PAWNEE NATION OF OKLAHOMA

Source Water Protection Plan

Developed by:
Pawnee Nation of Oklahoma
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Updated May, 2014

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1.0 Introduction

The Pawnee Nation Water District (District) prepared this Source Water/Wellhead Protection Plan (WHPP) in accordance with the Pawnee Nation Natural Resource Protection Act Title XII Chapter 8 to ensure that the public drinking water supplies provided by the District are safe from potential sources of groundwater contamination. Information contained in this Plan has been assembled from several sources within the Pawnee Nation and the Source Water Assessment prepared by the Bureau of Reclamation in 2011. This section provides a brief introduction to the WHPP, its purpose, the past investigations that have been completed and the statutory and regulatory basis for the preparation and implementation of this plan.

The District serves the Pawnee Nation Campus to include Tribal, Federal and Residential facilities. Figure 1 is a general map of the service area and location of the District's water wells. The district relies on two active water wells and the potential to add an existing third well to the system.

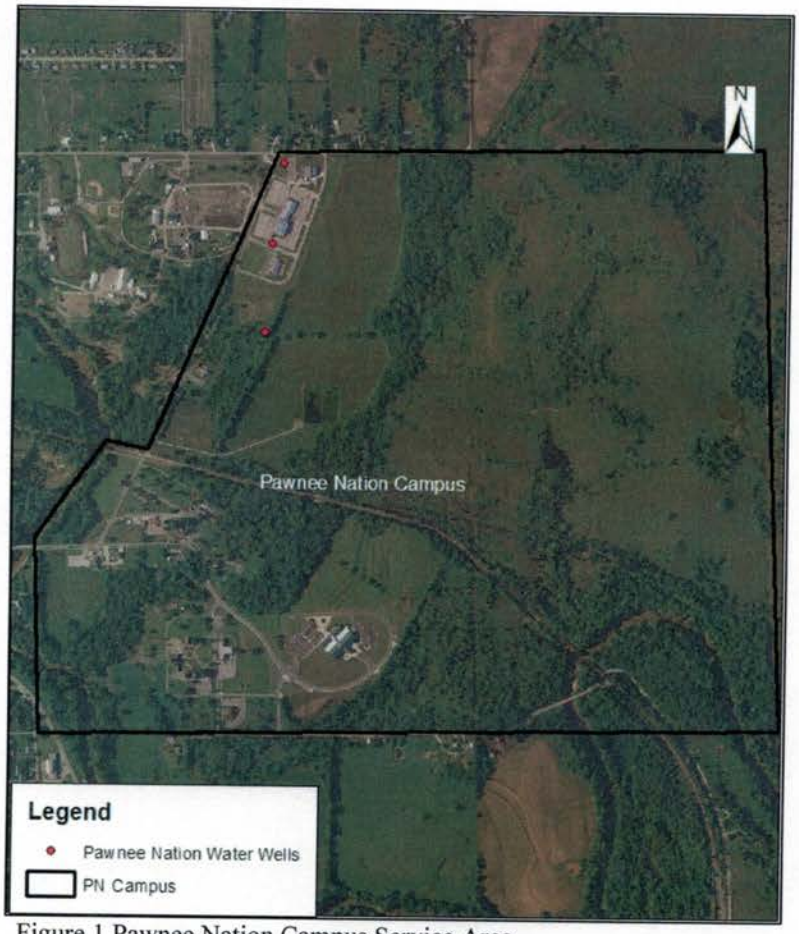


Figure 1 Pawnee Nation Campus Service Area

2.0 Purpose

The purpose of this WHPP is to provide a framework for the long-term management and the protection of the District's public water supply sources. This framework includes the following elements:

- Develop a Wellhead Protection Team and define the roles and responsibilities of the participants;
- Define Wellhead Protection Areas that include the delineation of the area of concern of the water wells used for public water supplies;
- Conduct an inventory and risk assessment of the potential contaminate sources that could result in groundwater contamination and develop contaminant source management strategies;
- Identify sites for new water supply wells, and develop contingency plans for response to interruptions of primary water supply service; and
- Develop educational material to improve public participation.

2.1 Past Investigations

Information used in the developing of this WHPP was obtained from the Source Water Assessment completed by the Bureau of Reclamation for the Pawnee Nation in 2011. The assessment can be found in attachment 1. Information obtained included:

- Identification of the groundwater flow direction,
- Source water delineation for the existing wells, and
- Identification of the zone of influence for the wells.

2.2 Regulatory Basis

The primary regulatory bases for the development of the WHPPs are the 1986 Amendments to the Safe Drinking Water Act of 1974 (Section 1428) which mandates States in the development of WHPP. As Tribal Nations are not required under the Amendments, the Pawnee Nation Natural Resource Protection Act Title XII Chapter 8 allows for the Environmental Regulatory Commission to develop regulations to prevent pollution of public water supply systems including but not limited to a Wellhead Protection Program. The guidelines are listed in the Law and the Director and Commission may assist communities with long term planning for meeting water supply needs form groundwater, surface water and other sources.

3.0 Wellhead Protection Team

3.1 Members

The members of the Wellhead Protection Team include representatives from the Pawnee Nation Government, Divisions and/or members of the community. The goal of the WHPP Team is to develop and implement management strategies that are aimed at protecting the potable water supplies of the District's service area. The responsibilities of the team include updating this plan to reflect new information or data pertaining to changes in water supply sources, new potential sources of contamination, and changes in land uses.

Name	Division/Agency	Responsibilities
Jimmy Jestes	Tribal Operations/Drinking Water Operator	Operations and maintenance of system
Robert Pratt	Tribal Operations/Drinking Water Operator	Operations and maintenance of system
Utility Commissioners (3)	Pawnee Nation Utility Commission	Manages Water District

3.2 Jurisdictional Authorities

The Pawnee Nation Water District is located at the Tribal Campus (Headquarters) within the Pawnee Nation Reservation boundaries as established by the Act of April 10, 1876. The Pawnee Nation recognizes all lands which have been validly set apart for the use and benefit of the Pawnee Indian(s), including, but not limited to, any lands or interest in lands of the Pawnee Nation or an individual Pawnee Indian held "reserved" in trust by the United States, or which is subject to Federal restrictions against alienation, including mineral resources and mineral estates reserved to Pawnee Indian(s) in the conveyance of a surface or non-mineral estate. Further, the Pawnee Nation recognizes its ownership and jurisdictional authority over the corpus of the waters (surface and ground) within its original boundaries as established on April 10 1876 (see 19 Stat., 28). The Pawnee Nation through its sovereign powers, rights, privileges and ability, recognizes the need to assert this Wellhead Protection Plan throughout its jurisdiction in part under the authorization as supported by U.S. Congress under the approval of the Constitution of the Pawnee Nation of Oklahoma on April 27, 1998 (Secretarial Order # 3177).

3.3 Goals and Objectives

The goals of the District's Wellhead Protection Program are: 1) to ensure clean drinking water supplies for future generations; 2) to reduce the risk to human health by ensuring that the District's service area has an uninterrupted supply of uncontaminated drinking water; and 3) reduce the District's operating costs by minimizing monitoring requirements. To achieve these goals, the following objectives must be met through the development and implementation of this plan:

- Delineate WHPAs by characterizing the conditions of each water supply source;

- Define critical recharge areas by characterizing the conditions in the Black Bear Creek Watershed;
- Determine potential man-made sources of contamination that could threaten water supplies;
- Recommend management procedures to prevent the degradation of drinking water sources;
- Develop contingency plans for alternate drinking water supplies if primary supplies are contaminated or otherwise rendered unusable;
- Identify new sources of water and implement measures to protect those sources; and
- Document and discuss the findings from inventories and field investigations.

By achieving these objectives, the Wellhead Protection Team will be able to implement this plan to benefit all those who rely upon the District's water system for a safe drinking water supply.

4.0 Aquifer and Water Supply System Overview

The District has developed two groundwater sourced wells on the Pawnee Nation Campus for operation of the drinking water system. The wells are titled the North Well and Middle Well. Different readers and agencies may have different names for these wells as determined by record checking sanitary surveys, inspections and maintenance reports. For the purposes of this document the reader should be aware of the names as prescribed by the Pawnee Nation and not a consultant or acting regulatory agency. There is a potential for upgrading a third well and connecting it to the system to meet any additional needs the District may require. Table 2 details the water supply sources and information known of the system.

In 1998, the Pawnee Nation with the assistance from the Bureau of Reclamation (BOR) developed three existing wells as a public water supply. It is believed these wells originally were constructed in the late 1940s. Currently the Pawnee Nation has a watershed protection plan for Black Bear Creek, which runs through the City of Pawnee and the Pawnee Nation near the public water supply wells location (approx. 1,400 ft.). This Watershed plan was developed to mitigate non-point sources of pollution into Black Bear Creek.

Table 2 Pawnee Water District Water Supply Sources

PWS ID	Source Name	Average Production (gpm)	Surface Elevation	Static Water Level	Screened Interval Depth
064026001	North Well (Well 1)	15,000	847 feet	9.3 feet	37-52 feet
	Middle Well (Well 2)	15,000	840 feet	2.8 feet	41-51 feet
Not assigned to system	South Well	Not connected		11.6 feet	

As determined by the BOR in the Source Water Assessment, all three of the District's wells produce water from a confined aquifer that is located close to the Vamoosa-Ada aquifer, approximately 6 miles to the east of the District's wells. A study of the USGS (2003) geologic map of Oklahoma suggests the wells are located in the Pennsylvanian Vanoss Group with Quaternary Alluvium located to the south along Black Bear Creek and to the west along Skedee Creek. The Vanoss Group is described as consisting of alternating layers of limestone, shale, sandstone and some minor conglomerate. (Figure 2)

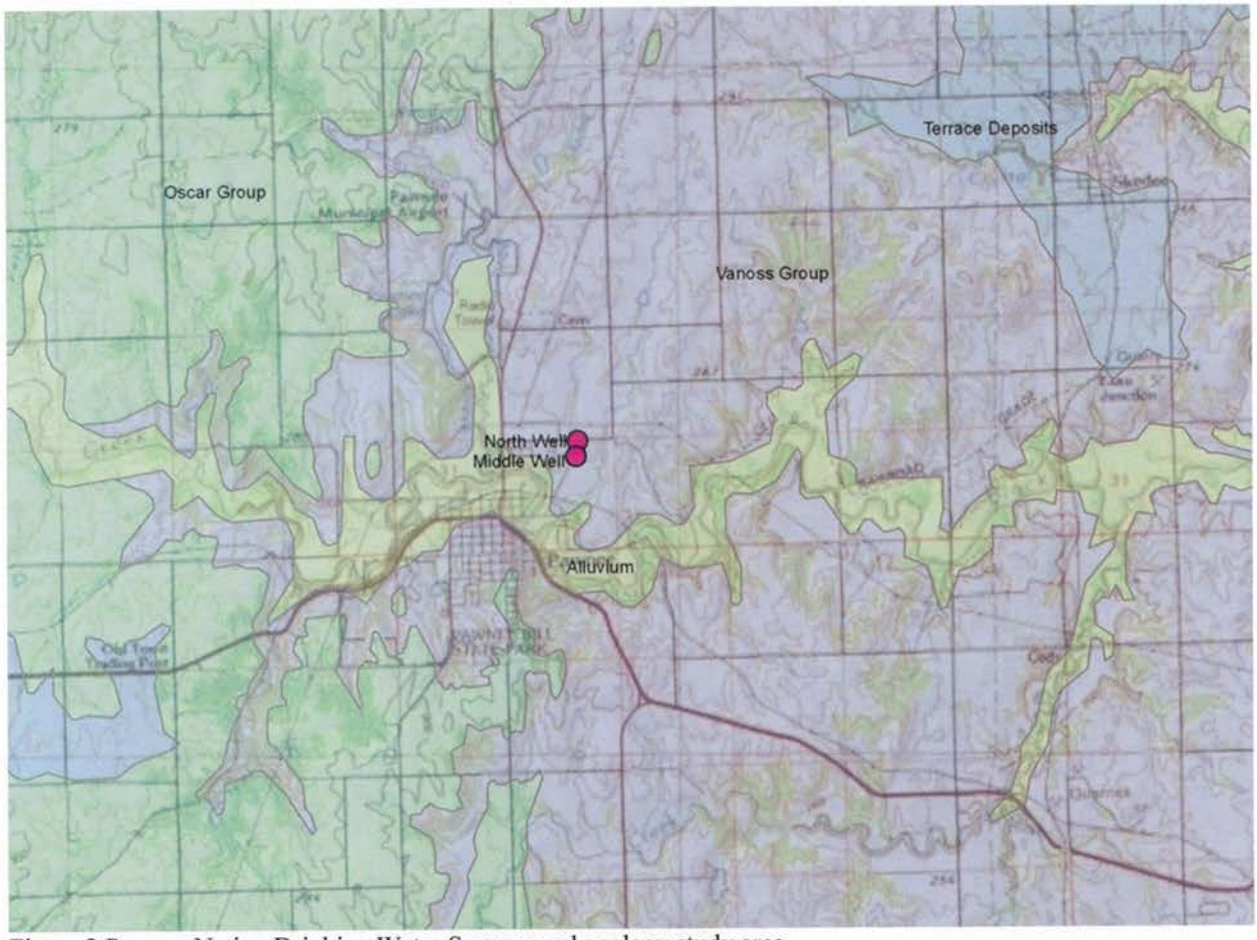


Figure 2 Pawnee Nation Drinking Water Sources and geology study area

Subsurface geologic maps indicated that the local aquifer system for the wells is probably the Pennsylvanian Vanoss Group. With the apparent regional water table gradient dipping towards the south and southwest, sources of recharge would be precipitation over land to the north and northwest of the wells and other surface water sources overlying the Vanoss Group and the eastern edge of the Oscar group to the north and northwest of the District wells.

Aquifer storativity calculated from pumping test (Reclamation, 1998) indicated that the aquifer in the vicinity of the supply wells is confined. This could be caused by relatively impermeable shale layers above and below the aquifer production zone. The continuity of alternating layers of shale, sandstone, and limestone over horizontal distances is unknown, leaving uncertainty of the hydraulic connection between aquifer layers and connections with surface waterbodies. (Reclamation, 2011)

The lack of information on the local aquifer system makes it difficult to define the extent of the aquifer and areas of recharge. Based on elevations in the area, Black Bear Creek is a probable area of discharge for the local aquifer. Figure 3 shows the simulated particle path lines for the recharge area as determined by the BOR using the WhAEM2000 analytic element model. The pathlines represent the 15 year time of transport zone for the two supply wells.

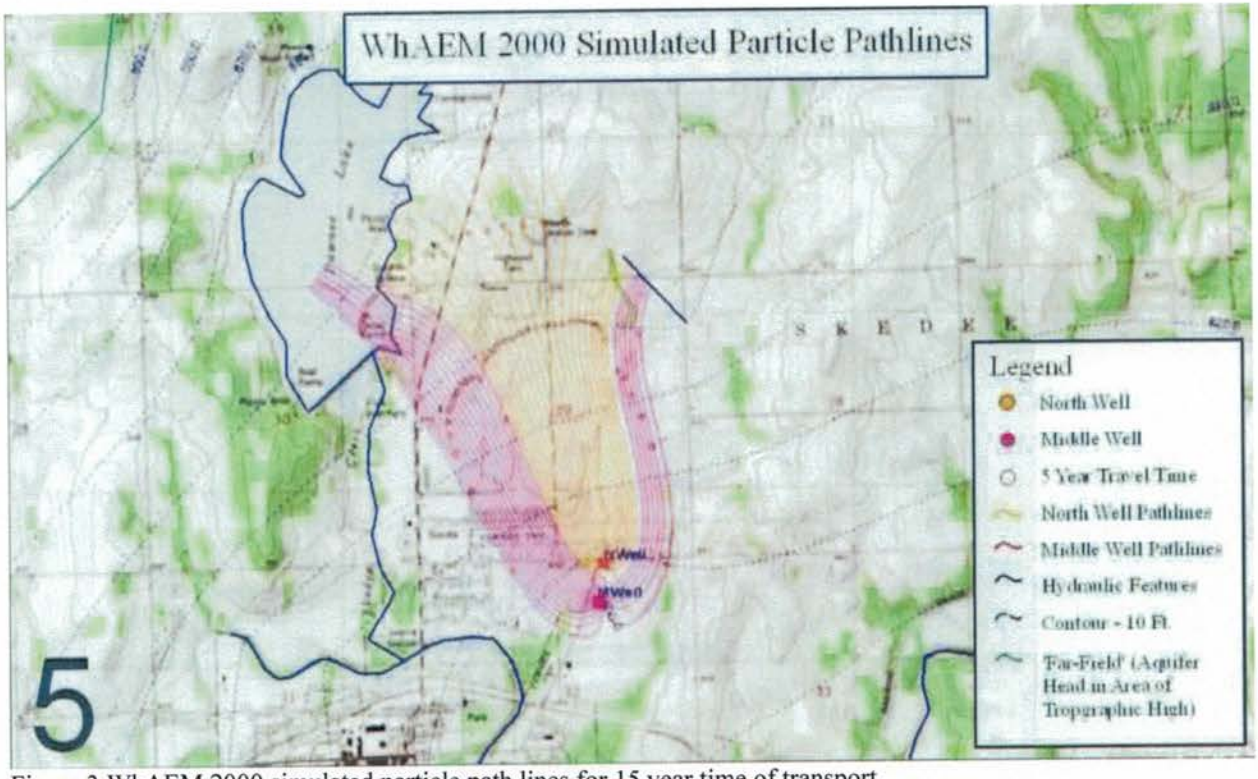


Figure 3 WhAEM 2000 simulated particle path lines for 15 year time of transport

5.0 Wellhead Protection Areas

In this section, the Wellhead Protection Areas (WHPA) are defined for the District's source water supply wells. The delineation of the WHPA is one of the primary objectives of the District's Wellhead Protection Program. This section provides background information on WHPAs and details the approach to defining the WHPAs for the wells. The rationale behind the selection of the specific methods is presented along with maps of the WHPA.

The wellhead protection area is shown in Figure 4. Supporting documentation is listed in Appendix B. The process of protecting groundwater and public health and safety is by minimizing contamination to shallow/surficial aquifers and preserving and protecting existing and potential sources of drinking water supplies. It is the intent to accomplish this through application of zoning, construction standards, both public education and public cooperation, as well as by creating appropriate regulation that may be imposed in addition to those currently imposed by law. (PNNRPA, Chapter 8)

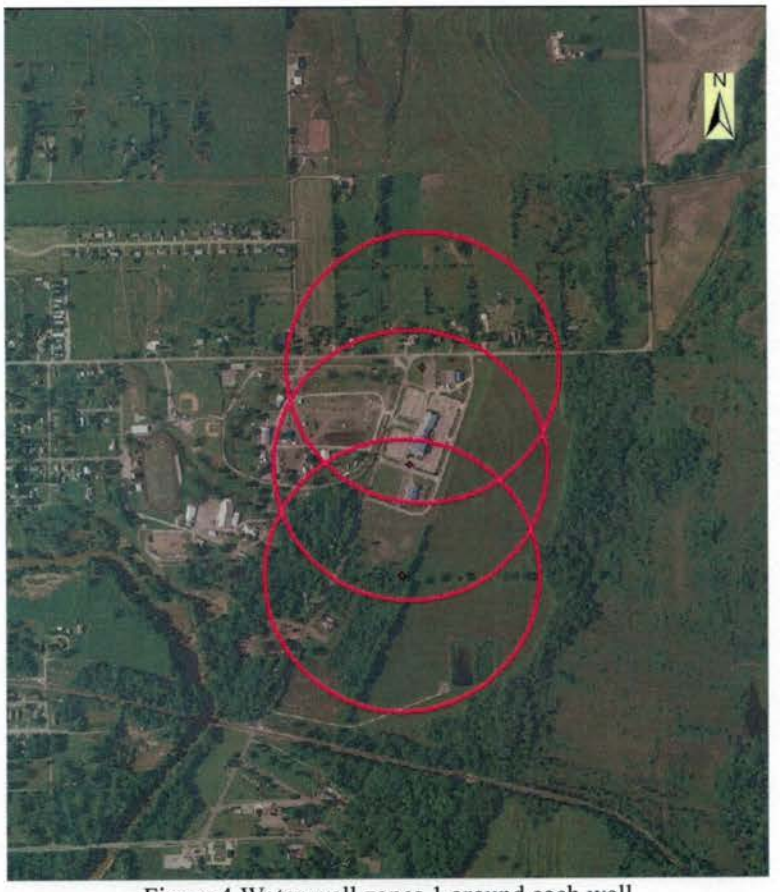


Figure 4 Water well zones 1 around each well

According to Chapter 8 Groundwater Resource Protection of the Natural Resources Protection Act, two zones are applied to any public drinking water well on Pawnee Nation land. Zone 1 is defined as the area within the 6 month time of travel distance around all public water supply wells. This zone is presumed to be the area within 1000 feet of a public water supply well. Zone

2 is the remainder of the Pawnee Nation Jurisdiction not included in Zone 1, but deemed necessary to ensure adequate protection of public drinking water supplies.

Chapter Eight lists prohibited land uses in Zone 1 and are listed in Table 3.

Table 3. Zone 1 Prohibited uses	
(i)	Automobile body/repair shop;
(ii)	Gas station;
(iii)	Fleet/trucking/bus terminal;
(iv)	Dry cleaner;
(v)	Electrical/electronic manufacturing facility;
(vi)	Machine shop;
(vii)	Metal plating/finishing/fabricating facility;
(viii)	Chemical processing/storage facility;
(ix)	Wood preserving/treating facility;
(x)	Junk/scrap/salvage yard;
(xi)	Mines/gravel pit
(xii)	Irrigated nursery/greenhouse stock
(xiii)	Confined animal feeding operations
(xiv)	Land divisions resulting in high density (>1 unit/acre) septic systems;
(xv)	Equipment maintenance/fueling areas;
(xvi)	Injection wells/dry wells/sumps, except for single-family residences directing gutter downspouts to a drywell;
(xvii)	Underground storage tanks, (except those with spill, overfill, and corrosion protection requirements in place);
(xviii)	All other facilities involving the collection, handling, manufacture, use, storage, transfer or disposal of any solid or liquid material or waste having potentially harmful impact on groundwater quality;
(xix)	All uses not permitted in the underlying zone district

6.0 Potential Contaminant Source Inventory

The identification of potential contamination sources in the vicinity of existing wells or springs is a critical component of this program. An accurate knowledge of the potential threats to groundwater quality will allow the District to create the best plan to protect local water resources.

Many types of potential contaminant sources are present in or near the District, and other potential sources also exist. Many common household products that we rely on have the potential to impact groundwater. The tables on the following pages provide lists of the types of activities that may result in groundwater contamination and the types of contaminants and risks that may be associated with those activities.

To identify the potential sources of groundwater contamination in the District, a comprehensive contaminant source inventory was conducted. For most WHPP applications, only those potential contaminant sources within the WHPAs for water supply wells are inventoried. This approach was taken to provide District planners with the most comprehensive information on the locations and status of potential sources of concern in the community.

Table 4 Activities That May Contaminate Drinking Water
Residential Uses: (viruses, bacteria, nitrates, chemical compounds) • Failing septic systems, chemical septic system cleaners • Improper storage and application of fertilizers, pesticides and lawn care chemicals • Disposal of household cleaners, automotive products, poisons, waste oil, paint thinners, • Gasoline, pet waste into septic systems, backyard pits and storm drains • Driveway runoff of oils, gasoline, heavy metals, de-icing chemicals • Leaking underground heating oil tanks
Schools and Institutions: (chemical compounds, solvents, nitrates) • Disposal of oil, paints, chemicals into floor drains, sinks or directly to the ground • Contaminated runoff from parking areas • Improper fertilization of recreation fields • Equipment wash waste water
Municipal Uses: (sodium chloride, heavy metals, petroleum) • Improper storage and application of deicing chemicals • Street sweeping • Public works garages; auto maintenance, equipment wash waste water • Uncapped/Unlined landfills, open dumps • Leaking sewer lines/oil lines • Improper storage/application of pesticides and fertilizers • Contaminated runoff from roads, parking lots
Commercial, Industrial Uses: (heavy metals, petroleum, sodium chloride) • Improper storage, disposal and management of hazardous materials/waste • Abandoned or leaking underground storage tanks • Spills and releases that go unattended • Floor drains which discharge directly to the ground • Exposed bodies of water from mining, sand and gravel operations • Waste storage lagoons • Transportation spills and releases
Agriculture Uses: (nitrates, bacteria, viruses) • Improper use/storage of pesticides, herbicides, animal manure, fertilizers

- Improper irrigation methods
- Animal burial
- Storage lagoons
- Concentrated animal feedlot operations
- Contaminated runoff and equipment wash waste water

Table 5. Potential Contaminant Sources									
Code	Class	Source	Category A	B	C	D	E	Risk Ranking	Within 15 year T-O-T
1	Agricultural	Animal Burial			X	X		High	
2		Animal Feedlots		X	X	X		Moderate to High	
3		Chemical application (e.g. pesticides, fungicides, & fertilizers)		X	X			High	Yes
4		Chemical mixing & Storage area	X	X	X			High	
5		Irrigated fields		X				Moderate	
		Irrigation ditches			X			High	
6		Manure spreading & pits	X		X			Moderate	
7		Unsealed irrigation wells	X		X			High	
8	Industrial	Chemical manufacturers, warehousing/distribution activities	X	X	X			High	
9		Electroplaters & fabricators			X			High	
10		Electrical products manufacturing			X			High	
11		Machine & metalworking shops	X					High	
12		Manufacturing sites	X	X	X			High	Yes
13		Petroleum products production, storage & distribution	X					High	Yes
14	Commercial	Dry cleaning establishments	X					High	
15		Furniture & wood stripper & refinishers	X					High	
16		Jewelry & metal plating			X			High	
17		Laundromats						Low	
18		Paint shops	X					High	
19		Photography establishments & printers			X			High	
20	Automotive	Auto repair shops	X					High	
21		Car washes	X		X	X		Moderate	
22		Gas stations	X					High	
23		Road deicing operation: storage & application areas			X			Moderate	Yes
24		Road maintenance depots	X		X			High	Yes
25	Residential	Household hazardous products	X	X	X			Moderate	Yes
26		Private wells	X	X	X	X		Moderate	Yes
27		Septic Systems, cesspools		X	X	X		Moderate to high	Yes
28	Medical/ Educational	Educational institutions (labs, lawn & chemical storage areas)		X	X			Moderate	
29		Medical institutions (medical, dental, vet)				X		Low	
30		Research laboratories	X	X	X	X		High	
31	Storage	Aboveground storage tanks	X					High	Yes
32		Underground storage tanks	X					High	
33		Public storage	X					Low	
34		Radioactive materials storage					X	High	
35	Municipal Waste	Dumps and landfills (historical/active)	X	X	X	X	X	High	
36		Municipal incinerators		X	X	X		Moderate	
37		Recycling & reduction facilities			X			High	
38		Scrap & junkyards	X		X			High	
39		Septage lagoons, wastewater treatment plants		X	X	X		High	Yes
40		Sewer transfer stations		X	X	X		High	
41	Miscellaneous	Airports	X					High	Yes
42		Asphalt plants	X					High	
43		Boat yards	X					High	
44		Cemeteries				X		Moderate	Yes
45		Construction areas	X					Moderate	Intermittent
46		Dry wells	X			X		High	
47		Fuel storage systems	X					High	Yes
48		Golf courses, parks & nurseries (chemical application)		X	X			High	Yes
49		Mining (surface & underground)	X		X			High	Yes
50		Pipelines (oil, gas, coal slurry)	X					High	Yes
51		Railroad tracks, yard & maintenance	X					High	Potential
52		Surface water impoundments, streams/ditches				X		High	Yes
53		Stormwater drains & retention basins	X	X	X	X		High	Yes
54		Unplugged abandoned well	X	X	X	X		High	Potential
55		Well: operating	X	X	X	X		High – low	Yes
	Contaminants: A= VOC B = SOC C = IOC D = Microbiological E = Radionuclides								

7.0 Wellhead Protection Plan Implementation

Developing and implementing effective wellhead protection measures and programs are the primary means to achieve the program goal of preventing ground water contamination. The Pawnee Nation Division of Tribal Operations and Utility Commission manage the Pawnee Water District and operate the system. The Pawnee Nation Natural Resource Protection Act Title XII and the Pawnee Nation Public Water Supply Regulation provide law and implementing regulations for the operation of any drinking water system within the Pawnee Nation's jurisdiction.

There will be several components to the Wellhead Protection Management Plan. However because much of the wellhead protection area is located beyond the Pawnee Nation Campus the primary focus of the plan will be on education, land purchase and the use existing regulations to limit risks posed by potential sources.

The Pawnee Nation will undertake the activities listed in the public education section of this plan. Because the Pawnee Nation does not have control or jurisdiction over much of the land within the wellhead protection area, public education will be the primary thrust of the management plan. In addition the Pawnee Nation has contacted local governments to enlist their assistance in promoting groundwater protection and best management practices.

The Pawnee Nation does not at this time have a groundwater monitoring program, but will work with other jurisdictions to implement and operate a program. The Pawnee Nation will promote water conservation by promoting low flow devices and enacting emergency conservation measures in times of drought as described in this report.

7.1 Zoning and Codes

The process of protecting groundwater and public health and safety is by minimizing contamination to shallow/surficial aquifers and preserving and protecting existing and potential sources of drinking water supplies. It is the intent to accomplish this through application of zoning, construction standards, both public education and public cooperation, as well as by creating appropriate regulation that may be imposed in addition to those currently imposed by law. (PNNRPA, Chapter 8) Land use zones have been established around the wells to prevent contamination and protect the water supply. (Figure 4)

7.2 Surface Water

The Pawnee Nation Water Quality Monitoring Program is comprised of a surface water monitoring program and ground water monitoring program. The goal of the Pawnee Nation Water Quality Monitoring Program is threefold: (1) to establish the baseline conditions of surface and ground waters on and flowing onto the Reservation, (2) to use this information to evaluate regulatory compliance of waters flowing onto the Reservation, and (3) to support the development and implementation of a water quality regulatory program on the Reservation.

Groundwater monitoring typically involved monitoring groundwater resources for surface water influences (i.e. Total coliform for drinking water wells) and direct contamination associated with UIC activity and agriculture (chloride contamination and pesticide contamination)

In 1997, the Pawnee Nation established the Department of Environmental Conservation and Safety (DECS). The goals of the DECS are to manage the Natural Resources of the Pawnee Nation and govern all Environmental Conservation issues involving Pawnee Indian Country. An Environmental Regulatory Commission has been established by law consisting of Tribal leaders and concerned members to oversee tribal permitting and other environmental complaints and concerns brought to them. Since its inception the DECS has established a comprehensive water quality monitoring program through the Clean Water Act (CWA) 106 program and 319 Nonpoint Source Pollution program. Beginning with monthly monitoring of 5 watersheds and now has expanded to 23. Monitoring activities consisted not only of chemical and physical parameters, but also biological parameters to include Marco invertebrates and Fish. Also the Department deploys periphytometers in at least one watershed per year to determine nutrient levels and trophic status.

7.3 Spill Prevention

The Pawnee Nation Division of Natural Resources and Safety has been actively developing spill prevention and response capabilities since the late-1990s. The practices that the Pawnee Nation can take to prevent spills of polluting material on the Campus and throughout its Reservation and actions the Pawnee Nation should take in response to spills on- or off-Reservation that threaten Reservation waters are included in the departmental Standard Operation Procedures.

Large amounts of crude oil, petroleum products, and other hazardous materials are transported and are stored within and near the Pawnee Nation Reservation. These hazardous materials are transported by pipelines, trucks, and railroad and are used, produced, and/or stored throughout the Reservation area. Spills or releases of petroleum products, chemicals, or other hazardous materials to land or waters can threaten public safety, public health, and destroy productive and valuable ecosystems.

The Pawnee Nation Department of Fire and Rescue, thePawnee Nation Department of Environmental Conservation and Safety, in cooperation with local spill response organizations, the local and county Department of Emergency Management, county LEPC, TERC, and other local fire and police agencies, are trained and prepared to plan for and respond to minor spills or releases of some hazardous materials. In response to a major spill, experts from the USEPA, Ecology, and local industries would be called in to help control the damage. A Spill Prevention and Response Plan further describe the emergency response capabilities of these agencies.

8.0 Public Education

Education and public involvement are essential elements of any wellhead protection program. While regulation and enforcement are important, implementing public education efforts is a proactive approach to protecting the ground water. Targeted and persuasive education and outreach is vital to changing the behavior of many individuals who collectively contribute to pollution.

Before community members are motivated to participate in wellhead protection program activities, they must first be aware of the importance of the local ground water resources, the potential sources of ground water contamination, and be educated about what they can do to prevent contamination. Public education activities should therefore be designed to involve and encourage the community to become aware of the problems and take action when appropriate to solve specific problems.

For wellhead protection, it is important that people are aware of:

- The importance of local ground water resources for community water supply;
- The value of wellhead protection and how it benefits the community;
- How wellhead regulations/ordinances affect their property and community;
- How they can ensure the safety of the ground water supply; and
- How they can get involved in wellhead protection in their community (i.e., opportunities for volunteer projects and/or community events).

The Pawnee Nation Wellhead Protection Program will inform and involve the community through community education and inter-jurisdictional coordination and cooperation.

1. **Community Education:** The public education element of the Pawnee Nation Wellhead Protection Program will include articles in the Pawnee Nation newspaper, *Chaticks si Chaticks,* describing the effects of pollution and the progress of the Pawnee Wellhead Protection Program development effort. The Pawnee Nation Division of Tribal Operations will provide copies of a Wellhead Protection Program fact sheet to community members. Also the Pawnee Nation Division of Natural Resources and Safety will post on their website wellhead protection materials including well drilling and decommissioning standards, ongoing Reservation wellhead protection projects, drinking water laws and regulations, and links to other wellhead and ground water protection websites.
2. **Inter-jurisdictional Coordination and Cooperation:** The inter-jurisdictional coordination and cooperation element of the plan will continue within the Pawnee Nation and with the U.S. Environmental Protection Agency. The Pawnee Nation Division of Tribal Operation will to continue working closely with the Pawnee Nation Planning Division and other agencies to implement the community education element of the wellhead protection program.

9.0 Conclusion and Summary

The overall purpose of the Pawnee Nation Wellhead Protection Program is to protect ground water within the Pawnee Nation Reservation ("Reservation") from contaminants. The Program is intended to reduce the risk of the Pawnee Nation's ground water resources becoming impaired or otherwise unusable as the primary water supply for the Pawnee Nation and residents of the Reservation.

As a finite resource, ground water is one of the most important and critical of the Pawnee Nation's resources. The Pawnee Nation is dependent on ground water for water supply. The Pawnee Nation Campus' water supply is currently pumped from local ground water wells. Most of the residences on Trust property are now connected to a rural water district there are still some residences utilizing groundwater for water supply.

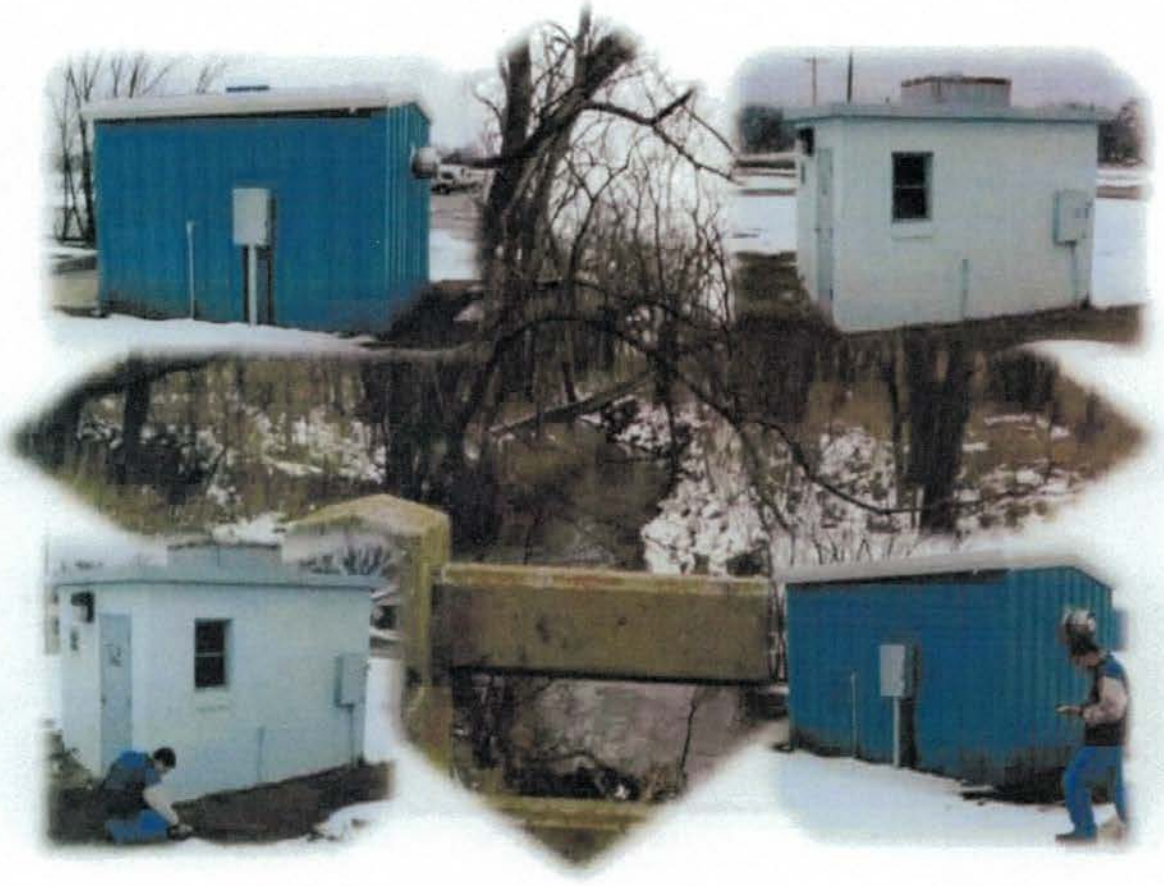
Ground water on the Reservation is withdrawn from one confined aquifer on the Reservation. This system flows onto the Reservation from the north and northwest and drains to the south and east (BOR, 2011). The Pawnee Nation delineated wellhead protections areas in order to protect the aquifer which provides the primary drinking water source on the Reservation.

Appendix A

RECLAMATION

Managing Water in the West

Source Water Assessment for Pawnee Nation Water Supply Wells Pawnee Nation, Oklahoma



U.S. Department of the Interior
Bureau of Reclamation
Technical Service Center
Denver, Colorado

The Pawnee Nation
Pawnee, Oklahoma

April 2011

Mission Statements

The U.S. Department of the Interior protects America's natural resources and heritage, honors our cultures and tribal communities, and supplies the energy to power our future.

The mission of the Bureau of Reclamation is to manage, develop, and protect water and related resources in an environmentally and economically sound manner in the interest of the American public.

Source Water Assessment for Pawnee Nation Water Supply Wells Pawnee Nation, Oklahoma

U.S. Department of the Interior
Bureau of Reclamation
Technical Service Center
Denver, Colorado

The Pawnee Nation
Pawnee, Oklahoma

April 2011

Abbreviations

AOC	area of concern
cfs	cubic feet per second
EPA	U.S. Environmental Protection Agency
ft^3/day	cubic feet per day
gpm	gallons per minute
GPRO	Great Plains Regional Office
Nation	Pawnee Nation
OCC	Oklahoma Corporation Commission
ODEQ	Oklahoma Department of Environmental Quality
OTAO	Oklahoma-Texas Area Office
OWRB	Oklahoma Water Resources Board
Reclamation	Bureau of Reclamation
USGS	U.S. Geological Survey
USTs	underground storage tanks
WHPA	wellhead protection area

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Executive Summary

The Bureau of Reclamation (Reclamation), Great Plains Region, Oklahoma Texas Area Office, is assisting the Pawnee Nation (Nation) with protecting the Nation's public water supply in Pawnee County, Oklahoma. The current public water supply consists of three shallow wells (supply wells), with two of the wellscurrently being utilized. These wells are located north of Pawnee Oklahoma in the watershed of Black Bear Creek, a tributary to the Arkansas River. The Nation is concerned with the potential of contaminants in the recharge area of these wells affecting this water supply and has requested assistance from Reclamation to determinine what potential exists.

The Great Plains Regional Office prepared a source water delineation for the supply wells to:

- Identify the ground water flow direction
- Delineate the 15-year flow path for the ground water contributing to these wells.
- Identify the zone of influence (recharge) for these wells

The Oklahoma Water Resources Board (OWRB) maintains well log data for the State of Oklahoma; OWRB data; however, was sparse in this area. The Nation gathered well data in the vicinity of the existing wells. The data included location, surface, and water level elevations. This data suggested a general flow direction of the ground water. The gradient of ground water in this area is from the west and northwest moving to the east and southeast towards Black Bear Creek and the Arkansas River. Under average conditions, the water levels at the Nation's wells are expected to be slightly higher than the stream stage in Black Bear Creek, with a resultant ground water flow direction from the wells towards the creek.

The aquifer parameters were taken from the existing information and used to develop a zone of transport for each well. The zone delineates the area in which the potential contaminants could be transported to the well. This was accomplished using the U.S. Environmental Protection Agency's (EPA) WhAEM2000 analytic element model to delineate the 15-year time-of-transport zone for the two Pawnee wells in service. WhAEM2000 computes a steady-state flow field in a single aquifer. The flow field is used to estimate probable particle path lines in the aquifer to the wells over a specified period of transport. The path line end points are used to define the extents of the zone of transport for the wells.

Reclamation extended the 15-year zone of transport identified to an area of concern (AOC). The AOC is the area in which the Nation should be concerned with potential pollution occurring on the surface and in the ground water.

Reclamation reviewed the existing land use and listed the potential contaminates within the AOC and best management practices to mitigate any potential contamination.

There are many data gaps and uncertainties in the existing data. In the absence of any new data, and/or in the absence of filling in the data gaps, the interpretations and conclusions presented in this document are an initial attempt to address potential areas of contamination. The Pawnee Nation should continue to gather data to refine the knowledge of the aquifer—in particular, in the area between of Black Bear Creek and the public supply wells as discussed in the results and conclusions section of this report.

However, considering the limited amount of data and the uncertainties in the quality and completeness of the available data, the interpretations of ground water gradients and possible source areas for the subject wells should be considered as generalized regional estimates at best.

Introduction

Treat the earth well: it was not given to you by your parents, it was loaned to you by your children. We do not inherit the Earth from our Ancestors; we borrow it from our Children.

Tribe Unknown[1]

This report is prepared for the Pawnee Nation (Nation) by the Bureau of Reclamation (Reclamation), Great Plains Region, Oklahoma–Texas Area Office (OTAO) to assist the Nation in developing a plan to protect the main source of water for the tribal facilities. The Pawnee Nation headquarters is located in Pawnee County, Pawnee, Oklahoma (see figure 1).

In 1998, the Pawnee Nation with assistance from Reclamation developed three existing wells as a public water supply. It is believed these wells originally were constructed in the 1940s. Currently, the Nation is developing a watershed protection plan for Black Bear Creek, which runs through the City of Pawnee near the public water supply wells location. Black Bear Creek is experiencing an E. coli contamination issue, and the Nation is concerned that the wells may become contaminated.

As part of the Native American Technical Assistance Program, Reclamation is assisting the Pawnee Nation to identify an area of concern (AOC) in which potential contaminants could impact this water supply within a specified 15-year timeframe. Other timeframes were considered, but it was felt that the accuracy of the models could not be reasonably extended to more than 15 years.

Reclamation[2] prepared a Source Water Delineation for the supply wells that attempted to identify:

- Ground water flow direction
- Source water delineation
- Zone of transport of contamination for existing wells

The information provided in the Source Water Delineation was used to develop an AOC. The uncertainties encountered in developing the Source

[1] http://www.legendsofamerica.com/NA-Proverbs.html.

[2] Source Water Delineation prepared by Mark Phillips, Geologist Great Plains Regional Office.

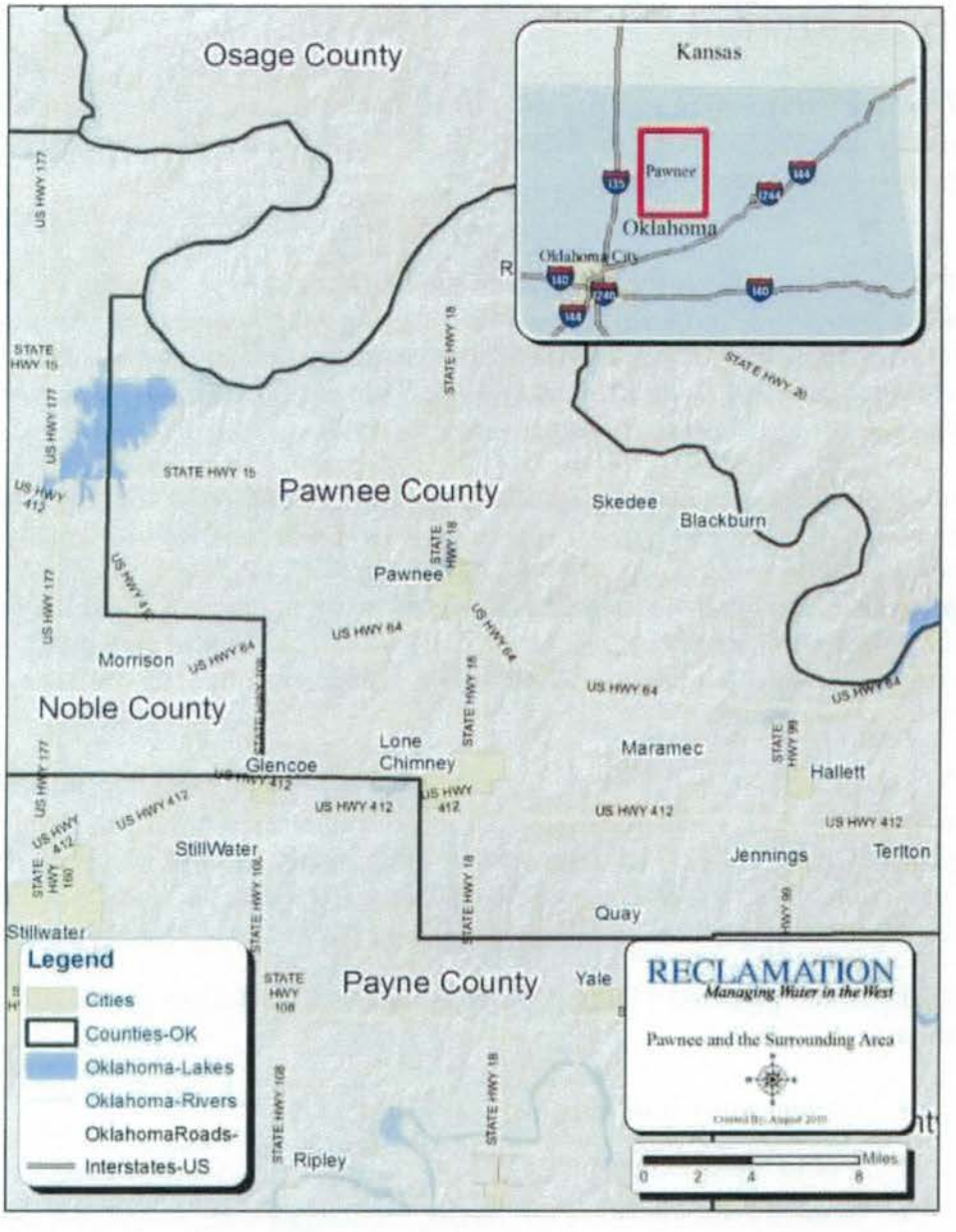

Figure 1. Pawnee County, Oklahoma.

Water Delineation were taken into consideration in identifying the AOC. Reclamation reviewed the AOC and identified the following:

- Potential sources of contamination for these wells
- Potential management strategies to reduce risks to the current water supply

The Nation has indicated that they wish to incorporate this information into a larger watershed protection plan for the Black Bear Creek.

Source Water Delineation

The Reclamation OTAO requested the Great Plains Regional Office (GPRO) to assist in developing a source water zone of transport regarding two public supply wells owned and operated by the Nation located at Pawnee, Oklahoma (see figure 1). The supply wells previously have been identified during a well yield analysis by Reclamation (1998) as the North Well and Middle Well. The supply wells are located in the NW ¼ of the NE ¼ of section 32 Township 22 North, Range 5 East.

GPRO undertook the following tasks:

- Task 1 - Identification of the ground water flow direction
- Task 2 - Source water delineation for the existing wells
- Task 3 - Identification of the zone of influence for supply wells.

To accomplish these tasks, Reclamation undertook the following steps:

1. Review of existing data and reports to determine the aquifer from which supply wells are producing and define aquifer extents and hydraulic parameters.

2. Utilize static water level measurements from wells and other hydrologic features in the study area to define the general direction and gradient of ground water levels.

3. Constructed an analytic element flow model of study area, utilizing the WhAEM2000[3] to delineate the area of contribution to the Pawnee wells. The area of contribution will be based on an assumed 15-year time of transport[4] for contaminants. This model is driven by the following data sets:

    - Aquifer boundaries – bottom or top elevations, aquifer thickness, areal extent defined by recharge sources such as streams or lakes, and edges of aquifer material.

[3] http://www.epa.gov/athens/software/whaem.

[4] Oklahoma Department of Environmental Quality was contacted regarding what parameters the State would recommend to define well-head protection areas. There do not appear to be formal requirements; but for previous studies, the State has used three zones defined by: 1) well radius of 300 feet, 2) 2-year time of transport, and
3) 10-year time-of-transport.

- Aquifer hydraulic properties – permeability and effective porosity.
- Generalized water table conditions – water level elevations describing generalized flow directions.
- Proposed well discharge rates that define the extent of aquifer drawdown. For this analysis, it was assumed that the wells would be pumping constantly at a rate of 200 gallons per minute (gpm) (38,448 cubic feet per day [ft^3/day]) for each well.

Existing Data Search

Reclamation (1998) describes bedrock formations in the vicinity of wells as consisting of the Permian Wellington-Admire Unit and Foraker Subunit. Wellington-Admire Unit consists of shale, sandstone, limestone, and siltstone. The Foraker Subunit consists of limestone, shale, and sandstone. Anecdotal information from Pawnee Nation staff suggested that wells were completed in limestone. The report concludes that the influence zones for both the North and Middle wells are in limestone. Limestone formations were reported to be exposed 6 – 8 feet below ground surface in creek banks nearby the wells.

A geologic map of Oklahoma showing formations in the study area (figure 2) has been developed by the USGS (2003)[5]. This map suggests that the subject wells are located in the Pennsylvanian Vanoss Group with Quaternary Alluvium located to the south along Black Bear Creek and to the west along Skedee Creek. The Vanoss Group is described as consisting of alternating layers of limestone, shale, sandstone, and some minor conglomerate. Total thickness of group ranges up to 500 feet. In general, the sub-surface outcrop of the Vanoss Group extends in an approximate 10-mile wide linear band extending from the Kansas-Oklahoma border into the southern portions of the state. The Vanoss Group generally slopes to the west[6].

Following is an excerpt from the map legend associated with the U.S. Geological Survey (USGS) geologic map (see figure 2) that describes the Vanoss Group in the vicinity of the ENID 250k quadrangle that encompasses Pawnee County:

> "ENID-Alternating layers of limestone and shale to north, grading southward into limestone, shale, and fine-grained arkosic sandstone. Locally the group contains thin coal seams. Near Kansas border, group includes (descending): "Salem Point Shale" (12 feet thick) at top, underlain by "Burr Limestone" (8 feet thick), "Legion Shale" (4 feet thick), "Sallyards Limestone" (3 feet

[5] U.S. Geological Survey;2003; Heran,William D., et al.;*A Digital Geologic Map Database for the State of Oklahoma*,;Open-File Report 03-247; http://pubs.usgs.gov/of/2003/ofr-03-247/.

[6] U.S. Geological Survey;1996; *Hydrologic Investigations Atlas 730-E*; "Ground Water Atlas of the United States, Segment 4, Oklahoma Texas," figure 8.

thick), "Roca Shale" (15 feet thick), "Red Eagle Limestone," IPvre (20 feet thick), "Johnson Shale" (35 feet thick), "Long Creek Limestone," IPvlc (10 feet thick), unnamed shale (3 feet thick), "Hughes Creek Limestone (15 feet thick), unnamed shale (12 feet thick), "Americus Limestone, "IPvam, (12 feet thick), "Oaks Shale" (3 feet thick), "Houchen Creek Limestone (8 feet thick), "Stine Shale" (20 feet thick), "Five Point Limestone" (3 feet thick), unnamed shale (12 feet thick), "Brownville Limestone, IPvb (8 feet thick), "Pony Creek Shale" (40 feet thick), "Grayhorse Limestone," IPvg (5 feet thick), unnamed shale (12 feet thick), "Nebraska CityLimestone" (5 feet thick), "French Creek Shale" (12 feet thick), "Jim Creek Limestone" (3 feet thick), "Friedrich Shale" (30 feet thick), "Grandhaven Limestone" (2 feet thick), "Dry Shale" (25 feet thick), "Dover Limestone" (30 feet thick), "Willard-Langdon Shale" (110 feet thick), "Elmont Limestone," IPve (10 feet thick), "Stonebreaker Shale" (20 feet thick), and "Reading Limestone" (20 feet thick) at base. Total thickness, about 500 feet (150 m)."

Figure 2. Geology of study area.

The Oklahoma Water Resources Board (OWRB) published a geospatial dataset showing the location of major aquifers in Oklahoma.[7] This dataset indicates that the the Vamoosa-Ada Aquifer is the closest major aquifer, located approximately 6 miles to the east of the Pawnee wells. The general dip of the Vamoosa-Ada Aquifer is towards the west.[8] This information suggests that the supply wells are located in a local minor aquifer system.

OWRB maintains an internet-based Water Well Record Search Database[9] that was used to query well-driller logs for lithology and static water levels in the vicinity of the supply wells. Only one well was found that contained a log of lithology considered representative of that in the vicinity of the Pawnee wells. A domestic well (OWRB Well ID 99302) is located approximately 0.5 miles to the north-northwest from the supply wells and was completed during April 2001. Following is the lithologic log:

Material	Encountered From (feet)	Encountered From (feet)	Saturated
Topsoil	0	2	N
Sandrock	2	11	N
Sandy shale	11	14	N
Shale	14	21	N
Limestone	21	26	N
Shale	26	33	N
Limestone	33	39	N
Shale	39	42	N
Limestone	42	43	N
Sandrock	43	71	Y
Limestone	71	73	N
Shale	73	89	N
Limestone	89	96	N

Based on a topographic map, the surface elevation at Well 99302 is estimated to be 863 feet above mean sea level. The driller's log indicated that the well was screened at depth interval of 76–96 feet (elevation 787–767). The stated well

[7] http://www.owrb.ok.gov/maps/data/layers/OWRB_major_Aquifers.zip.

[8] U.S. Geological Survey; 2008; Scientific Investigations Report 2008-5118; *Aquifer Tests and Characterization of Transmissivity, Ada-Vamoosa Aquifer on the Osage Reservation, Osage County, Oklahoma, 2006.*

[9] http://www.owrb.ok.gov/wd/search/search.php.

yield was 7 gpm. Depth to water at time of drilling was 43 feet (elevation 820). The driller also indicated first water zone was at a depth of 71 feet.

From the OWRB well database, domestic Well ID 12249 was completed during November 1984 and is located approximately 0.4 miles to the northeast from the Pawnee North Well. There is not a lithologic description of the borehole. Ground surface elevation is estimated to be 859 feet from a topographic map. Total depth of well is 67 feet and has a screened interval at depth 47-64 feet (elevation 812 -795). Driller reported the first water zone at depth 45 feet.

From the OWRB well database, test Well ID 70238 is located approximately 300 feet south of Black Bear Creek northwest of the town of Pawnee. The driller log for that well indicates silty sand and clay to a depth of 38 feet and shale and limestone from 38 to 60 feet. If the limestone layer at this well is connected to the aquifer supplying the Pawnee wells, then the potential exists for overlying clay and shale layers to impede the hydraulic connection of Black Bear Creek with the limestone layer from which the wells are producing.

The Pawnee North and Middle Wells static water levels and screened interval elevations based on Reclamation (1998) are listed below:

- Middle Well ground surface elevation = 840 feet. Static water level = 2.8 feet (elevation 837). Screened interval depth = 41–51 feet (elevation 799–789).

- North Well ground surface elevation = 847 feet. Static water level = 9.3 feet (elevation 838). Screened interval depth = 37–52 feet (elevation 810–795).

The USGS maintains a streamflow gauging station(USGS 07153000) on Black Bear Creek at Pawnee. The Nation reported that flow at this station is perennial. There are no additional recording stations on Bear Creek above, or below, this station that can be used to assess flow gains or losses to the creek. Contributing drainage area is 576 square miles. Period-of-record 20-percentile low flow is approximately 2.5 cubic feet per second (cfs), which could be considered base flow.

The surface elevation datum for the gauging station is 802.73 feet. At the time this document was prepared, , the stream stage for the past 120 days was generally 2.5 feet above datum, and the water surface elevation would be 805.2 feet. Width of stream is approximately 20 feet.

Other water resources located in the area are:

- Pawnee Lake – Pawnee Lake is a 257-acre lake that was constructed in 1932 and is owned and operated by the City of Pawnee.[10] The lake is managed as a municipal water supply. The dam is located approximately 1.2 miles to the northwest of the supply wells. Based on the topographic map, the water surface elevation is estimated to be 850 feet. No data was found to determine if the reservoir is hydraulically connected to the underlying aquifer system.

- Skedee Creek – Pawnee Nation staff indicated that flow in this creek is perennial between Pawnee Lake and Black Bear Creek. It appears that most of the flow in the creek is overflow from Pawnee Lake. Although no information was found defining the hydraulic connection between Skedee Creek and the local aquifer system, there is a potential for this creek to recharge the underlying aquifer influencing the supply wells.

- Possum Creek – This creek is located just to the east of the supply wells. Pawnee Nation staff indicated that this creek is not perennial. The creek is probably not a significant source of recharge to the underlying aquifer.

Based on the well-pumping test results from Reclamation (1998), the average aquifer transmissivity is 2 square feet per minute. The thickness of the aquifer in the vicinity of the supply wells is assumed to be 52 feet, based on estimated well completion depths. The resultant aquifer permeability would be approximately 0.038 feet per minute (55 feet per day).

The well-pumping tests analyses by Reclamation (1998) resulted in a storage coefficient of .0019, which indicates a confined aquifer in the vicinity of the supply wells. Confining conditions suggest that the hydraulic connection between surface water sources in the vicinity of the supply wells with the aquifer may be impeded.

No specific data regarding effective aquifer porosity for the study area was found. Effective porosity impacts the travel time for aquifer contaminants. According to Bouwer (1978),[11] carbonate rock with original and secondary porosity can have a porosity ranging from 10–20 percent (%). For this analysis, porosity was assumed to be 15%.

Precipitation Recharge

No specific information was found on the rate of recharge by precipitation to the aquifer in the vicinity of the supply wells. Metadata published on the Internet by the USGS for digital data sets describing aquifer characteristics of the

[10] http://www.owrb.ok.gov/quality/monitoring/bump/pdf_bump/Current/Lakes/pawnee.pdf.

[11] Bouwer, Herman;1978; *Ground water Hydrology*; McGraw-Hill Book Company.

Vamoosa-Ada Aquifer indicates that the recharge rate for that aquifer is generalized to 4% of annual precipitation.[12] Pawnee County receives an average of 40 inches of precipitation per year.[13] Assuming that 4% of annual precipitation recharges the aquifer system, the estimated recharge is 1.6 inches of recharge per year (0.00037 feet per day).

Ground Water Flow Direction

A review of existing ground water level data in the study area resulted in sparse information that reflected conditions from various time periods. Data that were found included:

- Static water levels reported in the OWRB water well records research database for select wells (see appendix A)
- Static water levels reported by Reclamation (1998) during well pumping tests
- Estimated water levels near Black Bear Creek based on the assumption that the creek is hydraulically connected to the adjacent aquifer system (supported by statements that limestone formations are exposed in creek channels near subject wells)

OWRB staff[14] were contacted to determine if any additional data exists, other than those listed in the OWRB wells database, that would assist in defining ground water flow directions in the study area. No additional data was found.

To assist in refining ground water levels near the supply wells, the Nation made additional static ground water level measurements during March 2010. This data is presented in appendix A. The Nation also provided supplemental static ground water levels measured on April 5, 2010, of 4 meters (13.1 feet) for the North Well and 3.4 meters (11.2 feet) for the Middle Well.

The above data was compiled into geospatial layers used to develop a ground water level contour map shown in figure 3.[15] Due to uncertainty regarding ground surface elevation at the Middle Well, the April 5 water level measurement by the tribe was not used to develop contours. The aquifer sources for reported water levels are not specified and may be from different aquifer systems or from other zones within the same aquifer system. The water level depth measurements also were obtained over a period of several years, thereby, representing

[12] http://water.usgs.gov/GIS/metadata/usgswrd/XML/ofr96-444_recharg.xml.

[13] http://climate.mesonet.org/normals_extremes.html.

[14] February 4, 2010, telephone communication with Noel Osborn of OWRB.

[15] Ground water level contours were developed using the Kriging function within Spatial Analyst of ESRI ArcGIS 9.3.1.

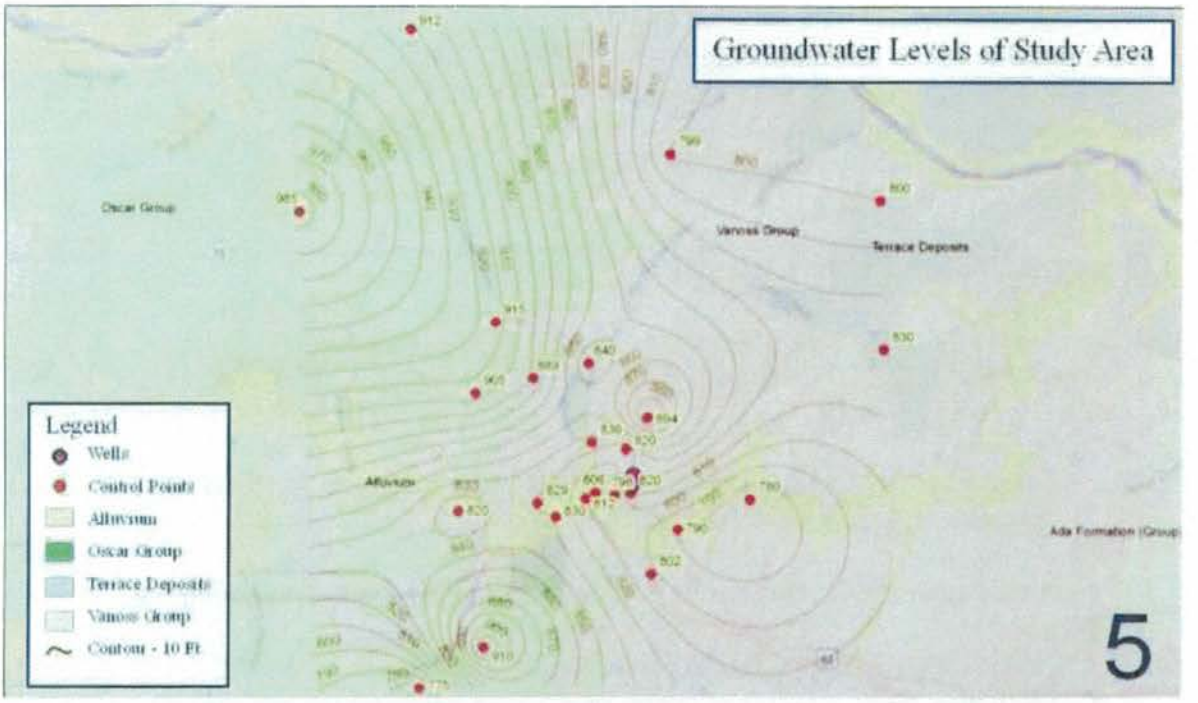

Figure 3. Ground water levels contour map of study area. Labels for control points indicate estimated static ground water level elevation (feet).

potentially different hydrological conditions. Inconsistencies of this type can incur as apparent localized anomalies in water table gradients.

Figure 4 suggests that the general regional gradient of ground water levels is higher in the west and northwest and lower in the east and southeast in the direction of Black Bear Creek and the Arkansas River. This correlates with land surface topographic highs that occur to the northwest of the supply wells. Figure 4 shows contours at a more localized scale with the Supply Wells.

The static ground water level at the Pawnee North Well measured by the Nation in 2010 was at elevation 834 feet, as compared to stream stage in Black Bear Creek that is approximately elevation 800–805 feet. Under constant pumping conditions for the Pawnee wells, the anticipated maximum drawdown from static water levels would be around 26 feet. Even in that case, the water levels at the wells would be expected to be slightly higher than the stream stage in Black Bear Creek, with a resultant ground water flow direction from the wells towards the stream.

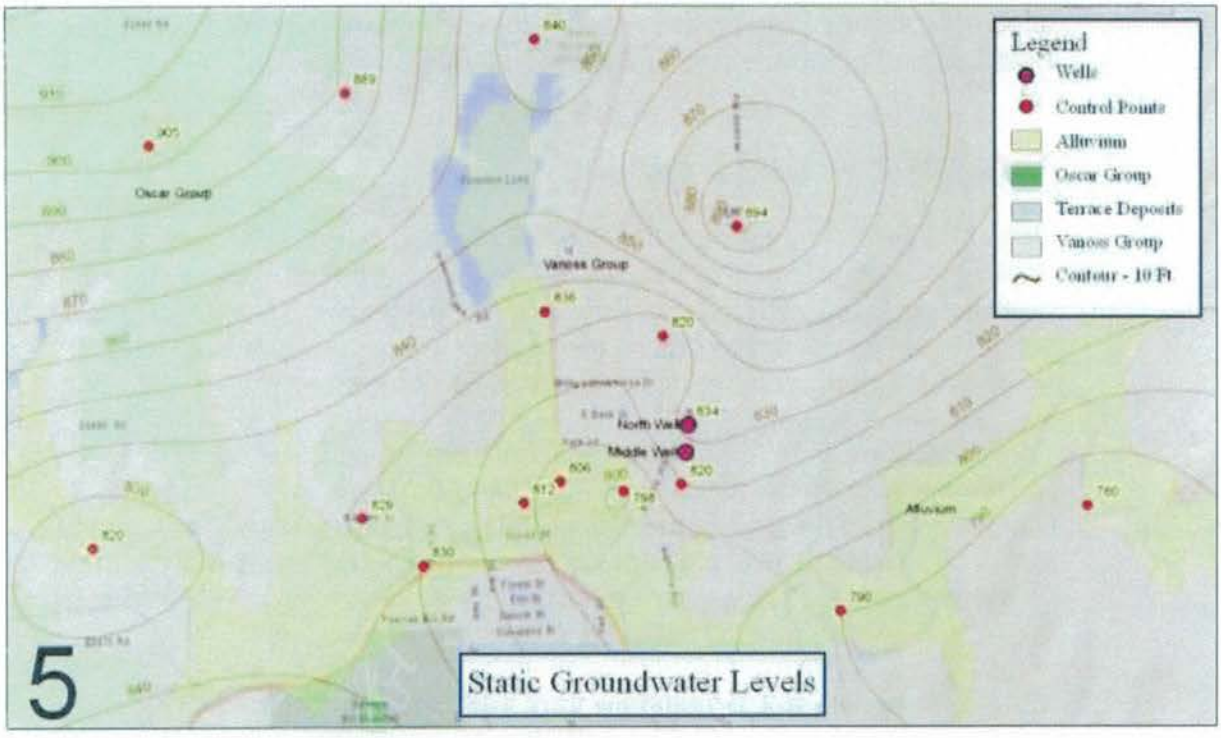

Figure 4. Static ground water level contour map.

Aquifer Extents

Subsurface geologic maps indicate that the local aquifer system for the wells is probably the Pennsylvanian Vanoss Group. With the apparent regional water table gradient dipping towards the south and southeast, sources of recharge would be precipitation over lands to the north and northwest of the wells and other surface water sources overlying the Vanoss Group and the eastern edge of the Oscar Group to the north and northwest of the Pawnee wells.

Aquifer storativity calculated from pumping test results (Reclamation, 1998) indicated that the aquifer in the vicinity of the supply wells is confined. This could be caused by relatively impermeable shale layers above and below the aquifer production zone. The continuity of alternating layers of shale, sandstone, and limestone over horizontal distances is unknown, leaving uncertainty of the hydraulic connection between aquifer layers and connections with surface water bodies.

The lack of information on the local aquifer system makes it difficult to define the extent of the aquifer and the areas of recharge. Based on existing data, it is probable that recharge for the Pawnee wells comes from sources to the north and northwest of the wells. This includes areas where surface streams have down cut through the aquifer layers. Pawnee Lake is another possible recharge source. It is not known what degree of connection exists between the lake bottom and the

underlying aquifer. Based on the water table elevations in the study area, Black Bear Creek is a probable area of discharge for the local aquifer.

Time-of-Transport Modeling

One of the possible ways to define the area of contribution to the supply wells is to use an analytic element model to estimate the extent of probable aquifer area contributing to the wells, based on a specified time period. That is, the model identifies the probable area around the wells where any contaminants introduced to the aquifer flow could reach the wells within a given time period.

For this analysis, the WhAEM2000 analytic element model was used to delineate the 15-year time-of-transport zone for the two supply wells. WhAEM2000 computes a steady-state flow field in a single aquifer. The flow field is used to estimate probable particle path lines in the aquifer to the wells over a specified period of transport. Then, path line end points are used to define the extents of the zone of contribution for the wells.

The following data and assumptions were used to construct the model:

- Aquifer parameters were taken from a Reclamation 1998 well yield analyses, as described in preceding sections.
- The supply wells were assumed to be pumping continuously and simultaneously at a rate of 200 gpm at each well.

WhAEM2000 uses various 'elements' to define the sources and discharge zones for water within a model area. For this analysis, the lack of adequate data required some subjective interpretation of the flow regime in the vicinity of the supply wells. It was assumed that the general source for ground water flow is from the topographic highs to the northwest of the supply wells. It was also assumed that Pawnee Lake and Skedee Creek provide some level of seepage into the ground water system. Black Bear Creek was assumed to act at a discharge zone for ground water flow from the northwest. And finally, the apparent higher water table head located approximately 1 mile to the north-northeast from the North Well was assumed to provide a small degree of control to the flow regime. These various hydraulic features were treated as line sinks in WhAEM2000. They were positioned and assigned heads and connection parameters, which resulted in modeled flow heads that, in a generalized fashion, approximate the ground water level gradients presented in figure 4.

The results from the WhaAEM2000 model are shown in figure 5. The particle path lines trace out the probable area of contribution to the supply wells over a 15-year period. Basically, this figure indicates that ground water flow occurring in Township 22 North-Range 5 East section 29 and the southern half of section 20 is a probable contributor over a 15-year period to the supply wells, along with the

Pawnee Lake area. It is these areas where a wellhead protection plan should focus. It is important to reiterate that the model simulated conditions that are assumed to be controlling the ground water flow supplying the Pawnee wells. With the obvious potential that those assumptions may be in error, it would be appropriate also to incorporate into a wellhead protection plan some of the adjacent areas to the zone defined by the path lines as 'insurance' against unknowns.

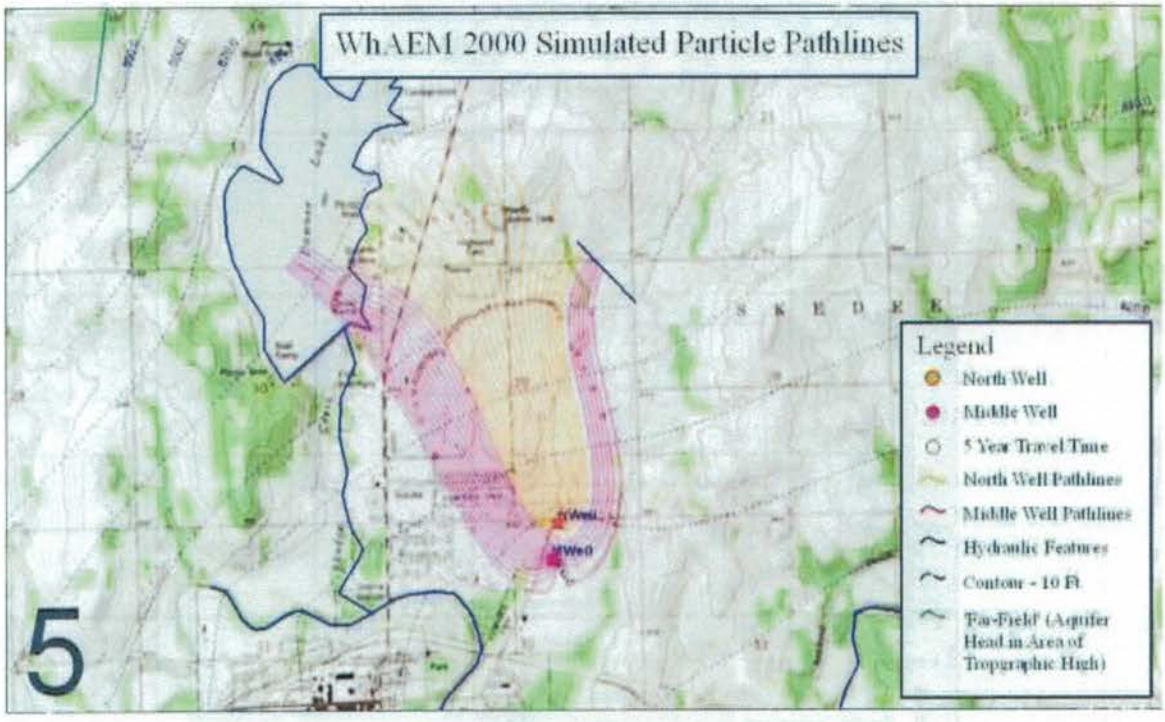

Figure 5. Simulated particle path lines for pumping North and Middle wells. Overall extent of path line represents travel length for 15-year period.

Inventory Potential Sources of Contamination

The WhAEM2000 model simulated path lines for pumping the supply wells to include a 15-year travel time for contaminate transport. This is the zone of transport for the wells. Considering the approximate nature of the information gathered to perform the model, Reclamation extended this zone to identify a larger area that possibly could contribute to the source water of the existing water supply wells to determine an AOC.

The delineation of the AOC is not an exact science, and the accuracy of the areas defined depends upon the level of information available, the natural variability of the hydrologic environment, and many factors. Because of these uncertainties, a conservative approach was employed in tdeveloping the AOC. Reclamation considered the area as shown on figure 6 to be the AOC.

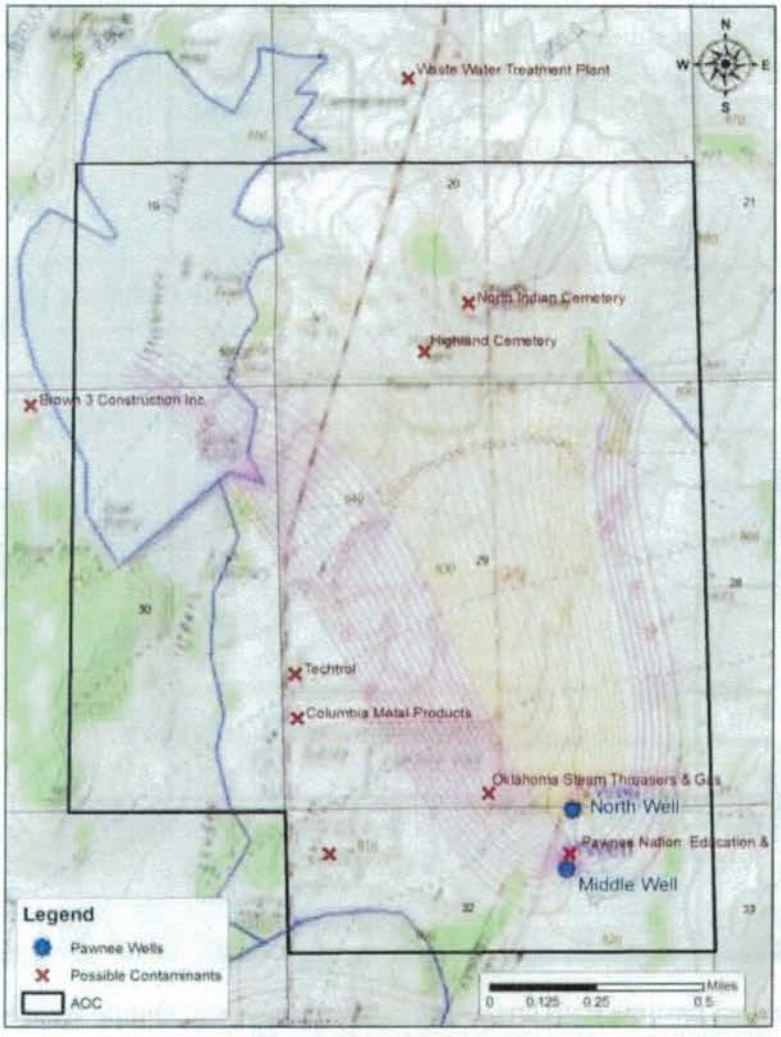

Figure 6. Possible containments and delineation of AOC.

Contaminant Source Survey

Appendix B, "Drinking Water Contaminant Source Index" is attached to identify contaminates when searching for any potential contamination sources. Appendix C shows types of activities that can result in ground water contamination. Many of these types of contamination sources are present in all areas, and other potential contamination sources also exist. Many common household products that are relied on daily have the potential to impact ground water.

The primary land uses within the AOC are low input grazing and agricultural. However, some residential and industrial areas also exist. Even though

agriculture typically poses a low risk of ground water contamination, some risk still exists. In addition, non-permitted trash dumps and abandoned water wells are common in rural areas. These potential contaminant sources are likely to exist in the AOC.

Method of Conducting Inventory

In conducting the contamination source inventory, a number of information sources were used. Reclamation searched the telephone and Internet records for any of the potential sources of contaminants as listed on Appendix B, "EPA's Drinking Water Contaminant Source Index." The Pawnee Nation Environmental Protection Office is encouraged to perform a field survey of the area to further identify any potential contamination sources. Figure 5 and the associated table show the location and the lists on the sites identified.

In addition to the potential contaminant sources identified during the field survey, a number of nonpoint sources are present. These potential nonpoint sources include agricultural land, parks, cemeteries, and golf courses.

Contaminant Source Management

Management tools available to the Nation to protect the AOC consist of regulatory and nonregulatory methods, as referenced below. Updates to the contaminant source inventory should be made by the Nation on regular intervals. The level of risk associated with potential contaminant sources should be taken into consideration along with the acceptable risk and degree of management that the local community is willing to support. Appendix C lists several nonspecific contaminate sources and a corresponding management strategy.

Regulatory management options consist of the following:

- Zoning
- Prohibit various land uses
- Special permitting
- Large lot zoning
- Drainage requirements standards
- Health regulations

Source prohibitions are regulations that prohibit the presence or use of chemicals or hazardous activities within a given area.

Nonregulatory management options consist of primarily public education. Public education of best management practices is encouraged by education aimed at:

- Private citizens with regard to septic systems
- Commercial operations with respect to materials management

Fact sheets, reports, and educational materials are available from a number of sources, as well as Internet sites.

Conclusions and Recommendations

The WhaAEM2000 model developed particle path lines that trace out the probable area of contribution to the supply wells over a 15-year period. The results indicate that ground water flow occurring in Township 22 North-Range 5 East Section 29 and the southern half of section 20 is a probable contributor over a 15-year period to the supply wells, along with the Pawnee Lake area. It is these areas where a wellhead protection plan should focus. It is important to reiterate that the model simulated conditions that are assumed to be controlling the ground water flow are supplying the Pawnee wells.

The lack of information on the local aquifer system makes it difficult to define the extent of the aquifer, flow gradients, and the areas of recharge. The ground water contour maps were generated from water level readings that were measured over several years, potentially various aquifer zones, climatic conditions, and possible interference from adjacent wells. This report acknowledges that there are many data gaps and uncertainties in the existing data, and consequently, in the usefulness of the measurements. The source water model is an attempt to display the areas of contribution with the limited data.

As part of this report, an AOC was identified north and west of the wells. The lack of information on the local aquifer system makes it difficult to define the zone of transport with a high level of confidence. Therefore, the AOC was expanded to a larger area than the identified 15-year source water path lines.

The AOC is primarily rural in nature and poses a low risk of ground water contamination, yet some risk still exists. Nonpermitted trash dumps and abandoned water wells are common in rural areas.

Pawnee Lake and the overflow into Skedee Creek are potential sources of recharge to the wells. Pawnee Lake is a 257-acre lake, with an approximate 2,000-acre drainage basin. Pawnee Lake was constructed in 1932 and is owned and operated by the City of Pawnee. The lake is managed as a municipal water supply and offers numerous recreational opportunities to the public. Pawnee Lake is the primary water supply for the City of Pawnee, and the local community has vested interests in maintaining the quality of this water supply.

Black Bear Creek also is included in the AOC. Any water quality issues in Black Bear Creek may also impact the quality of water in the supply wells. If the source wells are in hydraulic connectivity with Black Bear Creek anywhere within the influence zone of the wells, then Black Bear Creek could potentially impact the supply wells. Water level gradients identified in this study are based on what was assumed to be average conditions. Under above-average runoff events, the potential for contributions from Black Bear Creek to the aquifer will increase.

The Pawnee Nation should continue to gather data from any future wells constructed in the AOC and continue to gather water level measurements that would allow refinement of the underground water flow. The definition of the zone of contribution could be greatly enhanced by collecting water levels in wells completed in the same aquifer zone as the supply wells and obtaining more information on gradients between Black Bear Creek and the wells.

The Nation should monitor abandoned wells, nonpermitted dumping, and other land uses in the AOC.

Appendix A
Water Level Measurement

Oklahoma Water Resources Board (OWRB) Well Identification	Ground Surface Elevation[1] (feet)	Static Water Level Depth[2] (feet)	Static Water Level Elevation (feet)	Assumed Measurement Year
103865	885	40	840	2006
99302	863	43	820	2001
104320	955	40	915	2006
110575	925	15	910	2005
80488	845	15	830	2003
122425	910	135	775	2006
120777	892	90	802	2008
86769	850	20	830	2004
103019	970	65	905	2006
117464	860	60	800	2008
92273	920	121	799	2001
117607	1,000	15	985	2008
104597	932	20	912	2006

[1] Ground surface elevation estimated from topographic map.

[2] Estimated static water level depths derived from OWRB well database.

Supplemental Water Level Measurement s provided by Pawnee Nation (delivered on March 3, 2010)

Water wells in the vicinity of Pawnee Nation's water wells

Sec#	TN	RE	Latitude	Longitude	Elevation (ft)	Use	Static Water Level (m)	Information
32	22	5	36°20'51.1	-96°47'16.8	836	Yes		#1 North well
32	22	5	36°20'44.2	-96°47'17.9	835	Yes		#2 South well
32	22	5	36°20'35.5	-96°47'19.3	831	No	3.5 m (open)	#3 Not in use well
18	22	5	36°22'40.4	-96°48'15.0	885			City of Pawnee Airport
29	22	5	36°21'42.9	-96°46'58.7	900	No	1.75 m (open)	Leading fox EW 4500 NS 3490
30	22	5	36°21'21.7	-96°48'02.5	839	No	~1.0 m (open)	Old pump across from front door salon
24	22	4	36°22'20.0	-96°49'06.7	932	Yes	13.0 m (open)	Doug Tilden
36	22	4	36°20'28.7	-96°49'04.3	838	No	2.8 m (open)	Kansas St at 3470
31	22	5	36°20'31.0	-96°48'11.0	812			Black Bear Creek Low water dam
32	22	5	36°20'34.0	-96°47'38.2	798			Black Bear Creek at fairgrounds

Appendix B
EPA's "Drinking Water Contaminant Source Index"

POTENTIAL SOURCE	CONTAMINANT
Commercial/Industrial	
Above-ground storage tanks	Arsenic, Barium, Benzene, Cadmium, 1,4-Dichlorobenzene or P-Dichlorobenzene, cis 1,2-Dichloroethylene, trans 1,2-Dichloroethylene, Dichloromethane or Methylene Chloride, Lead, Trichloroethylene (TCE), Tetrachloroethylene or Perchlorethylene (Perc)
Automobile, Body Shops/Repair Shops	Arsenic, Barium, Benzene, Cadmium, Chlorobenzene, Copper, cis 1,2-Dichloroethylene, trans 1,2-Dichloroethylene, 1,4-Dichlorobenzene or P-Dichlorobenzene, Lead, Fluoride, 1,1,1-Trichloroethane or Methyl Chloroform, Dichloromethane or Methylene Chloride, Tetrachloroethylene or Perchlorethylene (Perc), Trichloroethylene (TCE), Xylene (Mixed Isomers)
Boat Repair/Refinishing/Marinas	Benzene, Cadmium, cis 1,2-Dichloroethylene, Coliform, Cryptosporidium, Dichloromethane or Methylene Chloride, Giardia Lambia, Lead, Mercury, Nitrate, Nitrite, trans 1,2-Dichloroethylene,◆ Tetrachloroethylene or Perchlorethylene (Perc), Trichloroethylene◆ (TCE), Vinyl Chloride, Viruses◆
Cement/Concrete Plants◆	Barium, Benzene, Dichloromethane or Methylene Chloride, Ethylbenzene, Lead, Styrene, Tetrachloroethylene or Perchlorethylene (Perc), Toluene, Xylene (Mixed Isomers)
Chemical/Petroleum Processing	Acrylamide, Arsenic, Atrazine, Alachlor, Aluminum (Fume or Dust), Barium, Benzene, Cadmium, Carbofuran, Carbon Tetrachloride, Chlorobenzene, Copper, Cyanide, 2,4-D, 1,2-Dibromoethane or Ethylene Dibromide (EDB), 1,2-Dichlorobenzene or O-Dichlorobenzene, 1,4-Dichlorobenzene or P-Dichlorobenzene, 1,1-Dichloroethylene or Vinylidene Chloride, cis 1,2 Dichloroethylene, Dichloromethane or Methylene Chloride, Di(2-ethylhexyl) adipate, Di(2-ethylhexyl) phthlate, 1,2-Dichloroethane or Ethylene Dichloride, Dioxin, Endrin, Epichlorohydrin, Ethylbenzene, Hexachlorobenzene, Hexachlorocyclopentadiene, Lead, Mercury, Methoxychlor,Polychlorinated Biphenyls, Selenium, Styrene, Sulfate, Tetrachloroethylene or Perchlorethylene (Perc), Toluene, 1,2,4-Trichlorobenzene, 1,1,1-Trichloroethane or Methyl Chloroform, Trichloroethylene (TCE), Vinyl Chloride, Xylene (Mixed Isomers), Zinc (Fume or Dust)
Construction/Demolition	Arsenic, Asbestos, Benzene, Cadmium, Chloride, Copper,Cyanide, cis 1,2-Dichloroethylene, trans 1,2-Dichloroethylene, Dichloromethane or Methylene Chloride, Fluorides, Lead, Selenium, Tetrachloroethylene or Perchlorethylene (Perc), 1,1,1-Trichloroethane or Methyl Chloroform, Trichloroethylene (TCE), Turbidity, Xylene (Mixed Isomers), Zinc (Fume or Dust)
Dry Cleaners/Dry Cleaning◆	Tetrachloroethylene or Perchlorethylene (Perc), 1,1,1-Trichloroethane or Methyl Chloroform, 1,1,2-Trichloroethane◆
Dry Goods Manufacturing	Barium, Benzene, Cadmium, Copper, Dichloromethane or Methylene Chloride, Di(2-ethylhexyl) phthlate, Lead, 1,1,1-Trichloroethane or Methyl Chloroform, Polychlorinated Biphenyls, Tetrachloroethylene or Perchlorethylene (Perc), Toluene, Trichloroethylene (TCE), Xylene (Mixed Isomers)

Electrical/Electronic Manufacturing	Aluminum (Fume or Dust), Antimony, Arsenic, Barium, Benzene, Cadmium, Chlorobenzene, Copper, Cyanide, Carbon Tetrachloride, 1,2-Dichlorobenzene or O-Dichlorobenzene, 1,2-Dichloroethane or Ethylene Dichloride, cis 1,2-Dichloroethylene, trans 1,2-Dichloroethylene, Dichloromethane or Methylene Chloride, Di(2-ethylhexyl) phthlate, Ethylbenzene, Lead, Mercury, Polychlorinated Biphenyls, Selenium, Styrene, Sulfate, Tetrachloroethylene or Perchlorethylene (Perc), 1,1,1-Trichloroethane or Methyl Chloroform, 1,1,2-Trichloroethane, Trichloroethylene (TCE), Thallium, Toluene, Vinyl Chloride, Xylene (Mixed Isomers), Zinc (Fume or Dust)
Fleet/Trucking/ Bus Terminals	Arsenic, Acrylamide, Barium, Benzene, Benzo(a)pyrene, Cadmium, Chlorobenzene, Cyanide, Carbon Tetrachloride, 2,4-D, 1,2-Dichlorobenzene or O-Dichlorobenzene, 1,4-Dichlorobenzene or P-Dichlorobenzene, 1,2-Dichloroethane or Ethylene Dichloride, cis 1,2-Dichloroethylene, trans 1,2-Dichloroethylene, Dichloromethane or Methylene Chloride, Di(2-ethylhexyl) phthlate, Epichlorohydrin, Heptachlor (and Epoxide), Lead, Mercury, Methoxychlor, Pentachlorophenol, Propylene Dichloride or 1,2-Dichloropropane, Selenium, Styrene, Toxaphene, Tetrachloroethylene or Perchlorethylene (Perc), Toluene, 1,1,1-Trichloroethane or Methyl Chloroform, Trichloroethylene (TCE), Vinyl Chloride, Xylene (Mixed Isomers)
Food Processing	Arsenic, Benzene, Cadmium, Copper, Carbon Tetrachloride, Dichloromethane or Methylene Chloride, Lead, Mercury, Picloram, Tetrachloroethylene or Perchlorethylene (Perc), Toluene, 1,1,1-Trichloroethane or Methyl Chloroform, Trichloroethylene (TCE), Xylene (Mixed Isomers)
Funeral Services/Taxidermy	Glyphosate, Dichloromethane or Methylene Chloride, Nitrate, Nitrite, Total Coliforms, Viruses
Furniture Repair/Manufacturing	Barium, 1,2-Dichloroethane or Ethylene Dichloride, Dichloromethane or Methylene Chloride, Ethylbenzene, Lead, Mercury, Selenium, Trichloroethylene (TCE)
Gas Stations (see also above ground/underground storage tanks,	cis 1,2-Dichloroethylene, trans 1,2-Dichloroethylene, Dichloromethane or Methylene Chloride, Tetrachloroethylene or Perchlorethylene (Perc), Trichloroethylene (TCE)
Graveyards/Cemetaries	Dalapon, Lindane, Nitrate, Nitrite, Total Coliforms, Viruses.
Hardware/Lumber/Parts Stores	Aluminum (Fume or Dust), Barium, Benzene, Cadmium, Chlorobenzene, Copper, Dichloromethane or Methylene Chloride, Di(2-ethylhexyl)adipate, Di(2-ethylhexyl) phthlate, 1,4-Dichlorobenzene or P-Dichlorobenzene, Ethylbenzene, Lead, Mercury, Tetrachloroethylene or Perchlorethylene (Perc), 1,1,1-Trichloroethane or Methyl Chloroform, Trichloroethylene (TCE), Toluene, Xylene (Mixed Isomers)
Historic Waste Dumps/Landfills	Atrazine, Alachlor, Carbofuran, cis 1,2-Dichloroethylene, trans 1,2-Dichloroethylene, Diquat, Dalapon, Glyphosate, Dichloromethane or Methylene Chloride, Nitrate, Nitrite, Oxamyl (Vydate), Sulfate, Simazine, Tetrachloroethylene or Perchlorethylene (Perc), Trichloroethylene(TCE)
Home Manufacturing◆	Arsenic, Barium, Benzene, Cadmium, Chlorobenzene, Copper, Carbon Tetrachloride, 1,2-Dichlorobenzene or O-Dichlorobenzene, cis 1,2-Dichloroethylene, trans 1,2-Dichloroethylene, Dichloromethane or Methylene Chloride, Di(2-ethylhexyl) phthlate, Ethylbenzene, Lead, Mercury, Selenium, Styrene, Tetrachloroethylene or Perchlorethylene (Perc), 1,1,1-Trichloroethane or Methyl Chloroform, Trichloroethylene (TCE), Toluene, Turbidity, Xylene (Mixed Isomers)◆

Industrial Waste Disposal Wells	Acrylamide, Arsenic, Atrazine, Alachlor, Aluminum (Fume or Dust), Ammonia, Barium, Benzene, Cadmium, Carbofuran, Carbon Tetrachloride, Chlorobenzene, Copper, Cyanide, 2,4-D, 1,2-Dibromoethane or Ethylene Dibromide (EDB), 1,2-Dichlorobenzene or O-Dichlorobenzene, 1,4-Dichlorobenzene or p-Dichlorobenzene, 1,1-Dichloroethylene or Vinylidene Chloride, cis 1,2 Dichloroethylene, Dichloromethane or Methylene Chloride, Di(2-ethylhexyl) adipate, Di(2-ethylhexyl) phthlate, 1,2-Dichloroethane or Ethylene Dichloride, Dioxin, Endrin, Epichlorohydrin, Hexachlorobenzene, Hexachlorocyclopentadiene, Lead, Mercury, Methoxychlor, Oxamyl (Vydate), Polychlorinated Biphenyls, Selenium, Styrene, Sulfate, Tetrachloroethylene or Perchlorethylene (Perc), Toluene, 1,2,4-Trichlorobenzene, 1,1,1-Trichloroethane or Methyl Chloroform, Trichloroethylene (TCE), Vinyl Chloride, Xylene (Mixed Isomers), Zinc (Fume or Dust)
Junk/Scrap/Salvage Yards	Barium, Benzene, Copper, Dalapon, cis 1,2-Dichloroethylene, Diquat, Glyphosate, Lead, Polychlorinated Biphenyls, Sulfate, Simazine, Trichloroethylene (TCE), Tetrachloroethylene or Perchlorethylene (Perc)
Machine Shops	Arsenic, Aluminum (Fume or Dust), Barium, Benzene, Boric Acid, Cadmium, Chlorobenzene, Copper, Cyanide, Carbon Tetrachloride 2,4-D, 1,4-Dichlorobenzene or P-Dichlorobenzene, 1,2-Dichloroethane or Ethylene Dichloride, 1,1-Dichloroethylene or Vinylidene Chloride, cis 1,2-Dichloroethylene, trans 1,2-Dichloroethylene, Dichloromethane or Methylene Chloride, Di(2-ethylhexyl) phthlate, Ethylbenzene, Fluoride, Hexachlorobenzene, Lead, Mercury, Polychlorinated Biphenyls, Pentachlorophenol, Selenium, Styrene, Tetrachloroethylene or Perchlorethylene (Perc), Toluene, 1,1,1-Trichloroethane or Methyl Chloroform, 1,1,2-Trichloroethane, Trichloroethylene (TCE), Xylene (Mixed Isomers), Zinc (Fume or Dust)
Medical/Vet Offices	Arsenic, Acrylamide, Barium, Benzene, Cadmium, Copper, Cyanide, Carbon Tetrachloride, Dichloromethane or Methylene Chloride, 1,2-Dichloroethane or Ethylene Dichloride, Lead, Mercury, Methoxychlor, 1,1,1-Trichloroethane or Methyl Chloroform, Radionuclides, Selenium, Silver, Tetrachloroethylene or Perchlorethylene (Perc), 2,4,5-TP (Silvex), Thallium, Xylene (Mixed Isomers)
Metal Plating/Finishing/Fabricating	Antimony, Aluminum (Fume or Dust), Arsenic, Barium, Benzene, Cadmium, Carbon Tetrachloride, Chlorobenzene, Chromium, Copper, Cyanide, 1,4-Dichlorobenzene or P-Dichlorobenzene, cis 1,2-Dichloroethylene, trans 1,2-Dichloroethylene, Dichloromethane or Methylene Chloride, Di(2-ethylhexyl) adipate, Ethylbenzene,Lead, Mercury, Polychlorinated Biphenyls, Pentachlorophenol, Selenium, Styrene, Sulfate, Tetrachloroethylene or Perchlorethylene (Perc), , Thallium, Toluene, 1,1,1-Trichloroethane or Methyl Chloroform, 1,1,2-Trichloroethane, Trichloroethylene(TCE), Vinyl Chloride, Xylene (Mixed Isomers), Zinc (Fume or Dust)
Military Installations	Arsenic, Barium, Benzene, Cadmium, Chlorobenzene, 1,2-Dichlorobenzene or O-Dichlorobenzene, 1,2-Dichloroethane or Ethylene Dichloride, cis 1,2-Dichloroethylene, trans 1,2-Dichloroethylene, Dichloromethane or Methylene Chloride, Hexachlorobenzene, Lead, Mercury, Methoxychlor, 1,1,1-Trichloroethane or Methyl Chloroform, Radionuclides, Selenium, Tetrachloroethylene or Perchlorethylene (Perc), , Toluene, Trichloroethylene (TCE)
Mines/Gravel Pits	Lead, Selenium, Sulfate, Tetrachloroethylene or Perchlorethylene (Perc), 1,1,1-Trichloroethane or Methyl Chloroform, Turbidity
Motor Pools	cis 1,2-Dichloroethylene, trans 1,2-Dichloroethylene, Dichloromethane or Methylene Chloride

Motor Vehicle Waste Disposal Wells (gas stations, repair shops); see UIC for more on concerns for these sources	Arsenic, Barium, Benzene, Cadmium, Chlorobenzene, Copper, cis 1,2-Dichloroethylene, trans 1,2-Dichloroethylene, 1,4-Dichlorobenzene or P-Dichlorobenzene, Lead, Fluoride, 1,1,1-Trichloroethane or Methyl Chloroform, Dichloromethane or Methylene Chloride, Tetrachloroethylene or Perchlorethylene (Perc), Trichloroethylene (TCE), Xylene (Mixed Isomers)
Office Building/Complex	Barium, Benzene, Cadmium, Copper, 2,4-D, Diazinon, 1,2-Dichlorobenzene or O-Dichlorobenzene, Dichloromethane or Methylene Chloride, Diquat, 1,2-Dichloroethane or Ethylene Dichloride, Ethylbenzene, Glyphosate, Lead, Mercury, Selenium, Simazine, Tetrachloroethylene or Perchlorethylene (Perc), 1,1,1-Trichloroethane or Methyl Chloroform, Trichloroethylene (TCE), Vinyl Chloride, Xylene (Mixed Isomers)
Photo Processing/Printing	Acrylamide, Aluminum (Fume or Dust), Arsenic, Barium, Benzene, Cadmium, Carbon Tetrachloride, Chlorobenzene, Copper, Cyanide, 1,1-Dichloroethylene or Vinylidene Chloride, cis 1,2-Dichloroethylene, trans 1,2-Dichloroethylene, Dichloromethane or Methylene Chloride, Di(2-ethylhexyl) phthlate, 1,2-Dichlorobenzene or O-Dichlorobenzene, 1,4-Dichlorobenzene or P-Dichlorobenzene, 1,2-Dichloroethane or Ethylene Dichloride, 1,2-Dibromoethane or Ethylene Dibromide (EDB), Heptachlor epoxide, Hexachlorobenzene, Lead, Lindane, Mercury, Methoxychlor, Propylene Dichloride or 1,2-Dichloropropane, Selenium, Styrene, Tetrachloroethylene or Perchlorethylene (Perc), 1,1,1-Trichloroethane or Methyl Chloroform, Toluene, 1,1,2-Trichloroethane, Trichloroethylene(TCE), Vinyl Chloride, Xylene (Mixed Isomers), Zinc (Fume or Dust)
Synthetic / Plastics Production	Antimony, Arsenic, Barium, Benzene, Cadmium, Carbon Tetrachloride, Chlorobenzene, Copper, Cyanide, 1,2-Dichlorobenzene or O-Dichlorobenzene, 1,4-Dichlorobenzene or P-Dichlorobenzene, 1,2-Dichloroethane or Ethylene Dichloride, cis 1,2-Dichloroethylene, trans 1,2-Dichloroethylene, Dichloromethane or Methylene Chloride, Di(2-ethylhexyl) adipate, Di(2-ethylhexyl) phthlate, Ethylbenzene, Hexachlorobenzene, Lead, Mercury, Methyl Chloroform or 1,1,1-Trichloroethane, Pentachlorophenol, Selenium, Styrene, Tetrachloroethylene or Perchlorethylene (Perk), Toluene,, Trichloroethylene (TCE), Vinyl Chloride, Xylene (Mixed Isomers), Zinc (Fume or Dust)
RV/Mini Storage	Arsenic, Barium, Cyanide, 2,4-D, Endrin, Lead, Methoxychlor
Railroad Yards/Maintenance/Fueling Areas	Atrazine, Barium, Benzene, Cadmium, Dalapon, 1,4-Dichlorobenzene or P-Dichlorobenzene, cis 1,2-Dichloroethylene, trans 1,2-Dichloroethylene, Dichloromethane or Methylene Chloride, Lead, Mercury, Tetrachloroethylene or Perchlorethylene (Perc), Trichloroethylene (TCE).
Research Laboratories	Arsenic, Barium, Benzene, Beryllium Powder, Cadmium, Carbon Tetrachloride, Chlorobenzene, Cyanide, 1,2-Dichloroethane or Ethylene Dichloride, 1,1-Dichloroethylene or Vinylidene Chloride, cis 1,2-Dichloroethylene, trans 1,2-Dichloroethylene, Dichloromethane or Methylene Chloride, Endrin, Lead, Mercury, Polychlorinated Biphenyls, Selenium, Tetrachloroethylene or Perchlorethylene (Perc), Thallium, Thiosulfates, Toluene, 1,1,1-Trichloroethane or Methyl Chloroform, Trichloroethylene (TCE), Vinyl Chloride, Xylene (Mixed Isomers)
Retail Operations	Arsenic, Barium, Benzene, Cadmium, 2,4-D, 1,2-Dichloroethane or Ethylene Dichloride, Lead, Mercury, Styrene, Tetrachloroethylene or Perchlorethylene (Perc), Toluene, 1,1,1-Trichloroethane, Vinyl Chloride
Underground Storage Tanks	Arsenic, Barium, Benzene, Cadmium, 1,4-Dichlorobenzene or P-Dichlorobenzene, cis 1,2-Dichloroethylene, trans 1,2-Dichloroethylene, Dichloromethane or Methylene Chloride, Lead, Tetrachloroethylene or Perchlorethylene (Perc), Trichloroethylene (TCE).
Wood Preserving/Treating	cis 1,2-Dichloroethylene, trans 1,2-Dichloroethylene, Lead, Sulfate

Wood/Pulp/Paper Processing	Arsenic, Barium, Benzene, Cadmium, Carbon Tetrachloride, Copper, Dichloromethane or Methylene Chloride, Dioxin, 1,2-Dichloroethane or Ethylene Dichloride, Ethylbenzene, Lead, Mercury, Polychlorinated Biphenyls, Selenium, Styrene, Tetrachloroethylene or Perchlorethylene (Perc), Trichloroethylene (TCE), Toluene, 1,1,1-Trichloroethane or Methyl Chloroform, Xylene (Mixed Isomers)
Residential / Municipal	
Airports (Maintenance/Fueling Areas)◆	Arsenic, Barium, Benzene, Cadmium, Carbon Tetrachloride, cis 1,2-Dichloroethylene, Dichloromethane or Methylene Chloride, Ethylbenzene, Lead, Mercury, Selenium, Tetrachloroethylene or Perchlorethylene (Perc), 1,1,1-Trichloroethane or Methyl Chloroform, Trichloroethylene (TCE), Xylene (Mixed Isomers)
Apartments and Condominiums	Atrazine, Alachlor, Coliform, Cryptosporidium, Dalapon, Diquat, Giardia Lambia, Glyphosate, Nitrate, Nitrite, Picloram,Sulfate,Simazine, Vinyl Chloride, Viruses
Camp Grounds/RV Parks	Benomyl, Coliform, Cryptosporidium, Diquat, Dalapon, Giardia Lambia, Glyphosate, Isopropanol, Nitrate, Nitrite, Picloram,Sulfate,Simazine, Turbidity, Vinyl Chloride, Viruses
Cesspools - Large Capacity	Atrazine, Alachlor, Carbofuran, Coliform, Cryptosporidium, Diquat, Dalapon, Giardia Lambia, Glyphosate, Nitrate, Nitrite, Oxamyl (Vydate), Picloram,Sulfate,Simazine, Vinyl Chloride, Viruses
Drinking Water Treatment Facilities	Atrazine, Benzene, Cadmium, Cyanide, Fluoride, Lead, Polychlorinated Biphenyls, Toluene, Total Trihalomethanes, 1,1,1-Trichloroethane or Methyl Chloroform
Gas Pipelines	cis 1,2-Dichloroethylene, trans 1,2-Dichloroethylene, Dichloromethane or Methylene Chloride, Tetrachloroethylene or Perchlorethylene (Perc), Trichloroethylene or TCE
Golf Courses and Urban Parks	Arsenic, Atrazine, Benzene, Chlorobenzene, Carbofuran, 2,4-D, Diquat, Dalapon, Glyphosate, Lead, Methoxychlor, Nitrate, Nitrite, Picloram, Simazine, Turbidity
Housing Developments	Atrazine, Alachlor, Coliform, Cryptosporidium, Carbofuran, Diquat, Dalapon, Giardia Lambia, Glyphosate, Dichloromethane or Methylene Chloride, Nitrate, Nitrite, Picloram, Simazine, Trichloroethylene (TCE), Turbidity, Vinyl Chloride, Viruses
Landfills/Dumps	Arsenic, Atrazine, Alachlor, Barium, Benzene, Cadmium, Carbofuran, cis 1,2 Dichloroethylene, Diquat, Glyphosate, Lead, Lindane, Mercury, 1,1,1-Trichloroethane or Methyl Chloroform, Dichloromethane or Methylene Chloride, Nitrate, Nitrite, Picloram, Selenium, Simazine, Trichloroethylene (TCE)
Public Buildings (e.g., schools, town halls, fire stations, police stations) and Civic Organizations	Arsenic, Acrylamide, Barium, Benzene, Beryllium Powder, Cadmium, Carbon Tetrachloride, Chlorobenzene, Cyanide, 2,4-D, 1,2-Dichlorobenzene or O-Dichlorobenzene, 1,4-Dichlorobenzene or P-Dichlorobenzene, Dichloromethane or Methylene Chloride, Di(2-ethylhexyl) phthlate, 1,2-Dichloroethane or Ethylene Dichloride, Endothall, Endrin, 1,2-Dibromoethane or Ethylene Dibromide (EDB), Lead, Lindane, Mercury, Methoxychlor, Selenium, Toluene, 1,1,1-Trichloroethane or Methyl Chloroform, Trichloroethylene (TCE), Vinyl Chloride, Xylene (Mixed Isomers)
Septic Systems	Atrazine, Alachlor, Carbofuran, Coliform, Cryptosporidium, Diquat, Dalapon, Giardia Lambia, Glyphosate, Nitrate, Nitrite, Oxamyl (Vydate), Picloram, Sulfate, Simazine, Vinyl Chloride, Viruses
Sewer Lines	Coliform, Cryptosporidium, Diquat, Dalapon, Giardia Lambia, Glyphosate, Nitrate, Nitrite, Oxamyl (Vydate), Picloram,Sulfate,Simazine, Vinyl Chloride, Viruses
Stormwater Infiltration Basins/Injection Into Wells (UIC Class V), Runoff Zones	Atrazine, Alachlor, Coliform, Cryptosporidium, Carbofuran, Chlorine, Diquat, Dalapon, Giardia Lambia, Glyphosate, Dichloromethane or Methylene Chloride, Nitrate, Nitrite, Nitrosamine, Oxamyl (Vydate), Phosphates, Picloram, Simazine, Trichloroethylene(TCE), Turbidity, Vinyl Chloride, Viruses

Transportation Corridors (e.g., Roads, Railroads)	Dalapon, Picloram, Simazine, Sodium, Sodium Chloride, Turbidity
Utility Stations	Arsenic, Barium, Benzene, Cadmium, Chlorobenzene, Cyanide, 2,4-D, 1,4-Dichlorobenzene or P-Dichlorobenzene, 1,2-Dichloroethane or Ethylene Dichloride, cis 1,2-Dichloroethylene, trans 1,2-Dichloroethylene, Dichloromethane or Methylene Chloride, Lead, Mercury, Picloram, Toluene, 1,1,2,2- Tetrachloroethane, Tetrachloroethylene or Perchlorethylene (Perc), Trichloroethylene (TCE), Xylene (Mixed Isomers)
Waste Transfer /Recycling	Coliform, Cryptosporidium, Giardia Lambia, Nitrate, Nitrite, Vinyl Chloride, Viruses
Wastewater Treatment Facilities/Discharge Locations (including land disposal and underground injection of sludge)	Cadmium, Coliform, Cryptosporidium, cis 1,2-Dichloroethylene, trans 1,2-Dichloroethylene, Dichloromethane or Methylene Chloride, Fluoride, Giardia Lambia, Lead, Mercury, Nitrate, Nitrite, Tetrachloroethylene or Perchlorethylene (Perc) Selenium, sulfate,Trichloroethylene (TCE), Vinyl Chloride, Viruses
Agricultural / Rural	
Auction Lots/Boarding Stables	Coliform, Cryptosporidium, Giardia Lambia, Nitrate, Nitrite,Sulfate,Viruses
Animal Feeding Operations/ Confined Animal Feeding Operations	Coliform, Cryptosporidium, Giardia Lambia, Nitrate, Nitrite, Sulfate, Turbidity, Viruses
Bird Rookeries/Wildlife Feeding/ Migration Zones	Coliform, Cryptosporidium, Giardia Lambia, Nitrate , Nitrite , Sulfate, Turbidity, Viruses
Crops - Irrigated + Nonirrigated	Benzene, 2,4-D, Dalapon, Dinoseb, Diquat, Glyphosate, Lindane, Lead, Nitrate, Nitrite , Picloram, Simazine, Turbidity
Dairy Operations	Coliform, Cryptosporidium, Giardia Lambia, Nitrate , Nitrite,Sulfate,Turbidity, Viruses
Drainage Wells, Lagoons and Liquid Waste Disposal - Agricultural	Atrazine, Alachlor, Coliform, Cryptosporidium, Carbofuran, Diquat, Dalapon, Giardia Lambia, Glyphosate, Nitrate, Nitrite, Oxamyl (Vydate), Picloram,Sulfate,Simazine, Vinyl Chloride, Viruses
Managed Forests/Grass Lands	Atrazine, Diquat, Glyphosate, Picloram, Simazine, Turbidity
Pesticide/Fertilizer Storage Facilities	Atrazine, Alachlor, Carbofuran, Chlordane, 2,4-D, Diquat, Dalapon, 1,2-Dibromo-3-Chloropropane or DBCP, Glyphosate, Nitrate, Nitrite, Oxamyl (Vydate), Picloram, Simazine, 2,4,5-TP (Silvex)
Rangeland/Grazing Lands	Coliform, Cryptosporidium, Giardia Lambia, Nitrate, Nitrite, Sulfate, Turbidity, Viruses
Residential Wastewater Lagoons	Atrazine, Alachlor, Carbofuran, Coliform, Cryptosporidium, Diquat, Dalapon, Giardia Lambia, Glyphosate, Nitrate, Nitrite, Oxamyl (Vydate), Picloram,Sulfate,Simazine, Vinyl Chloride, Viruses
Rural Homesteads	Atrazine, Alachlor, Carbofuran, Coliform, Cryptosporidium, cis 1,2-Dichloroethylene, trans 1,2-Dichloroethylene, Diquat, Dalapon, Giardia Lambia, Glyphosate, Nitrate, Nitrite,Oxamyl (Vydate), Picloram, Sulfate, Simazine, Vinyl Chloride, Viruses
MISCELLANEOUS SOURCES	
Abandoned Drinking Water Wells (conduits for contamination)	Atrazine, Alachlor, Coliform, Cryptosporidium, Carbofuran, Diquat, Dalapon, Giardia Lambia, Glyphosate, Dichloromethane or Methylene Chloride, Nitrate, Nitrite, Oxamyl (Vydate), Picloram, Simazine, Trichloroethylene (TCE), Turbidity, Vinyl Chloride, Viruses
Naturally Occurring	Arsenic, Asbestos, Barium, Cadmium, Chromium, Coliform, Copper, Cryptosporidium, Fluoride, Giardia Lambia, Iron, Lead, Manganese, Mercury, Nitrate, Nitrite, Radionuclides, Selenium, Silver, Sulfate, Viruses, Zinc (Fume or Dust)

Appendix C
Contaminant Source Management Strategies

Contaminant Sources	Suggested Management Approach	Applicability to WHPP
Service Stations (auto repair shops, car wash, gas stations, etc.) Class V Disposal Wells	The disposal of hazardous materials through wells is illegal and can cause serious threats to ground water. Permits must be obtained from Oklahoma Department of Environmental Quality (ODEQ) to dispose of nonhazardous liquids through these wells.	No permits issued or injection wells used within Pawnee Nation wellhead protection area (WHPA).
Auto Salvage Yards	Automotive fluids should be properly collected, contained and disposed of according to local regulations. Monitor activities near WHPA to detect for violations. Encourage recycling.	This approach is appropriate. The contaminant source inventory should be updated for the WHPAs every 5 years.
Abandoned Water Wells	Poorly constructed wells and improperly abandoned wells can act as a 'direct route' for ground water contamination. State regulations require proper plugging of water wells. Technical assistance is available from Oklahoma Water Resources Board (OWRB).	There are several water wells in the WHPA, and an unknown number may be abandoned. An ongoing effort to identify and prioritize abandoned wells is appropriate.
Illegal Dumping	Monitor WHPAs to detect illegal dumping.	An ongoing effort in this area is needed. Educate residents with the problems associated with illegal dumping.
Accidental Spills	Monitor WHPAs for accidental spills. Prepare an emergency response/contingency plan ready if an accidental event threatens your water supply.	Emergency response plans should be in place.
Underground Storage Tanks (USTs)/Home Heating Oil Tanks	All UST's should be monitored and tested according to the requirements of U.S. Environmental Protection Agency. Leaking tanks should be removed as soon as possible and corrective actions should be taken for site remediation.	The Pawnee Nation should consider working with the Oklahoma Corporation Commission (OCC) on issues within the WHPA. Encourage citizens to report any evidence of released fuel to OCC at 405-521-4683.
Aboveground Storage Tanks	All aboveground storage tanks should be monitored.	This approach is appropriate and should be implemented if funding can be obtained.
Septic Systems	Proper design, construction and maintenance of septic systems are vital for your water quality. It is important not to dispose of common household hazardous materials into your septic system. Educate the citizens in your community.	Educational materials are at available ODEQ.
Chemical Storage Facilities	Avoid storage or use of chemicals/hazardous activities within WHPAs. Storage and transportation of chemicals/hazardous materials should comply with all applicable laws.	This approach is appropriate and should be implemented if funding can be obtained.

Appendix B

Pawnee Nation Law and Order Code

Title XII Natural Resource Protection Act

CHAPTER EIGHT – Groundwater Resource Protection

Section 801. Purpose and Intent

(a) The Council finds that a safe public groundwater supply is one of the most valuable natural resources in this Nation.

(b) The Council recognizes and declares that the management, protection and conservation of groundwater supplies and the beneficial uses thereof are essential to the economic prosperity and future well-being of the Nation. As such, the public interest demands procedures for the development and implementation of management practices to conserve and protect public groundwater supplies.

(c) The Council recognizes that many residents rely on groundwater for their safe drinking water supply, and that certain land uses, including drilling, construction and alteration of wells within Pawnee Indian Country can contaminate groundwater particularly in shallow/surficial aquifers.

(d) The purpose of this section is to protect public health and safety by minimizing contamination to shallow/surficial aquifers and preserving and protecting existing and potential sources of drinking water supplies. It is the intent to accomplish this through application of zoning, construction standards, both public education and public cooperation, as well as by creating appropriate regulations that may be imposed in addition to those currently imposed by law.

Section 802. Definitions

For the purposes of this section, the following terms are defined below:

(a) AQUIFER. A geological formation, group of formations or part of a formation composed of rock, sand or gravel capable of storing and yielding groundwater to wells and springs.

(b) CONTAMINATION. An impairment of water quality by chemicals, radionuclides, biologic organisms, or other extraneous matter whether or not it affects the potential or intended beneficial use of water.

(c) DEVELOPMENT. The carrying out of any construction, reconstruction, alteration of surface at or below the soil profile, or structure or change of land use or intensity of use.

(d) FACILITY. Something that is built, installed, or established for a particular purpose.

(e) GREY WATER: All domestic wastewater except toilet discharge water or otherwise containing dangerous levels of pollutant.

(f) GROUNDWATER PROTECTION OVERLAY DISTRICT: The zoning district defined to overlay other zoning districts in the Pawnee Nation. This district may include specifically designated recharge areas that collect precipitation or surface water and carry it to aquifers.

(g) HAZARDOUS MATERIAL. A material which is defined in one or more of the following categories:

(1) Ignitable: A gas, liquid or solid which may cause fires through friction, absorption of moisture, or which has low flash points. Examples: white phosphorous and gasoline.

(2) Carcinogenic: A gas, liquid, or solid which is normally considered to be cancer causing or mutagenic. Examples: PCB's in some waste oils.

(3) Explosive: A reactive gas, liquid or solid which will vigorously and energetically react uncontrollably if exposed to heat, shock, pressure or combinations thereof. Examples: dynamite, organic peroxides and ammonium nitrate.

(4) Highly Toxic: A gas, liquid, or solid so dangerous to man as to afford an unusual hazard to life. Example: chlorine gas.

(5) Moderately Toxic: A gas, liquid or solid which through repeated exposure or in a single large dose can be hazardous to man.

(6) Corrosive: Any material, whether acid or alkaline, which will cause severe damage to human tissue, or in case of leakage might damage or destroy other containers of hazardous materials and cause the release of their contents. Examples: battery acid and phosphoric acid.

(h) PRIMARY CONTAINMENT FACILITY: A tank, pit, container, pipe or vessel of first containment of a liquid or chemical.

(i) RELEASE: Any unplanned or improper discharge, leak, or spill of a potential contaminant including a hazardous material.

(j) SECONDARY CONTAINMENT FACILITY: A second tank, catchment pit, pipe, or vessel that limits and contains liquid or chemical leaking or leaching from a primary containment area; monitoring and recovery are required,

(k) SHALLOW/SURFICIAL AQUIFER: An aquifer in which the permeable medial (sand and gravel) starts at the land surface or immediately below the soil profile.

(l) SPILL RESPONSE PLANS: Detailed plans for control, re-containment, recovery, and cleanup of hazardous material releases, such as during fires or equipment failures.

(m) STORMWATER TREATMENT PRACTICES (STPs): Measures, either structural or nonstructural, that are determined to be the most effective, practical means of preventing or reducing point source or nonpoint source pollution inputs to storm water runoff and water bodies.

(n) TIME-OF-TRAVEL DISTANCE: The distance that groundwater will travel in a specified time. This distance is generally a function of the permeability and slope of the aquifer.

Section 803. Zones

(b.) ZONE 1 - DRINKING WATER CRITICAL IMPACT ZONE.

(1) Zone 1 is defined as the area within the 6-month time-of-travel distance mapped around all the public water supply well(s). This zone shall be presumed to be the area within 1000 feet of a public water supply well.

(2) Encouraged Uses. The following uses are encouraged within Zone 1 provided they meet the appropriate performance standards outlined in (b)(4) below and are designed so as to prevent any groundwater contamination.

(i) Parks, greenways, or publicly-owned recreational areas such as foot, bicycle or horse paths, and bridges.

(ii) Necessary public utilities/facilities including the construction, maintenance, repair, and enlargement of drinking water supply related facilities such as, but not limited to, wells, pipelines, aqueducts, and tunnels..

(iii) Conservation efforts for soil, water, plants, and wildlife;

(3) Special Exceptions. The uses identified in (a)(5) are permitted only under the terms of a special exception and must conform to provisions of the underlying zoning district and meet the performance standards outlined in (b)(4) below.

(4) Expansion of existing nonconforming uses to the extent allowed by the underlying district: The applicant should consult the local zoning plan to confirm nonconforming uses. The Agency reserves the right to review all applications and shall not grant approval unless it finds such expansion does not pose greater potential contamination of groundwater than the existing use.

(5) Prohibited Uses. The following uses, unless granted a special exception, are prohibited within Zone 1, the 6- month time-of-travel zone.

(i) Automobile body/repair shop;
(ii) Gas station;
(iii) Fleet/trucking/bus terminal;
(iv) Dry cleaner;
(v) Electrical/electronic manufacturing facility;
(vi) Machine shop;
(vii) Metal plating/finishing/fabricating facility;
(viii) Chemical processing/storage facility;
(ix) Wood preserving/treating facility;
(x) Junk/scrap/salvage yard;
(xi) Mines/gravel pit
(xii) Irrigated nursery/greenhouse stock
(xiii) Confined animal feeding operations
(xiv) Land divisions resulting in high density (>1 unit/acre) septic systems;
(xv) Equipment maintenance/fueling areas;
(xvi) Injection wells/dry wells/sumps, except for single-family residences directing gutter downspouts to a drywell;
(xvii) Underground storage tanks, (except those with spill, overfill, and corrosion protection requirements in place);
(xviii) All other facilities involving the collection, handling, manufacture, use, storage, transfer or disposal of any solid or liquid material or waste having potentially harmful impact on groundwater quality;
(xix) All uses not permitted in the underlying zone district

(c.) ZONE 2 - DRINKING WATER POTENTIAL IMPACT ZONE.

(1) Zone 2 is established as the remainder of the Pawnee Nation Jurisdiction not included in Zone 1, but deemed necessary to ensure adequate protection of public drinking water supplies.

(2) Permitted Uses: All uses permitted in the underlying zoning districts provided that they can meet the Performance Standards as outlined for the Groundwater Protection Overlay District.

(3) Special Exceptions: All special exceptions may be approved by the Director provided they can meet performance standards outlined for the Groundwater Protection Overlay District.

(4) Performance Standards: The following standards shall apply to uses in Zones 1 and 2:

(i) Any facility involving the collection, handling, manufacture, use, storage, transfer or disposal of any solid or liquid material or wastes, unless granted a special exception either through permit or another ordinance, must have a secondary containment system which is easily inspected and whose purpose is to intercept any leak or release from the primary containment vessel or structure. Underground tanks or

buried pipes carrying such materials must have double walls and sumps capable of inspection.

(ii) Open liquid waste ponds containing materials referred to in item (i) above will not be permitted without a secondary containment system.

(iii) Storage of petroleum products in quantities exceeding 500 gallons at one locality in one tank or series of tanks must be in elevated tanks; such tanks must have a secondary containment system noted in item (i) above where it is deemed necessary by the Agency.

(iv) All permitted facilities must adhere to appropriate federal and state standards for storage, handling and disposal of any hazardous waste materials.

(v) An acceptable contingency plan for all permitted facilities must be prepared for preventing hazardous materials from contaminating the shallow/surficial aquifer should floods, fire, or other natural catastrophes, equipment failure, or releases occur:

(I) For flood control, all underground facilities shall include but not be limited to a monitoring system and secondary standpipe above the 100 year flood control level, for monitoring and recovery. For above ground facilities, an impervious dike, above the 100 year flood level and capable of containing 100 percent of the largest volume of storage, will be provided with an overflow recovery catchment area (sump).

(II) For fire control, plans shall include but not be limited to a safe firefighting procedure, a fire retarding system, effective containment of any liquid runoff, and provide for dealing safely with any other health and technical hazards that may be encountered by disaster control personnel in combating fire. Hazards to be considered are pipes, liquids, chemicals, or open flames in the immediate vicinity.

(III) For equipment failures, plans shall include but not be limited to:

a. Below ground level, removal and replacement of leaking parts, a leak detection system with monitoring, and an overfill protection system.

b. Above ground level, liquid and leaching monitoring of primary containment systems, the replacement or repair and cleanup or repair of the impervious surface.

(IV) For any other release occurring, the owner or operator shall report all incidents involving liquid or chemical material to the Director.

(vi) Since it is known that improperly abandoned wells can become a direct conduit for contamination of groundwater by surface water, all abandoned wells should be properly plugged according to Section 806.

Section 804. Liability

Nothing in this ordinance shall be construed to imply that the Pawnee Nation has accepted any of an owner/developer's liability if a permitted facility or use contaminates groundwater in any aquifer.

Section 805. Water Well Construction Standards

For the purpose of this part, water wells and geothermal wells shall both be referred to as "water well" and shall be zoned, permitted, constructed, maintained, and regulated under the same standards unless approved otherwise by the Director.

(a) No water well shall be constructed, maintained, or abandoned in such a manner as to constitute a health threat or health hazard, or threat to public safety.

(b) No water well shall be used as a disposal pit for sewage, industrial waste, or other materials that could contaminate the ground water.

(c) All water used in the construction, alteration, repair or abandonment of water wells shall be potable.

(d) Organic materials which foster or promote undesired organic growth or have the potential to degrade water quality shall not be employed in the construction of water wells. This includes, but is not limited to, brans, hulls, grains, starches and proteins.

(e) A water well shall not be constructed in a manner that allows commingling or leakage of ground water by gravity flow or artesian pressure from one aquifer to another. Wells drawing water from perched zones must be constructed to prevent the waste of this type of ground water.

(f) All wells shall be covered to protect public health and safety, when unattended during construction.

(g) No person shall construct a water well within –

(1) 50 feet of any septic tank,

(2) 100 feet of a septic drain line or sewage disposal structure or facility;

(3) 50 feet of a closed sewage or storm drainage system, unless the drainage system is underneath a building;

(4) 100 feet of any sewage sludge disposal area;

(5) 50 feet of any animal waste holding area, such as a pond or lagoon; or

(6) 500 feet of a hazardous waste storage, disposal or treatment unit.

(h) Water wells drilled into unconsolidated, water-bearing strata overlain by unconsolidated water-bearing strata such as sand, silt or gravel, shall have a watertight imperforated well casing extending to a minimum of eighteen (18) feet below land surface. An upper oversized drill hole, four inches greater in diameter than the nominal diameter of the casing, shall be constructed to a minimum of eighteen (18) feet in length. To prevent caving, a temporary surface casing, at least eighteen (18) feet in length, shall be used throughout the construction of the annular seal space.

(i) Water wells drilled into unconsolidated, water-bearing strata overlain by unconsolidated deposits of clay, or sand and gravel in which significant interbeds of clay are present, shall have a watertight, nonperforated, permanent well casing extending at least five (5) feet into clay or other impermeable stratum overlying the water-bearing zone. An upper oversized drill hole, at least four (4) inches greater in diameter than the nominal diameter of the permanent well casing shall be constructed to the same depth. In the event that the subsurface materials tend to cave, an outer, temporary surface casing shall be used to remove caving materials. If the clay or other impermeable stratum is thirteen (13) feet or less below the land surface, the watertight, nonperforated well casing and the upper, oversize drill hole shall extend to a minimum depth of eighteen (18) feet below surface. If necessary, the single, permanent well casing may be extended below the required sealing depth prior to sealing the well with grout. A smaller diameter casing, liner or well screen may be installed. The annular space between the permanent well casing and the upper, oversized drill hole shall be completely full of grout after the permanent well

casing is set into final position. The temporary surface casing shall be removed from the well as the annular space is filled.

(j) Water wells drilled into a water-bearing rock formation overlain by clay, silt, sand, gravel or similar materials shall be constructed in accordance with one of the following methods:

(1) *Continuous Seal* An upper drill hole, four (4) inches greater in diameter than the nominal diameter of the permanent well, casing to be installed, shall extend from land surface to at least five (5) feet into solid, creviced, consolidated rock overlying the water-bearing rock formation below a depth of thirteen (13) feet. Unperforated, permanent well casing shall extend to this same depth. The annular space between the casing and the drill hole wall within the rock formation shall be filled with grout. The upper annular space between the casing and drill hole wall shall be filled from land surface to at least five (5) feet into an impermeable clay stratum below a depth of thirteen (13) feet. The annular space between the upper and lower sealing intervals shall be filled with an impermeable sealing material. If necessary, a smaller diameter well casing, liner pipe or well screen many be installed. If cement grout is placed from the bottom of the well casing to the land surface, the upper drill hole shall be at least two (2) inches larger than the nominal diameter of the casing.

(2) *Step-down Casing* An upper drill hole, four (4) inches greater in diameter that the permanent well casing to be installed, shall extend to from land surface to at least five (5) feet into an impermeable clay stratum below a depth of thirteen (13) feet. Unperforated, permanent well casing shall extend to, and be driven into, solid, uncreviced, consolidated rock overlying the water-bearing rock formation. A lower drill hole, equal in diameter to the inside diameter of the upper, permanent well casing, shall be constructed at least five (5) feet into solid , uncreviced, consolidated rock overlying the water-bearing rock formation. A smaller diameter casing, at least two (2) inches smaller in diameter than the diameter of the upper permanent well casing, shall extend at least five (5) feet into the lower drill hole and at least eight (8) feet into the upper permanent well casing. The annular space between the upper oversize drill hole and the permanent well casing, and the annular space between the smaller diameter lower casing and the lower drill hole, shall be completely filled with grout, after the permanent well casing and the lower casing are set into final position.

(3) *Under-Reaming* An upper drill hole, four (4) inches greater in diameter that the permanent well casing to be installed, shall extend to from land surface to at least five (5) feet into an impermeable clay stratum below a depth of thirteen (13) feet. A lower drill hole, at least two (2) inches greater in diameter than the diameter of the permanent well casing, shall be constructed at least five (5) feet into solid, uncreviced, consolidated rock by under-reaming methods. Unperforated, permanent well casing shall extend to, and be driven into, solid , uncreviced, consolidated rock at the bottom of the under-reamed section following placement of the sealing material. The annular space between the lower under-reamed drill hole and the upper permanent well casing shall be filled with cement grout. The annular space between the lower under-reamed drill hole wall and the permanent well casing shall be completely filled with grout applied under pressure.

In all cases under any method utilized pursuant to this subsection, if materials penetrated by the upper oversized drill hole cave, an outer temporary surface casing shall be used to remove caving material. The temporary surface casing shall be withdrawn as the annular space is filled with grout.

(k) Water supply wells penetrating into an artesian aquifer shall have an upper oversize drill hole, four (4) inches greater in diameter than the nominal diameter of the permanent well casing. Watertight unperforated casing shall extend and be sealed at least five feet into the confining formation immediately overlying the artesian water-bearing zone. In all cases a minimum of eighteen (18) feet of casing and casing seal shall be required.

(l) There shall be no openings in the casing of a water well, between the top of the casing and the bottom of the required casing seal, except for pitless adaptors, measuring access ports, or grout installed. In no case shall holes be cut in the casing for the purpose of lifting or lowering casing into the well bore, unless such holes are properly welded closed and watertight prior to placement into the bore.

(m) Plastic casing used for a water well shall not be driven, and may only be installed in an oversized drill hole. Plastic casing may be installed only after drilling has been completed. Plastic casing shall be of polymerized vinyl chloride (PVC) type 1120 or 1220, SDR 21 (Class 200) or SDR 26 (Class 160) or greater wall thickness, and meet all applicable industry standards of the National Sanitation Foundation. The well casing must be clearly marked by the manufacturer, showing:

(1) size;
(2) type of plastic material;
(3) Standard Dimension Ratio;
(4) American Society for Testing Materials (ASTM) designation; and
(5) Seal of Approval by the National Sanitation Foundation.

(n) Steel casing used for a water well shall be in new or like condition, being free of pits or breaks, and shall meet or exceed the minimum ASTM specifications for the applicable size.

(o) In no event shall drill cuttings or chips be allowed to fill or partially fill, or fall into the required sealing interval of a water well during construction or completion of the well.

(p) When using cement grout as the sealing material in a water well, it must be of high early strength type of cement or high alumina cement, uniformly mixed in appropriate proportions.

(q) Concrete for use in the construction of a dug well, or for filling the annular space or well bore of a well, shall consist of clean, hard and durable aggregate, and not less than five sacks of cement per cubic yard of concrete. Concrete may be used only when the oversize drill hole is at least eight (8) inches larger in diameter than the well casing. The maximum diameter of aggregate particles shall not exceed one and one-half inches, and in any event shall not exceed one fifth (1/5) or twenty (20) percent of the width of the space to be filled. The ratio of course aggregate to fine aggregate is shall be approximately one and one half to one (1.5 /1), but in no event shall it be less than one to two (1/2).

(r) Unhydrated bentonite used in construction of casing seals for water wells shall be specifically designed for sealing wells and be within industry tolerances for dry western sodium bentonite. Bentonite shall be free of polymers that promote bacteria growth. The placement of bentonite shall conform to the manufacturer's specifications and result in a

seal that is free of voids or bridges. Powdered bentonite and bentonite grout or slurry shall not be used as an annular seal material.

Section 806. Well Testing

Upon completion, every well shall be tested for yield and drawdown either by bailing, pumping or air testing for a period of not less than one hour. The testing method used must provide for drawdown measurements. The results of all tests shall be provided to the Director.

Section 807. Disinfection Requirements

Prior to or after being placed in the well, pumping equipment, sand, gravel and well casing shall be thoroughly hosed or sluiced with water and shall be disinfected with a solution containing at least fifty (50) parts per million chlorine. All water introduced into a well during construction shall be clean and potable. Upon completion, the well and its equipment, including the interior of the well casing, shall be thoroughly swabbed and cleaned to remove all oil, grease and other foreign substances. The well and its equipment shall be disinfected by thoroughly agitating and mixing in the well a solution containing enough chlorine to leave a residual twenty-five (25) parts per million throughout the well for a period of 24 hours.

Section 808. Water Well Maintenance; Prevention of Ground Water Contamination

(a) The landowner of the property on which the water well is located is ultimately responsible for the maintenance and proper usage of the well, excepting for such wells that are subject to a maintenance agreement with other persons or entity.

(b) All water wells shall be maintained in such a condition that
   (1) they are not a health threat or health hazard,
   (2) they are not a source of contamination of the ground water; and
   (3) they are not a source of waste.

(c) If the DECS determines that a water well violates this Section, in addition to any other authority it possesses under this Law, the DECS may order discontinuance of, or impose conditions upon, the use of such well.

Section 809. Abandonment; Decommissioning of Well

(a) Any water well abandoned for a period of ninety (90) days or less, shall be capped with a watertight seal, welded steel cap or threaded cap. A water well abandoned for a period of more than ninety (90) days shall be decommissioned and shall comply with the requirements of subsection (b) of this section.

(b) A water well that is decommissioned shall be completely filled in such a manner that vertical movement of water within the well bore, including the annular space surrounding the well casing, is effectively and permanently prevented. The decommissioning of a well must be conducted by a contractor holding a water well operator's license. The well contractor shall report the decommissioning of a water well to the DECS.

Section 810. Water Well Contractor's License

(a) No person shall construct, alter or decommission a well without a license issued by the Commission, obtained pursuant to this section.

(b) A person shall be qualified to receive a water well operator's license if the person:

(1) Has submitted a completed application to the on forms provided by the Pawnee Nation and has paid to the commission the application fee determined by rule adopted pursuant to this section; and

(2) Has the field experience and educational training needed to properly construct, alter and decommission wells, as determined by the Commission; and

(c) The holding of a well contractor license duly issued by a neighboring state shall constitute prima facie evidence of that an applicant meets the criteria contained in subsection (b) (2) of this section.

(d) *Duration and Renewal of Licenses*

(1) Licenses issued pursuant to this section shall be renewed every two years. A license shall be renewed upon payment of a renewal fee and completion of any continuing education required by rule by the Commission. If a licensee fails to submit an application for renewal, the renewal fee, and proof of completion of the required continuing education, the license shall expire at the end of its effective term.

(2) The Commission may refuse to renew a license if the licensee has not imposed in accordance with this section, unless the order or penalty is under appeal.

(3) The Commission may issue a conditional license to enable a former licensee to comply with an order to correct problems with a well.

(e) *Actions Against Licenses* The Commission may revoke, or suspend, for any period deemed warranted, a license issued pursuant to this section, for any of the following reasons:

(1) For fraud or deception in obtaining the license;

(2) For fraud or deception in reporting;

(3) For violating any provisions of this law, its implementing regulations, or of any administrative order of the Commission issued pursuant to this section.

No person whose license is revoked shall be eligible to apply for a license for one year from the effective date of the final order of revocation.

(f) Any person may make a complaint against any well contractor or operator for violating this Law or its implementing regulations. The complaint shall be in writing, signed by the complainant, and specify the grievances against the licensee. The Commission shall respond to the complaint by issuance of an order it deems appropriate. Review of the order shall be subject to the General Hearings Provisions.

(g) An applicant for a license whose application is denied by the Commission, or a license holder whose license is revoked or suspended, may appeal to the Commission.

Section 811. Enforcement and Penalties

(a.) Penalties that may be assessed for those deemed to be in violation include the following:

(1) A civil penalty not to exceed $5,000.00 for each violation. Every day that such violation(s) continue will be considered a separate offense.

(2) A criminal penalty in the form of a fine of not more than $5,000.00 for each violation, imprisonment for not more than 90 days, or both. Every day that such violation(s) continue will be considered a separate offense.

(b.) Anyone who knowingly makes any false statements in any application, record, or plan required by this ordinance shall upon conviction be punished by a fine of not more than $5,000.00 for each violation, imprisonment for not more than 180 days, or both.

(c.) In addition to any other sanctions listed in this Chapter, a person who fails to comply with the provisions of this groundwater resource protection law shall be liable to the

Pawnee Nation in a civil action for damages in an amount equal to twice the cost of remediation and/or well closure. Damages that are recovered in accordance with this action shall be used for the administration of programs for the protection and restoration of ground water resources.

(d.) Licensed well drillers who are in willful violation of this ground water resource protection law are subject to having their license suspended or terminated by the Director.

Section 812. Wellhead and Water Supply Protection Program.

(a) The Commission may develop regulations and programs to prevent pollution of public water supply systems, including but not limited to a wellhead protection program to assist communities, states, municipalities, rural water districts, non-profit water corporations and other public groundwater suppliers in the conservation and protection of their public groundwater supplies. Such a program may provide guidelines for:

(1) specifying the duties of local communities and governments in developing and implementing a wellhead protection program;

(2) determining all potential and actual pollution sources which may have an adverse effect on public health;

(3) taking into consideration potential sources of pollution when sighting new wells or intake structures for public water supplies;

(4) promulgating regulations concerning well drilling and capping; and

(5) developing contingency plans for pollution release containment, cleanup and the provision of alternative drinking water supplies for each public water system in the event of pollution.

(b) The Director and Commission may assist communities with long-term planning for meeting water supply needs from groundwater, surface water or other sources.