Date of Meeting: <u>December 6, 1999</u>

#1

BOARD OF SUPERVISORS
LAND USE COMMITTEE
ACTION ITEM

SUBJECT: **PRELIMINARY GROUNDWATER ADVISORY COMMITTEE REPORT**

ELECTION DISTRICT: **CountyWide**

CRITICAL ACTION DATE: **At the pleasure of the Board.**

RECOMMENDATIONS:

Staff: Should the Board desire to endorse and proceed with the Groundwater Advisory Committee's Phase II recommendations, staff would recommend the County Administrator be directed to develop an enhancement to be considered by the Board of Supervisors during its FY 01 and 02 biannual budget process.

Groundwater Advisory Committee: The Groundwater Advisory Committee recommends that the County proceed with Phase II of the attached Preliminary Groundwater Report.

BACKGROUND:

On October 5, 1999 the Land Use Committee appointed an ad-hoc Groundwater Advisory Committee (GAC) to collect the necessary data to determine the appropriate action to address the groundwater resource issue. The committee has developed the attached preliminary report that reflects a three-phase approach to meet the objectives of this effort.

ISSUES:

<u>Phase I</u> is identified as GAC's efforts to date whereby available information was used to produce the following findings:

- Availability of groundwater is directly related to the geological makeup of a particular area within the County;
- The County has in place substantive ordinances and regulations regarding groundwater;

ALTERNATIVES:

1. The Board may endorse the GAC's preliminary report and direct staff to proceed with the preparation of the necessary budget enhancement package.

2. The Board may defer action on the GAC's preliminary report at this time.

DRAFT MOTIONS:

1. I move that the Land Use Committee recommend that the Board of Supervisors endorse the Groundwater Advisory Committee's Preliminary Report and direct staff to include the necessary enhancements in the upcoming biannual budget process to support the Phase II recommendations; or

2. I move that the Land Use Committee recommend that the Board of Supervisors defer action on the recommendations made by the Groundwater Advisory Committee.

ATTACHMENT: Preliminary Groundwater Report

Staff Contacts: Linda Erbs-Nagy, Building and Development
Alex Blackburn, Building and Development

BOS Land Use Committee
December 6, 1999

Preliminary Analysis of Groundwater Issues in Loudoun County, Virginia

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Prepared by

Groundwater Advisory Committee

December 1999

ATTACHMENT 1

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I. Introduction and Summary

The Land Use Committee of the Loudoun County Board of Supervisors appointed a "Groundwater Advisory Committee" (GAC) in October 1999, whose members are listed in Table 1.

The Land Use Committee requested that the GAC undertake the following tasks:

- Analyze existing and projected groundwater quantity and quality conditions as available resources permit and current science allows;
- Identify potential problem areas that require the Board's attention;
- Recommend both short and long-term and/or phased action plans and program strategies, such as funding and implementation tools, to address identified issues;
- Address future long-term planning issues to address the preservation of groundwater resources; and
- Recommend adjustments to current policies and ordinance criteria as deemed appropriate.

In this preliminary report the GAC discusses the work accomplished to date on the above work tasks, including recommendations for additional activities. The key elements of this work are summarized below under the headings of "key findings" and "recommended action plan."

Key Findings

The GAC has conducted a brief and preliminary investigation of groundwater issues in Loudoun County. Emphasis was placed on review of existing information. The key findings of these investigations include the following:

1. Groundwater in the county is contained primarily in fractures in bedrock and in solution channels, with lesser amounts in sapprolite. There are significant quantities of groundwater in the bedrock, but groundwater availability ranges widely depending on the size and interconnection of fractures and other underground openings.

2. The quantity of groundwater available for use without depleting the resource depends on the rate of recharge of such water and the amount of aquifer storage available. The rate of recharge is primarily dictated by the amount of precipitation, the topography, and the permeability of soils and bedrock in the County.

3. A large amount of groundwater quantity and quality data is available in Loudoun County's Geographic Information System (GIS) or in paper form in the County Health Department files. This "hydrogeological data base" includes such items as well depth, water yield, geologic type, topography, bacterial information, and some 97 chemical parameters. Several thousand wells are involved. Due to staffing limitations this data has not been updated or analyzed for several years.

4. The County does not have in place a system for monitoring groundwater levels and related streamflows.

5. Water recharge mechanisms in the County need to be better understood, which, among other things, will require measurement of streamflows.

6. There is no integrated County program to deal with groundwater quality, which may be affected by underground storage tanks (USTs) as well as fertilizers, pesticides, and other stormwater runoffs. Groundwater quality is partially addressed by County and state sewage disposal systems standards, and certain State programs dealing with USTs. Surface water quality is addressed to some extent by volunteer sampling efforts through the Soil and Water Conservation District.

7. The recent drought has offered an opportunity to evaluate what problem or vulnerabilities may exist within the County's current water planning activities.

8. The current use of numerous individual wells, as opposed to public wells, may not be the most technically or environmentally sound approach in new housing developments which are based on groundwater supplies.

Recommended Action Plan

The work contained in this report was conducted over about a six-week time frame and is thus very preliminary. This work can be referred to as Phase I of what is recommended to become a three phase program. It is recommended that the Phase II work include the following items:

- Update the County's hydrogeological data base by analyzing and incorporating data collected during the past several years. Furthermore, these data files should be compiled, evaluated, and reviewed with the objective of assessing the status of Loudoun County's groundwater resources. The results of such an evaluation would form the technical basis for conducting future action items, such as those described below.

- Develop a detailed description of a county groundwater and stream monitoring plan as needed to assess fluctuations in groundwater levels as a function of such items as precipitation amounts and land use changes. This monitoring system would likely include additional groundwater monitoring wells placed strategically throughout the County as well as systems for measuring streamflows. Maximum use should be made of the current hydrogeological data base as well as existing wells available to the County.

- Investigate the effect of the recent drought with respect to major problem areas, including water deficiencies and impacts on existing wells.

- Consider the potential need for new groundwater policies. Additional policies may be needed to address such issues as wellhead protection, surface water and groundwater quality, land use issues, and regional impacts of groundwater withdrawal.

- Explore the availability of State, Federal, and other funding which could be used to execute the work resulting from Phase II.

Phase II is expected to take about one year to complete, and will require additional county staff and other resources. The technical and policy information developed in Phase II would be used to carefully plan the Phase III activities.

Phase III would likely involve the installation and use of required groundwater monitoring systems, development of required predictive tools, ongoing maintenance of the hydrogeological database, and potential Board action on new groundwater policies.

Table 1

Loudoun County
Groundwater Advisory Committee

J. Winston Porter, Chairman

Marion Czarnecki, Vice Chairman

Charles A. Appel

Eric Deaver

James Emery

Thomas Foggin

Bruce Gilbert

Otto Gutenson

Dale Hammes

Tom Lancaster

David Nelms

Jerry Peaks

Newell Trask

David Ward

Roger Wolff

II. General Groundwater Situation

Approximately 40-50 percent of Loudoun County residents depend on groundwater wells for their water supply. Several thousand residents have their own water wells. Others, primarily in the towns of Middleburg, Hamilton, Purcellville, Round Hill, and Lovettsville, receive their water from community groundwater wells.

All groundwater is part of a complex system involving the water itself, the rocks and unconsolidated materials in which it occurs, and the influences of human activities. Changes to any part of the system, such as withdrawal through pumping, will affect the other parts. Management of groundwater in a sustainable mode requires an understanding of the functioning of each part of the system. Figure 1 shows schematically the basic components and processes in a groundwater system. There is no easy and direct answer to the question of how much pumping a groundwater system can sustain; each component of the system needs to be looked at and value judgments arrived at as to what degree of change is acceptable (Alley and others, 1999).

In this section a brief description is first provided of important geological and hydrological features which influence groundwater supplies in Loudoun County. Following this description is a summary of the groundwater uses in the County.

Geology of Loudoun County

Loudoun County lies within two of the major physiographic provinces of the southeastern United States. The Blue Ridge Province on the west is separated from the Piedmont Province on the east by a major fault within the County which extends approximately from Point of Rocks, Maryland to Gilberts Corner on Route 50. The soils and bedrock in the two provinces differ in important ways that affect the occurrence and flow of groundwater. A summary of the geohydrologic setting and an explanation of hydrologic terms were provided in "Interpretive Guide to Geology and Groundwater in Loudoun County, Virginia" (Department of Environmental Resources, 1993).

The surface of Loudoun County is covered with soil, consisting of partially weathered and broken bedrock, clay, silt, and organic matter necessary to support plant life. Underneath these soils are solid bedrock, with the depth to such rock ranging from the ground surface, to more than 200 feet. In the Blue Ridge province (primarily in Western Loudoun) the depth to rock is typically about 10-40 feet. In the Piedmont province, depth to rock is usually less than 10 feet.

The soil layer contains significant amounts of groundwater in some places, but this shallow supply is not typically used due to the possibility of shallow wells being contaminated by septic tanks or other waste sources. However, the soil layer plays an important role as a reservoir and filter for water that moves downward and into fractures in the underlying bedrock.

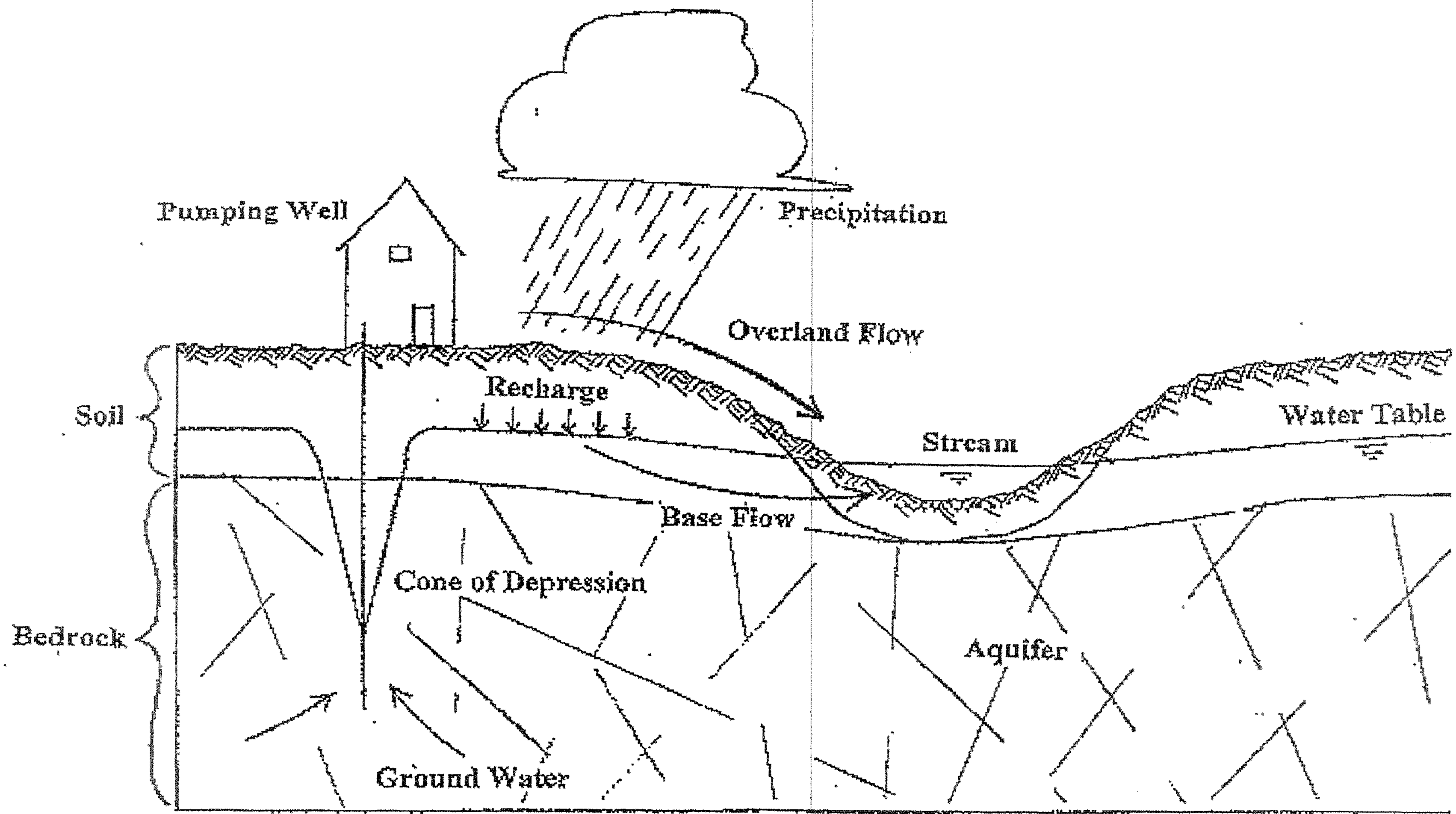

Figure 1: Components of a Groundwater System.

Thus, the groundwater supply of Loudoun County is largely drawn from wells completed in the bedrock underlying the surface soils. These bedrock materials are briefly outlined below.

The bedrock of Loudoun County was mapped in the 1980s by the U.S. Geological Survey; the resulting map shows the distribution and properties of all major rock units. An up-to-date digitized version of the geologic map of the County has been published (Southworth and others, 1999)

Blue Ridge Province

Bedrock in the Blue Ridge Province of western Loudoun consists of folded and uplifted metamorphic rocks. The most widespread rock units are 1) granitic gneiss and related rocks that form the floor of the Loudoun Valley and 2) the Catoctin Formation which occurs within the ridges bounding the Valley - Blue Ridge Mountain, Short Hill Mountain, Bull Run Mountains, and the Catoctin Ridge (Southworth and others, 1999).

These rocks were folded and metamorphosed at great depths within the earth millions of years ago. In more recent geologic times, they were cooled, uplifted, and partially eroded. As the rocks cooled and moved upward, they developed fractures, and the fractures are where ground water occurs now.

Piedmont Province

Bedrock in the Piedmont Province in eastern Loudoun County consists of sedimentary rocks including siltstone, shale, sandstone, and conglomerate; igneous rocks including diabase and basalt, and contact metamorphic rocks, mostly hornfels. The sedimentary rocks were deposited in a shallow basin (the Culpepper Basin) which formed in response to the opening of the Atlantic Ocean in early Mesozoic time. Following deposition and consolidation, the sedimentary rocks were stretched apart under continued expansion of the earth's crust, broken by faults, and tilted as they were forced to accommodate the increasing volume of the shallow crust. Diabase intrusions and basalt flows formed during this time, and heat from these igneous rocks baked adjacent areas of the shale and siltstone into hornfels (Southworth and others, 1999).

An area of special concern for land use professionals regarding groundwater occurrence is the Leesburg Conglomerate Member of the Balls Bluff Siltstone. It occurs in a relatively narrow band in and around Leesburg and extending north between Catoctin Ridge and the Potomac River.

Groundwater in Loudoun County

As described above, Loudoun County is underlain by hard bedrock that is sparsely to highly fractured. Potable water is located mainly in the bedrock fractures.

Groundwater in the Blue Ridge (Western Loudoun)

As the metamorphic rocks in the Blue Ridge were uplifted and cooled they developed fractures, and the fractures are where groundwater occurs now.

The distribution of porosity in groundwater systems governed by fractures is highly irregular. This property makes location and prediction of good groundwater yields from drilled wells very difficult. Dry holes and wells with adequate yields may lie very close to one another as one may traverse a fracture system while the other does not. Detailed studies elsewhere of fractured granitic intrusive and metamorphic rocks, such as occur in the Blue Ridge province of Loudoun County, suggest two important properties (Hsieh, 1996):

- The bulk of the water flow is in zones of closely spaced fractures or fracture zones, not in individual isolated cracks. The fracture zones are highly irregular. Fracture zones come in and fade out over space and they may or may not be plugged with secondary minerals.
- Some highly productive fracture zones are subhorizontal and cannot be observed by linear features on the ground surface.

Groundwater in the Piedmont (Culpeper Basin) (Eastern Loudoun)

Ground water in the complex mix of rocks in eastern Loudoun County occurs in pore spaces, minor joints and fractures, and solution channels. The diabase intrusions bear very little water. Soils developed on the rocks of the Culpepper Basin are typically poorly drained; they are not well suited to agriculture or to the placement of properly functioning septic drain fields (Interpretive Guide to the use of soils maps, LCV, updated 1999).

The abundance of carbonate fragments in the Leesburg Conglomerate and the presence of carbonate cement in the matrix give it many of the properties of pure limestone and dolostone rocks such as occur in the Shenandoah Valley. The relative solubility of the carbonate can result in underground openings, sink holes, and collapse. Springs and sink holes are common at many points in the outcrop band of the Leesburg Conglomerate along Route 15. Very high yields in some wells drilled into the conglomerate indicate the likely presence of solution channels. These channels can provide high groundwater yields but also afford ready avenues by which surface contamination can migrate downward into groundwater sources.

Groundwater Recharge

Groundwater is recharged (replenished) by surface water infiltrating through soils and through fractures, joints, and pore spaces in the rocks. This process is called groundwater recharge. Several factors affect recharge and recharge rate including:

- the volume and duration of precipitation
- permeability of the soils and rock
- topography
- degree of fracture to fracture interconnection

Areas with good groundwater recharge in Loudoun County could be characterized by considerable rock fracturing and deep permeable soils allowing water on the ground surface to infiltrate (LC Groundwater Recharge Map #PDRP-012).

A rough estimate of the net amount of recharge to a groundwater system in a watershed can be made by considering stream flow. Precipitation runs into streams directly from overland flows and indirectly after passing through the groundwater system (figure 1). Streams continue to flow in the summer months long after overland flow ceases. The magnitude of this flow, termed base flow, can be roughly correlated with overall recharge to the groundwater in the watershed.

Such an analysis was made for the stream flow in Catoctin Creek at the Taylorstown gaging station for the period 1981-90, yielding a recharge rate of 8.95 inches per year (Rutledge and Mesko, 1996; Powell and Abe, 1985). Comparable rates have been obtained at other locations in the Blue Ridge province (Powell and Abe, 1985). To appreciate the implications of this rate, consider that if 9 inches per year of water is recharged on a 3-acre lot, and if all of that water is available for discharge to a well, it could provide 2000 gallons per day of water. Of course, not all of the water that enters the soil on a lot will make its way to a well, and the rate of recharge would be considerably less during periods of drought.

Groundwater Users in Loudoun County

There are about 12,000 private wells serving individual homes, primarily located in Western Loudoun County. In addition, there are approximately 234 public use wells (commmunity and non-community) serving towns, schools, private subdivisions, restaurants, gas stations, etc. in Loudoun County. In Table 2 more detail is provided for the community well systems for the Western Loudoun towns of Middleburg, Round Hill, Hamilton, Purcellville and Lovettsville.

Finally, Loudoun has about 98 irrigation wells and 13 industrial wells. These are often non-potable water sources and are used for industries such as concrete plants or irrigation of golf courses.

Table 2—Town Groundwater Systems

	LOVETTSVILLE Mayor Elaine Walker Bill Nester (882-5788)	MIDDLEBURG Alice Love (687-5152)
What is the Town's water service?	Wells.	Wells.
If using wells, how many does the Town operate?	3 (originally operated 5 wells, one caved in and one stopped yielding, so they were closed).	2 ground wells. They were originally operating 3 wells until the wells were tested and one well was discovered to contain radon. They closed that well in 1991 and drilled a new well which also had the same radioactive qualities. As a result, the new well was never put into operation. They are hoping to resolve the problem and reopen a third well next year.
What is the average depth of wells?	Well #3 was 400' is now 200' - pump set at 193' Well #4 is 235' - pump set at 189' Well #5 is 705' - pump set at 340'	1 well is 350' deep, the other well is 685' deep for an average of 518'.
How much water is the Town currently using? (Average # of gallons per house/#of subscribers)	319 water connection – population 833. Monthly average for January, which was their highest usage month, and October which is lowest usage month thus far. **January** 3,131,200 gallons (total) 724,970 gallons (used for backwashing) 2,406,230 gallons (total used by Town customers) **October** 2,441,500 gallons (total) 377,000 gallons (used for backwashing 2,064,500 gallons (total used by Town customers)	110,000 gallons/420 total customers =262 Gallons Per Day Per Service
Has the Town experienced any problems or concerns relating to water quality?	Treatment of iron and manganese needed with Potassium Permanganate, which removes MGA and Chlorine.	They are in compliance, however, water contains iron and manganese which sometimes causes muddy water, dirty laundry, etc.
Does the Town have any growth projections that would impact the demand for water resources?	Going to loan closure for a new Wastewater Plan to be online in 2001. This will increase capacity from 92,000 gallons to 250,000. This will provide an increase of 320 connections.	No.

Table 2, Continued

	ROUND HILL Tom Bergner (338-7746)	HAMILTON Kay Tewell (338-2811)	PURCELLVILLE Karen McKnight (338-7421)
What is the Town's water service?	Wells.	Wells.	Spring-fed reservoir and wells.
If using wells, how many does the Town operate?	6	9	3 - a 4th is not developed.
What is the average depth of wells?	Wells range from 304' to 600'.	Information unavailable.	2 wells are 450' 1 well is 160'
How much water is the Town currently using? (Average # of gallons per house/#of subscribers)	Based on the middle of August to middle of September billing period, there were 536 water connections (does not include waste water). Usage for that period was 2,688,100 gallons equaling 5,015 gallons per connections.	Information unavailable.	
Has the Town experienced any problems or concerns relating to water quality?	Yes, they are in compliance, however, there are three concerns: 1) one well contains iron and manganese; 2) only one well is chlorinated; and 3) total quantity of water	No major concerns.	Yes. The deeper two wells are treated for MTBC; TCE; PCE; 1, 2 Dichloroethene and CIS with granular activated carbon. Small amount of VOC - below MCL.
Does the Town have any growth projections that would impact the demand for water resources?	Declined to answer as they are currently in litigation.	Not sure - water lines are old and they will be looking into what, if anything, must be done to maintain service.	Conducting a Water Resource Study to find more water. Building Water Treatment Plant which will be a 1 MGD facility.

III. Current Groundwater Regulatory Requirements

Loudoun County has a number of policies and ordinances related to the location, construction and testing of groundwater wells (see Appendix). All the "water systems" are regulated by Chapter 1040 of the Loudoun County codified ordinances. For the purpose of this report, well types are separated into three categories; individual wells serving single dwellings, public wells serving multiple dwellings, schools, restaurants, etc. and industrial/irrigation wells which generally produce non-potable water extracted for use by industry or agricultural irrigation. These requirements are briefly summarized below for different categories of well usage.

Individual Wells on Existing Lots

The local Health Department reviews and permits each individual well location. Wells must be drilled and tested prior to issuance of a building permit. Such wells must produce at least one gallon per minute (gpm) of water and pass a water quality test.

Individual Wells in Subdivisions

Preliminary Hydrological Reports are required for these wells. These hydro reports must be submitted at the preliminary subdivision stage for all proposed subdivisions with any lots measuring less than ten acres in size, except as identified below, where the subdivision contains nine lots or less, is a family subdivision, or has a waiver. These reports are reviewed by the local Health Department. Subdivisions with nine lots or less have the following options: 1) To prepare a Preliminary Hydro Report, or 2) Drill each well and test for quality and quantity in accordance with the requirements of the codified Ordinance for Loudoun County (Chapter 1040-Water). Generally, smaller subdivisions are submitted as a Preliminary /Record Plat with the wells already drilled and tested.

Detailed Hydrological Reports are required in some cases. East of the Bull Run Fault hydro testing is not required except when a subdivision is proposed on Diabase or Basalt. If the proposed development is on diabase or basalt and contains more than 30 lots the hydro test must include drilling and testing for 10 percent of the wells. If less than 30 lots are proposed in the subdivision, there is no requirement for hydro testing.

West of the Bull Run Fault detailed hydro report must be submitted with the Record Plat for all proposed subdivisions with any lots measuring less than ten acres in size, except as identified below where the subdivision contains 1) nine lots or less or, 2) if it is a family subdivision, or 3) if it is a waiver. The detailed hydro report requires a minimum of three (3) test wells and shall be installed on 30% of the proposed lots. Each well is tested for a minimum of 8 continuous hours of pumping. Water level recovery must be measured in each pumping well until the water level reaches 90% of static water level. Water level in two of the closest wells are measured. A minimum yield of one gallon per minute is required.

Public Wells

Public wells require a Hydro Test and a report which must include a 48 hour (minimum) yield and drawdown test with at least two monitoring wells. The local Health Department reviews the well location, completeness of the hydro report, and issues the necessary permit. The Comprehensive Plan calls for Loudoun County Sanitation Authority to provide operation and maintenance of wells once the system has been installed and is approved by the Office of Water Programs.

New groundwater wells for the towns are regulated by the state. The local Health Department also reviews well locations and has additional construction requirements.

Industrial/Irrigation Wells

The local Health Department reviews well location and permit applications as set in Chapter 1040 of the County Ordinance. There are no standards for testing this type of well. There is no State or Loudoun County Sanitation Authority involvement with industrial and/or irrigation wells. However, the Virginia Department of Environmental Quality(DEQ) monitors the volume of groundwater withdrawal on an annual basis.

IV. Potential Problem Areas

There are a number of potential problem areas related to groundwater quantity or quality considerations. The objective of this section is to identify such potential problem areas, and briefly discuss them in a very general way.

Impacts of groundwater withdrawals on the water table

An important problem area has to do with the potential effect of additional groundwater withdrawals on the County's overall groundwater supply. It is not generally known whether additional wells will lower the overall groundwater table, or affect regional groundwater resources.

In consideration of the fact that the Towns (see Table 2) currently have a high demand for groundwater, promoting additional high density growth may have a negative impact on the Towns' ability to produce an adequate water supply. In those areas in which the greatest demand and reliance on the groundwater resource already exists, current land use planning may further stress the resource.

Efforts should be made by the County to work cooperatively with Towns that use significant groundwater in an effort to combine land use planning with well head protection.

There are currently three wells for monitoring ground water levels in the County. One of these wells is located on the west slope of Short Hill Mountain and one is just east of Leesburg. The third well is in the open space of the Telegraph Spring Hamlet, just south of Purcellville. It was deeded to the county, but no data is currently being collected from this third well.

Two of these wells are part of a statewide system maintained cooperatively by the USGS and the Virginia Department of Environmental Quality. This lack of more extensive groundwater monitoring data results in an inability to analyze in real-time the effects that existing groundwater extraction, land use, or weather patterns have on the resource.

Impact of ground water withdrawal on neighboring wells

Even if the regional groundwater table is not expected to be impacted by additional removals, it is possible that there could be localized impacts on existing water wells from new withdrawals. When a well is pumped it creates what is called a "cone of depression," whereby a local reduction in water level occurs, potentially affecting nearby wells.

Currently, applicants for new wells are not required to project potential regional impact of new wells or developments. Furthermore, the policies currently followed by the County allow each "phase" of a development to be analyzed independently and allow the developer to avoid the projection of the impact of the entire development on the groundwater resource even within the confines of its own property boundary.

Impacts on Stream Flows

Depending on general rainfall conditions it is possible for groundwater withdrawals to adversely impact some stream or creek flows in the county, since such surface waters are partially fed by groundwater supplies. Furthermore, stream flow monitoring (especially under drought conditions) can be an accurate measure of the overall effects of long-term extraction of the groundwater resource. Indeed, the effect of groundwater extraction is one of the major issues that must be addressed in a groundwater policy since much of the water extracted is not returned to the streams, especially during droughts.

Currently stream flows are not monitored in a formal way in the County except for gauging stations on Catoctin Creek at Taylorstown and on Goose Creek at Evergreen Mills. Also, St. Louis monitors stream flow at the discharge point of their sewage treatment plant.

Septic Tank Water Quality Issues

In most areas of the county where water wells are used, the wastewater from wells and homes flows to septic tanks. Such septic tanks treat the wastewater by a process known as anaerobic decomposition, which breaks down most of the organic materials. The treated wastewater then flows to a "leach field" whereby the effluents return to the ground, usually about 1.5 to 4 feet below the surface.

If not properly managed and maintained, septic tanks can potentially contaminate both ground and surface waters. If this does occur, potential problems can range from pathogenic bacteria problems to chemical contamination in the form of nitrates or other chemicals.

Currently, Loudoun County addresses such issues by requiring the projection of nitrate loading on the groundwater resource as part of the Detailed Hydrogeologic Study performed for larger subdivisions. For individual well owners, there are no County requirements (other than set-back requirements) to address this issue. This potential problem area, therefore pertains mainly to individual well and septic field owners and their neighbors where homes are closesly spaced.

Runoff of Chemicals

Various fertilizers, pesticides and herbicides are used in Loudoun County by agricultural, industrial, and residential interests. It is possible for such chemicals to seep into the soil and groundwater, or directly into streams and creeks.

Currently, the County relies on the Virginia Cooperative Extension Service and the Soil and Water Conservation District to assist farmers and homeowners with proper applications of lime, fertilizer, and other chemicals. Best Management Practices (BMPs) are required by the County's Facilities Standards manual as part of urban residential and commercial projects.

One area in which additional work may be needed has to do with nitrates entering the groundwater at levels potentially above drinking water standards. Such nitrates can emanate from both septic systems and various fertilizers.

Leakage From Hydrocarbon Storage Tanks

The County has many underground gasoline storage tanks as well as numerous heating oil tanks. The leakage of such tanks can cause various hydrocarbons to enter the groundwater, causing potential taste, and even health, problems.

The nature of the hydrogeology of much of western Loudoun County results in a possibility that some of these compounds may adversely impact the general groundwater supply. Several of the incorporated Towns in western Loudoun County have reported measurable quantities of gasoline components or additives (MTBE in particular) in their groundwater supply. Similar quantities have been measured in some private water supply wells.

The County Fire Marshall has the responsibility within the county to regulate and govern these petroleum storage tanks. However, the Fire Marshall is primarily concerned with fire prevention and may not be fully knowledgeable about the potential impact that releases from these tanks might have on the groundwater resource. For this reason, much of the regulation of these tanks, as well as the remediation of any releases, is driven by State level regulations and enforcement by the Virginia Department of Environmental Quality.

Leesburg Limestone Conglomerate Formation

The effects of continued development in areas underlain by the Leesburg Limestone Conglomerate need to be carefully evaluated. The solubility of this carbonate rock has resulted in the creation of solution channels and sink holes which in turn can lead to construction problems and heightened susceptibility of groundwater to surface contamination.

Public Versus Individual Wells

Due to a variety of regulatory and economic factors private housing developments are generally opting for individual wells and septic tanks for each housing unit, as opposed to community systems.

This type of practice may not be the best approach from technical and environmental standpoints, since each new well can represent an additional conduit for contamination directly to the groundwater. This practice should be investigated further.

Wellhead Protection

Areas around community groundwater wells can be contaminated by many land use activities. It is important that the County carefully analyze its procedures to deal with land use planning issues as they pertain to protection of groundwater quality in the capture zones of public wells.

V. Recommended Approach to Problem Areas

Based on the findings of this preliminary report a recommended action plan is presented to develop a better understanding of both the near and longer term groundwater situation in Loudoun County. Brief discussion are presented below of the primary elements of this action plan.

Updating of Current Hydrogeological Data Base

Loudoun County currently has a large amount of groundwater quality and quantity information in it's GIS and Health Department files. Due to lack of staff resources this hydrogeological data base has not been updated in several years. The most important recommendation is that this data should be updated and analyzed in order to (1) see what conclusions can be gleaned from existing data, and (2) better plan the additional work activities.

Groundwater Monitoring System

A groundwater monitoring system should be developed for Loudoun County. Such a system would allow the county to monitor groundwater levels and take remedial actions in the event of drought or overuse of the groundwater resource.

The approach to this item would involve the identification of existing wells, which could be monitored for groundwater levels, and perhaps also for water quality. After analysis of these wells and their locations additional new wells may be required for a reliable county-wide monitoring system. Surface monitoring stations will also need to be established in order to fully understand the total water resource. There are specific examples of other counties such as Chester County, Pennsylvania that have established similar monitoring programs.

Regional Groundwater Impacts

As the County grows it will be increasingly important to better understand the impacts of new groundwater wells on existing, neighboring wells. This issue is especially important for community wells which are typically pumped at much higher rates than individual domestic wells.

It is recommended that the existing procedures used to evaluate the potential impact of individual developments on the local and regional groundwater resource be scrutinized to address this issue. Some possibilities to consider in such an undertaking could include:

- Requiring subdivision applicants to evaluate the impact to groundwater from potential contaminant sources (not just from the septic fields).

- Requiring a hydrogeologic study of an entire development seeking approval, and perhaps eliminate the "phased" approach currently being employed.

- Requiring demonstration of no detectable impact at the boundaries of a development (i.e., versus off-site monitoring) from the cumulative effects of groundwater extraction within that development.

- Examining groundwater recharge rates versus Land Use policies to evaluate the projected long term effects on a localized basis. The use of simple predictive models could be considered.

Septic Tank Issues

It is recommended that policy changes be considered in view of (1) the expected increase in such tanks, and (2) the older ages of many existing tanks. Some issues to consider include:

- Establishing a management policy to ensure minimum operating and maintenance procedures for on-site sewage disposal.

- Calculation of nitrate loading from certain septic fields.

- Minimizing the density of septic systems when necessary to prevent cumulative nitrate loading.

Other Water Quality Issues

In addition to septic tank contamination, other water quality concerns may include leaking underground storage tanks and infiltration from various agricultural and other chemicals.

While the existence of such a problem may be identifiable through well water quality monitoring, perhaps in conjunction with the above-mentioned monitoring programs, a more preventative program may be called for. For example, the County might consider the analysis of the potential effects of surficial activities on groundwater quality through simple predictive models and perhaps using these results to adjust Land Use policies.

Surface Water Monitoring

Data developed through the monitoring of groundwater levels in wells and recording of precipitation should be augmented with information about surface water flows in selected locations in the County. A countywide stream-monitoring project would close this information-gathering circle and, in addition, could produce valuable information regarding the location and types of non-point sources of water pollution. Such information could support a stream monitoring program to complement more technical studies of groundwater contamination being conducted by the US Geological Survey (USGS) and by local municipal authorities.

Groups of Loudoun Wildlife Conservancy volunteers are currently performing stream testing in several areas of the County with the help of the Loudoun Soil and Water Conservation District. Extension of these efforts to all of Loudoun's major watersheds could likely be accomplished at modest costs.

Wellhead Protection

The USGS is presently engaged in source water assessment, studying sources of community water supplies in Loudoun and in our neighboring counties. Of collateral interest to the USGS is the susceptibility of public water supplies to contamination. The agency's findings should become available in three to four years.

Without waiting for the publication of those findings, the County should consider a program of wellhead protection. This undertaking would need to be supported with hydrogeologic studies to delineate wellhead protection areas for community wells and an active program of public education. It should also be coordinated with the Towns and the LCSA to ensure county-wide implementation.

Appendix

Bibliography of Studies of Groundwater Quality and Quantity in Loudoun County

1. Benegar, JJ, 1996, Groundwater Modeling of Western Loudoun County to Demonstrate Recharge Mapping and Wellhead Protection Planning. Report presented to the Loudoun Co. Board of Supervisors. Contains a summary of transmissivity data for the major rock units of western Loudoun Co.

2. Dept. of Environmental Resources, Loudoun Co., 1993, Statistical Analysis of Groundwater in Loudoun Co. Volume 1: Groundwater Quantity. Unpublished report prepared for the Loudoun Co. Board of Supervisors. This paper focussed on the well yields and depths for the various geological formations and as a function of ground elevation.

3. Johnson, P.M., 1960, Ground-Water Supplies in Shale and Sandstone in Fairfax, Loudoun and Prince William Counties, Virginia, Geological Survey Circular 424.

4. Laczniak, R. J and Zenone, C, 1985, Ground-water resources of the Culpeper Basin, Virginia and Maryland. U. S. Geological Survey Miscellaneous Investigations Series 1-1313-F.

5. Leffel, E.,.1996, Well Water Levels of Fluoride and other Chemicals in Rural Loudoun County, unpublished master's project for Geo. Wash. Univ. Public Health Program. This study attempted to correlate fluoride content of post-1982 wells to soil type and well depth, but did not find any obvious trends.

6. Murphy, JR., 1979, Loudoun County Groundwater - Present Conditions and Prospects, Va. State Water Control Board Planning Bulletin no. 315. This paper describes the natural chemistry and hydrogeology of many of the geologic units, along with a map of groundwater potential as it was understood at that time.

7. Posner, A. and Zenone, C, 1983, Chemical quality of ground water in the Culpeper Basin, Virginia and Maryland, Miscellaneous Investigations Series - U. S. Geological Survey, 1 1313- D. This study took a relatively small number of wells to analyze the natural water chemistry.
8. Ross, B.B., Parrott K.P. and Herbert, N.M., 1995, Evaluation of Household Water Quality in Loudoun Co., VA, Virginia Tech Household Water Quality Series, no. 12. In collaboration with the North Fork Goose Creek Watershed Project, they took 131 household water samples for Fe, Mn, hardness, S04, Cl, F, total dissolved solids, pH, Cu, Na, N03 and total and fecal coliform bacteria. Fe, Mn and coliform bacteria were the primary concerns for most wells.

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10. Alley, William M., Thomas E. Reilly, and O.Lehn Franke, 1999, Sustainability of Ground Water Resources: U.S. Geological Survey Circular 1186.

11. Hsieh, P.A., 1996, An overview of field investigations of fluid flow in fractured crystalline rocks on the scale of hundreds of meters, in Stevens, P.R., Nicholson, T.J., eds., Joint USGS/U.S. Nuclear Regulatory Workshop Commission on Research Related to Low-Level Radioactive Waste Disposal, May 4-6, 1993, National Center, Reston, VA, proceeding: USGS Water-Resources Investigations Report 95-4015, p. 182-185.

12. Loudoun County Department of Natural Resources, 1993, Interpretive Guide to Geology and Groundwater in Loudoun County, Virginia.

13. John D. Powell and Joseph M. Abe, 1985, Availability and quality of ground water in the Piedmont province of Virginia: U.S. Geological Survey Water Resources Investigations Report 85-4235.

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15. Schreffler Curtis L., 1997, Drought-trigger ground-water levels and analysis of historical water-level trends in Chester County, Pennsylvania: U.S. Geological Survey Water Resources Investigations Report 97-4113.

16. Southworth, Scott, William C. Burton, J. Stephen Schneider, and Albert J. Froelich, 1999, Digital Geologic map of Loudoun County Virginia: U.S. Geological Survey Open-file R port 99-150 (Digital compilation by Remo Nardini, Pete Chirico, and Jim Reddy.)

17. N.J. Trask, E.H. Roseboom, R.D. Watts, and M.S. Bedinger, 1986, Exploration of crystalline rocks for nuclear waste repositories: some strategies for area characterization: U.S. Geological Survey Open-file report 86-379.

18. Interpretive Guide to the Use of Soils Maps in Loudoun Cunty, VA. Alex Blackburn, County Soil Scientist, 1999

Ordinances, Regulations, and Policies that Govern the use of Groundwater in Loudoun County

I. **State Regulations** Statewide minimum regulations for sewage and water supplies.

II. **County Zoning Ordinance** Sets the requirements for water supplies needed in each type of zoning such as A-3, Commercial, Villages and Hamlets, etc.

III. **Loudoun County Land Development and Subdivision Ordinance** Defines when wells and drainfields (water and sewer) or Hydro Studies are required in the development process. Refers to chapter 6 of the FSM for study requirements.

IV. **Facilties Standards Manual (FSM—Chapter 6)** Establishes the requirments for Hydro Studies. This is the technical manual.

V. **Codified Ordinance - Chapter 1040** This chapter of the Codified Ordinance sets construction standards for water supplies/wells.

VI. **Loudoun County Well Policy Book** These are Loudoun County Policies that "fill inthe blanks" and define in detail how to abandon wells, termite-treat homes with existing wells, sample wells, etc. within Loudoun County.

All County Ordinances, Policies, and Standards Manuals define criteria that "meet or exceed" the State Regulations.