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TO: Ed DiBello, EG&G, Idaho

FROM: Debbie Struhsacker and Kip Smith, ESL

SUBJECT: Review of "Geothermal Space Heating Applications for the Fort Peck Indian Reservation in the Vicinity of Poplar, Montana.

The Geothermal Potential of the Madison Aquifer

Hot (180-210°F) water in the Poplar, Montana area is produced along with oil from Poplar Oil Field wells in the Madison Group. The Murphy Oil Company is the principal producer in the Poplar Oil Field; much of the data presented in this study is from Murphy Company oil wells. Hot-water production from the entire field is reportedly 18,000-20,000 barrels a day (p. I-28), or 396 to 440 gpm. Since these wells were drilled for oil rather than hot water, the perforated zones are probably limited to intervals with a hydrocarbon show. Thus, the hot water from these wells is produced from thin intervals within the 2,000 foot thick Madison section and probably does not represent the production capacity of the entire Madison system. Likewise, the drill stem production data presented in this study tests only a limited portion of the Madison. Those intervals tested in the drill stem tests have an average porosity of about 4% (Table I-2, p. I-22) and produce between .5 and 10 gpm of water per foot of aquifer (Table I-3, p. I-27). Assuming this range of flow rates per foot, a well drilled into the Madison would require production zones ranging from 1,000 to 50 feet in thickness in order to obtain the desired 500 gpm flow rate. It must be stressed, however, that an accurate assessment of the hot water producing capabilities of the Madison can only be based upon a production test of the entire aquifer rather than thin zones.

Suggested Additional Data Compilation

A study similar to that discussed by Miller (1976) is suggested for the Poplar area. Miller (1976) presents a complete guide for evaluating the water-bearing properties of the Madison Group. Miller (1976) explains the types of data that are needed, how to acquire them, and how to understand them. The maps used by Miller (1976) are precisely those needed in a hydrologic study of the Poplar Dome area. The discussion of drill-stem tests and geophysical logs, the two fundamental sets of available data, are tailored to the Madison

Group and are concise, accurate, up-to-date, and abundantly referenced.

W. Roger Miller works for the U.S. Geological Survey, Water Resources Division, Billings, Montana, (406) 657-6113.

All page and figure numbers in the following discussion refer to:

> Miller, W.R., 1976, Water in carbonate rocks of the Madison Group in Southeastern Montana - A preliminary evaluation: U.S. Geol. Survey Water-Supply Paper 2043, 51p.

A study of the hydrothermal potential of the Madison Group in the Poplar Dome area must first assemble all available data (p. 2-3). It must then present these data in map form. In addition to a map of the water temperature, the study must contain a potentiometric-surface map (Plate 1a) and a water-quality map (Plate 1b). These maps are required before it can be determined whether the water is chemically suitable for its intended use, and whether it rises above the land surface or to a depth where pumping is economical.

If the water and the head in the Madison Group in the Poplar Dome area meet the projected requirements, detailed quantitative analyses of the aquifer porosity and permeability are warranted. "Most of the information describing the Madison aquifer is from test holes drilled to find oil...Hydrologic information from oil-test holes consists mainly of data obtained during drill-stem tests and from geophysical logs," (p. 11). Undoubtedly, Murphy Oil and other Poplar Dome oil producers have records of many drill-stem tests. Geophysical logs are available from Federal, State, and private sources (p. 2-3).

Drill-stem tests should be analyzed for transmissivity, the rate at which water moves through a unit width of aquifer under a unit hydraulic gradient (p. 12-17). Maps of the transmissivity of sections of aquifer that can be correlated from well to well should be drawn. The head in each correlatable section should be mapped as well. These maps will reveal which stratigraphic intervals are most permeable and will sustain the highest pressures upon production.

If the Poplar Dome area is shown in these maps to be an area with anomalously low fluid potential (head) it is possible that faulting is allowing vertical leakage out of the Madison aquifer (p. 27). If this is the case, a shallower thermal aquifer may exist. This possibility can be quantified only after potentiometric-surface maps for a number of water-bearing intervals have been constructed.

The most beneficial geophysical logs to analyze for porosity are the electric, gamma, density (gamma-gamma), and acoustic logs (p. 42). Temperature and caliper logs are necessary to quantify the data from these logs. In addition to the methods detailed by Miller (p. 33-42), cross-plots of neutron count versus gamma-gamma density should be made to assess formation porosity.

This additional study should emphasize collection and analysis of data from those wells nearest to Poplar. Wells #42, #43, #44, #45, and #46 (Figure I-3) are all "dry" oil wells within two miles of Poplar. There is probably a complete suite of well logs available for these wells.

If there are insufficient down-hole geophysical logs available for these wells or other wells nearby, additional well logging should be considered. Another possible avenue would be production testing of the Madison section in an uncased well (if any are available), or testing of a well in which the casing could be perforated throughout the Madison interval. It should be noted that there is apt to be significant mud damage to many of the water-producing zones in these wells, and additional reworking of existing wells may be necessary in order to test properly their production capacity.

Shallow Aquifer Model

The possible existence of a shallow warm-water aquifer above the Madison should be explored fully. An analysis of the well logs for intervals above the Madison should readily reveal the presence of any warm water. The model proposed by PRC Toups relies heavily upon the inferred existence of faults in the area. Confirmation of faulting could readily be obtained from some of the well logs and any seismic or gravity surveys which were probably made in the Poplar Oil Field. Faulting probably plays a very minor role, if any, in controlling geothermal fluids in the area. The Poplar geothermal system is most likely aquifer-controlled rather than fault-controlled.

Temperature Gradient Survey

Faults cannot be mapped using 10-foot deep temperature measurement holes. The thermal anomaly indicated by this survey is most likely due to a shallow glacial aquifer as discussed by Cartwright, K., 1966, Thermal prospecting for shallow glacial and alluvial aquifers in Illinois: Illinois State Geol. Survey Circ. 433, 41p., and Cartwright, K., 1968, Thermal prospecting for ground water: Water Resources Research, v. 4, no. 2.

Interference with Oil Production

Production of significant quantities of water from the Madison in the Poplar Oil Field could interfere with petroleum production if the field is a water-driven system dependent upon the flow of water to move the oil into suitable structural traps from which it is produced. The Poplar Oil Field producers will undoubtedly know if the field is water-driven and what effect, if any, geothermal production could have on the field.

Miscellaneous Recommendations

Serious consideration should be given to the use of existing wells for production and injection rather than drilling new holes. A great deal is known about the oil- and water-bearing characteristics of the Madison Group

in northeastern Montana.

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