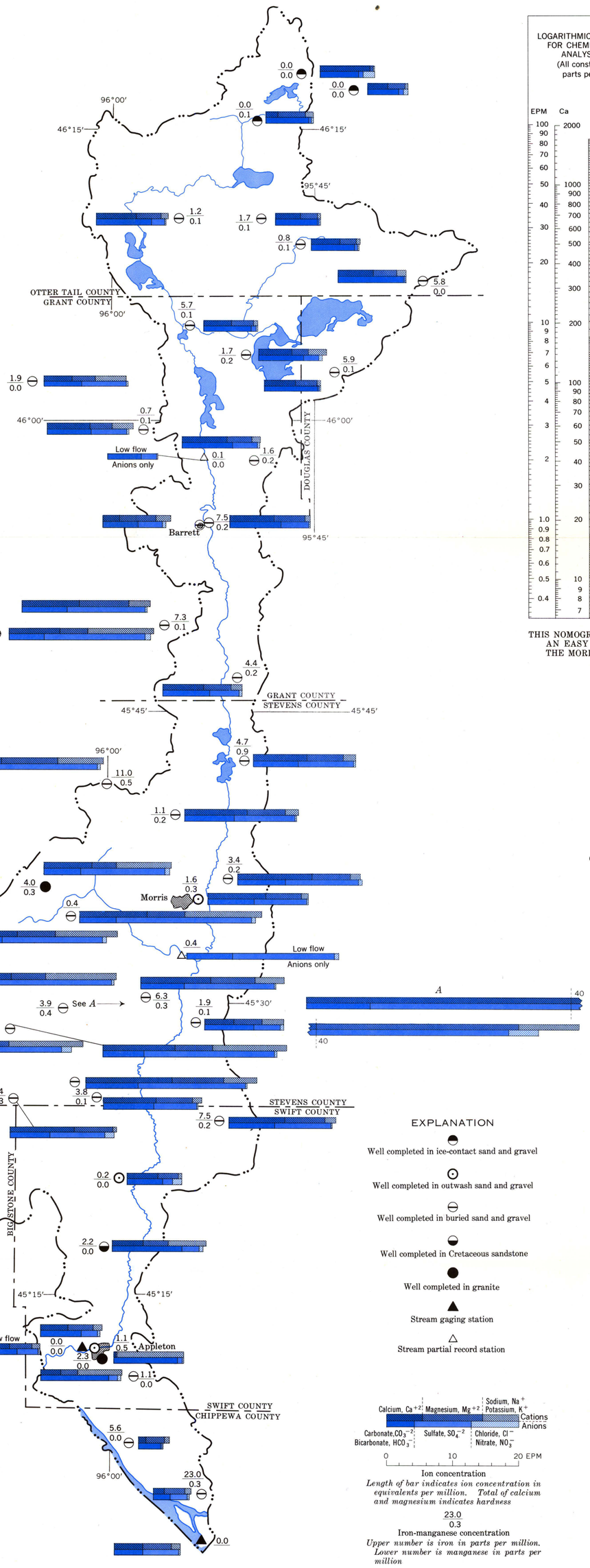
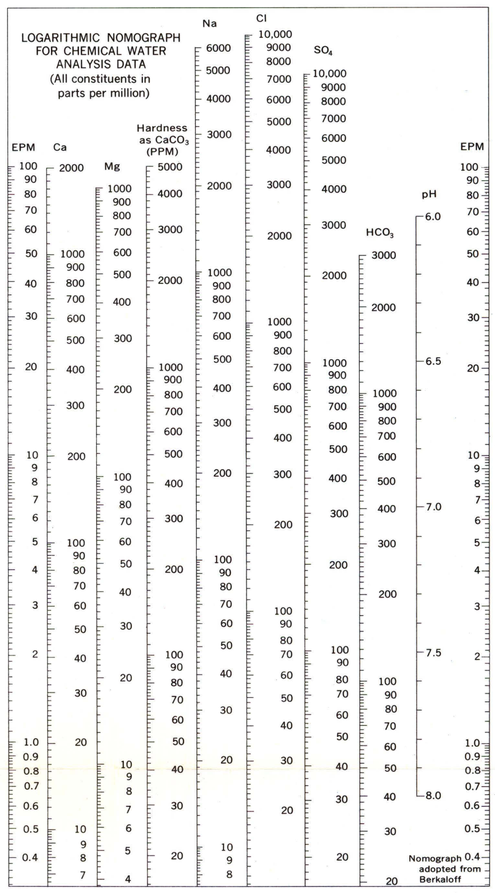
DEPARTMENT OF THE INTERIOR
UNITED STATES GEOLOGICAL SURVEY

PREPARED IN COOPERATION WITH
THE MINNESOTA DEPARTMENT OF CONSERVATION
DIVISION OF WATERS

HYDROLOGIC INVESTIGATIONS
ATLAS HA-220 (SHEET 4 OF 4)

CHEMICAL QUALITY OF WATER





THIS NOMOGRAPH (VORHIS, WRITTEN COMMUNICATION, 1954) PROVIDES AN EASY CONVERSION FROM EPM (EQUIVALENTS PER MILLION) TO THE MORE COMMON PPM (PARTS PER MILLION)

EXPLANATION

Well completed in ice-contact sand and gravel

Well completed in outwash sand and gravel

Well completed in buried sand and gravel

Well completed in Cretaceous sandstone

Well completed in granite

Stream gaging station

Stream partial record station

Ion concentration

Length of bar indicates ion concentration in equivalents per million. Total of calcium and magnesium indicates hardness

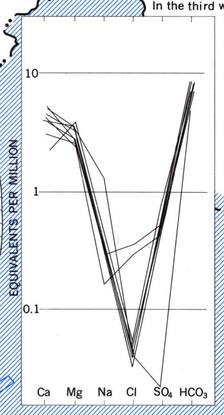
23.0 / 0.3

Iron-manganese concentration

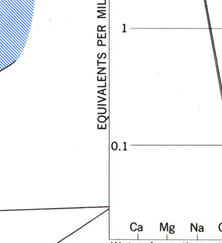
Upper number is iron in parts per million. Lower number is manganese in parts per million

CHEMICAL QUALITY OF WATERS IN THE WATERSHED IS SUITABLE FOR MOST PURPOSES ALTHOUGH THE WATERS ARE COMMONLY HARD AND HIGH IN IRON.—*Water from surface sources and from wells completed in outwash and ice-contact sand and gravel is suitable for irrigation. A high content of chloride and nitrate in water from shallow wells in permeable surficial deposits indicates organic contamination. The high chloride content of water from wells in the southern part of the watershed may be due in part to mixing of water from glacial drift with water from underlying Cretaceous rocks. Analyses of surface water were from samples taken at low flow. Total dissolved solids will be lower at high streamflow. Analyses were made by the Minnesota Dept. of Health and the U.S. Geological Survey*

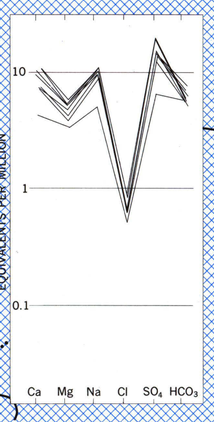
In this area of permeable ice-contact deposits, recharge is high and precipitation containing CO_2 has dissolved Ca^{+2}, Mg^{+2}, and HCO_3^{-} from glacial deposits rich in carbonate rocks.
Analyses from 3 wells in this area deviate from the group. Two of these are shallow wells having high Cl^{-} and NO_3 content probably from organic contamination.
In the third well SO_4^{-2} has been reduced to H_2S

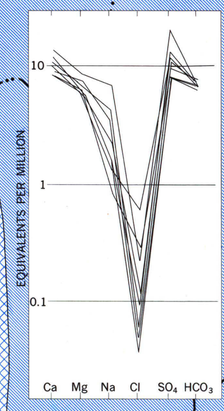


With longer contact with the rocks the water which is now dissolving Ca^{+2}, Mg^{+2}, and HCO_3^{-} at a diminishing rate shows a relative increase in Na^{+} and SO_4^{-2}



Content of Na^{+}, Cl^{-}, and SO_4^{-2} increases. Na^{+} now exceeds Ca^{+2} although Ca^{+2} and Mg^{+2} show a slight decrease

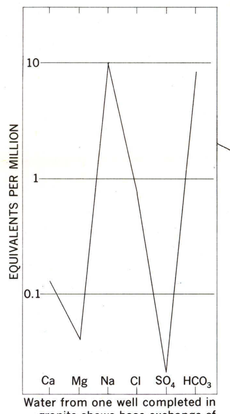




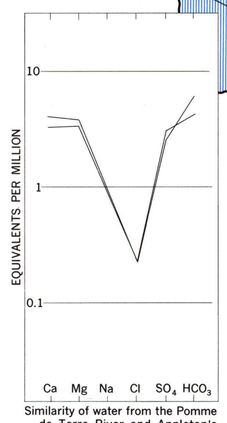
The water approaches a peak concentration of Ca^{+2}, Mg^{+2}, and HCO_3^{-}, but continues to dissolve more of the less soluble, less available SO_4^{-2} to where this exceeds HCO_3^{-}. Na^{+} continues to increase

Graphs of chemical constituents for the 4 wells completed in glacial drift in this part of the watershed have little similarity and are not shown

Water from these two wells have similar plots. One is reportedly completed in Cretaceous rocks and the other is of similar depth

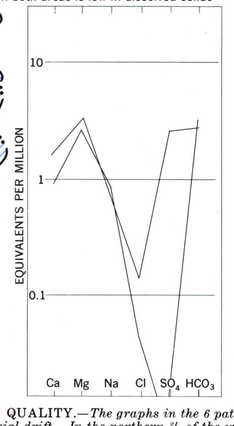


Water from one well completed in granite shows base exchange of Na^{+} for Ca^{+2}, and Mg^{+2}



Similarity of water from the Pomme de Terre River and Appleton's city well shows a hydrologic connection between river and aquifer

These waters are similar to those in the adjacent area except that Ca^{+2} is much less than Mg^{+2}. Water in both areas is low in dissolved solids



EXPLANATION

Direction of ground-water movement

Well completed in bedrock

THE WATERSHED HAS BEEN DIVIDED INTO 6 AREAS OF SIMILAR WATER QUALITY.—*The graphs in the 6 patterned areas are plots of 6 chemical constituents of water from streams and wells completed in glacial drift. In the northern 2/3 of the watershed the shape of the graphs can be related to the ground-water movement In the down-gradient direction the quality changes from "calcium magnesium-bicarbonate" water through "sulfate" water, to a sodium-rich water, relatively high in chloride. Sources for calcium (Ca^{+2}), magnesium (Mg^{+2}), and bicarbonate (HCO_3^{-}) ions are much more abundant in rocks of the watershed than sources for sulfate (SO_4^{-2}), chloride (Cl^{-}), and sodium (Na^{+}) ions. The increase in the latter 3 constituents are caused by exposure to more rocks. Little similarity was found in part of the lower basin and graphs are not shown. Two graphs represent individual wells probably completed in bedrock, and do not define any area*

SCALE 1:250 000

5 0 5 10 15 20 MILES

INTERIOR—GEOLOGICAL SURVEY, WASHINGTON, D. C.—1966—W66120

WATER RESOURCES OF THE POMME DE TERRE RIVER WATERSHED, WEST-CENTRAL MINNESOTA

By
R. D. Cotter and L. E. Bidwell

1966