Proposed Origins for the Hadley Lake Depression, Tippecanoe County, Indiana

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Abstract

This paper concerns a study of an unusual linear topographic depression in northwestern Tippecanoe County, Indiana. This depression contains Indian Creek, Hadley Lake, a branch of Burnett Creek, and a reach of the Wabash River.

Four hypotheses are presented for the origin and development of the topographic depression:

1. A partly abandoned glacial sluiceway.
2. An esker trough or *rinnentäler*.
3. A segment of the "original" Wabash River channel.
4. Stream capture.

After evaluating available evidence, it is concluded that hypotheses 1 and 4 may be combined and appear to provide a reasonable solution to the problem. Hypothesis 2 is an exciting possibility and hypothesis 3 is not totally implausible.

Additional fieldwork, particularly shallow exploration geophysical methods to determine bedrock configuration and altitude, is needed to verify one of the hypotheses, a combination of more than one of them, or provide evidence that none are reasonable explanations of the observed phenomenon.

Introduction

The most striking topographic feature in Tippecanoe County is the Wabash River and its tributary valleys. The Wabash enters the county near the northeastern corner and leaves near the middle of the western boundary. All other streams drain to the Wabash River making it the local base level of erosion. Changes in gradient or level of the Wabash thus will change the erosive and transportive power of streams entering it.

The Wabash flows, for the most part, in a wide, alluviated valley bounded by relatively steep, terraced valley walls (Fig. 1). The modern stream may be classed as "underfit" in the sense of volume of flow and channel width and configuration compared with total valley width. Present-day flow did not carve this wide valley; thus, proglacial and immediate postglacial flow were much greater than now. Two distinct levels of paired terraces along the valley sides, the Mississinewa and Maumee terraces of Thornbury (8) and an indistinct third terrace level, whose place in the late glacial history of the valley is uncertain, suggest the importance of the Wabash valley as a spillway for meltwater draining away from the retreating Wisconsinan glacier.

But did late-glacial Wabash River, in the Lafayette vicinity, always follow its present-day course? The reason for posing this question lies in examining the topographic maps of Tippecanoe County and neighboring areas to the northeast and southwest. Overall, the Wabash flows from northeast to southwest; the river enters the county flowing southwestward, gradually changes course to south, but at Lafayette makes a nearly right-angle bend and flows in a nearly due west direction for

FIGURE 1. *Oblique topographic model of the Lafayette area, Tippecanoe County, Indiana (After A.K.F. Turner).*

several miles. It then resumes a southwestward course along nearly the same vector followed when entering the county from the northeast (Fig. 2).

The near right-angle bend at Lafayette is also marked by a significant increase in width of an already wide valley. This has been attributed to the fact that at this location the present river intersects the glacially-filled valleys of the preglacial Teays River and Anderson Valley, the latter a tributary of the ancient Teays which entered it from the east along the general line of present-day Wildcat Creek (9). Thus we have an apparently adequate explanation for the great bend of the Wabash, but another problem arises. It is generally accepted that the present drainage of the glaciated portion of Indiana is, except for reaches of the upper middle Wabash drainage, independent of lines of preglacial drainage. Why, then, should the modern Wabash intersect the buried Teays Valley at this particular location?

The key to the question may lie in an explanation of an unusual topographic lineament, just northwest of West Lafayette, where a small natural lake, Hadley Lake, and several other closed, undrained depres-

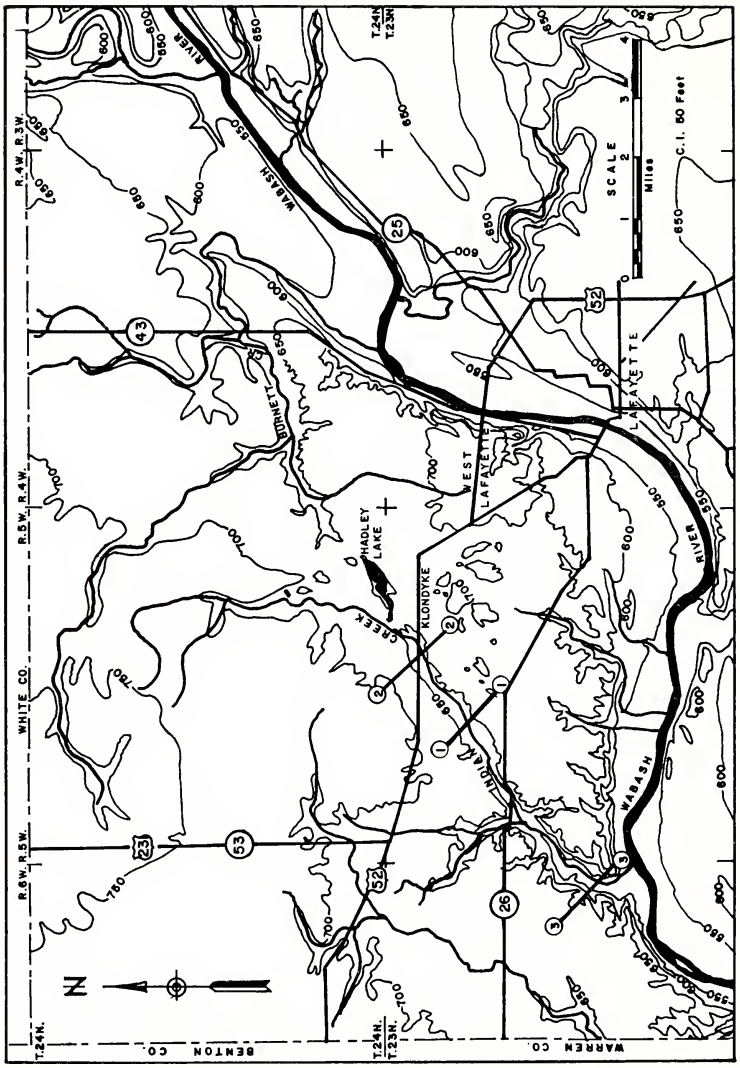

FIGURE 2. *Topographic map of northwest portion of Tippecanoe County, Indiana.*

sions, lie athwart the crest of the present drainage divide. Two creeks drain away from Hadley Lake, but the lake has no outlet. These creeks are Indian Creek flowing southwestward and the northeastward flowing Burnett Creek. These creeks also appear "underfit" in terms of cross-section profile versus flow, indicating that both valleys carried a greater flow of water in the past.

The question now becomes, "Is the apparent alinement of Indian Creek, Hadley Lake, Burnett Creek, and the Wabash River significant,

and if so what is its meaning in respect to development of the modern Waabsh?" There may be several acceptable answers, considering the paucity of currently available data, but before elaborating the problem a brief review is required of the late glacial history of the area as now interpreted.

Late Glacial History

By late Tertiary time, bedrock subcrop data, especially abundant from Illinois, indicates regionally mature topography (in the Davisian sense). Lithologies of the region are Paleozoic sedimentary rocks—sandstones, shales, and limestones—on which polycyclic episodes of regional planation during the Tertiary produced smoothly rounded uplands, broad valleys of meandering streams, and local rock benches or straths marking the record of the polycyclic events. The master drainage system was the Teays River and its tributaries. The flow direction of the Teays was westward to join the preglacial Mississippi River in central Illinois. Preglacial Wabash River was tributary to preglacial Ohio River, as today, but the Wabash drainage basin was much smaller than now, and separated from Teays drainage by a watershed divide located somewhere south of Lafayette, probably along a line intersecting the modern Wabash bedrock gorge somewhere between Attica and Covington. The drainage of Tippecanoe County was entirely within the Teays basin.

Multiple Pleistocene glaciations effected many topographic changes and drainage diversions in the northern ⅔ of Indiana. The principal effects of ice invasion were to smooth terrain by filling of valleys in existing topography with glacial till or outwash. During interglacial stages, progressive erosion occurred, with many streams re-establishing themselves in their original valleys partly filled with glacial debris. The present topography of the Wabash bend area, however, is principally a function of late Wisconsinan deposition and subsequent erosion after the ice departed perhaps 12,000± years ago. Minor deposition of loess on uplands since glacial retreat has effected small topographic modifications but these are irrelevant to the problem at hand.

Retreat and melting of ice produced great volumes of flood waters to be drained, but drainage was complicated by obstructions of various kinds—local ice lobation, ice-damming to create lakes, different erosional properties of surficial materials, and existing surface topography. Glacial drainage lines, or sluiceways, are commonly occupied by modern streams; however, these valleys are too large for the present flow volume, and are in this sense "underfit." This is a key factor in attempting to re-establish drainage systems as they existed during retreat and melting of the ice. Indeed, underfit streams (in the sense used in this paper) are common in Tippecanoe and adjacent counties. Essentially all the larger streams fit into this category.

Glaciation also made broad-scale changes in drainage-basin organization in the Midwest. Teays River disappeared and the upper Wabash River occupied in part, and by sequential events not yet understood, the

old Teays drainage basin in Indiana. Thus Tippecanoe County now is totally incorporated within the Wabash River drainage system.

In the northeastern part of the state, drainage is toward the lower Great Lakes, or more specifically, is part of the St. Lawrence River drainage basin. During later stages of Wisconsinan glaciation, there is evidence that part of the St. Lawrence drainage was reversed for some time. The eastern glacial Great Lakes used the upper Wabash River as an outlet, and a significant flow of water (Maumee flood) was added to the Wabash Valley sluiceway.

In summation, the picture of what happened to drainage systems during ice melting and shortly after the glaciers disappeared from the region is by no means totally clear. Climatic and vegetation conditions are unknown or only inferred. These two factors have great significance in determining type and rate of erosion and landscape modification. Erosion and/or change in climate and vegetation may obscure or destroy the evidence of former location of a stream, and we must accept the fact that a stream is where it is for no good reason that we can ascertain. The stream is where it is because it started out in this location for reasons not now apparent. These unknowns probably explain why many areas in Indiana look peculiar to the geomorphologist or airphoto interpreter; they can not be fully explained, and look more like a "geomorphic happening" than something that developed by rational ordering. But the reasons are there. We have not yet found them.

Previous Work

Tippecanoe County and the great bend of the Wabash appears to have been a popular area for geographic field investigations in the early part of this century. McBeth (5) investigated many features resulting from glaciation, as well as development of the Wabash drainage system, but his papers make no reference to a Hadley Lake-Wabash River lineament; very probably it escaped his notice because it is not a topographically prominent feature as compared to eskers and terraces, and of course he lacked topographic maps or air photos on which the lineament immediately attracts attention. F. J. Breeze (1) apparently recognized the peculiar relations of Burnett Creek and Indian Creek in a paper presented before the Indiana Academy in 1916 but no abstract or paper was published and thus details of his observations or interpretations are lost. The early report on Tippecanoe County by Gorby (3) likewise fails to mention the Hadley Lake depression. Gorby's report is not particularly admirable even by geologic standards of his time, though his statement that ". . . The assertion may be ventured that no county in the Union affords a more varied exhibit of this puzzling deposit (i.e., the Glacial drift) than Tippecanoe . . ." might draw plaudits from modern workers. Leverett's classic work (4) also lacks mention of the Hadley Lake lake and trench.

No further geomorphic work was done in the Tippecanoe region until recent years. Schneider and others (6) describe three sets of linear

features in western Indiana, which consist of straight, shallow troughs and discontinuous low ridges or elongated knobs of sand and gravel. They relate these linear features (one of which is Hadley Lake trough) to subparallel northeast-southwest drainage developed in accord with ice movement from the northeast. West and Barr (11) describe groundwater problems in the area immediately west of Hadley Lake and infer a substantial thickening of glacial drift eastward into the depression. Schneider and Wayne (7) suggest that the depression is an esker-trough that is a downstream continuation of that segment of the Wabash River extending from near Lafayette upstream to Georgetown in Cass County.

We are now in a position to again ask the question, "Is the alinement of Burnett Creek, Indian Creek, and Hadley Lake significant, and in what relation to the modern course of the Wabash River?" Let us look at four preliminary hypotheses in an attempt to answer this question.

Hypotheses of Origin

We suggest four possible hypotheses for development of this peculiar alinement of land forms.

1. An abandoned glacial sluiceway
2. An esker trough, or perhaps a *rinnentäler*
3. The "original" post-glacial Wabash river channel
4. Stream capture

All hypotheses deal with fluvial processes as an erosional factor. What is not taken into consideration are bedrock topography, joint control, faulting (if any), and general structural geology of the area. As the buried extension of the Knobstone cuesta must pass almost directly beneath the linear surface depression, bedrock cannot be eliminated as a determinant in developing a satisfactory explanation for surface drainage adjustments despite a rather thick covering blanket of glacial till or outwash. Too few bedrock data are available, however, to assess its importance at this time, although Wayne (10) produced a preliminary bedrock physiography map of the area based on limited information.

Let us look at each hypothesis in some detail.

Glacial Sluiceway

This is the most popular local explanation of the landforms by geomorphologists and air photo interpreters. The assumptions behind this interpretation follow:

1) The Wabash River has not changed its course.

2) The sluiceway received large volumes of water from a stagnant glacier or glacier receding primarily by vertical ablation.

3) The glacial source of meltwater was nearby, perhaps as close as the northern border of Tippecanoe County because the

sluiceway is not traced farther northeast; if it did extend farther, post-glacial erosion or colluviation has destroyed evidence of former existence.

4) The time of origin is thus placed as late-glacial, when the glaciers left the area about 12,000± years ago, or about the time of formation of the Iroquois (?) moraine.
5) The sluiceway carried water for only a short time, and later creeks occupied the depression and began to cut new valleys.

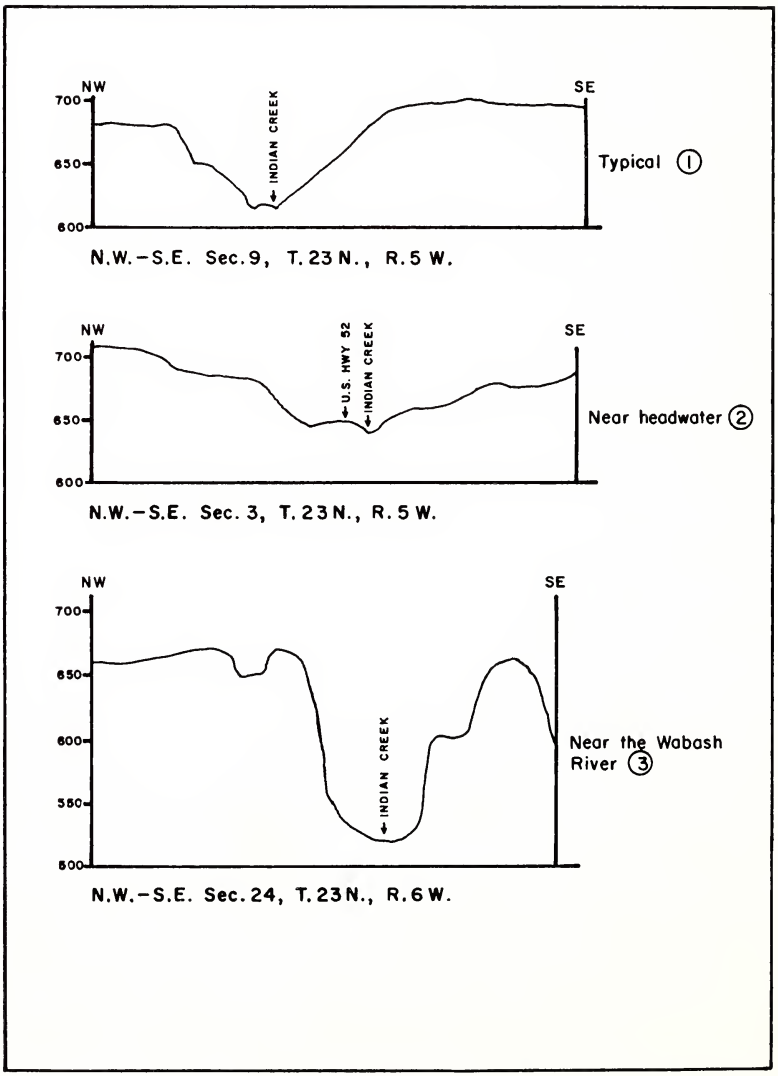

FIGURE 3. *Cross-section of present Indian Creek (See Fig. 2 for locations).*

Indian Creek and Burnett Creek thus formed. Hadley Lake was left as a ponded local segment of the trench because the bedrock high southwest of the lake prevented free drainage in that direction.

The conclusion is thus reached that the trench is essentially a temporary overflow distributary of the Wabash. With further retreat of the ice, the source of water was gone and the sluiceway was occupied by small, newly-formed streams.

Cross-sections of Indian Creek valley (Fig. 3) show clearly at least two cycles of erosion, with a wide valley representing the sluiceway stage, and a smaller valley of the modern creek. Thus the sluiceway hypothesis appears adequate to explain the landform feature of the trench; however, it explains neither the reason for location or alinement. The hypothesis fails to take into account either bedrock topography or correlation between this, the present Wabash Valley, and the preglacial Teays River Valley. The glacial sluiceway interpretation suggests that the landforms are independent of these latter factors and dependent only on an abundant source of melt-water.

Esker Trough or *Rinnentäler*

This hypothesis implies subglacial or englacial scour creating a bedrock trench of linear section. Leverett used the term esker trough for similar linear features in Montgomery County, near Muncie, and elsewhere in the state, limiting the term to linear depressions now containing only relicit patches or knobs of sand and gravel, and as noted previously, Schneider has continued usage of this term in describing three sets of linear features in west-central Indiana.

As no relict patches remain in the Hadley Lake trench there is no proof that an esker was ever present. The suggestion is tenable that the trench is a *rinnentäler* (channel-valley). These valleys may be cut uphill beneath the ice because of pressure; terminal base-level of streams may raise and streams flow englacially or even superglacially over collapsed ice filling the *rinnentäler* (2)

Acceptance of this hypothesis requires formation in a glacial rather than proglacial environment as suggested by the glacial sluiceway theory. The fact that the Hadley Lake trench cuts uphill and across a bedrock divide appears to favor the *rinnentäler* over the esker trough hypothesis of origin.

"Original" Post-glacial Wabash River Channel

This is a bold hypothesis but is worth consideration.

1) The hypothesis is not dependent on a particular source of meltwater, but rather a large flow for a longer period of time, as could be expected during the time of glacial melting.
2) The hypothesis assumes a correlation between alinement of the landform, bedrock topography, the Teays valley, and the modern Wabash River.

Let us project a sequence of events which could produce the alinement of the Indian Creek-Hadley Lake-Burnett Creek system and the Wabash River (Fig. 4).

When the ice retreated and the land surface was re-exposed, preexisting topography was buried by glacial drift. Preglacial drainage channels were buried and running water commenced re-dissecting the new surface. The ample water available gave birth to a Wabash River

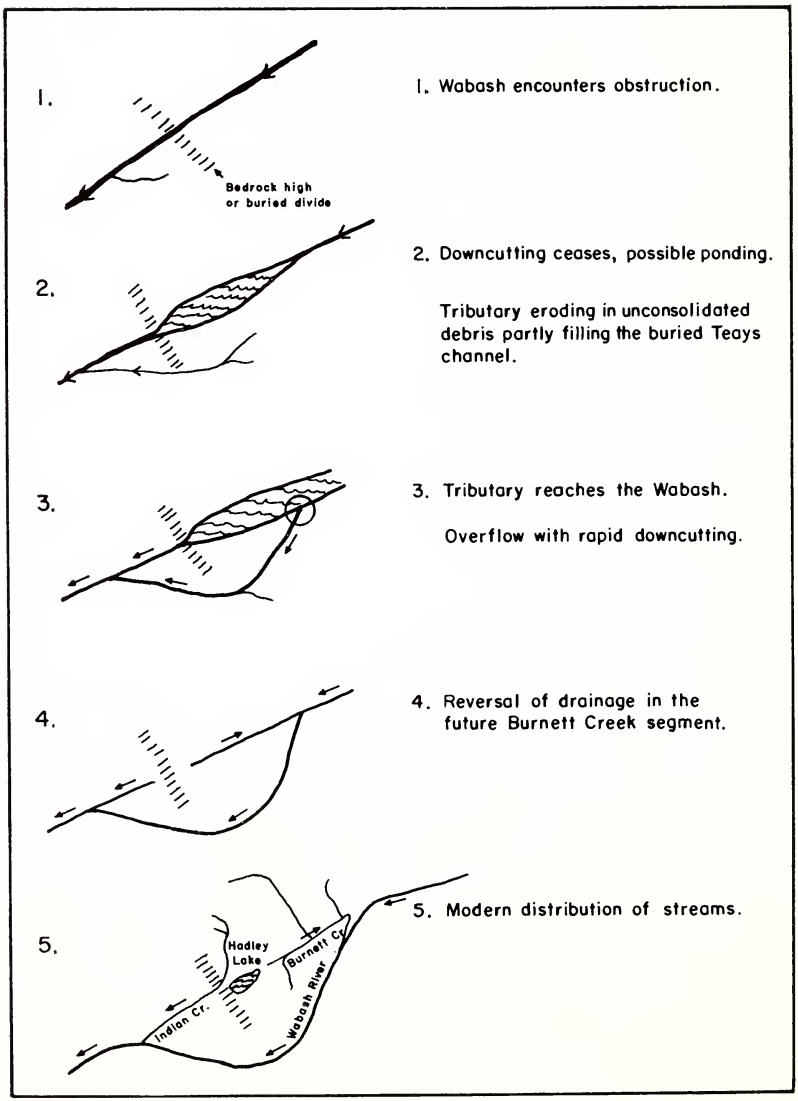

FIGURE 4. *Projected sequence of events creating the Hadley Lake trough.*

flowing in almost a straight southwestern direction. The new stream was unaffected by buried topography; soon, however, downcutting encountered the bedrock "high" located southwest of present Hadley Lake. This produced a temporary base level; the rate of downcutting could have slowed upstream from the obstruction and ponding possibly took place. Downstream, Indian Creek continued its work of grading this segment to the next lower temporary base level control at some unknown point further down the Wabash valley.

In time, overflow from the upstream segment may have occurred approximately where Tippecanoe River enters the modern Wabash. Overflow may have combined with headward erosion of tributaries from the east and south; these tributaries in part were re-occupying an only partly filled segment of the old Teays Valley. Once diversion occurred, upstream erosion was accelerated, for the stream was now completely cutting in glacial drift filling the old Teays and Anderson valleys and no longer had to contend with the bedrock high athwart its previous course. As the softer fill was exposed to less overall consolidation by glaciation, it provided no obstruction to lateral corrasion. In time, a marked widening of the Wabash Valley occurred southward, in the upstream direction of the old Anderson Valley.

The "original Wabash" valley was thus abandoned. The small streams in this valley continued slow development. Hadley Lake was left behind as a ponded depression blocked by the bedrock divide. Some factors needing verification if this hypothesis is to be supported are:

1) The presence of lacustrine sediments in the Hadley Lake basin, provided the original lake existed long enough.
2) Geophysical profiles or drill holes along the axis of the trough to determine depth to bedrock, gradient of the postulated river, and evidence, if any, of former terraces along this postulated course.
3) Composition of soil materials along the postulated course to determine if they were deposited by running water or if the till has been reworked by fluvial action.

There can be, admittedly, substantial objections to this hypothesis. Nevertheless, it deserves consideration until negative proof is forthcoming.

Stream Capture

This hypothesis describes a chain of events to explain the linear depression. Some fundamental assumptions used in suggesting a simple case of stream capture are:

1) The Wabash River did not change its course, but did have a much greater flow volume.
2) Notation of the peculiar alinement of Burnett Creek, with a northeastward, or opposite, direction of flow.

3) The presence of a bedrock high or divide southwest of Hadley Lake.

The sequence of events may have been as follows. Wabash River and its tributaries were carrying a tremendous volume of meltwater, whereas the north fork of Burnett Creek followed the Hadley Lake-Indian Creek channel southwestward. As flow was obstructed by the bedrock high, the upper reaches of the system (Burnett Creek) lost most of its erosive power. Wabash River and the Indian Creek segment continued downcutting. Meanwhile a small tributary was eroding northward from the Wabash River in section 22, T. 24 N., R. 4 W. This tributary eventually reached Burnett Creek in the E ½ section 21, T. 24 N., R. 4 W., and at this time a more favorable outlet to the Wabash River was provided. Consequently, Burnett Creek reversed its flow direction and Hadley Lake was left as a local depression behind the bedrock dam. Indian Creek and Burnett Creek became two independent drainage systems, and a wide abandoned valley, or col, was left across the bedrock divide. Proof of this hypothesis of drainage reversal awaits identification of terrace deposits on Burnett Creek and determination of whether the gradient of the terraces correspond to a supposed flow in the opposite direction from that of the modern stream.

Conclusions

Four hypotheses have been presented to explain the origin of the Hadley Lake depression and related fluvially carved landforms. Two of these (abandoned glacial sluiceway and stream capture) may be combined and appear to offer a reasonable explanation. All hypotheses, however, must remain in consideration until sufficient evidence or proof is provided to explain the observed phenomena.

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