The following is an excerpt from *Chapter 2 - Identifying & Resolving Quality of Life Issues* from the Community & Environmental Defense Services (CEDS) book *How to Win Land Development Issues: A Citizens Guide to Preserving & Enhancing Quality of Life in Developing Areas*. You will find this section more helpful if you read the Chapter 2 introductory text. Also, the following is just the text we could fit into the book without making it unduly large. We have a substantially greater amount of information available in our files on this topic. To learn how CEDS can assist you with concerns about this topic visit the CEDS website at: www.ceds.org or contact us at: 1-800-773-4571 or info@ceds.org

AQUATIC RESOURCES

Aquatic resources include wetlands, streams, lakes, rivers, springs, seeps, ponds, and groundwater. Existing and newly created development has damaged the quality of nearly 35,000 miles of streams and rivers in the United States, which makes it the fourth leading cause of impaired waterways.[1] For lakes and wetlands development is the third leading cause of degradation and comes in as the second most significant cause of impaired coastal waters.[2]

How Development Impacts Aquatic Resources

Beginning with a study I published in 1979[3], a number of researchers throughout the United States and Canada have found a consistent relationship between watershed development and the health of aquatic systems.[4] Most researchers use *percent impervious area* to quantify the degree of watershed development. An impervious surface is any material which prevents precipitation from soaking into the soil and includes rooftops, parking lots, streets, sidewalks, and so forth. A *watershed* is defined as all the land area draining to a specific point. The perimeter of a watershed is formed by hilltops, ridgelines and other highpoints. When rain falls upon the ridgeline it flows (or is shed) to a specific water body or waterway.

Wetlands begin exhibiting signs of adverse effect when watershed imperviousness exceeds 2% to 4% or about one house for every eight- to ten-acres of watershed area.[5] Streams supporting trout, salmon, and other coldwater species do best when watershed imperviousness is less than

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[1] See *2000 National Water Quality Inventory* available for download at: http://www.epa.gov/305b/2000report/

[2] Ibid.

[3] Klein, R.D., 1979. Urbanization and stream quality impairment. *Water Resources Bulletin* 15(4):948-963.

[4] These studies are summarized in several of the reports which can be downloaded from the waterways page of the CEDS website: http://www.ceds.org/publications.html

[5] Hicks, A.L. and J.S. Larson. 1997. Aquatic invertebrates as an index for estimating the impacts of urbanization on freshwater wetlands. The Environmental Institute, University of Amherst, MA. Report submitted to U.S. Environmental Protection Agency, Corvallis, OR. Reinelt, L.E. and R.R. Horner, 1991. Urban storm water impacts on the hydrology and water quality of palustrine wetlands in the Puget Sound region. In: *Puget Sound Research '91 Proceedings*, Puget Sound Water Quality Authority, Vol. 1, pp. 33-42.

4%.[6] Warmwater streams and rivers begin exhibiting signs of adverse effect when watershed imperviousness exceeds 8% (about one house/two acres).[7] Lakes begin showing signs of excessive nutrient input when watershed imperviousness is in the range of 10%.[8] A relationship also exists between the health of tidal waters and watershed development, though the threshold of impact is not clearly defined. A number of studies have also found a relationship between the density of septic systems in a watershed and aquatic resource quality *(see the section of this chapter on Septic Systems).*

The causes of development-induced aquatic resource degradation can be summarized as follows:

1. physical destruction of aquatic habitat through actions such as filling of wetlands, altering stream channel, dredging waterways, etc.;
2. release of eroded soil (sediment pollution) during the construction phase;
3. increased runoff volume which accelerates channel erosion and exacerbates flooding;
4. a decrease in the amount of precipitation soaking into the soil and recharging groundwater systems, which reduces the dry-weather inflow to wetlands, streams, lakes, wells and other aquatic resources;
5. elevating water temperature through actions such as the removal of streamside shading vegetation, heated runoff from sun-baked impervious surfaces, and the heating of runoff while it drains out of stormwater ponds during the summer; and
6. increasing the quantity of nutrients, toxics and other pollutants released into the aquatic environment.

In addition to these ecosystem impacts, watershed development can damage structures located along streams and other waterways. Converting a forest to homes on quarter-acre lots could increase the frequency and severity of flooding by a hundred fold.[9] In other words, floodwater volumes seen only once every century might recur annually following watershed development. Any homes or other structures located along the affected waterways would be subject to more

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[6] Boward, D., P. Kayzak, S. Stanko, M. Hurd, and A. Prochaska, 1999. *From the mountains to the Sea: The state of Maryland's freshwater streams.* Maryland Department of Natural Resources, Tawes State Office Building, Annapolis, MD 21401. Steedman, R.J. 1988. Modification and assessment of an index of biotic integrity to quantify stream quality in southern Ontario. *Canadian Journal of Fisheries & Aquatic Sciences* 45:492-501. May, C. R. Horner, J. Karr, B. Mar, and E. Welch. 1997. Effects of Urbanization on Small Streams In the Puget Sound Lowland Ecoregion. *Watershed Protection Techniques*, 2(4): 483-494.

[7] Shaver, E., J. Maxted, G. Curtis, and D. Carter. 1994. Watershed protection using an integrated approach. Delaware Department of Natural Resources and Environmental Control. Booth D.B. and C.R. Jackson. 1994. Urbanization of aquatic systems - degradation thresholds and the limits of mitigation. *Proceedings Annual Summer Symposium of the American Water Resources Association - Effects of Human-Induced Changes on Hydrologic Systems*, pp 425-434.

[8] See the Center for Watershed Protection *Watershed Vulnerability Analysis* which is available for download from http://www.cwp.org/Vulnerability_Analysis.pdf

[9] The hundred-fold increase in flooding due to conversion of a forest to quart-acre lots is based upon the procedures set forth in SCS, 1986. Urban hydrology for small watersheds. Technical Release 55, U.S. Soil Conservation Service, Post Office Box 2890, Washington, D.C. 20013.

frequent inundation and damage.

The increased flooding associated with watershed development also accelerates the pace of stream channel erosion. In fact, converting a forest watershed to suburban-urban uses can cause the channel draining the watershed to widen by two- to eight-fold through erosion.[10] Accelerated channel erosion results in habitat destruction, the release of sediment into downstream waters, and may jeopardize streamside structures.

Preventing Aquatic Resource Impacts

There are a number of *Best Management Practices* (BMPs) for reducing the impact of impervious surfaces upon aquatic systems. Examples of BMPs include:

- limiting watershed imperviousness;
- buffers to prevent direct physical damage to streams and wetlands; and
- ponds or filters to remove pollutants from runoff.

Not all BMPs are equally effective in preventing aquatic resource degradation.[11] Limiting watershed imperviousness is the most effective BMP. Ponds, filters and other structural practices can fail.

Watershed imperviousness can be limited through a variety of measures.[12] Examples would include reducing street width or lowering the number and size of parking spaces required for new development. Local governments have also set caps on how much imperviousness may be created within sensitive watersheds.[13] If a proposed development project would cause imperviousness to exceed the cap then it cannot be approved. There is also research showing that it is not enough just to cap impervious area; a minimum percentage of a watershed must also be preserved as forest.[14]

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[10] Klein, R.D., 1979. Urbanization and stream quality impairment. *Water Resources Bulletin* 15(4):948-963.

[11] Further detail on BMPs can be found in the CEDS factsheets *Buffers for Stream, Lake & Wetland Protection* and *How Much Development is Too Much for Streams, Rivers, Lakes, Tidal Waters & Wetlands*. These factsheets are available for download from our website (http://www.ceds.org/) along with various reports illustrating how to assess the aquatic resource impact of a proposed development project.

[12] See *Better Site Design: A Handbook for Changing Development Rules in Your Community* for a long list of measures for reducing impervious area. The handbook can be ordered from the Center for Watershed Protection http://www.cwp.org/index.html

[13] For examples of impervious area caps see the Montgomery County, MD Special Protection Areas website: http://www.montgomerycountymd.gov/siteHead.asp?page=/mc/services/dep/index.html and the Chesapeake Bay Critical Areas website: http://www.dnr.state.md.us/criticalarea/guidancepubs/impervioussurfaces.html

[14] For an example of the research showing the importance of forest cover in maintaining urban stream quality see: Booth, D.B., 2000. Forest Cover, Impervious-Surface Area, and the Mitigation of Urbanization Impacts in King County, Washington. Center for Urban Water Resources Management, Department of Civil and Environmental Engineering, University of Washington, Seattle, WA 98195-2700. Available for download at: http://depts.washington.edu/cuwrm/research/forest.pdf

But a limit on impervious area is in conflict with the Smart Growth principle of concentrating development rather than allowing it to sprawl over the countryside. Impervious area caps are usually applied only to resources which are highly valued and very sensitive. Examples would include waters:

- supporting rare, threatened or endangered species;
- supporting fish or shellfish considered important for commercial or recreational reasons;
- where fragile habitats such as bogs are present;
- serving as sources for drinking water supply;
- uniquely high quality waters,
- where existing homes or other structures are subject to flooding and could be placed in jeopardy by increased watershed development;
- where restoration programs are anticipated or underway; and
- where a further increase in stress could cause the resource to no longer support beneficial uses such as rivers, lakes or tidal waters considered moderately or highly enriched with nutrients (*mesotrophic or eutrophic)*.

Information on the sensitivity of aquatic resources in your area can be obtained from the U.S. Environmental Protection Agency's *Surf Your Watershed* website[15]. Additional information can be obtained from local and state government agencies, such as those overseeing natural resources, fisheries, wildlife, natural heritage (rare, threatened and endangered species), environmental protection, floodplain management, planning and zoning, and water quality management.

If little information is available for the aquatic resources of concern to you, then consider gathering your own data. On the EPA Volunteer Monitoring website[16] you will find publications explaining how to assess the health of streams, lakes, wetlands and estuaries. You will also find a directory of local and state programs which may provide training and equipment for volunteer monitoring.

To the extent possible, all development projects should utilize highly-effective BMPs, which would consist of:

- preventing direct physical damage to aquatic habitat by maintaining a buffer of at least 75 to 100 feet along the perimeter of all wetlands, seeps, springs, streams, rivers, lakes and ponds;
- buffers should be expanded to include any steep slopes or highly-erodible soils adjoining the aquatic resource;[17]
- prior to clearing a site perimeter sediment control measures, such as silt-fence, must be

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[15] http://www.epa.gov/surf/

[16] http://www.epa.gov/owow/monitoring/volunteer/

[17] A steep slope can be anywhere from 15% to 25% (rising 15-25 vertically for each 100 feet of horizontal distance) and highly-erodible soils are usually defined by the Soil Conservation District-Natural Resources Conservation Service.

installed along the downslope edge;

- for large sites, clearance should be phased to limit the amount of soil exposed to erosive forces;
- all disturbed soils should be brought up to rough grade within two weeks then treated with a temporary stabilization measure such as straw mulching and seeding with grass;
- all disturbed soil should also drain to sediment trapping measures such as settling ponds and silt fence, but these measures only remove half of the eroded soil suspended in runoff while stabilization measures reduce erosion by 90% or more;
- an effective enforcement program must be in place to ensure that erosion and sediment control measures are installed and maintained properly;[18]
- once construction is completed a minimum of 90% of all runoff from impervious surfaces should flow to a filtering device, such as bioretention, which preferably allows filtered runoff to recharge the water table through infiltration ;[19]
- ponds can cause runoff to heat to 85°F and should not be permitted in watersheds supporting trout and other temperature-sensitive species;[20] and
- a program must be in place to ensure that each stormwater management measure will be inspected at least once a year with prompt attention paid to any maintenance needs.

Fully evaluating the aquatic resource impact of a development project requires more detail than provided above. On the CEDS website[21] you will find examples of how to conduct the thorough analysis needed to determine if a project will adversely effect sensitive wetlands, streams, and other resources.

Specific Aquatic Resource Issues
Following are suggestions for resolving concerns about specific aquatic resource impacts or development types.

Fish Migration Barriers: Will the project involve the construction of a road across any stream, creek, river, or other waterway? If so then closely examine project plans for any indication that the crossing will create a barrier to the movement of fish or other aquatic organisms. For example, if the applicant has proposed the use of a pipe or box culvert, then a barrier may be formed. Both culvert types may replace the natural stream bed with one composed of steel or

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[18] Some of the components of an effective enforcement program are: each full-time inspector is responsible for no more than 100-200 active construction sites and serves primarily as a technical advisor but is backed up by a program with history of swiftly and aggressively prosecuting flagrant violators.

[19] For an illustration of stormwater filters view the *Maryland Stormwater Design Manual* at: http://www.mde.state.md.us/Programs/WaterPrograms/SedimentandStormwater/stormwater_design/index.asp

[20] Bahr, R.P., 1996. A temperature study of discharges from three extended detention/wetland stormwater management basins in Maryland. Chesapeake Biological Laboratory, University of Maryland, Solomons, MD 20688. Galli, J., 1990. Thermal impacts associated with urbanization and stormwater management best practices. Department of Environmental Programs, Metropolitan Washington Council of Governments, 777 North Capitol Street, N.E., Washington, D.C. 20002. (202) 962-3200

[21] www.ceds.org

concrete. But this alone does not necessarily result in a migration barrier. If the steel or concrete will be exposed at the stream bed elevation, then future scour and erosion may result in a water drop which then bars upstream migration. Generally, bridges and bottomless arches do not result in migration barriers. Dams and similar structures obviously have a strong likelihood of blocking fish migrations. Talk with State fishery biologists whenever you believe a project may create a barrier to fish migrations.

Golf Courses: Construction of a golf course may disturb a hundred acres of land. Few uses cause as much land disturbance. Thus the potential exists for considerable soil erosion and sediment pollution during golf course construction. Once the course is completed aquatic resources may be impacted through leaching of fertilizers and pesticides. A golf course can require a quarter-million gallons a day of irrigation water during the 20-month grow-in period. If this water is drawn from wells or waterways then substantial resource impact may occur.

Over the past decade institutions such as the U.S. Golf Association have had considerable success in reducing the adverse effects of golf courses. Today there are even "organic" golf courses.

If you are concerned about a proposed golf course, then compare the project with the recommendations contained in the CEDS publications *Golf Courses & the Aquatic Environment* and *Protecting the Aquatic Environment from the Effects of Golf Courses,* both of which can be downloaded from our website[22].

Highways: New roads and highways can cause many of the aquatic resource impacts described above for impervious areas. In addition a highway can introduce other threats, such as hazardous material spills resulting from accidents. Of particular concern are common substances such as the methyl tertiary butyl ether (MTBE) added to gasoline. MTBE is highly mobile and can contaminate groundwater when present at an extremely low concentration. One gallon of MTBE treated gasoline can contaminate four million gallons of drinking water.[23] On the CEDS website[24] you will find examples of how to assess and resolve the impact of a proposed highway, including hazardous material spills.

Landfills: A landfill is used to store waste materials such as household garbage which is not being recycled, flyash from coal-fired power plants, industrial waste, and so forth. A landfill can impact the environment through the loss of groundwater recharge caused by impermeable liners or caps, construction phase sediment pollution, the release of the highly-contaminated leachate which forms as water passes through decomposing waste, from the release of volatile contaminants to the atmosphere, and from the trucks traveling to and from the facility. For further information see the publications on the CEDS website pertaining to landfills and other

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[22] www.ceds.org

[23] Kiner, N.E. 2001. Fate, Transport and Remediation of MTBE. Civil/Environmental Engineering, University of New Hampshire, Durham, NH. Available online at: http://www.asce.org/pdf/kinnertestimony.pdf

[24] www.ceds.org

solid waste facilities.

Marinas: Boating facilities such as marinas and launching ramps can impact an aquatic resource through boat wake induced shore erosion, resuspension of bottom sediments by boat propellers, the release of highly-toxic anti-fouling coatings from boat hulls and treated timbers, discharge of sewage from vessels, toxic runoff from boat repair and maintenance areas, and all the other impacts associated with impervious surfaces. These impacts tend to be particularly severe when a small tidal creek is involved. Recommendations for assessing the impacts of a marina, boat launching ramp, pier, slip, or any other boating facility are provided in the CEDS website publication *The Effects of Marinas & Boating Activity Upon Tidal Waterways.*

Mining: Hard rock mining, coal mines, sand and gravel quarrying, and other forms of mineral extraction can cause a host of impacts. All can damage nearby waterways through erosion and sediment pollution, changes in ground and surface water flows, physical destruction of aquatic habitat, and increased truck traffic. Additional impacts may come from the release of toxic materials such as the acidity and metals from some forms of coal mining. Mineral processing with the use of water can impact aquatic resources due to turbidity or stream flow depletion. One of the best sources of information for mining impacts is the Earthworks website[25].

Public Water Supply: If a project will rely upon water obtained from a public or community supply, then determine if the source can accommodate additional users. For example, if the water is drawn from a lake or river then determine how much more can be consumed without adversely affecting aquatic life or recreational uses, such as boating.[26] Your state natural resources agency may have information on minimum flows for fishery and boating needs.

Contact the agency which administers the public water supply to find out how much capacity remains. The local fire marshal office may also have information on the adequacy of the supply for fire fighting needs. Contact the state environmental protection or public health agency to learn the results of recent inspections of the supply.[27] Ask if monitoring results show that the supply meets the minimum standards for protection of public health. If either the quantity or quality of the supply is questionable then perhaps additional users should not be added until the deficiencies are resolved.

Septic Systems: In rural areas, on-site sewage disposal systems are used to manage the relatively small volume of wastewater generated in homes and businesses. Typically, sewage flows first to a septic tank where grease and solids are removed. The partially treated wastewater is then released into the soil where additional pollution removal may occur.

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[25] http://www.mineralpolicy.org/ewa/index.cfm

[26] The Instream Flow Incremental Methodology provides an approach for determining how much water must remain in a stream, river or other resource to support various uses. Detail on IFIM can be found at: http://www.mesc.usgs.gov/products/software/ifim/ifim.asp

[27] Compliance information for community water systems can also be viewed at: http://www.epa.gov/enviro/html/water.html#SDWIS

In most areas, approval from the local health department is required before a septic system may be constructed. To receive approval the applicant must demonstrate that soils meet minimum criteria such as water percolation rate and depth to water table or bedrock. An indication of soil suitability for septic systems can be gained by referring to the appropriate soil survey.[28] Frequently, minimum separation distances must be met between wells, streams, property lines and so forth. Unfortunately, compliance with these criteria do not always resolve water quality concerns. Following is a description of situations where septic systems may create problems. Development projects utilizing septic systems should be closely scrutinized for compliance with local-state regulatory requirements as well as the conditions described below.

Septic systems can adversely affect water quality through the release of disease-causing organisms and nitrogen. In fact septic systems are the second leading cause of groundwater contamination in the United States.[29]

A number of researchers have found a positive relationship between septic system density and groundwater contamination.[30] In general, well water will be protected from nitrate contamination if the density of homes served by septic systems averages no less than one per acre. In North Carolina researchers found a relationship between bacteria levels and the density of septic systems in areas draining to tidal waters from which oysters and other shellfish are harvested. When septic system density was more intense than one per six acres of watershed area, bacteria levels exceeded that deemed safe for shellfish harvesting.[31]

If a well screened at shallow depth is located within 200 feet downgradient of a septic system then contamination becomes more likely.[32] By shallow depth I mean a well where the casing ends at a depth of 60 feet or less (from the ground surface) and is not separated from the surface by a layer of clay or some other impermeable barrier.[33] Deeper wells may also be at risk if placed in coarse soils or where bedrock lies close to the point where septic system effluent is released into the ground. In both situations contaminant removal may be minimal.

Septic system are relatively ineffective at removing nitrogen. In fact, an average of 90% of the

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[28] Check with the local Soil Conservation District or Natural Resources Conservation Service office for soil survey information. To locate your local SCD or NRCS office visit: http://www.nrcs.usda.gov/contact/ A copy of the soil survey may also be found in a local public library.

[29] See *2000 National Water Quality Inventory* available for download at: http://www.epa.gov/305b/2000report/

[30] See *On-site sewage disposal - influence of system densities on water quality* for a review of these studies. This review is available for download at: http://pasture.ecn.purdue.edu/~epados/septics/septic/density.htm

[31] Duda, A.M. and K.D. Cromartie. 1982. *Coastal Pollution from Septic Tank Drainfields.* Journal of the Environmental Engineering Division ASCE. 108:1265-1279.

[32] Ibid and Ford, K.L., J.H. Schott, and T.J. Keefe, 1980. Mountain residential development minimum well protective distances well water quality. Journal of Environmental Health 43(3):130-133.

[33] Tuthill, A., D.B. Meikle and M.C.R. Alavanja, 1998. Coliform bacteria and nitrate contamination of wells in major soils of Frederick, Maryland.. Environmental Health, April 1998, p. 16-20.

nitrogen released into a septic tank is discharged to the soils beneath the drain field. A home served by a conventional septic system releases 27 pounds of nitrogen per year to the aquatic environment.[34] That's more nitrogen than released from an acre of cropfield and nine times the forest release rate.[35] Increasing the number of homes served by septic systems can cause a significant impact to lakes, estuaries or other waters considered threatened or impaired by nitrogen. Septic systems can be upgraded with filters and other measures which will reduce nitrogen loads by 50%.[36]

Wastewater Treatment Plants: If a project will connect to an existing sewerline, then take a look at the treatment plant which receives the wastewater carried by the sewer. If the plant is near or over capacity, then further connections to the sewer should not be allowed. Contact your state environmental protection agency to learn how frequently the plant violates pollution discharge limits.[37] If the plant has been cited for *significant noncompliance* then find out why. Further connections should be postponed until the cause(s) of noncompliance is corrected.

Using the volunteer monitoring techniques described above, examine the waterway which receives the effluent from the plant. Look for indications that the discharge is harming water quality.

If the applicant is proposing to construct a new wastewater treatment plant, then request an opportunity to review the application and other materials submitted to your state environmental protection agency. Determine if the proposed pollution discharge limits will adequately protect the receiving waters. Be certain to investigate any wetland permits the applicant must obtain to construct the plant or sewage collection system. If the applicant owns/operates existing treatment facilities, then find out how well these plants are run. Examine the effects of several existing plants that use the same treatment processes as the proposed plant.

Contact the agency responsible for maintaining the sewerline which will carry wastewater from the project site to the treatment plant. Find out how often sewage overflows occur, how close the line is to capacity, and the results of the latest inspection of the sewer. If the line is near or over capacity then further connections should be postponed until capacity is increased. If overflows have occurred during the last five years, determine why. If the causative factors have not been resolved, then, again, further connections should be postponed until repairs are made.

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[34] Maizel, M.S., G. Muehlbach, P. Baynham, J. Zoerkler, D. Monds, T. Livari, P. Welle, J. Robbin, and J. Wiles, 1997. The Potential for Nutrient Loadings from Septic Systems to Ground and Surface Water Resources and the Chesapeake Bay, published by the USEPA Chesapeake Bay Program, 410 Severn Avenue, Annapolis, MD 21403, April 1997.

[35] *Chesapeake Bay Program Watershed Model Application To Calculate Bay Nutrient Loadings*, U.S. Environmental Protection Agency, 410 Severn Avenue, Annapolis, MD 21403.

[36] Ibid.

[37] The US EPA maintains a website through which you can view compliance information for existing pollution discharges: http://www.epa.gov/enviro/html/water.html#PCS

If you have difficulty getting information about sewer condition or you would like to verify what you have learned, then walk along a mile or so of the line downstream of the proposed development site. Look for any point where sewage, appearing as a gray to black liquid, is seeping from the sewer or adjoining stream banks. At each manhole look for toilet paper, tampons, condoms, and other material indicating a recent sewage overflow. Talk to those who live near sewage pumping stations to learn how often overflows occur.

Wells: If the project will rely upon wells, then assess the ability of groundwater aquifers to accommodate additional water use without impacting existing users, depleting the flow to nearby wetlands or streams, or causing saltwater intrusion. Request an opportunity to review the results of any aquifer tests conducted on the site along with well logs and pumping tests for individual wells. Contact the state and U.S. Geological Survey[38] for the history of well yield in the area. If historically yields have been poor, then adding additional groundwater users may aggravate the problem.

[38] http://www.usgs.gov/