

# Appendix F

## Basic Assumptions Used in the Development of the Department of Natural Resources Proposed Method to Determine Whether a Stream and the Hydrologically Connected Ground Water Aquifers Are Fully Appropriated

Nebraska Revised Statutes § 46-713(3) states that a river basin subbasin or reach shall be deemed fully appropriated if the department determines that then-current uses of hydrologically connected surface water and ground water in the river basin, subbasin, or reach cause or will in the reasonably foreseeable future cause: (a) the surface water supply to be insufficient to sustain over the long term the beneficial or useful purposes for which existing natural flow or storage appropriations and the beneficial or useful purposes for which, at the time of approval, any existing instream appropriation was granted, (b) the streamflow to be insufficient to sustain over the long term the beneficial uses from wells constructed in aquifers dependent on recharge from the river or stream involved and (c) reduction in the flow of a river or stream sufficient to cause noncompliance by Nebraska with an interstate compact or decree, or other formal state contract or agreement, or applicable state or federal laws. This memo will address the assumptions relied upon to develop the method the Department proposes to use to address sections a and b of the statute.

In essence, if streamflow is sufficient enough to supply surface water appropriators, it is also sufficient to supply recharge for ground water wells dependent on the streamflow. This is true because any ground water aquifer that is hydrologically connected to a fully appropriated stream is also fully appropriated because the surface water and hydrologically connected ground water are both part of one interconnected system. A depletion in one component of this system depletes the other component. If there is an additional well and consumptive use of water in the ground water aquifers connected to the stream, the new well will either intercept and consume water that otherwise would have flowed to the stream or cause more water to flow from the stream to the aquifer. Eventually this additional consumption will cause not only additional depletions to the aquifer, but also additional depletions to the stream. In essence, the test of looking at the sufficiency of streamflow to satisfy a junior surface water right is like a canary in the coal mine; the junior water rights act as an alarm system signaling that the stream and the hydrologically connected ground water aquifers are both fully appropriated.

The nature of the connection between the stream and the aquifer determines how much and how fast water will flow between the stream and the aquifer. Water flows from a hydrologically connected aquifer to a stream, or vice versa, in response to the difference in the hydraulic head between the stream and the aquifer. Water flows down the hydraulic head gradient from areas of higher hydraulic head to areas of lower hydrologic head. Hydraulic head in ground water is a function of the combination of both the elevation and the pressure of the

water. Water flows downhill in response to gravity and uphill in response to pressure from the weight of overlying aquifer materials and water.

In the case of a gaining stream, the water in the aquifer has a higher hydraulic head than the stream and water flows down gradient from the aquifer to the stream. In this situation, the addition of a pumping ground water well that removes water from the aquifer will lower the hydraulic head of the ground water in the aquifer and decrease the gradient between the higher hydraulic head in the aquifer and the lower hydraulic head in the stream. The decrease in the hydraulic gradient results in less water flowing from the aquifer to the stream.

In the case of a losing stream the water in the stream is at a higher hydraulic head than the ground water and water flows down gradient from the stream to the aquifer. As before, the addition of a pumping ground water well that removes water from the aquifer will lower the hydraulic head of the ground water in the aquifer. In this case the well will increase the hydraulic gradient between the higher head of the stream and the lower head in the aquifer and more water will flow from the stream to the aquifer, further depleting the stream. In either case, if the stream itself is already determined to be fully appropriated, than the whole integrated system must be fully appropriated.

One must also ask, is it possible for a stream itself to have sufficient water for all surface water rights but not have sufficient ground water to recharge wells dependent on streamflow? In this case, all the demands of the surface water rights would have to be satisfied, but the water in the ground water aquifer would be insufficient for the existing wells. Such a system could not happen on a gaining stream because if the ground water were insufficient to sustain the wells, there would be little or no water in the stream for the surface water users. According to Bentall and Shafer (1979) most streams in the State of Nebraska are gaining streams<sup>1</sup>.

The remaining case would be a losing stream on which the major water supply to the stream and the hydrologically connected aquifers was from surface water runoff to the stream. Furthermore, this runoff would have to be sufficient to satisfy the junior surface water rights, or it would be determined to be fully appropriated under criteria (a) of the statute, but not sufficient enough to satisfy ground water wells for which the stream flow was a critical component of the supply. In areas on the White and Hat Creeks in western Nebraska, where isolated fractures in the Brule Formation are in close hydrologic connection to the stream but not to a surrounding ground water aquifer, there could be small stock and domestic wells that depend primarily on streamflow as their sole source of water. However, these streams have already been declared fully appropriated because the demands of the existing surface water rights are not met. There may also be such

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<sup>1</sup> Availability and Use of Water in Nebraska 1975. 1979. Nebraska Water Survey Paper Number 48. Conservation and Survey Division Institute of Agriculture and Natural Resources, University of Nebraska Lincoln.

isolated physical systems in other parts of the state such as in the glacial till area of the eastern part of the state and along the Missouri River, but like the White River and Hat Creek, if the demands of the hydrologically wells are not being met, it is unlikely that the demands of any existing surface water rights would be met.