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SURFICIAL GEOLOGIC MAP OF THE WEST FRANKLIN QUADRANGLE, VANDERBURGH AND POSEY COUNTIES, INDIANA, AND HENDERSON COUNTY, KENTUCKY

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DESCRIPTION OF MAP UNITS

Artificial fill (late Holocene)—Unconsolidated silt and fine sand, crushed stone, masonry, and paving materials in roadbeds, dams, and manmade levees; degrees of grading and compaction vary. Earthen dams are chiefly loess containing some shale and sandstone fragments. Railroad ballast is crushed rock generally 6 cm or less in diameter. In southeastern part of quadrangle, the north-northwest-trending, narrow, linear Louisville and Nashville railroad is a manmade, earthen levee topped by gravel ballast. Thickness of fill throughout quadrangle 1–7 m

Alluvium in sloughs (Holocene)—Brown (10YR 4/3), grayish-brown (2.5Y 5/2), and dark-gray (5Y 4/1) clayey silt, silty clay, and silty clay loam (McWilliams, 1979), containing 5–15 percent very fine, micaceous sand, relatively rich in organic matter. Three-dimensional shape of unit is narrow, long, and thin. At about 0.5–1 m depth, large dark-yellowish-brown (10YR 4/4) mottles are common. Thick laminae of fine sand are present. Presumably, older, genetically equivalent clayey deposits are present within the Ohio River alluvium (unit Qal), marking positions of former sloughs. Estimated thickness 1–3 m

Colluvium (Holocene)—Moderate-yellowish-brown (10YR 5/4) silt, silty sand, and granules mixed with sparse, angular pebbles of sandy shale, siltstone, and sandstone on hillslopes. Locally common are pedogenic nodules of calcium carbonate, calcium magnesium carbonate (dolomite), and iron-manganese oxide(?) 1–5 mm in diameter. Unit comprises loess and pebble-size bedrock detritus imperceptibly creeping down hillslopes. It is eroded locally, exposing meter-scale bedrock outcrops. Although colluvium is present on hillslopes throughout quadrangle, only the steepest (18–25 percent) slopes were mapped because these may be unstable during earthquakes or problematic as building sites. Locally present are sparse, shallow (<1.5 m) slumps and a hummocky surface that overlie a low-angle failure surface, probably at the contact with the underlying bedrock. Thickness 0.5–1.5 m

Creek alluvium and sheetwash alluvium (Holocene and late Pleistocene)—Underlies creek floodplains. Upper several meters (Holocene) is moderate-yellowish-brown (10YR 5/4) and light-yellowish-brown (10YR 6/4) silt and slightly clayey silt, silty very fine sand, and sandy silt, massive and planar laminated. This part includes silty sheetwash alluvium eroded from nearby loess-covered hills. Near bedrock valley walls, unit grades laterally to silty colluvial aprons (toe slopes of hills) that contain small pieces of shale and sandstone. Locally, unit contains brownish-yellow (10YR 6/6) shale and concretion pieces. It may include sediments of intermittent slackwater lakes. Base of unit is not exposed, and in many places is presumed by most workers to be inset into older valley fill at an erosional contact. Possibly, in places, unit grades downward into fine-grained, laminated sediment that is lacustrine or older creek alluvium of late Pleistocene age. General thickness of unit about 2–8 m

River floodplain alluvium, levee alluvium, and outwash (Holocene and late Pleistocene)—Ohio River valley fill, the most voluminous alluvial unit in map area. Unit underlies the river floodplain, of which low areas are flooded almost yearly or once in 2–3 yr. Unit is chiefly lithic quartz sand; yellowish-brown (10YR 5/6) fine-grained sand, silt, and clay grading downward to dark-grayish-brown (2.5YR 4/2) and olive-gray (5Y 4/2) medium- to coarse-grained sand, granules, gravelly sand, and sandy gravel. B and C horizons of a buried soil, developed on a pre-European settlement land surface, were penetrated at 1.3–2.4 m depth in auger hole DH–2. The buried soil is in brown (10YR 5/3) clayey silt having clay skins, prismatic peds, and yellowish-brown (10YR 5/6) medium mottles, underlain by clayey silt containing abundant $CaCO_3$ concretions 1–2 cm in diameter. Deposits of unit Qal locally include laminae of fine sand and lenses of clay, silty clay, and sandy pebble gravel, which may have been deposited in meander-scroll swales on a late Pleistocene floodplain (equivalent to Holocene unit Qas) (McWilliams, 1979). Gravel pits in Evansville South quadrangle (adjoining to the east) expose cross bedding in sets 10 cm to 1 m thick, and planar bedding 2–10 cm thick on average. Alluvium in the pits is chiefly sand, pebbles, and sparse cobbles composed of chert, dolostone, sandstone, limestone, granitoid rock, dacite, quartzite, and quartz. About 5 percent of sand is coal and dark-gray carbonaceous shale. Thickness is uncertain because of no definite base within the entire fill of the Ohio River valley. Maximum known thickness of valley fill, 35–39.6 m, is above a bedrock paleochannel in Kentucky at south edge of West Franklin quadrangle (Harvey, 1956, p. 75 and plate 5)

River terrace alluvium (Holocene and late Pleistocene)—Dark-brown (10YR 3/3) and dark-yellowish-brown (10YR 4/4), fine- to coarse-grained quartz and subordinate lithic sand; includes lenses of granules and pebbles in lower part. Upper part of unit, from surface to 3–9 m depth, is Holocene in age and is mainly fine sandy silt, silt, and clayey silt. This upper part includes some loess, alluvium deposited in swales, and sheetwash alluvium derived from nearby hillslopes, all reworked by occasional river flooding. Main body, below 3–9 m, probably was deposited in braided channels by turbid glacial meltwater during and in waning phase of floods. Layers 0.5–2 m thick of olive-gray (5Y 4/2), light-blue (5B 7/6), and very dark gray (10YR 3/1) plastic and sticky clay ("blue clay" or "blue mud" as described by water-well drillers) were penetrated by auger (Appendix, DH–3 lithologic log, 25–30 ft and 35–37 ft depths), and are clay plugs of an oxbow lake deposit and (or) older lacustrine clay that interfingers with adjacent sandy alluvium. Top several meters of DH–3 are a lacustrine terrace deposit that rims northern arcuate edge of the river terrace. Sandy layers below about 7 m depth are river-terrace alluvium or outwash. Elevation of terrace surface is 370–380 ft above sea level, 28–40 ft (8.5–12 m) above normal-pool elevation of Ohio River—printed on 1981 topographic quadrangle map as 342 ft above sea level. The latter exceeds the previously published normal-pool elevations of 329 ft (1956) and 338 ft (1971), probably a result of construction of the J.T. Myers dam downstream (near Uniontown, Ky.), completed in 1975 (William Andrews, oral commun., 2006). Parts of the terrace were flooded by the 1937 flood, perhaps a 100-yr flood. The lower, coarse sand, granules, and gravelly part of unit are channel and bar deposits (outwash) deposited in late Pleistocene time (Fraser and Fishbaugh, 1986). This part underlies unit Qal (fig. 5). Thickness of main body is estimated to be 10–28 m, and 2–3 m near its margins

Lacustrine terrace deposit (late Pleistocene)—Moderate-yellowish-brown (10YR 5/4) silt, clayey silt, and clay, containing laminae of silty, very fine sand. Below about 5 m, unit is gray (10YR 5/1) laminated silt, slightly clayey silt, and very fine grained sand laminae in places. Near base of auger hole 1 (DH–1 on map), very dark gray (10YR 3/1) lenses, 1 cm thick, of fine-grained sand and sparse, black (10YR 2/1) peaty material. In DH–1, deposit contains fossil wood, algae stems, beetle elytra (wing coverings), and aquatic-obligate (water-loving) snails whose ages are about 16,600–11,100 radiocarbon yr B.P. (table 1). The "Subsurface Data" section of this report interprets these data. Deposit is poorly exposed and forms a terrace 3–6 m higher than creek floodplains near mouths of tributary creeks, except at Wolf Creek and Little Creek in northwest corner of quadrangle, which are flat-bottomed valleys. They are headwater tributaries of the Wabash River, 25 km west. In headwater tributaries, surfaces of lake deposits converge with floodplains of creeks making a broad, undissected valley floor (Shaw, 1915). Lacustrine terrace deposits in southwestern part of quadrangle rim the northern, arcuate edge of Ohio River terrace alluvium. Unit is horizontally laminated to very thin bedded, relatively impermeable, and porous; clays in deposit hold hygroscopic (not gravity influenced) water. Map unit corresponds to slackwater-lake deposits and lacustrine facies of the Atherton Formation (Wayne, 1963, p. 35). Mapped extent in West Franklin quadrangle is less than that depicted on previous maps (Gray and others, 1991). Unit may include occult loess. Unit probably interfingers with buried levees and alluvium of the river, as suggested by thin interbeds of sand, silty sand, and sandy silt detected in penetrometer soundings VHC036 and VHC037 (fig. 3). Similar vertical sequences of lacustrine clay interbedded with fine sandy levee deposits were sensed in penetrometer soundings under the lake plain east of Evansville (fig. 1) (accessed at URL http://earthquake.usgs.gov/regional/nca/cpt/data/?map=evansville). Upper beds of unit include thin non-glaciogenic flood sediments (chiefly silt and clay) of Holocene age. Terraces are flooded locally during major floods, as shown in photographs of the 1937 flood (Willard Library archives). Unit supports high runoff and high water table, is unsatisfactory as septic tank field, and has poor load-bearing characteristics (Gray, 1971). Beds of clay and organic material, sensed by penetrometer soundings (fig. 3), probably formed in oxbow lakes, marshes, ponds, and (or) slackwater lakes. Shear-wave velocities ranged from 183 m/s in clayey and silty intervals to as much as 258 m/s in lower sandy ones. Thickness of unit in Wolf Creek valley is about 8.5 m and about 11.5 m in Little Creek valley (northwestern part of map area). In northeastern part of map area, unit is about 18.5 m thick under

Carpentier Creek and 22 m thick under an unnamed tributary to Bayou Creek near Mud Center. Unit is thickest in downstream parts of valleys of tributary creeks to the Ohio River

Loess, undifferentiated (late Pleistocene)—Brownish-yellow (10YR 6/6), pale-brown (10YR 6/3), yellowish-brown (10YR 5/8), and strong-brown (7.5YR 5/6) quartz and feldspar silt (4–64 microns in diameter) and clayey silt; pink (7.5YR 8/6) on some broken surfaces. Loess continuously covers bedrock hills. Unit is mainly Peoria Silt (Ray, 1963a, b), which, in few places, may overlie remnants of Roxana Silt (>25 ka), the Farmdale Silt or Farmdale Loess of previous workers (Hansel and Johnson, 1996). Peoria Silt may overlie Sangamon Geosol formed in older silt or formed on bedrock (perhaps combined with Yarmouth Geosol?). Unit is cohesive; upper part is structureless to platy; massive (no discernible bedding) and stands in high vertical cuts. Vertical fractures are present locally; contains abundant small pores (0.1–0.2 mm in diameter); permeable and well drained. Locally present are blocky, medium soil peds and sparse to common black (N2) iron-manganese oxide nodules 1–10 mm in diameter in discontinuous zones 0.5–1 m thick. Oxidized and leached of calcium carbonate above about 3 m; below 3 m oxidized and unleached (slightly calcareous). Compact, firm, and plastic where moist and clayey. Average proportions of grain size classes of six loess samples from 0 to 9.1 m depth near Newburg, Ind., (Fehrenbacher and others, 1965b) are (in percent): sand 2.9; silt 78.2; clay 18.8. Clay is illite with lesser amounts of expandables (montmorillonite and vermiculite), chlorite, and kaolinite. Pebbles are present in thin colluvium at base of unit. Under toe slopes of hills, loess grades laterally to creek alluvium (unit Qa), lacustrine terrace deposit (unit Qlt), silty sheetwash alluvium, and colluvium.

At a measured section now obscured by vegetation, Ruhe and Olson (1978) and Olson and Ruhe (1979) described two bench cuts north of Bayou Creek in N1/2 sec. 9, T. 7 S., R. 11 W., about 150 m west of Pleasant Road as follows (top to bottom): Upper bench—solum 4.6 ft (1.3 m); Peoria Silt 11.8 ft (3.6 m); Farmdale Silt 2.3 ft (0.7 m); late Sangamon Geosol >1.3 ft (>0.3 m). Lower bench—Peoria Silt 7.2 ft (2.2 m); Farmdale Silt 3.0 ft (0.9 m); late Sangamon Geosol 6.5 ft (1.9 m) developed on Pennsylvanian shale.

We estimate Peoria Silt in the Ohio River valley to be 22–12 ka, slightly younger than a consensus age of 25–11 ka (Wang and others, 2000) based on radiocarbon dated samples from the Mississippi River Valley (Don McKay, written commun., 2006). Counts and others (2005) dated Peoria

Silt, 41 km (26 mi) east-southeast of West Franklin quadrangle near Bon Harbor Hills. Thermoluminescence ages of 17,650, 12,030, and 11,855 yr B.P. were obtained on samples near the base upward through a 14-m-thick section. The loess section overlies a water-laid sand bar (dated at about 22,000 years B.P.), which covers Sangamon Geosol(?) on the underlying bedrock. Loess thickness in West Franklin quadrangle within about 3 km of Ohio River is as much as 7.5 m thick, thinning to <3.7 m more than 3 km north of the river (Fehrenbacher and others, 1965a, p. 568)

Bedrock (Pennsylvanian)—Very pale brown (10YR 7/4) and yellow (10YR 7/6), silty, micaceous shale. Pale-yellow (2.5Y 7/4) and light-gray (2.5Y 7/2), clayey, silty, fine- to medium-grained sandstone; hackly fractured, moderately fissile claystone. A strong paleosol, probably Sangamon Geosol (compounded with Yarmouth Geosol?), is developed at bedrock surface in places. Sandstone is planar thick bedded, cross bedded, and moderately well cemented. Unit is overlain by loess, alluvium, and colluvium and is sparsely exposed in manmade cuts and stream banks. The Inglefield Sandstone Member of the Patoka Formation is exposed in banks of an unnamed creek near tennis courts at University of Southern Indiana campus (shown on map as Indiana State University slightly north of center of map) (Clark and others, 2002; Inkenbrandt and others, 2005). Well exposed in cliffs at village of West Franklin, Ind., type locality of the West Franklin Limestone Member of the Shelburn Formation, which underlies the Ditney Coal Member and Inglefield Sandstone Member of the Patoka Formation (Shaver and others, 1986). Base of unit covered

Contact
Erosional scarp—Hachures at base of scarp
Auger hole
Test drill hole in unconsolidated deposits—Approximately located
Cone penetrometer sounding
Well—Approximately located. Number is bedrock altitude in feet above mean sea level

SUBSURFACE DATA AND DEPOSITIONAL ENVIRONMENTS OF THE WATER-TRANSPORTED DEPOSITS

RIVER FLOODPLAIN ALLUVIUM, LEVEE ALLUVIUM, AND OUTWASH (UNIT Qal)

The deepest auger hole, DH–2, penetrated about one-half the entire thickness of river alluvium (see map and Appendix).

A more complete characterization of this unit was obtained by Fraser and Fishbaugh (1986) in 14 test holes drilled on a north-south transect in the southeastern part of the West Franklin quadrangle and southward into the Wilson quadrangle. The northern half (line A–A' on geologic map) of the transect sampled alluvium under the Ohio River terrace and floodplain (fig. 4). Fraser and Fishbaugh analyzed grain sizes of about 400 sediment samples from the test holes. They summarized the river alluvium as follows (p. 8):

“The basic sequence of the alluvial fill consists of mud [silt and clay] at the top passing downward through sandy mud and muddy sand into clean fine-grained sand. These sands locally overlie medium-grained granular sand that in turn overlies interbedded pebbly coarse sand and granular medium-fine sand. The basal part of the sequence consists of highly consolidated mud and pebbly sand that fill in an irregular topography on bedrock.”

The deepest alluvial fill that overlies the buried bedrock surface (fig. 4, unit 8) is highly consolidated mud, sand, and gravel, 2–6 m thick. Fraser and Fishbaugh (1986) stated that this deposit (fig. 4, unit 8) may be pre-Wisconsin outwash. This deep fill material is poorly sampled and age control is lacking. A non-glacial alluvial origin of undetermined age cannot be ruled out.

The pebbly and sandy alluvium below 7–10 m depth (fig. 4, units 6 and 7) probably was deposited in aggrading, braided channels that conveyed sediment-laden meltwater streams of the Wisconsin Episode ice sheet. This interval can also be interpreted plausibly to be the lateral, subsurface coeval extension of the alluvium mapped as river terrace (unit Qt), given the sparse age control for alluvium in the quadrangle. A Wisconsin age interpretation for deeper (below 7–10 m) alluvium is indirectly supported by radiocarbon ages of 3,980±75 radiocarbon yr B.P. on peat at about 5 m depth in drill hole FF–8 (see cross section A–A' on map and fig. 4; also Fraser and Fishbaugh, 1986, p. 13). The relatively coarse grained deposits below 7–10 m (fig.4, units 6 and 7) probably record high competence of floods in a glacial sluiceway (Fraser and Fishbaugh, 1986, p. 16).

In Holocene time, finer grained alluvium of the upper part of valley fill (fig. 4, units 1 through 5) was deposited by overbank flooding of a meandering Ohio River channel.

Units 1 through 5 probably mantle a buried Pleistocene terrace depicted on the map as unit Qt. The buried soil (see depth 4–8 ft in DH–2 lithologic log, Appendix) records a late Holocene stable land surface on the river floodplain, before being buried by accelerated deposition of the uppermost 2 m of silt, perhaps coeval with European settlement.

RIVER TERRACE ALLUVIUM (UNIT Qt)

A dramatic change in thickness exists near the southwest edge of the quadrangle and due north of DH–3. At the Kauffman Winery and Vineyard, a water well was drilled before our study and struck bedrock at 13 ft (4 m) depth (Mr. Kauffman, oral commun., 2005). The well is not shown on the map and is located 100 m south of the Lower Mount Vernon Road. About 200 m south of this point, we augered DH–3, 57 ft (17 m) into alluvium without hitting bedrock. Also, an older water well penetrated 115 ft (35 m) of river sand (Indiana Geological Survey iLith database) 1.6 km south of DH–3 (on Darnell School Road). This abrupt thickening of alluvium south of Lower Mount Vernon Road at the west edge of the map area indicates that the ancestral Ohio River deepened the buried bedrock surface along a northward-trending meander bend. Near the southwest edge of the map area, the obvious arcing contact between the upland (unit Ql) and units Qlt and Qt reveals the old meander.

The terrace alluvium was deposited during the Wisconsin Episode (perhaps Athens Subepisode) braided-channel aggradational river phase. Subsequently, a meandering channel of the Holocene Ohio River has cut slightly below the Wisconsin-age valley floor. Also major floods in Holocene time inundated parts of the terrace, eroding and redepositing the uppermost few meters of terrace alluvium. DH–3 penetrates the interfingering buried contact between unit Qt and a lacustrine-terrace deposit (unit Qlt), indicating that the thick clay layers sampled in the auger hole are slackwater lake or oxbow lake in origin. Maximum thickness of unit Qt is about 28 m (test hole FF–5, cross section A–A'), assuming the lower and upper few meters of alluvium in the test hole were deposited before and after, respectively, the main body.

LACUSTRINE TERRACE DEPOSIT (UNIT Qlt)

Terrace landforms exist in all lower reaches of tributary valleys except those of Wolf and Little Creeks (northwestern part of quadrangle). The terraces are 3–6 m higher than the creek floodplains. Deposits under terraces appear to be lacustrine because they are horizontally laminated clay and silt. Also they are located adjacent to the Ohio River terrace and floodplain at an elevation that is fitting with an interpretation of former slackwater lakes. Estimated thicknesses of the unit (8.5–22 m) reflect depths where penetrometer soundings encountered resistant rock. Laterally, the presumed lacustrine deposit probably interfingers with river terrace alluvium (fig. 5, unit Qt), owing to damming and back-flooding of tributary creeks by aggradation of outwash in the sluiceway valley (Ohio River valley). Possibly, the lakes alternated with swamps, mudflats, or marshes through time. Shaw (1915, p. 147) characterized the deposits of extinct lakes in southern Illinois and western Kentucky as mainly clay, greenish gray to purple gray, and of medium plasticity to "gumbo" (highly plastic). He noted that certain deposits in southwestern Indiana differ from such plastic clay in that they are yellowish and soft when dry, whereas the lacustrine clay is greenish and hard when dry. Whether Shaw examined the lacustrine terrace deposits in the West Franklin quadrangle is not known.

Shaw (1915) and subsequent workers interpreted slackwater lacustrine deposits in Illinois and Kentucky to result from damming and ponding of tributary streams near their mouths by rapid build-up of valley train in the Ohio River during late Pleistocene time. Ray (1965, p. 41–46) described in detail the process and resulting deposits near Owensboro, Ky. Slackwater-lake deposits in tributary creeks in the lower Ohio River valley are widely accepted and are suggested by the presence of bay-mouth bars or lakeshore-line features at the Tennessee River–Ohio River confluence (Finch and others, 1964, p. C130–C133) and 105 km east-northeast of Paducah, Ky. (Shaw, 1915, p. 147). Such features were not seen in the West Franklin quadrangle. Nonetheless, a slackwater-lake origin for this unit in the West Franklin and Evansville South quadrangles is plausible, based on a radiocarbon age and sedimentary structures in the unit. An age of 33,100±350 radiocarbon yr B.P. (Woodfield, 1998, p. 52) on wood buried in lake sediments near Little Pigeon Creek (32 km east of the West Franklin quadrangle) is in the Athens Subepisode of the Wisconsin Episode (Johnson and others, 1997). In the same area, Erik Kvale (Indiana Geological Survey, oral commun., 2006) observed pedologic features (cutans, blocky structure, rooting, mottling, and Ediaphicium–earthworm burrows) in several intervals of 22 m of a drill core of laminated silt and clay. He interpreted these features to record marsh or mudflat environments that alternated with laminated silt and clay of lake and stream paleoenvironments.

Samples of the deposits under Little Creek and a penetrometer sounding of deposits under the valley of Wolf Creek suggest a lacustrine origin. Analyses of the samples in some depth intervals do not exclude a marshy creek floodplain or wetland origin. These creeks, in the northwest corner of the quadrangle, are headwater tributaries to the Wabash River (26 km west). In the valley of Little Creek, fossil wood collected from DH–1 at 21 ft (6 m) depth and at 35 ft (10.5 m) was radiocarbon dated. An aquatic snail shell belonging to Family Hydrobiidae (Saxon Sharpe, Desert Research Institute, oral commun., 2005) was collected at 35 ft (10.5 m) and dated. The dates (table 1; John McGeehin, USGS, written commun., 2005) indicate Michigan Subepisode for the basal sediments and Hudson Episode (Johnson and others, 1997) for the approximate upper half of the deposit. Abundant, white, fossil gastropod shells (freshwater snails) were collected at 20–21 ft (6–6.1 m) depth. The shells are high spired, 3–6 mm long, basal width ~3 mm, and resemble Amnicola gelida Baker, holotype from Morris, Ill., (illustrated in Baker, 1928, Plate VI, fig. 19). A. gelida is common in late glacial lacustrine marl deposits in Ohio (Baker, 1928) and was present in post-12 ka marl deposited in cool waters of a small lake or pond (Gooding and Ogden, 1965, p. 10). Depositional environments of the sediment under Little Creek are suggested by fossils collected from DH–1. Cyclocypris ovuum (Jurine, 1820) is an ostracode, a small crustacean having a bivalve shell made of calcite, and was collected at 21 ft (6.1 m) depth. Rick Forester (USGS, written commun., 2006; Forester and others, 2005) identified the ostracode and described its preferred environmental setting. This ostracode commonly lives in shallow water, often amongst aquatic vegetation, in settings where ground-water/surface-water interchange is common. These settings include the littoral zone of fresh-water lakes, sluggish streams, oxbow ponds, wetlands, and springs. It has also been found in vernal recharge ponds among the prairie pothole wetlands in the upper Midwest. The biogeographic distribution of C. ovuum in the U.S.A. (http://www.kent.edu/nanode/) indicates it prefers cool to cold climates, including high elevation sites in the west. The gray (10YR 5/1) laminated silt and clayey silt at 20–21 ft (6–6.1 m) also contained charophyte (green algae) stems, mites, beetle elytra, a lot of woody debris, plant stems, and a small (6 mm) clam. Charophytes, like C. ovuum, commonly live in settings with ground-water/surface-water interchange. Collectively these fossils imply that these

sediments were deposited in a wetland, oxbow pond, or intermittent lake.
At Wolf Creek, a penetrometer sounding sensed 8.5 m of thinly bedded clay, silty clay, clayey silt, and organic material, and in the basal 2 m, thin beds of sand to silty sand (see PSY001 on map and fig. 3). The predominantly fine grained deposit and connection to Little Creek suggest depositional environments similar to those described above. The penetrometer measured shear-wave velocities of 188–258 m/s.

CREEK ALLUVIUM AND SHEETWASH ALLUVIUM (UNIT Qa)

This unit is mainly silt interbedded, interlaminated, and intermixed with scarce laminae and thin beds of very fine grained and fine-grained sand. The unit is poorly exposed and the base is covered. Auger holes penetrated light-olive-brown and light-yellowish-brown silt in the upper few meters before entering deeper, similar deposits, presumably of lacustrine origin. Identifying the base of the creek alluvium is problematic. Whereas the upper several meters of the alluvium is certainly Holocene in age, the contact with the buried pre-Holocene alluvium or lacustrine sediment cannot be located with certainty. Many workers consider the creek alluvium to be in erosional contact with lacustrine deposits (unit Qlt), especially in the lower reaches of the tributaries. This idea may be a deduction from a conceptual geomorphic model because creek alluvium and lacustrine deposits were not readily distinguishable in the field. Both have similar grain size and bedding, and similar fossils could exist in both, assuming a wet, cool periglacial climate; both deposits form in bottomlands and low-energy environments, excepting high-energy flood events. Previous workers mapped the deposits of Little Creek and Wolf Creek as slackwater-lake deposits (Wayne, 1958; Gray and others, 1991) and stream alluvium (Gray, 1989), illustrating ambivalence in interpretation of origin. Peat, abundant wood, and scarcity of granules or pebbles at the base of the fill in Little Creek valley (lithologic log DH–1, Appendix) suggest a marsh, swamp, pond, or lake depositional environment. Radiocarbon ages on fossil wood in DH–1 indicate that the lower beds (table 1) accumulated during some of the period of loess deposition, estimated 22–12 ka from thermoluminescence ages of loess 41 km east-southeast (Counts and others, 2005). Loess accumulation may have covered outcrops, eliminating a bedrock source of sand, granules, and gravel. Although we mapped lacustrine deposits in the valleys of Little Creek and Wolf Creek, we cannot rule out the possibility that the deposits there are, in large part, creek alluvium. The Little Creek bottomland possibly held intermittent shallow lakes owing to damming at the confluence of Big Creek (the trunk stream) with the Wabash River, 25 km west of this quadrangle. If that distance seems too great for back-water flooding of tributary creeks and into the West Franklin quadrangle, it is noted that in Illinois, beginning at about the same point on the Wabash, slackwater-lake deposits were mapped by previous workers 50 km upstream in the Little Wabash River.

SPECULATIONS ABOUT FLOODS AND SEDIMENTATION RATES FOLLOWING HUMAN DEVELOPMENT

During the 19th and 20th centuries, humans cleared the forests, drained marshes, channelized drainages, and built flood walls, levees, dams, and locks on the Ohio River. These actions changed the river regime as well as rates of sediment transport from uplands to bottomlands. Structures built on the river raised the normal-pool elevation of the river, possibly increasing the frequency of flooding.

The complex relations among manmade structures and river regime are beyond the scope of this report, and so our conclusions are speculative. Nevertheless, whether or not caused by river engineering, field evidence indicates that the upper 1 or 2 m of silty alluvium in the quadrangle were deposited in historic time. Evidence for recent surficial sediment deposition was seen in a ditch in an agricultural field (NW1⁄4NE1⁄4 sec. 23, T. 7 S., R.12 W., elevation 370 ft). There, about 1.5 m of silty alluvium bury A and B soil horizons of a soil. The deposit is mapped as river alluvium (unit Qal). This exposure, and buried soils penetrated in DH–1 at 7 ft and in DH–2 at 4 ft depths, suggests a former, stablized land surface recently buried by silty alluvium.

Flooding and sedimentation possibly were affected by construction of flood walls, levees, dams, locks, and rip-rap at Evansville and upstream. Successive USGS topographic maps of the West Franklin quadrangle, for example, show increases in the normal-pool elevation of the river from 331 ft above sea level in 1957 to 342 ft in 1981. This 11-ft rise may increase frequency of flooding of the river and tributaries like Bayou Creek, depositing thicker silt and clay layers than in time before engineering.

Engineering structures on the river serve to aid navigation and minimize minor flooding. We do not know which

structures, if any, were in place prior to the "mega-flood" of 1937. That flood (Mansfield, 1938), a 100-yr or even a 500-yr flood, crested at 57.75 ft (Evansville flood-gage) on January 31, 1937 (http://www.crh.noaa.gov). Other large floods in 1993 and 1997 followed lock and dam construction. The lower valley saw at least two major floods in the 20th century, even with the existing flood-control structures. Smaller, more frequent floods also have occurred. This was apparent as recently as January 2005, when floodwater inundated much of the river floodplain (unit Qal), Bayou Creek floodplain (unit Qa), and low parts of the terrace (unit Qt) south of Bayou Creek. Since the late 1800's more than a dozen Ohio River floods, all (excluding the 1937 flood) smaller than the 1993 flood, are recorded (Jackson and Vivian, 1997). During this period of record a significant flood occurred each decade on average. When the river floods, thin increments of sediment settle on floodplains of the river and tributary streams (Mansfield, 1938; Ray, 1974, p. 65). Photographs of the 1937 flood (Willard Library archives) show water standing at features identified in the Evansville area on the topographic map at 385 ft above sea level. One of us (Moore) observed water backed up about 2 km in Bayou Creek and its floodplain during a 2003 flood of the Ohio River (for details see Vanderburgh County Westside Watershed Project, 2004).
Acceleration of erosion of hillslopes and sedimentation in creek valleys probably resulted from land clearing. Late 18th and early 19th century documents, including those compiled by surveyors of the General Land Survey Office, describe vast, dense hardwood forests on uplands and bottomland marshes in Indiana. Bramble and Miller (1966, p. 547) wrote:

"As seen by early French explorers, the great forests sprawling from the tip of Lake Michigan, far southward to the Ohio River, were a magnificent yet forbidding wilderness of giant hardwoods."

Before settlement, broad marshes or thick forests covered floodplains of the Wabash River and Ohio River (Fuller and Clapp, 1904, p. 10–11; Den Uyl, 1957; Lindsey, 1966; Franklin, 1994). Ridgway (1872) identified numerous taxa in the dense, diverse vegetation in a Posey County bottomland bayou (pond). Subsequently, the marshes and wetlands were drained, streams were artificially channelized, and forests were almost entirely cleared. Did these changes accelerate erosion of the previously forested hills and alluviate low-lying areas? We assume so and believe that at least 1 m, perhaps 2 m in places, of silt were deposited on creek floodplains and high terraces of the Ohio River in the past 200 yr. The position of farm houses and barns on elevated berms and elevated railroad ways in the southern part of the quadrangle indicates the extent of areas that are frequently flooded. The buried soils in the drainage ditch and in DH–2 mark the position of a stable land surface before the onset of accelerated deposition.

The creek alluvium is estimated to be 5–7 m thick in the northwestern part of the map area and about 7–10 m in the eastern and northeastern part. If the uppermost 2 m was deposited in the 19th and 20th centuries, that is approximately 20 or 25 percent of the total creek alluvium estimated in the map area.

HISTORICAL SYNOPSIS OF THE QUATERNARY DEPOSITS

The alluvial fill and loess were derived indirectly from drift of late Pleistocene continental glaciers. Although the Pleistocene Epoch in the Great Lakes region is defined by episodes of growth and retreat of the Laurentide ice sheet, the West Franklin quadrangle itself escaped direct ice cover. Nonetheless, voluminous outwash (meltwater sediment) moved through the Ohio River valley and accumulated in it owing to a wet, cool periglacial climate, intensified weathering, and great volumes of meltwater. These factors loaded the Ohio River and Wabash River, the main regional meltwater channels. During the Illinois Episode, about 310–128 ka, an ice sheet advanced to 20 km northwest of the quadrangle (Fullerton and others, 2003) to a terminal moraine made of Butlerville Till Member of the Jessup Formation (Gray and others, 1991). Effects of this glacial episode on deposits in the quadrangle are obscure. Perhaps the Ohio River bedrock valley was filled by meltwater sediment. That presumed sediment (valley train) was removed by the river perhaps during the interglacial Sangamon Episode, about 127–75 ka. There followed a cooling of climate (Wisconsin Episode) and renewed advance of the Laurentide ice sheet. The East White Sublobe of the Huron-Erie Lobe advanced southward, terminating about 21 ka in an area between Indianapolis and Bloomington (Fullerton, 1986). During this time (Michigan Subepisode) the Ohio River conveyed debris-laden meltwater from the front of the ice lobe through the West Franklin quadrangle, depositing thick valley train (Thornbury, 1950; Wayne, 1958; Woodfield and Fenelon, 1994), raising the river valley floor. Westerly winds deflated silt from the valley train during low river levels and deposited it (Peoria Silt) on the upland (Fehrenbacher and others, 1965a). The build-up of marginal levees by the Ohio River dammed the tributary creeks at their mouths, which flooded their valleys, forming slackwater lakes. The suspended load of the creeks, carried into the lakes, settled out as laminae of silt and clay, which accumulated to substantial thickness. At times, lake levels dropped and marshes and mudflats existed on the valley floors.

The Wisconsin Episode ended with deglaciation of the Great Lakes region and the Hudson Interglaciation (Holocene Age) began and continues today. As the sediment load of the Ohio River diminished, meandering channels replaced braided ones. The channels incised valley fill, lowering base level and leaving former floodplain remnants as terraces standing higher than the modern floodplain. Tributary creeks, energized by the lowered base level of the river channels, breached the dams at their mouths. The creeks continued to cut into and laterally erode the slackwater-lake sediments, leaving lacustrine terrace deposits.

Silty and clayey creek alluvium accumulated in late Pleistocene and Holocene time. The source of the alluvium is chiefly upland loess deposits. We speculate that erosion of the land and the consequent sedimentation on bottomlands accelerated as settlers and their descendents cleared the forests and drained the wetlands.

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