Relation of ground water to stream flow at Battle Creek, Mich.

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This is a summary of statements made by G. E. Eddy, State Geologist of Michigan, and J. G. Ferris, district engineer, Ground Water Branch, U. S. Geological Survey, Lansing, Mich., in a conference during the fall of 1949 with John Spoden, Chief of the Maintenance and Flood Control Division of the district office of the Corps of Engineers, Milwaukee, Wis. The conference related to the probable effect on ground-water conditions at Battle Creek of flood-control measures proposed by the Corps of Engineers.

The principal aquifer in the Battle Creek area is the Marshall sandstone, which ranges in thickness from 100 to perhaps 150 feet through the greater part of the metropolitan area, except in the southwest and east-central parts of the city where the sandstone was removed by a pre-glacial stream. Ground water in the Marshall sandstone occurs under artesian conditions, the piezometric surface ranging from about the stage of the Kalamazoo River to as much as 30 feet above this stage. At numerous places along the courses of Battle Creek and the Kalamazoo River the Marshall sandstone crops out at or near river level. The available information suggests that hydraulic interconnection exists between the ground water of the Marshall sandstone and the surface water of Battle Creek and the Kalamazoo River. However, until the completion of present studies in the Battle Creek area, it would be difficult to prove rigidly the extent and degree of such interconnection.

When hydraulic interconnection exists between a stream and an aquifer, the level of that stream is a determining factor in the amount of inflow to or outflow from the aquifer. The proposed lowering of the base-flow stage of the Kalamazoo River through the central part of Battle Creek may effect important changes in ground-water level, ground-water discharge, and the performance of some wells. The degree and extent of these changes will vary with time and with distance from the stream channel. In addition to the transmission and storage properties of an aquifer, the drawdown of a riverside well depends upon the rate of pumping, the distance of the well from the stream, the permeability of the stream channel, the temperature of the water, and the stage of the stream. If all other factors are assumed constant, for a given stream stage a specific gradient is established between the stream and the well to satisfy the rate of pumping and this gradient determines the pumping level in the well. If all other factors are held constant and the stage of the stream is lowered, then the pumping level in the well is also lowered.

It is proposed to close a portion of the present stream channel and open a new course from the Monroe Street dam to the Kalamazoo River. If we assume hydraulic interconnection between the stream channel and the underlying Marshall sandstone, we can infer that present ground-water developments along the existing channel that depend in any large degree

upon the infiltration of stream water must necessarily pump future water supplies from somewhat increased depths. With the closing of the present channel, nearby wells would draw down to lower levels to provide the necessary gradient to move water from other and more distant sources of recharge. For wells along the course of the proposed channel, the distances from recharge source to well site would be decreased. If such decreases are appreciable, pumping levels at these well developments would be raised to more economical stages. Thus, we may infer that benefits might accrue to wells along the course of the new channel, whereas wells close to the abandoned channel might require increased pumping lift.

Most wells in the Battle Creek area that are finished in the Marshall sandstone are drilled through the full thickness of this formation. Static levels are relatively close to the surface and large yields with limited drawdown are common. However, wells that are presently operating with pump settings at or near the limits of existing pumping equipment will either break suction or decline in yield if water levels are lowered. Most large-capacity wells of recent construction are equipped with deep-well turbine pumps with bowl settings at moderate depths, and for many existing wells in this area several feet of lowering in pumping level probably would not require any major change of present pumping equipment.

An important consideration in the planning of proposed flood-control improvements in the Battle Creek area is the effect of lowered base-flow stage on regional ground-water levels and ground-water discharge. For some time following the lowering of base stage the discharge of water from the Marshall sandstone to Battle Creek and the Kalamazoo River may be increased appreciably. In view of the high permeability of the sandstone as shown by the large yields of wells per foot of drawdown in this area, it can be expected that a lowering of base stage will result in a substantial increase in the base flow of these streams. If changes in base flow are important to the planning of the Corps of Engineers, it would be desirable to obtain quantitative data on the transmission capacity of the Marshall sandstone and on the bearing of these data and other hydrologic factors on the probable variations of base flow with time as the result of lowering base-flow stage.

The restoration of equilibrium between recharge and discharge in the sandstone aquifer to meet the proposed change in head on the discharge outcrop may require considerable time. Important changes in the position of the regional divides of the ground-water basin may result. Any quantitative appraisal of the magnitude of the various effects of the proposed flood-control improvement on existing well developments or on springs and streams in the Battle Creek area would require a comprehensive hydro-geologic investigation.