Illinois State Geological Survey Division
Urbana, Illinois

Report on Examination of Geologic Conditions at West Landing of Proposed High-level Bridge across Illinois River at Hardin, Illinois

April 22, 1929

<u>Purpose</u>. The object of the examination was to determine whether the geologic conditions at the west landing of a proposed high-level bridge across Illinois River at Hardin, Illinois, are or are not of such nature that they would seriously affect the construction of the approaches required to connect the bridge with the existing highway (State Bond Issue Route No. 38).

The examination was made at the request of Mr. G. F. Burch, Bridge Engineer of the Illinois State Division of Highways. Mr. Burch, Mr. Frank T. Sheets, Chief Highway Engineer, and Mr. C. F. Slaymaker, District Highway Engineer of the 8th District, were present during the examination.

<u>Situation</u>. The west landing of the proposed bridge is located a few rods south of the ferry landing at the north end of the town of Hardin (see maps). It is also located along the west side and about three-sixteenths of a mile south of the northwest corner of sec. 26, T. 10 S., R. 2 W. of the 4th P. M. (see maps). It intersects the talus slope along the west side of the river some 40 feet above the present pavement (see cross-section).

In order to have a satisfactory grade, the approaches that will be required to connect the bridge-landing with the present highway will intersect the highway about 1000 feet on either side of the landing (see cross-section), and with minimum-radius curvature the north approach, and possibly also the south one, will extend to the face of the bluff (see map). Consequently deep and heavy excavation through the talus will be required along the entire length of the north approach and along much of the south approach (see cross-section).

Geologic situation. The bedrock that composes the bluffs and is more or less satisfactorily exposed consists of several formations, namely, in downward succession, the Burlington limestone, the Chouteau limestone, the Hannibal shale, the Louisiana limestone, all of which belong to the Mississippian system, and limestone formations belonging to the Devonian and Silurian systems which are not differentiated in this report (see cross-section). The bluffs are mantled by wind-blown dust, called loess, which was deposited during the Pleistocene (Glacial) period.

The Burlington formation is a medium to coarsely crystalline, massively bedded limestone, very light gray in color with yellowish or flesh-colored tints, and contains considerable white chert ("flint"). The total thickness of the formation is not exposed at this locality. The Chouteau formation, which is about 40 feet thick, is a dense or finely crystalline, thinly bedded, argillaceous limestone, dark bluish-gray in color. The differences in composition, texture, and color suffice to distinguish these formations sharply, although the contact between them is only slightly but plainly irregular. The Hannibal formation is a soft, light bluish-gray or greenish-gray, non-laminated shale which readily becomes plastic when saturated with moisture or exposed to weathering. The contact between the Chouteau and Hannibal formations is not exposed along the bluffs at this locality, but at one point (No. 6 on the cross-section) a massive, more argillaceous bed that is known to be the base of the Chouteau formation is visible. The Hannibal formation is about 90 feet thick. The Louisiana formation, which is only 8-10 feet thick, consists of dense, lithographic, very dark bluish-gray, sandy limestone in beds 2 to 6 inches thick, separated by thin laminae of dark greenish-gray shale. The limestone beds exhibit cross-bedding. When exposed, the limestone weathers white and the shale softens and disappears, creating an appearance that appropriately merits the local designation of "masonry beds". This formation is well exposed in a small quarry (No. 8 on cross-section) and thence south for some distance along the west side of an old road. The undifferentiated Devonian-Silurian formations are not well exposed at this locality, but elsewhere in the vicinity they are known to be dark or yellowish-gray limestones and dolomites. Their total thickness is approximately a hundred feet. The base of the bluff is concealed by talus that extends irregularly up the bluff for a vertical distance of 125 to 150 feet above the highway. It has an average surficial slope of 3:1, although at some places it is steeper and at others more gentle. It consists almost entirely of masses and fragments of the Burlington and Chouteau limestone thoroughly intermingled with the Hannibal shale. This heterogeneous mixture is well exposed beside and behind the McNabb house.

Seeps and springs issue at several points along the toe of the talus slope. The most marked places are opposite the ferry-landing and at the McNabb house.

Significance. Inasmuch as the matrix of the talus consists mainly of weathered Hannibal shale, which is so soft and plastic when wet that it yields readily under slight load and thus serves as a lubricant by which the broken masses of Burlington and Chouteau limestone in the talus move easily, the talus is not stable unless it has a constant slope of reduced angle (3:1 or less). If the slope be disturbed by removal of its toe or by any excavation, even if only a few feet deep, the weight of the rock masses in the unsupported talus will cause slipping and sliding. Thus a series of successive landslides eventually extending to the top of the talus slope will be started. Adequate demonstrations of this condition occur opposite the ferry-landing and at the McNabb house.

Slides in the talus are hastened and accelerated by the presence of water. At both places where the sliding is worst at present there is a large amount of seepage, which is an important contributing factor. But the same result would eventually occur at any place where the slope is disturbed, as ordinary rainfall, especially during periods of heavy or prolonged precipitation, would be sufficient to create similar conditions.

It cannot be determined whether the talus covers a buried slope developed on the Hannibal shale or abuts against a vertical bluff of the shale beneath the exposed Chouteau and Burlington limestones. If there be a buried slope, the talus would tend to move as a mass down that slope. This tendency would be increased when the underlying shale is wet and soft, so that it serves as a lubricated surface. In this case the removal of any considerable portion or all of the talus above the shale slope would permit massive landslides of the talus over the shale surface.

If there be a vertical bluff of Hannibal shale beneath the Chouteau and Burlington limestones, the shale tends to squeeze out from under the limestone, owing to its plasticity and to the weight of the limestone. This tendency is increased when the shale is wet or exposed. It is offset by the weight of the talus lying against the shale. If the talus be removed, then the shale could yield; this would allow a mass of the limestone to settle slightly, break away from the bluff, and fall forward.

Owing to its argillaceous content, the Chouteau limestone weathers by exfoliation (peeling off in flakes). This action is more marked in some beds, especially the massive basal portion, than in others, and it is more marked where there is seepage. The exfoliation causes the face of the limestone to recede slowly and thus undermine the overlying Burlington limestone. When the recession reaches a joint or crevice in the overlying limestone, a mass of the rock falls down on the talus slope. Thence by its own weight and assisted by the plasticity of the shale in the talus, this mass slowly advances down the slope.

Part of the rainfall that is precipitated on the bluffs runs down the slopes and collects in the valleys. A small vale that occurs west of the McNabb house is undoubtedly the locus for the collection of considerable water which it discharges into the talus below and before it. This water seeps down through the talus and is doubtless the source of the seeps and springs at the McNabb house.

Another part of the rainfall soaks down through the loess into the limestone and thence through pores, crevices, and channels in the limestone until it encounters the relatively impervious shale, where its downward movement is checked and it is forced to follow the surface of the shale. It may issue as seeps and springs along the contact of the Chouteau limestone and Hannibal shale. Thence it soaks down through the talus to reissue as seeps and springs along the toe of the talus slope. The rain that falls directly on the talus likewise soaks into the talus immediately and issues as seeps lower along the slope.

Opinion. As already discussed and as shown on the maps and cross-section diagram, the required approaches to the proposed bridge will have to be excavated deeply in the talus for the greater part of their length, and at one curve, if not at both curves, this excavation will be located along the face of the bluff. The general results of such excavation have been pointed out above.

Wherever the road is excavated in talus alone, there will be gross movement and sliding. Massive landslides will occur where the excavation is deep. They will also occur if a shale slope is uncovered beneath the talus. When such movement is once started, it will not cease until the angle of repose is restored, which means that a layer of talus as thick as the excavation is deep will eventually move into the excavation and have to be removed therefrom. If a buried shale slope be uncovered, it will be a locus along which all seepage water is concentrated. This water will issue into the road and present another problem.

Where the excavation is carried along the bluff, so that the talus is removed from in front of the shale, rock-falls will occur, as they did along a highway near Savanna, Illinois, where identical conditions (limestone over shale) were encountered.

Consequently it is plain that the construction of approaches to a high-level bridge at the designated site will introduce highly dangerous and unavoidable hazards to traffic and human life. There appear to be no practicable devices by which these hazards can be prevented. The hazards are all the more serious because the landslides and rock-falls are more likely than not to occur without previous warning.

Recommendations. In view of the existing geological situation and the hazard to human life that will be involved by excavation of the talus, a high-level bridge at the present site is impracticable. The trouble could be avoided either by lowering the bridge-landing at the proposed site to intersect the present highway directly, or by constructing a high-level bridge at the alternative site indicated on the large map. In the first case, the excavation of talus would be avoided, and in the second case the landing would intersect the highway where Burlington limestone alone composes the bluffs.

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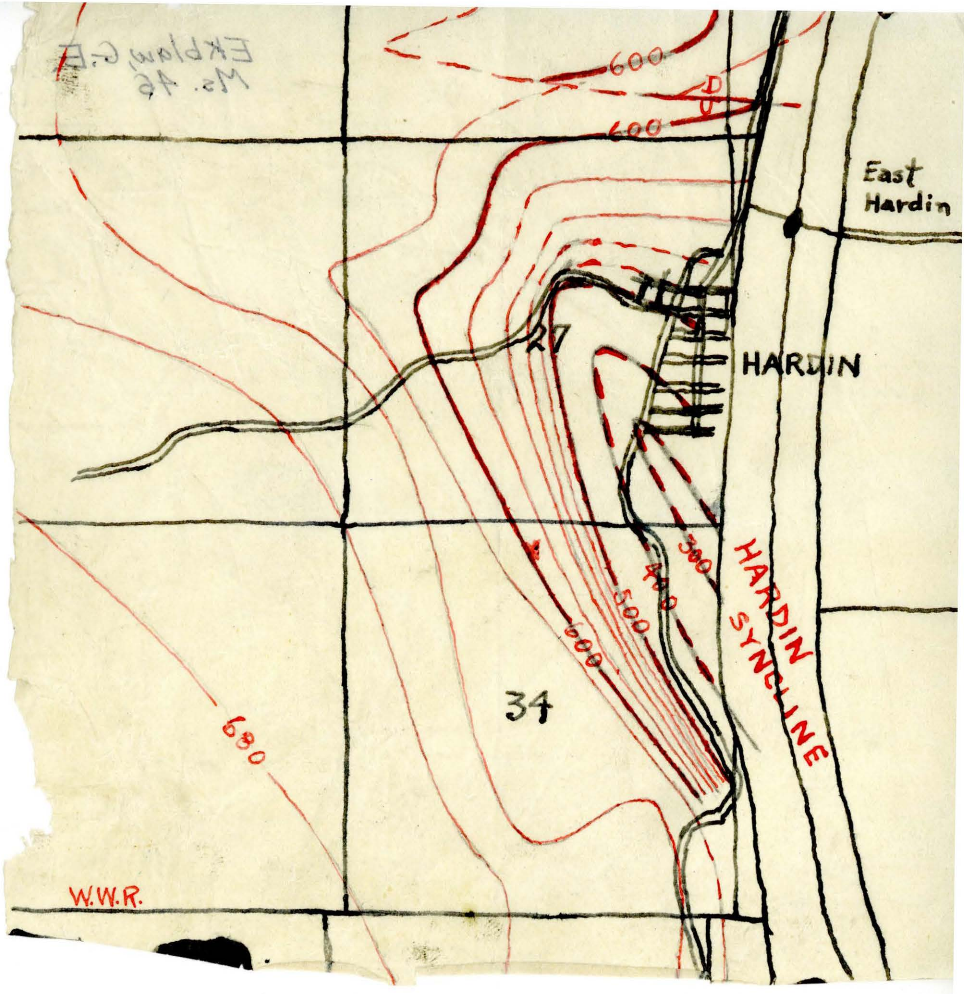
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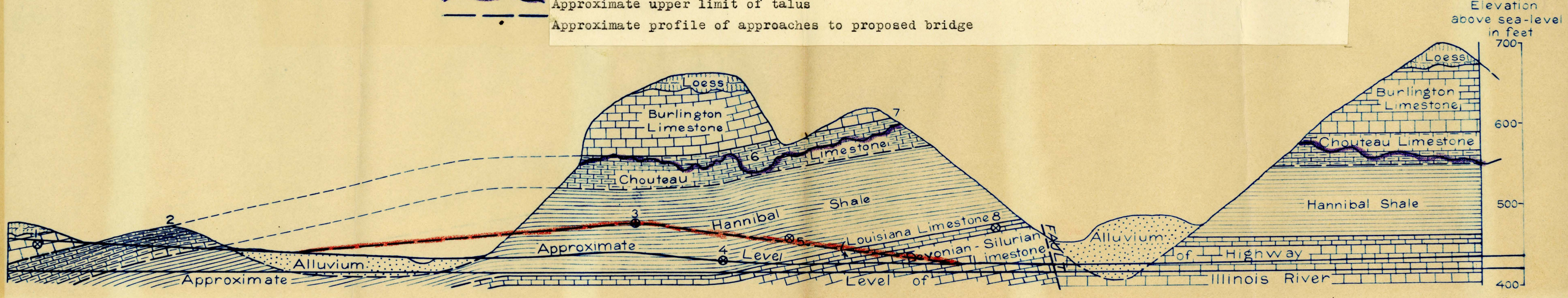
Cross-section diagram of rocks composing bluffs north of Hardin, Illinois

Topographic map of area around Hardin (From advance sheet of USGS topographic map of Hardin quadrangle). A-A-Line of cross-section diagram

1. Hardin High School, around which Burlington limestone is exposed
2. Local quarries in Chouteau limestone, with Burlington limestone higher and farther back on hill
3. Approximate landing of proposed bridge
4. Ferry-landing
5. McNabb house
6. Good exposure of Chouteau limestone
7. Chouteau-Burlington contact
8. Local quarry in Louisiana limestone

Approximate upper limit of talus

Approximate profile of approaches to proposed bridge



Horizontal Scale: 16 inches = 1 mile
Vertical scale exaggerated approximately 3 times horizontal scale

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Geologic Cross Section along Highway near Hardin, Calhoun County, Illinois.

Horizontal and Vertical Scale - 1 inch = 400 feet.