STATE OF WASHINGTON
DEPARTMENT OF ECOLOGY
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October 29, 2009

The Honorable Ron Walter
The Honorable Keith Goehner
The Honorable Doug England
Chelan County Board of Commissioners
400 Douglas Street, Suite 201
Wenatchee, WA 98801

The Honorable Mary Hunt
The Honorable Ken Stanton
The Honorable Dale Snyder
Douglas County Board of Commissioners
PO Box 747
Waterville, WA 98858-0747

RE: Upper Kittitas County Emergency Groundwater Rule

Dear Commissioners Hunt, Stanton, Snyder, Walter, Goehner, and England:

Thank you for the thoughtful letters describing your support of the Kittitas County Commissioners and your opposition to Ecology's withdrawal of groundwater from further appropriation in upper Kittitas County. We recognize and share your concern regarding potential economic implications of the withdrawal beyond Kittitas County and how it might impact water management in the greater Yakima basin and the rest of the state.

We know you appreciate the complex and challenging nature of water resource management, and we assure you we are committed to managing the waters of the state in a thoughtful manner.

We believe that our local communities, regional economy, and shared environmental resources will be best protected if the state and county governments work together, using a combination of County powers and land management authorities and State water management authorities. We look forward to working with you in these important efforts to meet both present and future water demands while protecting senior water right holders and instream flows.

The reliance of development on permit-exempt wells in upper Kittitas County helps to illustrate the complexity of managing water resources in the already complex Yakima River Basin. Left unmanaged, new permit-exempt wells in water short basins can reduce the value of senior water rights and put existing homeowners, farms and businesses throughout the basin at risk. Clarity in water rights and resources in the Yakima basin—gained through a water rights adjudication and extensive study of how groundwater pumping affects surface waters—provides a solid foundation for sound water solutions moving forward through effective water markets and thoughtful water supply projects.

The Yakima River Basin Water Enhancement Project 2009 Work Group, a work group of high level stakeholders is moving forward with an integrated approach to solve water problems in the Yakima basin. As the convener of that group, we are looking for new storage opportunities and improvements to the efficiency of water delivery systems. We're also looking at moving existing developed water supplies around through voluntary water right transfers. A major prerequisite to that success will be effective water banking and a functional water markets.

Much of our success in these areas will hinge on our understanding of how surface water and groundwater move in the basin and how junior water users can offset impacts of their groundwater pumping to avoid impairing senior rights during future droughts.
Working together to secure water supplies for municipal and domestic uses will need to be as important a factor to pursue in this undertaking as protecting existing irrigation and stream flow interests.

For these reasons we remain hopeful that the Yakima basin community can agree on long term water solutions that will sustain both the economic and the environmental health of the basin.

With that said, we believe the temporary withdrawal of the Upper Kittitas County area to all new unmitigated groundwater appropriations is necessary to protect senior water rights and stream flows and to reduce the legal risk of water supply curtailment for all existing water users throughout the basin. Our decision was not made lightly, and we fully recognize its gravity and importance.

Please see the background document attached for a more detailed assessment of water resource challenges and potential solutions in Kittitas County and the greater Yakima Basin.

If you have additional questions please contact our Central Regional Office Regional Director, Tom Tebb at thomas.tebb@ecy.wa.gov or at (509) 574-3989.

Sincerely,

Kenneth O. Slattery, Manager
Water Resources Program

Evan Sheffels, Special Assistant to the Director
Water Policy

Attachments (2)

cc: Tom Tebb, Ecology
Polly Zehm, Acting Director, Ecology
Ted Sturdevant, Ecology
Kittitas County Commissioners
Okanogan County Commissioners

Water Resource Challenges and Potential Solutions in Kittitas County and the Greater Yakima Basin

Water Supply Solutions—Our Focus

In the near term, Ecology is working with senior water right holders willing to make their water rights available to help people in the upper Kittitas establish new uses of groundwater for a variety of purposes, including for domestic use. The Yakima Pilot Water Bank will be used to hold trust water rights to mitigate for new groundwater development in areas where offset water is made available for purchase. Participants will make a one-time payment to purchase a small quantity of a senior water right to offset the impact of their future ground water withdrawal on existing water rights in the basin. Once an individual satisfies the mitigation requirements described in the emergency rule, Chapter 173-539A-050 WAC, their building plans may continue as normal and on their own timeline.

We are making progress in getting water into the bank, largely due to the certainty of water rights already adjudicated by the Yakima Superior Court. Even though adjudicated rights do provide a strong foundation for more efficient water market transactions, Ecology can't "make" a water market work or dictate its prices. Only willing buyers and sellers can make a water market work. Thus, local leaders have an important role to play in encouraging the participation of local water right holders and promoting the success of water bank efforts.

In addition, a work group of high level stakeholders is moving forward with an integrated approach to find long term solutions to the Yakima basin's water problems. This group, which includes representatives of the Yakama Nation, irrigation districts, environmental organizations, and federal, state, county and city governments, is pursuing a shared package of new storage and stream restoration opportunities. The group is also looking at projects to improve the efficiency of water delivery systems. Finding projects that can offset junior water use to avoid injury to senior rights during future droughts hinges on the understanding of how surface water and groundwater move in the basin. Fortunately, the scientific studies discussed later in this document will provide the hydrological foundation necessary to build broad community support for smart water supply projects.

While there are no easy fixes, we do believe durable water solutions can be found that do not come at the expense of existing water rights and stream flows in the Yakima basin.

The Yakima Basin – A Little Background

First and foremost it is important to understand water resource issues in the Yakima River Basin, where water supplies have been over-appropriated for decades. The 32-year old Yakima Surface Water rights Adjudication (*Ecology v. Acquavella*), the largest and most complex adjudication in state history, is close to wrapping up. Three times in the last decade junior surface rights (with priority dates after May 10, 1905) have been temporarily curtailed or shut off by the Yakima Superior Court. When there isn't enough surface water (storage and run-off combined) to satisfy all water rights in the Yakima Basin surface water rights with priority dates as senior as 1905 can expect to have their water supplies curtailed or shut off. This includes many domestic surface water users, irrigators like the Roza Irrigation District and the Kittitas Reclamation District (both 1905 priority date), and municipalities like Roslyn (1908 priority date), who have had their water supplies cut off to ensure that older, senior water rights can receive their full supply.

Against the backdrop of the adjudication, the Department of Ecology entered into a 1998 settlement agreement with the Yakama Nation and the United States Bureau of Reclamation. The agreement followed a legal challenge by the Yakama Nation that new groundwater pumping reduced surface water supplies. As a senior water right holder, Reclamation joined the challenge against Ecology to protect the federal Yakima Project's total water supply available. This was due to their concern that the expansion of groundwater wells takes water that would eventually reach streams and help fulfill their senior water rights. Under the settlement agreement, Ecology agreed not to issue additional groundwater rights pending completion of a USGS study of how groundwater aquifers and surface water supplies are interconnected in the basin. Though exempt wells were not included in the 1998 ban on new groundwater pumping, growing concerns regarding the cumulative impacts of exempt wells in Kittitas County have surfaced in the last several years.

Recent scientific studies conclude that most of the basin's groundwater flows into the Yakima River and its tributaries, and that new groundwater wells would affect streamflows and "capture" water supplies that would otherwise be available to senior surface water right holders in times of drought. Thus, increased use of new permit-exempt wells further contributes to the basin's already critical water supply problems.

Further exacerbating these problems, the frequency of water right curtailments in the basin, and economic losses associated with such curtailments, is expected to increase dramatically in the years ahead. A prominent group of scientists, including scientists at the Pacific Northwest National Laboratories and the University of Washington's Climate Impacts Group, recently reported the following for the Yakima Basin: "Without adaptation, shortages would likely occur 32% of years in the 2020s, 36% of years in the 2040s, and 77% of years in the 2080s (compared to 14% of years for the period 1916-2006). Due to lack of irrigation water and more frequent and severe curtailment, average production of apples and cherries would likely decline by approximately $23 million (about 5%) in the 2020s and $70 million (about 16%) in the 2080s." Their studies suggest that changes in climate will dramatically reduce the availability of summer water supplies in this snowpack-dependent basin, stretching an already water-short basin to the breaking point.

The combination of these factors creates unacceptable risk for tens of thousands of water users in the basin, including existing homeowners, cities, businesses and farms that have been relying on permitted and permit-exempt groundwater withdrawals. Like surface water users Roslyn and Roza virtually, all existing groundwater users in the basin share the potential legal jeopardy of court-ordered water use curtailment during the next drought. However, because the *Acquavella* adjudication deals only with surface waters, many groundwater users in the basin may not be fully aware of potential future risks to their water rights.

Existing community members with senior water rights deserve to have their water rights protected. Further, their years of contribution to the regional economy should be recognized and appreciated every bit as much as the developers, realtors and well drillers involved in bringing newcomers to the region.

A Roza Irrigation District representative said it best in a recent *Yakima Herald* article: "All these wells that are drilled are sucking water from the total water supply available. That total hit goes to the proratables." Favoring a mitigation system that will remove the impact new uses have, he said that irrigators "want a win-win. We want this to quit drafting on the total water supply available, but we want people to drill their wells through a permit out of a water bank."
This is why we have been working diligently with the citizens of the Yakima basin, as well as those in other water short basins of our state, to find sensible pathways to help new development move forward in a thoughtful manner. Success in these efforts is essential if future conflicts among water right holders are to be reduced or avoided. We invite and need the help of local leaders if we are going to get there.

Sound Water Resource Decisions—The Scientific Basis

Enclosed is an annotated bibliography. It includes excerpts from information sources on the interrelationship of ground and surface water. These sources, many of them produced by the United States Geological Survey (USGS), describe the scientific basis for our actions to date. The USGS is regarded as the leading scientific authority on water resources in the United States. Among sources cited are studies specific to the Yakima Basin's hydrogeology.

We believe more than ample scientific sources exist, going back decades, that support the conclusion that most of the groundwater in the basin is hydrologically connected to surface streams. The most recent report from the USGS found that while groundwater levels in sedimentary aquifers have remained fairly steady over the last 50 years, largely due to surface water and irrigation seepage, that water cannot be considered available for new use because it is relied on to meet existing downstream water rights. That means that unmitigated water uses for new development in the Yakima basin comes at the expense of the basin's existing water users because it reduces the basin's "total water supply available" during periods of drought. Though we, like you, want to do what we can to help new development move forward, it is only fair to require that such development find a path forward that does not destroy senior rights with clearly superior legal entitlements to the use of such water during periods of scarcity. We believe you would agree that these water rights are a valuable form of property right that needs to be protected.

Kittitas County and the State have agreed to conduct a separate study of groundwater movement in the higher elevation bedrock areas of upper Kittitas County. The legislature has provided the funding. This Upper Kittitas groundwater study is necessary because the current United States Geological Survey (USGS) groundwater study of the Yakima River Basin does not study or report on the Upper Kittitas County bedrock hydrogeology in sufficient detail to support effective mitigation for impacted streams in the headwater areas . While our hydrologists think such new uses in the bedrock area are likely to reduce total water supplies available to senior rights in the basin, a better understanding of how, when and where groundwater pumping in this area affects surface water is essential for water managers to make sound water resource decisions. The final results from both of these important studies will provide a necessary foundation for long-term water supply opportunities and will have a major bearing on how water is managed in the entirety of Kittitas County in the future, including permit exempt wells.

Partnership Efforts—Working Toward Common Ground

As you are aware, on July 16, 2009 the Department of Ecology (Ecology) adopted an emergency rule, Chapter 173-539A WAC, which temporarily withdraws aquifers in Upper Kittitas County to all new groundwater withdrawals. Ecology took this necessary and precautionary action to preclude new unmitigated water allocations in order to protect both existing and future water users facing court-ordered curtailments during future droughts and other water shortages in the greater Yakima Basin. Based on a request from Governor Gregoire, Ecology amended the rule on July 31, 2009, to allow excluded those people from the rule with vested building permit applications or building permits as of July 16, 2009 to proceed with their projects.

As you know the Department of Ecology and Kittitas County have been exploring a potential partnership agreement to allow some development to continue in the upper Kittitas under the permit exemption. The goal is to limit water use for individual projects using the exemption and stretch water supplies further to provide more development opportunities. However, a recent Attorney General's Opinion (AGO #6, 2009) concluded that while the Department of Ecology can stop new groundwater appropriations from both permitted and permit exempt wells, the department may not use the withdrawal provision of RCW 90.54.050(2) to place limits on permit exempt well extractions that are lower or different than the types and amounts authorized by RCW 90.44.050.

This means that our proposed partnership agreement now depends on the County using its authorities to conserve basin water supplies and stretch them further, potentially including use of its general police powers and authorities under the State Environmental Policy Act, the Growth Management Act, or other authorities, such as the County's authority to act upon subdivision (Chapter 58.17 RCW) or building permit applications (Chapter 19.27 RCW).

Unfortunately, the county's legal arguments in a current Court of Appeals case contend that the County lacks legal authority in key areas. The Attorney General respectfully declined to answer questions surrounding potential county authorities in this area because they raised issues currently pending in litigation before Division III of the Court of Appeals (*Kittitas County v. Kittitas County Conservation Ridge*).

In our view, the county does possess the requisite legal authorities to implement our proposed agreement. Further, it is our view that the building permit, platting and subdivision statutes require county consideration of whether the proposed water supply for a project is physically and legally adequate and appropriate.

Kittitas County's legal arguments in that pending litigation, if successful, would indirectly undermine and perhaps invalidate conservation and project review provisions central to our proposed partnership agreement. Among other things, this includes an ordinance the County has drafted and offered to enact which would limit unmitigated lawn and garden watering in bedrock areas of the Upper Kittitas basin. The ability to get to the goal of a viable partnership may ultimately depend on final resolution of the pending Court of Appeals case, or alternatively, on the County's willingness to modify its legal arguments to make them consistent with the actions and authorities needed to effectively implement key provisions of our proposed agreement.

Despite our difficulties in getting to common ground, we do hope to continue working with the Kittitas County Commissioners to develop a path forward for sustainable economic growth and ensure the protection of the greater Yakima Basin's water rights and water supplies upon which so many depend. In the meantime, recognizing that all permit exempt groundwater withdrawals in Kittitas (and the greater Yakima Basin) are junior in priority to senior surface water rights and most permitted groundwater rights, and thus vulnerable to future curtailment, Ecology is working diligently to develop a mitigation program (Yakima Pilot Water Bank) so such water users can continue to use water in times of shortage. We will also continue to work with area stakeholders on long-term water supply projects to accomplish the same result: enhanced water supply reliability and protection from curtailment during times of water shortage.

Authorities to Protect Water Rights and Resources

In passing the 1945 Ground Water Code the 1945 legislature did what it could to promote and encourage smart new economic development to help the post-war economy move forward. In doing so , however, the legislature ensured that the water needed to accommodate these new projects and investments would not be taken out of the pockets of the senior rights of citizens and businesses already in existence. Like the 1945 legislature, we first need to focus on keeping the cities, companies agricultural bounty and jobs we have today. To do that we need to protect existing water rights. Then we need to find creative ways to work together to accommodate future development in a manner that doesn't hurt the existing citizens, farms, tribes, businesses, homeowners and jobs we have today.

The 1946 State Division of Hydraulics and Water Resources Report to the Governor notes that the ground water code was enacted at the request of the Association of Washington Cities whose member cities and towns wanted to protect their large investments in well facilities for obtaining ground water supplies. The Report reflects the goal of the legislation as follows: "With a water code, under which the waters can be controlled and regulated, a water user may acquire definite rights to the use of water to protect investments made….Whereas, in absence of such a law, the development of this resource might become competitive to the extent that it could cause severe damage or loss to those who already make use of the ground water and possibly to the existing supply. Such destructive competition has been the experience of certain other states. In some sections of this state, uncontrolled withdrawal of water has already caused damage to existing rights and resources." (*Washington Public Documents*, 1945-1946, "Third Biennial Report of the Department of Conservation and Development," pp 45-46).

The 1945 Ground Water Code also clearly established that all existing senior surface water rights are to be protected from interference caused by subsequent new appropriations of groundwater: "…to the extent that any underground water is part of or tributary to the source of any surface stream or lake, or that the withdrawal of groundwater may affect the flow of any spring, water course, lake, or other body of surface water, the right of an appropriator and owner of surface water shall be superior to any subsequent right hereby authorized to be acquired in or to groundwater" (RCW 90.44.030).

The Legislature of 1971 added further detail to the need for precautionary measures to protect existing surface and ground water rights from potential injury by future groundwater uses: "Full recognition shall be given in the administration of water allocation and use programs to the natural interrelationships of surface and ground waters" RCW 90.54.020(8). This provision was part of the Water Resources Act of 1971, which also recognized that leaving water in the stream protected both out-of-stream water rights and instream water resources.

This 1971 Act also included the provision now codified at 90.54.050(2), which provides the basis for Ecology's existing temporary withdrawal rule to prevent new unmitigated groundwater appropriations in Upper Kittitas County. This provision clearly established that the department may, "when sufficient information and data are lacking to allow for the making of sound decisions, withdraw various waters of the state from additional appropriations until such data and information are available." Thus, the department may keep such a withdrawal in place until the Department gathers sufficient information and data to determine whether water can in fact be made available for new groundwater withdrawals, including from exempt wells, in a manner which will not harm senior water users.

In enacting this provision, the 1971 legislature authorized a precautionary approach to protect the rights of senior water right holders by stopping any new withdrawals that might deplete a water source such seniors depend upon.

Passage of this bill was a bi-partisan effort. The 1971 House, which had a Republican majority, included a number of familiar names, including Representatives Sid Flanagan (R- Kittitas, Grant); Stewart Bledsoe (R-Kittitas, Grant,); Joe Mentor (R-Island, Kitsap); Alan Thompson (D-Cowlitz); Eric Anderson (D-Grays Harbor); Ken Eikenberry (R-King); Sid Morrison (R-Yakima); and Irv Newhouse (R-Yakima). The 1971 Senate, which had a Democratic majority, also included a number of familiar names, including Senators Jim Matson (R-Yakima); Nat Washington (D-Kittitas, Grant); Bob McDougall (R-Chelan, Douglas); Hubert Donohue (D-Walla Walla, Asotin) Bruce Wilson (D-Okanogan, Ferry, Stevens); Sid Snyder (D-Pacific County); Gordon Sandison (D-Jefferson, Clallam); and Jack Metcalf (R-Island). The Governor at the time, Dan Evans, was a Republican.

Representative Flanagan, a Quincy Republican, was the Chairman of the House Natural Resources Committee for the Republican majority. He was a farmer and a cattleman who represented Grant and Kittitas Counties. He was also an irrigation district director and the President of the Washington State Reclamation Association (formerly the Washington Irrigation Institute), an organization dedicated to protecting the water rights and interests of irrigators. His committee, which had a 2 vote Republican majority, passed the bill. It included the withdrawal provision contained in RCW 90.54.050(2), showing that the bi-partisan legislature of 1971 legislature was serious about finding new water supply solutions and protecting the property rights held by senior water right holders.

We also choose to move forward in a bi-partisan spirit, in accord with the 1971 Ground Water Act and the Columbia River legislation of 2006. We all worked together to pass that bill, sponsored by Representative Bill Grant. We believe the legislative findings of that historic bill provide a wise and balanced focus for our efforts today, as we work together to develop new water supplies "in order to meet the economic and community development needs of people and the instream flow needs of fish" (RCW 90.90.005). Working together, we can make that goal a reality.

Ground Water and Surface Water

A Single Resource in the Yakima Basin

September 25, 2009

The need for coordinating the management and use of groundwater and surface water is becoming recognized throughout the western United States and much of the world. Although groundwater is a relatively small portion of the overall hydrologic cycle it is a critically important component in the natural movement of water though most watersheds. In part because groundwater was not well understood, its regulation and management has historically been approached separately and distinctly from surface water. However, as the scientific understanding of groundwater has increased, it has become apparent that groundwater and surface water use can only be effectively managed as a single resource.

All groundwater withdrawals result in impacts to the hydrologic system in which they occur. Although most individual withdrawals are relatively small and frequently undetectable at the basin scale, each new withdrawal adds to the total being consumed. And in the last 60 years, throughout most of Washington, the amount of groundwater withdrawn and consumed has increased each year.

In most cases, the hydrologic impacts from pumping manifest themselves as reductions in storage (declining water levels in the aquifer over time) and reduced discharge, (decreases in the amount of water flowing out of the aquifer). Because rivers and streams are frequently the primary natural drain for most aquifers tapped by wells, pumping and consuming groundwater almost always impacts surface water bodies. Most of the rivers and streams being impacted by pumping do not have water available without negative consequences to existing instream resources or impairment of senior water rights.

Late summer streamflow in most of Washington's rivers and streams is dependent on groundwater draining into the streambed. During the drier summer months when flows are the typically the lowest of the year, groundwater flowing into the stream is frequently providing almost all of the streamflow. Groundwater also provides a source of cooler water which is critical to fish reproduction and survival. It is widely known and accepted by hydrogeologists that use and consumption of groundwater typically results in decreases in streamflow. There are literally thousands of published references describing and quantifying groundwater – surface water interactions and why this occurs, including many good reports regarding conditions throughout Washington. Specific references regarding groundwater surface water interaction in the Yakima Basin are included in Attachment 1.

It is also becoming widely apparent through legal opinions and court rulings that surface and groundwater must be managed together and that groundwater withdrawals can and do impair surface water rights. This is consistent with the recommendation from Robert Hirsch, the Chief Hydrologist for the USGS, who wrote *"Effective policies and management practices must be built on a foundation that recognizes that surface water and ground water are simply two manifestations of a single integrated resource."* See: http://pubs.usgs.gov/circ/circ1139/#pdf Additional selected quotes and figures from USGS Circular 1139 are included in Attachment 2.

Another particularly relevant publication regarding the wise and sustainable use of groundwater as well as the impacts from development is USGS Circular 1186. See: http://pubs.usgs.gov/circ/circ1186/pdf/circ1186.pdf Selected quotes and figures from USGS Circular 1186 are included as Attachment 3.

ATTACHMENT 1

Ashbury, A. Brooke, Gazis, Carey A., and Ely, Lisa L., 2003, Characterization of geomorphology and hypopheric conditions of Spring Chinook salmon breeding habitat within the Yakima River Basin, 4th Symposium on the Hydrogeology of Washington State, April 8-10, 2003, Tacoma, Washington, Program, p. 14.

- Study looked at the link between the temperature and chemical characteristics of Chinook salmon spawning habitat it and reaches of the river with ground water discharge.

Associated Earth Sciences, Inc., 2000, Hydrogeologic Assessment Infiltration Gallery Siting Study, Mountain Star Master Planned Resort, Kittitas County, Washington, Report prepared by Associated Earth Sciences, Inc. for Trendwest Resorts, Inc.

- "The proximity of the pumping well (CR-P) to the Cle Elm River and the results of our aquifer testing and analysis indicate that a significant portion of the water extracted by the well is actually withdrawn from the Cle Elum River."

Associated Earth Sciences, Inc., 2004, Hydrogeologic Assessment / Wellfield Feasibility Study, Mountain Star Master Planned Resort, Kittitas County, Washington, Report prepared by Associated Earth Sciences, Inc. for MountainStar resort Development, LLC.

- This report assessed the viability of developing a wellfield adjacent to the Cle Elum river for the MountainStar Master Planned Resort. In the conclusions section of the report the authors state that "The rapid stabilization of water level drawdown in the pumping and observation wells and the indication of a positive hydraulic boundary in plots of drawdown data indicate a direct hydraulic connection between the alluvial aquifer and the Cle Elum River."

Foxworthy, B.L., 1962, Geology and Ground Water Resources of the Ahtanum Valley, Yakima County, Washington, USGS Water Supply Paper 1598, 100p.

- This study examined stream hydrographs and water levels in wells within the Ahtanum Valley. The author found that the Yakima River receives flow contribution through ground water discharge.

Gregg, D.O. and Bostwick, L., 1975, A general outline of the water resources of the Toppenish Creek Basin, Yakima Indian Reservation, Washington, USGS Opern File Report 75-19 46p.

- This study determined that continuity exists between surface waters and shallow ground water.

Hay, J.E. and Krautkramer, M.F., 2000, Hydrogeologic Characterization of the Ivan Hutchinson Pit and Proposed Expansion, Robinson & Noble, Inc. report conducted for Ellensburg Cement Products, Ellensburg, Washington 7 p. plus figures.

- This report document the investigation of the Ivan Hutchinson gravel pit located 2.5 miles west of the City of Ellensburg, Washington. In the section discussing the hydrogeologic setting, the authors state that "The same long-term observations over the course of the mine's period of operation also suggest that the majority of water enters the pit from the northeast face of the pit, indicating a flow gradient to the southwest toward the Yakima River." And, "The water moving in the surficial permeable deposits (present as the upper six to eight feet of the geologic section at this site) flows across the undulatory, eroded surface of the Thorp Gravel towards the Yakima River. The northeast wall of the pit intercepts water that would otherwise have flowed directly through the site to the river."

Hoselton, A., 1992, Yakima Greenway Well / G429825T, Wa. Dept. Ecology Central Regional Office intra office memo 6 p.

- It appears reasonable to assume that some degree of hydraulic continuity exists between the Yakima River and the Yakima Greenway.

Jones, M.A., Vaccaro, J.J., and Watkins, A.M., 2006, Hydrogeologic Framework of Sedimentary Deposits in Six Structural Basins, Yakima River Basin, Washington: U.S. Geological Survey Scientific Investigations Report 2006-5116, 24 p.

- Good description of the six structural basins that make up the Yakima River Basin. Report states that about 45 percent of the water diverted for irrigation is eventually returned to the river system as surface-water inflows and ground water discharge, but at varying time-lags. During the low-flow period, these return flows, on average, account for about 75 percent of the streamflow below the Yakima River near Parker streamflow gaging station. Much of the surface-water demand in the basin below Parker is met by these return flows and not by the release of water from the reservoirs.

Kinnison, H.B. and Sceva, J.E., 1963, Effects of Hydraulic and Geologic Factors on Streamflow of the Yakima River Basin Washington, USGS Water Supply Paper 1595 134 p.

- This study determined that continuity exists between surface waters and the sedimentary material within the Yakima Basin. The following are quotes from the report: "Ground water withdrawals affect stream flows in many ways. Large withdrawals may reduce the base flow of a stream..." "Ground water in the Yakima River Valley, downstream from Keechelus Dam, moves down valley and discharges into the Yakima River above the constriction at the southeastern end of the sub basin."

Packard, Frank A., 1981, Reconnaissance of Water Availability and Quality in Abandoned Coal Mines Near Roslyn, Kittitas County, Washington, USGS Water Resources Investigations Open-File Report 80-955 20 p.

- This report investigated pumping the ground water in abandoned coal mines in the Rosly-Cle Elum area to support flows in the Yakima River during periods of drought. The report investigated water quantity and water quality issues. The report indicated that "predicting the effects of downward leakage on the shallow ground water table and the flow on the Yakima River hazardous at best."

Stanford, J.A., Snyder, E.B., Lorang, M.N., Whited, D.C., Matson, P.L., and Chaffin, J.L., 2002, The Reaches Project: Ecological and Geomorphic Studies Supporting Normative Flows in the Yakima River Basin, Washington, Flathead Lake Biological Station, The University of Montana, Polson, Montana, Final Report to the USBR Yakima Office and Yakama Nation, 152 p.

- The major finding of this report is that the "Ground-surface water interactions were demonstrated for all five flood plains. Water table elevation in monitoring wells changed in direct relation to river stage (discharge). Water from the river circulates into the floodplain aquifers and back again as evidences by presence of flowing springs flood channels at base flow. Moreover, in the Cle Elum and Kittitas reaches, amphibitic stoneflies were commonly collected in monitoring wells. The organisms are well known as indicators of strong connectivity between the river and its floodplain aquifer.

Vaccaro, J.J., 2008, A thermal profile method for long river reaches to identify potential areas of ground-water discharge and preferred salmonid habitat and to document the longitudinal temperature regime, Symposium on Identifying, Protecting, and Restoring Thermal Refuges for Coldwater Fishes, A.F.S., May 4-8, 2008, Portland, Oregon

- This study discusses the ecological role of stream bed temperatures and how ground-water discharge to the stream bed is essential to ecological and biological functions of spawning salmon.

Vaccaro, J.J., 2005, Thermal profiling of long river reaches to characterize ground-water discharge and preferred salmonid habitat: Presentation by the U.S. Geological Survey at the 5th Washington Hydrogeology Symposium, Tacoma, Washington, April 12-14, 2005, 25 p.

- Study used thermal profiling of long river reaches in the Yakima Basin to show the relationshiop between ground water discharge and salmon spawning habitat.

Vaccaro, J.J., 2007, Yakima River Basin Ground-Water Investigation--An update: Presentation by U.S. Geological Survey at Yakima River Basin public update, Yakima, Washington, February 28, 2007, 85 p.

- Update includes a slide depicting the gaining and losing reaches of the Yakima River. Same slide shows gaining reach in Upper Kittitas County just below Keeculus dam. Gaining reach is attributed to ground water discharge. Good correlation between thermal profiling data and ground water discharge data.

Vaccaro, J.J., Keys, M.E., Julich, R.J., and Welch, W.B., 2008, Thermal profiles for selected river reaches in the Yakima River basin, Washington: U.S. Geological Survey Data Series 342

- Thermal profiles were collected to obtain information for identifying potential areas of ground-water discharge. The thermal profiles also provide information on potential preferred salmonid habitat.

Vaccaro, J.J., and Maloy, K.J., 2005, Thermal profiling of long river reaches to characterize ground-water discharge and preferred salmonid habitat [abs.]: 5th Washington Hydrogeology Symposium, Tacoma, Washington, April 12-14, 2005, Program, p. 66. (PDF, 2.13 MB)

- Thermal profiles were collected to obtain information for identifying potential areas of ground-water discharge. The thermal profiles also provide information on potential preferred salmonid habitat.

Vaccaro, J.J., and Maloy, K.J., 2006, A method to thermally profile long river reaches to identify potential areas of ground-water discharge and preferred salmonid habitat: U.S. Geological Survey Scientific Investigations Report 2006-5136, 16 p

- Using thermal profiling methods were able to locate ground water discharge areas. Temperature and therefore ground water discharge areas are thought to be a limiting factor for most life-history stages of salmonids in the Yakima River Basin

ATTACHMENT 2

USGS Circular 1139 – Ground Water and Surface Water A Single Resource

Selected Figures and Quotes

"Surface water commonly is hydraulically connected to ground water, but the interactions are difficult to observe and measure"

"Ground water moves along flow paths of varying lengths in transmitting water from areas of recharge to areas of discharge"

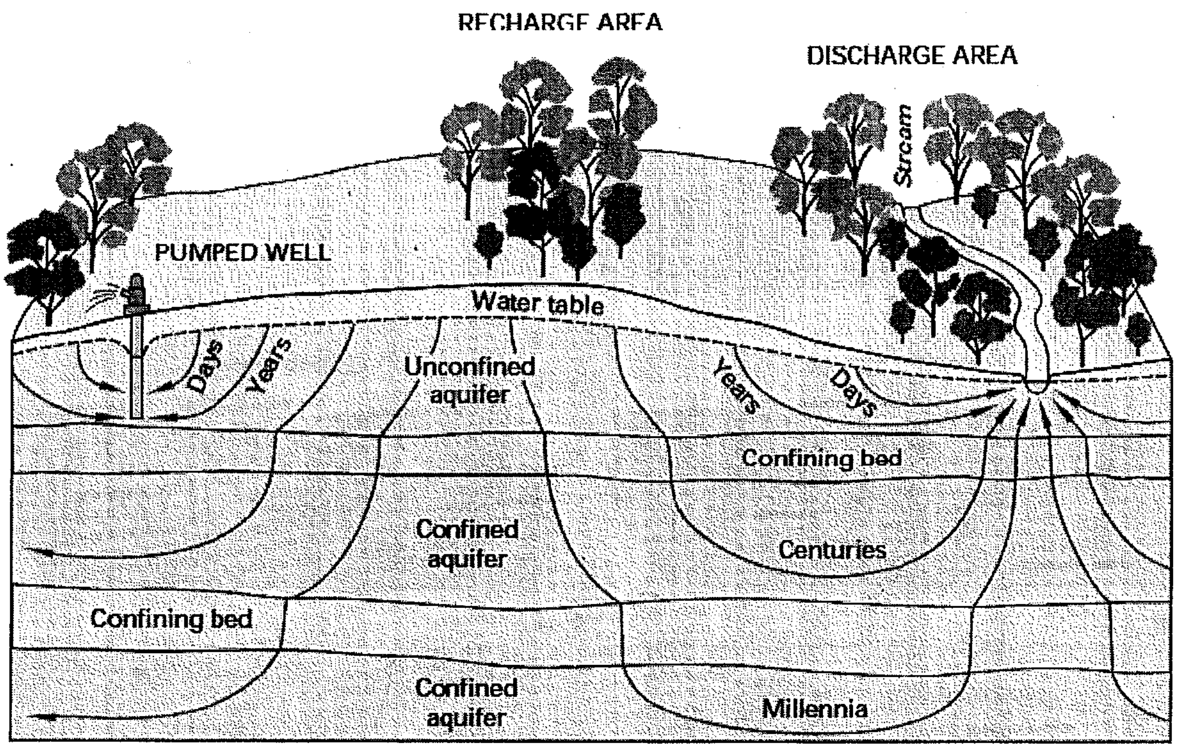

Figure 3. *Ground-water flow paths vary greatly in length, depth, and traveltime from points of recharge to points of discharge in the groundwater system.*

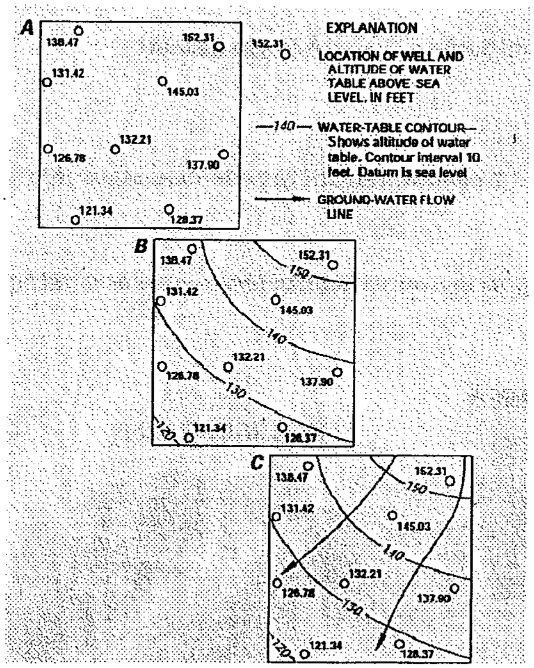

Figure A-2. Using known altitudes of the water table at individual wells (A), contour maps of the water-table surface can be drawn (B), and directions of ground-water flow along the water table can be determined (C) because flow usually is approximately perpendicular to the contours.

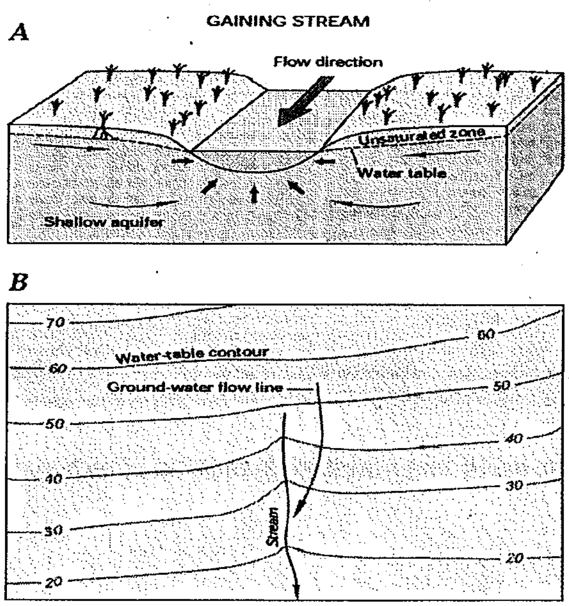

Figure 8. Gaining streams receive water from the ground-water system (A). This can be determined from water-table contour maps because the contour lines point in the upstream direction where they cross the stream (B).

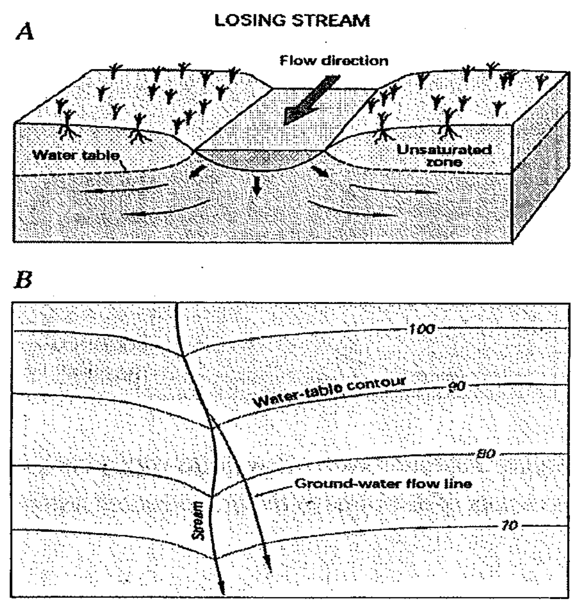

Figure 9. Losing streams lose water to the ground-water system (A). This can be determined from water-table contour maps because the contour lines point in the downstream direction where they cross the stream (B).

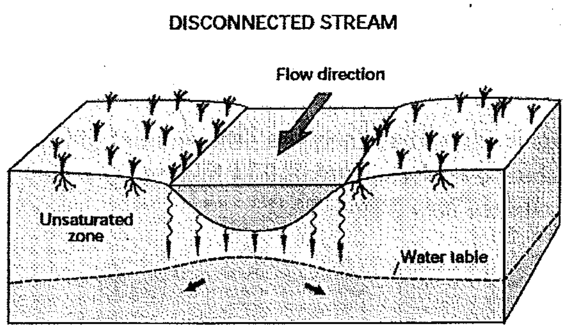

Figure 10. Disconnected streams are separated from the ground-water system by an unsaturated zone.

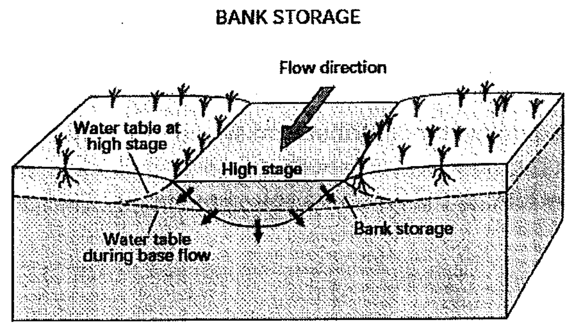

Figure 11. If stream levels rise higher than adjacent ground-water levels, stream water moves into the streambanks as bank storage.

"Streams interact with ground water in three basic ways: streams gain water from inflow of ground water through the streambed (gaining stream), they lose water to ground water by outflow through the streambed (losing stream), or they do both, gaining in some reaches and losing in other reaches"

Ground water contributes to streams in most physiographic and climatic settings. The amount of water that ground water contributes to streams can be estimated by analyzing streamflow hydrographs to determine the ground-water component, which is termed base flow (Figure B–1).

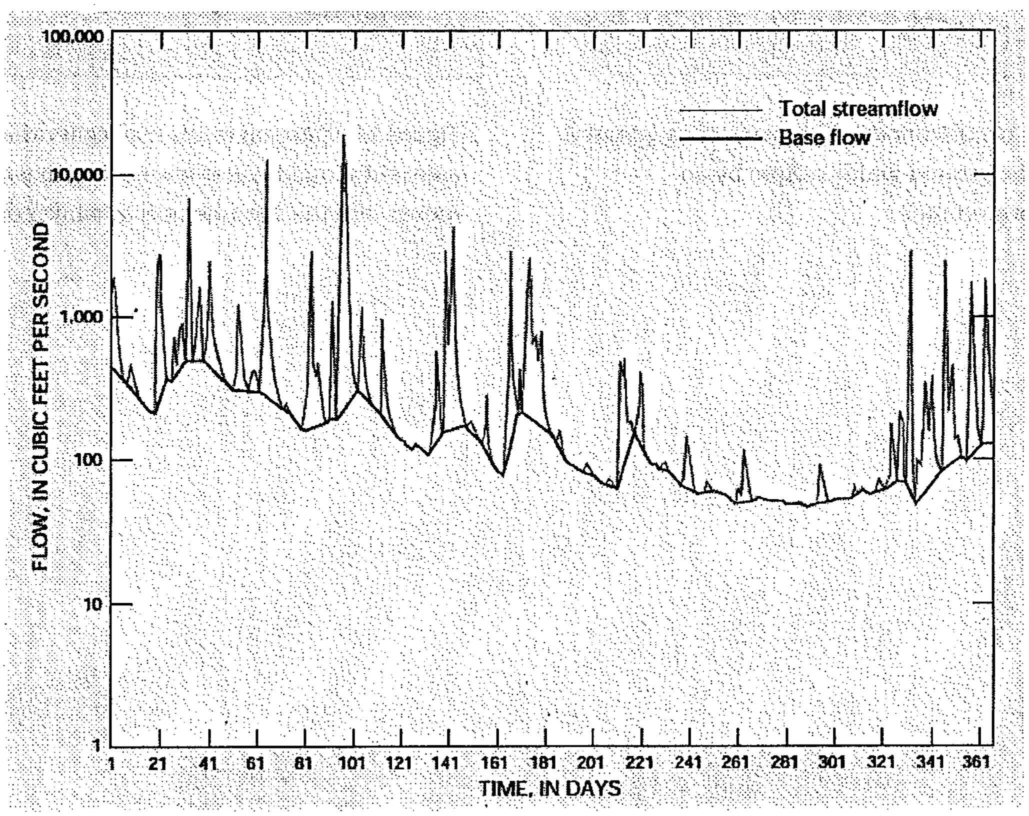

Figure B–1. *The ground-water component of streamflow was estimated from a streamflow hydrograph for the Homochitto River in Mississippi, using a method developed by the institute of Hydrology, United Kingdom. (Institute of Hydrology, 1980, Low flow studies: Wallingford, Oxon, United Kingdom, Research Report No. 1.)*

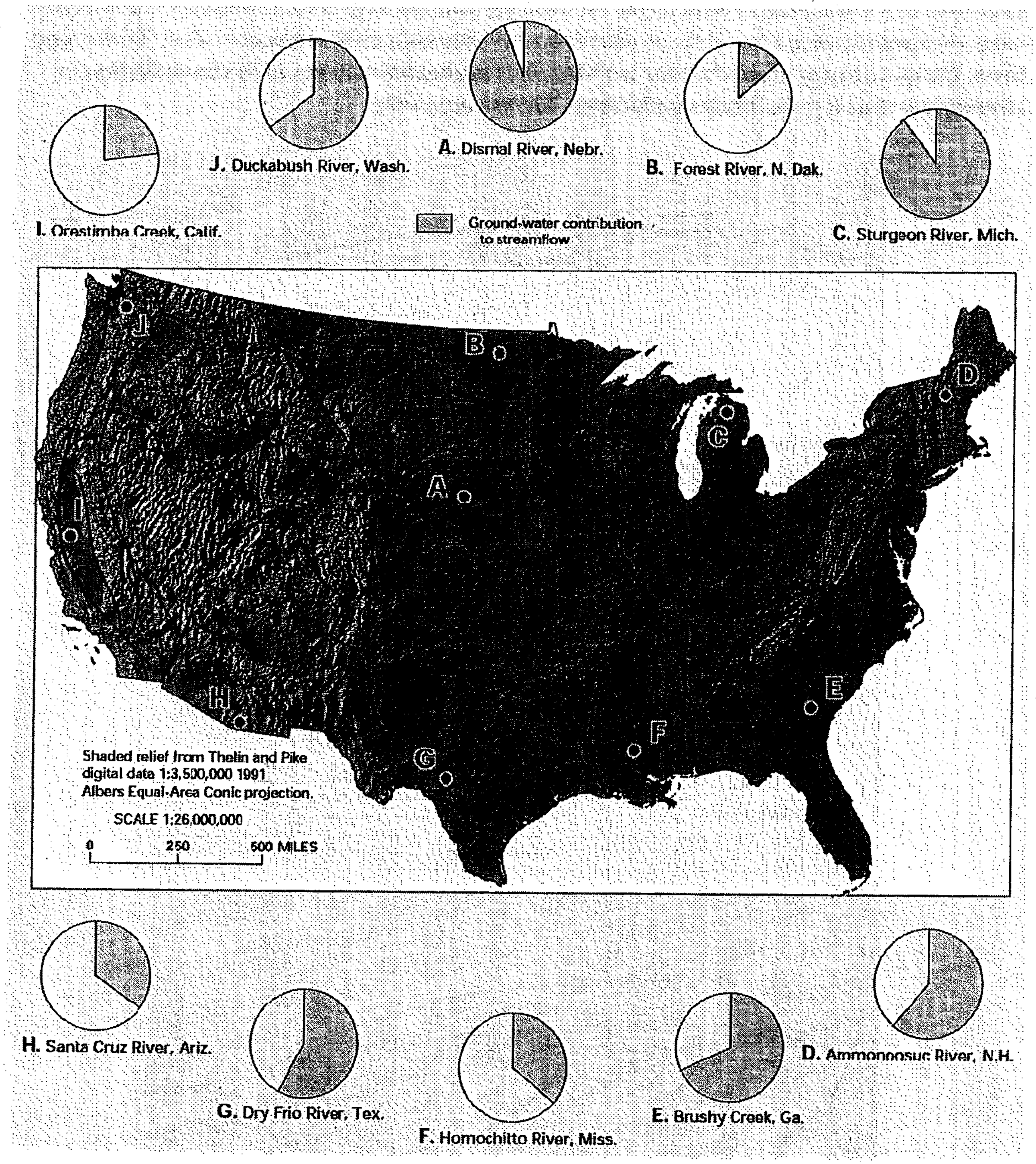

***Figure B–2.** In the conterminous United States, 24 regions were delineated where the interactions of ground water and surface water are considered to have similar characteristics. The estimated ground-water contribution to streamflow is shown for specific streams in 10 of the regions.*

The Effect of Ground-Water Withdrawals on Surface Water

Withdrawing water from shallow aquifers that are directly connected to surface-water bodies can have a significant effect on the movement of water between these two water bodies. The effects of pumping a *single well or a small group of wells on the hydrologic regime are local in scale. However, the effects of many wells withdrawing water from an aquifer over large areas may be regional in scale.* ***In the long term, the quantity of ground water withdrawn is approximately equal to the reduction in streamflow that is potentially available to downstream users.***

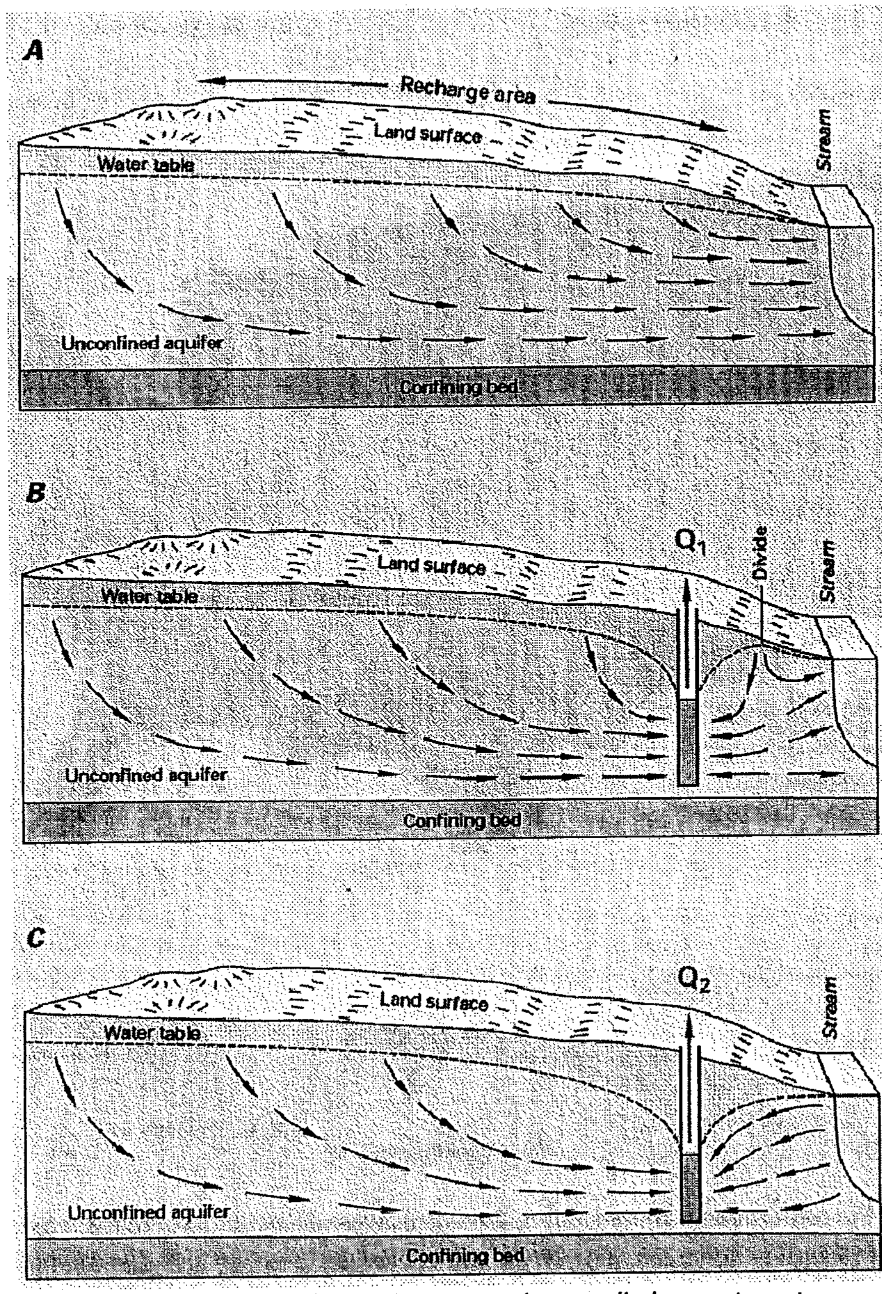

Figure C–1. *In a schematic hydrologic setting where ground water discharges to a stream under natural conditions (A), placement of a well pumping at a rate (Q1) near the stream will intercept part of the ground water that would have discharged to the stream (B). If the well is pumped at an even greater rate (Q2), it can intercept additional water that would have discharged to the stream in the vicinity of the well and can draw water from the stream to the well (C).*

Interaction of Ground Water and Surface Water in Mountainous Terrain

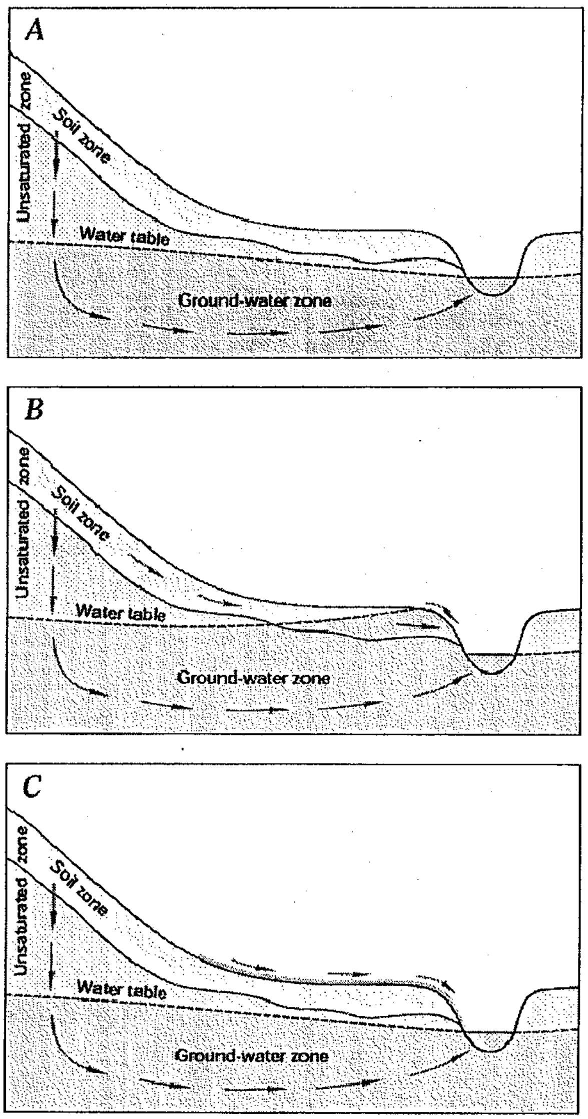

Figure 20*. Water from precipitation moves to mountain streams along several pathways. Between storms and snowmelt periods, most inflow to streams commonly is from ground water (A). During storms and snowmelt periods, much of the water inflow to streams is from shallow flow in saturated macropores in the soil zone. If infiltration to the water table is large enough, the water table will rise to the land surface and flow to the stream is from ground water, soil water, and overland runoff (B). In arid areas where soils are very dry and plants are sparse, infiltration is impeded and runoff from precipitation can occur as overland flow (C).*

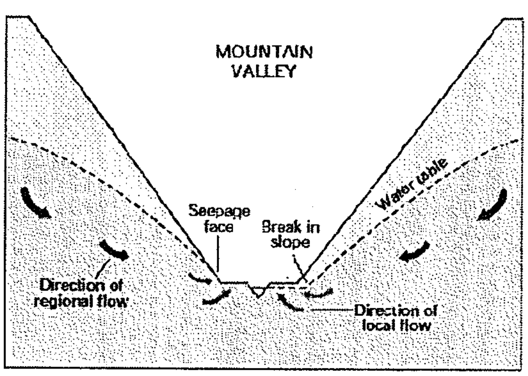

Figure 21*. In mountainous terrain, ground water can discharge at the base of steep slopes (left side of valley), at the edges of flood plains (right side of valley), and to the stream.*

Interaction of Ground Water and Surface Water in Riverine Terrain

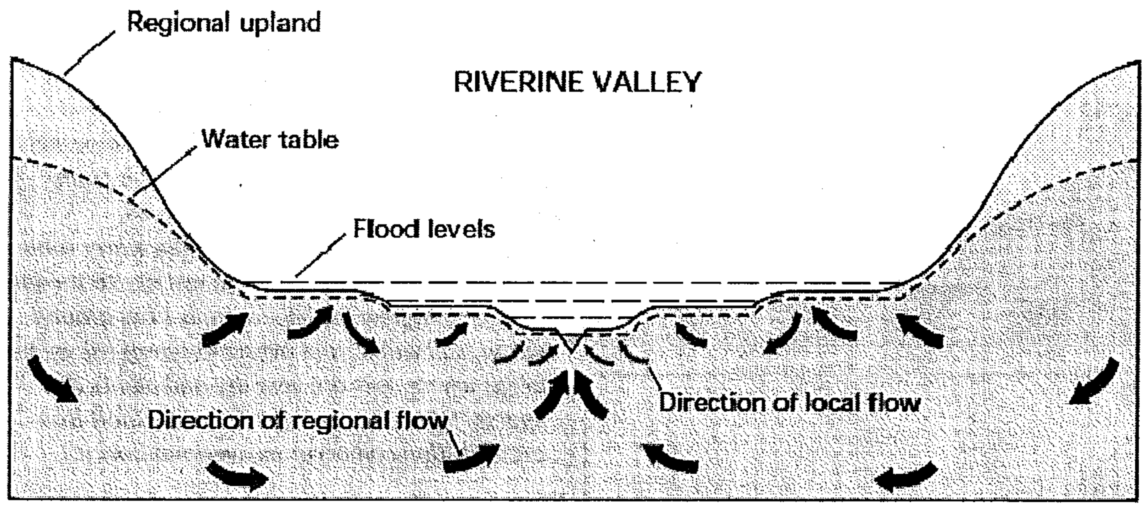

Figure 22. *In broad river valleys, small local ground-water flow systems associated with terraces overlie more regional ground-water flow systems. Recharge from flood waters superimposed on these ground-water flow systems further complicates the hydrology of river.*

ATTACHMENT 3

USGS Circular 1186 – Sustainability of Ground-Water Resources

Selected Figures and Quotes

"The sustainability of ground-water resources is a function of many factors, including depletion of ground-water storage, reductions in streamflow, potential loss of wetland and riparian ecosystems, land subsidence, saltwater intrusion, and changes in ground-water quality." – Charles G. Groat, Director, USGS.

Ground water is one of the Nation's most important natural resources.

Ground water is a major contributor to flow in many streams and rivers and has a strong influence on river and wetland habitats for plants and animals.

From an overall national perspective, the ground-water resource appears ample. Locally, however, the availability of ground water varies widely. **Moreover, only a part of the ground water stored in the subsurface can be recovered by wells in an economic manner and without adverse consequences.**

Ground water is not a nonrenewable resource, such as a mineral or petroleum deposit, nor is it completely renewable in the same manner and timeframe as solar energy.

If sustainable development is to mean anything, such development must be based on an appropriate understanding of the environment—an environment where knowledge of water resources is basic to virtually all endeavors.

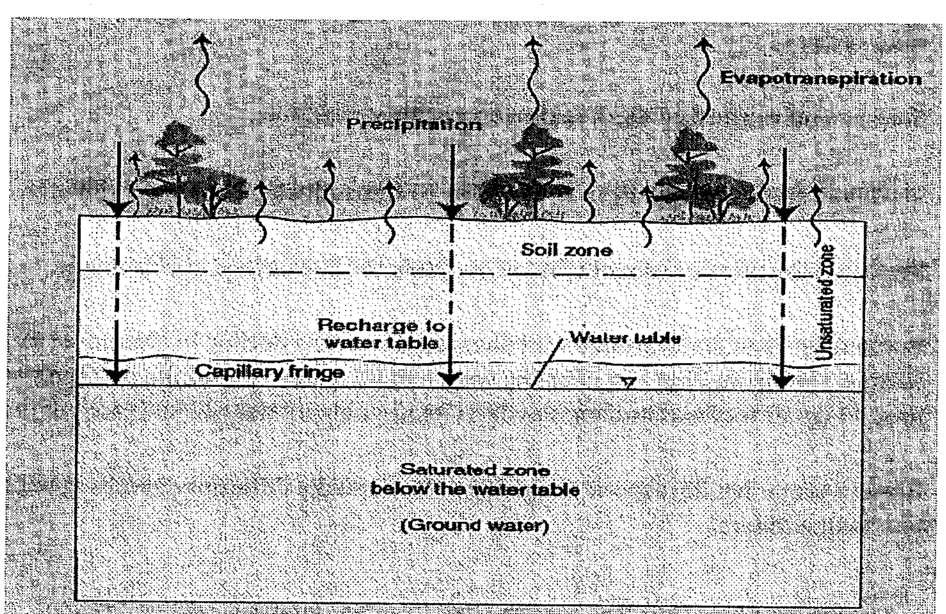

Figure 4. The unsaturated zone, capillary fringe, water table, and saturated zone.

GENERAL FACTS AND CONCEPTS ABOUT GROUND WATER

- Ground water occurs almost everywhere beneath the land surface.
- Natural sources of freshwater that become ground water are (1) areal recharge from precipitation that percolates through the unsaturated zone to the water table (Figure 4) and (2) losses of water from streams and other bodies of surface water such as lakes and wetlands.
- The top of the subsurface ground-water body, the water table, is a surface, generally below the land surface, that fluctuates seasonally and from year to year in response to changes in recharge from precipitation and surface water bodies.
- Ground water commonly is an important source of surface water.
- Ground water serves as a large subsurface water reservoir.
- Velocities of ground-water flow generally are low and are orders of magnitude less than velocities of streamflow.
- Under natural conditions, ground water moves along flow paths from areas of recharge to areas of discharge at springs or along streams, lakes, and wetlands.
- The areal extent of ground-water-flow systems varies from a few square miles or less to tens of thousands of square miles.
- The age (time since recharge) of ground water varies in different parts of ground-water flow systems.
- Surface and subsurface earth materials are highly variable.
- Earth materials vary widely in their ability to transmit and store ground water.
- Wells are the principal direct window to study the subsurface environment.
- Pumping ground water from a well always causes (1) a decline in ground-water levels (heads; see Figure 7) at and near the well, and (2) a diversion to the pumping well of ground water that was moving slowly to its natural, possibly distant, area of discharge.
- Ground-water heads respond to pumping to markedly different degrees in unconfined and confined aquifers.

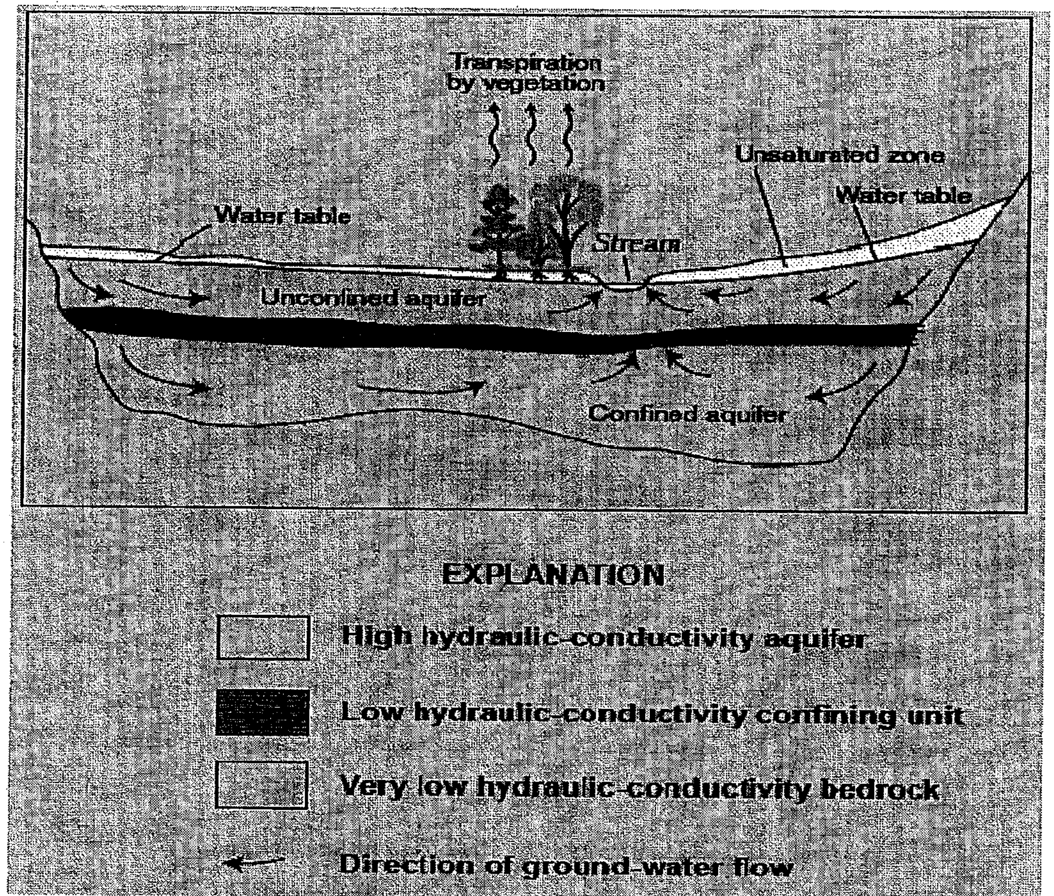

Figure 5. A local scale ground-water-flow system.

In this local scale ground-water-flow system, inflow of water from areal recharge occurs at the water table. Outflow of water occurs as (1) discharge to the atmosphere as ground-water evapotranspiration (transpiration by vegetation rooted at or near the water table or direct evaporation from the water table when it is at or close to the land surface) and (2) discharge of ground water directly through the streambed. Short, shallow flow paths originate at the water table near the stream. As distance from the stream increases, flow paths to the stream are longer and deeper. For long-term average conditions, inflow to this natural ground-water system must equal outflow.

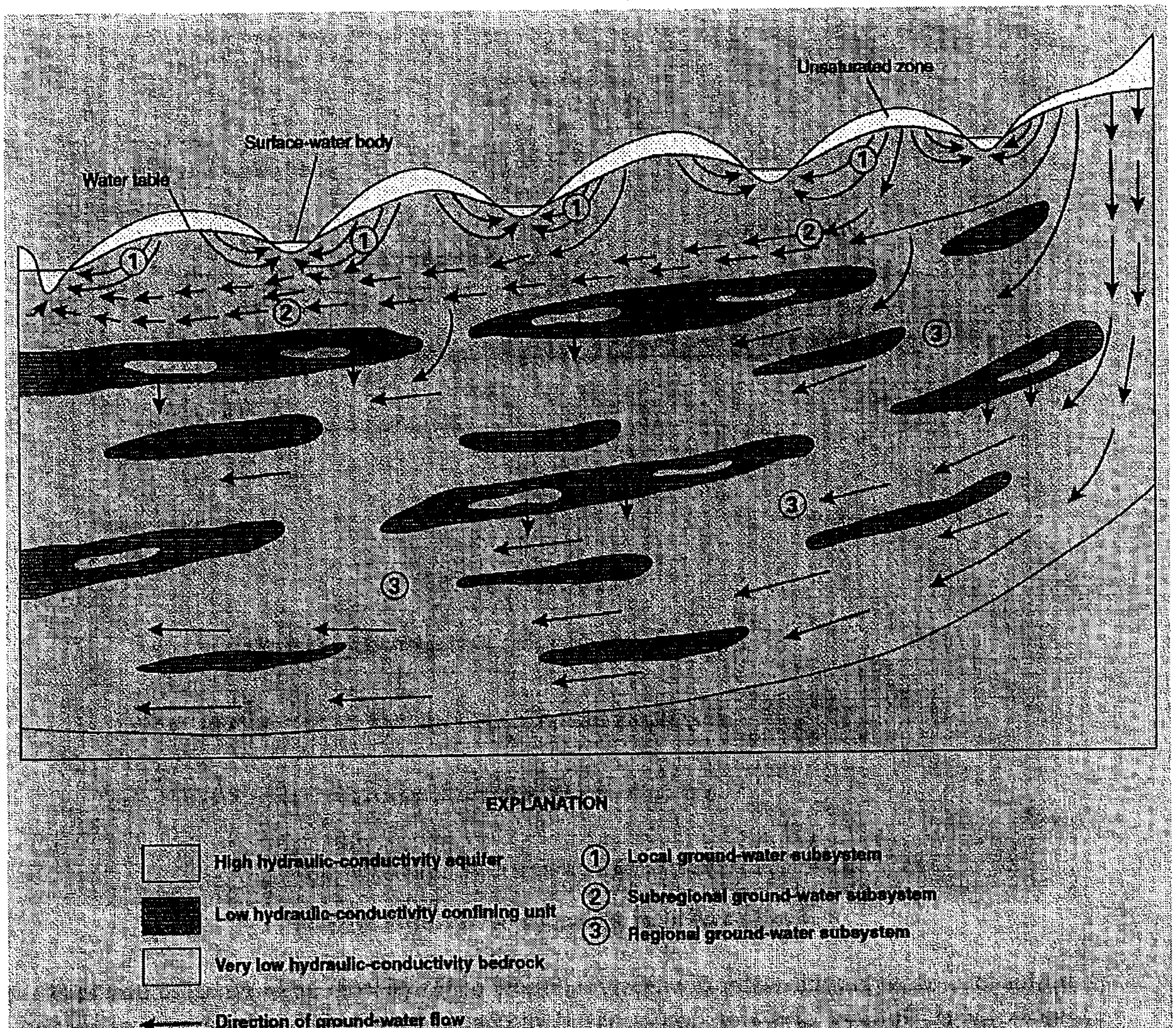

Figure 6. A regional ground-water-flow system that comprises subsystems at different scales and a complex hydrogeologic framework.

Significant features of this depiction of part of a regional ground-water-flow system include (1) local ground-water subsystems in the upper water-table aquifer that discharge to the nearest surface-water bodies (lakes or streams) and are separated by ground-water divides beneath topographically high areas; (2) a subregional ground-water subsystem in the water-table aquifer in which flow paths originating at the water table do not discharge into the nearest surface-water body but into a more distant one; and (3) a deep, regional ground-water-flow subsystem that lies beneath the water-table subsystems and is hydraulically connected to them. The hydrogeologic framework of the flow system exhibits a complicated spatial arrangement of high hydraulic-conductivity aquifer units and low hydraulic-conductivity confining units. The horizontal scale of the figure could range from tens to hundreds of miles.

GROUND-WATER DEVELOPMENT, SUSTAINABILITY, AND WATER BUDGETS

The one common factor for all ground-water systems, however, is that the total amount of water entering, leaving, and being stored in the system must be conserved. An accounting of all the inflows, outflows, and changes in storage is called a water budget.

Human activities, such as ground-water withdrawals and irrigation, change the natural flow patterns, and these changes must be accounted for in the calculation of the water budget. Because any water that is used must come from somewhere, human activities affect the amount and rate of movement of water in the system, entering the system, and leaving the system.

Some hydrologists believe that a predevelopment water budget for a ground-water system (that is, a water budget for the natural conditions before humans used the water) can be used to calculate the amount of water available for consumption (or the safe yield). In this case, the development of a ground-water system is considered to be "safe" if the rate of ground-water withdrawal does not exceed the rate of natural recharge. This concept has been referred to as the "**Water-Budget Myth**" (Bredehoeft and others, 1982). It is a myth because it is an oversimplification of the information that is needed to understand the effects of developing a ground-water system. As human activities change the system, the components of the water budget (inflows, outflows, and changes in storage) also will change and must be accounted for in any management decision. Understanding water budgets and how they change in response to human activities is an important aspect of ground-water hydrology; however, as we shall see, a predevelopment water budget by itself is of limited value in determining the amount of ground water that can be withdrawn on a sustained basis.

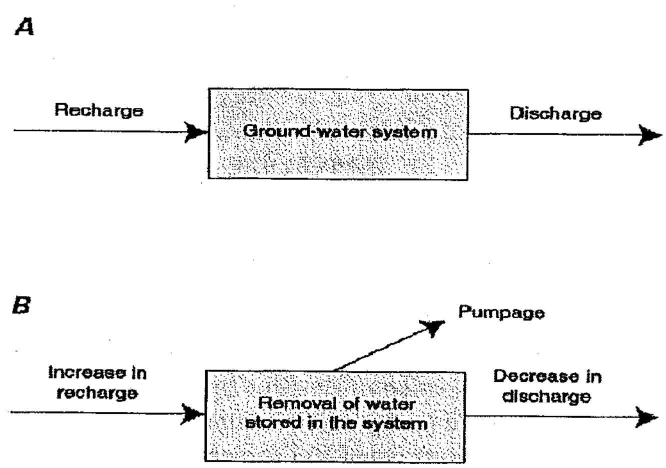

Figure 8. Diagrams illustrating water budgets for a ground-water system for predevelopment and development conditions.

(A) Predevelopment water-budget diagram illustrating that inflow equals outflow. (B) Water-budget diagram showing changes in flow for a ground-water system being pumped. The sources of water for the pumpage are changes in recharge, discharge, and the amount of water stored. The initial predevelopment values do not directly enter the budget calculation.

The source of water for pumpage is supplied by (1) more water entering the ground-water system (increased recharge), (2) less water leaving the system (decreased discharge), (3) removal of water that was stored in the system, or some combination of these three.

Because any use of ground water changes the subsurface and surface environment (that is, the water must come from somewhere), the public should determine the tradeoff between ground-water use and changes to the environment and set a threshold for what level of change becomes undesirable.

As development of land and water resources intensifies, it is increasingly apparent that development of either ground water or surface water affects the other.

From a sustainability perspective, the key point is that pumping decisions today will affect surface-water availability; however, these effects may not be fully realized for many years.

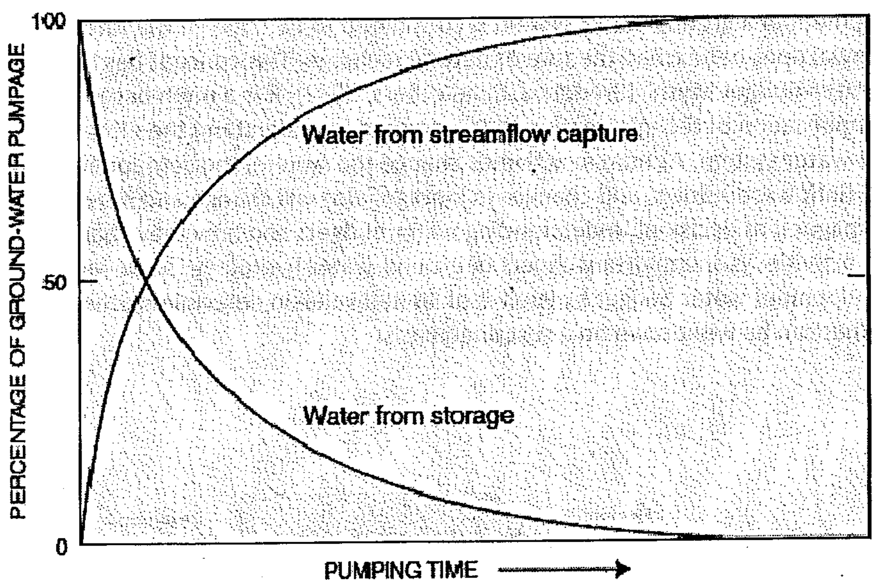

Figure 14. The principal source of water to a well can change with time from ground-water storage to capture of streamflow.

The percentage of ground-water pumpage derived from ground-water storage and capture of streamflow (decrease in ground-water discharge to the stream or increase in ground-water recharge from the stream) is shown as a function of time for the hypothetical stream-aquifer system shown in Figure 13. A constant pumping rate of the well is assumed. For this simple system, water derived from storage plus streamflow capture must equal 100 percent. The time scale of the curves shown depends on the hydraulic characteristics of the aquifer and the distance of the well from the stream.

A key feature of some aquifers and ground-water systems is the large volume of ground water in storage, which allows the possibility of using aquifers for temporary storage, that is, managing inflow and outflow of ground water in storage in a manner similar to surface-water reservoirs.

The foundation of any good ground-water analysis, including those analyses whose objective is to propose and evaluate alternative management strategies, is the availability of high-quality data.

Strategies for Sustainability

- Use sources of water other than local ground water.
- Change rates or spatial patterns of ground-water pumpage.
- Increase recharge to the ground-water system.
- Decrease discharge from the ground-water system.
- Change the volume of ground water in storage at different time scales.

Innovative approaches that have been undertaken to enhance the sustainability of ground-water resources typically involve some combination of use of aquifers as storage reservoirs, conjunctive use of surface water and ground water, artificial recharge of water through wells or surface spreading, and the use of recycled or reclaimed water.

Concluding Remarks

- The most important and most extensively discussed concept in this report is that volumes of water pumped from a groundwater system must come from somewhere and must cause a change in the groundwater system. Possible sources of water for pumpage are (1) more water entering the ground-water system (increased recharge), (2) less water leaving the system (decreased discharge), and (3) removal of water that was stored in the system.
- One of the critical linkages in both unstressed and stressed ground-water systems is between ground water and surface water.
- Continuing large withdrawals of water from an aquifer often result in undesirable consequences. From a management standpoint, water managers, stakeholders, and the public must decide the specific conditions under which the undesirable consequences can no longer be tolerated.
- The effects of ground-water development may require many years to become evident. Thus, there is an unfortunate tendency to forego the data collection and analysis that is needed to support informed decision making until well after problems materialize.