts, November 19-21, 1996.

Invited to serve as a convenor for five technical sessions on stream habitat restoration for the XXVII Congress of the International Association of Hydraulic Research, August 10 15, 1997.

Invited to present keynote address in May 1998 at the International Symposium on River Restoration, Technology Research Center for Riverfront Development, Tokyo, Japan, July 15, 1997.

Invited to serve as examiner for PhD dissertation, "On the role of woody vegetation in riverbank stability," by Bruce Abernethy. Ph.D. thesis submitted to Department of Civil Engineering, Monash University, Clayton, Victoria, Australia, March 1999.

Invited to present lecture, "Ecological engineering in research and practice," to annual meeting of the American Ecological Engineering Society, University of Georgia, Athens, May 1, 2001.

Invited to make presentation "Interactions of riparian zones with aquatic restoration," to American Water Resources Association Summer Specialty Conference on Riparian Ecosystems, June, 2004.

Invited to make presentation on river restoration monitoring to meeting of National River Restoration Synthesis Project, Santa Barbara, California, August 20, 2005. (declined)

Invited to join the National Center for Earth Dynamics Stream Restoration Partners Group, University of Minnesota, February 9, 2005. Later invited to participate in expert panel workshop on training for stream restoration practitioners sponsored by the NCED, April 2-4, 2006.

Invited to chair session and make presentation on large wood in streams at the Sixth Annual Stream Restoration Design Symposium, Skamania Lodge, WA, February 7, 2007

Invited to make presentation, "Stream Restoration Design," and serve on panel for discussion of new ASCE Manual of Practice: Manual 110 Sedimentation Engineering at the Environmental and Water Resources Institute World Water Congress 2007, Tampa, Florida, May 17, 2007.

Invited to make presentation, "Role of vegetation in bank stability & revetments" and participate in a panel discussion, "Applying the engineering and science to solutions," as part of the Levee Vegetation Symposium organized by Sacramento Area Flood Control Agency (SAFCA). This symposium was sponsored by the Corps, State of California Reclamation Board, California Department of Water Resources and SAFCA to explore science, real-world experience, challenges, and policy solutions related to levee vegetation. The Corps proposed tighter vegetation regulations for earthen levees in the wake of the Katrina disaster, triggering a crisis for local sponsors of levee projects. Registration numbers revealed over 511 people from 21 states nationwide registered for the symposium, representing over 151 agencies from federal, state and local flood management, resource agencies, academic institutions and consulting engineering and environmental firms. August 28-29, 2007.

Invited by the National Oceanic and Atmospheric Administration National Marine Fisheries Service to serve on an expert panel on setting up a process for reviewing proposed stream habitat restoration projects, December 11-12, 2007.

Invited by Natonal Marine Fisheries Service to serve as expert reviewer for River Restoration Analysis Tool, http://www.restorationreview.com/, 2010.

Interviewed by the U.S. Government Accountability Office to provide input to a comprehensive review of the hydrologic and environmental effects of river training structures on the Mississippi River, http://www.gao.gov/products/GAO-12-41, 2011.

Invited by Bureau of Reclamation to participate in a Technical Workshop on Large Wood Applications and Research Needs in River Restoration, 2012.

Invited to present a series of lectures on river restoration research and challenges, US Bureau of Reclamation, Denver, CO, 2014.

Invited to present webinars on Stream Restoration by ASCE/EWRI Distinguished Member Webinar Series, 2014.

Advisory activities

Between 1985 and 1990, served as in-house expert for U. S. Corps of Engineers field offices for environmental issues related to stream channel modifications, dredging, and dredged material disposal (nationwide). Consultations (3 to 6 per year) sometimes were limited to telephone conversations, but usually involved face to face meetings, seminar presentations, site visits, literature review, and preparation of letter reports. Typical examples include preparation of a monitoring plan for sediment deposition in cutoff meander bends along the Tombigbee River portion of the Tennessee-Tombigbee Waterway (Mobile District, 1985); field consultation with the New England Division (1986) regarding impacts of gravel mining in Naugatuck River, Connnecticut; seminar for interagency group at Memphis District (1987) regarding application of stream obstruction removal guidelines to the Cache River, Arkansas; field and office consultations regarding habitat restoration within Anacostia River Basin, MD (Baltimore District, 1990).

Similar short-term consultations were also provided to personnel of other government agencies one to three times per year. Examples included work with the George D. Aiken Resource, Conservation, and Development Area of Randolph, Vermont regarding engineering design criteria for aquatic habitat improvement structures for the Ottauquechee River, Vermont (1984); the Minnesota Department of Natural Resources, regarding selective removal of large woody debris from streams for flood stage reduction (1984);U.S. Fish and Wildlife Service, Bloomington, Indiana regarding incorporation of artificial wetlands in an enlarged channel, (1987); and staff of the New Jersey legislature regarding construction of dredged material containment islands, (1988).

Participated in periodic coordination meetings for the Demonstration Erosion Control Project with technical experts from Corps, NRCS, USGS, and universities. Presented stream restoration research plans and results. Contributed to discussions regarding morphologic evolution of incised channels and attendant impacts on habitat and downstream sediment yield. Meetings included: Stream restoration sites (October 28-29, 1991), Greenwood, MS (August 20, 1992), Hotophia Creek restoration site (January 14, 1992), Waterways Experiment Station Hydraulics Laboratory (September 8, 1992, January 12-13, 1993, February 25, 1993), NSL (October 21, 1993 and April 22, 1993)

Organized briefings and field trips for interagency groups and foreign visitors to incumbent's stream restoration and stabilization research sites for technology transfer, including fellows of the Food and Agriculture Organization of the United Nations (1991), twelve engineers and scientists from the Corps of Engineers, NRCS, U.S. Fish and Wildlife Service, ARS, and the State of Mississippi (1992), Eight engineers and scientists from U.S. Corps of Engineers. Mobile District (1993), two engineers from m Korean Institute of Construction Technology (1993), five engineers and biologists from Baltimore District, U.S. Corps of Engineers working on Passaic River, New Jersey, flood control project (1994), the Options Appraisal Manager, National Centre for Risk Analysis and Options Appraisal, the Environment Agency, England and Wales (1997), six engineers and scientists from Missouri Department of Conservation (1999).

Provided consultation and literature to Executive Director, Golden State Wildlife Federation, Sacramento, CA, regarding effects of levees on riverine and floodplain ecosystems, October 21, 1993.

At the request of the St. Louis District of the Corps of Engineers, worked as part of an interdisciplinary team to provide recommendations regarding aquatic and wetland habitat restoration opportunities associated with repair of levees damaged by the 1993 Midwest flood. Concepts were used by Corps personnel in a report to district managers, November 30-December 2, 1993.

Technology transfer to Stream Program Coordinator, Missouri Department of Conservation, including in-depth discussions, inspection of field research sites, and provision of literature to support programs of stream rehabilitation technology demonstration and transfer to riparian landowners, April 4-5, 1995 and January 21-23, 2003.

Provided field consultation to hydraulic engineer of the U. S. Corps Engineers Mobile District and research hydraulic engineer of the U. S. Army Engineer Waterways Experiment Station regarding stream restoration design for a 2.5-mile long, $1 million project on Twentymile Creek, Mississippi. (May 22, 1995). Summarized observations in a letter report. Provided additional consultation to hydraulic engineers and biologists of the Mobile District regarding planning and design for restoration structures and plantings for this project, August 31, 1995 and May 14, 1996.

Provided information to Chief of River Engineering Division, Coastal and Hydraulic Engineering Laboratory, U.S. Army Engineer Waterways Experiment Station regarding status and probable environmental impacts of Hidrovia Parana-Paraguay Waterway Project, September 3, 1997.

At the invitation of the U.S. Forest Service, provided on-site consultation and a letter report regarding stabilization and restoration of stream corridors threatened with incision in the Homochitto National Forest, November 2001.

At the invitation of the Corps of Engineers, provided on-site advice and consultation regarding planning and design for restoration of the Salmon River near Challis, Idaho, July 30-August 1, 2002.

Assisted in hosting delegations from Korean Institute of Construction Technology and National Center for Computational Hydroscience and Engineering, University of Mississippi for briefings on river restoration research and tours of NSL, May 29, 2002 and October 15, 2002.

At the invitation of the Michigan Sea Grant Program, provided invited lecture and participated in panel discussion for a workshop on environmentally sensitive streambank and shoreline erosion control, ~100 participants, October 29, 2003.

Provided invited review of research plans for Center for Bottomland Hardwoods Research, Southern Research Station, US Forest Service, May 26, 2004.

Organized workshop on stream restoration research for 25 participants from three states, October 24-25, 2006. Presentations by 8 NSL scientists and tour of restoration research field sites.

National Center for Earth Dynamics Stream Restoration Partners Group, University of Minnesota, invited panel and workshop participation on stream restoration research (2005) and training stream restoration practitioners (2006).

Invited presentation and panel discussion, Levee Vegetation Symposium, Sacramento, California, 500 participants, August 28-29, 2007.

Reviewer for Journal of Environmental Quality, AI Applications in Natural Resource Management, Environmental Management, Soil Science Society of America Journal, Journal of Environmental Engineering, Transactions of the American Society of Agricultural Engineers, Regulated Rivers: Research and Management, Geomorphology, Journal of Hydraulic Engineering, North American Journal of Fisheries Management, Fisheries, Aquatic Conservation, Water Resources Bulletin, Journal of the American Water Resources Association, and Journal of Hydrologic Engineering. Editorial board, Environmental Management, 1999-2003.

Special assignments

1982-87 Environmental Manual Advisory Group, U.S. Army Engineer Waterways Experiment Station. Responsible for production of a series of manuals to incorporate environmental criteria into standard procedures for design, operation, and maintenance of reservoir, waterway, and flood control channel projects.

1985 Environmental Water Quality and Operational Studies overview briefing team, U.S. Army Corps of Engineers. Team visited Corps field offices and presented seminars summarizing findings of 5-year, $30 million research program. These presentations laid groundwork for ensuing transfer of technology to field offices.

1982-93 Regular lecturer on environmental design considerations for the following annual short courses conducted at the U.S. Army Engineer Waterways Experiment Station:

Streambank Protection

Hydraulic Design of Flood Control Channels

Environmental Aspects of Local Flood Protection Projects

Hydraulic Design for Project Engineers and Planners

1996 Chaired meeting involving scientists from University of Middlesex, U.K. engaged in study of engineering uses of willows, USDA-NRCS plant materials center personnel, active and retired NSL scientists, and visiting scientists. Meeting included briefing on findings of current and recently completed research and visits to field sites. Data and findings were used by visitors in their study, August 23, 1996.

1996 Co-hosted of tour of Demonstration Erosion Control Project watersheds for a group composed of NRCS state conservationists from ten southeastern states, Soil and Water Conservation Commissioners, and other officials.

1997 Served as technical program co-chair and co-editor of Proceedings of the international conference, Management of Landscapes Disturbed by Channel Incision. Conference drew 250 participants from 25 states and 26 foreign countries. (#161)

1999-2004 Served as director of the Little Topashaw Creek Stream Corridor Rehabilitation Project, coordinating work among NSL scientists, cooperators, and landowners. This project provided a setting for interdisciplinary research involving three universities and three federal agencies in areas relating to erosion control, ecosystem rehabilitation, and water quality within an agricultural watershed. To date, this project has provided a basis for 18 proceedings papers, 3 poster presentations, two technical sessions at a national conference, and 11 refereed journal papers. Project hosted field tours by U.S. Corps of Engineers Advanced Streambank Protection Short Course (Twice), scientists and engineers from USDA-NRCS, Mississippi offices, students and professor from Oklahoma State University, and eight scientists from Northeast Forest University, China. Developed website to facilitate technology transfer. (http://ars.usda.gov/Research/docs.htm?docid=5526)

1999 Directed the technical watershed tour for about 35 participants in the US-China Bilateral Workshop: Sediment management in agricultural watersheds.

2004 Directed the technical watershed tour for the Third International Conference on Gully Erosion (GEC III).

2004-2010. Served as coordinator of Coldwater River Watershed Rehabilitation project. This project is an investigation of riverine backwater management to yield ecological services in the agricultural landscape. Developed website to transfer initial findings. (http://www.ars.usda.gov/Research/docs.htm?docid=12773)

2007-2008 Served as the technical publications co-chair for the conference, "The National Sedimentation Laboratory: 50 Years of Soil and Water Research in a Changing Agricultural Environment."

Peer-Reviewed Publications

Shields, F. D., Jr. 1982. Environmental features for flood control channels. Water Resources Bulletin. 18 (5):779-784.

Schroeder, P. R. and Shields, F. D., Jr. 1983. Chemical clarification of dredged material. Journal of Environmental Engineering. 109 (2):414-427.

Shields, F. D., Jr. 1983. Design of habitat structures for open channels. Journal of Water Resources Planning and Management. 109 (4):331-344.

Shields, F. D., Jr. and Nunnally, N. R. 1984. Environmental aspects of clearing and snagging. Journal of Environmental Engineering. 110 (1):152-165.

Shields, F. D., Jr. and Sanders, T. G. 1986. Water quality effects of excavation and diversion. Journal of Environmental Engineering. 112 (2):211-228.

Nunnally, N. R., Hynson, J. R. and Shields, F. D., Jr. Environmental considerations for levees and floodwalls. Environmental Management. 11 (2):183-191. 1987.

Thackston, E. L., Shields, F. D., Jr. and Schroeder, P. R. 1987. Residence time distributions of shallow basins. Journal of Environmental Engineering. 113 (6):1319-1332.

Shields, F. D., Jr. and Abt, S. R. 1989. Sediment deposition in cutoff meander bends and implications for effective management. Regulated Rivers: Research and Management. 4:381-396.

Shields, F. D., Jr. 1990. ENDOW--Selecting environmental features for stream alteration projects. AI Applications in Natural Resource Management. 4 (3):62-63.

Shields, F. D., Jr. 1991.Woody vegetation and riprap stability along the Sacramento river mile 84.5 to 119. Water Resources Bulletin. 27 (3):527-536.

Shields, F. D., Jr. and Hoover, J. J. 1991.Effects of channel restabilization on habitat diversity, Twentymile Creek, Mississippi. Regulated Rivers: Research and Management. 6 (3):163-181.

Shields, F. D., Jr. and Thackston, E. L. 1991.Designing treatment basin dimensions to reduce cost. Journal of Environmental Engineering. 117 (3):381-386.

Shields, F. D., Jr. and Aziz, N. 1992.Knowledge-based system for environmental design of stream modifications. Applied Engineering in Agriculture. 8 (4):553-562.

Shields, F. D., Jr. and Gray, D. H. 1992. Effects of woody vegetation on sandy levee integrity. Water Resources Bulletin. 28 (5):917-931.

Shields, F. D., Jr. and Milhous, R. T. 1992.Sediment and aquatic habitat in river systems. Final Report, American Society of Civil Engineers Task Committee on Sediment Transport and Aquatic Habitat. Journal of Hydraulic Engineering. 118 (5):669-687.

Shields, F. D., Jr. and Smith, R. H. 1992. Effects of large woody debris removal on physical characteristics of a sand-bed river. Aquatic Conservation: Marine and Freshwater Systems. 2:145-163.

Shields, F. D., Jr., Cooper, C. M. and Knight, S. S. 1993. Initial habitat response to incised channel rehabilitation. Aquatic Conservation: Marine and Freshwater Systems. 3:93-103.

Shields, F. D., Jr., Knight, S. S. and Cooper, C. M. 1994. Effects of channel incision on base flow stream habitats and fishes. Environmental Management. 18 (1):43-57.

Shields, F. D., Jr., Cooper, C. M. and Knight, S. S. 1995.Experiment in stream restoration. Journal of Hydraulic Engineering. 121 (6): 494-502.

Shields, F. D., Jr. and Gippel, C. J. 1995. Prediction of effects of woody debris removal on flow resistance. Journal of Hydraulic Engineering. 121 (4):341-354.

Gore, J. A. and Shields, F. D., Jr. 1995.Can large rivers be restored? A focus on rehabilitation. Bioscience. 45 (3): 142-152.

Shields, F. D., Jr., Knight, S. S. and Cooper, C. M. 1995.Use of the index of biotic integrity to assess physical habitat degradation in warmwater streams. Hydrobiologia. 312 (3): 191-208.

Shields, F. D., Jr., Knight, S. S. and Cooper, C. M. 1995. Incised stream physical habitat restoration with stone weirs. Regulated Rivers: Research and Management. 10:181-198.

Shields, F. D., Jr., Bowie, A. J. and Cooper, C. M. 1995. Control of streambank erosion due to bed degradation with vegetation and structure. Water Resources Bulletin. 31 (3):475-489.

Shields, F. D., Jr. . 1995. Fate of Lower Mississippi River habitats associated with river training dikes. Aquatic Conservation: Marine and Freshwater Systems. 5:97-108

Shields, F. D., Jr., Knight, S. S. and Cooper, C. M. 1995. Rehabilitation of watersheds with incising channels. Water Resources Bulletin. 31 (6):971-982.

Shields, F. D., Jr. 1996.Closure of discussion of, "Prediction of effects of woody debris removal on flow resistance." Journal of Hydraulic Engineering. 122 (8):471-472.

Shields, F. D., Jr., Knight, S. S. and Cooper, C. M. 1997.Rehabilitation of warmwater stream ecosystems following channel incision. Ecological Engineering. 8 (2):93-116.

Pezeshki, S. R., Anderson, P. H. and Shields, F. D., Jr. 1998.Effects of soil moisture regimes on growth and survival of black willow (Salix nigra) posts (cuttings). Wetlands. 18 (3):460-470.

Shields, F. D., Jr., Knight, S. S. and Cooper, C. M. 1998. Addition of spurs to stone toe protection for warmwater fish habitat rehabilitation. Journal of the American Water Resources Association. 34 (6): 1427-1436.

Shields, F. D., Jr., Knight, S. S. and Cooper, C. M. 1998. Rehabilitation of aquatic habitats in warmwater streams damaged by channel incision in Mississippi. Hydrobiologia. 382:63-86.

Kuhnle, R. A., Alonso, C. V. and Shields, F. D., Jr. 1999.Volume of scour holes associated with 90-degree spur dikes. Journal of Hydraulic Engineering. 125 (9):972-978.

Shields, F. D., Jr., Simon, A. and Steffen, L. J. 2000.Reservoir effects on river channel migration. Environmental Conservation. 27 (1):54-66.

Shields, F. D., Jr., Knight, S. S. and Cooper, C. M. 2000. Cyclic perturbation of lowland river channels and ecological response. Regulated Rivers: Research and Management. 16 (4):307-325.

Shields, F. D., Jr. and Cooper, C. M. 2000.Woody vegetation and debris for in channel sediment control. International Journal of Sediment Research. 15 (1):83-92.

Cooper, C. M., Shields, F. D., Jr., Testa, S., III and Knight, S. S. 2000.Sediment retention and water quality enhancement prescriptions for disturbed watersheds. International Journal of Sediment Research. 15 (1):121-134.

Doyle, M. W. and Shields, F. D., Jr. 2000.Incorporation of bed texture into a channel evolution model. Geomorphology. 34:291-309.

Shields, F. D., Jr., Knight, S. S. and Cooper, C. M. 2000.Warmwater stream bank protection and fish habitat: a comparative study. Environmental Management. 26 (3):317-328.

Schaff, S. D., Pezeshki, S. R. and Shields, F. D., Jr. 2000. Soils influence survival and growth of willow posts at streambank restoration project (Mississippi). Ecological Restoration. 18 (1):56-57. (by invitation)

Cooper, C. M., Testa, S., III and Shields, F. D., Jr. 2001. Stream Restoration: Response of Benthos to Engineered Stable Riffle/Pool Habitat. Verh. Int. Ver. Limnol. SIL. 27 (3):1520-1527.

Moore, M. T., Bennett, E. R., Cooper, C. M., Smith, S., Jr., Shields, F. D., Jr., Milam, C. D. and Farris, J. L. 2001. Transport and fate of atrazine and lambda-cyhalothrin in an agricultural drainage ditch in the Mississippi Delta, USA. Agriculture, Ecosystems and Environment. 87 (3):309-314.

Shields, F. D., Jr., Smiley, P. C., Jr. and Cooper, C. M. 2002.Design and Management of Edge-of-Field Water Control Structures for Ecological Benefits. Journal of Soil and Water Conservation. 57 (3):151-157.

Schaff, S. D., Pezeshki, S. R. and Shields, F. D., Jr. 2002.The effect of pre-planting soaking on growth and survival of black willow (Salix nigra) cuttings. Restoration Ecology. 10 (2):267-274.

Simon, A., Thomas, R. E., Curini, A. and Shields, F. D., Jr. 2002.Case study: Channel stability of the Missouri River, Eastern Montana. Journal of Hydraulic Engineering. 128 (10):880-990.

Kuhnle, R. A., Alonso, C. V. and Shields, F. D., Jr. 2002. Local scour associated with angled spur dikes. Journal of Hydraulic Engineering. 128 (12):1087-1093.

Schaff, S. D., Pezeshki, S. R. and Shields, F. D., Jr. 2003. The effects of soil conditions on survival and growth of black willow cuttings. Environmental Management. 31 (6):748-763.

Shields, F. D., Jr., Knight, S. S., Morin, N. and Blank, J. C. 2003. Response of fishes and aquatic habitats to sand-bed stream restoration using large woody debris. Hydrobiologia. 494:251-257.

Shields, F. D., Jr., Knight, S. S., Testa, S. and Cooper, C. M. 2003.Use of acoustic Doppler current profilers to describe velocity distributions at the reach scale. Journal of the American Water Resources Association. 39 (6):1397-1408.

Shields, F. D., Jr., Cooper, C. M., Knight, S. S. and Moore, M. T. 2003. Stream corridor restoration research: a long and winding road. Journal of Ecological Engineering. 20:441-454.

Shields, F. D., Jr., Copeland, R. R., Klingeman, P. C., Doyle, M. W. and Simon, A. 2003. Design for stream restoration. Journal of Hydraulic Engineering. 129 (3):575-584.

Martin, L.T., Pezeshki, S. R. and Shields, F. D., Jr. 2004. High oxygen level in a soaking treatment improves early root and shoot development of black willow cuttings. The Scientific World Journal. 4:899-907.

Dabney, S., Shields, F. D., Jr., Temple, D. and Langendoen, E. 2004. Erosion processes in gullies modified by establishing grass hedges. Transactions of American Society of Agricultural Engineers. 47 (5): 1561–1571.

Cooper, C. M., Moore, M. T., Bennett, E. R., Smith, S., Jr., Farris, J. L., Milam, C. D. and Shields, F. D., Jr. 2004. Innovative uses of vegetated drainage ditches for reducing agricultural runoff. Water Science and Technology. 49 (3):117-123.

Shields, F. D., Jr., Morin, N. and Cooper, C. M. 2004. Large woody debris structures for sand bed channels. Journal of Hydraulic Engineering. 130 (3):208-217.

Li, S., Pezeshki, S. R., Goodwin, S. and Shields, F. D., Jr. 2004. Physiological Responses of black willow (Salix nigra) cuttings to a range of soil moisture regimes. Photosynthetica. 42 (4):585-590.

Martin, L.T., Pezeshki, S. R. and Shields, F. D., Jr. 2005. Soaking treatment increases survival of black willow posts in a large-scale field study. Ecological Restoration. 23 (2):95-98.

Shields, F. D., Jr. and Rigby, J. R. 2005.River habitat quality from river velocities measured using acoustic Doppler current profiler. Environmental Management. 36 (4):565-575.

Shields, F. D., Jr. 2005. Streambank Stabilization. Encyclopedia of Water Science. doi: 10.1081/E-EWS-120010041. 2005. (Article for reference book)

Li, S., Martin, L. T., Pezeshki, S. R. and Shields, F. D., Jr. 2005.Responses of black willow (Salix nigra) cuttings to herbivory and flooding. Acta Oecologica. 28 (2):173-180.

Pezeshki, S. R., Brown, C. E., Elcan, J. M. and Shields, F. D., Jr. 2005.Responses of nondormant black willow (Salix nigra) cuttings to pre-planting soaking and soil moisture. Restoration Ecology. 13 (1):1-7.

Wu, W., Shields, F. D., Jr., Bennett, S. J. and Wang, S. S. Y. 2004.A depth-averaged two-dimensional model for flow, sediment transport, and bed topography in curved channels with riparian vegetation. Water Resources Research. 41 (3): W03015. 2005. doi:10.1029/2004WR003730.

Shields, F. D., Jr., Knight, S. S. and Cooper, C. M. 2005.Stream ecosystem restoration: Is watershed treatment effective without instream habitat rehabilitation? Ecological Restoration 23 (2):103-109.

Bennett, E. R., Moore, M. T., Cooper, C. M., Smith, S., Jr., Shields, F. D., Jr., Drouillard, K. G. and Schulz, R. 2005.Vegetated agricultural drainage ditches for the mitigation of pyrethroid associated runoff. Environmental Toxicology and Chemistry. 24:2121-2127.

Shields, F. D., Jr., Dabney, S. M., Langendoen, E. J. and Temple, D. M. 2005.Control of gully erosion using stiff grasses. International Journal of Sediment Research. 20 (4):319-332.

Shields, F. D., Jr., Langendoen, E. J. and Doyle, M. W. 2006.Adapting existing models to examine effects of agricultural conservation programs on stream habitat quality. Journal of the American Water Resources Association. 42 (1):25-33.

Pezeshki, S. R. and Shields, F. D., Jr. 2006.Black willow cutting survival in streambank plantings, Southeastern United States. Journal of the American Water Resources Association. 42 (1):191-200.

Li, S., Pezeshki, S. R. and Shields, F. D., Jr. 2006. Partial flooding enhances aeration in adventitious roots of black willow (Salix nigra) cuttings. Journal of Plant Physiology. 163(12):619-628.

Shields, F. D., Jr., Knight, S. S. and Stofleth, J. M. 2006.Large wood addition for aquatic habitat rehabilitation in an incised, sand-bed stream, Little Topashaw Creek, Mississippi. River Research and Applications. 22 (7):803-817.

Smith, S., Jr., Cooper, C. M., Lizotte, R., and Shields, F. D., Jr. 2006. Storm pesticide concentrations in Little Topashaw Creek, USA. International Journal of Ecology and Environmental Sciences. 32 (2):173-182.

Chao, X., Jia, Y., Cooper, C. M., Shields, F. D., Jr. and Wang, S. S. Y. 2006.Development and application of a phosphorus model for a shallow oxbow lake. Journal of Environmental Engineering. 132 (11):1498-1507. 2006. doi: 10.1061/(ASCE)0733-9372(2006) 132:11(1498).

Pezeshki, S. R., Li, S., Shields, F. D., Jr. and Martin, L. T. 2006. Factors governing survival of black willow (Salix nigra) cuttings in a field restoration project. Ecological Engineering. 29 (1):56-65. doi:10.1016/j.ecoleng.2006.07.014.

Greer, E. S., Pezeshki, S. R. and Shields, F. D., Jr. 2006.Root elongation of black willow stakes in response to cutting size and soil moisture regime (Tennessee). Ecological Restoration. 24 (3):195-197.

Greer, E. S., Pezeshki, S. R. and Shields, F. D., Jr. 2006.Influences of cutting diameter and soil moisture on growth and survival of black willow, Salix nigra. Journal of Soil and Water Conservation. 61 (5):311-323.

Shields, F. D., Jr., Langendoen, E. J. and Doyle, M. W. 2006.Reply to discussion of, "Adapting existing models to examine effects of agricultural conservation programs on stream habitat quality." Journal of the American Water Resources Association. 42 (6):1711-1713.

Wilson, G. V., Periketi, R., Fox, G. A., Dabney, S., Shields, F. D., Jr. and Cullum, R. F. Soil properties controlling seepage erosion contributions to streambank failure. Earth Surface Processes and Landforms. 32:447-459. 2007. DOI: 10.1002/esp.1405

Doyle, M. W., Shields, F. D., Jr., Boyd, K. F., Skidmore, P. B. and Dominick, D. Channel-forming discharge selection in river restoration design. Journal of Hydraulic Engineering. 133 (7):831-837. 2007. doi:10.1061/(ASCE)0733-9429(2007)133:7(831)

Shields, F. D., Jr., Knight, S. S. and Cooper, C. M.2007. Can warmwater streams be rehabilitated using watershed-scale standard erosion control measures alone? Environmental Management. 40:62-79. 2007. DOI 10.1007/s00267-006-0191-0.

Chao, X., Jia, Y., Shields, F. D., Jr. and Wang, S. S. Y. 2007. Numerical modeling of water quality and sediment related processes. Ecological Modeling 201: 385–397. doi: 10.1016/j.ecolmodel.2006.10.003

Simon, A., Doyle, M. W., Kondolf, M., Shields, F. D., Jr., Rhoads, B. and McPhillips, M. 2007.Critical evaluation of how the Rosgen Classification and Associated "Natural Channel Design" Methods Fail to Integrate and Quantify Fluvial Processes and Channel Response. Journal of the American Water Resources Association. 43 (5):1117-1131. 2007. doi: 10.1111/j.1752-1688.2007.00091.x.

Slate, L. O., Shields, F. D., Jr., Schwartz, J. S., Carpenter, D. D. and Freeman G. E. 2007. Engineering design standards for stream channel modification or restoration. Journal of Hydraulic Engineering 133 (10):1099-1185. 2007. doi:10.1061/(ASCE)0733-9429(2007)133:10(1099)

Shields, F. D., Jr., Knight, S. S. and Stofleth, J. M. 2008.Stream bed organic carbon and biotic integrity. Aquatic Conservation. 18:761–779.

Skinner, K., Shields, F. D., Jr., Harrison, S. 2008. Measures of Success: Defining the Outcomes. In S. E. Darby and Sear, D. (eds.) River Restoration: Managing the Uncertainty in Restoring Physical Habitat. John Wiley & Sons. Chichester, UK., pp. 187 – 208. ISBN: 978-0-470-86706-8.

Shields, F. D., Jr. 2008.Effects of a regional channel stabilization project on suspended sediment yield. Journal of Soil and Water Conservation 63 (2):59-69.

Stofleth, J., Shields, F. D., Jr. and Fox, G. A. 2008. Hyporheic and total hydraulic retention in small sand-bed streams. Hydrologic Processes. 22:1885-1894. doi: 10.1002/hyp.6773.

Chao, X., Jia, Y., Shields, F. D., Jr., Wang, S. S. Y. and Cooper, C. M. 2008.Three Dimensional Numerical Modeling of Cohesive Sediment Transport and Wind-Wave Impact in a Shallow Oxbow Lake. Advances in Water Resources. 31: 1004-1014.

Simon, A., Doyle, M. W., Kondolf, M., Shields, F. D., Jr., Rhoads, B. and McPhillips, M. 2008.Reply to discussion of "Critical evaluation of how the Rosgen Classification and Associated 'Natural

Channel Design' Methods Fail to Integrate and Quantify Fluvial Processes and Channel Response. Journal of the American Water Resources Association. 44 (3):793-802.

Wilson, G. V., Shields, F. D., Jr., Bingner, R. L., Reid-Rhoades, P., DiCarlo, D. A. and Dabney, S. M. Conservation Practices and Gully Erosion Contributions in the Topashaw Canal Watershed. 2008. Journal of Soil and Water Conservation. 63 (6):420-429. doi: 10.2489/jswc.63.6.420.

Shields, F. D., Jr., Pezeshki, S. R., Wilson, G. V., Wu, W. and Dabney, S. M. 2008. Rehabilitation of an incised stream with plant materials: the dominance of geomorphic processes. Ecology and Society 13 (2): 54. [online] URL: http://www.ecologyandsociety.org/vol13/iss2/art54/

Shields, F. D., Jr., Simon, A. and Dabney, S. 2009. Streambank dewatering for increased stability. Hydrological Processes. 23:1537–1547. doi: 10.1002/hyp.7286.

Knight, S. S., Lizotte, R. E., Jr., Moore, M. T., Smith, S., Jr. and Shields, F. D., Jr. 2009. Mississippi oxbow lake sediment quality during an artificial flood. Bulletin of Environmental Contamination and Toxicology. 82 (4):496-500. doi: 10.1007/200128-009-9653-4.

Knight, S. S., Lizotte, R. E., Jr. and Shields, F. D., Jr. Hyalella azteca responses to Coldwater River backwater sediments in Mississippi, USA. Bulletin of Environmental Contamination and Toxicology. 83 (4):493-496. doi: 10.1007/s00128-009-9804-7.

Lizotte, R. E., Shields, F. D., Jr., Knight, S. S. and Bryant, C. T. 2009. Efficiency of a Modified Backwater Wetland in Trapping a Pesticide Mixture. Ecohydrology. 2 (3):287-293. doi: 10.1002/eco.52.

Shields, F. D., Jr., Testa, S., III. and Cooper, C. M. 2009. Nitrogen and Phosphorus Levels in the Yazoo River Basin, Mississippi. Ecohydrology. 2 (3):270-278. doi: 10.1002/eco.49.

Smiley, P. C., Knight, S. S., Shields, F. D., Jr. and Cooper, C. M. 2009. Influence of gully erosion control on amphibian and reptile communities within riparian zones of channelized streams. Ecohydrology. 2 (3):303-312. doi: 10.1002/eco.59.

He, Z., Wu, W. and Shields, F. D., Jr. 2009. Numerical Analysis of Effects of Large Wood Structures on Channel Morphology and Fish Habitat Suitability in a Southern U.S. Sandy Creek. Ecohydrology. 2 (3):370-380. doi: 10.1002/eco.60.

Chao, X., Jia, Y., Shields, F. D., Jr., Wang, S. S. Y. and Cooper, C. M. 2009. Numerical simulation of sediment-associated water quality processes for a Mississippi Delta lake. Ecohydrology. 2 (3):350-359. doi: 10.1002/eco.72.

Langendoen, E. J., Shields, F. D., Jr. and Romkens, M. J. M. The National Sedimentation Laboratory: 50 Years of Soil and Water Research in a Changing Environment. Ecohydrology. 2 (3):227-234. 2009. doi: 10.1002/eco.85.

Shields, F. D., Jr. Do we know enough about controlling sediment to mitigate damage to stream ecosystems? 2009. Ecological Engineering. 35:1727–1733. doi: 10.1016/j.ecoleng.2009.07.004.

Smiley, P. C., Jr., Shields, F. D., Jr. and Knight, S. S. 2009. Designing impact assessments for evaluating ecological effects of agricultural conservation practices on streams. Journal of American Water Resources Association. 45:867-878.

Lizotte, R. E., Jr., Knight, S. S., Shields, F. D., Jr. and Bryant, C. T. 2009. Effects of an Atrazine, Metolachlor, and Fipronil Mixture on Hyalella azteca (Saussure) in a Modified Backwater Wetland. Bulletin of Environmental Contamination and Toxicology. 83:836-840. doi: 10.1007/s00128-009-9850-1.

Chao, X., Jia, Y., Shields, F. D., Jr., Wang, S. S. Y. and Cooper. C. M. 2010. Three-dimensional numerical simulation of water quality and sediment-associated processes with application to a Mississippi Delta lake. Journal of Environmental Management. 91:1456-1466. doi: 10.1016/j.jenvman.2010.02.009.

Farris, J. L., Milam, C. D., Moore, M. T., Bennett, E. R., Cooper, C. M., Smith, S., Jr. and Shields, F. D., Jr. 2010. Evaluating toxicity of atrazine and lambda-cyhalothrin amendments in agricultural ditch mesocosms. Chapter 10 in Moore, M. T. and Kroger, R. (eds.) Agricultural Drainage Ditches: Mitigation Wetlands for the 21st Century. 223-237.

Shields, F. D., Jr., Lizotte, R. E., Jr., Knight, S. S., Cooper, C. M. and Wilcox, D. L. 2010. The stream channel incision syndrome and water quality. Ecological Engineering. 36:78-90. DOI:10.1016/j.ecoleng.2009.09.014.

Shields, F. D., Jr. and Pearce, C. W. 2010. Control of agricultural nonpoint source pollution by natural wetland management. Journal of Environmental Science and Engineering. 4 (4):62-70.

Shields, F. D., Jr., Knight, S. S., Lizotte, R. E. and Wren, D. G. 2010. Connectivity and variability: Metrics for riverine floodplain backwater rehabilitation. In Simon, A., Bennett, S., Castro, J. and Thorne, C. R. (eds.) The Scientific Basis for Stream Restoration in Dynamic Fluvial Systems: Deterministic Approaches, Analyses and Tools. American Geophysical Union. 2010, Geophysical Monograph Series 194, pp. 233-246, doi 10.1029/2010GM000985.

Shields, F. D., Jr. Aquatic habitat bottom classification using ADCP. 2010. Journal of Hydraulic Engineering. 136 (5):336-342.

Testa, S., Shields, F. D., Jr. and Cooper, C. M. 2011. Macroinvertebrate response to stream restoration by large wood addition. Ecohydrology, 4: 631–643. doi: 10.1002/eco.146.

Lizotte, R. E., Jr., Shields, F. D., Jr., Knight, S. S., Cooper, C. M, Testa, S. III and Bryant, C. T. 2011. Effects of artificial flooding on water quality of a Coldwater River floodplain backwater. River Research and Applications. Published online. doi: 10.1002/rra.1553.

Shields, F. D., Jr., Lizotte, R. E., Jr. and Knight, S. S. 2011. Spatial and temporal water quality variability in aquatic habitats of a cultivated floodplain. River Research and Applications. Published online. doi: 10.1002/rra.1596

Shields, F. D., Jr. and Knight, S. S. 2011. Significance of riverine hypoxia for fish: The case of the Big Sunflower River, Mississippi. Journal of American Water Resources Association. Paper No. JAWRA-10-0164-P. Published online. doi: 10.1111/j.1752-1688.2011.00606.x

Kroger, R., Lizotte, R. E., Jr., Shields, F. D., Jr., and Usborne, E. 2012. Inundation influences on bioavailability of phosphorus in managed wetland sediments in agricultural landscapes, Journal of Environmental Quality 41(2):604-614. doi: 10.2134/jeq2011.0251

Doyle, M. W. and Shields, F. D., Jr. 2012. Compensatory mitigation for streams under the Clean Water Act: Reassessing science and redirecting policy. Journal of the American Water Resources Association (JAWRA) 48(3), 494-509. doi: 10.1111/j.1752-1688.2011.00631.x

Lizotte, R. E., Jr., Shields, F. D., Jr. Murdock, J. N., and Knight, S. S. 2012. Responses of Hyalella azteca and phytoplankton chlorophyll to a simulated agricultural runoff event in a managed backwater wetland. Chemosphere 87(2012):684-691. doi:10.1016/j.chemosphere.201.12.058

Lizotte, R. E., Jr., Shields, F. D., Jr., Murdock, J. N., Kroger, R., and Knight, S. S. 2012. Mitigating agrichemicals from an artificial runoff event using a managed riverine wetland. Science of the Total Environment 427–428 (2012), 373–381.

Shields, F. D., Jr. and Alonso, C. V. 2012. Assessment of flow forces on large wood in rivers. Water Resources Research. doi:10.1029/2011WR011547.

Shields, F.D., Jr. and Knight, S.S. 2012. Significance of riverine hypoxia for fish: The case of the Big Sunflower River, Mississippi. Journal of the American Water Resources Association 48(1), 170-186.

Lizotte, R. E., Jr., Shields, F. D., Jr. and Testa, Sam III. 2012. Effects of a simulated agricultural runoff event on sediment toxicity in a managed backwater wetland. Water, Air and Soil Pollution 223(18): 5375-5389. doi: 10.1007/s11270-012-1287-1

Knight, S.S., Shields, F. D., Jr., Smiley, P. C. 2012. Effects of channelization on fish biomass in river systems. Journal of Environmental Science and Engineering. A 1 (2012) 980-985.

Lizotte, Jr., R., Shields, Jr., F., Locke, M., Murdock, J. and Knight, S. 2013. Factors affecting low summer dissolved oxygen concentrations in Mississippi Delta bayous. Surface Water Quality.

Murdock, J. N, Shields, F. D., Jr. and Lizotte, R.E., Jr. 2013. Periphyton responses to nutrient and atrazine mixtures introduced through agricultural runoff. Ecotoxicology 22:215-230.

Shields, F.D., Jr. Knight, S.S. 2013. Floodplain restoration with flood control: Fish habitat value of levee borrow pits. Ecological Engineering 53(2013) 217-227.

Niezgoda, S. L., Wilock, P. R., Baker, D. W., Price, J. M., Castro, J. M., Curran, J. C., Thompson-Wynn, T., Schwartz, J. S., and Shields, F. D. 2014. Defining a stream restoration body of knowledge as a basis for national certification. Journal of Hydraulic Engineering, 140, 123-136.

Garbrecht, J. D., Nearing, M. A., Shields, F. D., Tomer, M. D., Salder, E. J., Bonta, J. V., and Baffaut, C. 2014. Impact of weather and climate scenarios on conservation assessment outcomes. Journal of Soil and Water Conservation, 69(5), 383-401.

Knight, S.S., Lizotte, R., and Shields, F.D. 2014. Effects of contaminated sediments on a backwater restoration project in the Mississippi River Delta. Journal of International Environmental Application and Science, 9(2), 231-237.

Knight, S.S., Shields Jr, F.D. 2014. Fish communities associated with a complex Mississippi stream system. International Journal of Ecological Science and Environmental Engineering. 1(3):73-79.

Surbeck, C.Q., Shields, F.D., Jr. and Cooper, A.M. 2016. Fecal indicator bacteria entrainment from streambed to water column: Transport by unsteady flow over a sand bed. Journal of Environmental Quality. Published online. doi: 10.2134/jeq2015.08.0441

Research Reports, Proceedings, Book Chapters and Technical Manuals

Shields, F. D., Jr. 1977. An evaluation of the Edinger-Polk Model for a heated discharge into a uniform current. Nashville, TN: Vanderbilt University. 50 pp. (Masters Thesis)

Shields, F. D., Jr. and Traggitt, G. N. 1978. Methane production from anaerobic fermentation of beef feedlot waste. Paper No. 78-4010, American Society of Agricultural Engineers, St. Joseph, MI.

Shields, F. D., Jr. and Traggitt, G. N. 1978. An evaluation of a complete disposal-recycle scheme for agricultural solid wastes. Final Report, CSRS Grant No. 616-15-122. Tennessee State University, Department of Civil Engineering, Nashville.

Shields, F. D., Jr. 1979. Turbidity under pre-construction conditions, divide cut, Tennessee-Tombigbee Waterway. U. S. Army Engineer District, Nashville, TN. (Technical report provided to States, later included as appendix to Supplemental Environmental Impact Statement for the Tennessee-Tombigbee Waterway)

Palermo, M. R., Shields, F. D., Jr. and Hayes, D. F. 1981. Development of a management plan for Craney Island disposal area. Technical Report EL-81-11, U. S. Army Engineer Waterways Experiment Station, Vicksburg, MS. 180 pp.

Shields, F. D., Jr. 1981. Environmental considerations for flood control channel modification. Environmental Water Quality and Operational Studies Information Exchange Bulletin, Vol. E-80-1 1-6. U. S. Army Engineer Waterways Experiment Station, Vicksburg, MS.

Shields, F. D., Jr. 1981. Reducing suspended solids in fine grained dredged material effluents. In Proceedings, Progress in the Dewatering of Fine Particles Conf., U. S. Bureau of Mines and the University of Alabama, Tuscaloosa, Alabama.

Shields, F. D., Jr. 1982. Environmental features for flood control channels. Technical Report E 82-7, U. S. Army Engineer Waterways Experiment Station, Vicksburg, MS, 133 pp.

Shields, F. D., Jr. and Montgomery, R. L. 1982. Environmental Engineer Manual Series Plan. Environmental Water Quality and Operational Studies Information Exchange Bulletin, Vol., E-83-3, U. S. Army Engineer Waterways Experiment Station, Vicksburg, MS, 5-8 pp.

Shields, F. D., Jr. and Palermo, M. R. 1982. Assessment of environmental considerations in the design and construction of waterway projects. Technical Report E-82-8, U. S. Army Engineer Waterways Experiment, Vicksburg, MS, 214 pp.

Shields, F. D., Jr. 1983. Dike field meeting. Environmental Water Quality and Operational Studies Information Exchange Bulletin, Vol. E-83-1, U. S. Army Engineer Waterways Experiment Station, Vicksburg, MS, 2-4 pp.

Burch, C. W., Abell, P. R., Stevens, M. A., Dolan, R., Dawson, B. and Shields, F. D., Jr. 1984. Environmental guidelines for dike fields. Technical Report E-84-4, U. S. Army Engineer Waterways Experiment Station, Vicksburg, MS, 236 pp. 1984.

Henderson, J. E. and Shields, F. D., Jr. 1984. Environmental features for bank protection projects. Technical Report E-84-11, U. S. Army Engineer Waterways Experiment Station, Vicksburg, MS, 150 pp.

Shields, F. D., Jr. 1984. Environmental guidelines for dike fields. In: C.M. Elliott, editor. Proceedings of the Conference Rivers '83. River Meandering, 430-442.

Shields, F. D., Jr. and Montgomery, R. L. 1984. Fundamentals of capping contaminated dredged material. In: Proceedings of the Conference Dredging '84. Dredging and Dredged Material Disposal, November 14-16, 1984, Clearwater, Florida, 446-460.

Hynson, J. R., Adamus, P. R., Elmer, J. O., Dewan, T. and Shields, F. D., Jr. 1985. Environmental features for levee projects. Technical Report E-85-7, U. S. Army Engineer Waterways Experiment Station, Vicksburg, MS, 297 pp.

Nunnally, N. R. and Shields, F. D., Jr. Incorporation of environmental features in design and construction of flood control channel projects. Technical Report E-85-3, U. S. Army Engineer Waterways Experiment Station, Vicksburg, MS, 277 pp.

Shields, F. D., Jr. and Abt, S. R. 1986. Management strategy for severed meander bends. In: M. Karamouz, G. R. Baumli, and W. J. Brick, editors. Proceedings of Water Forum '86. World Water Issues in Evolution, 1702-1709.

Shields, F. D., Jr. and Abt, S. R. 1986. Selection of management strategy for severed meander bends. In: S. Y. Wang, H. W. Shen, and L. Z. Ding, editors, Proceedings of the Third International Symposium on River Sedimentation. River Sedimentation, Volume III. School of Engineering, The University of Mississippi, Oxford, MS, 1013-1022.

Shields, F. D., Jr. and Nunnally, N. R. 1986. Effects of river training structures on aquatic habitat distribution. Water Operations Technical Support Information Exchange Bulletin, Vol. E-86-1, U. S. Army Engineer Waterways Experiment Station, Vicksburg, MS, 1-3 pp.

Shields, F. D., Jr. and Nunnally, N. R. 1986. Screening streambank protection alternatives for environmental considerations. Water Operations Technical Support Information Exchange Bulletin, Vol. E-86-2. U. S. Army Engineer Waterways Experiment Station, Vicksburg, MS, 1 4 pp.

Shields, F. D., Jr. 1987. Management of cutoff meander bends, Fort Collins, Colorado: Colorado State University, 226 pp. (Ph.D. Dissertation)

Shields, F. D., Jr. 1987. Management of environmental resources associated with cutoff bends along the Tennessee-Tombigbee Waterway. Miscellaneous Paper EL-87-12, U. S. Army Engineer Waterways Experiment Station, Vicksburg, MS, 204 pp.

Shields, F. D., Jr. and Nunnally, N. R. 1987. ENDOW, an expert system for screening environmental features for stream alterations. In: A. D. Feldman, editor. Proceedings of the Symposium of Engineering Hydrology, American Society of Civil Engineers, New York. 133-138.

Shields, F. D., Jr., Thackston, E. L., Schroeder, P. R. and Bach, D. P. 1987. Design and management of dredged material containment areas to improve hydraulic performance. Technical Report D-87-2, U. S. Army Engineer Waterways Experiment Station, Vicksburg, MS. 141 pp.

Shields, F. D., Jr. (with others). 1987. Environmental engineering for deep draft waterways. EM 1110-2-1202, U. S. Army Corps of Engineers, Washington, D.C.

Pennington, C. H., Shields, F. D., Jr., Sjostrom, J. W. and Myers, K. A. 1988. Biological and physical effects of Missouri River spur dike notching. Miscellaneous Paper EL-88-11, U. S. Army Engineer Waterways Experiment Station, Vicksburg, MS. 56 pp.

Shields, F. D., Jr. 1988. Effectiveness of spur dike notching. In: Proceedings of the 1988 National Conference on Hydraulic Engineering, August 8-12, 1988. 334-339.

Shields, F. D., Jr. 1988. ENDOW, an expert system for technology transfer. Water Operations Technical Support Information Exchange Bulletin, Vol. E-88-3, U. S. Army Engineer Waterways Experiment Station, Vicksburg, MS. 1-5 pp.

Shields, F. D., Jr. 1988. Settling and consolidation tests of shoal material, Kings Bay, Georgia. Internal Working Document EL-88-3, U. S. Army Engineer Waterways Experiment Station, Vicksburg, MS.

Walski, T. M., Sharp, W. W. and Shields, F. D., Jr. 1988. Predicting internal roughness in water mains. Miscellaneous Paper EL-88-2, U. S. Army Engineer Waterways Experiment Station, Vicksburg, MS, 29 pp.

Shields, F. D., Jr. 1989. Economic optimization of confined disposal area dimensions. Technical Note EEDP-06-5, U. S. Army Engineer Waterways Experiment Station, Vicksburg, MS.

Shields, F. D., Jr. and Gibson, A. C. 1989. Physical changes in cutoff bends along the Tennessee-Tombigbee Waterway. Miscellaneous Paper EL-89-5, U. S. Army Engineer Waterways Experiment Station, Vicksburg, MS. 133 pp.

Shields, F. D., Jr., MacDonald, A. and Pahl, H. H. 1989. Vegetation on riprap revetment: Problem definition and study approach. In: Proceedings of the 16th Annual Conference of Water Resources Planning and Management. American Society of Civil Engineers, New York. 669-672.

Shields, F. D., Jr. with others. 1989. Environmental engineering for local flood control channels. Engineer Manual 1110-2-1205, Headquarters, U. S. Army Corps of Engineers, Washington, D.C. 92 pp.

Milhous, R. T., MacArthur, R. C., Shields, F. D., Jr. and Adams, J. R. 1990. Sediment and aquatic habitat associations in river systems. In: Proceedings of the American Society of Civil Engineers National Conference on Hydraulic Engineering, July 30-August 3, 1990, San Diego, California. 1104-1109.

Shields, F. D., Jr. and Schaefer, T. E. Analysis of management alternatives for Aberdeen Lake bendways. Report submitted to the U.S. Army Engineer District, Mobile, Alabama, U. S. Army Engineer Waterways Experiment Station, Vicksburg, MS. 13 pp. 1990.

Shields, F. D., Jr., Cobb, S. P., Elliott, C. E. and Gibson, A. C. 1990. Environmental design criteria for lower Mississippi River dike systems. Report submitted to Lower Mississippi River Environmental Program, Mississippi River Commission, Vicksburg, MS.

Shields, F. D., Jr. and Copeland, R. R. 1990. Environmental design of channels - Can it be done? In: Proceedings of the American Society of Civil Engineers National Conference on Hydraulic Engineering, July 30-August 3, 1990, San Diego, California. 181-186.

Shields, F. D., Jr., Ethridge, L. T. and Waller, T. N. 1990. A study of vegetation on revetments, Sacramento River bank protection project, Phase 1: Literature Review and Pilot Study. Technical Report HL-90-19, U. S. Army Engineer Waterways Experiment Station, Vicksburg, MS. 138 pp.

Shields, F. D., Jr., Hoover, J. J., Nunnally, N. R., Killgore, K. J. and Schaefer, T. E. 1990. Hydraulic and environmental effects of channel stabilization, Twentymile Creek, Mississippi. Technical Report EL-90-14, U. S. Army Engineer Waterways Experiment Station, Vicksburg, MS. 117 pp.

Shields, F. D., Jr., and Ingram, J. J. 1990. River engineering and environmental resources. Proceedings of the American Society of Civil Engineers National Conference on Hydraulic Engineering, July 30-August 3, 1990, San Diego, California. 1128-1133.

Shields, F. D., Jr. and Lightcap, T. A. Tenn-Tom Bendways -1990. Lessons from another system. In: Loftin, M. K., Toth, L. A. Obeysekera, J. T. B., editors. Proceedings of the Kissimmee River Restoration Symposium, October 17-20, 1988, Orlando, Florida. 257-268.

Shields, F. D., Jr. and Schaefer, T. E. 1990. ENDOW users' guide. Instruction Report W-90-1, U. S. Army Engineer Waterways Experiment Station, Vicksburg, MS. 53 pp.

Shields, F. D., Jr., Schaefer, T. A. and Gibson, A. C. 1990. Relationships of physical and biological characteristics of cutoff bends along the Tennessee-Tombigbee Waterway. Miscellaneous Paper EL-90-4, U. S. Army Engineer Waterways Experiment Station, Vicksburg, MS. 67 pp.

Smith, R. H. and Shields, F. D., Jr. 1990. Effects of clearing and snagging on physical conditions of rivers. In: Proceedings of the Mississippi Water Resources Conference, 10-11 April 1990, Jackson, Mississippi. 41-51.

Gray, D. H., MacDonald, A., Thomann, T., Blatz, I. and Shields, F. D., Jr. 1991. Effects of woody vegetation on the structural integrity of sandy levees. Technical Report REMR-EI-5, U. S. Army Engineer Waterways Experiment Station, Vicksburg, MS. 145 pp.

Miller, J. and Shields, F. D., Jr. 1991. A knowledge-based system for the environmental design of waterways (ENDOW). In: Shane, R. M., editor. Proceedings of the 1991 National Conference of Hydraulic Engineering, American Society of Civil Engineers, New York. 912-917.

Shields, F. D., Jr. and Smith, R. H. 1991. Large woody debris effects on channel friction factor. In Shane, R. M., (ed.), Proceedings of the 1991 National Conference of Hydraulic Engineering, American Society of Civil Engineers, New York, 757-762.

Smith, R. H., Shields, F. D., Jr. and Dardeau, E. A., Jr. 1991. Large woody debris effects on physical conditions of rivers. In: Proceedings of the 27th Annual Conference, Water Management of River Systems, American Water Resources Association, Bethesda, Maryland. 353-354.

Shields, F. D., Jr. and Cooper, C. M. 1992. Status of wetlands and riparian program: Agricultural Research Service. In: W. H. Blackburn and J. G. King, editors. Proceedings of the First USDA Water Resource Research/Technology Transfer Workshop. Water Resource Challenges and Opportunities for the 21st Century. U. S. Department of Agriculture, Agricultural Research Service, ARS-101. 35-42.

Shields, F. D., Jr., Cooper, C. M. and Knight, S. S. 1992. Rehabilitation of aquatic habitats in unstable streams. In P. Larsen and N. Eisenhauer, editors, Proceedings of the Fifth International Symposium on River Sedimentation, Karlsruhe, Germany. 1093-1102.

Smith, R. H., Shields, F. D., Jr., Dardeau, T., Schaefer, T. E. and Gibson, A. C. 1992. Incremental effects of large woody debris removal on physical aquatic habitat. Technical Report EL-92-35, U.S. Army Engineer Waterways Experiment Station, Vicksburg, MS. 83 pp.

Pennington, C. H. and Shields, F. D., Jr. 1993. Dikes and levees. In: F. C. Bryan and D. A. Rutherford, editors. Impacts on warmwater streams: guidelines for evaluation. Southern Division, American Fisheries Society, Little Rock, Arkansas. pp.115-134.

Cooper, C. M., Shields, F. D., Jr. and Knight, S. S. 1993. Beyond the Fence: Implications of Agricultural Erosion for Aquatic Ecosystems. In: Proceedings of the First International Conference on Hydro-Science and Engineering, Washington, D. C., June 7-11, 1993, Center for Computational Hydroscience and Engineering, The University of Mississippi. 596-605.

Shields, F. D., Jr., Knight, S. S. and Cooper, C. M. 1993. Restoration of an incised channel: preliminary results. Proceedings of the First International Conference on Hydro-Science and -Engineering, Washington, D. C., June 7-11, 1993, Center for Computational Hydroscience and Engineering, The University of Mississippi. 1364-1369.

Shields, F. D., Jr. and Cooper, C. M. 1994. Riparian Wetlands and Flood Stages. In: G. V. Controneo and R. R. Rumer, editors. Proceedings of the 1994 Conference, Hydraulic Engineering '94, American Society of Civil Engineers, New York. 351-355.

Shields, F. D., Jr., Knight, S. S. and Cooper, C. M. 1994. Rehabilitation of watersheds with incising channels in Mississippi, U.S.A. Proceedings of the Korean Society of Civil Engineers, Annual Meeting, October 21-22, 1994, Pusan. 101-121.

Shields, F. D., Jr., Cooper, C. M. and Testa, S, III. 1995. Towards greener riprap: environmental considerations from microscale to macroscale. In: Thorne, C. R., Abt, S. R, Barends, F. B. J., Maynord, S. T., Pilarczyk, K. W., editors. River, coastal and shoreline protection: erosion control using riprap and armourstone. John Wiley & Sons, Ltd., Chichester, U. K. 557-574 pp.

Shields, F. D., Jr., Knight, S. S. and Cooper, C. M. 1995. Streambank protection and habitat restoration. In Espey, W. H., Jr., Combs, P. G., editors. Proceedings of the First International

Conference on Water Resources Engineering, American Society of Civil Engineers, New York. 721-725.

Knight, S. S., Cooper, C. M. and Shields, F. D., Jr. 1995. Ecological evaluation of watershed management projects. In: Proceedings of the Second International Conference on Hydroscience and Engineering, Tsinghua University Press, Beijing. 813-821.

Shields, F. D., Jr., Knight, S. S. and Cooper, C. M. 1996. A tale of two streams: restoration strategies compared. In: Proceedings, Sixth Federal Interagency Sedimentation Conference. Vol. 1, II. 24-31.

Knight, S. S., Shields, F. D., Jr. and Cooper, C. M. 1996. Ecological studies on the Demonstration Erosion Control Project in the Yazoo Basin. In: Proceedings, Sixth Federal Interagency Sedimentation Conference, Vol. 1, II. 6-13.

Shields, F. D., Jr., Doyle, M. W., Knight, S. S. and Cooper, C. M. 1996. Channel restoration of incising, mixed grain size streams: lessons learned. In Bathala, C. T., editor. Proceedings of the North American Water and Environment Congress, American Society of Civil Engineers, New York, CD-ROM.

Brookes, A. and Shields, F. D., Jr., editors. 1996. River Channel Restoration. John Wiley & Sons, Ltd., Chichester, U. K. 433 pp.

Brookes, A. and Shields, F. D., Jr. 1996. Perspectives on river channel restoration. In Chapter 1 in Brookes, A., Shields, F. D., Jr. (eds.) River Channel Restoration, John Wiley and Sons, Ltd., Chichester, U. K. 1-20 pp.

Shields, F. D., Jr. Hydraulic and Hydrologic Stability. 1996. In Chapter 2 in Brookes, A., Shields, F. D., Jr. (eds.) River Channel Restoration, John Wiley and Sons, Ltd., Chichester, U. K. 23-74 pp.

Brookes, A., Knight, S. S. and Shields, F. D., Jr. 1996. Habitat enhancement. In Chapter 4 in Brookes, A., Shields, F. D., Jr. (eds.) River Channel Restoration, John Wiley and Sons, Ltd., Chichester, U. K. 103-126 pp.

Brookes, A. and Shields, F. D., Jr. 1996. A sustainable approach to river restoration. In Chapter 14 in Brookes, A., Shields, F. D., Jr. (eds.) River Channel Restoration, John Wiley and Sons, Ltd., Chichester, U. K. 385-402 pp.

Shields, F. D., Jr. 1997. Reach-average dimensions for channel reconstruction. In Wang, S. Y., Carstens, T. (eds.) Proceedings of Environmental and Coastal Hydraulics: Protecting the Aquatic Habitat. Theme B, Vol. 1, XXVII Congress of the International Association for Hydraulic Research, ASCE, New York. 388-393.

Cooper, C. M., Knight, S. S. and Shields, F. D., Jr. 1997. The Demonstration Erosion Control Project: Water Quality in Incised Streams. In Wang, S. Y., Langendoen, E., Shields, F. D., Jr. (eds.) Proceedings of Management of Landscapes Disturbed by Channel Incision, Stabilization, Rehabilitation, and Restoration, Center for Computational Hydroscience and Engineering, University of Mississippi, University, Mississippi. 1025-1028.

Knight, S. S., Shields, F. D., Jr. and Cooper, C. M. 1997. Fisheries-Based Characterization of Demonstration Erosion Control Project Streams. In Wang, S. Y., Langendoen, E., Shields, F. D., Jr. (eds.) Management of Landscapes Disturbed by Channel Incision, Stabilization, Rehabilitation, and Restoration, Center for Computational Hydroscience and Engineering, University of Mississippi, University, Mississippi. 893-897.

Cooper, C. M., Testa, S., III and Shields, F. D., Jr. 1997. Invertebrate Response to Physical Habitat Changes Resulting from Rehabilitation Efforts in an Incised Unstable Stream. In Wang, S. Y., Langendoen, E., Shields, F. D., Jr. (eds.) Management of Landscapes Disturbed by Channel Incision, Stabilization, Rehabilitation, and Restoration, Center for Computational Hydroscience and Engineering, University of Mississippi, University, Mississippi. 887-892.

Doyle, M. W., Shields, F. D., Jr., Cooper, C. M. and Wallerstein, N. 1997. Incised channel bed material size trends in northwestern Mississippi. In Wang, S. Y., Langendoen, E. and Shields, F. D., Jr. (eds.) Management of Landscapes Disturbed by Channel Incision, Stabilization, Rehabilitation, and Restoration, Center for Computational Hydroscience and Engineering, University of Mississippi, University, Mississippi. 641-646.

Shields, F. D., Jr. and Cooper, C. M. 1997. Stream Habitat Restoration Using Spurs Added to Stone Toe Protection. In Wang, S. Y., Langendoen, E. and Shields, F. D., Jr. (eds.) Management of Landscapes Disturbed by Channel Incision, Stabilization, Rehabilitation, and Restoration, Center for Computational Hydroscience and Engineering, University of Mississippi, University, Mississippi. 667-672.

Bernard, J., Shields, F. D., Jr., Munsey, T. and Steffen, L. 1997. The Missouri River below Ft. Peck Dam, Montana: To Fix the River or To Fix the Banks? In Wang, S. Y., Langendoen, E., Shields, F. D., Jr. (eds.) Management of Landscapes Disturbed by Channel Incision, Stabilization, Rehabilitation, and Restoration, Center for Computational Hydroscience and Engineering, University of Mississippi, University, Mississippi. 781-787.

Kuhnle, R. A., Alonso, C. V. and Shields, F. D., Jr. 1997. Volume of scour holes associated with spur dikes. In Wang, S. Y. and Carstens, T. (eds.) Proceedings of Environmental and Coastal Hydraulics: Protecting the Aquatic Habitat. Theme B, Vol. 1, XXVII Congress of the International Association for Hydraulic Research. 418-423.

Kuhnle, R. A., Alonso, C. V. and Shields, F. D., Jr. 1997. Geometry of scour holes around spur dikes, an experimental study. In Wang, S. Y., Langendoen, E., Shields, F. D., Jr. (eds.) Management of Landscapes Disturbed by Channel Incision, Stabilization, Rehabilitation, and Restoration, University of Mississippi, University, Mississippi. 283-287.

Wang, S. Y., Langendoen, E. and Shields, F. D., Jr. 1997. (eds.) Management of Landscapes Disturbed by Channel Incision, Stabilization, Rehabilitation, and Restoration. University, Mississippi, University of Mississippi. 1134.

Shields, F. D., Jr. and Cooper, C. M. 1998. Principles for Woody Vegetation in River Restoration: Problems and Opportunities. Keynote lecture for the Proceedings of the International Symposium on River Restoration, Technology Research Center for Riverfront Development, Tokyo. 43-52.

Shields, F. D., Jr. and Bernard, J. M. 1998. Rehabilitation strategies for degraded stream corridors: Research opportunities involving vegetation. Paper No. 98-2130, American Society of Agricultural Engineers, St. Joseph, MI.

Knight, S. S., Cooper, C. M. and Shields, F. D., Jr. 1998. Impact of sediment in aquatic ecosystems. Paper No. 98-2129, American Society of Agricultural Engineers, St. Joseph, MI.

Doyle, M. W. and Shields, F. D., Jr. 1998. Perturbations of stage hydrographs caused by channelization and incision. In Abt, S. R., Young-Pezeshk, J. and Watson, C. C. (eds.) Proceedings of the International Conference on Water Resources Engineering. American Society of Civil Engineers, New York. 736-741.

Kuhnle, R. A., Alonso, C. V. and Shields, F. D., Jr. 1998. Volume of scour holes for angled spur dikes. In Abt, S. R., Young-Pezeshk, J. and Watson, C. C. (eds.), Proceedings of the International Conference on Water Resources Engineering. American Society of Civil Engineers, New York. 1613-1618.

Pezeshki, S. R., Shields, F. D., Jr. and Anderson, P. H. 1998. The relationships between soil conditions and growth of willow posts on streambanks. In Abt, S. R., Young-Pezeshk, J. and Watson, C. C. (eds.) Proceedings of the International Conference on Water Resources Engineering. American Society of Civil Engineers, New York. 447-452.

Shields, F. D., Jr. 1998. Woody vegetation in river restoration: problems and opportunities. In Abt, S. R., Young-Pezeshk, J. and Watson, C. C. (eds.) Proceedings of the International Conference on Water Resources Engineering. American Society of Civil Engineers, New York. 660-665.

Shields, F. D., Jr., Pezeshki, S. R. and Anderson, P. 1998. Probable causes for willow post mortality. In Hayes, D. F. (ed.) Proceedings of the 1998 Wetlands Engineering and River Restoration Conference, Engineering Approaches to Ecosystem Restoration. American Society of Civil Engineers, New York. CD-ROM.

Cooper, C. M., Shields, F. D., Jr. and Knight, S. S. 1998. Channel rehabilitation in incised streams: combining structures and ecology. In Hansen, H. O. and Madsen, B. L. (eds.) Proceedings of River Restoration '96—Session Lectures Proceedings. National Environmental Research Institute, Ministry of Environment and Energy, Denmark. 192-198.

Cooper, C. M., Hudson, F. D., Knight, S. S. and Shields, F. D., Jr. 1998. Channel Rehabilitation in Incised Streams: Using Stabilization Measures for Habitat Enhancement. Proceedings, The Delta: Connecting Points of View for Sustainable Natural Resources, Lower Mississippi Valley Natural Resources Partnership. 197-208.

Cooper, C. M., Testa, S., III, Gillespie, W. B., Jr., Shields, F. D., Jr. and Smiley, P. C., Jr. 1998. Preliminary assessment of the water quality, biological habitat, and biotic communities of the Yalobusha Watershed. National Sedimentation Laboratory Research Report No. 7.

Shields, F. D., Jr. and others. 1998. Analysis of corridor condition. Chapter 7 in Federal Interagency Stream Restoration Working Group, Stream Corridor Restoration: Principles, Processes and Practices. National Technical Information Service, U. S. Department of Commerce, Springfield, VA. 7-1—7-96 pp. 1998. . Also published as NRCS, U.S. Department of Agriculture (1998) Stream Corridor Restoration: Principles, Processes, and Practices. National Engineering Handbook (NEH), Part 653. Washington, D.C.

Shields, F. D., Jr. and others. 1998. Restoration design. Chapter 8 in Federal Interagency Stream Restoration Working Group, Stream Corridor Restoration: Principles, Processes and Practices. National Technical Information Service, U. S. Department of Commerce, Springfield, VA. 8-1—8-102 pp. 1998. . Also published as NRCS, U.S. Department of Agriculture (1998) Stream Corridor Restoration: Principles, Processes, and Practices. National Engineering Handbook (NEH), Part 653. Washington, D.C.

Shields, F. D., Jr., Brookes, A. and Haltiner, J. 1999. Geomorphological Approaches to Incised Stream Channel Restoration in the United States and Europe. In Chapter 14 in Darby, S. E. and Simon, A. (eds.) Incised River Channels: Processes, Forms, Engineering and Management, John Wiley and Sons, Ltd., Chichester, U. K. 371-394 pp.

Shields, F. D., Jr. Stream Corridor Restoration: Principles, Processes, and Practices (new federal interagency guidance document). Journal of Hydraulic Engineering. 125:5 440-442. 1999. (invited essay)

Shields, F. D., Jr. and Doyle, M. W. 2000. Sedimentation Engineering Design in River Restoration: System Stability Assessment for Design Guidance. In Walton, R. and Nece, R. E. (eds.) Proceedings of the 1999 International Water Resources Engineering Conference, Environmental and Water Resources Institute of the American Society of Civil Engineers, Reston, VA. CD-ROM.

Simon, A., Curini, A., Shields, F. D, Jr. and Bell, R. B. 2000. Bank instabilities along the Missouri River: The role of pore-water pressures and flow releases. In Proceedings of the ASCE 2000 Joint Conference on Water Resources Planning and Management, Environmental and Water Resources Institute of the American Society of Civil Engineers, Reston, VA. CD-ROM.

Simon, A., Shields, F. D., Jr., Ettema, R., Alonso, C., Marshall-Gardjo, M., Curini, A. and Steffen, L. 2000. Channel erosion on the Missouri River, Montana between Ft. Peck Dam and the North Dakota border. USDA-Agricultural Research Service National Sedimentation Laboratory, Oxford, Mississippi.

Shields, F. D., Jr., Knight, S. S., Cooper, C. M. and Testa, S., III. 2000. Large woody debris structures for incised channel rehabilitation. In Hotchkiss R. H. and Glade, M. (eds.) Proceedings of the Joint Conference on Water Resources Engineering and Water Resources Planning and Management, Building Partnerships. Environmental and Water Resources Institute of the American Society of Civil Engineers, Reston, VA. CD-ROM.

Shields, F. D., Jr., Morin, N. and Cooper, C. M. 2001. Design of large woody debris structures for channel rehabilitation. In U. S. Subcommittee on Sedimentation. Proceedings of the Federal Interagency Sedimentation Conferences, 1947 to 2001, Seventh Conference Proceedings, CD-ROM, Washington, D. C. II-42 – II-49.

Knight, S. S., Shields, F. D., Jr., Smiley, P. C. and Cooper, C. M. 2001. Comparison of fish catches from sediment damaged river ecosystems. Proceedings of the Federal Interagency Sedimentation Conferences, 1947 to 2001, Seventh Conference Proceedings, CD-ROM, Washington, D. C. Vol. I. P50 - P53.

Shields, F. D., Jr., Morin, N. and Kuhnle, R. A. 2001. Effects of large woody debris structures on stream hydraulics. In Hayes, D. F. (ed.) Proceedings of the 2001 Wetlands Engineering and River Restoration Conference, American Society of Civil Engineers, Reston, VA. CD-ROM.

Skidmore, P. B., Shields, F. D., Jr., Doyle, M. W. and Miller, D. E. 2001. A categorization of approaches to natural channel design. In Hayes, D. F. (ed.) Proceedings of the 2001 Wetlands Engineering and River Restoration Conference, American Society of Civil Engineers, Reston, VA. CD-ROM.

Pezeshki, S. R., Schaff, S. D. and Shields, F. D., Jr. 2002. Riverbank restoration in southern United States: The effects of soil texture and moisture regime on survival and growth of willow posts. In Holland, M. M., Warren M. L., Jr. and Stanturf, J. A. (eds.) Proceedings of the conference on sustainability of wetland and water resources. May 23-25, 2000, University of Mississippi, Oxford. USDA Forest Service, Southern Research Station, General Technical Report SRS-50, US Forest Service, Washington, D.C. 146-152.

Dabney, S., Shields, F. D., Jr., Temple, D., Collison, A. and Simon, A. 2002. Layout and Establishment of Grass Hedges for Gully Control. Proceedings of the 12th International Soil Conservation Organization Conference, May 26-31, 2002, Beijing, China. 464-470.

Moore, M. T., Cooper, C. M., Smith, S., Jr., Bennett, E. R., Schulz, R., Farris, J. L. and Shields, F.D., Jr. 2002. Influence of vegetation in mitigation of methyl parathion runoff. Proceedings of the 6th International Conference on Diffuse Pollution. International Water Association, London. 111-118.

Shields, F. D., Jr. and Knight, S. S. 2004. Ten Years After: Retrospective Evaluation of a Stream Habitat Restoration Project. In Clar, M., Carpenter, D., Gracie, J. and Slate, L. (eds.) Proceedings of the Symposium of Protection and Restoration or Urban and Rural Streams, American Society of Civil Engineers, Reston, VA. 38-50.

Shields Jr, F. D. 2003. Large wood as a restoration tool: I fought the law, and the law won. STREAMS Channel Protection and Restoration Conference. Ohio State Univ., Columbus, 6-7.

Shields Jr, F. D., and Knight, S. 2003. Ten years after: stream habitat restoration project in retrospect. In Proceedings of the World Water and Environmental Resources Congress, ASCE, Reston, VA, 23-26.

Shields Jr, F. D., Knight, S. S., Morin, N. and Blank, J. 2003. Response of fishes and aquatic habitats to sand-bed stream restoration using large woody debris. In: The Interactions between Sediments and Water. Springer, the Netherlands, 251-257.

Moore, M. T., Cooper, C. M., Bennett, E. R., Smith, S., Jr., Shields, F. D., Jr. and Farris, J. L. 2004. Vegetated drainage ditch research in the Mississippi Delta Management Systems Evaluation Area (MDMSEA): Current results and future directions. In Water Quality Assessments in the

Mississippi Delta: Regional Solutions and National Scope. American Chemical Society Symposium Series No. 877. 194-203 pp.

Zhu, T., Jia Y. and Shields, F. D., Jr. 2004. Water Quality Modeling of Lake Using CCHE2D. In Clar, M., Carpenter, D., Gracie, J. and Slate, L. (eds.) Proceedings of the Symposium of Protection and Restoration or Urban and Rural Streams, American Society of Civil Engineers, Reston, VA. 306-315.

Chao, X., Jia, Y. and Shields, F. D., Jr. 2004. Three-Dimensional Numerical Simulation of Flow and Mass Transport in a Shallow Oxbow Lake. In Sehlke, G., Hayes, D. F. and Stevens, D. K. (eds.) Proceedings of the 2004 World Water and Environmental Resources Congress: Critical transitions in Water and Environmental Resources. American Society of Civil Engineers, Reston, VA. CD-ROM.

Stofleth, J. M., Shields, F. D., Jr. and Fox, G. A. 2004. Organic carbon concentrations in hyporheic zone sediments: A tool for measuring stream integrity. In Sehlke, G., Hayes, D. F. and Stevens, D. K. (eds.) Proceedings of the 2004 World Water and Environmental Resources Congress: Critical transitions in Water and Environmental Resources. American Society of Civil Engineers, Reston, Virginia. CD-ROM.

Dabney, S. M., Shields, F. D., Jr. and Temple, D. M. 2004. Grass Hedge Effects on Gully Hydraulics and Erosion. In Proceedings, Third International Conference on Gully Erosion (GEC III), April 28-May 1, 2004, Oxford, Mississippi.

Shields, F. D., Jr., Langendoen, E. J. and Doyle, M. W. 2004. Assessing impacts of agricultural conservation on stream corridor ecosystems. Invited paper, In Lowrance, R. (ed.) Proceedings of American Water Resources Association 2004 Summer Specialty Conference: Riparian Ecosystems and Buffers: Multi-scale Structure, Function, and Management. AWRA, Middleburg, Virginia. CD-ROM.

Pezeshki, S. R. and Shields, F. D., Jr. 2004. Riparian ecosystem restoration using willow cuttings: Studies in Southern U.S. In Lowrance, R. (ed.) Proceedings of American Water Resources Association 2004 Summer Specialty Conference: Riparian Ecosystems and Buffers: Multi-scale Structure, Function, and Management. AWRA, Middleburg, Virginia. CD-ROM.

Shields, F. D., Jr. and Knight, S. S. 2005. Large wood for stream habitat restorations: harder than it looks. Stream Notes. Stream Systems Technology Center, Rocky Mountain Research Station, Fort Collins, CO. 4-6 pp.

Alonso, C. A., Shields, F. D., Jr. and Temple, D. M. 2005. Experimental Study of Drag and Lift Forces on Prototype-Scale Models of Large Wood. In R. Walton (ed.) Proceedings of the 2005 World Water and Environmental Resources Congress: Impacts of global climate change. American Society of Civil Engineers Proceedings 173 (581), Reston, Virginia. CD-ROM.

Simon, A., Doyle, M. W., Kondolf, M., Shields, F. D., Jr., Rhoads, B., Grant, G., Fitzpatrick, F., Juracek, K., McPhillips, M. and MacBroom, J. 2005. How well do the Rosgen and associated "natural channel design" methods integrate and quantify fluvial processes and channel response?" In Walton, R. (ed.) Proceedings of the 2005 World Water and Environmental

Resources Congress: Impacts of global climate change. American Society of Civil Engineers Proceedings 173 (584), Reston, Virginia. CD-ROM.

Shields, F. D., Jr., Knight, S. S. and Stofleth, J. M. 2005. Alternatives for riverine backwater restoration by manipulation of severed meander bend. In Walton, R. (ed.) Proceedings of the 2005 World Water and Environmental Resources Congress: Impacts of global climate change. American Society of Civil Engineers Proceedings 173 (566), Reston, Virginia. CD-ROM.

Stofleth, J. M., Shields, F. D., Jr. and Fox, G. A. 2005. Hyporheic and Total Storage Exchange in Small Sand-Bed Streams. In R. Walton (ed.) Proceedings of the 2005 World Water and Environmental Resources Congress: Impacts of global climate change. American Society of Civil Engineers Proceedings 173 (587), doi: 10.1061/40792(173)587, Reston, VA.

Chao, X., Jia, Y., Cooper, C. M. and Shields, F. D., Jr. 2005. Numerical Modeling of the Phosphorus Cycle in a Shallow Oxbow Lake. In Walton, R. (ed.) Proceedings of the 2005 World Water and Environmental Resources Congress: Impacts of global climate change. American Society of Civil Engineers Proceedings 173 (430), Reston, Virginia. CD-ROM.

Kuhnle, R. A., Alonso, C. V., Bingner, R. L., Langendoen, E. J., Simon, A., Wilson, C. G. and Shields, F. D., Jr. 2005. Goodwin Creek Experimental Watershed – Assessment of Conservation and Environmental Effects. Paper Number: 052130, 2005 American Society of Agricultural Engineers, ASAE Annual International Meeting, Tampa Convention Center, Tampa, Florida, 17 - 20 July 2005, St. Joseph, MI.

Chao, X., Jia, Y., Shields, F. D. Jr. and Wang, S. S. Y. 2005. Development and application of a three-dimensional water quality model for a shallow oxbow lake. Proceedings, U.S. – China Workshop on Advanced Computational Modeling in Hydroscience and Engineering, Oxford, Miss. USA September 19-21, 2005. National Center for Computational Hydroscience and Engineering, The University of Mississippi. CD-ROM.

Shields, F. D., Jr. and Copeland, R. R. 2006. A comparison of empirical and analytical approaches for stream channel design. Proceedings, Eighth Federal Interagency Sedimentation Conference, April 2-6, Reno, Nevada, Advisory Committee on Water Information, Subcommittee on Sedimentation, Washington, DC. CD-ROM.

Wu, W., He, Z., Wang, S. S. Y. and Shields, F. D., Jr. 2006. Analysis of aquatic habitat suitability using a depth-averaged 2-D model. Proceedings, Third Federal Interagency Hydrologic Modeling Conference, April 2-6, Reno, Nev., Advisory Committee on Water Information, Subcommittee on Hydrology, Washington, DC, CD-ROM.

Chao, X., Jia, Y., Shields, F. D., Jr. and Cooper, C. M. 2006. Three dimensional numerical modeling of cohesive sediment transport in a shallow oxbow lake. In Randall Graham (ed.) Proceedings of the 2006 World Water and Environmental Resources Congress: Examining the Confluence of Environmental and Water Concerns. American Society of Civil Engineers Proceedings, May 21-25, Reston, Virginia. CD-ROM.

Boyer, K. L. and Shields, F. D., Jr. 2007. Ecological and physical considerations for stream projects. Chapter 1 in Stream Restoration Design, National Engineering Handbook Part 654, USDA-NRCS Washington, D.C., CD-ROM.

Shields, F. D. Jr., Doyle, M. W., Copeland, R. R. and Fripp, J. 2007. Channel Forming Discharge. Section 654.0508 in Stream Restoration Design, National Engineering Handbook Part 654, USDA-NRCS, Washington, D.C., CD-ROM.

Shields, F. D., Jr. and Wood, A. D. 2007. The use of large woody material for habitat and bank protection. Technical Supplement 14J in Stream Restoration Design, National Engineering Handbook Part 654, USDA-NRCS Washington, D.C. CD-ROM.

Shields, F. D., Jr. 2007. Scour calculations. Technical Supplement 14B in Stream Restoration Design, National Engineering Handbook Part 654, USDA-NRCS, Washington, D. C., CD-ROM

Fripp, J. B., Copeland, R. R., Shields, F. D., Jr., Bernard, J., McComas, D., Jonas, M. and Goertz, L. 2007. Sediment impact assessments. Chapter 13 in Stream Restoration Design, National Engineering Handbook Part 654, USDA-NRCS, Washington, D.C., CD-ROM.

Ward, R. A., Brown, G. O, Weckler, P. R., Temple, D. M., Shields, F. D., Jr. and Alonso, C. V. 2007. Design of large wood structures in sand bed streams. Proceedings of the American Society of Agricultural and Biological Engineers, Paper Number 072241, 2007 Annual Meeting, ASABE, St. Joseph, MI.

Lowrance, R. R., Isenhart, T. M., Gburek, W. J., Shields, F. D., Jr., Wigington, P. J., Jr. and Dabney, S. M. 2006. Landscape Management Practices. In Schnepf, M. and Cox, C. (eds.) Environmental Benefits of Conservation on Cropland: The Status of Our Knowledge. The Soil and Water Conservation Society, Ankeny, Iowa. 269-317 pp.

Chao, X., Jia, Y., Shields, F. D., Jr. and Cooper, C. M. 2006. Numerical simulation of sediment related processes in water quality model. Proceedings of the 7th International Conference on Hydroscience and Engineering (ICHE-2006). Sep 10 - Sep 13, Philadelphia USA. ISBN 0977447405. 2007. http://idea.library.drexel.edu/handle/1860/1466.

Ward, R. A., Brown, G. O, Weckler, P. R., Temple, D. M., Shields, F. D., Jr. and Alonso, C. V. 2007. Modeling large wood structures in sand bed streams. Proceedings of the World Environmental and Water Resources Congress 2007, American Society of Civil Engineers, Reston, VA, CD-ROM.

Shields, F. D., Jr., Smiley, P. C., Jr. and Cooper, C. M. Modifying erosion control structures for ecological benefits. Journal of Soil and Water Conservation 62 (6):157A. 2007. (invited summary)

Shields, F. D., Jr. Long-term evaluation of regional erosion control. Journal of Soil and Water Conservation 62 (6):50A. 2008. (Invited summary)

Shields, F. D., Jr., Cooper, C. M., Testa, S., III and Ursic, M. E. 2008. Nutrient transport in the Yazoo River Basin. US Dept of Agriculture Agricultural Research Service National Sedimentation Laboratory, Research Report 60, Oxford, Miss.

Shields, F. D., Jr., Copeland, R. R., Klingeman, P. C., Doyle, M. W. and Simon, A. 2008. Stream restoration. In Chapter 9 in Sedimentation Engineering: Processes, Measurements, Modeling and Practice, Manual of Practice 110, American Society of Engineers, Reston, Virginia. 461-499 pp.

Shields, F. D., Jr., Testa, S., III and Cooper, C. M. 2008. Nutrient levels in the Yazoo River Basin. Proceedings of the conference, Fifty Years of Soil and Water Research in a Changing Agricultural Environment, September 2-5, 2008. National Sedimentation Laboratory, USDA Agricultural Research Service, Oxford, MS.

Shields, F. D., Jr. and Knight, S. S. 2008. Kondolf diagram for river restoration. In Babcock, R. W. and Walton, R. (eds.) Proceedings, 2008 World Environmental & Water Resources Congress. American Society of Civil Engineers, Reston, VA. CD-ROM.

Chao, X., Jia, Y., Shields, F. D., Jr., Wang, S. S. Y. and Cooper, C. M. 2008. Three-Dimensional Numerical Simulation of Water Quality and Sediment-Associated Processes with Application to a Delta Lake. Proceedings of the conference, Fifty Years of Soil and Water Research in a Changing Agricultural Environment, September 2-5, 2008. National Sedimentation Laboratory, USDA Agricultural Research Service, Oxford, MS.

Smiley, P. C., Jr., Knight, S. S., Shields, F. D., Jr. and Cooper, C. M. 2008. Influence of gully erosion control on amphibian and reptile communities within riparian zones of channelized streams. Proceedings of the conference, Fifty Years of Soil and Water Research in a Changing Agricultural Environment, September 2-5, 2008. National Sedimentation Laboratory, USDA Agricultural Research Service, Oxford, MS.

Wu, W., He, Z. and Shields, F. D., Jr. 2008. Numerical Analysis of Effects of Large Wood Structures on Channel Morphology and Fish Habitat Suitability in Little Topashaw Creek. Proceedings of the conference, Fifty Years of Soil and Water Research in a Changing Agricultural Environment, September 2-5, 2008. National Sedimentation Laboratory, USDA Agricultural Research Service, Oxford, MS.

Alonso, C. V., Shields, F. D., Jr. and Temple, D. M. 2009. Dynamics of large wood: A prototype-scale flume experiment. Water Engineering for a Sustainable Environment. Proceedings, International Association for Hydraulic Research 33rd Congress, IAHR, Madrid, CD-ROM.

Shields, F. D., Jr. 2009. River bed sediment classification using ADCP. In Starrett, S. (ed.) Proceedings of the World Environmental and Water Resources Congress: Great Rivers. American Society of Civil Engineers, Reston, VA. CD-ROM.

Shields, F. D., Jr., Knight, S. S., Stofleth, J. M. and Wren, D. G. 2009. Towards a basis for designing backwater and side channel restorations. Water Engineering for a Sustainable Environment. Proceedings, International Association for Hydraulic Research 33rd Congress, IAHR, Madrid, CD-ROM.

Chao, X., Jia, Y. and Shields, F. D., Jr. 2009. Three-dimensional numerical simulation of flow and pollutant transport with application to a shallow, natural lake. Water Engineering for a Sustainable Environment. Proceedings, International Association for Hydraulic Research 33rd Congress, IAHR, Madrid. CD-ROM.

Shields, F. D., Jr., Wilson, C. N., Bryant, C. T. and Testa, S., III. 2010. Management of an abandoned river channel wetland for mitigation of nonpoint source pollution. Proceedings, 2009 Mississippi Water Resources Conference, Mississippi Water Resources Research Institute, Mississippi State, Mississippi. 103-113.

Shields, F. D., Jr. and Knight, S. S. 2010. Pre-restoration assessment, Big Sunflower River, Mississippi: Where to Begin? Proceedings, 2010 World Water Congress, American Society of Civil Engineers, Reston, VA. CD-ROM.

Shields, F. D., Jr., Knight, S. S., Lizotte, R. E. and Wren, D. G. 2010. Floodplain river backwater restoration: a case study. Proceedings, 9th Federal Interagency Sedimentation Conference, Joint Federal Interagency Conference Organizing Committee, Washington, D.C., CD-ROM.

Lizotte, R. E., Shields, F. D., Jr., Knight, S. S., and Bryant, C. T. 2011. Pesticide Trapping Efficiency of a Modified Backwater Wetland Using a Simulated Runoff Event. Proceedings of the conference, "Fifty Years of Soil and Water Research in a Changing Agricultural Environment," September 2-5, 2008, National Sedimentation Laboratory, USDA Agricultural Research Service, Oxford, MS, CD-ROM, National Sedimentation Laboratory, Oxford, MS.

Shields, F. D., Jr., Testa, S. III, and Cooper, C. M. 2011. Nutrient levels in the Yazoo River Basin. Proceedings of the conference, "Fifty Years of Soil and Water Research in a Changing Agricultural Environment," September 2-5, 2008, National Sedimentation Laboratory, USDA Agricultural Research Service, Oxford, MS, CD-ROM, National Sedimentation Laboratory, Oxford, MS.

Wu, W., He, Z., and Shields, F. D., Jr. 2011. Numerical Analysis of Effects of Large Wood Structures on Channel Morphology and Fish Habitat Suitability in Little Topashaw Creek. Proceedings of the conference, "Fifty Years of Soil and Water Research in a Changing Agricultural Environment," September 2-5, 2008, National Sedimentation Laboratory, USDA Agricultural Research Service, Oxford, MS, CD-ROM, National Sedimentation Laboratory, Oxford, MS.

Smiley Jr., P. C., Knight, S. S., Shields, F. D., Jr., Cooper, C. M. 2011. Influence of gully erosion control on amphibian and reptile communities within riparian zones of channelized streams. Proceedings of the conference, "Fifty Years of Soil and Water Research in a Changing Agricultural Environment," September 2-5, 2008, National Sedimentation Laboratory, USDA Agricultural Research Service, Oxford, MS, , CD-ROM, National Sedimentation Laboratory, Oxford, MS.

Shields, F. D., Jr., Langendoen, E. J., Thomas, R. E. and Simon, A. 2011. Cyclical fluvial response caused by rechannelization. Proceedings, World Environmental and Water Resources Congress 2011, American Society of Civil Engineers, Reston, VA, CD-ROM.

Dabney, S.M., Shields, F. D., Bingner, R.L., Kuhnle, R. A. and Rigby, J. R. 2012. Watershed Management for Erosion and Sedimentation Control Case Study: Goodwin Creek, Panola County, MS. Chapter 20 in Soil Water and Agronomic Productivity, Advances in Soil Science, Taylor and Francis, Boca Raton, Florida.

Lizotte, R. E., Shields, F. D., Locke, M., Murdock, J., and Knight, S. S. 2013. Factors affecting low summer dissolved oxygen concentrations in Mississippi Delta bayous. Proc., Mississippi Water Resource Conference, 27-35. Mississippi Water Resources Institute. Starkville, MS.

Shields, F. D., and Brooks, A. 2014. Stream restoration. In Reference Module in Earth Systems and Environmental Sciences, Elsevier. <http://www.sciencedirect.com/science/article/pii/B9780124095489090424> (April 29, 2014).

California Department of Transportation. 2015. Caltrans Hydro modification Requirements Guidance Storm Water Best Management Practices Rapid Assessment of Stream Crossings Higher Level stream stability analysis. CTSW-OT-14-314.05. Sacramento, California.

Shields, F.D and others. 2016. National Large Wood Manual: Assessment, Planning, Design, and Maintenance of Large Wood in Fluvial Ecosystems: Restoring Process, Function, and Structure. 628 pages + Appendix. Available: www.usbr.gov/pn/. Prepared for U.S. Bureau of Reclamation and U.S. Army Corps of Engineers.

Shields, F.D. 2016. Synthesis of Levee Vegetation Research Results (2007-2014). Prepared for California Levee Vegetation Research Program. California Department of Water Resources. <http://www.water.ca.gov/floodsafe/leveeveg/levee_documents/2016-0127-Levee-Veg-Synthesis-Report-FINAL.pdf> (accessed March 30,2016).

Lagasse, P.F., Clopper, P.E., Thornton, C.I., Shields, F.D., McCullah, J. and Spitz, W.J. 2016. Final Report NCHRP Project No.24-39 Evaluation and assessment of environmentally sensitive stream bank protection measures. Prepared for National Cooperative High Research Board, Transportation Research Board and Nation Research Council. Washington, D.C.

Consulting Reports

Shields, F. D., Jr. 2005. Greenbank decision support system. Environmentally sensitive streambank stabilization software, Salix Applied Earthcare, Redding California. Produced under National Council for Highway Research Program, Transportation Research Board. www.esenss.com.

Shields, F. D. Jr. and Nickens, P.R. 2005. Site Protection for Kinishba Ruins at Kinishba Wash. Prepared for White Mountain Apache Tribe Historic Preservation Office, Whiteriver, AZ.

Shields, F. D. Jr. 2006. An examination of runoff, storm drainage, erosion and sedimentation issues surrounding design of the Main Street Taylor Development, Taylor Mississippi-Phase 1. Prepared for Mayor and Board of Aldermen Village of Taylor, Mississippi.

Nickens, Paul R., Jill A. Onken, F. Douglas Shields, Jr., and Michelle A. Wienhold. 2007. Archaeological Site Treatment Assessment: 10NP151 – Hasotino Village, Lower Granite reservoir, Nez Perce County, Idaho. Prepared for U.S. Army Corps of Engineers, Walla Walla District. Nickens and Associates, Tucson, AZ.

Shields, F. D. Jr. 2007. Miller Creek Stream Restoration Project—Site Visit and Recommendations. Letter report submitted to Volkert Environmental Group, Foley, AL.

Shields, F. D. Jr., Thomas, W. A., and Hudson, G. W. 2008. Geomorphology and Restoration Concepts for the Amite River Louisiana. Prepared for Taylor Engineering Baton Rouge, LA.

Shields, F. D. Jr. 2010. Hydrologic and Hydraulic Engineering Analyses to Support Daniel, Coker, Horton & Bell, P. A. in their defense of the City of Saltillo in the Case(s) of Crockett et al. v. City of Saltillo, MS. Submitted to Mr. Terry D. Little, esq. Daniel, Coker, Horton & Bell.

Shields, F. D., Jr. 2013. Hydrologic and Hydraulic Engineering Analyses to Support Daniel, Coker, Horton & Bell, P. A. in their Defense of the City of Corinth in the Case of Kmart Corporation v. City of Corinth, MS. et al. Submitted to Mr. Terry D. Little, esq. Daniel, Coker, Horton & Bell.

Shields, F.D. Jr. 2015. Caltrans Hydromodification Requirements Guidance
Storm Water Best Management Practices Rapid Assessment of Stream Crossings Higher Level Stream Stability Analysis. CTSW-OT-14-314.05. California Department of Transportation and cbec, inc. Sacramento, CA.

Lagasse, P.F., Clopper, P.E., Thornton, C.I., Shields, F.D., McCullah, J. and Spitz, W.J. 2015. Final Report NCHRP Project No.24-39 Evaluation and assessment of environmentally sensitive stream bank protection measures. Prepared for National Cooperative High Research Boar, Transportation Research Board and Nation Research Council. Washington, D.C.

Russian River Independent Science Review Panel. 2016. Conceptual model of watershed hydrology, surface water and groundwater interactions and stream ecology for the Russian River Watershed. Prepared for Sonoma County Water Agency and Russian River Mendocino County Flood Control and Water Conservation District, Russian River Water Conservation Council, and California Land Stewardship Institute. California Land Stewardship Institute. Napa, CA.

Clients

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Sacramento Area Flood Control Agency

cbec, inc. eco engineers

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Village of Taylor, Mississippi

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