EXPERT REPORT: Case No. 18 WATER 14014

for

Joseph T. Pajor, Deputy Director, City of Wichita Public Works and Utilities

a) Consulted for: Wichita's historical interactions with Groundwater Management District No. 2, the history of the City's water resources and the purposes of the changes contemplated by the City's current ASR proposal
b) The grounds for Joseph T. Pajor's opinions are knowledge of pertinent information presented in City of Wichita's Response to Production Request of Equus Beds Groundwater Management District No.2 and City of Wichita's Responses to Intervener's Production Requests, as referenced in the summaries of the respective opinions below, and in several cases, excerpted and attached for convenience of reference.
c) Joseph T. Pajor's factual observations and opinions, as presented in the Proposal documents and summarized herein, include:
    i. Expert opinions based on factual observations:
        - 3.0 Aquifer Maintenance Credits proposal
            - <u>The ability to establish and recover ASR credits is a critical component of the City's plan to meet demand for raw water during an extended drought.</u>

              On several occasions in 2014, Wichita City Council considered a Strategic Plan in which improvements to the City's water supply were contemplated. During this process, it was determined that protection from drought conditions should be attained through contemplated improvements to the ASR project. On August 5, 2014, the Council approved the Strategic Plan and its implementation through a Special Question Election.

              Presentations and other documents considered during development of the Strategic Plan are presented in the Exhibits: Strategic Plan.

              Excerpted pages 28-31 of Exhibits: Strategic Plan are presented as Attachment A.
            - <u>Current ASR permit condition allow lowering groundwater levels in the EBWF to create physical recharge capacity and storage for the ASR system.</u>

The Findings and Order for the City's applications to appropriate water, associated with Phases 1 and 2 of the ASR project contain no constraint on lowering groundwater levels to create physical recharge capacity. They also contain no cap on the quantity of physical recharge credits that may be accumulated.

The applicable Findings and Order documents have not been provided as Exhibits or Attachment to this report.

Rather than lowering groundwater levels in the EBWF to create physical recharge capacity and storage for the ASR system, an alternative recharge credit development strategy during full aquifer conditions is being proposed for consideration.

- <u>The City proposes that the quantity of water diverted from the Little Arkansas River that cannot be physically recharged through the ASR system could be sent to the City's main water treatment plant to directly meet City water demands.</u>

- <u>The water left in the aquifer as a result of utilizing Little Arkansas River flows would be considered as an ASR Aquifer Maintenance Credit (AMC) with similar characteristics to the current ASR recharge credits.</u>

  Testimony to House Agriculture (3/1/2018) and Senate Agriculture and Natural Resources Committee (1/23/2018) presents a briefing of Wichita's ASR program and proposed changes. The City proposes to keep the aquifer as full as possible, and use ASR credits less frequently, enabled by the proposed permit changes. This testimony is provided as Attachment B, and was provided in Exhibits: Public Information and Wichita Documents.

- 3.1 Integrated Local Water Supply Plan (ILWSP)

  - <u>The implementation of the ILWSP has resulted in a substantial increase in the percentage of surface water used by the City to meet demands.</u>

    Figure 12 of the Proposal (provided as Attachment C-1) illustrates historic trends in water use. Figure 12 is excerpted from USGS Scientific Investigations Report 2015–5121.

  - <u>The groundwater level recoveries within the EBWF area are a direct result of the implementation of the ILWSP and the City's ASR program.</u>

    Figure 13 of the Proposal (provided as Attachment C-2) illustrates recent aquifer conditions. Figure 13 is excerpted from USGS Scientific Investigations Report 2016–5165.

Figure 2 of Exhibits: Additional Exhibits (equus_water_use.pdf, provided as Attachment C-3) provides recent water use and precipitation trends. Figure 2 is excerpted and modified from USGS Scientific Investigations Report 2016–5165, also provided in Exhibits: Water Levels.

As shown in Figure 2, total groundwater use in the central Wichita wellfield area historically follows Wichita's municipal use, except in dry conditions.

- Figure 12 - Historic Water Use in the ASR BSA
  - Figure 12 of the Proposal further demonstrates:

    The City total use of water for public supply has not demonstrated any increase since approximately 1992.

    The City has demonstrated the ability to reduce its use of groundwater.

    Groundwater use for irrigation in drought years of 2011 to 2013 were slightly higher than other historical peak use years.
- Figure 13 - Historic Groundwater Level Changes in the ASR BSA
  - Figure 13 of the Proposal demonstrates:

    The City's efforts to reduce its use of groundwater can result in aquifer recovery in areas depleted by pumping.
- 3.6 Outcome Based Management of Water Resources
  - The City of Wichita remains committed to optimizing the use of all available water supply resources both in times of abundance and times of drought.
  - The City remains committed to using water resource management practices that are governed by outcome based results focused on the long-term sustainability of all available water supplies.
  - The City will continue to maintain an ASR operational priority focused on generation of physical recharge credits where and when possible.
  - The ability to develop and recover AMCs results in an aquifer management strategy focused on maintaining the maximum quantity of water possible in aquifer storage within the EBWF.
- Table 3-1: Benefits to Multiple Aquifer Users and Water Resources from AMCs
  - Table 3-1 of the Proposal (provided as Attachment D) demonstrates:

– The AMC proposal will result in benefits to each water resource.

ii. Expert opinions based on scientific analyses:

- The requested Aquifer Maintenance Credits and associated ASR credit accounting changes are in the public interest.

  – As envisioned, AMCs should serve the public interest by facilitating fuller aquifer conditions without allowing the use of new or unappropriated water. This is accomplished by allowing the same source water currently used by Wichita's ASR project to be diverted and treated as if it would be injected Into the aquifer, but instead allowing it to be diverted to Wichita.

  – AMCs are the functional equivalent of existing recharge credits and serve the public interest by maintaining a fuller aquifer instead of requiring Wichita to create additional capacity in the aquifer.
  Allowing use of transient water resources in this way will serve to keep the aquifer more full in average non-drought conditions, and prevents fluctuations in the aquifer levels. By enabling Wichita to prepare for a future drought without intentionally lowering the aquifer, the aquifer may be kept at near-full conditions in years between drought.
  Higher aquifer conditions are known to slow, but not stop, progress of the Burrton chloride plume. By allowing the aquifer to remain at a near-full status, attenuation of the chloride plume can be maximized.
  Summary and Conclusions of USGS Open-File Report 2014-1162 (presented with Exhibits: Chloride Simulation) are provided as Attachment E.
  Higher water levels reduces the risk of impairment of wells adjacent to the City's wellfield. Use of AMC credits will be limited to the same rate and quantity as existing ASR credit recovery rights.

  – The requested changes to ASR credit accounting is reasonable, as the City has expressed its willingness to accept a cap on the total credits that may be accumulated, and has proposed a means to ensure physical recharge will occur when possible. Recharge cannot cause the unreasonable increasing of water levels, as permits prevent such excessive recharge.

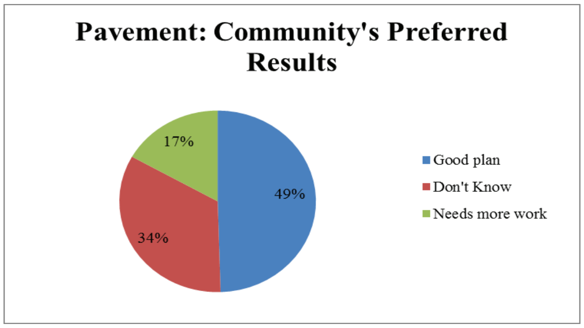
d) Joseph T. Pajor is a City of Wichita employee; his compensation is publicly available.

e) Joseph T. Pajor's qualifications are as presented in the City of Wichita's Preliminary Expert Disclosure.

f) Joseph T. Pajor’s factual observations and opinions are as presented above in this Expert Report, ASR Permit Modification Proposal, cover letter, and supporting appendices.

Joseph T. Pajor, Deputy Director, City of Wichita Public Works and Utilities

Pavement Maintenance Proposal Feedback



Pavement Maintenance Proposal Feedback - *Themes*

- Critical Need
- Future Funding Source
- Specific Functions

Summary of Feedback – Community Information Meetings

- Overall, the responses were favorable to the plans being a needed investment for the public good and for an opportunity for a better community for the next generation.

- All plans indicated significant overall support of community investment as either critical or good idea.
  Water – 93% (Critical or good idea)
  Jobs – 86%
  Public Transit – 89%
  Pavement Maintenance – 91%

Engagement – Activate Wichita

- The questions from the community information meeting comment cards were used as the premise for the Activate Wichita engagement.
- **102** participants and **99** responses
- Results:
  - Responses indicated overall support for community investment plans by identifying each as either critical or a good idea
    - Water Supply: **80%**
    - Jobs: **69%**
    - Public Transit: **72%**
    - Pavement Maintenance: **84%**

Conclusion

Information received through participant responses to comment card questions in the **Sales Tax Proposal Community Information Meetings** and **Activate Wichita** engagement continue to support the previous work of the **Community Investments Plan Survey** and the **ACT ICT** engagement project.

Water Supply

Water Supply Issues

- Based on growth and consumption projections, current supplies will not be adequate through the planning horizon (2060).
- Current supplies would require significant quality of life disruptions in the event of a 1% drought.
- Funding a supply option, coupled with moderate conservation, will provide 1% drought protection, and provide adequate supplies through 2060.

Water Supply Objectives and Strategies

	Current	Goal
Final Year of 1% Drought Protection	2011	2060
Strategies Combination of new water supply and long-term conservation is necessary		
Add New Water Supply	---	10 MGD
Strategies Secure a cost-effective new water source for the Wichita system		
Annual Water Conservation	---	0.35%
Strategies Rebate programs, landscaping incentives, private well usage, targeted re-use, etc.		

Explanation of Water Supply Options

Treated Water from El Dorado

- Drinking water would be sent from El Dorado Lake to a northeast pump station.
- Pre-payment of water would end between 2021 and 2024.

Raw Water from El Dorado

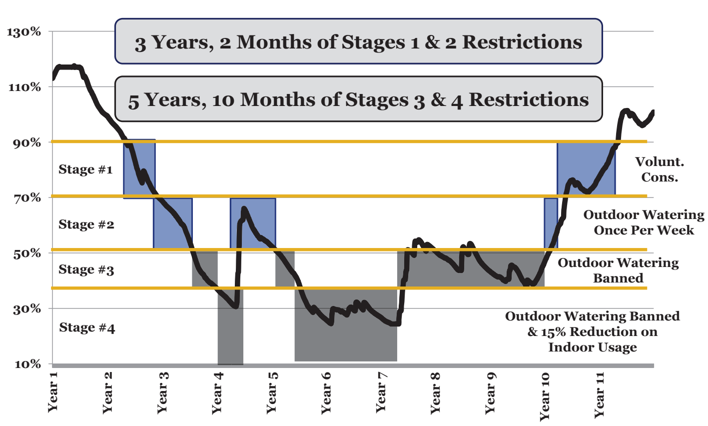
- Untreated water would be delivered from El Dorado to the City of Wichita main treatment plant.
- Water would be pre-paid until 2051.

Explanation of Water Supply Options

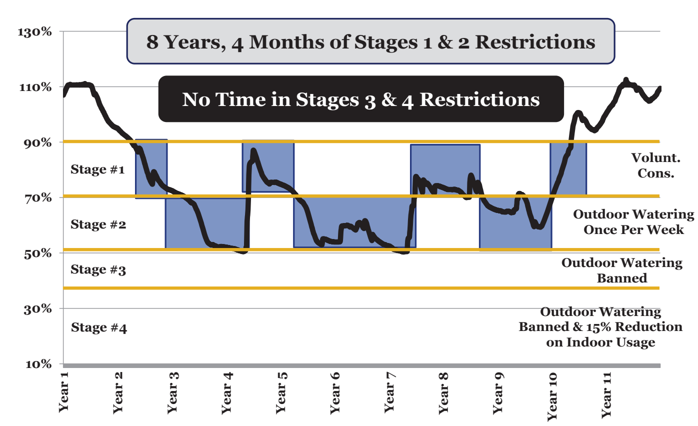
Aquifer Storage & Recovery (ASR) Improvements

- Drills additional wells and constructs a sidestream storage reservoir.
- Allows the availability of more water to be pumped through the existing treatment plant.

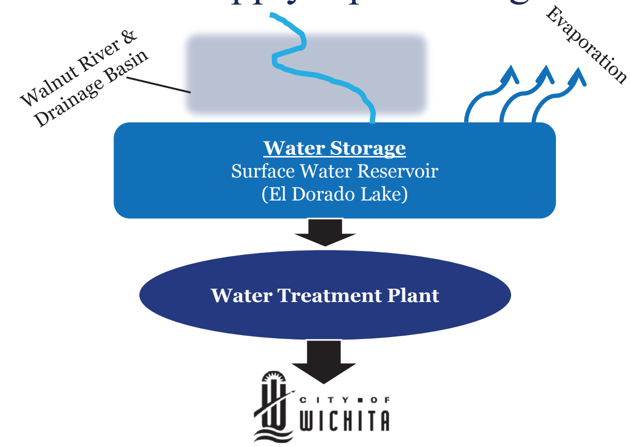
1% Drought Without New Supply



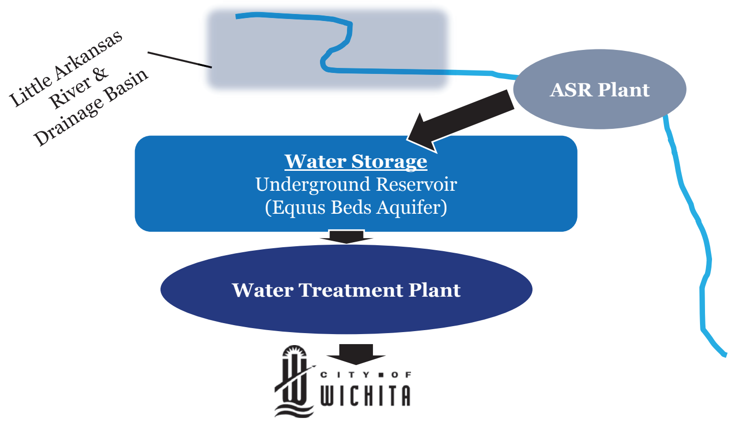
1% Drought – With New Supply



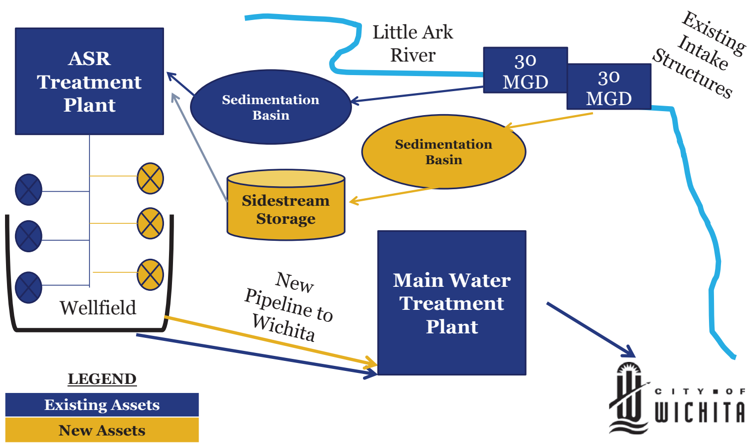
El Dorado Supply Option Diagram



ASR Water Supply Option Diagram



New ASR Improvements



Process Timeline

Jan. 2013 — DEVELOPMENT OF WATER SUPPLY OPTIONS — July 2014

- Demand projections created by PEC with data from the MAPD
- Water supply and drought scenario models created by SAIC
- River modeling created by High Country Hydrology, with data from CSU and Burns & McDonnell
- Data provided by the US Geological Survey on river flows and Equus Beds Hydrology
- Nine water supply options presented to Council on April 8th

Process Timeline

Jan. 2013 — DEVELOPMENT OF WATER SUPPLY OPTIONS — July 2014

- Nine options presented on April 8th, resulting from input of seven different independent experts
- Water economists at Metering Technology Consultants and Water DM reviewed financial analysis model and role of conservation
- Water planning narrowed to two options that count on long-term conservation coupled with new supplies from El Dorado Lake or an ASR project
- Engineers from Black & Veatch and Burns & McDonnell worked through analysis, while Burns & McDonnell developed 1% ASR design

Final Cost Comparison

	Aquifer Storage & Recovery (ASR)	El Dorado Treated Water	El Dorado Raw Water
Yield	**10 MGD [1]**	**10 MGD [2]**	**10 MGD [2]**
Year Drought Protection Ends with No Conservation	2030	2030	2030
Required Annual Conservation for 1% Drought Protection	0.35%	0.35%	0.35%
Total Cost from 2015 - 2060	**$421 million**	**$700 million**	**$375 million**

[1] *A 1% engineering design showed this is a conservative estimate, and the project may yield more water.*

[2] *Discussions with the El Dorado team have not confirmed that this water would be available exclusively to Wichita in a 1% drought.*

- ASR costs have changed compared to previous estimates due to the inclusion of additional funds for annual renewal and replacement costs and a revision to the capital costs based on a 1% engineering study.

ASR Estimated Capital Cost

One-Time Costs	
Raw Water Facility	$9,515,921
Sidestream Storage	$29,784,833
New Wells & Improvements	$68,221,224
Parallel Pipeline	$86,579,022
Other Improvements	$5,899,000
TOTAL CAPITAL COSTS	**$200,000,000**

The capital costs shown are preliminary and based on a 1% engineering study. Since final design and scope will determine actual project costs, the proposed sales tax allocation is maintained at $250 million.

ASR Est. Annual Operating Costs

Annual Costs	
Chemicals at ASR & Filter Plant	$654,895
Electricity at ASR & Filter Plant	$945,105
Staffing/Renewal & Replacements	$1,200,000
TOTAL OPERATING COSTS	**$2,800,000**

Recommendation: ASR Improvements

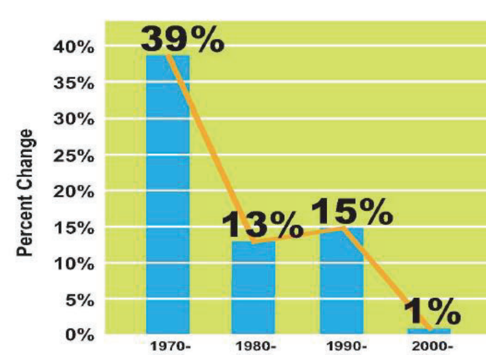
- Lower amount of sales tax funding could be needed.
- More certainty that ASR can yield 10 MGD to provide critical drought protection.
- Potential for lower future costs for improvements to add next new water source.
- Fights chloride migration into one of City's two existing water supplies (Equus Beds).
- Additional ASR usage will increase efficiency, allowing ASR to operate closer to design capacity.

Jobs Initiative

Jobs Initiative Issues

- Job growth in the last decade was only 1%
- Since the recession, job growth in Wichita has not kept up with regional peer cities
- Neighboring communities and states are aggressively pursuing jobs

Sedgwick County Employment – Growth by Decade



Source: Woods & Poole Economics, Inc., U.S. Census Bureau, and Bureau of Labor Statistics.

CITY OF WICHITA

Department of Public Works & Utilities

Testimony Provided to the

Senate Agriculture and Natural Resources
January 23, 2018

Joseph T. Pajor

Briefing on City of Wichita Aquifer Storage and Recovery (ASR) Program

Honorable Committee Members:

The purpose of this briefing is to update the Committee on the City of Wichita's Aquifer Storage and Recovery (ASR) Program.

Purpose:

The four objectives in this briefing are:
1. To provide an overview of the history of the project to date,
2. To cover how the water supply needs of our customers and conditions in the aquifer have changed over the years since ASR was first envisioned,
3. Explain how those changes impact the role of the ASR project, and
4. To answer any questions the Committee members might have including providing any desired follow up information.

History:

The ASR program was first included in the City of Wichita's water strategy in our Integrated Local Water Supply Plan in 1993. The ASR program was intentionally planned in a number of phases. This phasing provided several benefits including:
1. Construction of additional capacity as customer demand occurred,
2. Adoption of the latest technological developments as they became available, and
3. Allow both intergenerational rate payer equity and smaller rate increases as phases were brought on-line.

This phased approach has proven very beneficial especially as it relates to changing customer demand over time. Our current forecast for water demand from our customers for the next fifty years is considerably different than what was projected in the early 1990s. Improvements in water efficiency of appliances, manufacturing process changes, and changes in customer behavior in response to water rate increases have all combined to temper water demand growth. The City has also now built in an explicit annual reduction attributable to conservation into our demand projections.

The net result of all of these changes is that for the next fifty years Wichita has sufficient water resources to meet customer needs except in extreme drought events. The role of ASR has changed in response to these considerations.

ASR was originally intended to accomplish three key objectives. These were:

1. Allow surface water from transient high flow events in the Little Arkansas River to be diverted and treated to drinking water standards to be injected into the Equus Beds aquifer. This water would be used in dryer than normal years to augment the City's native groundwater rights and surface water rights from Cheney Reservoir.
2. Create a hydraulic barrier within the Equus Beds to stop the advance of the Burton Salt Plume. This salt plume resulted from wastewater disposal practices from legacy oil field development in the Burton area from the 1930s.
3. Work to reduce the extent of the "hole" that had been created in the Equus Beds in the vicinity of the 55 square mile City of Wichita wellfield. This "hole" resulted from over appropriation of this area prior to the establishment of safe yield practices for the granting of water rights in the Equus Beds aquifer.

Phase 1 of ASR was designed with production capacity of 10 MGD (millions of gallons per day) and it went in service in 2007. Originally, Phase 1 had both a surface water diversion point and three bank storage diversion wells. To date, this Phase has produced 1,233,000,000 gallons of water and all of this water has been injected in front of the leading edge of the Burton salt plume. Phase II of ASR is capable of producing 30 MGD from a surface water intake and became operational in 2013 and to date has produced 2,095,000,000 gallons of water. Future enhancements of ASR are planned.

Current Conditions:

In addition to the reduction in projected future water demand of our customers, two other significant changes have occurred. They are:

1. It is now clear that injection of clean water in front of the Burton salt plume can and is reducing the rate of advancement of the plume but that this approach cannot stop it. Eventually the plume will either need to be remediated or it will make a portion of the water in the Equus Beds unfit for irrigation and it will require more intensive and expensive treatment to make it usable as potable water and

2. The aquifer in the vicinity of the City's wellfield has recovered to very close to predevelopment conditions through a combination of the City utilizing less of our native water rights, conservation measures by irrigators in the area, precipitation induced natural recharge and ASR recharge. The City has reduced our water usage from the Equus Beds by sourcing more of our water from Cheney Reservoir.

These changes in conditions have put the aquifer in a much better situation, but now present new challenges to the revised mission of ASR. Today, ASR must be utilized to produce credits over time to be used when drought conditions necessitate an additional source of supply. Under our current permit conditions, the City would need to operate in a way that is not in the best interest of the public or the utility and we seek therefor to modify the permit conditions to allow us to meet our goal in a way the benefits all parties and that takes advantage of the very full aquifer we enjoy today.

The City is therefore seeking two changes to our permit conditions.

Recovery of ASR Credits:

The first concerns the level at which we can recover our ASR credits. That level was set as the level of the aquifer in 1993 in the original permit. Modeling of extreme drought conditions in the aquifer, shows that the aquifer level during the drought would drop below that 1993 levels. This would result in the stranding of our ASR credits at the very time we need to use them.

Today, we would need to take our credits early in a drought to avoid stranding them. Unfortunately, in the early years of a drought you do not know how long it will last or how sever it will turn out. The result is that under current permit conditions we would end up drawing out credits more often than necessary. This approach also results in needlessly lower average aquifer levels. Lower aquifer levels are not in the public interest or the interest of any of the water rights holders in the area.

We seek therefore to reduce the minimum level at which we can recover our credits from an average of 88% of the saturated thickness to 80% of the saturated thickness.

Aquifer Maintenance Credits:

The second consideration concerns producing ASR credits with a virtually full aquifer. When the aquifer was depleted it provided an ideal place to store cleaned surface water produced by ASR. Today, to be able to produce credits, we would need to first take water out of the aquifer to make room for cleaned surface water to be injected to earn an ASR credit. The water removed could have been better sourced from Cheney Reservoir.

Department of Public Works & Utilities

The City is proposing to leave the aquifer as full as possible. When water is produced by ASR and there is no room for it in the aquifer and there is a need for water in town, the City would send ASR water directly to town and leave the equivalent amount in the aquifer and earn aquifer maintenance ASR credits to be used in time of severe drought.

Conclusion:

The City has the ability to produce ASR credits and utilize them under our current permit conditions. The modified permit conditions we seek will allow us to operate in a way that meets our needs but does so in a way that is much better aligned with the public good and the interest of all water rights holders.

The City of Wichita appreciates the time and attention of the members of the Senate Agriculture and Natural Resources Committee and the opportunity to present this briefing on the Aquifer Storage and Recovery project.

Prepared By:

Joseph T. Pajor, Deputy Director
Department of Public Works & Utilities

Attachment: Handout titled "Equus Beds Aquifer and Preparing Wichita for Drought: Proposed Changes"

Office of the Director

City Hall • Eighth Floor • 455 North Main • Wichita, Kansas 67202-1606

T 316.268.4422 **W** www.wichitagov.org

Equus Beds Aquifer and Preparing Wichita for Drought:

Proposed Changes

CITY OF WICHITA
wichita.gov

Background

The City of Wichita's Aquifer Storage & Recovery (ASR) project diverts water from the Little Arkansas River when the river flows are high, treats it to drinking water standards and injects the processed water into the Equus Beds aquifer. By doing this, the City accumulates ***recharge*** credits with the Kansas Department of Agriculture allowing it to withdraw this additional water from the Equus Beds aquifer when needed. The ability to establish and utilize these credits is critical to ensuring the City can meet the demand during an extended drought (referred to as a 1% drought). There are two interrelated issues that could hamper the City and other user's drought preparedness and compromise the quantity and quality of the water supply.

The Issues

Water Level Limits

Current water permit regulations only allow the use of recharge credits when aquifer groundwater levels are at or above a **minimum standard.** That standard is based on the lowest level in the aquifer's history **(88% of pre-development water depths)**, recorded in 1993. The unintended result of this limitation is that at the beginning of a drought, it may be necessary for the City to draw as much water out of the aquifer as possible before reaching the 1993 limit. Other aquifer users will also be making full use of their water rights, which means the 1993 limit will be reached faster before other water rights are utilized and the aquifer water level is lowered even further.

Credit Creation

In 2017, the aquifer had recovered to 98% full. While a high groundwater level provides significant benefits to users and the aquifer, it severely limits the physical recharge capacity of the ASR system and, thereby, the creation of recharge credits and the City's drought readiness. Instead of injecting water into the aquifer, the ASR system can pump the treated water directly to the City, but permit regulations do not allow recharge credit creation through this process. The City can only accumulate recharge credits while the aquifer level is high by drawing water out for City use, then using the ASR system to inject water back into the aquifer.

Proposed Solutions

The City proposes lowering the limit when accrued credits can be used to **80% of pre-development water depths.** This proposed modification would eliminate the need to immediately draw water from the aquifer during a drought and extend the amount time before the City would need to access credits by years, keeping aquifer water levels higher.

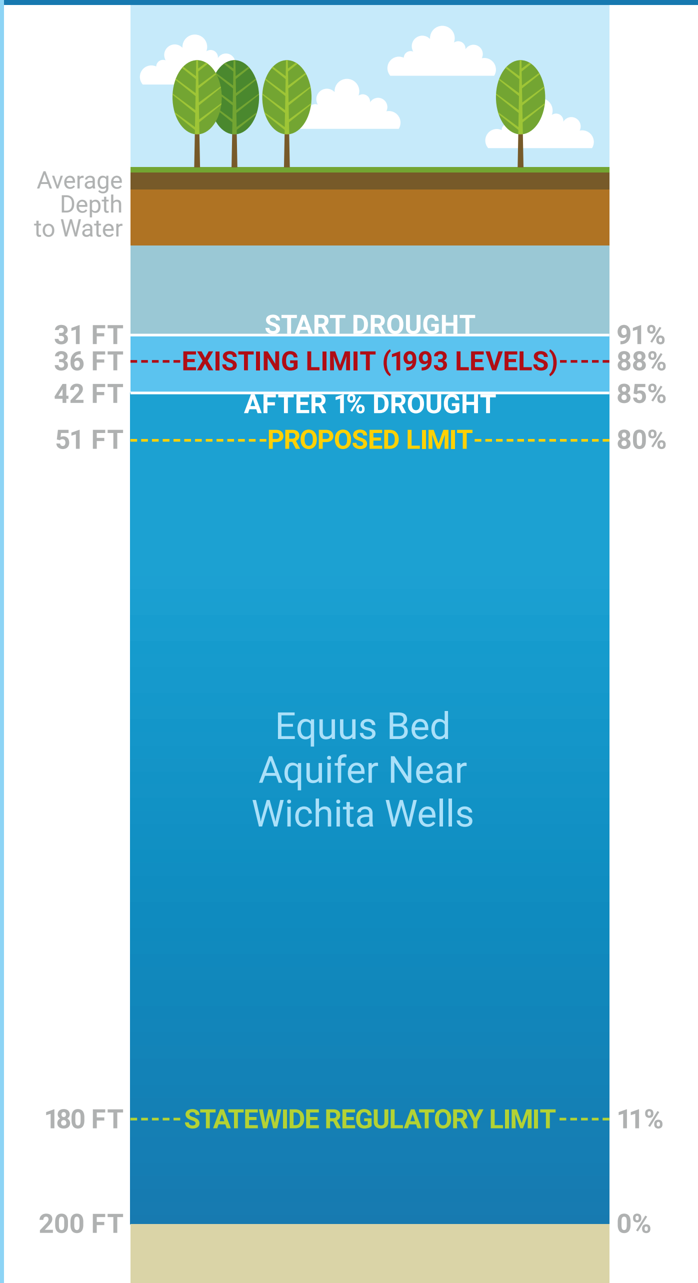
The City proposes that new ***maintenance*** credits will be accrued by using the ASR system to divert Little Arkansas River water to supply Wichita directly, allowing the City to build the credits needed during a drought. This proposed modification would allow the aquifer to be as full as possible which benefits all users and helps maintain the aquifer's water quality.

Next Steps

The City will present the proposed changes to the public including other aquifer users during a series of public engagement meetings. The proposal will also be shared with the Chief Engineer of the Kansas Department of Agriculture who will make the final decision on whether to revise the water level permit conditions.

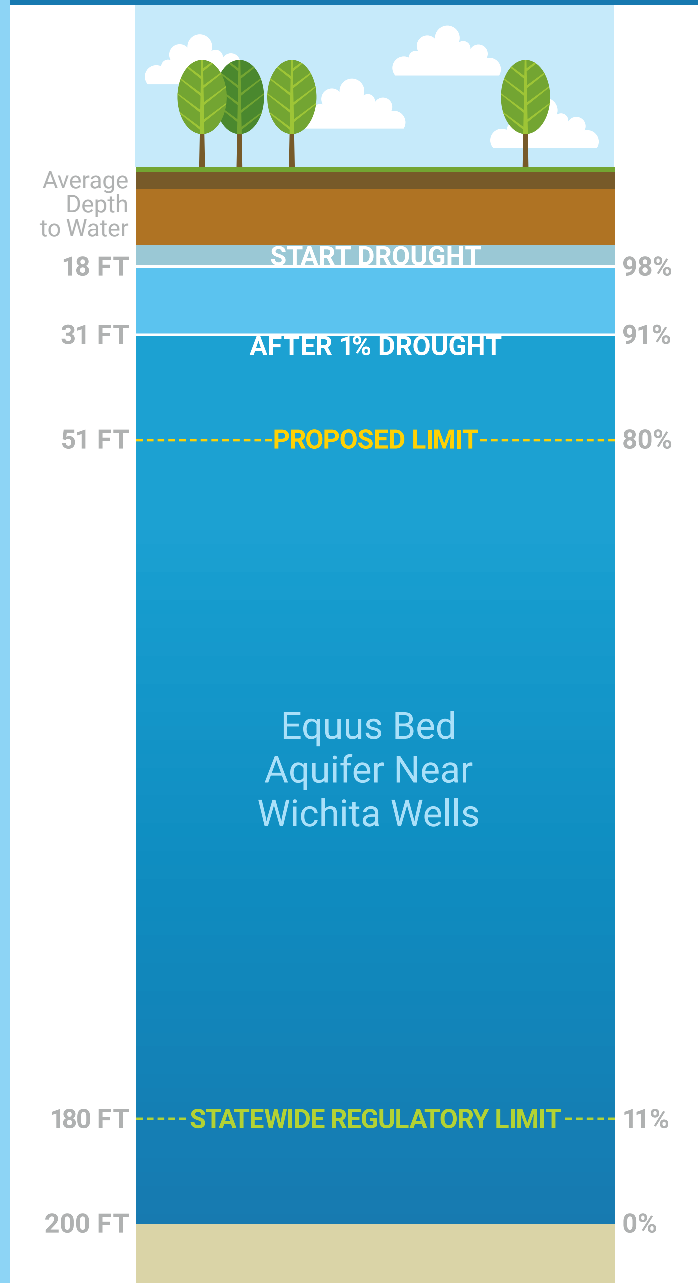
Outcome of 1% Drought Comparisons

Existing Permit Conditions



- The City could access their credits early in the drought while above 1993 levels
- The aquifer depth will lower to 1993 levels within 2 years
- This could occur every 10 years
- This results in lower aquifer levels on an ongoing basis

Proposed Permit Modifications



- The aquifer would be maintained at optimum levels
- The aquifer is protected from unnecessary fluctuations
- This protects water quality — it leaves more native water in the aquifer and slows chloride intrusions

CITY OF WICHITA

Department of Public Works & Utilities

Testimony Provided to the

House Agriculture
March 1, 2018

Joseph T. Pajor

Briefing on City of Wichita Aquifer Storage and Recovery (ASR) Program

Honorable Committee Members:

The purpose of this briefing is to update the Committee on the City of Wichita's Aquifer Storage and Recovery (ASR) Program.

Purpose:

The four objectives in this briefing are:

1. To provide an overview of the history of the project to date,
2. To cover how the water supply needs of our customers and conditions in the aquifer have changed over the years since ASR was first envisioned,
3. Explain how those changes impact the role of the ASR project, and
4. To answer any questions the Committee members might have including providing any desired follow up information.

History:

The ASR program was first included in the City of Wichita's water strategy in our Integrated Local Water Supply Plan in 1993. The ASR program was intentionally planned in a number of phases. This phasing provided several benefits including:

1. Construction of additional capacity as customer demand occurred,
2. Adoption of the latest technological developments as they became available, and
3. Allow both intergenerational rate payer equity and smaller rate increases as phases were brought on-line.

This phased approach has proven very beneficial especially as it relates to changing customer demand over time. Our current forecast for water demand from our customers for the next fifty years is considerably different than what was projected in the early 1990s. Improvements in water efficiency of appliances, manufacturing process changes, and changes in customer behavior in response to water rate increases have all combined to temper water demand growth. The City has also now built in an explicit annual reduction attributable to conservation into our demand projections.

The net result of all of these changes is that for the next fifty years Wichita has sufficient water resources to meet customer needs except in extreme drought events. The role of ASR has changed in response to these considerations.

ASR was originally intended to accomplish three key objectives. These were:

1. Allow surface water from transient high flow events in the Little Arkansas River to be diverted and treated to drinking water standards to be injected into the Equus Beds aquifer. This water would be used in dryer than normal years to augment the City's native groundwater rights and surface water rights from Cheney Reservoir.
2. Create a hydraulic barrier within the Equus Beds to stop the advance of the Burton Salt Plume. This salt plume resulted from wastewater disposal practices from legacy oil field development in the Burton area from the 1930s.
3. Work to reduce the extent of the "hole" that had been created in the Equus Beds in the vicinity of the 55 square mile City of Wichita wellfield. This "hole" resulted from over appropriation of this area prior to the establishment of safe yield practices for the granting of water rights in the Equus Beds aquifer.

Phase 1 of ASR was designed with production capacity of 10 MGD (millions of gallons per day) and it went in service in 2007. Originally, Phase 1 had both a surface water diversion point and three bank storage diversion wells. To date, this Phase has produced 1,233,000,000 gallons of water and all of this water has been injected in front of the leading edge of the Burton salt plume. Phase II of ASR is capable of producing 30 MGD from a surface water intake and became operational in 2013 and to date has produced 2,095,000,000 gallons of water. Future enhancements of ASR are planned.

Current Conditions:

In addition to the reduction in projected future water demand of our customers, two other significant changes have occurred. They are:

1. It is now clear that injection of clean water in front of the Burton salt plume can and is reducing the rate of advancement of the plume but that this approach cannot stop it. Eventually the plume will either need to be remediated or it will make a portion of the water in the Equus Beds unfit for irrigation and it will require more intensive and expensive treatment to make it usable as potable water and

2. The aquifer in the vicinity of the City's wellfield has recovered to very close to predevelopment conditions through a combination of the City utilizing less of our native water rights, conservation measures by irrigators in the area, precipitation induced natural recharge and ASR recharge. The City has reduced our water usage from the Equus Beds by sourcing more of our water from Cheney Reservoir.

These changes in conditions have put the aquifer in a much better situation, but now present new challenges to the revised mission of ASR. Today, ASR must be utilized to produce credits over time to be used when drought conditions necessitate an additional source of supply. Under our current permit conditions, the City would need to operate in a way that is not in the best interest of the public or the utility and we seek therefor to modify the permit conditions to allow us to meet our goal in a way the benefits all parties and that takes advantage of the very full aquifer we enjoy today.

The City is therefore seeking two changes to our permit conditions.

Recovery of ASR Credits:

The first concerns the level at which we can recover our ASR credits. That level was set as the level of the aquifer in 1993 in the original permit. Modeling of extreme drought conditions in the aquifer, shows that the aquifer level during the drought would drop below that 1993 levels. This would result in the stranding of our ASR credits at the very time we need to use them.

Today, we would need to take our credits early in a drought to avoid stranding them. Unfortunately, in the early years of a drought you do not know how long it will last or how sever it will turn out. The result is that under current permit conditions we would end up drawing out credits more often than necessary. This approach also results in needlessly lower average aquifer levels. Lower aquifer levels are not in the public interest or the interest of any of the water rights holders in the area.

We seek therefore to reduce the minimum level at which we can recover our credits from an average of 88% of the saturated thickness to 80% of the saturated thickness.

Aquifer Maintenance Credits:

The second consideration concerns producing ASR credits with a virtually full aquifer. When the aquifer was depleted it provided an ideal place to store cleaned surface water produced by ASR. Today, to be able to produce credits, we would need to first take water out of the aquifer to make room for cleaned surface water to be injected to earn an ASR credit. The water removed could have been better sourced from Cheney Reservoir.

The City is proposing to leave the aquifer as full as possible. When water is produced by ASR and there is no room for it in the aquifer and there is a need for water in town, the City would send ASR water directly to town and leave the equivalent amount in the aquifer and earn aquifer maintenance ASR credits to be used in time of severe drought.

Conclusion:

The City has the ability to produce ASR credits and utilize them under our current permit conditions. The modified permit conditions we seek will allow us to operate in a way that meets our needs but does so in a way that is much better aligned with the public good and the interest of all water rights holders.

The City of Wichita appreciates the time and attention of the members of the House Agriculture Committee and the opportunity to present this briefing on the Aquifer Storage and Recovery project.

Prepared By:

Joseph T. Pajor, Deputy Director
Department of Public Works & Utilities

Attachment: Handout titled "Equus Beds Aquifer and Preparing Wichita for Drought: Proposed Changes"

Equus Beds Aquifer and Preparing Wichita for Drought:

Proposed Changes

CITY OF WICHITA
wichita.gov

Background

The City of Wichita's Aquifer Storage & Recovery (ASR) project diverts water from the Little Arkansas River when the river flows are high, treats it to drinking water standards and injects the processed water into the Equus Beds aquifer. By doing this, the City accumulates ***recharge*** credits with the Kansas Department of Agriculture allowing it to withdraw this additional water from the Equus Beds aquifer when needed. The ability to establish and utilize these credits is critical to ensuring the City can meet the demand during an extended drought (referred to as a 1% drought). There are two interrelated issues that could hamper the City and other user's drought preparedness and compromise the quantity and quality of the water supply.

The Issues

Water Level Limits

Current water permit regulations only allow the use of recharge credits when aquifer groundwater levels are at or above a **minimum standard.** That standard is based on the lowest level in the aquifer's history **(88% of pre-development water depths)**, recorded in 1993. The unintended result of this limitation is that at the beginning of a drought, it may be necessary for the City to draw as much water out of the aquifer as possible before reaching the 1993 limit. Other aquifer users will also be making full use of their water rights, which means the 1993 limit will be reached faster before other water rights are utilized and the aquifer water level is lowered even further.

Credit Creation

In 2017, the aquifer had recovered to 98% full. While a high groundwater level provides significant benefits to users and the aquifer, it severely limits the physical recharge capacity of the ASR system and, thereby, the creation of recharge credits and the City's drought readiness. Instead of injecting water into the aquifer, the ASR system can pump the treated water directly to the City, but permit regulations do not allow recharge credit creation through this process. The City can only accumulate recharge credits while the aquifer level is high by drawing water out for City use, then using the ASR system to inject water back into the aquifer.

Proposed Solutions

The City proposes lowering the limit when accrued credits can be used to **80% of pre-development water depths.** This proposed modification would eliminate the need to immediately draw water from the aquifer during a drought and extend the amount time before the City would need to access credits by years, keeping aquifer water levels higher.

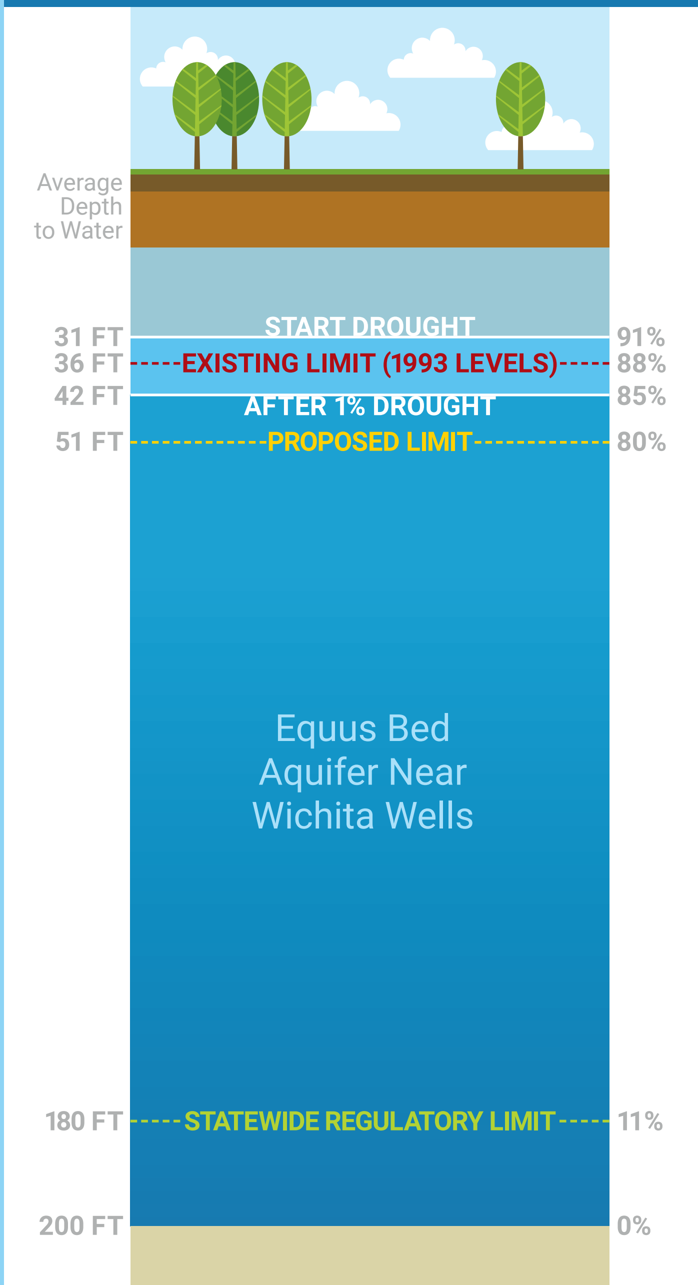
The City proposes that new ***maintenance*** credits will be accrued by using the ASR system to divert Little Arkansas River water to supply Wichita directly, allowing the City to build the credits needed during a drought. This proposed modification would allow the aquifer to be as full as possible which benefits all users and helps maintain the aquifer's water quality.

Next Steps

The City will present the proposed changes to the public including other aquifer users during a series of public engagement meetings. The proposal will also be shared with the Chief Engineer of the Kansas Department of Agriculture who will make the final decision on whether to revise the water level permit conditions.

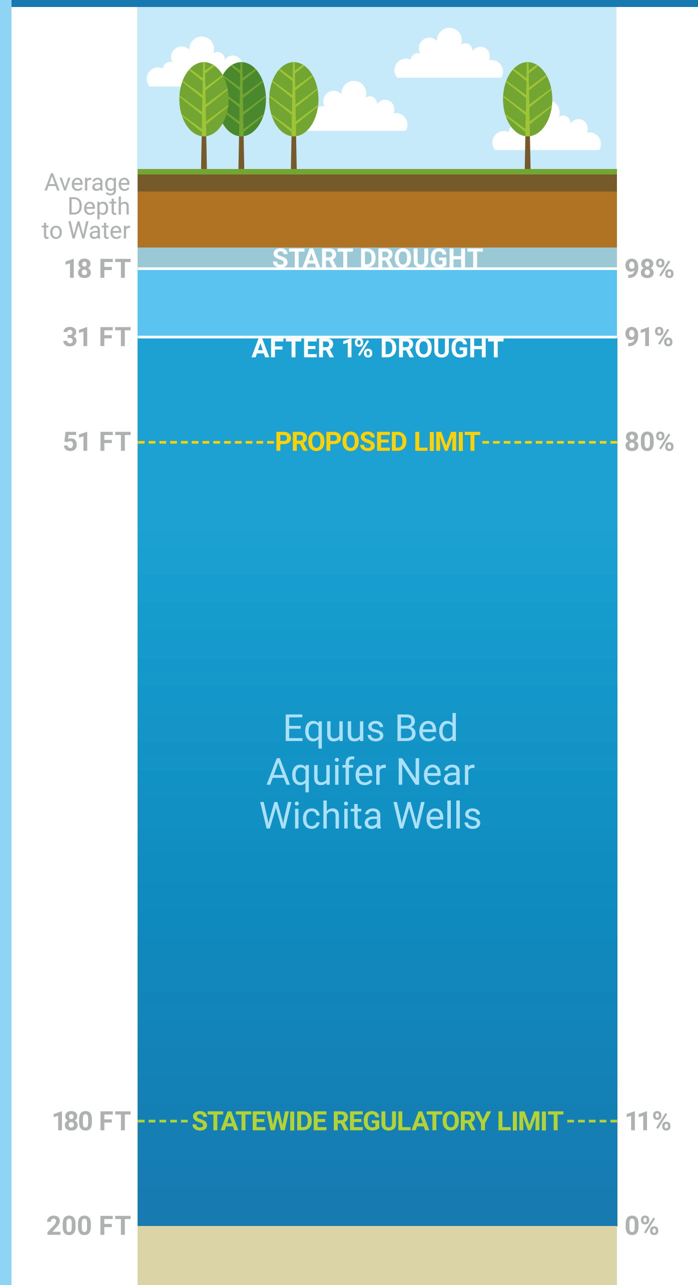
Outcome of 1% Drought Comparisons

Existing Permit Conditions



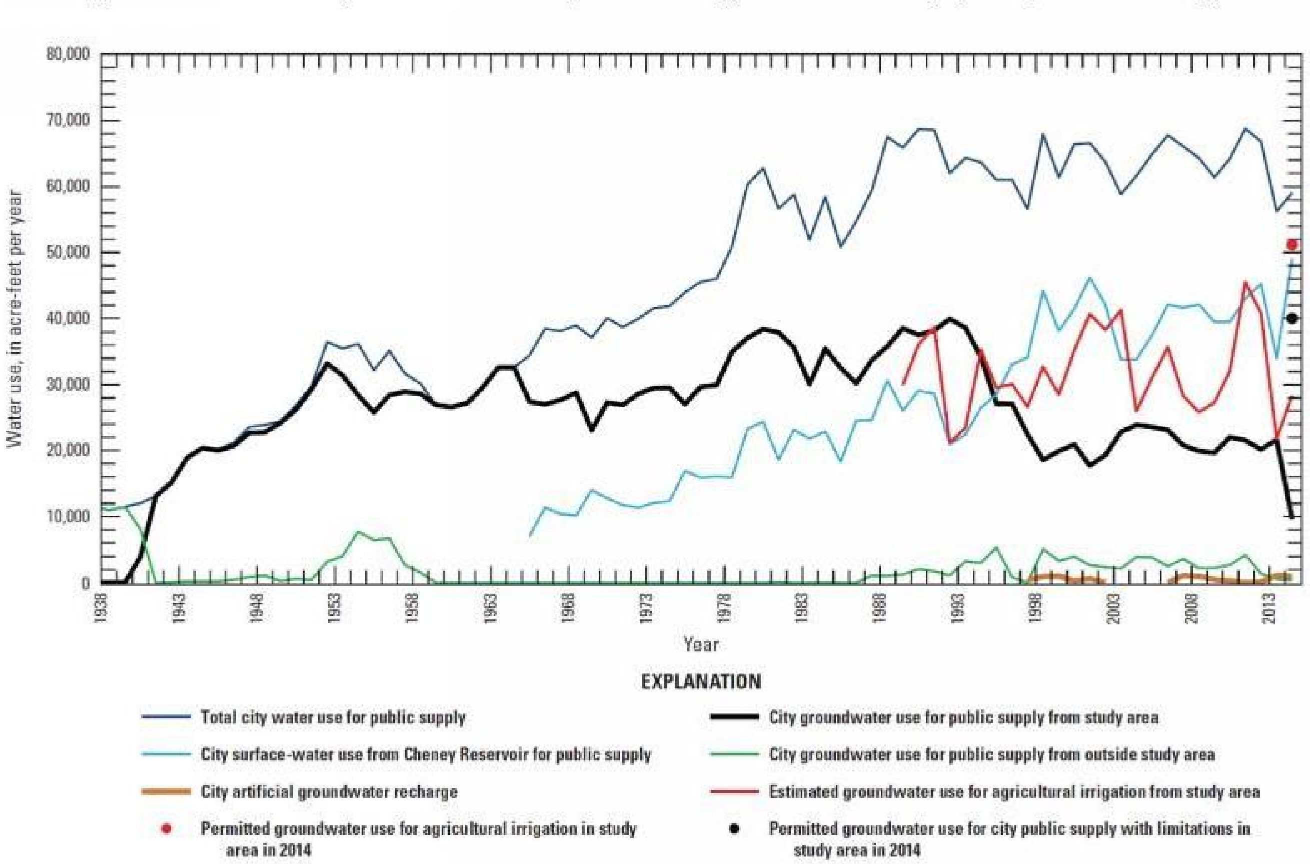
- The City could access their credits early in the drought while above 1993 levels
- The aquifer depth will lower to 1993 levels within 2 years
- This could occur every 10 years
- This results in lower aquifer levels on an ongoing basis

Proposed Permit Modifications



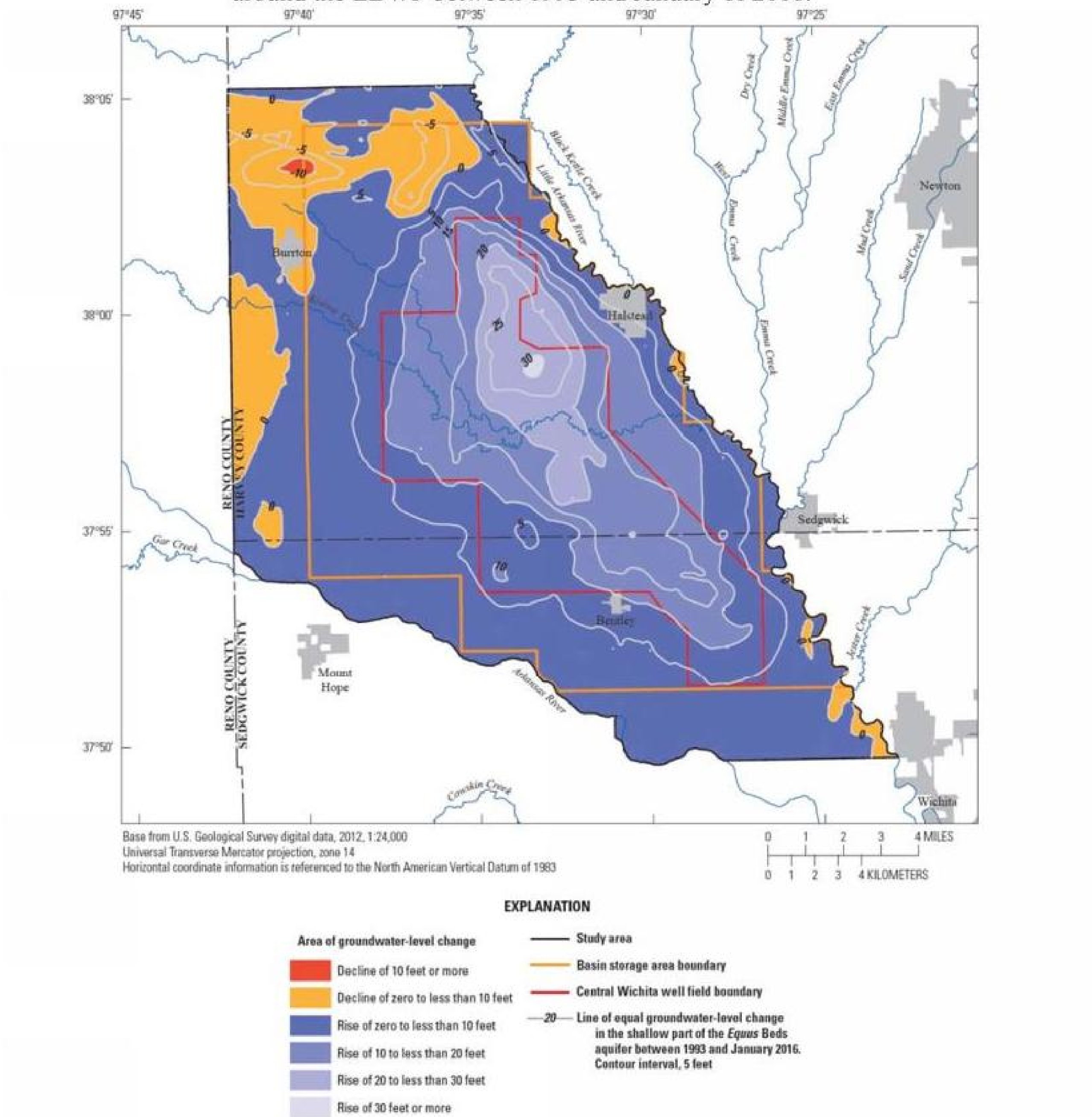
- The aquifer would be maintained at optimum levels
- The aquifer is protected from unnecessary fluctuations
- This protects water quality — it leaves more native water in the aquifer and slows chloride intrusions

Figure 12 – Historic water use for the City of Wichita and surrounding Agricultural Irrigation near the City of Wichita's Aquifer Storage and Recovery (ASR) Basin Storage



Source: Whisnant, J.A., Hansen, C.V., and Eslick, P.J., 2015, Groundwater-level and storage-volume changes in the Equus Beds Aquifer near Wichita, Kansas, predevelopment through January 2015: U.S. Geological Survey Scientific Investigations Report 2015–5121, 27 p., http://dx.doi.org/10.3133/sir20155121.

Figure 13 – Groundwater level changes in the shallow part of the Equus Beds aquifer in and around the EBWF between 1993 and January of 2016.



Source: Klager, B.J., 2016, Status of groundwater levels and storage volume in the Equus Beds aquifer near Wichita, Kansas, January 2016: U.S. Geological Survey Scientific Investigations Report 2016–5165, 15 p., https://doi.org/10.3133/sir20165165.

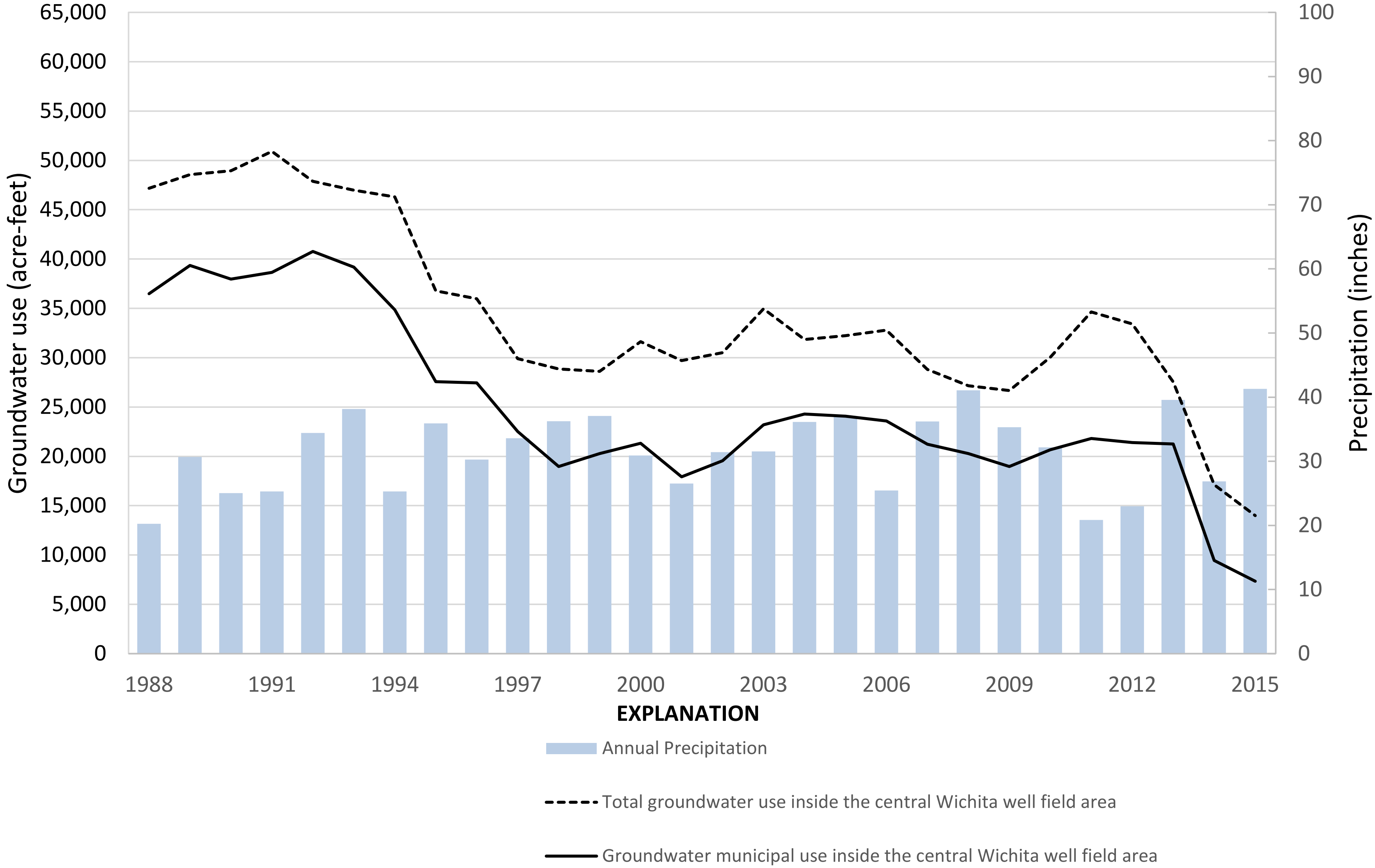


Figure 2. Annual groundwater use in the central Wichita well field area and in the rest of the study area and average annual precipitation in the study area, 1988 through 2015. [Water-use data are from Kansas Geological Survey and Kansas Department of Agriculture (2016); precipitation data are from National Oceanic and Atmospheric Administration (2016a, 2016b)] [modified from Hansen and others (2014) and Whisnant and others (2015)].

chloride intrusion from the Arkansas River, and through enhancement of base flow to creeks, streams, and rivers.

Table 3-1: *Benefits to Multiple Aquifer Users and Water Resources from AMCs*

Water Resource Parameter	Results Without Aquifer Maintenance Credits	Results With Aquifer Maintenance Credits
ASR Phase I	Regional groundwater levels including those at Phase I would be lowered from pumping in the core of the City's wellfield.	ASR Phase I permits would not be modified, regional groundwater levels can be managed to the benefit of water quality and all users.
ASR Phase II & Future	Regional groundwater levels would be lowered and managed at levels to facilitate physical recharge capacity for the ASR system.	Regional groundwater levels can be managed at near full conditions, improved groundwater quality and resource availability for all users.
Little Arkansas River Diversions	Water is lost downstream during periods when the ASR system lacks physical recharge capacity.	Additional river flow events can be put to beneficial use, river water directly replaces groundwater that would have been utilized from the City's Equus Beds Wellfield.
Cheney Reservoir	During full conditions water that could have been used by the City bypasses the reservoir as production remains focused on the Equus Beds Wellfield.	Increased use during full periods, optimized use of water resources matching the daily capacity and seasonal condition of all available resources.

Summary and Conclusions

The *Equus* Beds aquifer is a primary water-supply source for the city of Wichita, Kansas. Water level declines because of municipal and agricultural pumping and periodic drought conditions have led to concern about the adequacy of the aquifer as a future water supply for Wichita. Chloride migration toward Wichita's central well field is another concern. Sources of chloride include oil-field brines that leaked from surface disposal pits and injection wells in the Burrton oil field area, municipal wastewater facility discharges, and mineralized water from the underlying Wellington Formation, and the high chloride waters from the Arkansas River to the southwest of the well field. In order to increase the volume of water stored in the aquifer and to protect the water quality from the chloride threats, in 2006 the city of Wichita began construction of the *Equus* Beds Aquifer Storage and Recovery project, to artificially recharge excess surface water flow from the Little Arkansas River into the aquifer for later recovery and to form a hydraulic barrier to retard movement of chloride in a brine plume near Burrton, Kansas.

In 2009, the USGS, in cooperation with the city of Wichita and as part of the *Equus* Beds Aquifer Storage and Recovery project, began a study to determine groundwater flow in the area between the Arkansas and Little Arkansas Rivers, which includes the Wichita well field and chloride transport from the Arkansas River and the Burrton oil field to the Wichita well field. A groundwater-flow model was developed using MODFLOW. Chloride transport was simulated for the *Equus* Beds aquifer using SEAWAT, a computer program that combines the groundwater-flow model MODFLOW-2000 and the solute-transport model MT3DMS. Chloride transport in the *Equus* Beds aquifer was simulated between the Arkansas and Little Arkansas Rivers near the Wichita well field. The chloride-transport model was used to simulate the period from 1990 through 2008 and the effects of five well pumping scenarios and one artificial recharge scenario. The chloride distribution in the aquifer for the beginning of 1990 was interpolated from groundwater samples from around that time, and the chloride concentrations in rivers for the study period were interpolated from surface water samples.

The SEAWAT model was used to compare chloride transport and groundwater flow between the existing-pumping and artificial-recharge scenario, four hypothetical well-pumping scenarios, and one hypothetical artificial-recharge scenario. The scenarios tested were (1) the existing 1990 through 2008 pumping and artificial recharge conditions, to serve as a baseline scenario for comparison with others; (2) no pumping in the model area, to demonstrate the chloride movement without the influence of well pumping; (3) double Wichita municipal pumping from the Wichita well field with existing irrigation pumping; (4) existing Wichita municipal pumping with no irrigation pumping in the model area; (5) double Wichita municipal pumping in the Wichita well field and no irrigation pumping in the model area; and (6) increasing artificial recharge to the Phase 1 Artificial Storage and Recovery project sites by 2,300 acre-ft per year.

In the existing pumping scenario, in the area between the Arkansas River and the southern boundary of the well field, the simulated chloride front moved north at an average rate of approximately 660 ft/yr in the shallow layer (layer 1), 780 ft/yr in the middle layer (layer 2), and 660 ft/yr in the deep layer (layer 3). The simulated chloride front moved toward the Wichita well field from the Burrton area at an approximate rate of 400 ft/yr in the shallow layer, 150 ft/yr in the middle layer, and 310 ft/yr in the deep layer.

In the no pumping scenario, chloride from the Arkansas River and the Burrton plume moved toward the Wichita well field. The chloride front from the Arkansas River near the southern part of the well field moved north toward the well field at an approximate average rate of 500 ft/yr in layer 1 (160 ft/yr slower than in the baseline scenario), 570 ft/yr in layer 2 (210 ft/yr slower than in the baseline scenario), and 510 ft/yr in layer 3 (150 ft/yr slower than in the baseline scenario). The simulated chloride front in the Burrton plume moved southeast toward the well field at a rate of approximately 520 ft/yr in layer 1 (120 ft/yr faster than in the baseline scenario), 70 ft/yr in layer 2 (80 ft/yr slower than in the baseline), and 190 ft/yr in layer 3 (120 ft/yr slower than in the baseline scenario).

In the double Wichita municipal pumping, existing irrigation pumping scenario, chloride from the Arkansas River and from the Burrton plume moved toward the Wichita well field. The simulated chloride front from the Arkansas near the southern part of the well field moved north toward and into the well field at an approximate rate of 810 ft/yr in layer 1 (150 ft/yr faster than in the baseline scenario), 870 ft/yr in layer 2 (90 ft/yr faster than in the baseline scenario), and 740 ft/yr in layer 3 (80 ft/yr faster than in the baseline scenario). The simulated chloride front in the main body of the Burrton plume moved southeast towards the well field at a rate of approximately 350 ft/yr in layer 1 (50 ft/yr slower than in the baseline scenario), 210 ft/yr in layer 2 (60 ft/yr faster than in the baseline scenario), and 440 ft/yr in layer 3 (130 ft/yr faster than in the baseline scenario).

In the existing Wichita municipal pumping and no irrigation pumping scenario, chloride from the Arkansas River near the southern part of the well field and from the Burrton plume moved toward the Wichita well field. The simulated chloride front from the Arkansas River moved north at an approximate rate of 590 ft/yr in layer 1 (70 ft/yr slower than in the baseline scenario), 710 ft/yr in layer 2 (70 ft/yr slower than in the baseline scenario), and 620 ft/yr in layer 3 (40 ft/yr slower than in the baseline scenario). The simulated chloride front of the main body of the Burrton plume moved southeast toward the well field at a rate of approximately 510 ft/yr in layer 1 (110 ft/yr faster than in the baseline scenario), 100 ft/yr in layer 2 (50 ft/yr slower than in the baseline scenario), and 260 ft/yr in layer 3 (50 ft/yr slower than in the baseline scenario).

In the double Wichita municipal pumping and no irrigation pumping scenario, chloride from the Arkansas River and the Burrton plume moved toward the well field. The simulated chloride front from the Arkansas River near the southern part of the well field moved north toward and into the well field at an average rate of approximately 770 ft/yr in layer 1 (110 ft/yr faster than in the baseline scenario), 850 ft/yr in layer 2 (70 ft/yr faster than in the baseline scenario), and 710 ft/yr in layer 3 (50 ft/yr faster than in baseline scenario). The simulated chloride front of the main body of the Burrton plume moved southeast at an average rate of approximately 500 ft/yr in layer 1 (100 ft/yr faster than in the baseline scenario), 150 ft/yr in layer 2 (the same as the rate estimate in the baseline scenario), and 400 ft/yr in layer 3 (90 ft/yr faster than in the baseline scenario).

In the increased Phase 1 artificial recharge scenario, the chloride transport from the Arkansas River near the southern part of the well field was similar to that of the baseline scenario. The simulated chloride front moved at the same rate in the increased Phase 1 artificial recharge scenario as in the baseline scenario. In the Burrton area, the simulated chloride front moved southeast toward the well field at an approximate average rate of 430 ft/yr in layer 1 (30 ft/yr faster than in the baseline scenario), 140 ft/yr in layer 2 (10 ft/yr slower than in the baseline scenario), and 270 ft/yr in layer 3 (60 ft/yr slower than in the baseline scenario). The eastward movement of the Burrton plume was slowed by the additional artificial recharge at the Phase 1 sites.

The average of simulated water levels from the end of the 2008 stress period in index monitoring wells in the Basin Storage Area was calculated for each scenario. Compared to the baseline scenario, the no pumping scenario was 5.05 feet higher, the double Wichita pumping with existing irrigation scenario was 4.72 feet lower, the no irrigation pumping with existing Wichita municipal pumping scenario was 2.49 feet higher, the double Wichita municipal pumping with no irrigation scenario was 1.53 feet lower, and the increased Phase 1 artificial recharge scenario was 0.48 feet higher.

The groundwater flow was simulated with a preexisting groundwater-flow model, which was not altered to calibrate the solute-transport model to observed chloride-concentration data. Therefore, in some parts of the model area, simulated and observed chloride concentration data match poorly. Most notably, chloride from the Arkansas River southwest of the well field moved northeast at a higher rate than the data indicate, and the simulated chloride front entered the most southern part of the well field in all scenarios simulated. Compared to the observed location of the chloride front interpreted from data collected in 2011, in the Arkansas River area the simulated chloride front moved from the river toward the well field about twice the rate of the chloride front interpreted from observed concentrations in layer 1 and about four times the rate of the chloride front interpreted from observed concentrations in layer 3. Achieving a better agreement between simulated and observed chloride data in the chloride-transport model may require changes to the groundwater-flow model. Future updates and recalibrations of the groundwater-flow and chloride-transport model will allow for changes in the groundwater-flow model parameters, including hydraulic conductivity, riverbed properties, and effective porosity, to accommodate the chloride-transport model in places where the chloride-transport model fit indicates problems with the groundwater flow.

Results of the modeling scenarios indicate that the Burrton chloride plume will continue moving toward the well field regardless of pumping in the area and that one alternative is to increase pumping from within the plume area to reverse the flow gradients and remove the plume. The modeling scenarios also indicate that the eastward movement of the Burrton plume could be slowed by additional artificial recharge at the Phase 1 sites. Decreasing pumping along the Arkansas River or increasing water levels in the aquifer near the river may retard the movement of chloride and may prevent further encroachment into the southern part of the well field area.

References Cited

Alkaeed, Othoman, Flores, Clariza, Jinno, Kenji, and Tsutsumi, Atsushi, 2006, Comparison of several references evapotranspiration methods for Itoshima Peninsula area, Fukuoko, Japan: Memoirs of the Faculty of Engineering, Kyushu University, v. 66, no. 1, p. 1-14. (Also available at *http://civil.kyushu-u.ac.jp/suiken/Lab/reserch/othoman.pdf*)

Aucott , W.R., Myers, N.C., 1998, Changes in ground-water levels and storage in the Wichita well field area, south-central Kansas, 1940-98: U.S. Geological Survey Water-Resources Investigations Report 98-4141, 20 p. (Also available at *http://pubs.er.usgs.gov/publication/wri984141*.)

Bauder, T.A., Waskom, R.M., Sutherland, P.L., and Davis, J.G., 2011, Irrigation water quality criteria; Colorado State University Extension, Fact Sheet No. 0.506, accessed October 22, 2013 at *http://www.ext.colostate.edu/PUBS/crops/00506.html*

Bayne, C.K., 1956, Geology and ground-water resources of Reno County, Kansas: Kansas Geological Survey Bulletin 120, accessed October 6, 2011 at *http://www.kgs.ku.edu/General/Geology/Reno/geog01.html*.

Burns and McDonnell Engineering Consultants, 2008, Aquifer Storage and Recovery Project 2007 Accounting Report: Kansas City, Mo., Burns and McDonnell Engineering Consultants, [prepared for the Wichita Water and Sewer Department], [variously paged].

Burns and McDonnell Engineering Consultants, 2009, Aquifer Storage and Recovery Project 2008 Accounting Report: Kansas City, Mo., Burns and McDonnell Engineering Consultants, [prepared for the Wichita Water and Sewer Department], [variously paged].

Burrton Task Force, 1984, Proposed Burrton Intensive Groundwater Use Control Area: prepared for the Kansas State Board of Agriculture, Division of Water Resources, 103 p.

Cunningham, W.L., and Schalk, C.W., comps., 2011, Groundwater technical procedures of the U.S. Geological Survey: U.S. Geological Survey Techniques and Methods, book 1, chap. A1, 151 p. (Also available at *http://pubs.er.usgs.gov/publication/ofr02293*.)