Before the Public Utilities Commission
of the State of South Dakota

IN THE MATTER OF THE APPLICATION BY TRANSCANADA KEYSTONE PIPELINE, LP FOR A PERMIT UNDER THE SOUTH DAKOTA ENERGY CONVERSION AND TRANSMISSION FACILITIES ACT TO CONSTRUCT THE KEYSTONE PIPELINE PROJECT	))))))	**HP 07-001** **DIRECT TESTIMONY OF Perry H. Rahn Ph.D, PE November 13, 2007**

Geological Factors for the Proposed Keystone Pipeline

by
Perry H. Rahn [(1)]
1207 11th St.
Rapid City, SD 57701
November 13, 2007

Please state your name and address for the record.

My name is Perry H. Rahn. My address is 1207 11th Street, Rapid City, SD 57701

Please state your professional qualifications and background.

I'm a Professional Engineer and a Certified Professor Geologist. I have a PhD in geology from the Pennsylvania State University (1965) and have taught in the Department of Geology & and Geological Engineering at the South Dakota School of Mines and Technology since 1968. I retired as Professor Emeritus in 1997. I specialized in Ground Water and Engineering Geology.

Have you provided a copy of your resume with your testimony?

Yes

Please provide us with a summary testimony.

This paper was written to evaluate geologic information concerning aquifers in the eastern South Dakota for the South Dakota Public Utilities hearing to be held in December, 2007. This information is relative to the application for a permit (re: the South Dakota Energy Conversion and Transmission Act) to construct the Keystone Pipeline Project by TransCanada.

The proposed pipeline route is shown in Figure 1. The route extends along the eastern side of the James River Valley from Marshall County to Yankton County.

Please provide us with a summary of the geology and aquifers located in the area that would be crossed by the proposed pipeline route.

AQUIFERS

The geology of eastern South Dakota consists of glacial drift and alluvium on top of Cretaceous or Precambrian bedrock.

Till underlies much of eastern South Dakota. These deposits have very low permeability. Barari and Hedges (1985) show, for example, that ^{14}C dates on water in unweathered till are approximately 10,000 years old.

The major aquifers in eastern South Dakota are: (1) glacial outwash and (2) alluvium underlying flood plains. Bedrock aquifers including the Cretaceous Dakota Sandstone also exist in some places. The primary concern relative to a possible oil pipeline break is the near surface aquifers such as alluvium and outwash.

Outwash aquifers consist of fine to very coarse sand and gravel (Hamilton, 1978). There are published hydrogeologic studies that show the location of outwash aquifers near the proposed pipeline route. For example, Koch and Bradford (1978) describe the outwash aquifers that are a water supply for Aberdeen.

Koch (1975) describes the "James aquifer" in Marshall County. This outwash aquifer provides 500 gpm or more to wells. It can be very near the land surface, extending to 200 ft depth in some places (Koch, 1975, Figure 19). Recharge to this outwash is by ground water inflow and by percolation from precipitation.

In Clark County, Altamont Aquifer 2 underlies 630 square miles, and has a depth ranging from 10 ft in the west to 480 ft under the Coteau de Prairie (Hamilton, 1986). Up to 2,000 gpm can be obtained from wells in this aquifer.

Alluvium under flood plains is the primary source of water for Sioux Falls (Koch, 1982) and Brookings. The deposits are typically less than 100 ft thick, but typically are very permeable. Leap (1988) and Rahn (1988) describe the origin of alluvial and glacial deposits in Day County, and their relation to the numerous glacial lakes.

In your professional opinion, what are the potential impacts that could result if the TransCanada-Keystone Pipeline were constructed and operated through eastern South Dakota as proposed?

POTENTIAL IMPACTS FROM THE PROPOSED TRANSCANADA PIPELINE

The proposed pipeline crosses several geologic units in eastern South Dakota. Figure 1 is the state geologic map showing these Quaternary units, including lacustrine deposits in Marshall County, and alluvium and till (ground moraine) in Day, Clark, in Day, Miner, Hanson, McCook, Hutchinson, and Yankton Counties.

The geological map of South Dakota (Martin et al., 2004) can be used to study the potential impacts to ground water caused by a pipeline leak. The map (Figure 1, to be presented at the December hearings) is available on-line; the map used in this study was printed at 1:500,000 scale. There are more detailed geologic maps of some locales, such as Marshall (Koch, 1975), Day (Leap, 1988), and Clark (Hamilton, 1978) Counties. In order to examine the geologic factors involved along the entire pipeline route, this map by Martin et al. (2004) was chosen because is shows the entire route at the same scale with consistent geologic units.

Maps showing the proposed pipeline route and mileposts for the Keystone Pipeline Project are available at the TransCanada website. This proposed oil pipeline would cross the general area served by WEB Water. The WEB Water Development operates a regional water pipeline system to 8,000 homes and 105 towns in this area. WEB Water is currently exploring the use of ground water in glacial drift in Marshall, Day and Clark Counties; this ground water would be used to blend with Missouri River water for use by WEB Water.

The primary factor in assessing the environmental impact to ground water supplies is the possibility of a leak from the pipeline. Alluvium and glacial outwash are highly susceptible to contamination because they are quite permeable. Till, on the other hand, is virtually impermeable.

From the Canadian border to the Missouri River Valley at Yankton, the proposed pipeline crosses 24 different streams where alluvium is extensive enough to be mapped at 1:500,000 scale. Using the geological map by Martin et al. (2004) a total of 17 miles of alluvium would be traversed by a pipeline where it crosses these stream valleys.

An oil leak into these alluvial deposits would not only contaminate the alluvium near the pipeline, but would most likely surface into a nearly stream. In the alluvial aquifer, the contaminants would move slowly downgradient (westerly) into the James River Valley. The contaminants could migrate from alluvium to outwash because the alluvium is hydraulically connected to outwash aquifers. Because outwash and alluvial aquifers are being utilized, these deposits should be considered “geological sensitive” areas. They are “High Consequence Areas” (HCA) and need special protection.

What impact on water quality, public safety and the environment in general would a crude oil leak from the TransCanada-Keystone Pipeline cause?

An oil leak into these alluvial deposits would not only contaminate the alluvium near the pipeline, but would most likely surface into a nearly stream. In the alluvial aquifer, the contaminants would move slowly downgradient (westerly) into the James River Valley. The contaminants could migrate from alluvium to outwash because the alluvium is hydraulically connected to outwash aquifers. Because outwash and alluvial aquifers are being utilized, these deposits should be considered "geological sensitive" areas. They are "High Consequence Areas" (HCA) and need special protection.

What could be done by TransCanada and/or the State of South Dakota to protect against contamination of ground water?

ALTERNATE ROUTE

It appears that the only alternative route for the Keystone pipeline that has been proposed by TransCanada is along I-29, roughly 40 miles east of the proposed pipeline.

Another alternative route should be studied that would have minimal potential for ground water contamination. If the pipeline were moved about 8 miles to the east of the proposed pipeline, there would no stream crossings where alluvium would be encountered. [See Figure 1 (to be presented at the December hearing).]

This alternative route, along the western edge of the Prairie Coteau, is underlain by lateral and stagnation moraines that are composed of till (Rahn, 1977; Gries, 1996). Due to the extremely low permeability of till, in the event of a pipeline rupture, there would be little opportunity to contaminate permeable alluvial deposits.

After reviewing the information available to you on the TransCanada- Keystone Project, what conclusion have you reached and what recommendation would you offer?

CONCLUSION

I urge the PUC to deny the application by TransCanada until another alternative route is studied. The alternative route that I am proposing is about 8 miles east of the route proposed by TransCanada. The route I am proposing takes into account the geology. It is a vastly superior route because the pipeline would be excavated into glacial till. It would not cross 17 miles of alluvium like the route proposed by TransCanada. Hence, in the event of a leak, the oil would have much less opportunity to contaminate the aquifers.

Does this conclude your direct testimony?

Yes.

Would you be available to present testimony and respond to questions on a dated schedule during the formal hearing process set for December 3 to December 14, 2007?

Yes

Date this 13th day of November, 2007.

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Perry H. Rahn, Ph.D, Professional Engineer

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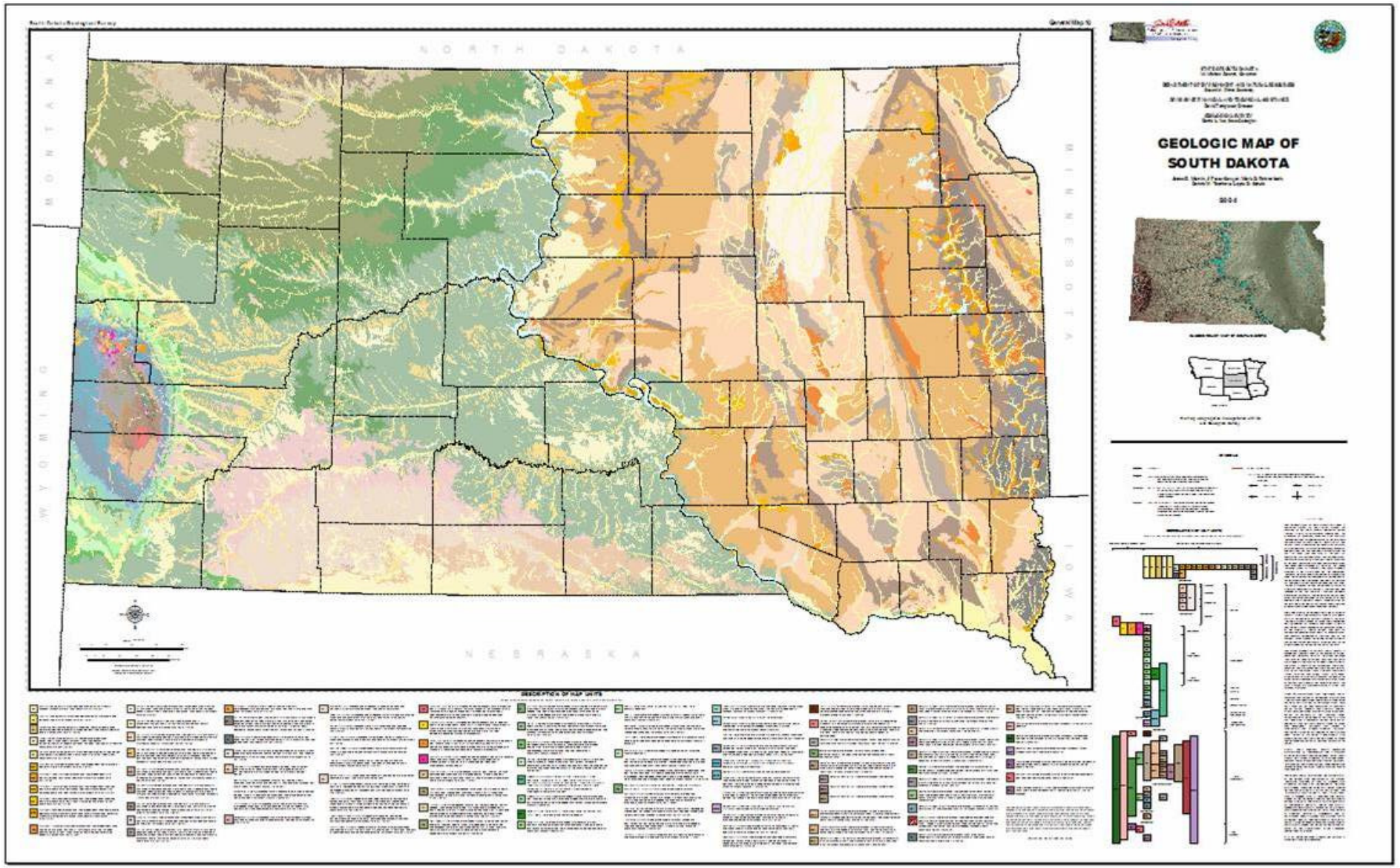
NORTH DAKOTA
MONTANA
WYOMING
MINNESOTA
IOWA
NEBRASKA
GEOLOGIC MAP OF
SOUTH DAKOTA
DESCRIPTION OF MAP UNITS

September 11, 2007

VITA

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Education

B.A., (Geology) Lafayette College, 1959
B.S., (Civil Engineering) Lafayette College, 1959
Ph.D., (Geology) Pennsylvania State University, 1965

Professional Organizations and Honors

1. Fellow, Geological Society of America (Engr. Geol. Div.), 1965 to present.
2. Member, Association of Engineering Geologists, 1965 to present.
3. Member, American Institute of Professional Geologists, 1977 to present (Cert. Prof. Geol. Sci. #3724).
4 Member, South Dakota Academy of Science, 1969 to present.
5. Member, National Society of Professional Engineers, 1980 to present (President, Black Hills Chapter, 1993). [Registered Professional Engineer, #SD 4513]
6. Recipient of Assoc. Engr. Geologists "Claire P. Holdredge Award" for book "Engineering Geology, an Environmental Approach", 1987.
7. Member, Restoration Advisory Board, Ellsworth AFB Superfund Site, 1990-present.
8. Recipient of Eng. Geol. Div., Geol. Soc. Am. "E.B. Burwell, Jr." award for book "Engineering Geology, an Environmental Approach", 1990.
9. "Engineer of the Year" by Black Hills Chapter of S.D. Engr. Soc., 1995.
10. Editorial Board for "Engineering Geology" (% Elsevier Publ. Co., Netherlands), 1995 to present.
11. "Drinking Water Protection" committee, City of Rapid City, 2000 to present.
12. Richard H. Jahns Lecturer, Eng. Geol. Div., Geological Society of America and Association of Engineering Geologists, 2002.
13. Distinguished Practice Award, Association of Engineering Geologists, 2003.

Work Experience

1. Engineering Geologist, Calif. Dept. of Water Resources, Oroville, CA, 1959-61.
2. Assistant Professor, University of Connecticut, Storrs, CT, 1965-68
3. Assistant Professor, S.D. School of Mines and Tech., Rapid City, SD, 1968-70
4. Associate Professor, S.D. School of Mines and Tech., 1970-79
5. Professor, S.D. School of Mines and Tech., 1979-1997.
6. Professor Emeritus, S.D. School of Mines and Tech., 1997-present.

7. Visiting Scientist, Division of Environmental Impact Studies, Argonne National Laboratory, Argonne, Illinois, 1977-78 (15 months)
8. Hydrologist, U.S. Geological Survey, Phoenix, AZ, Summer 1963
9. Visiting Professor, Pennsylvania State University Geology Field Camp, Red Lodge, Montana, Summer 1965
10. Glacial Geologist, Conn. Geological Survey, Middletown, CT, Summer 1967
11. Hydrogeologist, S.D. Geological Survey, Vermillion, SD, Summers 1968-72
12. Geomorphologist, S.D. Remote Sensing Institute, Summers 1973-74
13. Hydrogeologist, S.D. School of Mines & Technology research projects, Summers 1975, 1976, 1979, 1980, 1981, 1984-1993
13. Visiting Professor, Bucknell U., Lewisburg, PA., Spring Semester, 1989
14. Director, Black Hills Nat. Science Field Station, 1995 to 1999.

Publications

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