Keeping Our Streams Flowing: Tonto National Forest Groundwater Policy

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Rapid population growth in central Arizona has increased the demand for water supplies. As surface water sources are fully appropriated, current development efforts are focused on groundwater. The Tonto National Forest has been the recipient of an increasing number of requests to develop groundwater resources from a variety of entities including communities and subdivisions, copper mines, Native American tribes and state agencies. Because groundwater pumping could have an impact on national forest resources, the Tonto National Forest has required development proponents to conduct aquifer tests prior to authorizing long-term pumping. Several of these tests indicated that groundwater removal would have a significant impact on stream flows and associated water-dependent resources. As a result, the forest developed a groundwater policy aimed primarily at protecting National Forest resources. The policy identifies the objectives for managing groundwater and specifies the steps that groundwater development proponents must follow before use of groundwater will be authorized. This paper describes the current groundwater situation relative to the Tonto National Forest. It also illustrates, through a series of case studies, the interdependence between ground and surface water and the dramatic impacts that groundwater withdrawals can have on surface waters. Finally, the primary elements of the forest groundwater policy are discussed. This policy provides managers with an additional tool to protect valuable streams, springs and riparian areas on the forest.

Keywords: *groundwater, water policy, stream flow, riparian, water dependent resources, surface/groundwater interaction*

Existing Groundwater Situation

Demand for development of forest groundwater resources is increasing. Most of this demand involves the development of water for transport and use off-forest. The increase in requests to use groundwater can be attributed primarily to:

Rapid Population Growth. The population of central Arizona is growing very rapidly. This increase in growth translates into a growing demand for water resources.

Fully Appropriated Surface Water Resources. Most surface waters are fully appropriated by existing users. As a result, groundwater is often the only source of water available for future needs.

Arizona Water Law. Arizona water law is somewhat unique in that there are few regulations governing groundwater resources (outside of several specially designated areas including Phoenix and Tucson). In most areas of the state, the right to develop groundwater rests with the overlying landowner and no water right is required. Thus, all that is required to obtain National Forest groundwater resources is a Special-Use Authorization for well drilling and water conveyance.

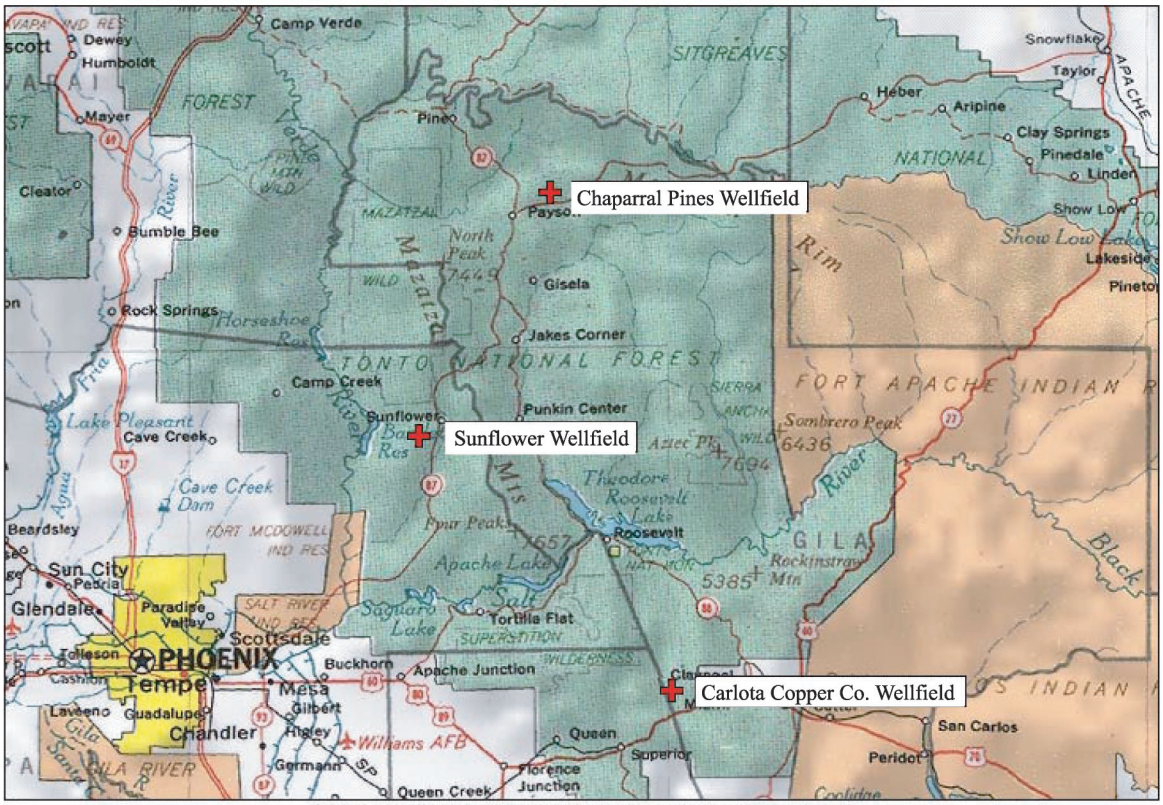
Cost. The Forest Service charges nothing for the water it provides, only for the land use authorization.

Case Studies

The Tonto National Forest's groundwater policy evolved from our experiences with proposed groundwater development projects. Three of these projects include: The proposed Carlota Copper Mine, a medium sized copper mine partially located on the forest; the Sunflower Well, a well on private land that was proposed to provide water for widening and relocating a highway located on the forest; and the Chaparral Pines pipeline, a water supply pipeline that conveys water from a wellfield on private land across the forest to a subdivision near Payson, Arizona, also on private land (Figure 1). The discussion that follows provides brief descriptions of each of these projects.

M Furniss, C Clifton, and K Ronnenberg, eds., 2007. *Advancing the Fundamental Sciences: Proceedings of the Forest Service National Earth Sciences Conference, San Diego, CA, 18-22 October 2004*, PNW-GTR-689, Portland, OR: U.S. Department of Agriculture, Forest Service, Pacific Northwest Research Station.

Figure 1. Groundwater development project locations.



Carlota Copper Company Wellfield

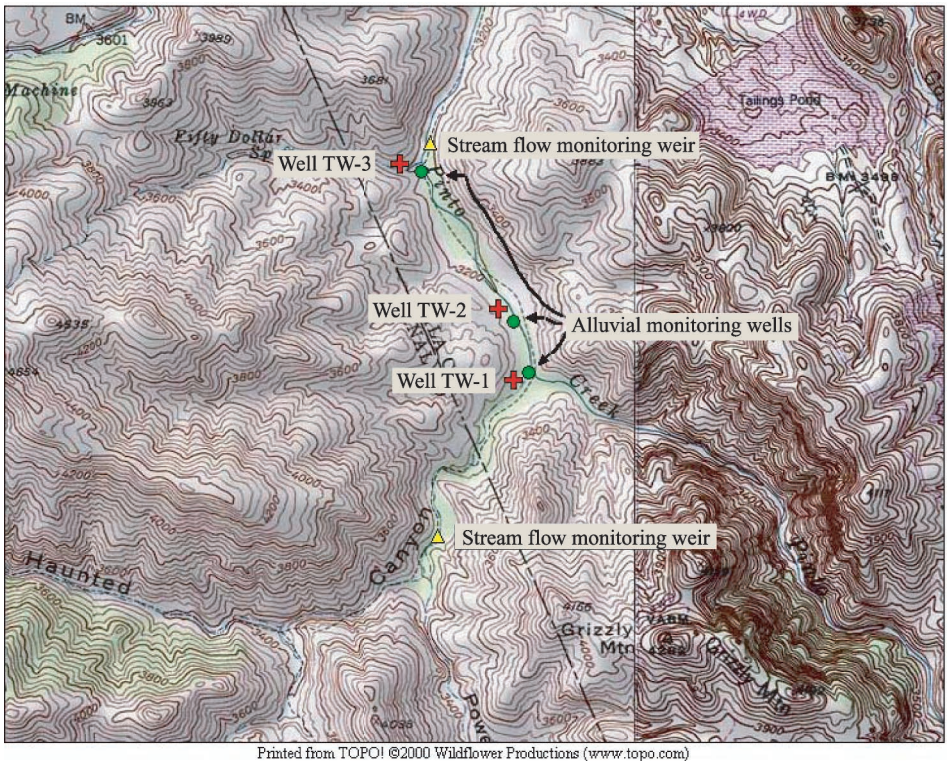
The proposed Carlota Copper Mine is located six miles (9.6 km) west of Miami, Arizona, at an elevation of approximately 3,700 feet (1128 m) in a rugged mountainous semiarid region. Vegetation is composed predominately of chaparral, desert brush and juniper-grassland. The Carlota Copper Company proposes to mine 100 million tons (90.7 million metric tons) of ore from open pits over a twenty-year period to produce 900 million pounds (409 million kg) of copper. The ore would be leached with a sulfuric acid solution in a heap leach process. Water requirements for the mine average 590 gallons per minute (gpm) [1,926 liters per minute (Lpm)] with peak water requirements of 850 gpm [3,217 Lpm] during dry months.

The mine is located in the Pinto Creek watershed, which drains into Roosevelt Lake, a major water supply reservoir for the Phoenix metropolitan area. Pinto Creek, which becomes perennial below the project area, is a valuable resource on the forest, and is a rare perennial stream in the Sonoran desert (Figure 2). Pinto Creek has been designated as an Aquatic Resource of National Importance (ARNI) by the EPA, has been studied for eligibility for inclusion in the nation's Wild and Scenic River System, has been nominated for unique waters status, has been named as one of the ten most endangered rivers in the nation by the American Rivers environmental group, and has been called a "jewel in the desert" by Barry Goldwater. To protect the stream, the forest applied for and received an instream flow water right from the state that seeks to maintain median monthly flows along a nine mile reach of the stream located approximately four miles below the Carlota project area. These flows range from 1 to 2.7 cubic feet per second (cfs) [0.03 to 0.08 cubic meters per second (cms)].

The mining company conducted an extensive search for water that included: acquisition of Central Arizona Project

Figure 2. Pinto Creek.

Figure 3. Carlota Wellfield.



water from Roosevelt Lake, five surface water reservoir sites on Pinto Creek and Powers Gulch, water purchased from nearby municipalities or other commercial sources, low quality water from adjacent mining operations, and groundwater from a variety of locations. For various reasons, many of these water supply sources could not meet mine requirements, and the source ultimately selected included groundwater from a wellfield located approximately two miles (3.2 km) downstream of the main project area near the confluence of Pinto Creek and Haunted Canyon (Figure 3).

Three test wells were drilled at this site from June to September 1993, ranging in depth from 755 feet to 1220 feet (230 m to 372 m) below ground surface. All three wells experienced artesian flows with artesian discharge from the middle well (TW-2) flowing at 250 gpm (946 Lpm). Test pumping of these wells was conducted to evaluate the long-term yield potential of the aquifer, and the impact of pumping on surface water resources and on alluvial groundwater elevations. Well TW-2 was pumped for 25 days at a rate of 600 gpm (2,271 Lpm). A monitoring network was installed to detect potential impacts. The network included three shallow alluvial monitoring wells, four bedrock complex monitoring wells, weirs at two springs, and a weir or Parshall flume at two locations in Haunted Canyon and Pinto Creek.

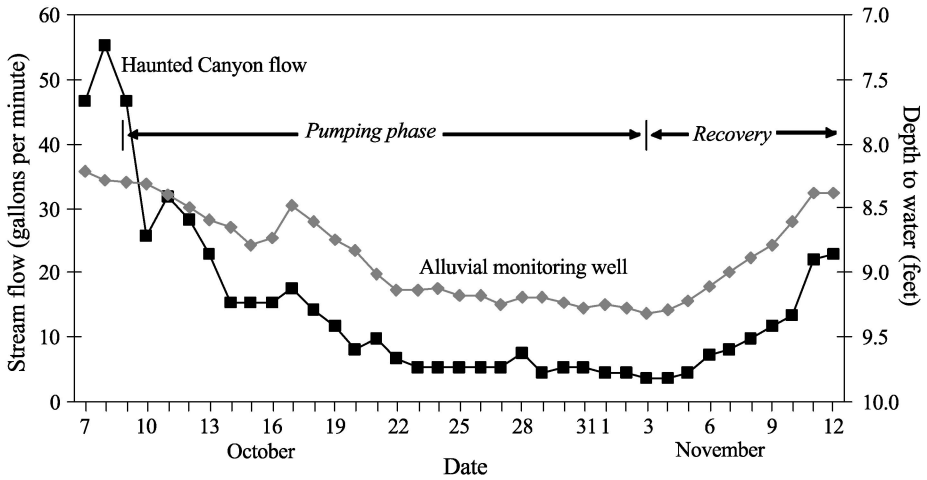
During the 25-day pump test of TW-2, stream flow at a weir in Haunted Canyon (located approximately 2,300 feet [701 m] south of the TW-2 well) declined from approximately 45 gpm at the start of the test to 5 gpm at the end of the test (170 to 19 Lpm). Flow increased progressively to approximately 27 gpm (102 Lpm) within a few days of shutting off the pump. The water level in an alluvial monitoring well in Haunted Canyon located approximately 1,550 feet (472 m) south of TW-2, declined approximately one foot during the 25-day test and recovered slowly following the test (Figure 4).

Based on these test results, the forest sent a letter to the Arizona Department of Water Resources (ADWR) requesting an appropriability determination. In Arizona, water pumped from a well is considered to be appropriable if withdrawing that water tends to directly and appreciably reduce flow in a surface water source. ADWR reviewed the aquifer test results and concluded that the well was withdrawing appropriable water and would need a water right if it was to be used. The Carlota Copper Company subsequently submitted a water right application. The forest protested the application based on its instream flow water right downstream on Pinto Creek. The forest negotiated a wellfield mitigation program with the mine that seeks to maintain median monthly flows in Haunted Canyon and Pinto Creek in exchange for the forest's withdrawal of its protest.

Sunflower Well

The second groundwater withdrawal project influencing the development of the forest's groundwater policy was

Figure 4. Carlota Project pump test results.



the Sunflower Well. This well was proposed as a water supply source for upgrading a portion of Arizona State Highway 87 that carries heavy traffic from the Phoenix metropolitan area to summer recreation areas in the high country along the Mogollon Rim in north-central Arizona. Water requirements for highway construction were estimated to be about 200 gpm (757 L per minute) for compaction of fills and for dust control.

The Sunflower Well is located on private land near Sycamore Creek, which has reaches of both intermittent and perennial flow near the well. Sycamore Creek, like Pinto Creek, is a stream with reaches of perennial flow in the Sonoran Desert. It supports valuable riparian vegetation, provides habitat for native fish, and is a popular recreation area.

The Record of Decision (ROD) for the Environmental Impact Statement (EIS) prepared for the highway upgrading project stated that construction water would not be withdrawn from Sycamore Creek. To evaluate the effects of the well on Sycamore Creek, an aquifer test with observation wells and a streamflow monitoring flume was conducted.

The proposed production well was completed to a depth of 240 feet (73 m) in fractured basalt. Water rose under artesian pressure to a depth of approximately 20 feet (6.1 m) below ground surface. The monitoring network consisted of four shallow observation wells in the alluvium bordering the creek, two deep observation wells in the bedrock basalt aquifer and a Parshall flume in a perennial reach of Sycamore Creek just downstream of the well (Figure 5). The aquifer test was originally scheduled for three days with the production well pumping at an average rate of 250 gpm (946 Lpm).

Water levels in the shallow monitoring wells declined before, during and after the test. Water levels declined at a slightly greater rate during the test. The majority of the decline was believed to be attributable to natural conditions. The impact of pumping on stream flow through the flume was dramatically different than the impact to the shallow observation wells. Prior to beginning the test the flow rate through the flume was about 90 gpm (90 Lpm). About six minutes after the pump in the production well was turned on, flow through the flume started to decline. Approximately six hours into the test, flow in Sycamore Creek declined to zero. One hour and 20 minutes after the pump was turned off, Sycamore Creek started flowing through the flume again. Two hours after the pump was turned off, flow through the flume was 37 gpm (140 Lpm), and 10 hours after turning the pump off, flow through the flume was 61 gpm (230 Lpm) (Figure 6).

Based on the results of this test the contractor was not allowed to use the well for the highway upgrade project.

Mayfield Canyon Wellfield

The purpose of this project was to provide water for a subdivision and golf course near the community of Payson, Arizona. The wellfield was located on a parcel of private land, known as Calhoun Ranch, that is entirely surrounded by National Forest System lands. The proponents intended to construct a pipeline that would transport water from the wellfield across the forest and back onto private lands where the subdivision and golf course were located. Mayfield Canyon flows through the private lands where the wellfield is located, enters the forest for approximately one-half mile, then flows back onto private lands in the community of Star Valley (Figure 7). The stream becomes perennial on the Calhoun Ranch private lands due to groundwater discharge that seeps into the bed and banks of the channel and from a significant spring (estimated to discharge at approximately 30-40 gpm [113-151 Lpm]). Perennial flow continues downstream of the private land onto the forest for approximately 200 yards (183 m) until it seeps into

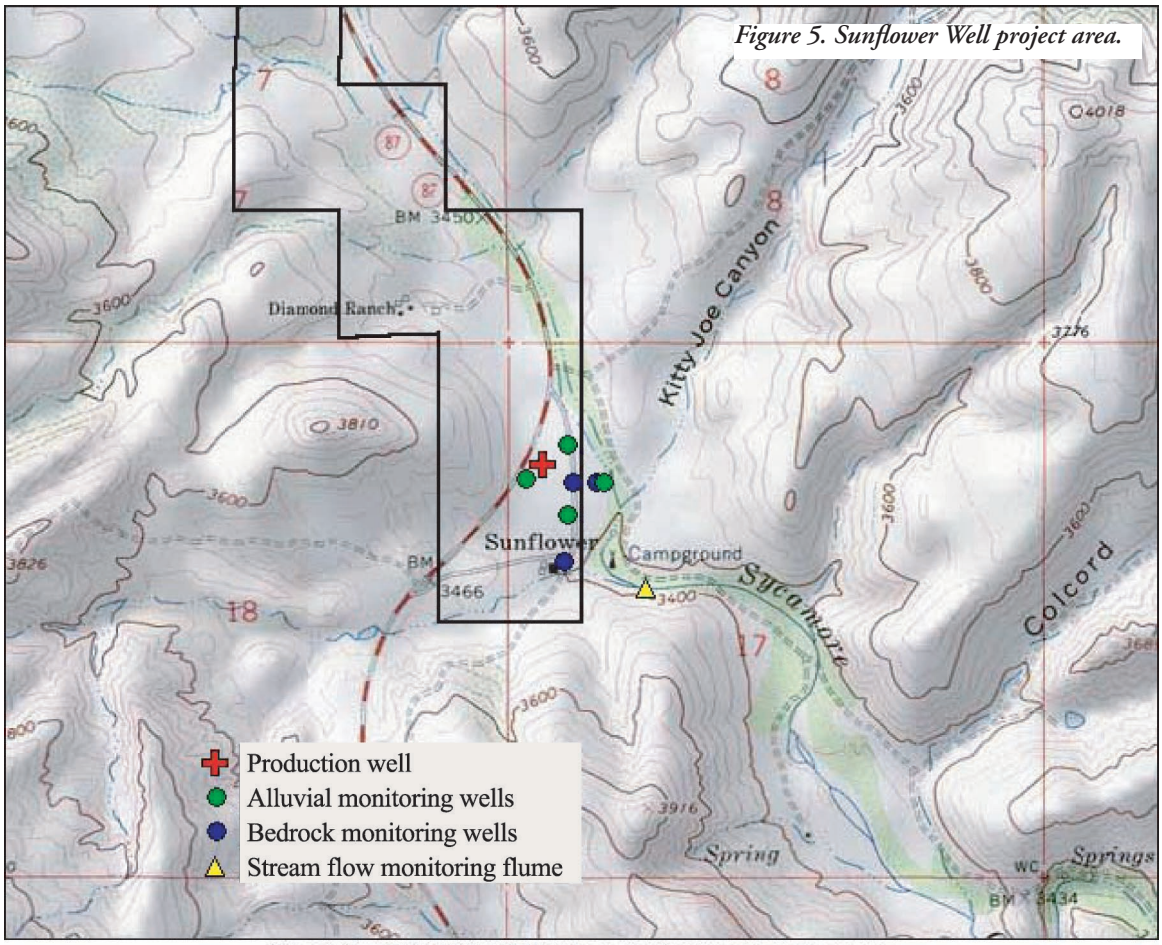


Figure 5. Sunflower Well project area.

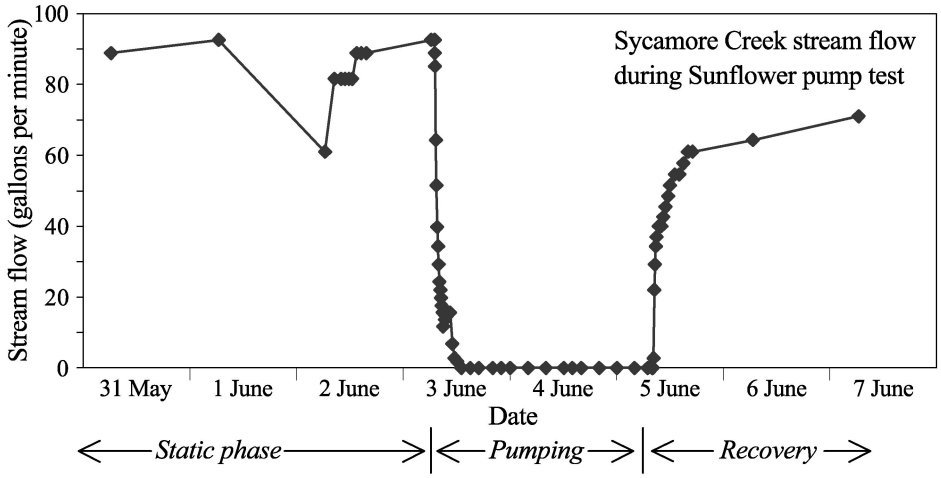


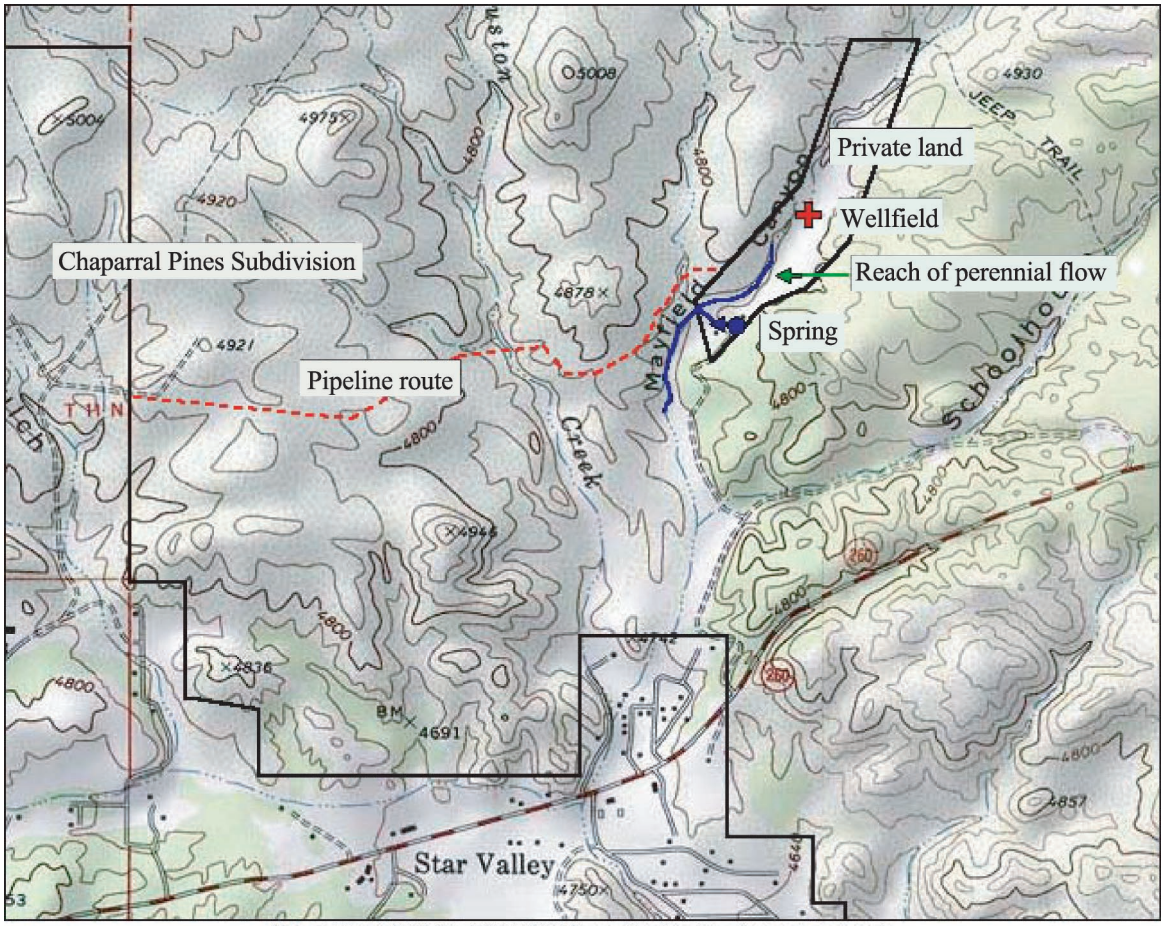
Figure 6. Sunflower pump test, Sycamore Creek streamflow.

the sands and gravels of the stream bottom alluvium. The reach of perennial flow on the forest supports a lush riparian zone of cottonwood and willow trees. Peak water requirements for the golf course and subdivision were estimated at approximately 360 gpm (1,362 Lpm). The residents of Star Valley who are dependent on wells for the majority of their water needs were concerned that development of the wellfield on Mayfield Canyon (which is up gradient of Star Valley) would reduce groundwater availability to their wells.

The subdivision developer needed a Special-Use Permit from the forest for the pipeline from Calhoun Ranch to the subdivision at Chaparral Pines. The forest, as part of its compliance with the National Environmental Policy Act (NEPA) evaluated the actions connected with the project proposal. In this instance, it meant looking at the impacts of pumping the groundwater as well as the impacts of the pipeline itself.

Eight wells were drilled at the Calhoun Ranch site ranging in depth from 200 to 500 feet (61 to 152 m)

Figure 7. Chaparral Pines Wellfield and Pipeline.



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and completed in fractured granite. Prior to submitting an application for a Special-Use Permit, the developer completed a number of aquifer tests including a 33-day test on the most productive well, which was pumped at a constant rate of 300 gpm (1,135 Lpm) during the test. Drawdown in five observation wells ranged from 20 to 30 feet (6.1 to 9.2 m) during the test. Streamflow in Mayfield Canyon was not monitored during this test. The developer's consultant concluded that impacts on surface water flows from operation of the wellfield would be negligible because flow in Mayfield Canyon is intermittent and the result of precipitation events.

Once the developer submitted a Special-Use Permit application, the forest requested a second 30-day aquifer test with flow measurements in Mayfield Canyon to directly assess impacts to stream flows. The developer refused, stating that a long-term aquifer test had already been completed and that the consultants who conducted the test had reached their conclusions about groundwater-surface water impacts. As an alternative, the forest asked the developer to conduct a water budget analysis that would assess the impacts of groundwater withdrawals on inputs and outputs of water resources in the watershed. The developer agreed to this request and subsequently concluded that groundwater pumping would not reduce the surface runoff component of the water budget, but could affect baseflow in the reach of Mayfield Canyon above the cone of influence of the groundwater wells. A Special-Use Permit was subsequently issued and the photos in Figure 8 display the impacts of wellfield operation on the reach of Mayfield Canyon within the national forest.

GROUNDWATER PUMPING CONCERNS

Effect On National Forest Resources

Groundwater and surface water form an interconnected hydrologic system. Recharge to groundwater supplies originates from precipitation and surface waters. Conversely, groundwater discharge is the reason that perennial streams, springs and seeps flow throughout the year. Groundwater pumping from wells can result in lower water tables and reduced stream flows. Because surface water and shallow groundwater sustain riparian and aquatic ecosystems, groundwater removal can have negative impacts on these resources.

Figure 8. Mayfield Canyon riparian vegetation, prior to (left) and following (above) startup of wellfield.

Effect on Adjacent Water Supplies

Many public and private entities within and adjacent to the forest currently rely on groundwater for a variety of purposes. Authorization of additional wells and removal of groundwater from the forest can lower water levels and affect these existing groundwater users.

Limited NEPA Analysis

Historically, NEPA analyses of proposals to develop forest groundwater resources have focused on the impacts of drilling and the construction of infrastructure such as wells, pumping facilities, roads and power lines. Little attention has been paid to the potential impact on forest water resources, associated riparian areas, and adjacent water supplies. Continuation of our historic methods for evaluating impacts could result in the authorization of new water developments that adversely affect important forest resources and activities. The potentially serious degree of resource damage also implies that the forest should evaluate any new requests for groundwater carefully prior to authorization.

Special-Use Permits Are Long-Term Commitments

Special-Use Permits for the conveyance of water across the forest are issued for a specific number of years. Although the Forest Service has the legal right to deny reissuance of such permits, it is often difficult to do so. In essence, most Special-Use Permits for water are permanent commitments. This makes it very difficult to correct existing resource problems that can be attributed to such developments.

Lack Of Consistency

Historically, the forest responded with a variety of approaches to requests for the development and use of groundwater. In some instances we immediately denied such requests, while in others we encouraged such development and use. Such inconsistency without a sound rationale usually leads to problems.

Groundwater Policy

Policy: Groundwater shall be managed for the long-term protection and enhancement of the Forest's streams, springs and seeps, and associated riparian and aquatic ecosystems. Development and use of groundwater for consumptive purposes shall be permitted only if it can be demonstrated that such proposals will adequately protect Forest resources.

Criteria For Development And Use Of Groundwater

Proposals to develop and use groundwater derived from National Forest System (NFS) lands must meet the following conditions:

A. The proposal to use water must be consistent with applicable laws, regulations, polices, rules, and forest land and resource management plans (Forest Service

Manual [FSM] 2702 & 2703).

B. The proposal to use water must adequately protect National Forest resources (FSM 2702.1 & 2541.34).

C. If the proposed place of use of water will be located on non-NFS lands, the proponent must demonstrate that alternative water sources do not exist off-forest (FSM 2703.2).

Consistency With Existing Policies And Management Direction

The forest policy for the development and use of groundwater is consistent with National and Regional policy and direction. For instance, the Forest Service Manual (FSM) 2541.34 indicates that if projected water requirements of uses not directly related to Forest Service programs "will adversely affect national forest resources, the potential permittee must seek alternative water sources or develop mitigation plans acceptable to the Forest Service." Similarly, the manual indicates that Special-use authorizations should be denied if they are in conflict with other forest management objectives, or can reasonably be accommodated on non-NFS lands (FSM 2703.2).

Procedures - Methods to Implement Policy

The evaluation of water development proposals has three phases.

1. Preliminary Analysis

This phase initiates the evaluation process. If water is to be used off-forest, the proponent must demonstrate that alternative water sources do not exist off-forest. For all proposals, the following information is assembled and evaluated.

Description of Proposal
Quantity of water needed
Infrastructure requirements

Inventory of Key Resources
The location of potentially affected surface water resources.
The location and description of riparian vegetation.
Any known Threatened and Endangered species.
Pertinent geologic information.
Pertinent hydrologic information.

Inventory of Existing Water Developments

2. Exploration And Testing

This phase involves drilling for a suitable water supply, and testing for impacts on forest resources and adjacent water supplies. The Exploration and Testing phase would be initiated only if the proposal satisfies the requirements of the screening process in the preliminary analysis phase.

Temporary Permit Issued. If the Preliminary Analysis indicates a reasonable likelihood of developing water without adverse impacts on forest resources or adjacent water users, a Temporary Permit may be issued for the Exploration and Testing phase of the proposal. This Temporary Permit shall contain the conditions necessary to minimize impacts to forest resources.

If sufficient water is found in the exploration phase to meet the needs of the proponent, testing is then conducted.

Testing Conducted. Prior to testing, a monitoring plan must be submitted to the Forest Service for approval. After approval of the monitoring plan, long-term pump testing, modeling, or both, are conducted, and effects of pumping are observed or predicted.

3. Construction And Production

This phase involves the permitting of all infrastructure, the conveyance of water, and long-term monitoring and mitigation. This phase occurs only if testing indicates that forest resources will not be adversely affected or can be mitigated, and nearby water developments can be adequately protected.

Permit Issued. Infrastructure needed to produce and convey water is constructed.

Monitoring And Mitigation. Any monitoring or mitigation measures necessary to ensure protection of forest resources during the construction of water storage and conveyance facilities, and during the long-term removal of groundwater will be included as a Plan of Operations attached to and made part of the Special-Use Permit. If long-term monitoring detects additional or unforeseen adverse impacts to forest resources that were not discovered during the exploration and testing phase, or if mitigation measures do not adequately protect forest resources, the Permit shall not be reissued.

Other Considerations

NEPA Analysis and Documentation

The scope of any analysis needed to comply with NEPA will depend largely on potential resource impacts, and on the level of public concern.

For NEPA purposes, groundwater exploration and development can often most logically be addressed in two distinct phases. The first NEPA analysis can address the impacts associated with the exploration and testing phase. This phase can be separated from the development and production phase because the availability of groundwater and the impacts from pumping are often unknown during the exploration phase. A second NEPA analysis can be conducted if a suitable supply of groundwater is found and if test pumping does not result in impacts that would constitute a reason for denial of a Special-Use Permit for the production phase. The second NEPA analysis would address impacts identified during the exploration and testing phase, from the construction of infrastructure, and from the operation of the proposed facilities.

Water Rights

Applicable laws and regulations governing wells and water rights will be adhered to for all proposals.

Conclusions

A rapidly growing population in the Southwest is causing increasing demands on scarce groundwater. Requests for Special Use Permits to withdraw groundwater on the national forests are now common and increasing as well. Case studies and hydrologic theory confirm that groundwater and surface water are usually strongly interconnected and form a single hydrologic system: groundwater withdrawals typically directly result in lower streamflows. Policies and procedures for considering groundwater development proposals are needed that work within the NEPA process to ensure that permits are granted only when consistent with our stewardship responsibilities to protect surface-water dependent values.