Groundwater Resources
Wayne County, PA
Planning For the Future

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- Citizen Monitoring Programs

Websites:
http://www.water-research.net
http://www.pacleanwater.org

Keystone Clean Water Team- pacleanwater.org

- Recycle Your Old Phones, Games Systems, small cameras, and iPods.
- Save Energy – Recycle - Support Groundwater Education
- Recycle YOUR Old Cell Phone – Fund Clean Water Education and Testing
- Bring your “Small” Devices to Local Drop Off !

Help Provide Power to 18,500 homes each Year – In Energy Savings

Current Programs

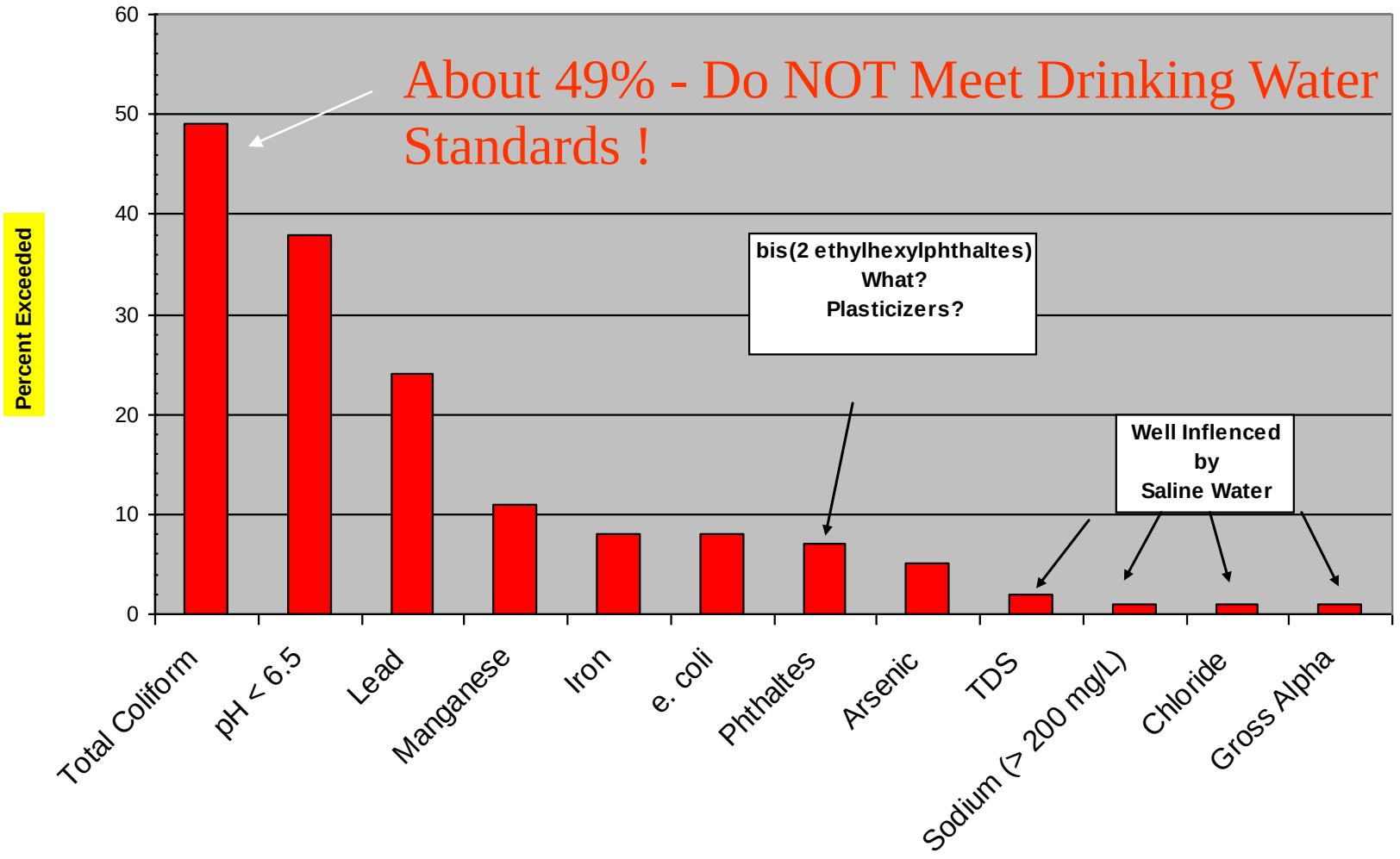
- Private Well Owner Outreach and Education, via KCWT
- Community Health – Healthy Community Database Search for Community Hazards
- Drinking Water App – In Development (Summer 2015)
- Water Quality Index App for Surface Water- In Development (Winter 2015)

Why Be Concerned about Groundwater Quality / Quantity ?

- In Wayne County - 67 % of residents serviced by private wells.
- Private Wells are not regulated by the PADEP or EPA
- Groundwater helps to maintain and sustain recreational areas and habitats, i.e., streams, lakes, wetlands, and most surface water features.
- Over withdrawal or groundwater mining can impact existing and future uses.
- Improper planning can result in groundwater contamination, which can cause a financial burden on individuals, business, and other entities in the County.

	# of homes served by private water systems			Avg. Change in homes served by private water systems per year	% of all homes served by public water	% of all homes served by private water system
County	1980	1990	2000			
Bradford	13,443	16,865	20,287	+342	37	63
Carbon	6,594	12,235	17,876	+564	55	45
Lackawanna	9,952	12,745	15,538	+279	86	14
Luzerne	19,994	24,662	29,330	+467	82	18
Monroe	21,129	37,246	53,363	+1612	32	68
Pike	9,441	16,875	24,309	+743	45	55
Sullivan	2,147	4,727	7,307	+258	13	87
Susquehanna	9,423	15,212	21,001	+579	25	75
Tioga	9,126	11,888	14,650	+276	35	65
Wayne	9,913	19,097	28,281	+918	33	67
Wyoming	7,236	8,657	10,078	+142	27	73
Region	118,398	180,209	242,020	+562	43	57

Baseline Data- Pre-Marcellus Shale Development



Recent Wayne County Water Quality Study

pH – 41 % outside of recommended range

11 samples - < 6.5

3 samples >8.5- Higher pH more As,

Fl, Na, Br, Li, Bo

Methane Present – 66 % of samples, highest value only 3.3 ppm (pH > 7.8)

Arsenic – 6% exceeded standard

Manganese – 3% exceeded standard

Radon – 97 % exceeded low rec. standard of 300 ppb.

Water Allocation Who and What !

- PADEP- Permitting Facilities, System Capacity, Non-Consumptive Use (Quality, Operations)
- DRBC – Consumptive Use, Non-Consumptive Use (Volume), Large Withdrawals and Inter-basin Transfers
- Municipalities and Local Agencies to not Regulation Water Use or Consumptive Use

PADEP Regulates Monitors, and, Oversees the following:

1. Public Water System – has 15 service connections and services at least 25 individuals for 6 months during the year (This could be as few as 7- 3 bedroom homes).
2. Bottle Water Operations, Bulk Water Haulers, and Water Vending Machines
3. Consumptive Use - DRBC

pennsylvania
DEPARTMENT OF ENVIRONMENTAL PROTECTION

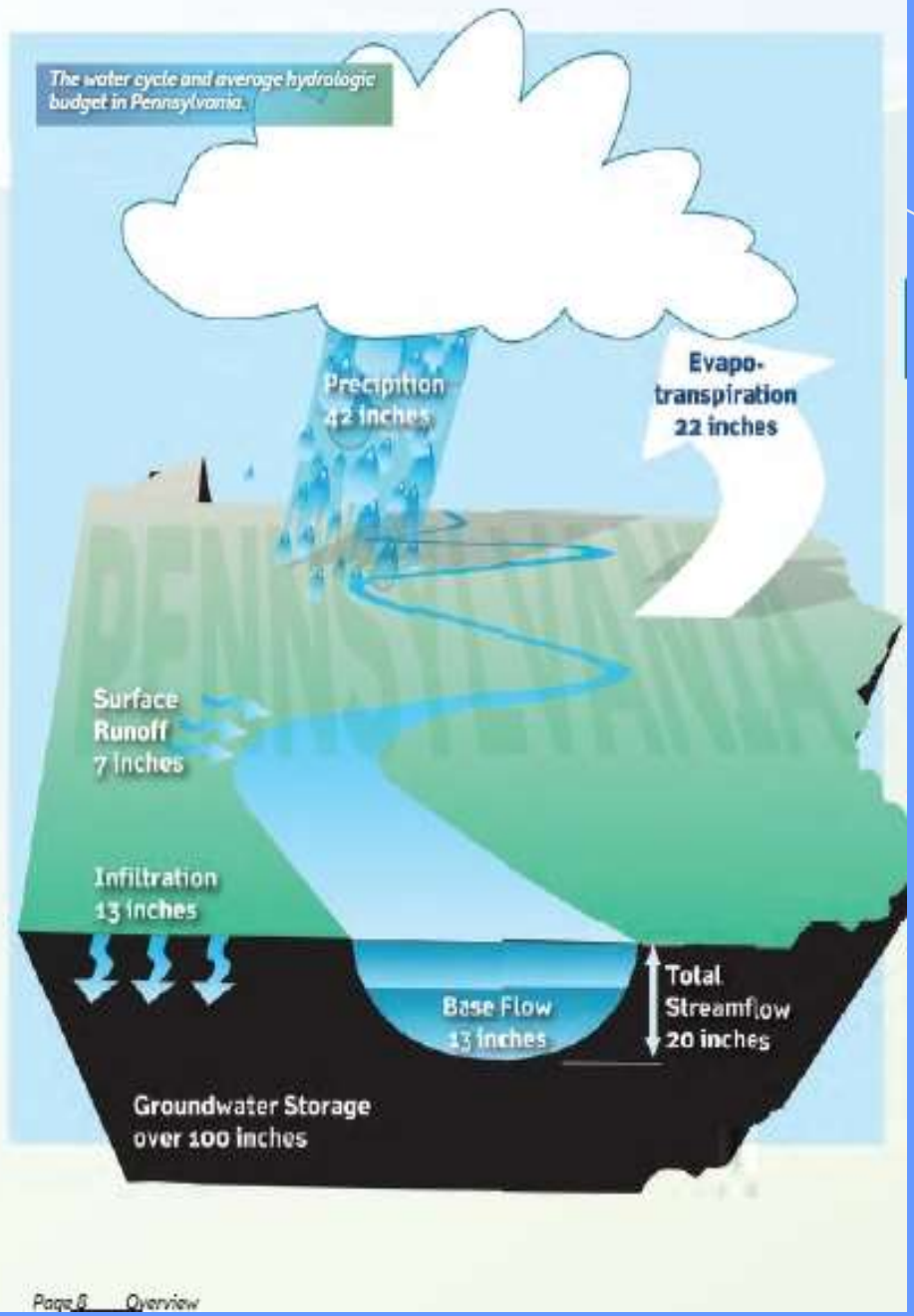
Delaware River Basin Commission
DELAWARE • NEW JERSEY
PENNSYLVANIA • NEW YORK
UNITED STATES OF AMERICA

PADEP
Permits / Regulates Public Systems

In Wayne County, Public Systems service only 33 % of the population.

Keys to Groundwater Resource Management and Planning- Local Agency

- Local or County regulations related to land-use, zoning, and wellhead protection.
- Well Siting, Drilling, and Construction Standards
- Groundwater Availability Analysis for Proposed Subdivisions or Proposed Expansions of Unregulated Water Systems.
- Community Education and Outreach
- Developing a Well Ordinance as part of the Act 537 Plan or Conducting Groundwater Availability Analysis during Planning



Water Budget for PA

In

Precipitation – 42 inches

Out

Evapotranspiration – 22”

Total Streamflow – 20”

Baseflow – 13”

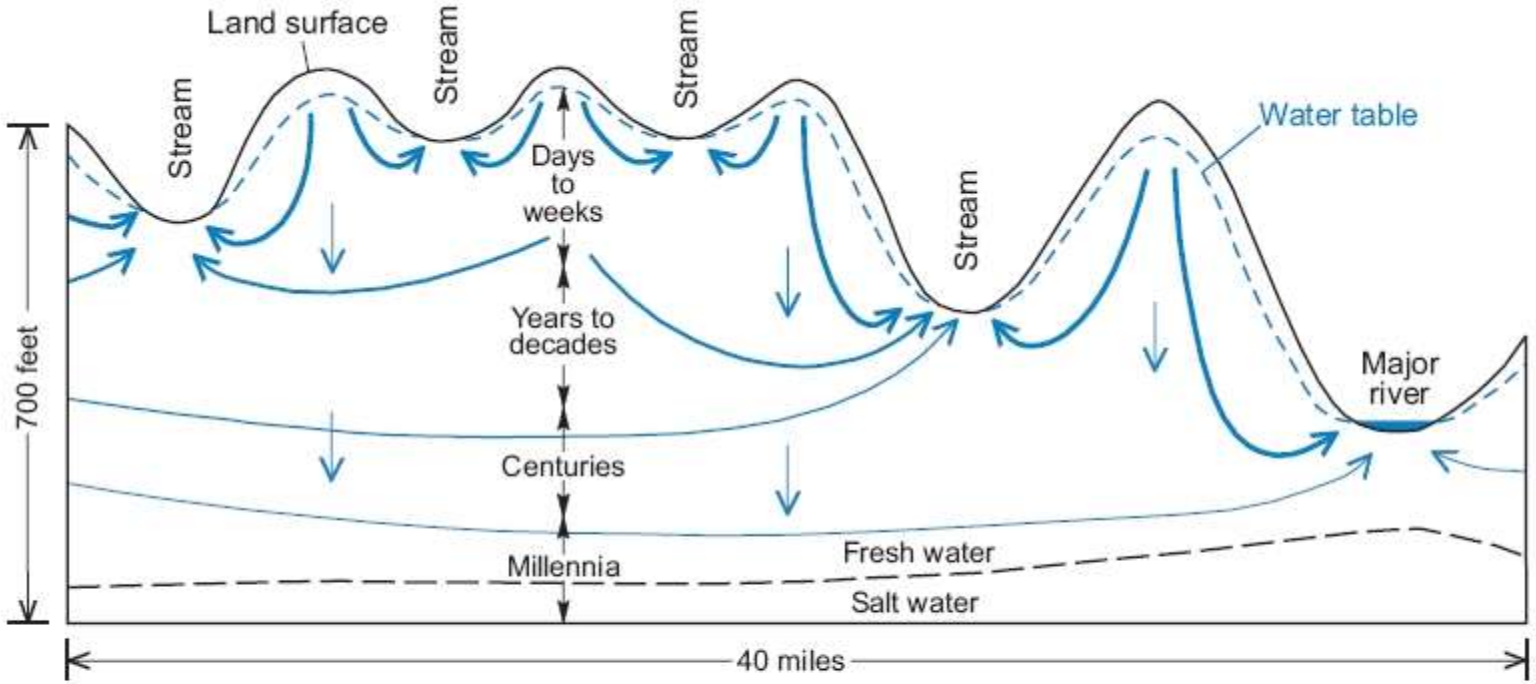
Surface Runoff – 7”

Therefore, 65% of streamflow is groundwater discharge.

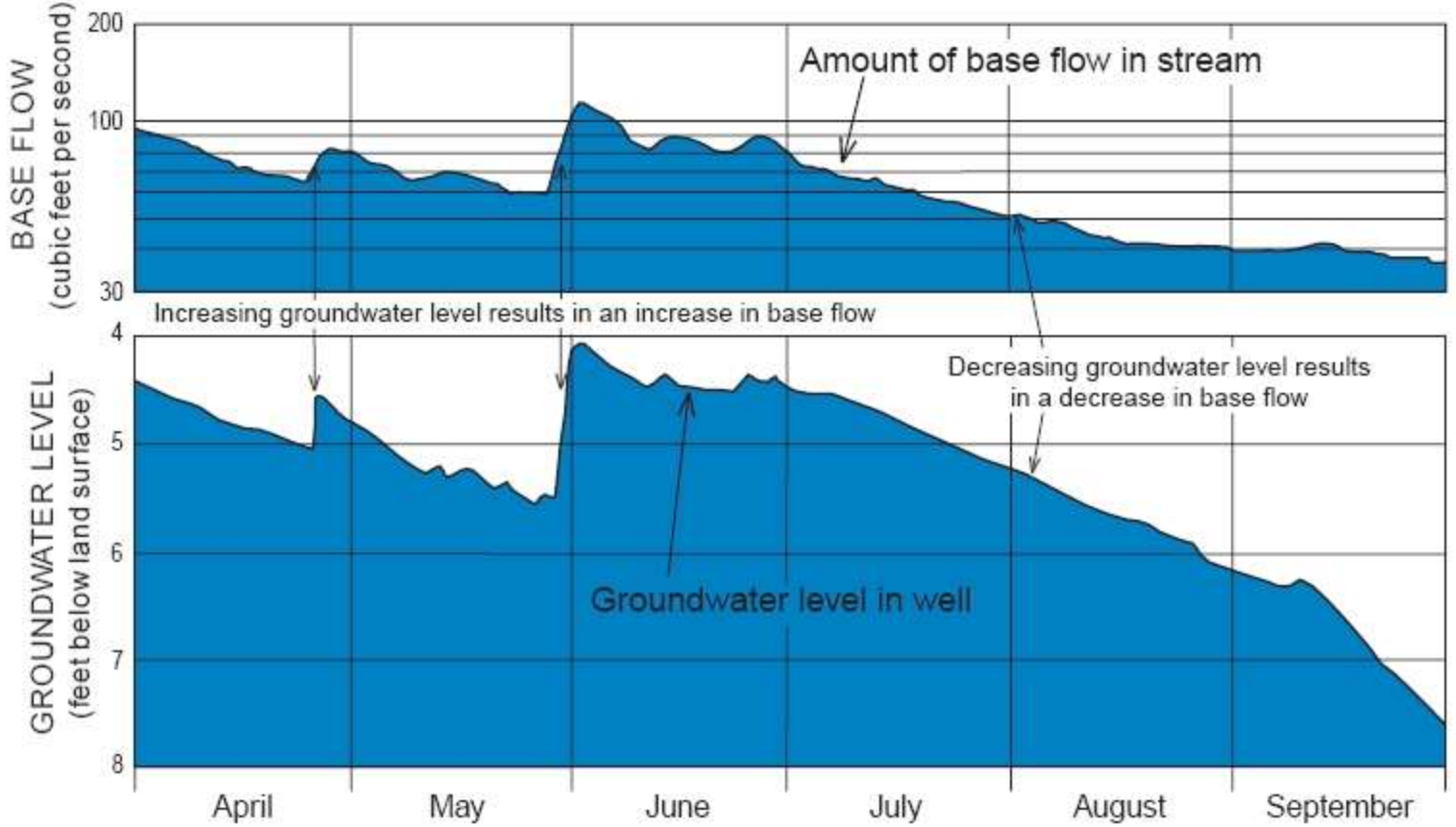
Other

Storage in Groundwater Aquifers over 100 inches*

* This is our “Water” Cushion.



Groundwater flow paths (indicated by the blue arrows). The thickness of the lines reflect the relative amount of groundwater flowing through the groundwater system.


BASE FLOW
(cubic feet per second)
200
100
30
Amount of base flow in stream
Increasing groundwater level results in an increase in base flow
GROUNDWATER LEVEL
(feet below land surface)
4
5
6
7
8
Decreasing groundwater level results
in a decrease in base flow
Groundwater level in well
April
May
June
July
August
September

Contaminated

Not Contaminated

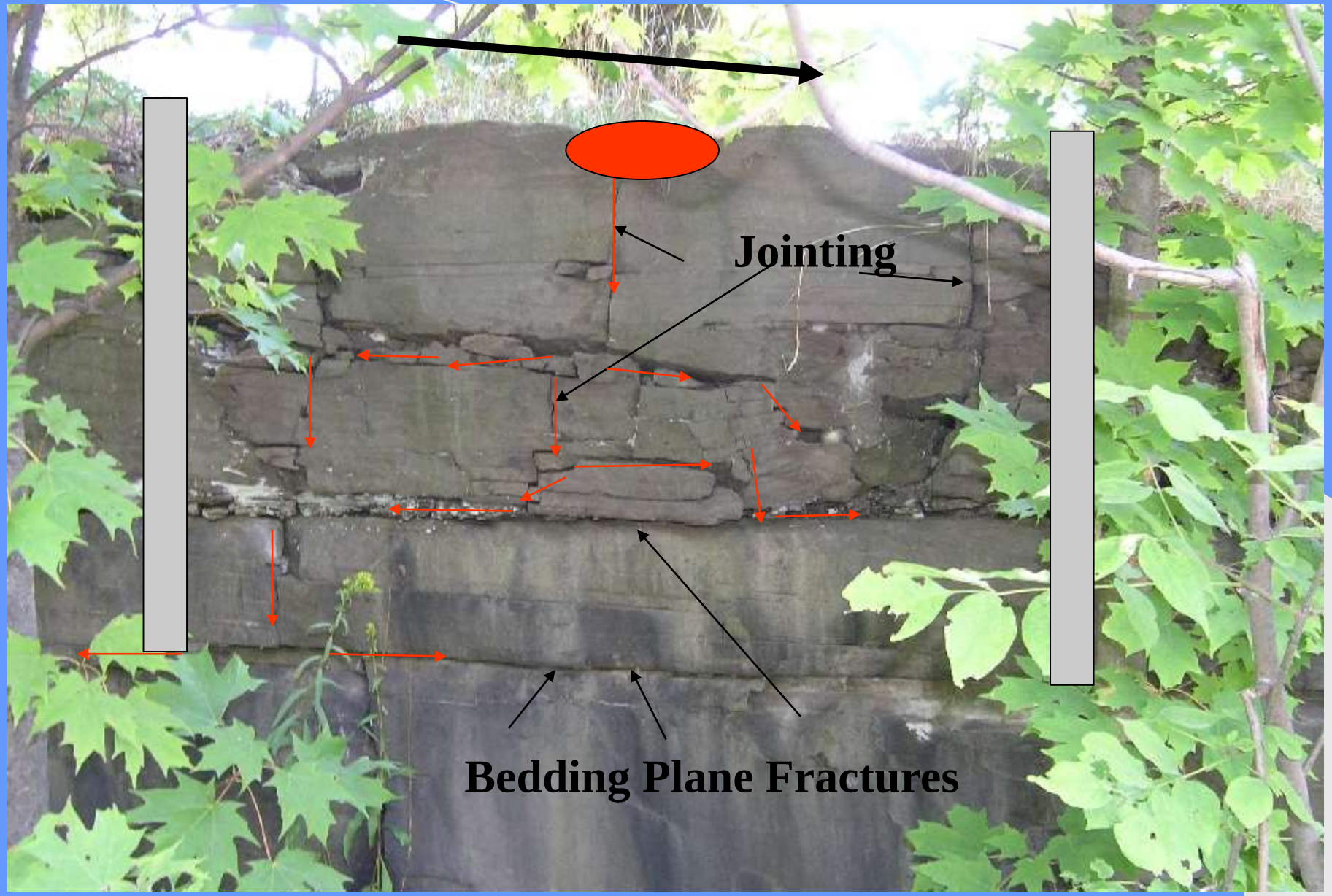


Photo by: Mr. Brian Oram (2004)

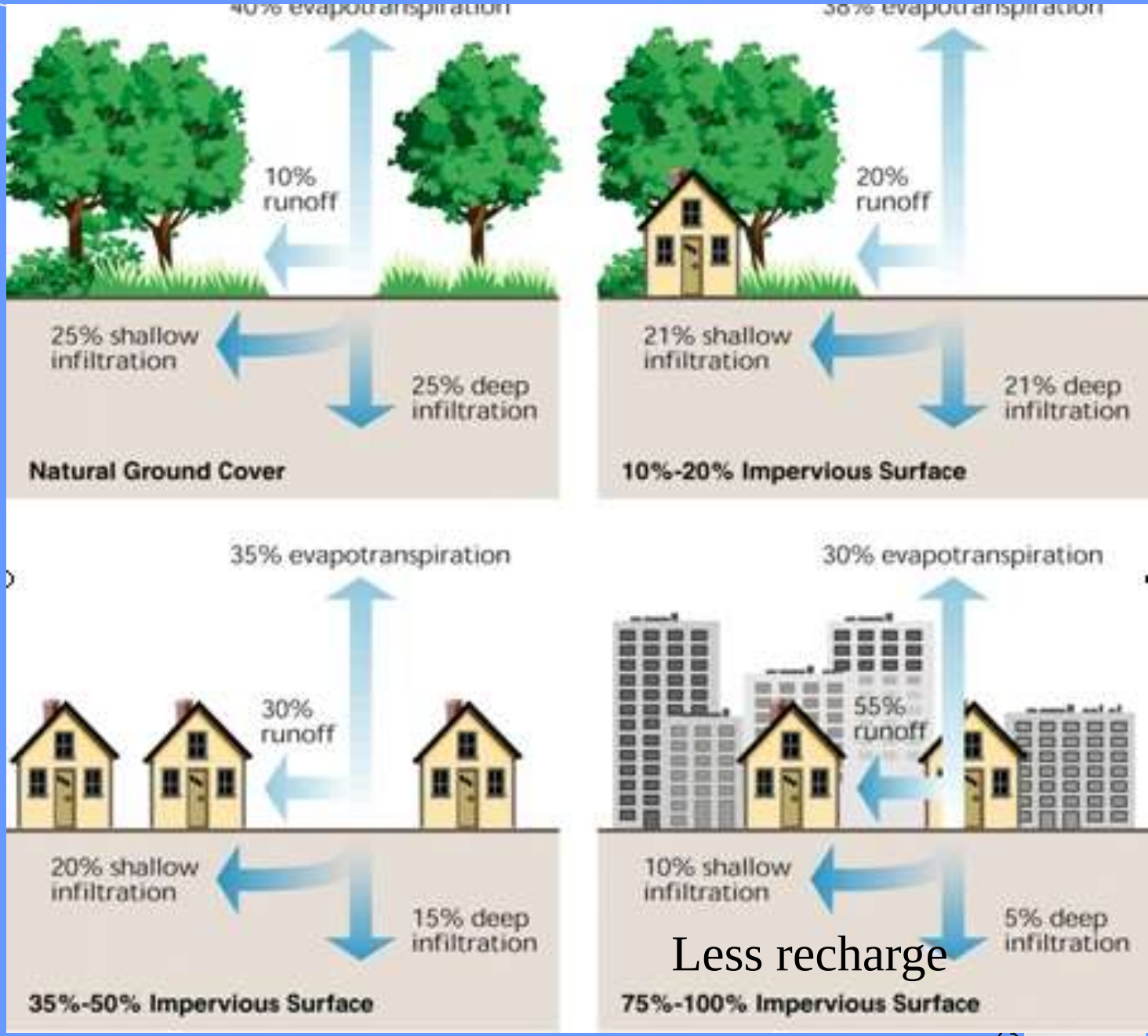
Keys to Wellhead Protection

- Geospatial Information for State and Region
- State Federal and Local Regulations Related to Land-use, Zoning, and Wellhead Protection
- Types of Well Water Sources and Aquifer
- Well Drilling and Construction
- Integrated State, Regional, and Local Agency Planning
- Community Education and Outreach
- GeoSpatial Analysis, Desktop Assessments, Drastic Analysis

Importance of Groundwater Analysis and Planning

- Protect the health, security, and well-being of the current residences and water users.
- Protect the environmental and recreational activities that rely on surface water – Groundwater and Surface Water are linked.
- Protect long-term economic growth by properly managing are resources.
- Evaluate projects to make sure that proposed densities or demands do not exceed the natural recharge capacity of the site.

As the area is converted from a natural woodland, grassland, or forest into developed lands, the amount of groundwater recharge decreases.



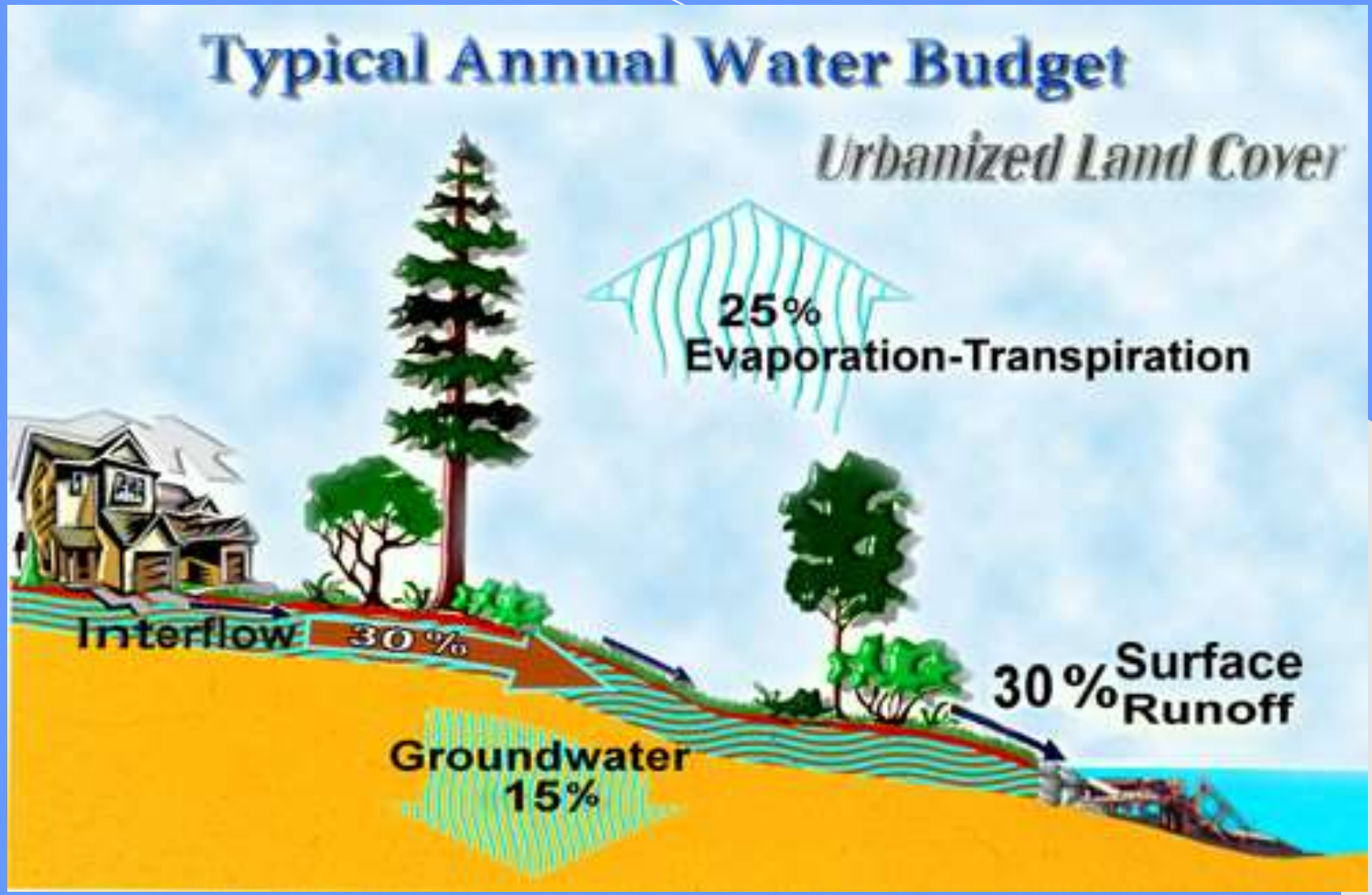
Less recharge

Source: Dr. Dale Bruns, Wilkes University

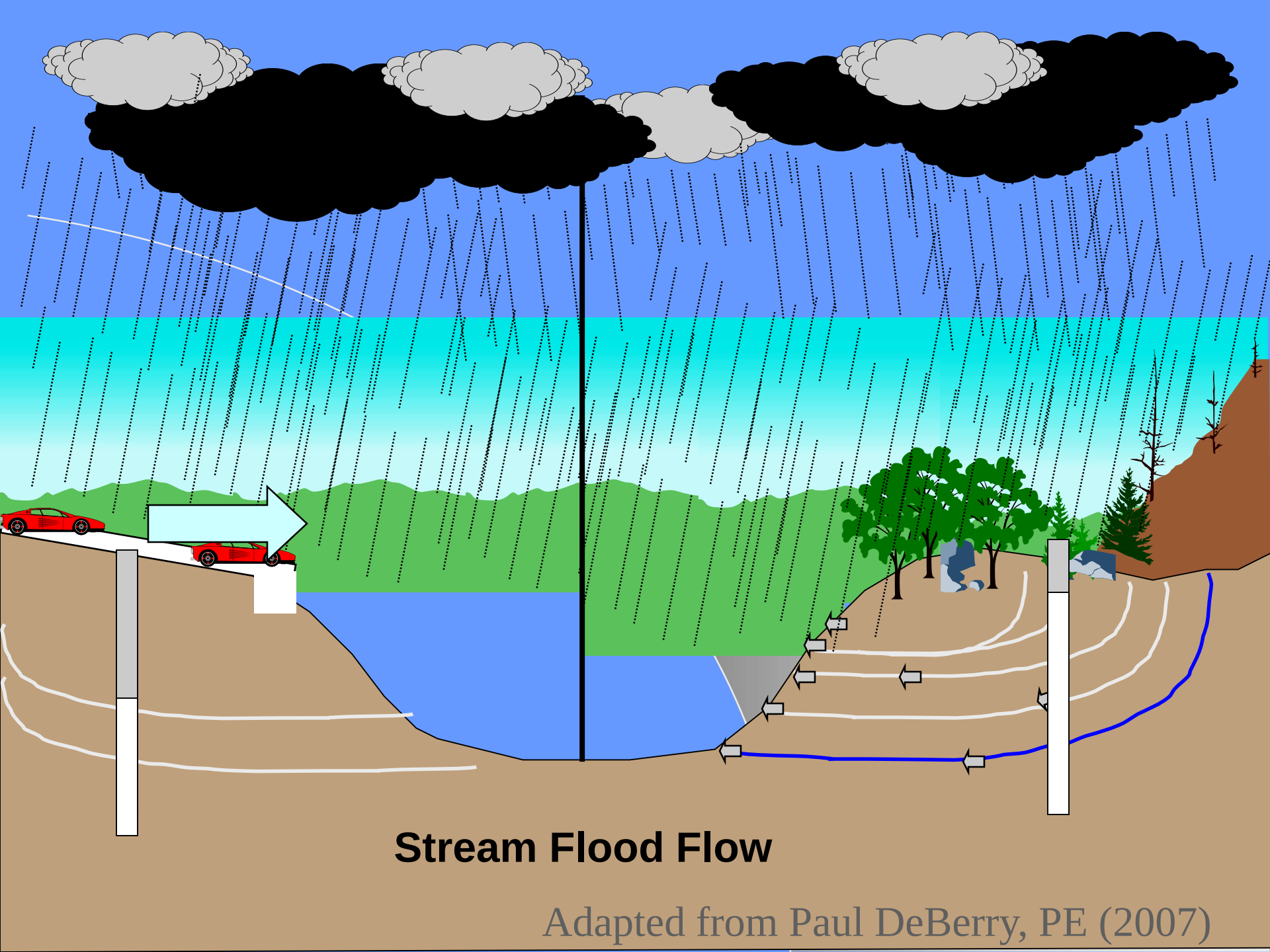
Hydrology Under Natural Conditions

Courtesy May, U of W

Developed Conditions

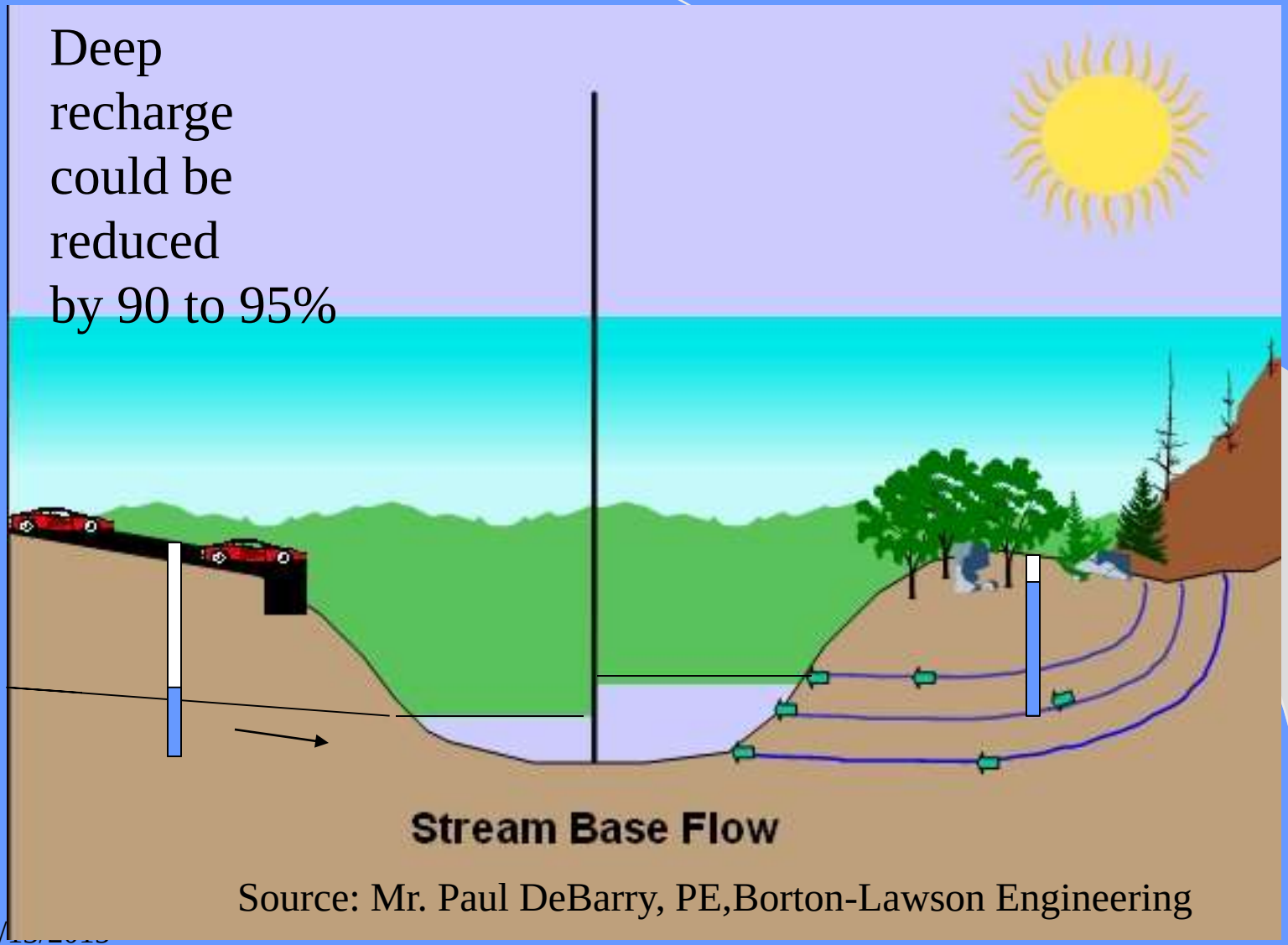


Courtesy May, U of W



Adapted from Paul DeBerry, PE (2007)

Because of increased impervious areas, over-pumping of groundwater sources, stream base flows will decrease.

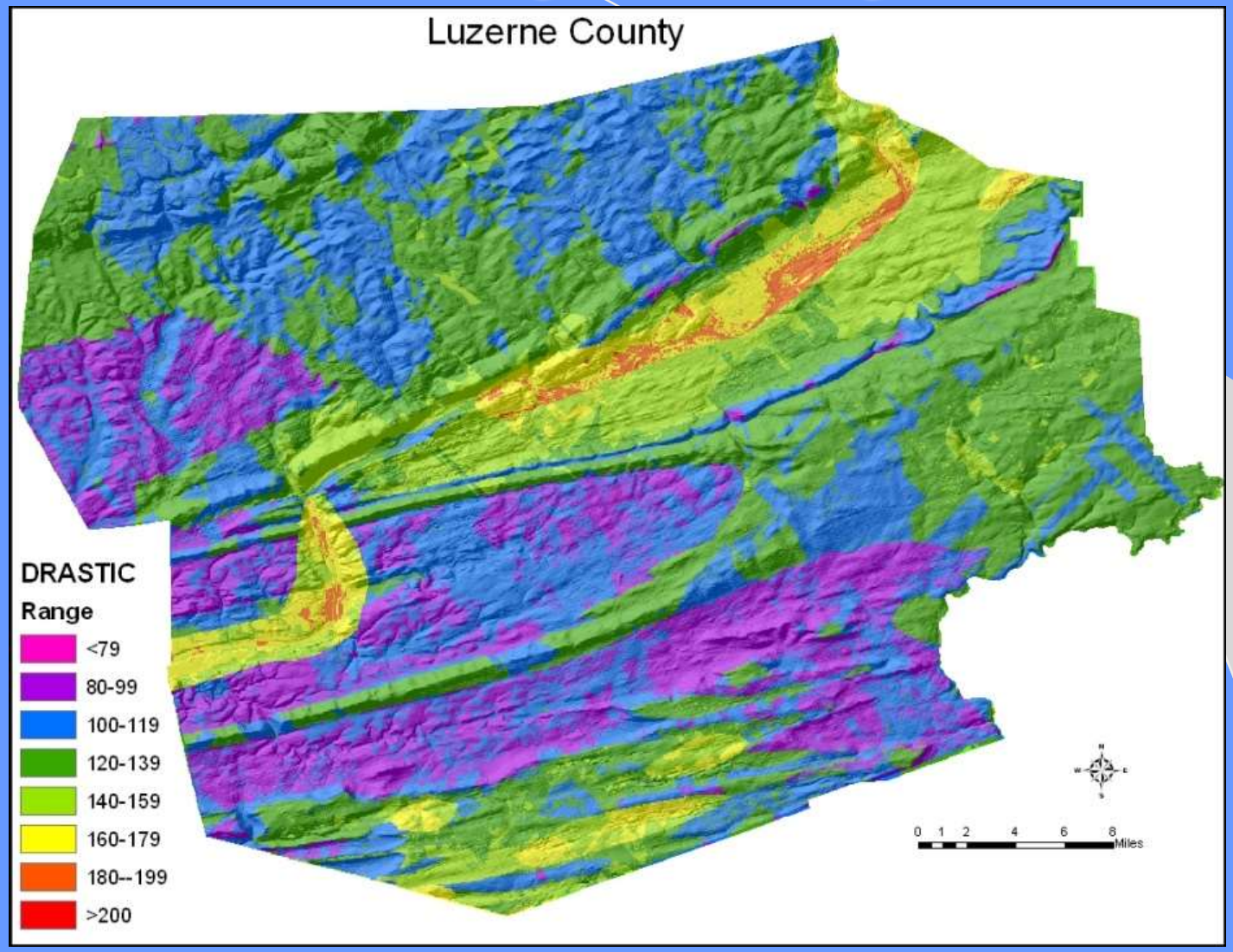


Source: Mr. Paul DeBarry, PE,Borton-Lawson Engineering

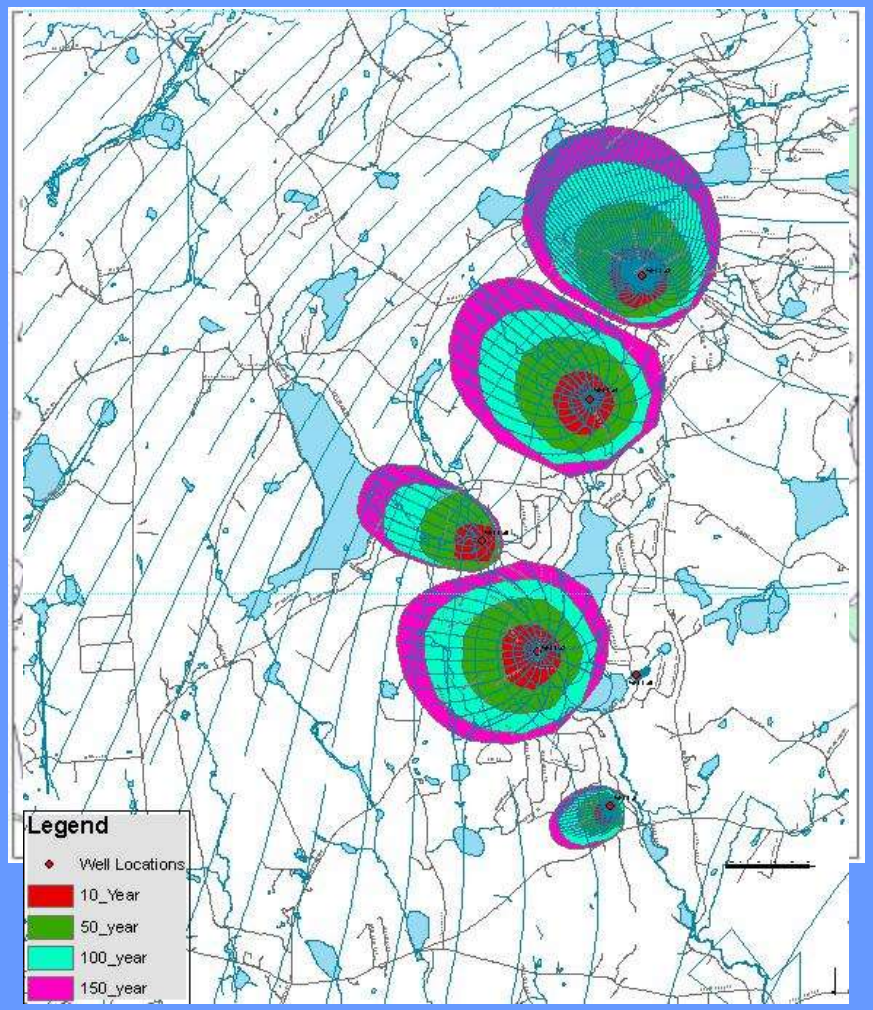
Types of Analysis

- Vulnerability Analysis – Based on Geologic Conditions and Soils – DRASTIC
  - Depth to Water
  - Net Recharge
  - Aquifer Media
  - Soil Media
  - Topography
  - Impact of the Vadose Zone Media
  - Hydraulic Conductivity of the Aquifer
- Environmental Hazard
- Wellhead Protection Zone Delineation

Vulnerability Analysis Map



Test Well Analysis
Modeling Well Approach

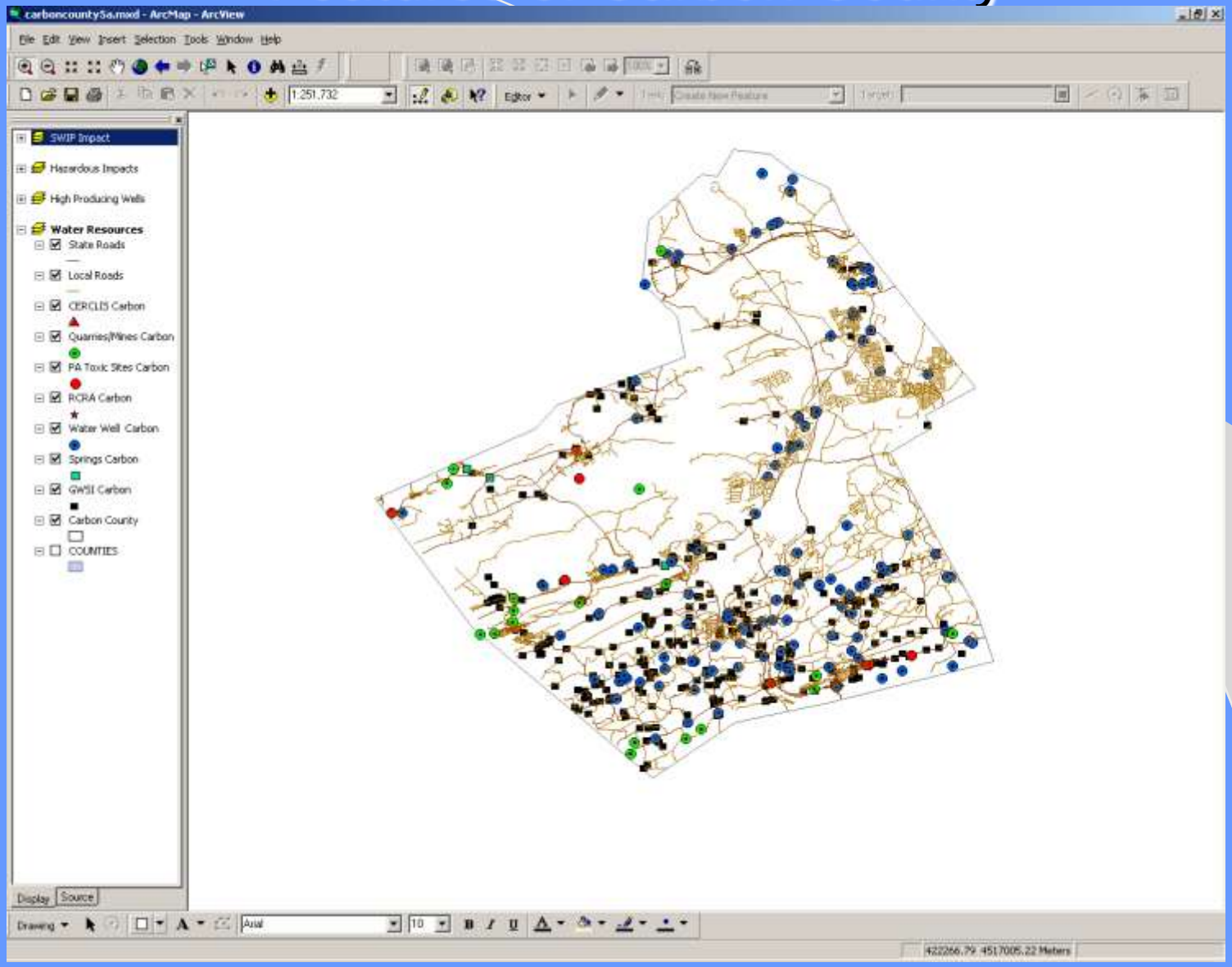


1. Develop a Well Construction Standard for the Project.

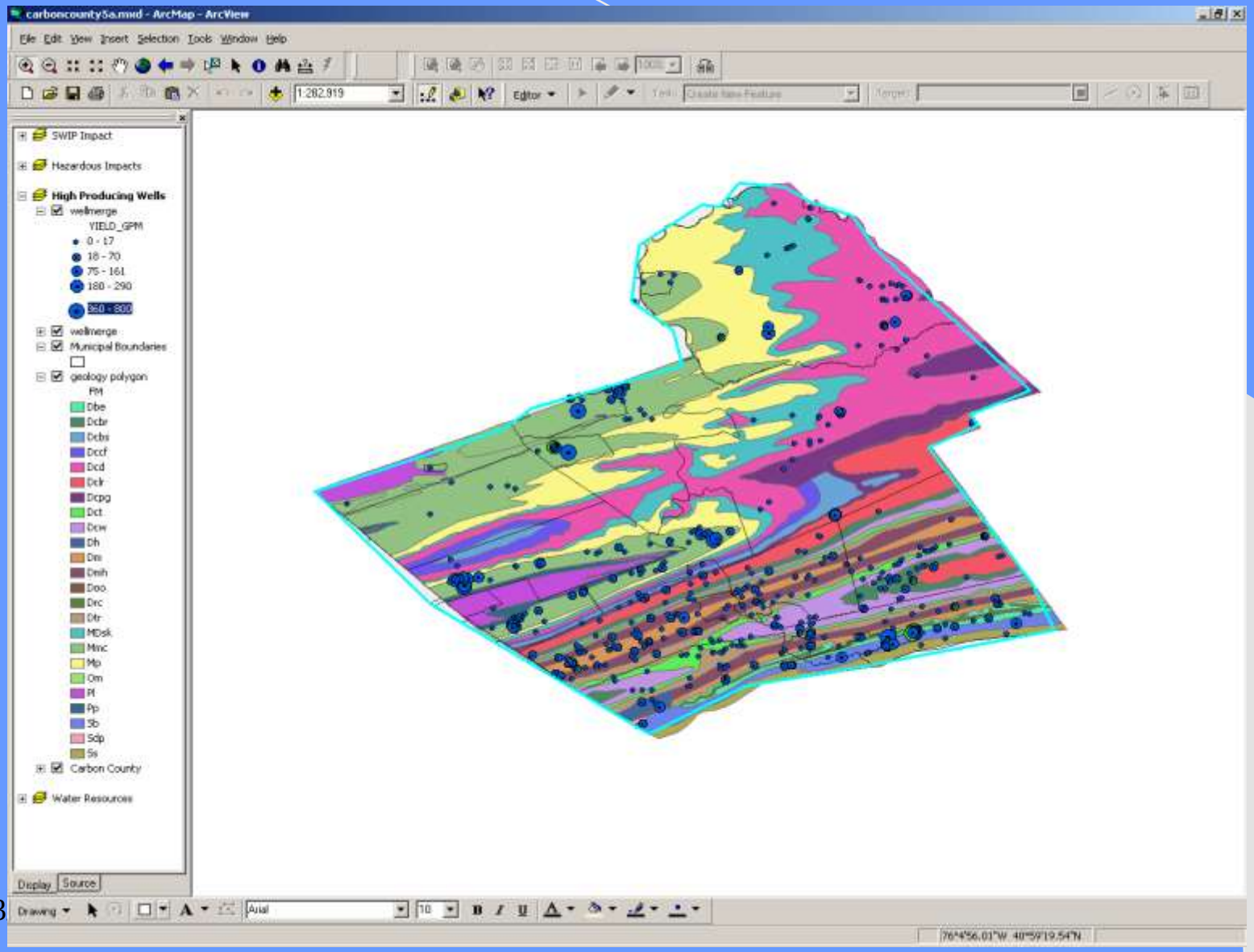
2. Identify Geological Boundaries.

3. Use a Groundwater Model to simulate the installation of 5 wells with a withdrawal equivalent to peak daily demand.

Features of Carbon County



Well Yields


carboncounty5a.mxd - ArcMap - ArcView
File Edit View Insert Selection Tools Window Help
SWIP Impact
Hazardous Impacts
High Producing Wells
wellmerge
YIELD_GPM
0 - 17
18 - 70
75 - 161
180 - 290
wellmerge
Municipal Boundaries
geology polygon
PM
Carbon County
Water Resources
Display
Source
Drawing
Arial

Why Conduct a Groundwater Availability Analysis ?

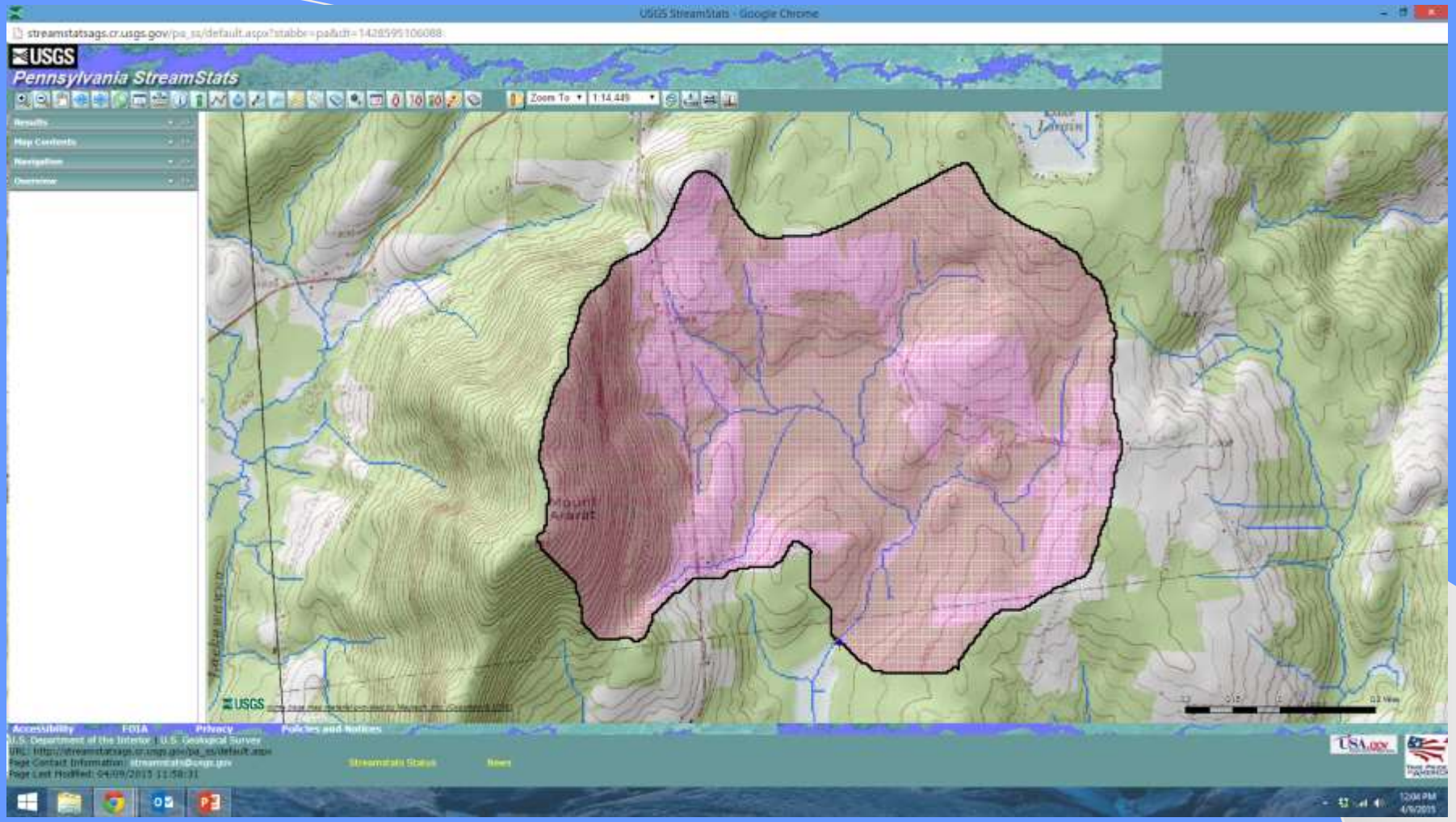
- A preliminary desktop assessment could help to identify potential impacts on existing uses or other regulated facilities during the planning process and existing problems within the community.
- Desktop assessments can be used to develop site-specific criteria for well construction for unregulated projects and long-term sustainability.
- For larger projects, a preliminary analysis may compile enough information to show that a more comprehensive site-specific analysis would provide sufficient data to show if the withdrawal is sustainable.
- Helps to provide a proactive means of managing groundwater and water resources and helps to ensure the long-term reliability, quality, and sustainability of the system.
- The groundwater system helps to sustain the water cycle during droughts.

When Should a Groundwater or Water Availability Analysis

- As part of planning and local approvals for new subdivisions or expansion of unregulated water systems, the applicant would conduct a groundwater availability analysis.
- For the Wayne County area, the analysis should be requested when the proposed density is greater than 1.5 edu per acres or when the project is proposing the use of a central wastewater disposal system with a stream discharge and not a land-based wastewater disposal system.
- Groundwater availability analysis and hydrological description should be conducted by a licensed professional geologist.
- The initial desktop assessment should include a view of published and readily available data.
- Where the desktop evaluation indicates the potential for over-pumping of the aquifer, insufficient yield, or poor water quality, the local regulations could require a more comprehensive hydrological analysis that could include the installation of test wells and conducting a short-term pumping test.

Recharge Rates

- Source – PAStreamstats – Use Watershed area and Baseflow 20 or 50 year return (60 % of Total Available Water Maximum) http://water.usgs.gov/osw/streamstats/pennsylvania.html
- Published Geologic Data by Watershed Area or Formation
- Summary of groundwater-recharge estimates for Pennsylvania: Pennsylvania Geological Survey, Water Resource Report 70.
- Regression method for estimating long-term mean annual ground-water recharge rates from base flow in Pennsylvania: USGS Scientific Investigations Report 2008-5185.



Watershed Area- 2.15 mi^2

Baseflow 25 year – 1.57 ft3/s; Baseflow 50 year- 1.46 ft3/s

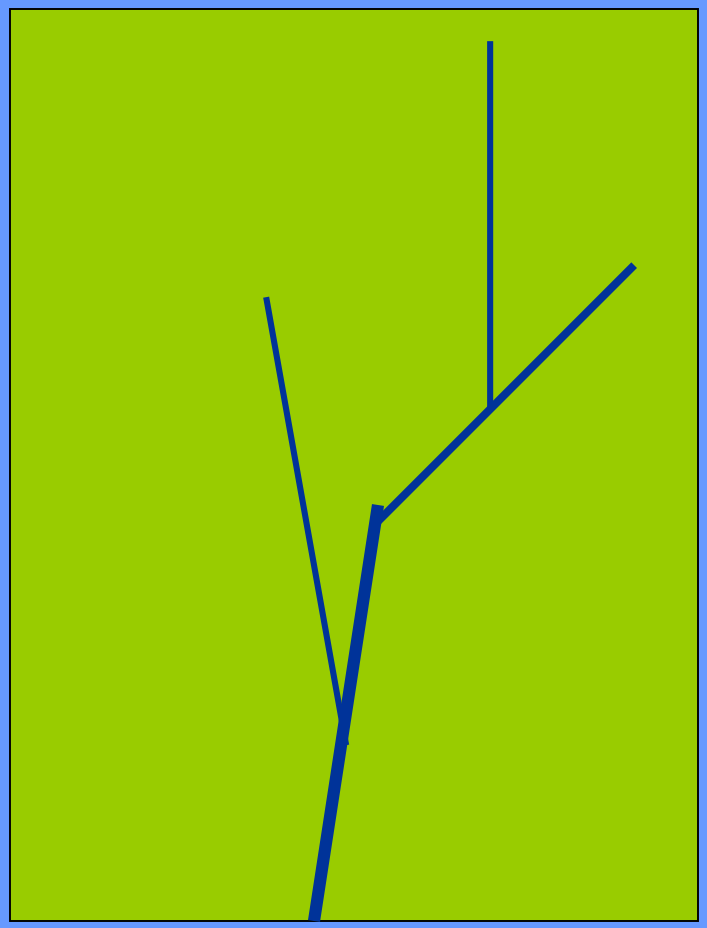
Baseflow 25 year – 737 gpd/ac ; Baseflow 50 year- 685 gpd/ac

Other Sources
Water Resource Report 70

Plate 6 Key	Rate - inches per year	Location of Study	Years	Method	Term Used	Reference
1	13.6	Basin 3I, White Clay Creek near Landenberg, Chester County	No dates given	Water budget; low flow as base flow	Base-flow discharge	Lehigh University, 1982
2	8.5	Red Clay Creek near Kennett Square, Chester County	No dates given	Water budget; low flow as base flow	Base-flow discharge	Lehigh University, 1982
3	12.3	Neshaminy Creek watershed, which includes most of Basin 2F (predominantly underlain by Stockton Formation), Bucks County	No dates given	Water budget and composite recession-curve method	Base runoff	Lehigh University, 1982
4	12.5	Basin 1F, eastern edge of Great Valley, Martins Creek at East Bangor, Northampton County	No dates given	Interpreted water-budget information	Groundwater contribution to runoff	Lehigh University, 1982
5	16.6	Basin 2B, Carbon County, eastern Schuylkill County, and southwestern Monroe County	1969-1978	Base-flow estimation by composite recession curve of streamflow, Brune method	Recharge	Lehigh University, 1982
6	10.1	Basin 7A, Shermansdale area, Sherman Creek; includes Bixby Run (Johnston, 1973), Perry County	1955-1965	Composite recession curve of streamflow	Base flow	Lehigh University, 1982
7	11.2	Basin 2A, located mostly in the Pocono Plateau; Monroe, Carbon, Luzerne, Lackawanna, and Wayne Counties	1969-1978	Base-flow estimation by composite recession curve of streamflow, Brune method	Recharge	Lehigh University, 1982
8	16	Basin 1C, Pike and Wayne Counties; using Basin 1B as representative	1969-1978	Using basing 1B, base-flow estimation by composite recession curve of streamflow, Brune method	Recharge	Lehigh University, 1982
9	21	Basin 1D, Pike and Monroe Counties; using Bushkill Creek watershed as representative of entire basin	1969-1978	Base-flow estimation by composite recession curve of streamflow, Brune method	Recharge	Lehigh University, 1982
10	19	Basin 1B, central Wayne County, northern Pike County	1969-1978	Base-flow estimation by composite recession curve of streamflow, Brune method	Recharge	Lehigh University, 1982
11	15.5	Basin 4D, portions of Bradford, Susquehanna, and Wyoming Counties	1969-1978	Hydrograph base-flow separation	Recharge	Lehigh University, 1982

Therefore, 35 to 45 % of Natural Rainfall Recharges Aquifer

Example Desktop Analysis Pre-Development



100 acre Forest Area
Annual Rainfall – 45 inches
Evapotranspiration – 24 inches
Mean Annual Recharge – 12 ac-inches/year
Drought Year Recharge – 7 ac-inches/year

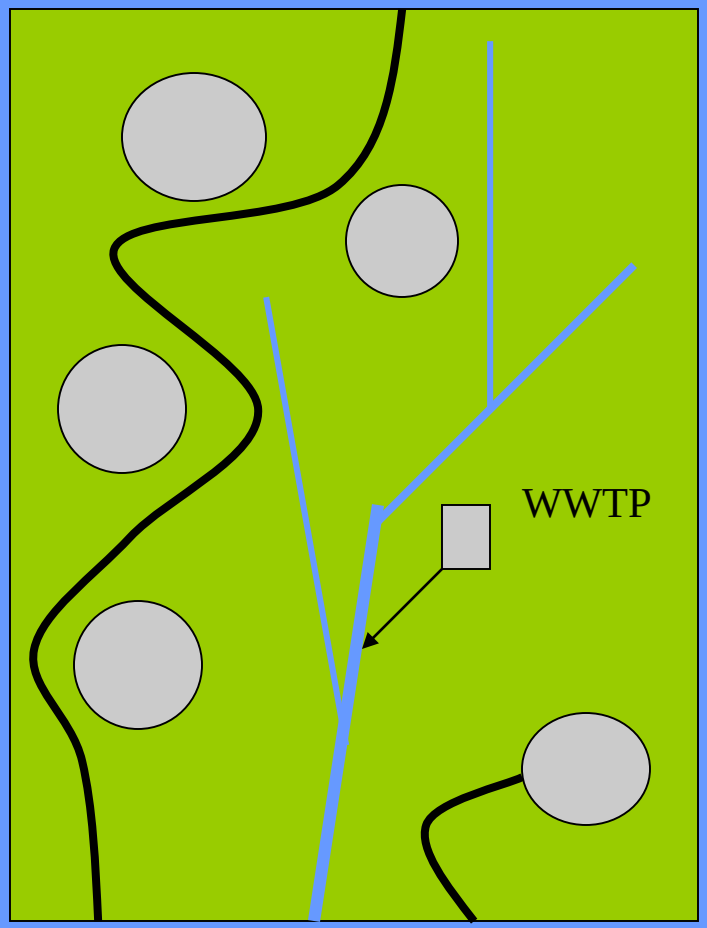
Normal Year Recharge Rate
100 acres * 12 ac-in/yr * 27154 gal/ac-in=
32,584,800 gallons per year or
89,273 gallons/day or 893 gpd/acre

Drought Year Recharge Rate
100 acres * 5 ac-in/yr * 27154 gal/ac-in=
13,757,000 gallons per year or
37690 gallons/day or 376 gpd/acre

Site capacity may be limited based on drought year recharge rate. The density should be greater than 1 acre per edu.

Example Desktop Analysis Proposed Post-Development

100 acre Parcel



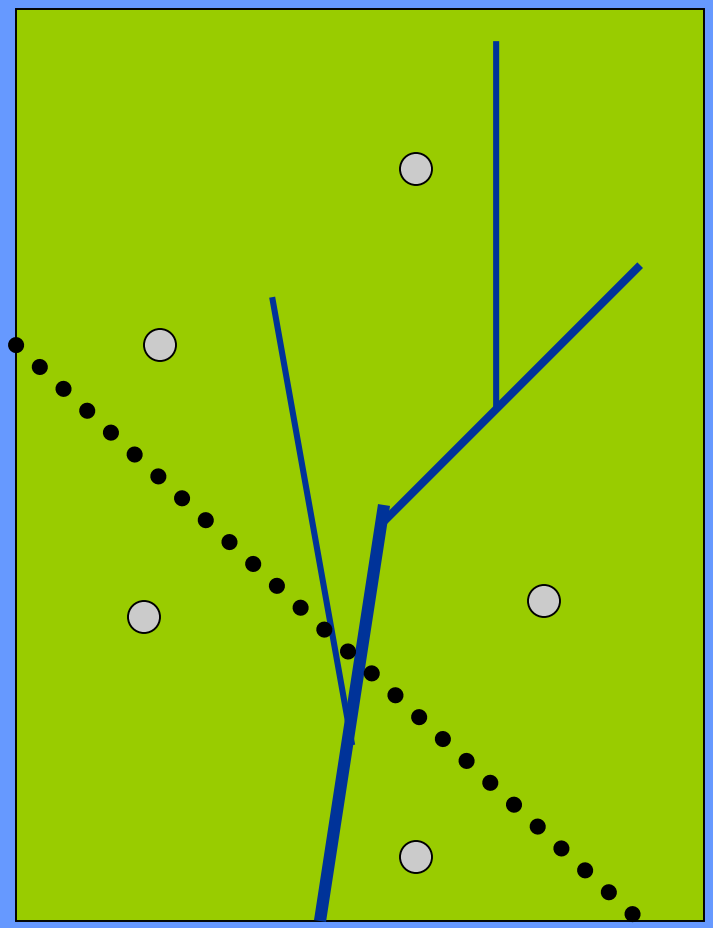
Impervious Area - Roofs /Driveways – 20 acres
Impervious Area - Roads/ Lawns 10 acres
Mean Annual Recharge – 12 ac-inches/year
Drought Year Recharge – 5 ac-inches/year
Water Demand – 85 units * 275 gpd= 23,375 gpd
Density = 1.17 acres per edu

Normal Year Recharge Rate
70 acres * 12 ac-in/yr * 27154 gal/ac-in=
22,809,360 gallons per year or 62,491 gpd
624 gpd/acre

Drought Year Recharge Rate
70 acres * 5 ac-in/yr * 27154 gal/ac-in=
9,503,900 gallons per year or 26,038 gpd
260 gpd/acre

Project is not groundwater mining, but demand is over 80% of drought year baseflow.

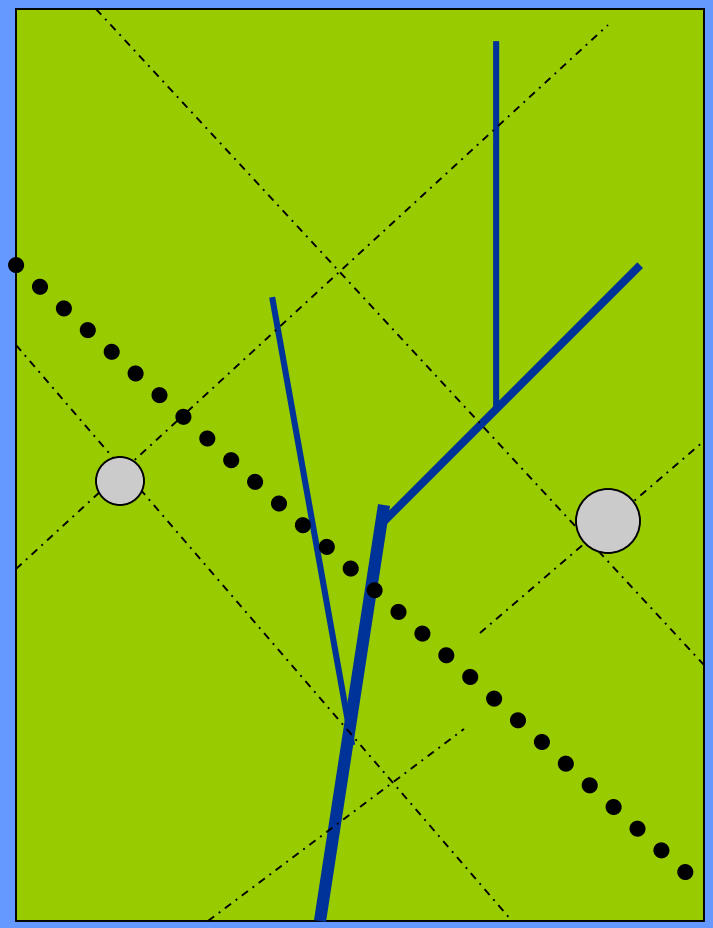
Test Well Analysis
Individual Well Approach



1. Develop a Well Construction Standard for the Project.
2. Identify Geological Boundaries.
3. Install a number of test wells to confirm aquifer yield and quality. For example, a project with 85 units it may be advisable to install 4 to 5 test wells.
4. Document yield of each well and water quality.
5. Document direction of groundwater flow.
6. Conduct a short pumping test on one or more of the wells to simulate average daily withdrawal.
7. Monitor off-site wells.

Site capacity may be limited based on drought year recharge rate. The density should be greater than 1 acre per edu.

Test Well Analysis
Community Approach



Delineate Geological Boundary, Conduct a Fracture Trace Analysis and prepare a Predrilling Plan for Submission to PADEP for Review.

85 units * 275 gpd = 23,375 gpd (avg demand)
23,375 * 2 = 46,750 gpd (peak daily demand)
46,750 gpd * (1/12 hour/pc) (1hr/60 min) =
64 .9 gpm (peak demand)

If formation typically has yields of 30 gpm, the system will require at least two production wells. Predrilling Plan for Submission to PADEP for Review.

Drill wells to PADEP Standards and Conduct a Preliminary Pumping Test to Confirm Yield and Monitor a Number of Private Wells.

Protect Your Water Source
Things a Citizen or Community Can Do

- Periodically Inspect
- Drain Surface Water Away
- **Install Sanitary Seal and Proper Well Construction**
- Annual Testing
- Maintain Records
- Start a Community Based Groundwater Education Program
- Carbon County Groundwater Guardians
  http://www.carbonwaters.org/
- Proper Abandonment
- Chemical Storage, Disposal and Use
- Groundwater or Water Availability Analysis as part of Planning
- Proper Well Location
- Septic System Maintenance
- Recycle used Oil and Participate in Hazardous Chemical Disposal Programs
- Well Ordinance

Protect Your Water Source
Things Local Agency Can Do

- Zoning and Planning Process that Includes a Groundwater Availability Analysis.
- Developing a Well Water Ordinance and Link the Well Water Ordinance to Act 537 Planning
- Developing Well Construction Standards
- Start or Support a Community Based Groundwater Education Program (KCWT)

Additional Options for Local Agency

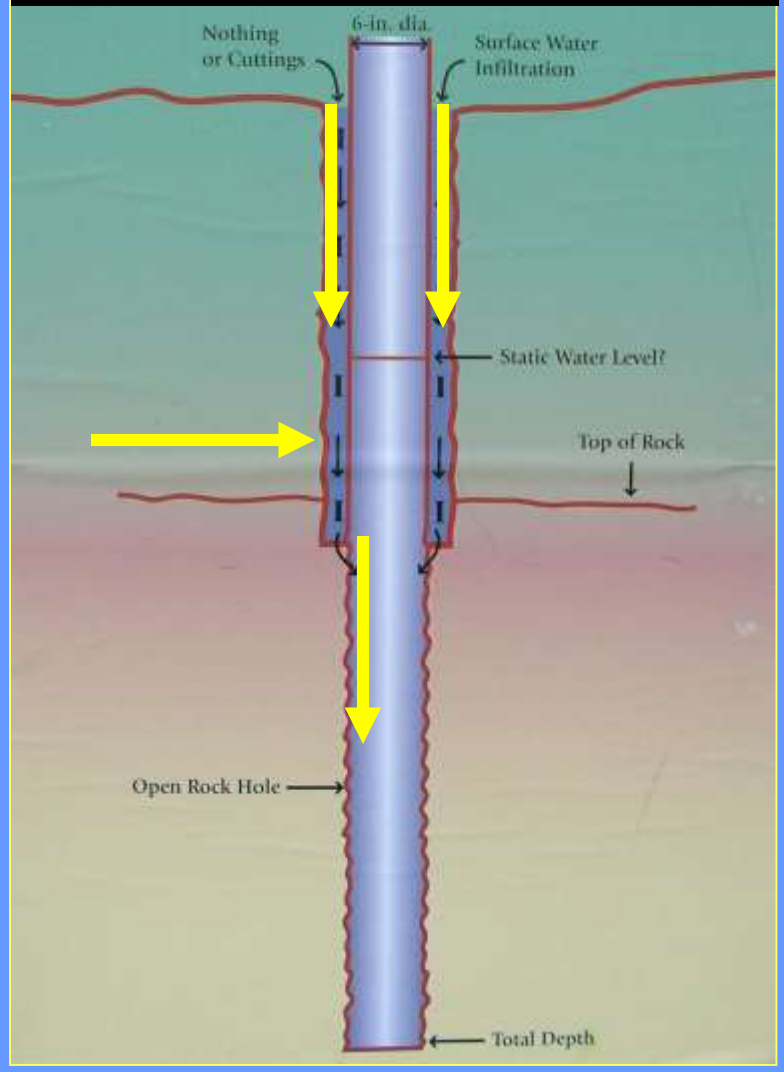
- Developing Water Well Ordinance that provides construction standards and an initial water quality and yield analysis.
- Developing Well Construction and Placement standards – beyond a minimum isolation distance from land-based wastewater systems, what about hazardous chemicals, manure storage, stormwater facilities, floodplains, etc.

Why an Ordinance?

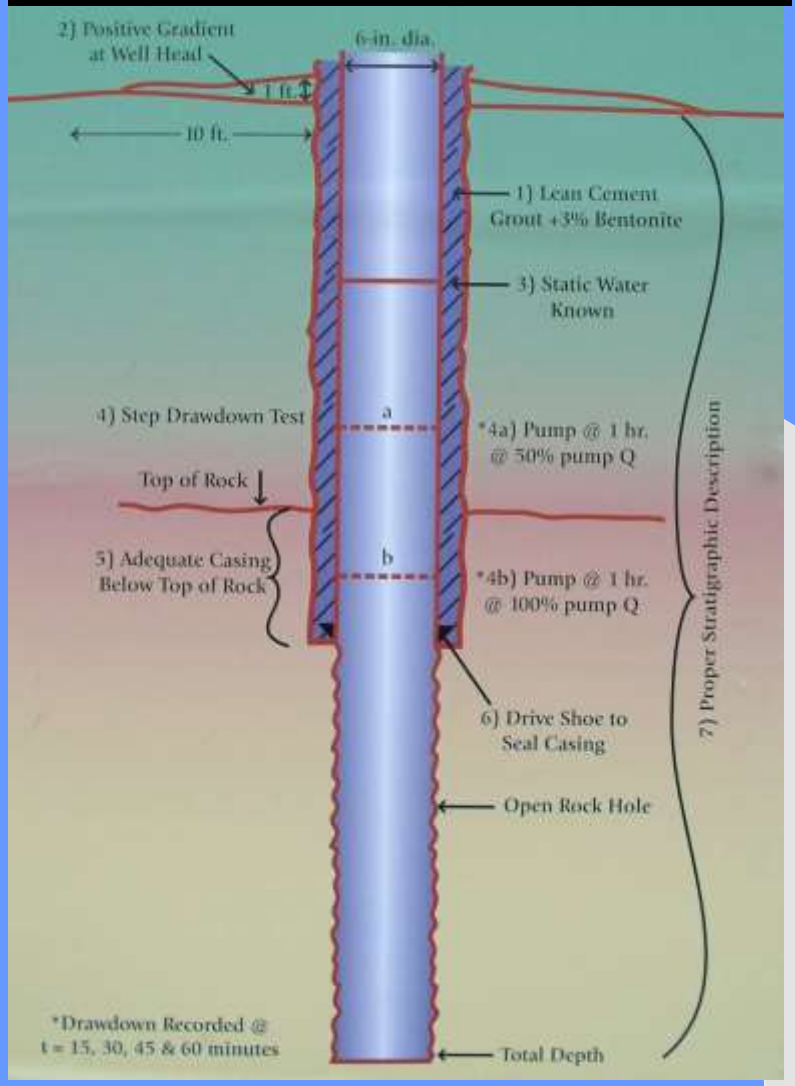
Primary reasons for the ordinances included:

- Improper Well Construction
- Incidents of Well Contamination
  - –Improper Siting
  - –Interconnection with Contaminated Site
  - –Induce Contamination – Lack of Grouting
  - –No Testing Requirements to ensure potability
- Overuse of the Groundwater Aquifer.

An Ungrouted Residential Well



A Properly Grouted Well



Well Construction Specs
Jackson Township, Monroe County, PA

- Casing must be 18 inch above grade
- Must use a sanitary well seal
- 19# casing must be at least 40 feet in length and 10 feet into bedrock (does not say the bedrock should be firm)
- All casing must be threaded and coupled or if welded, a certified welder must weld it.
- Annulus must be grouted with neat cement grout, Promix cement grout, or concrete grout to within approximately 5 feet of the top of the casing.
- Well must be disinfected – this does not mean long-term disinfection treatment, but shock disinfected.

Well Construction Specs
Paradise Township, Monroe County, PA

- Casing must be 24 inch above grade or the 100-year flood level of record
- Must use a sanitary well seal
- 19# casing must be at least 50 feet in length and 10 feet into bedrock (does not say the bedrock should be firm)
- Annulus must be grouted with bentonite grout.
- Well must be disinfected – this does not mean long-term disinfection treatment, but shock disinfected.

Well Construction Specs
Ryan Township, Schuylkill County, PA

- Casing must be 12 inch above grade
- Casing wall thickness must be at least 0.1875 inch (13#)
- Must use a sanitary well seal
- Casing must be at least 40 feet in length and 10 feet into bedrock (does not say the bedrock should be firm)
- Annulus must be grouted within 24 hours with bentonite grout or Neat cement grout (No disturbance – 2 hours bentonite and 48-hours cement).
- Well must be disinfected – this does not mean long-term disinfection treatment, but shock disinfected.

Our Latest Educational Resource

KEYSTONE
Clean Water Team

Description of the following:

a. Citizen Database
b. Baseline Testing
c. Drinking Water Standards
d. Specific Water Quality Standards
e. Treatment Options
f. How to Shock Disinfect a Well
g. How to Properly Construct a Well
h. General Guidelines on Baseline Testing Parameters.

And More. **cost$ 5.00**

Other Resources at http://www.water-research.net

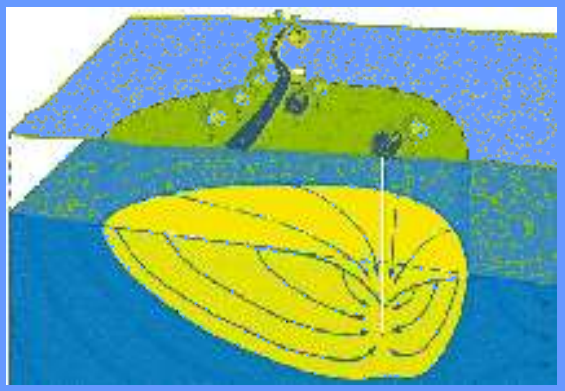
Supports a Local 501C3 – Carbonwaters.org

Groundwater Resources
Wayne County, PA
Planning For the Future

Mr. Brian Oram, PG
Professional Geologist, Soil Scientist,
PASEO, Licensed Well Driller

B.F. Environmental Consultants
Dallas, PA 18612

http://www.bfenvironmental



KEYSTONE
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