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Municipal Wellhead Protection Manual For Small Communities

A Guide for City Managers and Public Utility Managers

"Wellhead Protection Education for Communities and Homeowners"
CWA Section 319(h) FY 1997

Nonpoint Source Pollution Program Task 900
Oklahoma Conservation Commission Task #94

OSU Project Account AC-5-90310

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May 2001

Foreword

This guide was adapted from *Municipal Wellhead Protection Manual For Assisting Small Communities: 4 Guide for Agencies and Other Entities* developed with partial funding from the U. S. Environmental Protection Agency under Clean Water Act Section 319(h) FY 1997 Nonpoint Source Pollution Program Task 900, in cooperation with the Oklahoma Conservation Commission Task #94. The *Guide for Agencies* manual was developed by Dr. Marley Beem drawing on the work of Maifan Silitonga, Graduate Research Assistant, and Dr. LaDonna McCowan, Research Engineer.

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Introduction

Protection of ground water from contamination is an important goal for all ground water-dependent communities, regardless of size. Small communities may have a particularly difficult time marshalling the necessary resources and resolve to carry out even the most basic protection program. Lack of time, money, and experience limit many communities from taking action on their own. This manual aims to provide background and tools to assist a small community in developing its own ground water protection program.

The federal Safe Drinking Water Act specifies certain minimum components for wellhead protection programs:

- The roles and duties of state and local governments and public water suppliers in the management of wellhead protection programs must be established.
- The wellhead protection area for each well must be delineated (i.e., outlined or defined).
- Contamination sources within each wellhead protection area must be identified.
- Approaches for protecting the water supply in a wellhead protection area contamination sources must be developed.
- Contingency plans must be developed for use if public water supplies become contaminated.
- Provisions must be established for siting new wells to produce maximum water yield and reduce the potential for contamination.
- Provisions must be included to ensure public participation in the process.

This manual is addressed to the city manager or manager of a public utility who may be charged with implementing a community wellhead protection program.

Implementing a Ground Water Protection Program

Unless your community has experienced a contamination incident, wellhead protection may not be first on your list of priorities. You may be far busier fixing equipment, addressing problems, or stretching tight budgets to meet longstanding concerns. You and a few others may be trying to run the water distribution system, sewage treatment system, and garbage collection, perhaps with old equipment prone to breaking down. Water system customers may be dissatisfied with the taste or reliability of their water, and they may seem prone to go overboard when someone addresses water quality. To make matters worse your citizens may not tolerate anything that could increase their water bills. These factors may seem to make it too politically sensitive for you to consider promoting wellhead protection efforts.

As the Safe Drinking Water Act requires water utilities to report results of their mandatory water monitoring, questions may be raised that are likely to bring wellhead protection to people's minds. A solid education program can go a long way in keeping the drinking water discussion positive and productive. Public education is very much preferred over media hype, so it is advisable to begin an education program early.

Wellhead protection programs are a long-term undertaking with public reminders concerning personal pollution control actions, reports on monitoring efforts, and information on any new potential contaminants or sources. Although other priorities and emergencies may temporarily delay your wellhead protection program, don't let the program die from neglect.

Basic Concepts of Wellhead Protection

Protection consists largely of keeping potential contaminants at some distance from the well and its recharge zone.

1. Reduce the risk of contamination by keeping potential contaminants away from the well.
2. Clean up spills before the contaminants can reach ground water.
3. Monitor the aquifer for evidence of contamination with monitoring wells or frequent sampling.

Key People and Basic Concepts

Support of community leaders such as the mayor, public officials, utility system managers, school district superintendents, teachers, key business people, and retirees can drive the program. Consider using simple scenarios like those in Appendix 1 to communicate the idea that ground water is vulnerable to contamination and that potential contaminants close to the well are particularly risky. All participants should learn the basic concepts of wellhead protection (see box). As people gain understanding and commitment to the project, ask them to recommend others to bring onboard.

It is also essential to draw on professionals from other public agencies and involve them in efforts to help the target community. There are numerous state and federal agencies with interest in protecting ground water (see box, Environmental Agency Resources).

Environmental Agency Resources

Oklahoma Cooperative Extension Service (OCES) offers a variety of educational programs including ground water models and displays. Household water testing and Oklahom*A*Syst, a self-assessment program to evaluate nonpoint risks, is available through OCES County offices.

Conservation Districts, through alliance with the **Oklahoma Conservation Commission (OCC)**, offer outdoor classrooms and Project WET (Water Education for Teachers). The conservation district is located with federal partners, USDA Natural Resources Conservation Service and Farm Services Agency, which offer a variety of federal funding sources.

Oklahoma Water Resources Board (OWRB) has expertise in ground water resources, authority over water well drilling and closure, and offers financial resources such as grants and loans for community water systems. They should be involved in any well plugging activities. OWRB regional offices are located around the state.

Oklahoma Department of Environmental Quality (ODEQ) has regulatory authority for testing and certification of all public drinking water systems. Regional offices are located around the state. ODEQ can help with wellhead delineations and drinking water education programs.

Oklahoma Corporation Commission has regulatory authority over subsurface injection wells, oilfield activities, and fuel storage. Regional offices are located around the state.

US Environmetnal Protection Agency offers a variety of educational resources through its source water protection website: http://www.epa.gov/safewater/protect.html and the Safe Drinking Water Hotline: 1-800-426-4791.

Wellhead Delineation

The area from which a well gets its water, or recharge zone, can be broken into two zones as shown in Figure 1. The Zone of Contribution (ZOC) includes all the area that naturally drains toward the well, and the Zone of Influence (ZOI) is a smaller area influenced by pumping rate. Because a potential contaminant released inside this area has a high probability of reaching the well, the ZOI is generally designated as the Wellhead Protection Area (WHPA.

A larger the WHPA, the longer it will take a potential contaminant, released outside the WHPA zone, to reach the well. This allows a safety factor, time for the community to detect and correct any pollutants in the ground water. Generally this area is selected to assure a 10-year time of travel. In other words, it would take 10 years or longer for a contaminant released outside the

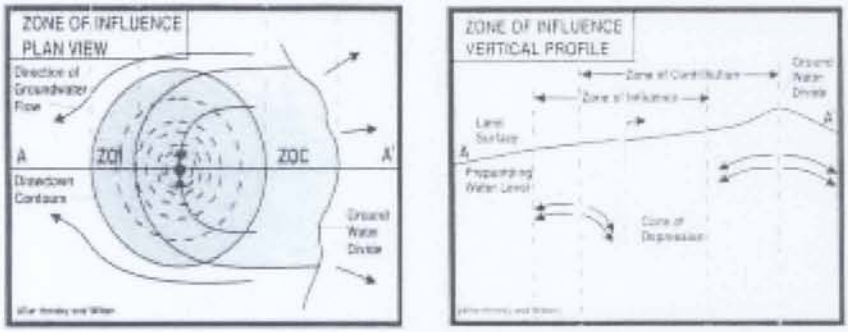

Figure 1 Wellhead protection area with ZOI based on 10-year time of travel.

WHPA to reach the well. Thus by keeping all potential contaminant sources outside the WHPA, the community will have at least 10 years time to correct any problems or find a new source of drinking water. The 10-year travel time gives especially good protection from contaminants that breakdown rapidly, like most herbicides and modern insecticides. For example, the concentration of a contaminant with a two-year half-life would decline 1000-fold in the 10 years it took to reach the well. A material with half-life of a few months would be undetectable in 10 years.

The WHPA delineation is generally a compromise because it is based on somewhat incomplete information. For example, we may not know all the potential pollutants in the area or all the details of the local geology and ground water flow. An example of a computer generated WHPA is shown in Appendix 2. When implemented, however, the WHPA boundaries may be drawn somewhat larger if there is concern that sources that outside the WHPA may, in fact, have a flow path into the protection zone.

The delineation method developed by Hydrogeologic, Inc. for the EPA Office of Ground Water (Blandford and Huyakorn, 1991), was used by OSU Cooperative Extension in the five well head delineations upon which this manual is based (Silitonga et al., 2001 and Propst et al., 2002).

(See Appendix 2). Such models can be used to determine the relative risk associated with each of the potential sources found, based on contaminant type, aquifer characteristics, and other factors. The use of such models can help you identify and evaluate potential contaminant sources and prioritize the risks associated with each.

Contaminant Source Surveys

A quick survey can identify potential sources that present a risk of contaminating ground water. Some sources, such as oil wells and active trash dumps for instance, are easily identified. Others like abandoned wells, underground storage tanks, or old dumpsites may be more difficult. Assistance of longtime residents and volunteers may be helpful in locating these less obvious sources. Someone who knows the area and its history might identify old, covered-over dump sites, oil or chemical spills, or where a dry cleaner or gas station once stood. Global Positioning System (GPS) receivers are an affordable means of obtaining the exact locations of each source as the survey is carried out. A list of potential sources to consider is given in the box (Potential Ground Water Contaminant Sources).

The survey process can be an opportunity to educate volunteers and city employees. Teach them to recognize potential contaminant sources, and give them a copy of Appendix 1 (*Is Your Community Taking Steps to Protect Ground Water? Contamination Scenarios for Community Leaders*). Formal surveying efforts may be limited in time and scope, but trained volunteers and city employees may continue the effort informally, thinking about the diversity of possible contaminants and identifying risky practices they observe within wellhead delineation zones.

A map that shows municipal wells and potential contaminant sources along with the boundaries of the wellhead protection area can be very helpful (See example in Appendix 2). Arc View® software in the hands of a knowledgeable user can produce attractive maps, but hand-drawn modifications to an existing street map or plat map can also work. Streets and landmarks should be indicated on the map along with businesses and industrial features.

POTENTIAL GROUND WATER CONTAMINANT SOURCES

Dry cleaners	Gas stations
Automobile repair Shops	Car washes
Laundromats	Trash dumps
Junkyards	Funeral or taxidermy services
Abandoned water wells	Septic systems
Waste lagoons	Waste disposal areas
Highways	Railroads
Fertilizer or pesticide storage	Pesticide loading, mixing areas
Livestock feeding or manure storage areas	Military installations
Livestock manure storage	Agricultural cropping areas
Abandoned oil wells	Oil tanks
Old pipelines	Sewer lines
Mines/gravel pits	Irrigated cropland
Underground injection sites	Food processing

The Priority Setting Approach (PSA)

When potential sources of contamination have been identified and characterized, a priority setting approach (U.S.E.P.A., 1991) can be used to evaluate the risk associated with each. This process generally requires professional

assistance. The priority setting approach (PSA) is useful when there is a large number of potential sources, or when a strong rationale is needed to convince residents that certain sources must be addressed.

The PSA is a formal model to determine the relative risk of potential contaminant sources in a wellhead protection area. Priority setting takes into account the depth to the ground water, characteristics of the specific contaminant and geology, and the likelihood of a release or spill to assign a relative risk. There are essentially five steps in the PSA process with detailed worksheets for each. The steps are:

1. Determine the location of the WHPA boundaries.
2. Identify potential sources of contamination in and near the WHPA. (See box, *Potential Ground Water Contaminant Sources.*)
3. Assess the likelihood of release of contaminants from each source.
4. Assess each contaminant's transport characteristics.
5. Estimate the risks or potential threats posed by each potential contamination.

Like any model, the PSA is limited by the assumptions upon which it is based and the reliability of the data that are used. The purpose of the model is not to pin down the risk of every potential source absolutely, but to give a relative ranking to set priority for addressing sources. The better the information available to the model, the better the WHPA plan will be.

Selecting Appropriate Management Options

Forty-one Best Management Practices (BMPs) are shown in Appendix 3. Each BMP consists of a set of actions that can be implemented to reduce the risk of ground water contamination. Some recommend direct changes to existing practices or land use. Others act by changing the community's rules, like zoning. Finally, some specify public education. Table 1 gives an overview of the BMPs. Together the BMPs constitute an Action Plan for WHPA protection.

Table 1 BMPs for Wellhead Protection Program. See full description in Appendix 3.

BMP description	Approach
Wellhead Protection Program	
1. Delineate Wellhead Protection Area (WHPA)	Technical
2. Post signs to identify WHPA	Education
Potential Contaminant Survey	
3. Conduct potential contaminant survey	Technical and volunteer
4. Identify trash dumps	Technical
5. Identify abandoned wells	Volunteer activity
On-site Waste Treatment and Sewer Lines	
6. Septic Tank pumping and maintenance	Education
7. Inspect Septic tank/drainfield distances	Volunteer, Education, Technical
8. Evaluate performance of septic tanks and on-site waste treatment systems	Technical
9. Upgrade waste systems	Technical
10. Discourage use of Septic Tank additives	Education
Fertilizer and Pesticide Use	
11. Soil testing for proper fertilizer rates	Education
12. Use of slow-release fertilizer	Education
13. Integrated Pest Management (IPM) Workshops	Education
14. Promote non-pesticide alternatives for pest control	Education
15. Require IPM in schools and food prep areas	Education
16. Proper storage and handling of pesticides and fertilizer	Education
Livestock Management	
17. Proper stocking rates and manure management	Education
18. Keep livestock away from water wells	Education
19. Limit manure/fertilizer application to OCES recommended rates	Education
Management of Private Water Wells	
20. Conduct Oklahom*A*Syst programs (see OCES)	Education
21. Inspect condition of water wells and correct problems	Volunteer, technical
22. Bring all wells up to standard	Technical
23. Identify abandoned wells for plugging	Education, Volunteer

	BMP description	Approach
Drainage into WHPA		
24.	Reroute drainage away from WHPA	Technical
25.	Clean up spills	Technical, education
Control Wellhead land use		
26.	Purchase or otherwise obtain title to lands in protection zone	Technical, political
27.	Develop lease restrictions inside WHPA	Voluntary, education
28.	Obtain conservation easements	Technical
Regulations		
29.	Prohibit certain landuses through zoning	Technical, political
30.	Employ building permits and occupancy permits	Technical
Wellhead Protection Program		
31.	Test existing wells (coordinate with Oklahom*A*Syst program	Voluntary
32.	Test private wells for nitrate, lead, or other pollutants	Voluntary, technical
33.	Install monitoring wells at key locations	Technical
Address Oil & Gas Production		
34.	Inventory and evaluate oil field activities	Technical
35.	Remove or renovate storage tanks	Technical
Contingency Planning		
36.	Develop a contingency plan	Technical, Education
37.	Train professionals and volunteers in emergency response	Education
38.	Stockpile absorbant materials and foam-type fire fighting materials	Technical
Hazardous Waste Collection		
39.	Conduct Oklahom*A*Syst program on household hazardous wastes	Education
40.	Conduct Hazardous Collection events	Technical, education
Public Education Program		
41.	Conduct Oklahom*A*Syst program	Education
42.	Conduct Environmental Fairs and other events	Education

The Action Plan

An *Action Plan* is a strategy and schedule for achieving the wellhead protection deemed important by the community. It is an essential part of an effective wellhead protection program. It is a list of selected BMPs organized as simple and practical steps your community will follow. The plan should begin with an educational program such as described in this manual. Once the

public and community officials have a good understanding of the risks and the reasons for the program, they can support the technical training of personnel and volunteers and make informed policy decisions on which the action plan will be based. A sample action plan, consisting of BMPs placed in sequence, is provided in Appendix 4. It can be used as a template and modified to account for local concerns, preferences, and priorities.

The Educational Program

The education plan should be a major component of every wellhead protection program. The education program can be built in four phases: (1) developing awareness, (2) developing understanding, (3) changing attitudes, and (4) changing behaviors. A full-scale, targeted educational program is a significant undertaking that would benefit from participation of the technical and educational professionals of the community. It can also benefit from assistance and support from outside agencies and organizations. Materials and expertise are available from OSU Cooperative Extension, the Oklahoma Department of Environmental Quality, the Oklahoma Conservation Commission. Programs from the Groundwater Foundation (Lincoln, NE) offer a nongovernmental approach for community leaders and active citizens, including community awards for successful programs.

The public notices required of the water supplier telling the public about the results of water testing can help alert the public to the quality of their water. Likewise, publicity from any spills or pollution event can alert the public to water quality as an issue. A well plugging demonstration and well or septic tank maintenance workshop can help develop awareness. Such events may go further helping people know learn about the connection between surface and ground water and the threat posed by abandoned, unused, or unsecured wells and the danger of spills in or near a well. Local well drillers can help demonstrate the process of plugging an abandoned well, and you can use the occasion to explain how such BMPs reduce the risk of contaminating the public's drinking water.

Appendix 5 contains promotional materials that may be useful in a public education program. It includes a flyer to announce a well plugging demonstration and an educational brochure that explains how individuals can help protect ground water. A flyer that shows a map of the location of the wellhead protection area and landmarks can also help people understand the intent of a wellhead protection program.

More intensive education should be developed through volunteer groups and with students in the schools. The OSU Cooperative Extension's Oklahom*A*Syst and the Conservation Commission's outdoor classrooms can educate youth of the community, and public seminars can explain the impact of the program and provide a forum in which to discuss policy alternatives.

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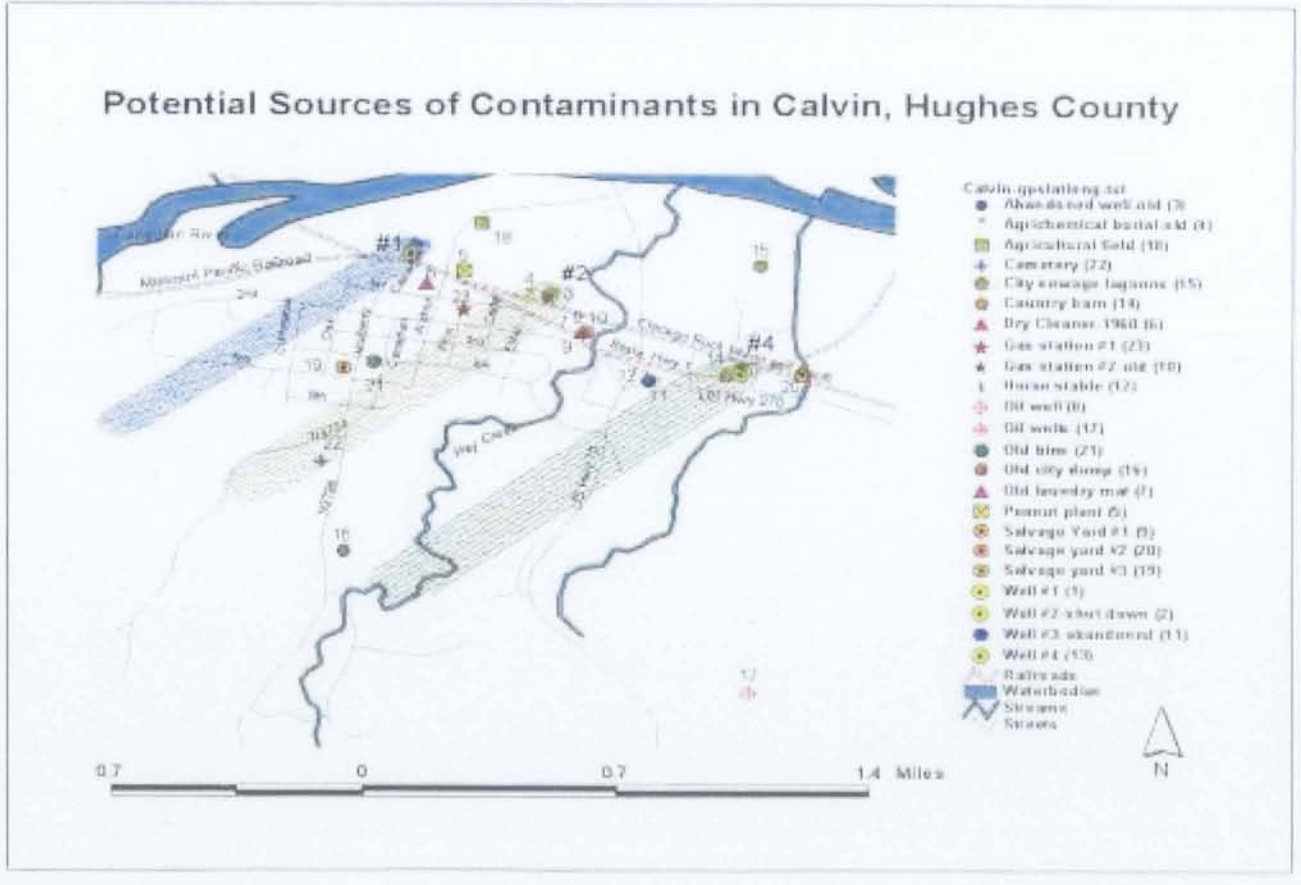
APPENDIX 1
Is Your Community Taking Steps to Protect Ground Water?

Contamination Scenarios for Community Leaders

Here are some scenarios, ways that your water supply could become contaminated

1. A workman finds that fire ants have gotten into the electrical box of one of the city wells. He/she cleans out the box and drenches nearby fire ant hills with (gasoline, oil, pesticide).
2. A tank truck carrying (solvents, pesticides, gasoline, etc.) turns over on the highway within a Wellhead Protection Area (WHPA). Fire department washes material into the roadside ditch. The fire department should have training on how to deal with hazardous material spills and protecting ground water? Will they know the spill is in a WHPA?
3. County roads department stores (road salt, pesticides, etc.) within the WHPA.
4. Construction begins on a _____ (garage, gas station, fertilizer storage bin, junkyard, feedlot, etc.) inside a WHPA. All of these are potential contaminant sources that would best be located outside WHPAs.
5. "Old Bill," who lives inside the WHPA, has several containers of paint thinner and some 15 year old liquid pesticide. Why not dump it in that out-of-sight trash dump? (Could be waste motor oil.)
6. Dust problems are often handled by treating dirt roads with petroleum wastes. This should be avoided particularly inside the WHPA.
7. The land around a well in the community water system is used for cattle grazing. A spigot is provided for the landowner to water cattle near the well Concentration of cattle at this location can be a source of nitrates and bacteria. The spigot should be moved away from the wellhead.

APPENDIX 2
Map of Wellhead Protection Area and Potential Sources



APPENDIX 3
Best Management Practices for Community Wellhead Protection

Wellhead Protection Area (WHPA) Delineation

1. Identify the wellhead protection area (WHPA) for each well used in the water supply system. Oklahoma DEQ can assist with this.
2. Post and maintain signs identifying WHPAs to discourage dumping of toxic materials and unnecessary use of pesticides. Signs may be available from DEQ.

Potential Contaminant Sources Inventory

1. Survey WHPAs for potential contamination sources, both new ones and old, undiscovered ones. For example, trash dumps, water wells, abandoned wells. Mark locations on map. Repeat every year during _____ (slowest month)
2. Identify the location of abandoned wells.

On-site Waste Systems and Sewer Lines in WHPAs

1. Septic tank pumping and inspection – offer free or partial subsidy for regular maintenance s (3 – 5 year intervals on average). Repeat offer every ___ years.
2. Inspect to assure adequate distance between septic systems and private water wells – 100 feet is required in most cases. Repeat for any new homes.
3. Evaluate performance of on-site waste treatment systems. Repeat every year during slowest month _____
3. Waste system upgrades – offer free or partial subsidy to install new lateral lines or other needed changes. Repeat offer every ___ years.
4. Discourage use of septic tank chemicals – educate WHPA septic system owners on the ineffectiveness and possible harm from chemical septic system additives. Ask Oklahoma Cooperative Extension or County Conservation District to do a septic system workshop or develop materials for mailing. Repeat effort every ___ years.
5. Identify any sewer lines running through WHPAs. Consider rerouting or upgrading old lines that are prone to leak.

Fertilizer Use in WHPAs

1. Offer free soil testing for WHPA residents lawns and gardens (available through Oklahoma Cooperative Extension county office for moderate cost). Advertise through direct mailing or a note inside water bill. Repeat offer to WHPA residents every ___ years.
2. Promote use of slow-release fertilizers in lawns.

Pesticide Use in WHPAs

3. Ask Oklahoma Cooperative Extension Service to conduct pest identification and Integrated Pest Management (IPM) workshops for WHPA residents. Caution residents to choose pesticides with low-risk to ground water.

4. Promote non-pesticide alternatives for pest control. Use direct mailing, note inside water bill, or other method. Repeat every __ years.
5. Require Integrated Pest Management to control insect and other pests in schools or food preparation areas. Conduct training through Cooperative Extension. Repeat every __ years.
6. Educate residents about proper storage and handling of pesticides and fertilizers. Do not store chemicals in well houses. Move agricultural chemical loading/mixing sites outside of WHPAs. Repeat every __ years.

Livestock Management Practices in WHPAs

1. Educate WHPA livestock producers to avoid overstocking pastures and not to store manure within the WHPAs. Consider all livestock (cattle, horses, goats, dogs, etc.). Use direct mailing, note inside water bill, or other method. Consult with Oklahoma Department of Agriculture concerning use of Feedyard Act License. Repeat education program every __ years.
2. Restrict livestock producers from feeding or watering livestock within 300 feet of a water well within the WHPAs.
3. Educate producers to limit manure and/or fertilizer application in crop and pasture land to rates recommended by Oklahoma Cooperative Extension Service. Repeat every __ years.

Private Water Wells in WHPAs

1. Conduct Oklahom*A*Syst program to educate well users concerning protection of the water supply. Contact Oklahoma Cooperative Extension. Repeat every __ years.
2. Inspect and bring all water wells up to standard: Grouting to seal gap between borehole and casing, slope land and pour a concrete slab around the well to prevent seepage down the outside of the well. Offer subsidy to assure problem wells are closed or repaired. To be done during _____ (slow work month).
3. Find and plug abandoned water wells. Also identify unused water wells that owners do not want to plug. Make these more secure by grouting around casing, pouring slabs and installing lock boxes. To be done during _____ (slow work month).

Drainage into WHPAs

1. Reroute drainage away from WHPA to prevent contamination from reaching WHPA. Spills on a road s or contamination from accidents a building fires will be washed into WHPA if drainage is toward WHPA.
2. New construction at boundary should consider direction of flow and reroute if necessary.

Control Wellhead landuse Through Title Transfers, Easements, or Voluntary Restrictions

1. Obtain title to wellhead zone properties through purchase or donation.
2. Lease restrictions – If WHPA land is leased, include restrictions in the lease on practices that might contaminate ground water.

3. Conservation easements - landowners can commit to disallow certain practices through an easement. For example, a farmer may restrict land used to low intensity livestock grazing and hunting in perpetuity. Nature Conservancy or US Fish and Wildlife Service (Partners for Wildlife program) might be able to assist. Alternatively, the city might pay a landowner to restrict land use practices.

Regulations

1. Prohibit certain land uses through "zoning" within WHPAs. Zoning could restrict certain types of industry such as concentrated animal feeding operations (CAFOs) or junkyards, or they could specify residential versus commercial development. The state of Oklahoma already requires a minimum 300-foot zone of control around public water system wells, but WHPAs may be much larger. Below are some examples.

   Zoning can be simple and straightforward. For example, "This land can only be used for grazing livestock. No more than __ head per acre."

   Zoning can be more complicated. Here are some "advanced" zoning options:

   Special Permitting – Adopts "thresholds" for various uses and structures within WHPAs. Grants special permits for "threshold" uses only if ground water will not be contaminated.

   Large-Lot Zoning – Increases minimum size lot required for building a home.

   Transfer of Development Rights – Identifies areas where development is to be transferred "from" and "to."

   Performance Standards – Does not allow development if contaminant levels rise to an established threshold.

   Growth Controls/Timing – Establishes building caps, subdivision phasing, or other limitations. Provides time to develop a wellhead protection plan and more specific zoning regulations.

2. Building permits and inspections can examine construction that affects ground water quality.

Monitoring

1. Test existing water wells in WHPA. Volunteer program can be coordinated with *Oklahom*A*Syst* educational program through Cooperative Extension.
2. Install monitoring wells between potential sources and the public system wells and set up sampling schedule. Coordinate program with ODEQ.
3. Test for nitrate plus nitrite concentration in ponds and creeks inside the WHPA – Oklahoma Cooperative Extension can assist. Heavy use by cattle or application of manure or chemical fertilizer in the watershed can lead to high levels of nitrate plus nitrite in ponds and streams. Repeat every ___ years.

Oil Production Activity and Hydrocarbon Storage Tanks in WHPAs

1. Work with Corporation Commission to inventory oil field activities within WHPAs and explore possible steps to decrease risk of ground water contamination. Provide Corporation Commission with copies of WHPA maps. Repeat every __ years.
2. Remove or bring up to standard any tanks found within the WHPAs. Work with Corporation Commission to ensure that fuel storage tanks meet standard. Repeat every __ years.

Contingency Planning

1. Develop a written plan for response to emergencies. Train employees and others to recognize and respond correctly to incidents. DEQ has sample plan. Update every ___ years
2. Educate local fire department(s) about the risks of ground water contamination, especially from tank truck spills, train derailments and runoff of water from fire fighting. Make them aware of the existence of sensitive areas by giving them copies of WHPA maps.
3. Stockpile absorbent materials for spill clean up and foam-type fire fighting equipment for fires inside the WHPA.

Hazardous Waste Collection

1. Conduct *Oklahom*A*Syst* program to educate residents on household hazardous waste. Arrange program with Cooperative Extension.
2. Conduct community or countywide hazardous waste collection. Hold annual hazardous collection events.

Public Education

1. Request educational help from Oklahoma Cooperative Extension Service, Conservation District, ODEQ, the Conservation District, and other agencies to raise awareness of the need to protect ground water
2. Use ground water models at Earthday events, "outdoor classroom" events sponsored by Conservation Districts, mailing to water system customers, and OCES *Oklahom*A*Syst* private water well owner workshops. Repeat yearly or every ___ years.

APPENDIX 4
Ground Water Protection Action Plan

City of Smithville

September 2002

Person Responsible – Frank Smith

The following steps will be taken to reduce the risk of ground water contamination:

1. Post and maintain signs identifying Wellhead Protection Areas (WHPAs) in order to discourage dumping, herbicide usage etc. Signs may be available for free from the Oklahoma Department of Environmental Quality. For more information contact ODEQ Water Quality at (405) 702-8100.

   Completed on _____ (date)

2. Make educational flyers available to Smithville customers as they drop by City Hall or through selective mailings. Topics will include septic system maintenance, integrated pest management, and household hazardous wastes.

   Completed on _____ (date)

3. Will investigate the feasibility of zoning or other restrictions to protect wellhead areas from contamination.

   Completed on _____ (date)

4. Determine the location of septic systems within city limits to determine which ones are within wellhead areas.

   Completed on _____ (date)

5. Take steps to reduce risk of contamination from any septic systems or sewer lines within wellhead areas. This may include subsidies for pumping and inspection of septic systems, upgrading sewer lines prone to breaks etc.

   Completed on _____ (date)

6. Contact state road department to determine what herbicides are being applied to roads within wellhead areas. Give them a copy of wellhead area maps. Ask Oklahoma Cooperative Extension Service to assess the risk of these herbicides to ground water. Take steps to reduce risks as appropriate.

   Completed on _____ (date)

7. Contact county road barn crew and county commissioner to educate about the vulnerability of the area around the new well. Give them a copy of wellhead area map. Urge them to keep any herbicide storage, loading or mixing areas as far from the well as possible.

Completed on _____ (date)

8. Secure any unused water wells within wellhead areas to make them safe from intentional and unintentional contamination. Add locks to caps or covers. Inject grout down to 10 feet to seal gap between casing and borehole. Slope land to drain away from the well and pour a slab around well.

Completed on _____ (date)

9. Investigate the drainage pattern of streets within wellhead zones. Streets should ideally direct runoff away from wellhead areas instead of towards them. This may not be feasible. If it is feasible, it will reduce the risk of contamination from vehicle spills and contaminated runoff from firefighting activity.

Completed on _____ (date)

10. Investigate the possibility of purchasing wellhead land as it becomes available on an affordable basis. This allows much greater control over land use and reduction of potential contamination.

Completed on _____ (date)

11. Carefully inspect wellhead areas at least once a year for potential contamination sources, both new ones and old, undiscovered ones. Mark calendar and make it a point to do so once each year.

Completed on _____ (date)

12. Consider contacting local office of the Corporation Commission, give them copies of WHPA maps, and make them aware of the special need to protect these areas. Repeat every three years or as needed.

Completed on _____ (date)

13. Will contact Smithville fire department and give them copies of WHPA maps. Make them aware of the added risk in these areas in the event of chemical spills or structure fires in which contaminants are likely to be involved. Repeat every three years or as needed.

Completed on _____ (date)

14. Support establishment of a county household hazardous waste collection facility. Contact Fenton Rood, ODEQ, at 405 702- 5159.

    Completed on _____ (date)

15. Develop a written plan for appropriate response to emergencies. Train employees and others to recognize and respond properly to incidents. DEQ has a sample plan and can advise further.

    Completed on _____ (date)

16. Request educational help from Oklahoma Cooperative Extension Service, Conservation District and other agencies to raise awareness of the need to protect ground water and WHPAs. Examples include earthday type events at local schools, mailings to water system customers and private water well and septic system owner workshops.

    Completed on _____ (date)

17. Review this plan and plan accomplishments every January,. Add to plan and revise as appropriate. Share results with Smithville board of trustees.

    Completed on _____, YEAR 1

    Completed on _____, YEAR 2

    Completed on _____, YEAR 3

    Completed on _____, YEAR 4

    Completed on _____, YEAR 5

"Without a strategy and schedule to accomplish the goals, an action plan is just a piece of paper."

PROTECT OUR WATER!

Pollutants put on the ground may reach ground water and eventually water wells

1. **Take care around wells.**

- **Don't store chemicals in well houses.**
- **Don't apply weed killers, insecticides, animal manures, or fertilizers within 100 feet of a water well unless you know it is safe – ask your County Extension Office for advice.**

2. **Beware of Abandoned Wells.**

- **Never dump anything down a well.**
- **Plug old wells. Follow the plugging regulations or you risk more harm. Ask for a copy of OWRB guidelines or work with a licensed well driller.**

3. **Don't Dump Household Chemicals on the Ground or Down Drains.**

- **Weed Killers & Pesticides – use up according to the label.**
- **Used Oil - Recycle at a local garage.**
- **Paint and Solvents - use up, evaporate, landfill small amounts.**

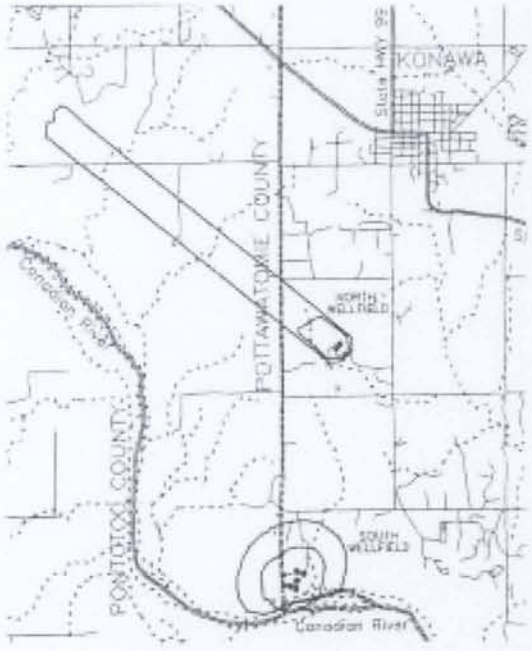
4. **Pump Out and Inspect Septic Tanks every 3 to 5 years**

For More Information:

Call _____

OSU
OKLAHOMA COOPERATIVE EXTENSION SERVICE

DO YOU LIVE INSIDE THESE LINES?



IF SO, WHAT YOU DO ON YOUR LAND CAN AFFECT KONAWA'S WATER SUPPLY

Public Water Is Regularly Tested For Safety...But Testing Is No Substitute For People Keeping It Clean In The First Place

A1.0 TITLE AND SIGNATURE PAGE

OKLAHOMA COOPERATIVE EXTENSION SERVICE
OKLAHOM *A* SYST WELLHEAD PROTECTION PROGRAM FY 1994 SECTION 319
QUALITY ASSURANCE PROJECT PLAN

APPROVING OFFICERS:

Oklahoma Cooperative Extension Service

Michael D. Smolen, Water Quality Coordinator

_____ Date: _____

Barbara J. Brown, Project Coordinator

_____ Date: _____

Michael A. Kizer, Project Coordinator

_____ Date: _____

Oklahoma Office of the Secretary of the Environment

Sylvia Ritzky - Environmental Program Administrator

_____ Date: _____

United States Environmental Protection Agency

USEPA Region VI Project Officer

_____ Date: _____

USEPA Region VI Office of Water Quality

_____ Date: _____

A2.0 TABLE OF CONTENTS

A3.0 DISTRIBUTION LIST

The following list of persons and their respective agencies will received finalized, signed and USEPA Region IV approved copies of this project plan:

John Hassell	Oklahoma Conservation Commission.
Sylvia Ritzky	Office of the Secretary of the Environment.
Scott Smith	USEPA Region IV.

Copies if the approved plan will be provided to the following:

Kendra Eddleman	Oklahoma Conservation Commission
Phil Moershel	Oklahoma Conservation Commission
Dan Butler	Oklahoma Conservation Commission
Michael Kizer	Oklahoma State University, Department of Biosystems and Agricultural Engineering
Barbara Brown	Oklahoma State University, Department of Nutritional Sciences
Mike Smolen	Oklahoma State University, Department of Biosystems and Agricultural Engineering

A4.0 PROJECT ORGANIZATION

The following is a list of key personnel and their corresponding responsibilities involved in this project.

1. Oklahoma Cooperative Extension Service Director-

   Samuel E. Curl, Dean and Director - Responsible for all operations of OCES, including water quality programs.

2. Water Quality Programs Coordinator-

   Michael Smolen - Responsible for all water quality programs.

3. Oklahom*A*Syst Project Manager -

   Kendra Eddleman - Responsible for project oversight.

3. Oklahom*A*Syst Coordinators -

   Barbara J. Brown and Michael A. Kizer - Responsible for project operation including project activities, tasks, milestones, and outputs planning, sample collection, field analysis, sample delivery, and report progress for quarterly submission through GRTS.

4. Oklahom*A*Syst technical staff-

   Nicole Gurski - Graduate Assistant, Responsible for laboratory equipment, sample analysis, development and revision of program materials.

   Sue Williams - State Extension Housing Specialist, Responsible for program delivery.

   Mitch Fram - NE District Water Quality Extension Specialist, Responsible for program delivery.

   Marley Beem - SE District Water Quality Extension Specialist, Responsible for program delivery.

   Wes Lee - SW District Water Quality Extension Specialist, Responsible for program delivery.

5. OCC Oklahom*A*Syst Program QA officer-

   Phillip Moershel - Responsible for all aspects of project QA.

The OSU Cooperative Extension Service Water Quality offices are located at:

218 Agriculture Hall
Stillwater, OK 74078-6021

The telephone number for the Water Quality offices is: (405) 744-5653.
The Fax number for the Water Quality offices is: (405) 744-6059.

All correspondence regarding the project should be directed to Michael D. Smolen, Coordinator, Water Quality Programs, at the address above.

A5.0 PROBLEM DEFINITION

Outside of the major metropolitan areas, the majority of Oklahoma residents rely on ground water for their drinking water supplies. Numerous activities in rural areas have the potential to affect the quality of water produced by water supply wells. A review of water tests performed by the Department of Environmental Quality between 1977 and 1981 revealed that of the 3,176 public and private water supply wells tested, 9.1% of them exceeded the safe drinking water standard of 10 mg/L for nitrate nitrogen.

Christensen and Rea (1993) identified volatile organic compounds (VOCs) and/or pesticides in over 40% of well samples from the Garber-Wellington formation, which underlies the central part of the state. Oklahoma City and a number of other major cities in the state have recently failed EPA water quality tests due to the presence of toxins like Diazinon insecticide in their municipal wastewater treatment plant effluent.

Oklahoma's 319 NPS Assessment (1991) also found serious degradation in virtually all the major streams in the state. The Assessment identified numerous problems, including pesticides, plant nutrients, bacteria, and unknown toxins in the major river and their tributaries.

A6.0 PROJECT DESCRIPTION

The Oklahom *A* Syst project will bring educational efforts to rural and suburban residents on the sources of drinking water and how to prevent drinking water contamination, especially in regards to private drinking water sources. Well owner education will be accomplished through seminars and workshops. The Oklahom *A* Syst program has two environmental self-assessment components. Home*A*Syst addresses the concerns of rural and suburban non-agricultural households. The Farm & Ranch *A* Syst program will emphasize risk assessment for the kinds of activities that take place on production agriculture farms and ranches.

As a participation incentive, the Oklahom*A*Syst program will offer water quality testing. Program advertising will invite people to bring a water sample to the educational meetings. During the meeting the water samples will be analyzed for: pH, conductivity, and nitrates and the results will be discussed. Any results that indicate possible pollutants will trigger a suggestion for further tests as detailed in Section A7.4. The attendees will also receive sample bottles so they can send a sample directly to the DEQ Environmental Laboratory for coliform bacteria analysis. The Oklahom*A*Syst project will not be directly involved in the collection, handling or testing of samples for bacterial analysis. Attendees will be advised that for a more complete picture of their drinking water quality. Those in attendance who desire one will be given a sterile sample bottle from the DEQ Environmental Laboratory and detailed instructions on how to collect a sample for submission to the laboratory.

A7.0 DATA QUALITY OBJECTIVES

Personnel involved in establishing the DQO for this project include with varying extent:

Mike Smolen
Mike Kizer
Barbara Brown
Nicole Gurski
Jennifer Meyers
Kendra Eddleman
Phillip Moershel

PROJECT DESCRIPTION

A variety of activities take place on rural and suburban property which can put the quality of drinking water produced by domestic wells in those locations at risk. Farms and ranches handle large quantities of animal waste, plant nutrients and pesticides. Non-farm residents may dispose of hazardous products such as pesticides, waste oil and antifreeze in an improper fashion. However, residents are unaware that their activities are high risk and they do not know what actions they should take to protect their water source; nor do they know the current quality of their drinking water. The Oklahom *A* Syst program provides residents with worksheets, supporting literature, and a seminar to help answer these and other questions. At the seminars we will also provide water quality tests to estimate the quality of a homeowner's water. The water quality tests will be used as incentives for homeowners to attend the well-owner seminars. Variables which will be tested include: pH, conductivity, and nitrates. The homeowner will also be provided materials for a bacteria test from DEQ Environmental Laboratory. The results from the sampling, especially results from the seminar sampling, will be used strictly for an educational tool. From the water evaluated at the Oklahom *A* Syst meeting, bacterial test, and recommendations from Extension specialists, a homeowner can determine if the quality of their water meets EPA drinking water standards.

ACTIONS or OUTCOMES

If the testing results are near or above the drinking water standards in any manner the homeowner will be encouraged to have the water resampled and retested using a certified laboratory. If the results from the testing at the Oklahom *A* Syst meeting are above 80% of the EPA drinking water standards, Oklahom*A*Syst will highly recommend, as the test is not completed under controlled conditions nor at a certified laboratory, the sample be retaken and retested by a certified laboratory. If the results are between 50% and 80% of the EPA drinking water standards Oklahom *A* Syst recommends, as the test is not completed under controlled conditions nor at a certified laboratory, the sample should be retaken and retested by a certified laboratory. If the results are below 50% of the drinking water standard Oklahom *A* Syst believes the water to be of good quality, however, for conclusive results have the sample taken and tested by a certified laboratory. If total coliforms are present in a 100 ml sample of well water DEQ Environmental Laboratory will strongly recommend the water be retested for the presence of total coliform.

Oklahom*A*Syst will also recommend ways to maintain or improve the quality of a homeowners drinking water through detecting potential risks to groundwater. This will be completed by assisting the homeowner in surveying their property to determine the proximity of pollution sources such as septic systems, petroleum storage systems, and fertilizer storage.

METHODS

The results of this project will be used as educational tools rather than for regulatory purposes. The results from this project are not achieved under controlled circumstances, not based on expert sampling techniques, nor are they tested by a certified laboratory.

At the Oklahom *A* Syst meetings, homeowners drinking well water will be tested for pH, nitrates, and conductivity. Testing for pH and conductivity will be performed using a Jenco Model 1671 Conductivity/pH meter according to standard method 2510B and standard method 4500H-B respectively. Nitrate testing will be accomplished using an ATI ORION Model 93-07 pH and pH/ION Meter according to 56 RF 318888 (July 17, 1992) and 56 FR 50758 (October 8, 1992).

PROJECT SCOPE

The initial pilot project area will encompass Lincoln and Caddo counties. Educational activities will address household hazardous waste, surface water, ground water, maintaining private wells, household septic systems, fertilizer and pesticide storage and handling, and animal waste management. Presenters may include personnel from OSU Cooperative Extension Service, Conservation Districts, NRCS districts, and the Department of Environmental Quality. The program will provide homeowners with an idea of the current status of their drinking water and worksheets which allow them to assess the potential environmental risk to their wells. Subsequent to completion of the pilot portion of the project, the Oklahom*A*Syst program will expand into any of the 77 counties of the State where Cooperative Extension Service, Conservation District, NRCS, or DEQ personnel identify a programming need and an interest on the part of local citizens and support from private and civic organizations.

DECISION RULES

Analysis during Education Program
No recommendations will be made for pH or Electrical Conductivity.

Decision Rule for Nitrates

Nitrate Testing Result	Decision	Recommended Action
>8ppm	Impaired Sample	Resampling and Retesting of the well by certified laboratory technician from the DEQ Environmental Laboratory is highly recommended. Have your well tested in subsequent years.
5-8ppm	Adequate Sample	Resampling and retesting of the well water by the DEQ Environmental Laboratory is recommended. Have your well tested in subsequent years.
<5ppm	Nonimpared Sample	Water appears to be of good quality. We suggest for conclusive results to have well water tested by the DEQ Environmental Laboratory. To maintain this quality have your well tested in the years to come

Result	**Classification**	**Consequence False Positive**	**Consequence False Negative**	**Recommendation**
<5 mg/l	Nonimpared		If true concentrations are high then may cause Methemoglobinemia.	Suggest for conclusive results retesting by certified laboratory
5-8 mg/l	Satisfactory		If true concentrations are higher could cause Methemoglobinemia	Recommend resampling and testing by certified laboratory
>8 mg/l	Impaired	Caused homeowners unnecessary duress.		Strongly recommend resampling and testing by certified laboratory

DATA SENSITIVITY

Detection limits for nutrients will allow defining high quality drinking waters as well as levels of impairment. Precision and accuracy of all data must of course, be as true as possible. As a general rule precision and accuracy must be within + or - 10 % except for parameters approaching detection limits, where practical considerations require a wider range of acceptable precision and accuracy. The precision and accuracy criteria presented in the City County Health Department of Oklahoma County laboratory Quality Assurance Plan are suitable for this study. OCCHD insures data quality through the use of analysis control charts for precision and accuracy following section 1020 of Standard Methods 1992. With these charts warning limits of + or - 2 standard deviations are established and Control limits of + or - 3 Standard deviations. General acceptance limits for field duplicates and spikes are based on table 1020:I of Standard Methods 1992. Method detection limits and acceptable limits for duplicates and spikes for the water quality parameters to be analyzed are shown in the following table.

Parameter/Method	Meter/ laboratory	Acceptable limits for precision of low level duplicates	Acceptable limits for precision of high level duplicates	Acceptable limits for accuracy	Method Detection level
Nitrates 56 FR 50758	ATI ORION Model 93-07 pH/ION Meter	10%	10%	10%*	.1mg/l
pH 4500 H-B	Jenco Model 1671 Conductivity/pH Meter	N/A	±.1% ±1 digit	±.1% ±1 digit	-2.0su
Conductivity 2510 B	Jenco Model 1671 Conductivity/pH Meter	N/A	±1%FS± digit	±1%FS± digit	0.0ms

* Acceptable limits for recovery of known additions

MEASURES OF SUCCESS

The primary measure of success are based on educational objectives these will be determined by pre and post surveys presented to the homeowners attending the Oklahom*A*Syst program(s). The pre survey will be given at the program presentation. The post survey will be given, by phone, 6 to 8 months after the presentation to determine if behavior and attitudes towards ground water pollution prevention has changed.

A8.0 SPECIAL TRAINING REQUIREMENTS

Principle investigators for this project require degrees in biological sciences.

A9.0 DOCUMENTATION AND RECORDS

Data acquired with this project will be following formats according to the type of data and intended use.

Data type	Primary reporting format	Computer format	Final reporting format
Water quality laboratory analysis	Laboratory report sheets, computer diskette	MicroSoft Excel	Tables, graphs, etc.
Water quality laboratory analysis - Field blanks duplicates and spike samples	Laboratory report sheets, computer diskette	MicroSoft Excel	QA summary tables

DATA ACQUISITION

B1.0 SAMPLING PROCESS DESIGN

SAMPLING DESIGN

The purpose of this program is strictly well owner education. The Oklahom*A*Syst program will demonstrate to homeowners the importance of proper well care and construction. As an incentive to attend the seminar Oklahom*A*Syst will either conduct water quality testing. Variables which will be tested include pH, conductivity, and nitrates. Each homeowner who attends the seminar will be allowed one sample of water tested.

B1.1 PROJECT ACTIVITIES AND TIME TABLE

The Farm & Ranch *A* Syst portion of the project was piloted in two counties (Lincoln and Caddo) in 1995. The Home*A*Syst portion of the program was developed in 1996. Eight counties were added in 1996, with two or more meetings in each county. In 1997, five additional counties were added. An additional five or six counties will be added to the program per year, funding permitting.

B1.2 PROGRAM SITE SELECTION

Oklahom*A*Syst meetings may be scheduled in counties where local county Extension staff, Conservation District staff, or other agency personnel have identified a critical population of private well owners. Priority for well owner educational programs will be given to locations where local personnel can arrange suitable meeting locations, advertising, and linkages with interested citizen or private sector groups to ensure reasonable success of the program.

B2.0 SAMPLING METHODS REQUIREMENTS

The following sampling method will allow homeowners to become familiar with the quality of their source of groundwater. It will also provide recommendations which will be helpful in deciding if the water coming from their tap is drinkable. The well sampling for this project will be completed by the homeowners themselves. Consequently, the accuracy of our results are dependent upon the techniques the homeowners utilize to complete their well water collections.

Homeowner Well Water Sample Procedure: Homeowners will bring a clean quart jar or larger sample of well water to the seminar to be tested by project personnel for nitrates, pH, and conductivity.

Seminar Testing: Conductivity and pH testing will be completed using a Jenco Model 1671 Conductivity/pH Meter following methods set forth in 2510B and 4500H-B. Nitrates will be completed using a ATI ORION Model 93-07 pH/ION Meter following EPA approved alternative methods set forth in 56 FR 50758.

B4.0 ANALYTICAL METHODS REQUIREMENTS

Analysis of well owner samples at the Oklahom*A*Syst workshops will be the responsibility the Oklahom*A*Syst Program and/or OSU Cooperative Extension. Conductivity and pH testing will be completed using a Jenco Model 1671 Conductivity/pH Meter following methods set forth in 2510B and 4500H-B. Nitrates will be completed using a ATI ORION Model 93-07 pH/ION Meter following EPA approved alternative methods set forth in 56 FR 50758.

B5.0 QUALITY CONTROL REQUIREMENTS

Nitrate spikes and duplicates will be analyzed for every 10 samples assessed during the workshop water quality analysis.

B7.0 INSTRUMENT CALIBRATION AND FREQUENCY

Calibration of field equipment used during the Oklahom *A* Syst program is the responsibility of Oklahom*A*Syst and/or OSU Cooperative Extension. Variables assessed during the well-owner education seminar includes conductivity, pH, and nitrates. Calibration of laboratory equipment used at the seminar will be completed by the Oklahom*A*Syst laboratory technician and will follow manufacturer instructions. The nitrate, pH and conductivity meters will be calibrated before each meeting where samples are tested. Any recalibration during the course of testing will be as required in accordance with the manufacturer's recommendations based on the results of spiked and duplicate sample testing.

B8.0 INSPECTION /ACCEPTANCE REQUIREMENTS FOR SUPPLIES

All supplies upon receipt are inspected for completeness and integrity. All reagents are checked for expiration dates and shelf life. Damaged, incomplete and expired supplies will not be used and will be returned to the supplier.

B9.0 DATA ACQUISITION REQUIREMENTS

Data acquired for use in this project from other projects or from outside sources will be reviewed for completeness, quality and how it meets with the data quality objectives. All data from outside sources will be cited appropriately.

B10.0 DATA QUALITY MANAGEMENT

The information resulting from the water analyses at Oklahom*A*Syst public meeting are for educational purposes only. The results are the property of the well-owner and will be reported to the owners at the end of the meeting. No individual data will be retained by the Oklahom*A*Syst project. In order to assure proper laboratory procedures are followed, and to document the extent of the educational program a standard laboratory notebook will be maintained. The results of analyses at each meeting will be recorded by sample number, with no ownership attributed.

ASSESSMENT/OVERSIGHT

C2.0 REPORTS TO MANAGEMENT

Quality assurances reports will be sent to the EPA Region VI project officer through the Office of the Oklahoma Secretary of the Environment. The quarterly reports will include: status of the project, results of performance and system audits, results of data quality assessments and significant quality assurance problems and solutions.

DATA VALIDATION AND USABILITY

D1.0 DATA REVIEW, VALIDATION AND VERIFICATION REQUIREMENTS

Acceptance criteria for water quality data resulting from spiked and duplicate samples will follow Table 1020:I of Standard Methods (APHA,AWWA,WPCF. 1992.). All data for a specific parameter for a given set of samples will be considered suspect if spike recovery or duplicate analysis result in figures exceeding the criteria in table 1020:I.

D2.0 VALIDATION AND VERIFICATION METHODS

Through the data management process as described in Section B 10 data are reviewed several times. Data validation is an integral part of this process. The mechanism of this process is already described in B 10. For spiked samples the percent recovery of a known addition to a sample will be calculated, and for duplicates the difference as the percentage of the mean will be calculated (Table 1020:I of Standard Methods (APHA,AWWA,WPCF. 1992.)). All data will be routinely reviewed for abnormalities, inconsistencies, or unusual results. If any of these occur, the data will be traced back to look for possible causes of the error. In the event that no error is found, the data will be assumed to be normal and appropriate for use in project reports and in decision making. If an error is found and no resolution can be arrived at concerning its source or cause, the data will be discarded.

D3.0 RECONCILIATION WITH DATA QUALITY OBJECTIVES

The objective of this Quality Assurance Project Plan is to provide data consistent with the work plan that is as complete as possible with the precision and accuracy necessary for meaningful interpretation. The data must also be representative of the activity performed. These data will primarily be utilized for educating homeowners. The samples are not collected or tested under controlled laboratory conditions.

The primary measure of success will be changes in the attitudes and behavior within homeowners who attend Oklahom*A*Syst programs.

These factors will be documented as part of the project and will also serve to document or qualify success of the project.

D4.0 BIBLIOGRAPHY.0

APHA,AWWA,WPCF. 1992. Standard Methods for Examination of water and Waste Water 18th edition, American Public Health Association, Washington DC.

Christensen, Scott, and A. Rea. 1993. Ground water quality in the Oklahoma City Urban area. In Regional Ground-Water Quality. Van Nostrand Reinhold. NY, NY.

Cuperus, G.W., J. Pruitt, and K. Pinkston. 1992. Extension Entomology at a Crossroads. Amer. Entomol. 38:78.

D5.0 APPENDIX A

Municipal Wellhead Protection Manual For Small Communities

A Guide for City Managers and Public Utility Managers

"Wellhead Protection Education for Communities and Homeowners"
CWA Section 319(h) FY 1997

Nonpoint Source Pollution Program Task 900
Oklahoma Conservation Commission Task #94

OSU Project Account AC-5-90310

Prepared by

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Oklahoma Cooperative Extension Service
Water Quality Program Coordinator

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Oklahoma Cooperative Extension Service
Natural Resource Specialist

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Oklahoma Cooperative Extension Service
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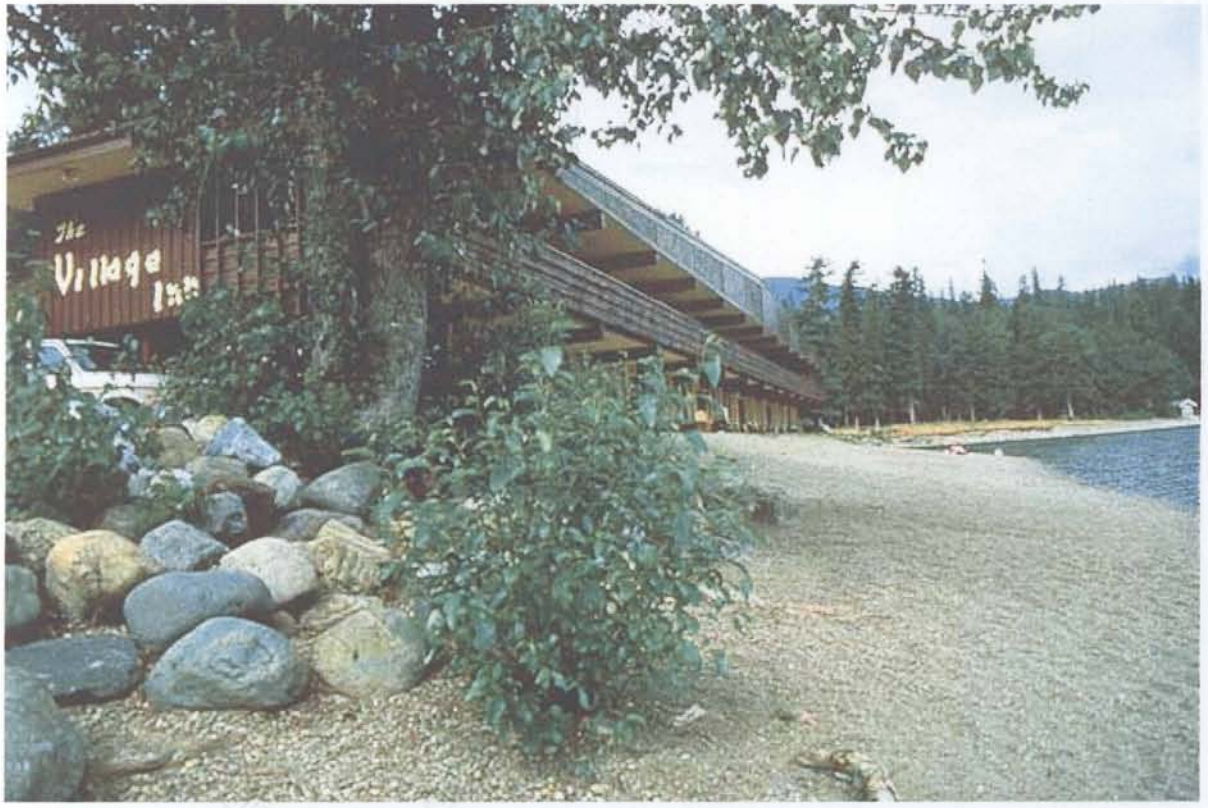
May 2001


The
Village
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