BEFORE THE OKLAHOMA WATER RESOURCES BOARD
STATE OF OKLAHOMA

IN THE MATTER of Determining the Maximum Annual Yield for the Arbuckle-Simpson Groundwater Basin underlying parts of Murray, Pontotoc, Johnston, Garvin, Coal and Carter Counties)

TENTATIVE DETERMINATION OF
MAXIMUM ANNUAL YIELD OF GROUNDWATER FROM THE
ARBUCKLE-SIMPSON GROUNDWATER BASIN

On this 13th day of March, 2012, there came for consideration a proposed order to establish the tentative determination of the maximum annual yield of groundwater to be produced from the Arbuckle-Simpson Groundwater Basin. Based on the hydrologic surveys and investigations made, the Board makes and enters the following tentative findings, tentative conclusions, order and directives.

TENTATIVE FINDINGS

1. HYDROLOGIC STUDIES AND REPORTS - The Board has made or caused to be made hydrologic surveys and investigations of the Arbuckle-Simpson aquifer which is located under parts of the following counties: Murray, Pontotoc, Johnston, Garvin, Coal and Carter Counties in south-central Oklahoma. The hydrologic surveys and investigations reviewed for this order include the United State Geological Survey (USGS) in September 2011 entitled Hydrogeology and simulation of groundwater flow in the Arbuckle-Simpson aquifer, south-central Oklahoma, scientific Investigations Report 2011-5029,, herein USGS Arbuckle-Simpson Report. The USGS Arbuckle-Simpson Report, other USGS reports, in-stream flow assessment reports, a tree ring analysis report to compare recent hydrological cycles with area hydrology over the previous 300 years, and other reports prepared as part of the Arbuckle-Simpson study can be reviewed and downloaded from the Reports & Updates section of the Oklahoma Water Resources Board Arbuckle-Simpson study webpage http://www.owrb.ok.gov/studies/groundwater/arbuckle_simpson/arbuckle_study.php.

2. AQUIFER CHARACTERISTICS - The Arbuckle-Simpson aquifer characteristics can be summarized as follows:

a. The Arbuckle-Simpson aquifer is contained within three major rock units of Upper Cambrian to Middle Ordovician age, including the (1) Timbered Hills Group, (2) Arbuckle Group, and (3) Simpson Group. A discussion of the hydrogeologic settings, rock unit characteristics and time and rock stratigraphic descriptions is found within the USGS Arbuckle-Simpson Report.

b. The Arbuckle-Simpson aquifer is considered a bedrock aquifer, as distinguished from an alluvium or alluvium and terrace aquifer. The bedrock is highly fractured,

folded, and faulted making a study and analysis of the geology more complex.

c. There are three major aquifer areas that were subject of the hydrology study, generally delineated and shown in Figure 2 of the USGS Arbuckle-Simpson Report. These aquifer areas are designated "Eastern Arbuckle-Simpson Aquifer", "Central Arbuckle-Simpson Aquifer" and "Western Arbuckle-Simpson Aquifer". In previous reports and newsletters, these three areas were often referred to as "anticlines" (i.e. Hunton Anticline, Tishomingo Anticline, and Arbuckle Anticline). Most delineated areas shown on the map are considered "outcrop" areas where the actual rock formations that constitute the aquifer form the land surface. However, an area in the northwestern portion of the Eastern Arbuckle-Simpson Aquifer was identified where the top of the aquifer dips below the surface and is referenced in the Figures 10 – 12 in the USGS Arbuckle-Simpson Report as the Arbuckle-Simpson "subcrop". This subcrop aquifer area is confined above by younger rocks of various ages. Where the Arbuckle-Simpson subcrop dips beneath rocks of lower permeability, the aquifer is confined, and wells that penetrate below the confining layer may be artesian. Several artesian wells flow in the valley of Rock Creek, near the City of Sulphur. A well known artesian well is Vendome Well located within the Chickasaw National Recreation Area (CNRA).

d. Although designated with three aquifer names for purposes of describing the general geographic areas where the major rock units are found, the geologic groups consisting of the three aquifer areas contains a distinct body of water overlain by contiguous land that has substantially the same geological and hydrological characteristics.

3. WELL YIELDS - Groundwater wells located throughout the aquifer areas yield at least 50 gallons per minute on the average.

4. GENERAL WATER QUALITY - The quality of groundwater produced from groundwater wells in the aquifer areas generally contains less than 500 milligrams per liter (mg/L) total dissolved solids.

5. OVERLYING LAND AREA - The total land area overlying the aquifer areas (including the narrow "connecting" areas between the three larger aquifer areas) is approximately 612.5 square miles, or 392,019 acres. The Board recognizes that site-specific information such as the lithology from a well drilled on a particular tract of land located near or on the boundaries shown in the map attached as Appendix 1 may show that a particular tract or acre of land overlie or do not overlie the aquifer material, but such site-specific information may be presented in an individual proceeding conducted to consider a particular application for permit to use groundwater with determinations as to inclusion or exclusion of acres of land made on that site-specific scale.

6. AQUIFER STORAGE – The amount of groundwater in storage in the Arbuckle-Simpson aquifer is determined to be about 11,000,000 acre-feet, calculated by using the storage coefficient of 0.008 and the average saturated thickness of 3,400 feet.

7. RATE OF RECHARGE - The Board tentatively finds the following regarding the rate of recharge to the Arbuckle-Simpson aquifer areas:

a. The average rate of recharge (volume of water that percolates into the geological formation from precipitation is estimated at 5.58 inches per year.

b. Using the average recharge rate and with the total land area overlying the aquifer of 392,019 acres, the total amount of recharge for the aquifer areas is calculated at 182,288 acre-feet of water per year. Accordingly, over a 20–year period, the cumulative total amount of recharge to the aquifer would be 3,645,760 acre-feet. However, as discussed in Tentative Conclusion Nos. 4 and 5 below, the total recharge figure based on a twenty-year basin life is not a significant factor to the determination of the maximum annual yield of the Arbuckle-Simpson aquifer, due to the unique provisions of Senate Bill 288.

8. TOTAL DISCHARGE - The Board tentatively finds the following regarding the total discharge from the Arbuckle-Simpson aquifer areas:

a. To calculate the total amount of discharge from the basin, the Board assumes that holder of "prior rights" will pump their full (100%) authorized annual volume of groundwater. "Prior rights" are rights to use groundwater established under state laws as those laws existed prior to July 1, 1973, with such rights being recognized in final orders of the OWRB determining prior rights to use groundwater. For the Arbuckle-Simpson aquifer, prior rights authorize withdrawal of a cumulative total of 5,432 acre-feet per year. Therefore, the cumulative total discharge attributable to the assumed full exercise of prior rights over a 20-year period is 108,640 acre-feet.

b. The amount of discharge from an aquifer usually includes water seeping from stream beds and banks, and water flowing from springs into "gaining" streams, which amounts can be estimated by calculating the average volume of stream flow that occurs during periods of little or no runoff, typically during the winter months. However, for the Arbuckle-Simpson aquifer, the provisions of Senate Bill 288 established the need to calculate the natural flow of streams emanating from a sensitive sole source groundwater basin for a separate reason, i.e. to ensure that the maximum annual yield will not reduce the natural flow of water from basin area springs and streams. See Tentative Conclusion No.5 below.

9. TRANSMISSIBILITY - Regarding transmissibility, the Arbuckle-Simpson aquifer has an average transmissivity of 11,000 feet squared per day based on an average hydraulic conductivity 3.3 feet per day and average saturated thickness of 3,400 feet.

10. POSSIBLILITY OF NATURAL POLLUTION - The possibility of pollution from natural sources is negligible. Study information does show that water of lower quality may found in differing aquifer formations located below and to the west of the know sub-crop area within the Eastern Aquifer area and that water from the differing aquifer formation is known to surface in springs within the CNRA (sometimes referred to as "bromide" water or "mineral" water). Induced infiltration of poorer quality water possible from formations outside the outcrop area of the Arbuckle Group and Simpson Formation in areas where heavy pumping of water could occur. The mineral springs located in the CNRA and Sulphur area is evidence of the mixing of these poorer quality waters with the fresh waters of the Arbuckle-Simpson aquifer. However, the water quality concerns cannot be quantified with reasonable certainty and are not expected to significantly alter the amount of water available from the basin for the typical purposes for which groundwater in the basin is used.

11. SENATE BILL 288 - In 2003, the Oklahoma Legislature enacted Senate Bill 288, which act amended the Oklahoma Groundwater Law. One of the provisions of Senate Bill 288 imposes a moratorium on the use of groundwater outside the boundaries of a sensitive sole source groundwater basin or subbasin until the Oklahoma Water Resources Board approves a maximum annual yield for such a basin that will ensure that any permit for the removal of water from such basin *will not reduce the natural flow* of basin area springs or streams. With respect to the impact of this provision of Senate Bill 288, see Tentative Conclusion No. 5 below.

12. INSTREAM FLOW ASSESSMENTS – To consider the potential effects of groundwater withdrawals (by pumping) on the natural flow of springs and streams in the aquifer areas, in-stream flow assessments were conducted.

a. Two species of minnows and two species of darters found in the Blue River and Pennington Creek were selected as representative species to assess the effects of changes to the flow of water on habitat. The Surface Water Technical Advisory Group recommended that if the five-year base flow calculated for area streams is not reduced by more than 25%, such a decrease should result in an acceptable maintenance of the representative fish species in the Blue River and Pennington Creek.

b. The Blue River and Pennington Creek carry water discharged from the Eastern Aquifer area and each stream has significant water-flow records from USGS gauges, which records were used in the in-stream flow assessments. The Board tentatively finds that Mill Creek also carries water discharged from the Eastern Aquifer area and some water discharged from the Central Aquifer area, that Oil Creek carries water discharged from the Central Aquifer Area, and that Honey Creek (on which Turner Falls is located) carries water discharged from the Western Aquifer area. The Board tentatively finds that the species of minnows and darters and effects of flow reduction on such species in Mill Creek, Oil Creek and Honey Creek would be substantially similar to that assessed for the Blue

River and Pennington Creek, and accordingly, a reduction in base flow of those streams of not more than 25% should be acceptable. .

13. MAXIMUM ANNUAL YIELD AND EQUAL PROPORTIONATE PART TO BE ALLOCATED BY REGULAR PERMIT –

a. Considering the hydrologic surveys and investigations, information in Tentative Findings Nos. 5 through 12 above and the declared policy of the Oklahoma Groundwater Law for reasonable regulation for the allocation for reasonable use of the groundwater, the maximum annual yield of the Arbuckle-Simpson aquifer is tentatively determined to be 78,404 acre-feet per year (equivalent to over 25.5 billion gallons of groundwater per year), and the equal proportionate part of the maximum annual yield to be allocated by regular permit to each acre of land overlying the aquifer areas tentatively determined to be 0.20 acre-foot per year (equivalent to 2.4 inches per acre per year).

TENTATIVE CONCLUSIONS

1. SUBJECT MATTER JURISDICTION - The Board is given authority by the Oklahoma Groundwater Law, 82 O.S. 2011, Sections 1020.4, 1020.5 and 1020.6 to make hydrologic surveys and investigations, enter orders to make tentative determinations, hold hearings on the tentative determinations, and make final determinations of the maximum annual yields of each groundwater basin and subbasin. The Board is also given authority to cooperate with state and federal agencies engaged in similar surveys and investigations and may accept and use the findings of such agencies.

2. MAJOR GROUNDWATER BASIN - In reviewing the hydrologic surveys and other information described in the Tentative Findings above and other information, the Board tentatively determines that the Arbuckle-Simpson aquifer areas should be designated as one "major groundwater basin" as defined by the Oklahoma Groundwater Law known as the Arbuckle-Simpson Groundwater Basin, with the general basin boundaries as shown in Appendix 1 to this tentative determination. See Section 1020.1(3) of Title 82 of the Oklahoma Statutes and Tentative Finding 2.d above.

a. In this regard, the Board acknowledges that hydrologic study activities were more intense on the Eastern Aquifer area for a variety of reasons, including the availability of more raw data for that area. Nevertheless, sufficient information and data shows that the three aquifer areas are substantially similar enough and can be considered as one groundwater basin.

b. The Board tentatively concludes that the information gathered and studied shows there are no separately identifiable subdivisions of the Arbuckle-Simpson Groundwater Basin that could be declared to be "subbasins" of the Arbuckle-Simpson Groundwater Basin. To the extent that other information is submitted for review, the Board could determine the existence of a subbasin or subbasins.

3. TYPICAL MAXIMUM ANNUAL YIELD FACTORS - According to Section 1020.5 of Title 82 of the Oklahoma Statutes, after completing hydrologic surveys, the Board is to make a tentative determination of the maximum annual yield of groundwater to be produced from a basin or subbasin based upon the following:

a. total land area overlying the basin or subbasin;
b. amount of water in storage in the basin or subbasin;
c. rate of recharge to and total discharge from the basin or subbasin;
d. transmissibility of the basin or subbasin; and
e. possibility of pollution of the basin or subbasin from natural sources.

Section 1020.5 also provides that the maximum annual yield shall be based on a minimum basin life of 20 years from the effective date of the final order determining the maximum annual yield. It should be noted that although Senate Bill 288 did not specifically amend Section 1020.5 of Title 82 and language setting out the factors described above, the Board tentatively determines that these provisions must be read in harmony with the later enacted provisions of Senate Bill 288.

4. RELEVANCE OF LIFE OF BASIN - By rule, and for purposes of the statutory provision on a minimum basin life of 20 years for determining the maximum annual yield for groundwater basins mentioned in Tentative Conclusion No. 3 above, the OWRB promulgated a definition of "life of a groundwater basin or subbasin" to mean that period of time when at least 50% of the total overlying land of the basin or subbasin retains a saturated thickness allowing pumping of the maximum annual yield for a minimum of 20 years, and that a saturated thickness to allow pumping is considered to be five feet for alluvium and terrace aquifers and 15 feet for bedrock aquifers. However, as discussed in Tentative Conclusion No. 5 below, the statutory factors on which a maximum annual yield shall be based, including the 20-year minimum basin life limitation, must be considered in light of the provisions of Senate Bill 288.

5. SENATE BILL 288 MAXIMUM ANNUAL YIELD LIMITATION - As noted in Tentative Finding No. 10, Senate Bill 288 amended the Oklahoma Groundwater Law and required additional determinations relating to the maximum annual yield of any "sensitive sole source groundwater basin or subbasin".

a. Senate Bill 288 added a new section to the Oklahoma Groundwater Law, designated as Section 1020.9A. Section 1020.9A imposes a moratorium on the issuance of "temporary" permits that allow for municipal use of groundwater from a sensitive sole source groundwater basin or subbasin outside of any county that overlies in whole or in part such basin or subbasin. It should be noted that:

(i) A "temporary permit" is defined by 82 O.S. Section 1020.11(B) as an authorization for the same purposes as a "regular" permit but granted by the OWRB prior to completion of a hydrologic survey and determination of the maximum annual yield of groundwater from the basin or subbasin from which the groundwater will be withdrawn. Pursuant to the provisions of Section

1020.11(B), the Legislature established that temporary permits shall allocate and authorize the withdrawal of two acre-feet of groundwater per acre of land per year, subject to limited circumstances where more or less than two acre-feet per acre can be authorized. Temporary permits are just that, temporary in nature, i.e. no permanent right to the allocation amount is provided, although the law provides for an "automatic" annual revalidation process.

(ii) A "regular" permit is described in Section 1020.11(A) as an authorization to put groundwater to beneficial use and is issued after completion of the hydrologic survey and determination of the maximum annual yield. Section 1020.9(B) of the Oklahoma Groundwater Law provides that a regular permit shall allocate to the applicant the proportionate part of the maximum annual yield of the basin or subbasin, which proportionate part shall be that percentage of the total annual yield of the basin or subbasin that is equal to the percentage of land overlying the basin or subbasin which the applicant owns or leases and which is dedicated to the application.

b. The moratorium on the issuance of temporary permits to withdraw groundwater from a sensitive sole source groundwater basin is in effect until such time as the OWRB conducts and completes a hydrologic survey and approves a maximum annual yield that will ensure that any permit for any removal of water from a sensitive sole source groundwater basin or subbasin pursuant to a permit *will not reduce the natural flow* of water from basin area springs or streams. See Section 1020.9A(B)(2)(emphasis added). Accordingly, the Board must consider the effects of existing and future pumping on the "natural flow" of basin area springs and streams in determining the maximum annual yield from such basin.

6. SENSITIVE SOLE SOURCE BASIN - Section 1020.9A of the Oklahoma Groundwater Law also contains a definition of "sensitive sole source groundwater basin" that must be integrated with other definitions in the Oklahoma Groundwater law.

a. Sensitive sole source groundwater basin means "a major groundwater basin or subbasin all or a portion of which has been designated as a 'Sole Source Aquifer' by the United States Environmental Protection Agency . . . and any portion of any contiguous aquifer located with five (5) miles of the known areal extent of the surface outcrop of the sensitive sole source groundwater basin."

b. As noted in Tentative Finding No. 2.d and Tentative Conclusion No. 2 above, the three aquifer areas studied, including the "subbcrop" area near and extending north from the City of Sulphur constitutes one "major groundwater basin" as defined in Section 1020.1 of the Oklahoma Groundwater Law.

c. The Eastern Aquifer area was designated as a "Sole Source Aquifer" by the EPA in September 1989 (see 54 Federal Register 39230).

d. The Arbuckle-Simpson Groundwater Basin qualifies as a "sensitive sole source groundwater basin" because a portion of the basin (Eastern Aquifer area) has been designated as a sole source aquifer by the EPA.

e. Accordingly, the provision of Senate Bill 288, codified in 82 O.S. Section 1020.9A, applies to the Arbuckle-Simpson Groundwater Basin and to the determination of the maximum annual yield of the basin.

7. STREAM FLOW ASSESSMENTS AND THE NATURAL FLOW - The new limitation in Section 1020.9A (from Senate Bill 288) relative to the determination of the maximum annual yield of sensitive sole source groundwater basin specifies that the Board must approve a yield to ensure that any permit issued by the OWRB will *not reduce the natural flow* of water from area springs and streams.

a. A position could be asserted that the removal of <u>any</u> amount of groundwater from the basin could technically, albeit indirectly, "reduce the natural flow" that may otherwise exist naturally in area springs and streams. A logical extension of such a position would be that the maximum annual yield of the basin must be determined to be zero (0) to ensure that any permits issued would not reduce the natural flow of water in area springs and streams.

b. A zero pumping position or interpretation would be considered a very strained, if not absurd, reading and understanding of the limitation imposed by Senate Bill 288, and could result in a cessation of all use of groundwater from the Arbuckle-Simpson Groundwater Basin. Such a strained interpretation does not appear to advance the declared policy of the Oklahoma Groundwater Law to utilize groundwater resources of the state and to provide reasonable regulations for the allocation for reasonable use of groundwater, as expressed in a later-enacted provision of the Oklahoma Groundwater Law. See 82 O.S. Section 1020.2(A). Furthermore, to the extent legislative enactments are susceptible to interpretation, interpretations that lead to absurd results are to be avoided.

c. By using the words "natural flow" in Senate Bill 288, the Board tentatively concludes that the Oklahoma Legislature intended to protect the water flow that constitutes an essential component of the natural habitat of area streams, and while the opening of springs may support other species of plants and animals, protecting the flow of springs is an integral component of the primary intent to protect area stream flows. Accordingly, an analysis of the effect of potential pumping of groundwater on the habitat of the area's flowing streams is a reasonable approach and consideration for a determination of the maximum annual yield of a sensitive sole source groundwater basin.

d. Additionally, Senate Bill 288 also contained a separately stated condition and limitation on the issuance of any kind of permits (not just regular permits after the maximum annual yield is determined) to use groundwater from a sensitive sole source groundwater basin. The separately stated condition should be read in

conjunction with Section 1020.9A relating to maximum annual yield determinations for sensitive sole source groundwater basins. The separately stated condition is found in Section 1020.9 which was amended by Senate Bill 288 to provide that before issuing a (i.e. any kind of) permit, the OWRB must determine whether the proposed use "is likely to degrade or interfere" with basin area springs and streams. The "degrade or interfere" language appears to contemplate some use of groundwater to be authorized by permits, but imposes the limitation that such use cannot "degrade or interfere" with the flow of springs or streams. Interpreting the contemporaneous "natural flow" limitation as indicating legislative intent that the maximum annual yield must prohibit any groundwater withdrawals, would be inconsistent with a reasonable interpretation of the permit specific "degrade or interfere" language that appears to authorize some pumping.

e. The Board tentatively determines that:

(i) the restriction on maximum annual yield determination to avoid reducing the natural flow of area springs and streams applies on a macro basin-wide scale, and requires a general analysis of the general effects of pumping groundwater on the average flow of area springs and streams, and
(ii) the "degrade or interfere" limitation language applies on a micro site-specific basis and lends itself to an analysis of evidence of potential impacts of specific pumping rates of specific wells on specific springs and streams.

f. Accordingly, the Board tentatively concludes that assessing in-stream flows and determining ranges of impacts to selected species that are indicators of the condition of the stream habitat is a reasonable exercise to calculate the extent of flow necessary to maintain natural conditions of area streams.

8. PHASED IMPLEMENTATION OF MAXIMUM ANNUAL YIELD - The Board makes the following tentative conclusions relative to requests for a phased implementation of a significantly reduced amount of groundwater to be allocated by permits issued by the Board:

a. The Board acknowledges that the tentative maximum annual yield and corresponding tentative equal proportionate part thereof to be allocated by regular permit as set forth herein, if adopted as the final determination and equal proportionate share, would authorize significantly less groundwater withdrawals and use than some existing allocations made by temporary permits issued by the OWRB pursuant to law prior to the enactment of Senate Bill 288, and even less than some temporary permits issued after the enactment of Senate Bill 288.

b. Furthermore, some of the previously existing temporary permit holders include municipalities and rural water districts that supply water for public water supply

systems. To the extent that a significant reduction in the annual amount of groundwater that can be allocated by a regular permit (compared to that allocated by an existing temporary permit) will force some existing groundwater right holders to acquire additional lands or leases of groundwater rights to have a sufficient water supply authorized to meet present or future demand, the OWRB acknowledges that it is reasonable to provide additional time for such existing temporary permit holders to take actions as they deem necessary and appropriate to acquire sufficient rights (ownership or leasehold) to groundwater for their present and future demands. The Board concludes that the process in which an implementation period can be recognized involves the issuance of a "regular" permit to replace an existing valid "temporary" permit, as discussed below.

c. Besides distinguishing between "regular" permits and "temporary" permits (issued before or after the maximum annual yield determination; see discussion in Tentative Conclusion 5.a), the Oklahoma Groundwater Law does not specifically provide a procedure or process for "converting" temporary permits to regular permits (with a corresponding adjustment to the amount allocated and authorized to be withdrawn) after the final determination of the maximum annual yield is made by the Board. However, rules of the Board address the issue as follows:

> **"785:30-9-6. Issuance of regular permit to temporary permit holder**
> "(a) As soon as practical after the maximum annual yield and equal proportionate share have been determined for a groundwater basin or subbasin, the Board shall issue a regular permit to each holder of a temporary permit to use groundwater from said basin.
> "(b) In issuing these regular permits, the Board shall notify the temporary permit holder by first class mail that his equal proportionate share of the basin or subbasin has been determined, that a regular permit has been issued to him based on this allocation, and that his temporary permit has lapsed. A copy of the regular permit shall be included with this notification. . . ."

d. As can be seen, the rule about converting from temporary to regular permits contemplates that the "temporary" permit holder is not required to separately apply for a new "regular" permit. An existing "temporary" permit holder is not required to provide notice of a "regular" permit application, and the "temporary" permit holder is not otherwise required to participate in potentially time consuming and costly administrative proceedings and hearings before the Board can issue a "regular" permit to the "temporary" permit holder. Furthermore, the rule does not provide a specific time within which a regular permit will be issued to replace the previously issued temporary permit, only that a regular permit will be issued "as soon as practical" after the maximum annual yield is determined.

e. The Board tentatively concludes that a reasonably practical timeframe for the issuance of regular permits to replace previously issued temporary permits from

the Arbuckle-Simpson Groundwater Basin is necessary, in light of the difference for the annual amount that would be allocated by a regular permit in relation to the amounts allocated by previously issued temporary permits and the need to implement potential expensive plans by holders of temporary permits to address the significant reduction in the allocation amounts. However, the statutes or the OWRB rules do not provide any express authority for the OWRB to issue a regular permit that would authorize the pumping of more than the determined equal proportionate share of the maximum annual yield. Accordingly, the Board does not adopt a phased implementation approach to issue regular permits that contain an incremental reduction of authorized amounts until the EPS equivalent is reached.

f. Senate Bill 288, and the limitation on the maximum annual yield from a sensitive sole source groundwater basin, was enacted about nine years ago, thus providing an alert to persons and entities holding temporary permits at the time of enactment of Senate Bill 288 as to the potential significant change to the amount that may be allocated by a regular permit after a limited maximum annual yield is determined.

g. Considering the amount of time that has already passed from enactment of Senate Bill 288, and the sensitivity of the flow of area springs and streams to withdrawals of groundwater, the reasonably practical timeframe described in paragraph e above should be no more than five (5) years from the date of final determination of the maximum annual yield, unless good cause is shown that additional time is needed to acquire more groundwater rights and/or establish new well locations, gathering lines and other appurtenances. The Board tentatively concludes that input should be solicited from interested persons during the public hearing on this Tentative Determination on criteria or standards that could be considered good cause for an extension of five year period established for the phased implementation.

9. WELL SET BACK DISTANCES FROM SPRINGS AND STREAMS – The Board tentatively determines that rules concerning well spacing and location exceptions for the Arbuckle-Simpson Groundwater Basin should be promulgated.

a. For a sensitive sole source groundwater basin, Senate Bill 288 requires the Board to limit the effects of pumping pursuant to a permit so that the proposed use of groundwater will not "degrade or interfere" with area springs or streams. Degradation or interference in this context should be interpreted to mean that the cumulative impact of pumping from existing wells and proposed pumping from a specific well that may detrimentally impact the flow of a particular identified spring or stream by more than 25% of the base flow in close proximity to the specific well.

b. According to Section 1020.17 of Title 82 of the Oklahoma Statues, the Board may promulgate *rules* to establish proper spacing of wells which, in the

Board's judgment, is necessary to an orderly withdrawal of water in relation to the allocation of water to the land overlying the basin. Previous to an amendment of the Oklahoma Groundwater Law in 1995, Section 1020.17 indicated that the Board could establish well spacing by *order*, which could have been implemented within an order establishing the maximum annual yield for each particular basin. After the 1995 amendment to the law, the Board can no longer adopt a well spacing requirement within the context of an order establishing the maximum annual yield.

c. The existing well spacing rules of the Board, found at Oklahoma Administrative Code 785:30-3-6, clarify that well spacing and location exception rules are applicable only after a determination of the maximum annual yield of a basin. The existing rules also establish a uniform spacing for new wells in bedrock aquifers to be located at least 1,320 feet from existing or previously authorized *wells* of another, and 660 feet from existing or previously authorized *wells* in alluvium and terrace aquifers. The existing rule does not provide a set back of new wells from a spring or stream.

d. The Arbuckle-Simpson Groundwater Basin contains highly fractured and faulted aquifer material. Site specific analysis of proposed wells and specific springs and streams in the area near a proposed well is necessary to assess the potential impacts from pumping the particular well on such particular springs and streams. However, to avoid or reduce uncertainties by applicants and other interested persons as to establishing well spacing on an ad hoc (application by application) basis, the Board tentatively determines that a rule should be promulgated to set out an established distance that new wells in the Arbuckle-Simpson Groundwater Basin must be from the location of springs and streams, with companion rules to adopt a methodology for estimating effects of pumping from the specific location of a proposed new well to analyze whether such pumping is likely to degrade or interfere with specific springs or streams.

e. The Board directs that preliminary comments should be invited as part of the hearing on the tentative determination of the maximum annual yield as to the appropriateness of initiating notice of rulemaking intent to adopt and promulgate an established well spacing distance from springs and streams, and a companion methodology for estimating potential effects of proposed pumping of proposed wells on particular springs or streams. A draft methodology is set forth with this tentative determination as Attachment 2 hereto.

10. PUBLIC HEARING ON TENTATIVE DETERMINATION - As required by Section 1020.6 of Title 82 of the Oklahoma Statutes relating to hearings on the maximum annual yield, a hearing shall be scheduled as required by law. The hydrologic survey and information relied on to make the tentative order shall be made available for inspection and examination to all interested persons, and notice is to be provided as required by Section 1020.6 of Title 82 of the Oklahoma Statutes. The Board further notes that relevant draft proposals, suggestions, and comment letters

should also be made available for inspection and examination with the hydrologic survey and other information to be made available.

ORDER AND DIRECTIVES

IT IS THEREFORE TENTATIVELY ORDERED by the Oklahoma Water Resources Board that:

1. The Arbuckle-Simpson aquifer underlying areas in Murray, Pontotoc, Johnston, Garvin, Coal and Carter Counties in the south central part of the state shall be and the same is hereby designated the Arbuckle-Simpson Groundwater Basin, with outcrop and subcrop boundaries generally depicted on the map set forth as Appendix 1;
2. The basin is hereby declared to be a major groundwater basin under the provisions of the Oklahoma Groundwater Law;
3. The basin is also declared to be a sensitive sole source groundwater basin under the provisions of the Oklahoma Groundwater Law as amended to Senate Bill 288 enacted in 2003;
4. The tentative determination of the maximum annual yield of the basin is 78,404 acre-feet;
5. The equal proportionate part of the yield to be allocated to each acre of land overlying the basin, based on the maximum annual yield and total overlying land area, is tentatively determined to be 0.20 acre-foot per acre per year (equivalent to two and four tenths inches (2.4") per acre per year); and
6. For reasonable implementation, before regular permits for the equal proportionate part of the maximum annual yield are issued to replace existing valid temporary permits to withdraw groundwater from the Arbuckle-Simpson Groundwater Basin, such temporary permits shall remain in effect (subject to revalidation) for a period of five (5) years from the effective date of a final order determining the maximum annual yield, unless an extension of time is granted for good cause shown.

IT IS FURTHER ORDERED that a hearing shall be held and notice thereof provided as required by the Oklahoma Groundwater Law. After said hearing or hearings, a proposed final order shall be prepared and submitted to the Board for consideration as required by law.

IT IS FURTHER ORDERED that in conjunction with the hearing held on this Tentative Determination, input should be solicited from interested persons on criteria or standards that could be considered good cause for approval of an extension of time of the five-year implementation period before regular permits are issued to replace existing temporary permits.

IT IS FURTHER ORDERED that in conjunction with the hearing held, staff should seek input concerning a potential modification of the well spacing provisions set forth in the current rules relating distances of proposed wells to other wells, and a proposal to adopt an established spacing distance between new proposed wells and springs and streams in the Arbuckle-Simpson Groundwater Basin, and a methodology for assessing

and determining the effects of proposed pumping of specifically proposed wells on specific springs and streams, as set forth in Appendix 2 to this order.

IT IS SO ORDERED by the Oklahoma Water Resources Board in regular and open meeting this 13th day of March, 2012.

OKLAHOMA WATER RESOURCES BOARD

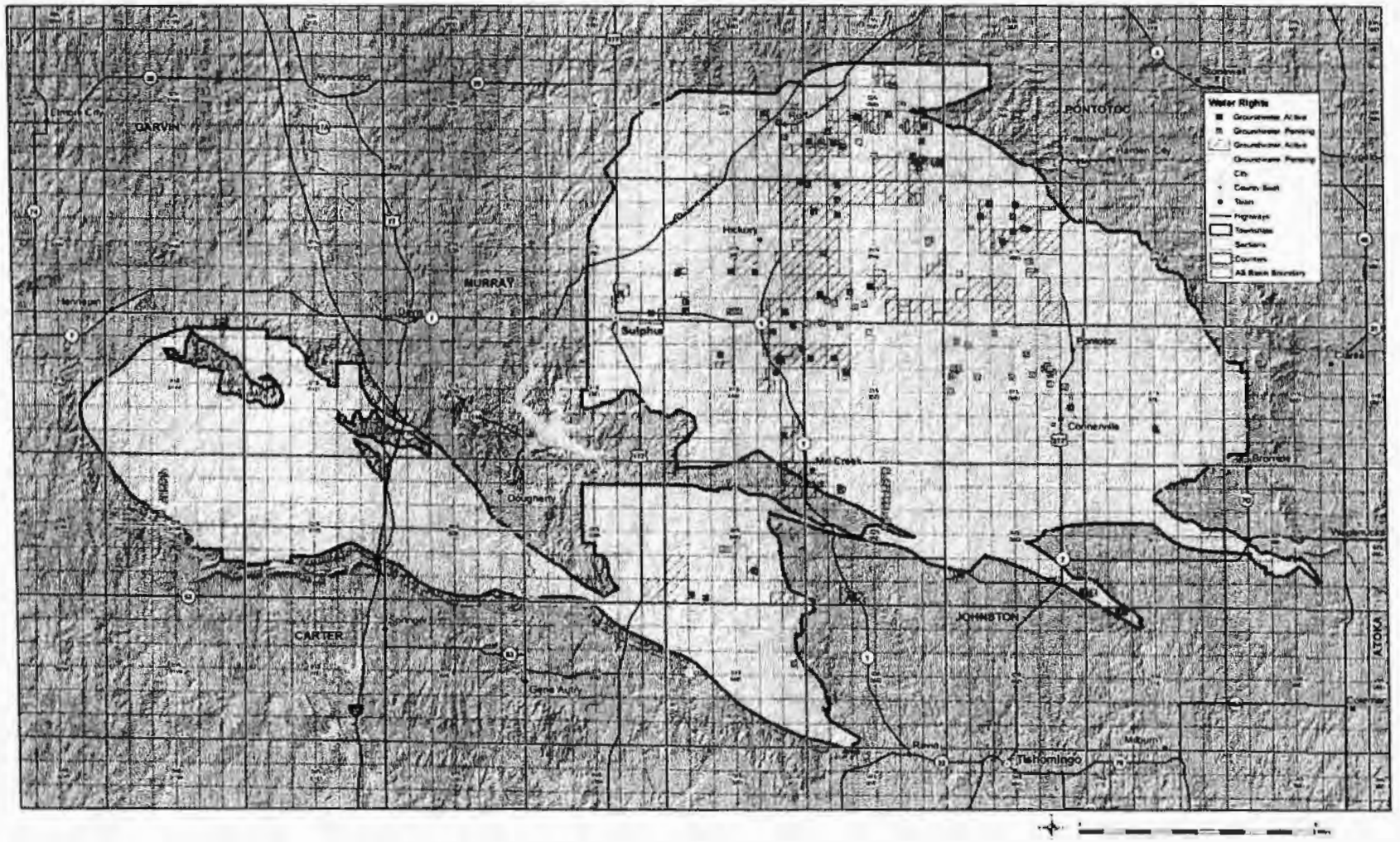
Linda P. Lambert
Chairman Date 3-13-2012

ATTEST:

Secretary Date 3-13-2012

OKLAHOMA WATER RESOURCES BOARD

Attachment 1. Boundaries of the Arbuckle-Simpson Groundwater Basin.



Attachment 2

CALCULATION OF PERCENT DEPLETION OF A SPRING OR STREAM BY PUMPING WELLS

A Description of Technical Procedures

Oklahoma Water Resources Board
Planning & Management Division
Technical Section

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Introduction

A method developed by C.V. Theis and Clyde Conover (1963), was used to determine the amount of spring or stream flow reduction caused by a pumping well. By applying hydraulic data obtained from the Arbuckle-Simpson Hydrology Study, this methodology may be used in evaluating groundwater permit applications in the Arbuckle-Simpson Groundwater Basin.

Background

If a water table aquifer and a stream or spring is hydraulically connected then part of the discharge from a well in that aquifer near the spring or stream will come from the surface water source. The depletion of a spring or stream by a pumping well is means either direct depletion or reduction of groundwater flow to the spring or stream. The theoretical component of the well discharge coming from the spring or stream can be determined using analytical calculations. The amount of diversion from the spring or stream from groundwater pumping is additive of all of the groundwater wells within the area around the spring or stream.

Theis and Conover (1963) developed an analytical solution and graphical method to determine the percentage of pumped water being diverted from a stream or spring (attached). Nicholas Engdahl, formerly with the USGS, developed a computer application (TheisCon) based on the equation used by Theis and Conover (Engdahl, 2009, personal communication). The computer application is easy to use, is less prone to errors, and provides more reproducible results than the graph than by conducting these calculations by hand.

The Theis-Conover method is used to calculate the theoretical percentage (P) of the pumped water from water wells that are being diverted from the stream or spring at a given distance (a) between the well and the stream or spring and at a given time (t) since pumping began. Aquifer parameters required for the analysis are storativity and transmissivity. Storativity, or storage coefficient (S), is the product of the specific storage (S_s) and the aquifer thickness.

Effects of Pumping Duration

To estimate the effect of time (t) since pumping began on the percentage of surface water (P) in the discharge of a well completed or to be completed in the Arbuckle-Simpson aquifer; calculations were made using a distance of one mile (Figure 1). Regional average storage coefficient for the Arbuckle Group is 0.00926 (Christenson, 2011). Transmissivity (T) is the product of hydraulic conductivity (K) and the saturated thickness. The regional average hydraulic conductivity, as used in the groundwater flow model, was 1.0 m/day (3.3 ft/day). This method is not sensitive to saturated thickness, because storage coefficient to transmissivity (S/T) remains the same, regardless of thickness.

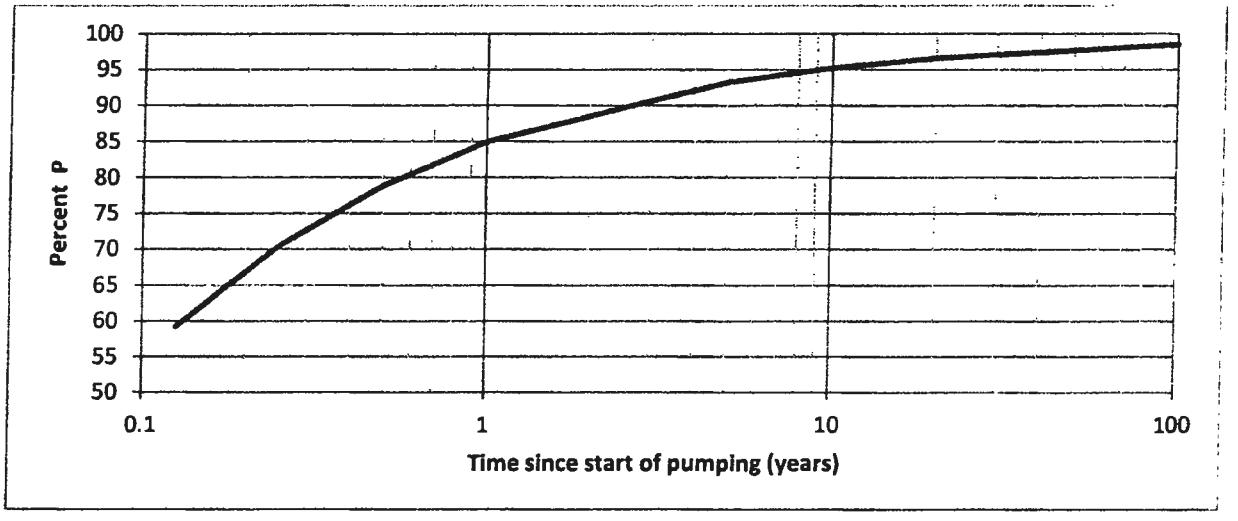

Figure 1. Chart showing percent of discharge from pumping well being diverted or intercepted from the spring or stream (P) over time; assuming a distance of one mile between well and spring or stream.

The percentage of the surface water component in water pumped from a well, increases with increasing time since the start of pumping (Figure 1). For example a pumping well located 1 mile from a spring or stream, the calculated percentage (*P*) of pumped water being diverted from the spring after 1 year is 0.85; after 20 years *P* is about 0.97, and after 100 years *P* is about 0.98. If pumped long enough, the percentage of pumped water from the well being diverted or intercepted from the spring or stream will be 100 percent. For example, if a stream is discharging 1,000 gallons per minute (gpm) and a nearby well starts pumping 100 gpm, eventually the stream discharge will decrease by 100 percent of the well discharge, or 1,000 gpm – 100 gpm = 900 gpm.

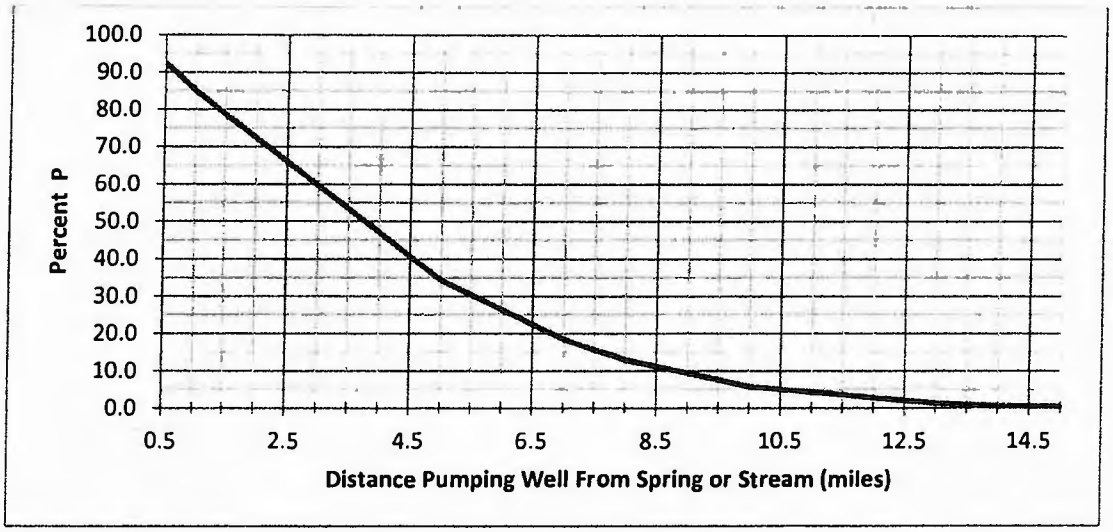

Figure 2. Chart showing percent of discharge from pumping well being diverted or intercepted from the spring or stream (P) with varying distance between the well and spring or stream; assuming pumping for 365 days.

Effects of Pumping Distance

Another calculation was made to determine the effect of distance of the well from a spring. For this calculation, a time of one year since pumping began was used. Percentage (*P*) was calculated for various distance as illustrated in Figure 2. As can be seen the farther a well is located from a spring, the smaller the percent of surface water in the discharge of the well at a specified time.

Effects of Spring Flow and Pumping Rates

To determine the reduction in spring flow resulting from a pumping well, the average discharge rate of the spring and well must be known. For example, for a spring or stream discharging 1,000 gpm and a well is located 1 mile from the spring or stream starts and the well is pumping 100 gpm, then the calculated spring depletion after 1 year is 8.5 percent; after 20 years spring depletion is 9.7 percent, and after 100 years spring depletion is 9.9 percent

Table 1 shows the average annual spring discharge rates of 100, 300, 500, 1,000, and 1,500 gpm are used to calculate the average annual pumping rate (and corresponding acre-feet/yr) of a well that would result in a 25% reduction of spring flow after one year of pumping (Table 1).

Table 1. Calculated pumping rates, Q (in gallons per minute and acre-feet/year), that result in 25% spring or stream flow reduction after one year of pumping, where *d* is the distance of well from spring; *P* is the

percentage of surface water in the discharge of the well; and the average spring flow is 100 gpm (gallons per minute).

Distance - d (miles)	Fraction of Spring or Stream Water in Discharge of Well - P	Avg. Spring Flow (gpm)	Well Pumping Rate - Q (gpm)	Well Pumping Rate - Q (af/yr)
0.5	0.94	100	27	43
1.0	0.87	100	29	47
2.0	0.75	100	34	55
0.5	0.94	300	80	130
1.0	0.87	300	87	140
2.0	0.75	300	102	164
0.5	0.94	500	134	216
1.0	0.87	500	144	233
2.0	0.75	500	170	274
0.5	0.94	1000	268	432
1.0	0.87	1000	289	466
2.0	0.75	1000	340	548
0.5	0.94	1500	402	648
1.0	0.87	1500	433	698
2.0	0.75	1500	509	822

As shown in Table 1, the farther away a pumping well is located from a spring, the less it will impact the spring and the more water the well can withdraw. For example, a well located 0.5 miles from a spring with an average flow of 300 gpm can withdraw 130 acre-feet/year (an average annual pumping rate of 80 gpm) of groundwater and result in a 25% reduction in spring flow. A well located 1 mile from the same spring could withdraw 140 acre-feet/year (87 gpm) and a well located 2 miles from the spring could withdraw 164 acre-fee/year (102 gpm), both resulting in a 25% reduction in spring flow at the end of one year. Potential impacts on a spring or stream by groundwater pumping is cumulative, with each additional pumping well adding to the total depletion of the spring or stream.

Methods & Assumptions

Assumptions

Assumptions used in the in the evaluation of potential depletion of a stream or spring will include:

1. Average storage coefficient of 0.008 and transmissivity of 83,937 gpd/ft are assumed unless site specific values are available;
2. Springs to be consideration for evaluation of potential depletion effects will include only those springs identified by the U.S. Geological Survey or Oklahoma Water Resources Board as flowing, on average, 1000 gallons per second or more. Stream segments to be considered for evaluation of potential depletion effects will include only those segments which are considered to be perennial streams in the U.S. Geological Survey's National Hydrology Dataset (NHD);
3. Well pumping duration for determination of spring or stream depletion will be 10 years;
4. All wells in the application or permit will be considered in the evaluation of potential depletion of the spring or stream;
5. The amount of depletion of the spring or stream will as specified in rule;
6. Pumping rate of a well will be calculated in gallons per minute based on the total amount of water pumped from the well over a year's time. As an example if a total 200 acre-feet over a year's time is to be pumped

from a well or wells then a relative pumping rate of 124 gallons per minute will be used for the pumping rate (200 af/year = 65,170,200 gallons/year = 178,548 gallons/day = 124 gallons/minute);

7. If there are multiple water wells associated with a permit or permit application then the depletion determination will be made assuming one well, pumping the combine amount of water permitted for all wells and the determination will use the location of the nearest well to the spring or stream segment to be evaluated;
8. If multiple major springs or streams are within the area of the existing or proposed well each major spring will be evaluated independently for possible depletion effect from the wells in the area; and
9. During the evaluation of the proposed or existing wells' possible depletion of the spring or stream flow, all permitted water wells within a four mile radius of the spring or stream segment may be considered.

Methodology

The Theis and Conover (1963) method will be used to determine the percent spring or stream water in the discharge from the proposed or existing water wells being evaluated. The percent of spring or stream flow being depleted by pumping wells is determined by:

$$\%Dep = (GW \times \%SW_{gw} / S_f) \times 100$$

Where: %Dep is the percent reduction in the spring or stream flow due to nearby pumping wells; GW is the pumping rate of the nearby wells (gpm); $\%SW_{gw}$ is the fraction of spring or stream water being pumped by the wells; and S_f is the spring or stream flow (gpm).

Limitations

The calculations used in this exercise were based on several assumptions and simplifications. These include:

1. Calculations are based on a single pumping well (may be the combine pumping of multiple wells).
2. The well pumps continuously at a constant rate for a given period of time.
3. The well is fully penetrating.
4. The aquifer is homogenous and isotropic; vertical hydraulic conductivity = horizontal conductivity.
5. The aquifer is infinite; no boundary conditions such as faults or change in lithology were considered.

The effect of multiple wells on a spring or stream is additive. When more than one well is pumping near the spring or stream, the effects of each well should be added together to determine the total stream reduction from groundwater withdrawals.

References

Theis, C.V. and Conover, C.S., 1963, Chart for determination of the percentage of pumped water being diverted from a stream or drain, *in* Bentall, Ray, compiler, Shortcuts and special problems in aquifer tests: U.S. Geological Survey Water-Supply Paper 1545-C, pp. C106-C109.

Jenkins, C.T., 1968, Computation of Rate and Volume of Stream Depletion by Wells, Techniques of Water-Resources Investigations of the United State Geological Survey, Chapter D1, Book 4, Hydrologic Analysis and Interpretation, 17 p.

Christenson, Scott, et.al., 2011, Hydrogeology and Simulation of Groundwater Flow in the Arbuckle-Simpson Aquifer, South-Central Oklahoma, U.S. Geological Survey Scientific Investigations Report 2011-5029, 104 p.