Surface Water Quantity

Introduction

This section discusses the potential impact to the presence and quantity of surface water resources. Surface water resources discussed in this section include washes, creeks, and stock tanks located within the analysis area. A detailed analysis of impacts to springs and seeps is provided in the "Seeps, Springs, and Riparian Areas" resource section of this chapter.

The analysis for surface water quantity resources considers all alternatives plus all connected actions, and the analysis area is based on the following two considerations: (1) the direct modification of the topography and alteration of the surface water regime in the project area as a result of mining and the development of mine infrastructure; and (2) the indirect effects of mining activities on downgradient surface water drainages. Downstream surface water drainages in the analysis area include the immediate sub-watersheds, including Barrel Canyon, the portion of Davidson Canyon that receives discharge from the project area and is tributary to lower Cienega Creek, and Cienega Creek downstream of its confluence with Davidson Canyon to the Pantano Dam (figure 61). While the project area itself drains to Davidson Canyon and ultimately Cienega Creek, also included in the analysis area for surface water quantity are the utility corridor to the west of the project (including an urbanized portion of the watershed within the town of Sahuarita that likely drains to storm drains and ultimately to the Santa Cruz River) and portions of watersheds to the east of the project (North Canyon, Oak Tree Canyon, and Empire Gulch) that are crossed by the Arizona National Scenic Trail alignment.

The temporal bounds of analysis includes all phases of mine life involving surface disturbance, including the premining, active mining, and final reclamation and closure phases of the project. Analysis of the reclamation and revegetation of the site to prevent erosion from occurring also encompasses the postclosure phase, as discussed in the "Soils and Revegetation" resource section of this chapter.

Changes from the Draft Environmental Impact Statement

Since publication of the DEIS, the most substantial change to the surface water section has been a redesign of postclosure stormwater management for the Barrel Alternative (see the "Overview of Stormwater Management" part of this resource section). In addition, in response to public comments, the modeling approach used for estimating storm flows has been further reviewed (see the "Coronado National Forest Review of Surface Water Modeling Techniques" part of this resource section).

Postclosure stormwater management for the Barrel Alternative has been redesigned to address public and agency concerns regarding: (1) the storage of stormwater on the top and benches of the tailings and waste rock facilities, (2) the use of flow-through drains beneath the tailings and waste rock facilities, and (3) the amount of water being removed in perpetuity from the upper reaches of the watershed. An iterative process involving a team of experts working closely with project engineers was a critical component in the redesign of the Barrel Alternative (SWCA Environmental Consultants 2013b). As a result of the redesign efforts, several design concerns were eliminated, and the amount of water being removed from the watershed has been improved. The flow-through drains have been eliminated for the Barrel Alternative due to concerns over their long-term maintenance. With regard to the amount of water being removed from the upper reaches of the watershed, postclosure stormwater retention ponds have been eliminated from the top of the tailings and waste rock facilities. Instead, these facilities shed all runoff, which is channeled to drop structures that discharge into

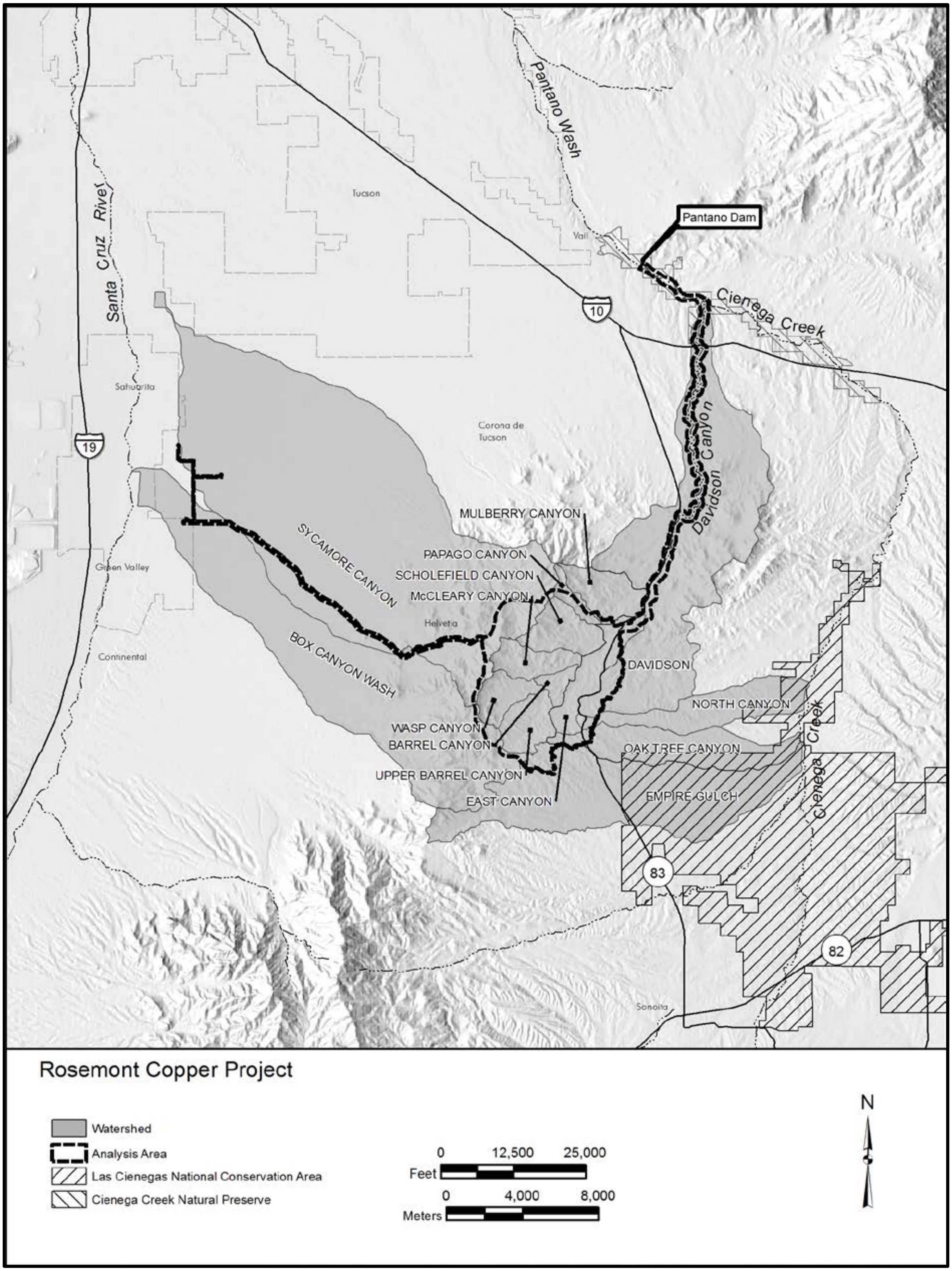

Figure 61. Analysis area for surface water quantity

Barrel Canyon or tributaries. As a result, the amount of runoff removed from the watershed has been reduced by half for the Barrel Alternative.

Additional mitigation measures have been incorporated into the document and assessed for effectiveness at reducing impacts (see the “Mitigation Effectiveness” part of this resource section, as well as appendix B).

Monitoring has been incorporated into the Mitigation and Monitoring plan (see appendix B) in order to address uncertainty associated with stormwater modeling (see the “Mitigation Effectiveness” and “Monitoring Intended to Assess Stormwater Modeling” parts of this resource section).

In response to public comments, particularly those received from Pima County, the hydrologic modeling approach used to estimate storm flows was reviewed for applicability in Pima County, and the Coronado contracted additional analysis to ensure that the modeling methods used are appropriate. Additional modeling sensitivity analyses were conducted, and the modeling approach used by Rosemont Copper was compared with other methods and determined to be reasonable.

Other changes from the DEIS include the following:

- The analysis area for indirect and cumulative impacts was expanded to include: (1) the watershed in which the electric transmission line and water supply pipeline are located; (2) both locations of proposed Arizona National Scenic reroutes; and (3) all road construction and decommissioning associated with the proposed project.
- Additional data were analyzed for offsite surface water rights (see the “Indirect Impacts to Offsite Surface Water Rights” part of this resource section).
- Additional data were analyzed for offsite stream flows (see the “Stream Flow” part of this resource section).
- The effectiveness of new mitigation measures and reclamation plans (including concurrent reclamation) was analyzed (see the “Mitigation Effectiveness” part of this resource section).

Issues, Cause and Effect Relationships of Concern

One significant issue was identified concerning surface water quantity.

Issue 3D: Surface Water Availability

Construction and operation of the mine pit, tailings, waste rock, and leach facilities have the potential to change surface water discharge to Davidson Canyon and Cienega Creek, portions of which are designated an Outstanding Arizona Water by the ADEQ. Additionally, the availability of water for stock watering tanks could be reduced.

Issue 3D Factors for Alternative Comparison

1. Quantitative assessment of water released and available for beneficial uses, measured as percent reduction from baseline
4. Number of stock watering tanks that would be unavailable
5. Change in volume, frequency, and magnitude of runoff from the project area
6. Change in recharge of the aquifer by runoff

Analysis Methodology, Assumptions, Uncertain and Unknown Information

The methodology for assessing changes in surface water quantity consists primarily of hydrologic modeling of 100-year peak storm flows resulting from design precipitation events (specifically, the National Oceanic and Atmospheric Administration Atlas 14 24-hour mean-precipitation value and the Natural Resources Conservation Service Type II 24-hour temporal storm distribution) using the U.S. Army Corps of Engineers' (USACE's) computer program Hydrologic Engineering Center Hydrologic Modeling System, Version 3.4. The same modeling is carried out under baseline conditions and for each action alternative, with both peak flow and total flow volume being modeled.

The watershed area considered in this modeling totals 8,960 acres. That area represents the portion of the watershed above the USGS stream gage on Barrel Canyon at SR 83. Below this point, the wash and any contributing watershed would remain undisturbed under all alternatives. Modeling results were then used to evaluate indirect impacts from reduced flows in washes downstream of the stream gage on Barrel Canyon.

In response to public comments regarding concerns over the hydrologic modeling approach chosen, modeling methods used for estimating storm flow were revisited. Zeller (2011b) validated the model results using the USGS Bulletin 17B statistical analysis and Region 13 Regional Regression Equation, and he calibrated the model using local data from two nearby USGS stream gages (Barrel Canyon and Davidson Canyon). Zeller determined that the modeling approach used was reasonable. Numerous public comments, primarily from Pima County, were received regarding the hydrologic modeling for surface flow at the Rosemont site. These comments focused mainly on: (1) the choice of the model that was used, and (2) the assumptions behind the model inputs that were used, including the curve number[1] and precipitation. To address these comments, the Coronado contracted Golder Associates to run additional surface water model scenarios based in part on the Pima County comments; the purpose of this remodeling effort was to evaluate the validity of the model that had been used and to analyze the sensitivity of a reasonable range of model inputs. Ultimately, the Coronado determined that the modeling as presented by Rosemont Copper is valid and appropriate; the additional modeling sensitivity runs conducted inform the possible range of results that could occur. Further detail is provided below.

In addition to surface flow modeling, public comments were also received that questioned the design parameters used for storage features (i.e., retention basins, process ponds). The Coronado determined that the storage criteria used in association with the proposed design of stormwater features were based on regulatory guidance and reasonable engineering practices; therefore, the Coronado did not undertake any additional modeling with respect to the design of storage features. Notwithstanding, the Coronado did request a redesign of the postclosure stormwater management for the Barrel Alternative to address, in part, concerns regarding the storage of stormwater on the top and benches of the tailings and waste rock facilities.

Volumes for individual stock ponds have not been measured, but reasonable estimates of stock pond volumes are available based on available ADWR data. Priority and validity of surface water rights

[1] The "curve number" is one way to describe how a watershed reacts to rainfall. The curve number is a measure of the amount of water that will run off the watershed after a storm, rather than infiltrate or evaporate from the watershed. High curve numbers mean that more water will run off. For instance, pavement has a curve number value of 98. Lower curve numbers mean that more water will remain on the watershed, usually because the water is slowed or captured by vegetation or soil.

affected by the project have not yet been determined by the Superior Court through the General Stream Adjudication of the Gila River; therefore, surface water rights could not be fully analyzed but were analyzed to the extent possible using available data from the ADWR.

Coronado National Forest Review of Surface Water Modeling Techniques

Golder Associates' new surface water model (hereafter, Golder model) to estimate changes in peak flows from pre- to postmining conditions incorporated the PC-Hydro computer software as recommended by Pima County Regional Flood Control District (Pima County 2012). Using the prescribed PC-Hydro model, Golder Associates performed a series of sensitivity analysis runs that consisted of four scenarios with variations of two model input parameters, rainfall and curve number.

With respect to the model, when the same model input parameters were applied to the Golder model that were used in the Rosemont Copper model (i.e., low rainfall and low curve number) the relative difference in percent change of peak flow was 13 percent for the Golder model, compared with 17 percent for the Rosemont Copper model. Given that the Golder (PC-Hydro) model produced the same relative predictions (within 4 percent) as the Rosemont Copper model when the same model parameters are used, the Coronado concluded that the model application used by Rosemont Copper was reasonable and appropriate.

For the sensitivity analysis, high and low values of precipitation and curve number were input into the Golder model. The high precipitation value of 5.35 inches was based on the 24-hour storm depth derived from methods recommended by Pima County Regional Flood Control District (i.e., the National Oceanic and Atmospheric Administration Atlas 14, Upper 90% Confidence Limits). The low precipitation value of 4.75 inches was based on the 24-hour storm depth, which was used in the Rosemont Copper model. Using the curve number tables recommended by Pima County Regional Flood Control District and provided in the PC-Hydro User Guide (Arroyo Engineering LLC 2007), Golder Associates determined that for existing conditions, the high curve number would be 90 (based on 20 percent cover density of mountain brush vegetation), and the low curve number would be 85 (based on 40 percent cover density of mountain brush vegetation). Based on this guidance, the curve numbers for dry-stack tailings and waste rock facility surfaces in postmining conditions were assigned values of 90 and 85 based on the range of cover density. In the Rosemont Copper model, a curve number of 85 was chosen for both existing and postmining conditions based on the larger watershed land use and soil type as well as the anticipated proposed soil type (soil type "C") to be used on mining facility features.

Golder model results show that the curve number is the more sensitive of the two input parameters of concern. When the curve number input remains constant and precipitation changes, model results change by 4 percentage points for low curve number (13 percent versus 17 percent) and by 2 percentage points for high curve number (26 percent versus 28 percent). When the precipitation input remains constant and the curve number changes, model results change by 13 percentage points for low precipitation (13 percent versus 26 percent) and by 11 percentage points for high precipitation (17 percent versus 28 percent).

Regardless of the differences in model software used and variations in model inputs, the Rosemont Copper model results (17 percent change in peak flow) were within the range of the sensitivity analysis performed by Golder Associates (13 percent to 28 percent change in peak flow). The Coronado concluded that for purposes of the EIS analysis, the Rosemont Copper modeling is reasonable and appropriate for comparison between alternatives. Rosemont Copper also compared their modeling efforts with the PC-Hydro method and concluded that the runoff volumes calculated using the PC-Hydro method were less than those generated with their model (Chee and Hemmen 2010); therefore, the Rosemont Copper modeling would tend to overestimate the amount of runoff necessary to accommodate stormwater channels and control structures.

Monitoring Intended to Assess Stormwater Modeling

In consideration of the concerns raised regarding the stormwater modeling, two monitoring components have been incorporated into the mitigation and monitoring plan (see appendix B for full details). The monitoring includes the following:

- **Monitoring to determine impacts from pit dewatering on downstream sites in Barrel and Davidson Canyons.** Monitoring would be conducted of surface water, alluvial groundwater, and deeper groundwater at sites in Barrel and Davidson Canyons. Several locations have already been installed and are being actively monitored, whereas others would require access from landowners.
- **Continued operation and data gathering of USGS flow gage that would provide data for surface water flows downstream of the mine site.** Rosemont Copper would annually fund the USGS to operate and maintain the existing flow gage at Barrel Canyon.

Summary of Effects by Issue Factor by Alternative

Table 76 presents the summary comparison of impacts from each alternative.

Table 76. Summary of effects

Issue Factor	No Action	Proposed Action	Phased Tailings	Barrel	Barrel Trail	Scholefield-McCleary
Issue 3D.1: Quantitative assessment of water released and available for beneficial uses	No change	Beneficial uses of ephemeral stream flows primarily related to stock tanks; after mitigation, negligible effect on beneficial uses	Same as for proposed action	Same as for proposed action	Same as for proposed action	Same as for proposed action
Issue 3D.4: Number of stock watering tanks that would be unavailable	0	11 stock tanks directly lost; 6 stock tanks possibly indirectly impacted downstream, but reduction in flow due to mine unlikely to affect tanks	11 stock tanks directly lost; 6 stock tanks possibly indirectly impacted downstream, but reduction in flow due to mine unlikely to affect tanks	15 stock tanks directly lost; 5 stock tanks possibly indirectly impacted downstream, but reduction in flow due to mine unlikely to affect tanks	15 stock tanks directly lost; 5 stock tanks possibly indirectly impacted downstream, but reduction in flow due to mine unlikely to affect tanks	5 stock tanks directly lost; 6 stock tanks possibly indirectly impacted downstream, but reduction in flow due to mine unlikely to affect tanks

Issue Factor	No Action	Proposed Action	Phased Tailings	Barrel	Barrel Trail	Scholefield-McCleary
Issue 3D.5: Change in volume, frequency, and magnitude of runoff from the project area	Possible reduction owing to climate change	Postclosure 45.8% reduction in average annual volume of stormwater flow; 53.1% reduction in 100-year, 24-hour peak stormwater flow; 9.7% reduction in stormwater flow in lower Davidson Canyon	Postclosure 44.3% reduction in average annual volume of stormwater flow; 49.9% reduction in 100-year, 24-hour peak stormwater flow; 11.1% reduction in stormwater flow in lower Davidson Canyon	Postclosure 17.2% reduction in average annual volume of stormwater flow; 22% reduction in 100-year, 24-hour peak stormwater flow; 4.3% reduction in stormwater flow in lower Davidson Canyon	Postclosure 42.0% reduction in average annual volume of stormwater flow; 40.0% reduction in 100-year, 24-hour peak stormwater flow; 10.5% reduction in stormwater flow in lower Davidson Canyon	Postclosure 22.8% reduction in average annual volume of stormwater flow; 29.5% reduction in 100-year, 24-hour peak stormwater flow; 5.7% reduction in stormwater flow in lower Davidson Canyon
Issue 3D.6: Change in recharge to the aquifer by runoff	Possible reduction owing to climate change	Reduction in recharge possible but not able to be quantified	Reduction in recharge possible but not able to be quantified	Reduction in recharge possible but not able to be quantified	Reduction in recharge possible but not able to be quantified	Reduction in recharge possible but not able to be quantified

Affected Environment

Relevant Laws, Regulations, Policies, and Plans

Table 77 lists the applicable laws, regulations, and policies related to the use, protection, and management of surface water quantity resources that would apply to the development and operation of the project. These laws, regulations, and policies, which will collectively be referred to in the following sections as “regulation(s),” are outlined in more detail in the following sections.

Table 77. Summary of the Federal, State, and local regulatory requirements applicable to the project with respect to surface water resources

Law/Regulation	Regulates
Federal	
CWA – Section 404	Discharge of dredged or fill material into waters of the U.S.
FSMs 2520, 2530, and 2880 and FS-881, “Technical Guide”	Watershed protection and management, water resource management, geological resources, and groundwater management
State	
Dam Safety Permit	Jurisdictional dams of certain purpose, height, width, or capacity
Surface Water Rights	Diversion of springs, surface flow, and certain wells
Local	
Pima County Floodplain and Erosion Hazard Management Ordinance	Regulatory floodplains and riparian habitat designated by Pima County

Federal

Clean Water Act Section 404

Section 404 of the CWA regulates the discharge of dredged or fill material into waters of the U.S. (WUS). While this has an effect on both surface water quantity and quality, as well as riparian areas, for the purposes of this EIS, Section 404 of the CWA is fully discussed in the "Surface Water Quality" resource section of chapter 3.

Forest Service Guidance

FSMs 2520, 2530, and 2880 provide guidance for watershed protection and management for both surface water and groundwater resources. These manuals and technical guides are described in the "Groundwater Quantity" resource section.

State

Dam Safety Permit (Arizona Administrative Code R12-15, Article 12)

ADWR regulates the safety of dams within the State of Arizona. Dam safety rules are applicable only to certain dams, with exemptions based on purpose, height, and capacity. The compliance dam located in the Barrel Canyon drainage would have a capacity of 2 acre-feet. This size dam is exempted under AAC R12-15-1203 from jurisdictional requirements set forth by ADWR and would not require the agency's approval prior to construction.

Surface Water Rights

Water rights within the State of Arizona operate within a bifurcated legal framework in which surface water rights are considered completely separate from groundwater rights. Surface water rights are assigned under the legal doctrine of prior appropriation or "first in time, first in right" and have a priority date based on when the water was first put to beneficial use. But a Federal reserved water right (water right associated with an Indian reservation or public lands) has a priority date that goes back at least as far as the date on which the lands were set aside. The doctrine of Federal reserved water rights was first established into law in 1908 when the U.S. Supreme Court ruled to reserve the water rights on Indian reservations. Federal reserved water rights are now extended to include all federally reserved public lands, such as national forests, national parks or recreation areas, military bases, and national wildlife refuges. The priority date of the water right is the date on which the public lands were established, and the quantity of reserved water rights is dependent on the specific purposes for which the land was reserved.

Historically, the administrative process of claiming or registering a surface water right in Arizona has not considered other water rights already claimed on the same water source. Thus, most water sources within the State are overappropriated, with multiple claims on the same water. The process of sorting through the priority of these conflicting rights is being handled by the Superior Court under the Arizona General Stream Adjudication. In addition to surface water sources, withdrawals from certain groundwater wells will eventually also be prioritized as surface water rights, depending on their effect on surface water sources.

Surface water rights that are located within the analysis area fall under the General Stream Adjudication of the Gila River. Currently, the Gila River Adjudication is focusing only on the first sub-watershed, that of the San Pedro River. No prioritization has yet occurred for surface water rights within the analysis area.

Local

Title 16 Pima County Floodplain and Erosion Hazard Management Ordinance (2010-FC5)

The Pima County Regional Flood Control District regulates flooding and erosion hazards on private property within unincorporated areas of Pima County through the Floodplain and Erosion Hazard Management Ordinance. The goal of the ordinance is twofold. The first goal of the ordinance is to ensure that new development within floodplains is safe from flooding and erosion hazards and does not adversely impact adjacent property. This is accomplished through implementation of the floodplain use permit process and conformance with the National Flood Insurance Program, as administered by the Federal Emergency Management Agency. The second goal of the ordinance is to protect natural resources within flood-prone areas. These riparian areas are recognized by the county for their importance in mitigating flood hazards, providing natural erosion control, and promoting recharge into underground aquifers.

In 2001, the Pima County Board of Supervisors adopted the Comprehensive Land System regional plan policy (Pima County 2004), which applies the science-based policies and principles of conservation developed in the “Sonoran Desert Conservation Plan” (Pima County 2009). Riparian areas are one of the five elements considered for conservation in the plan. As such, the Pima County Board of Supervisors has adopted maps of regulated riparian habitat throughout the county. As part of the floodplain use permit process, proposed developments are subject to review for impacts to mapped regulated riparian habitat if more than ⅓ acre of a property’s regulated riparian habitat is disturbed. In some instances where disturbed regulated riparian habitat is classified as Hydroriparian, Mesoriparian, and/or Important Riparian Area, a mitigation plan needs to be approved by the Pima County Board of Supervisors. Refer to the “Required Disclosures” section at the end of chapter 3 for more discussion regarding the “Sonoran Desert Conservation Plan.”

Existing Conditions

Regional Hydrologic Setting

The project lies within the Basin and Range physiographic province, which is characterized by northwest-trending mountain ranges separated by broad, thick alluvial basins. The project area lies at the border of the Sonoran Desert and Mexican Highland sub-provinces of southeastern Arizona and southwestern New Mexico (Tetra Tech 2010b). The Sonoran Desert sub-province consists of low mountain ranges and broad valleys, while the Mexican Highland sub-province is characterized by greater altitudes and local relief, along with dissected basins.

Hydrometeorology

The proposed project is located in an arid desert region where precipitation patterns vary significantly over short distances and temperatures vary with elevation. Local hydrometeorology parameters such as precipitation, temperature, and evaporation have been monitored in the general vicinity of the project area for decades and in the project area itself for several years. A summary of these data is presented in the “Air Quality and Climate Change” resource section in this chapter.

Surface Water

Past activities that have affected surface water quantity resources on the Coronado National Forest include historic grazing activities and mining. Use of natural resources on public lands for grazing livestock and mining dates back to settlement times (Baker Jr. et al. 2004). Historic excessive or improper livestock grazing practices in the Southwest have resulted in the loss of herbaceous cover and litter and an increase in erosion, surface runoff, flooding, and downcutting, although soil and vegetation conditions have been improving in the project area over the past few decades. The effects of grazing in the project area are discussed in the "Livestock Grazing" resource section in this chapter. Monitoring results by the Coronado have shown that conditions on the grazing allotments in the project area are satisfactory. Numerous small-scale and several large-scale mining projects have occurred in the past either on or in the vicinity of the project area.

Past wildfires have also affected surface water quantity resources on the Coronado National Forest. After a fire, the loss of vegetation cover and physical changes to the soil surface (i.e., hydrophobic soils) increase surface water runoff and erosion potential. The greatest impacts to surface water runoff occur in the first years after a fire, gradually decreasing over time as vegetation is reestablished. The speed of recovery could take up to decades and depends on factors such as the severity and intensity of the fire and the type of vegetation community that was burned. Since 1989, there have been nine fires larger than 10 acres that have occurred in the analysis area (table 78). Of the nine fires, four are greater than 10 percent of the area that is being analyzed; all four have occurred since 2005.

Table 78. Summary of past wildfires larger than 10 acres

Fire	Date Started	Acres	Affected Area Relative to Analysis Area (percent)
Gardner Fire	07/18/89	75	0.5
Fagan Fire	08/08/95	134	0.8
Florida Fire	07/07/05	23,186	142.5
Fagan Fire	04/30/07	533	3.3
Hilton Fire	2/11/12	432	2.7
Mulberry Fire	06/02/08	61	0.4
Melendrez Fire	05/29/09	5,791	35.6
Fish Fire	04/21/09	2,026	12.5
Greaterville Fire	05/02/11	2,331	14.3

Washes and Creeks (Natural Drainages) in Project Area

The project area is located in the foothills on the east side of the Santa Rita Mountains. This area is drained by ephemeral watercourses that flow primarily in a northeasterly direction from high-elevation ridges on the eastern flank of the Santa Rita Mountains through foothills toward larger drainages located at lower elevations on the basin floor. Four major drainages occur in the primary area of disturbance: Wasp, McCleary, Scholefield, and Barrel Canyons. Scholefield, Wasp, and McCleary Canyons drain to Barrel Canyon, which then joins Davidson Canyon approximately 4 miles to the east of the project area. Davidson Canyon wash flows northwesterly between the Empire and Santa Rita Mountains into Cienega Creek, which eventually becomes Pantano Wash downstream of Pantano Dam. The distance from the confluence of Barrel and Davidson Canyons to the outlet of Davidson Canyon at Cienega Creek is approximately 14 miles. Drainage from these systems eventually reaches the Santa Cruz River north of Tucson.

Barrel Canyon watershed is the largest of the four major drainages that occur in the primary area of disturbance. Two sub-watersheds, Upper and Lower Barrel, total more than 2,300 acres and combine to make Barrel Canyon proper. Barrel Canyon is the largest of the affected watersheds, extending almost 4 miles from its headwaters to its confluence with East Canyon; the average sandy-bottom channel width for washes in Barrel Canyon is estimated to be 51 feet. For comparison purposes, average wash widths in Wasp, McCleary, and Scholefield Canyons are approximately 38, 29, and 27 feet, respectively. Table 79 presents details on the four primary watersheds that occur within the project area.

Table 79. Summary of primary watersheds within the project area

Watershed	Drainage Size (acres)	Drainage Size (square miles)	Average Drainage Length (feet)	Average Wash Width (feet)	Average Slope (percent)	Elevation Range (feet above mean sea level)
Barrel Canyon*	2,304	3.6	20,581	51	4	5,400 to 4,550
Wasp Canyon	1,408	2.2	9,250	38	14	6,100 to 4,800
McCleary Canyon	1,536	2.4	16,635	29	7	5,700 to 4,550
Scholefield Canyon	2,048	3.2	11,643	27	12	5,800 to 4,400

* Includes both Upper Barrel and Lower Barrel Canyons.

Field reconnaissance was conducted by WestLand Resources Inc. (2010a; 2010b; 2010c) for the purpose of collecting data on drainage features within the project area. The results of their efforts indicate that perennial or nearly perennial surface water within the project area is limited to very small pools at spring sites or to stock ponds. Of the drainage features identified and recorded for the project area, more than 90 percent (265 out of 288) were identified as being ephemeral washes.

Groundcover varies from desert brush in the steep, rocky terrain of the east half of the project area to herbaceous and mountain brush on the west side. Dense xeroriparian vegetation consisting of trees and shrubs lines the margins of washes and occurs within floodplain areas, where moisture is stored in the alluvium. Riparian vegetation is discussed in detail in the “Seeps, Springs, and Riparian Areas” resource section in this chapter.

Stream bed material found within the major drainages consists of unconsolidated sand, gravel, silt, and clay. This recent alluvium is 2 to 4 feet thick on the bottom of the major drainages (Tetra Tech 2007). Floodplains at the lower elevations of the major washes are not more than 100 feet wide and are considerably more restricted in upstream reaches at higher elevations. Figure 61 depicts the major drainage basins on the project area, and table 79 summarizes the size and characteristics of the watersheds. Perennial or intermittent surface water in the project area occurs only as very small pools or stock ponds; all of the washes and drainages are ephemeral.

Water Resources Downgradient of the Mine

Surface drainage from the project area leaves via the Barrel Canyon drainage, including Scholefield and Papago Canyons, which drain a small portion of the northeastern part of the project area. Barrel Canyon connects with the Davidson Canyon drainage east of SR 83, approximately 4 miles downstream of the project area. Farther downstream in the watershed (approximately 14 miles), Davidson Canyon is tributary to Cienega Creek. Cienega Creek is the main surface water drainage in a basin that flows northwest into the Tucson Active Management Area and covers an area measuring approximately 605 square miles in southern Arizona (figure 62). Cienega Creek has significant reaches (approximately 8 miles) of intermittent or perennial water as it flows through Las Cienegas

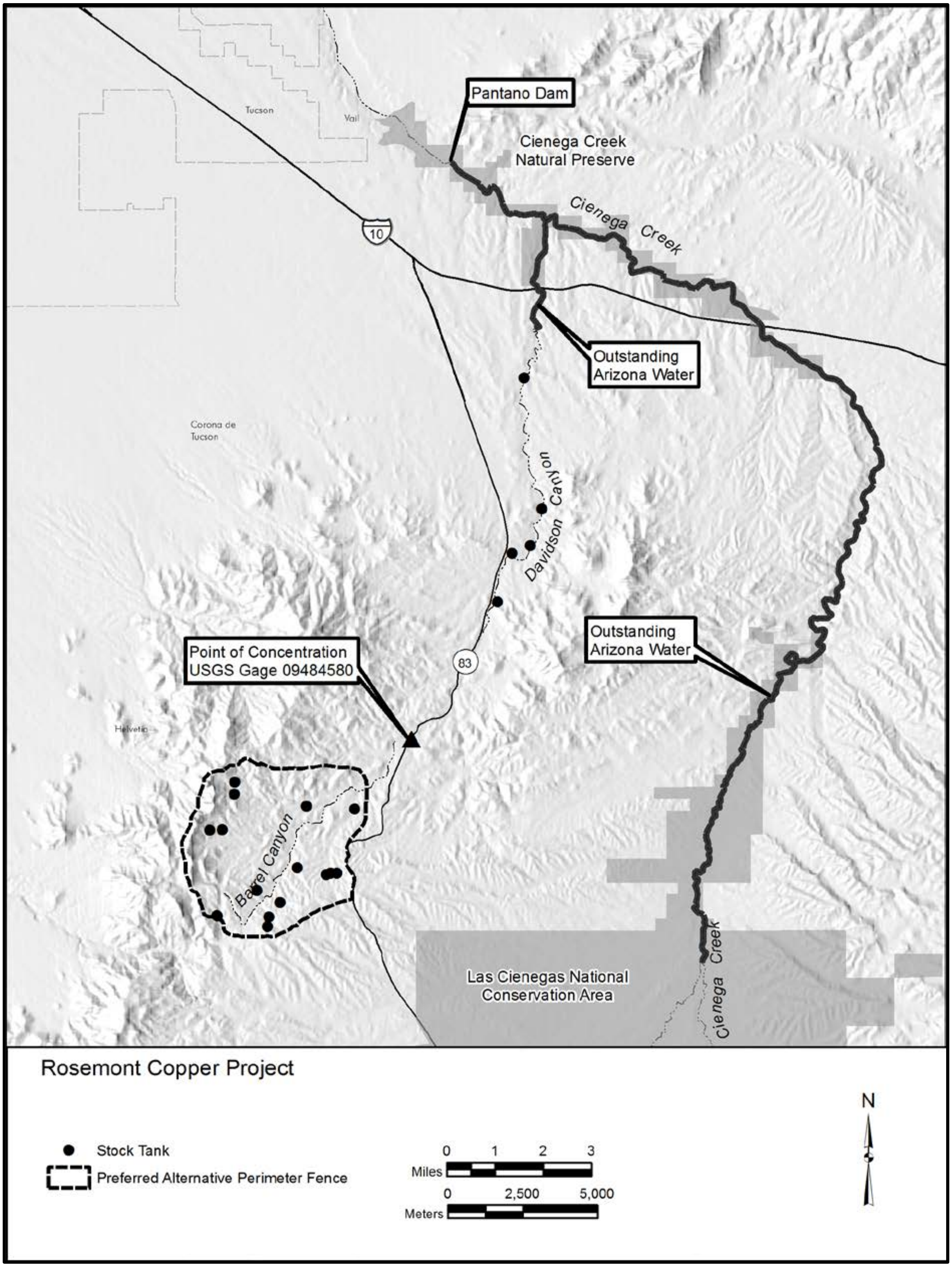

Figure 62. Outstanding Arizona Waters and stock tanks

National Conservation Area and in the vicinity of the confluence with Davidson Canyon. Farther downstream, Cienega Creek becomes Pantano Wash, which eventually flows into the Santa Cruz River on the northwest side of Tucson. Portions of Cienega Creek and a reach of Davidson Canyon approximately 11 miles downstream of the project area have been designated an Outstanding Arizona Water by the ADEQ. Both Cienega Creek and Davidson Canyon are outside any area of direct impact from the proposed project but could be indirectly impacted by reductions in stream flow. A full analysis of impacts to these Outstanding Arizona Waters is included in the “Seeps, Springs, and Riparian Areas” resource section in this chapter.

South and east of the project area, Cienega Creek passes through the Las Cienegas National Conservation Area. North of the project area, Cienega Creek passes through the Cienega Creek Natural Preserve, which stretches from just south of I-10 northwest to Colossal Cave Road. The western boundary of the Las Cienegas National Conservation Area is approximately 3 miles from the eastern boundary of the project area. Cienega Creek is divided into two sections: the upper section, which drains the central valley east of the project area; and the lower section, which flows through a narrow valley and becomes Pantano Wash north of the project area (see figure 62). Between the confluence with Davidson Canyon and the “Narrows” section, impermeable bedrock forces water to the surface, creating stretches of perennial flow. Limited flow data exist for both Davidson Canyon and Cienega Creek; data from USGS gage no. 09484550 on upper Cienega Creek (approximately 8 miles east of the project area) indicate perennial flow at this location from 2000 to 2009 (U.S. Geological Survey 2011).

The Outstanding Arizona Water portion of Davidson Canyon is identified as a perennial, free-flowing reach; however, field visits conducted in January 2010 to investigate spring flow within Davidson Canyon found that most of the southern portion of the reach was dry (Tetra Tech 2010a). With the exception of small perennial sections, based on data from 1968 through 1975 (Arizona Department of Water Resources 2011a), both Davidson Canyon and Lower Cienega Creek are intermittent streams that flow for limited portions of the year, with some perennial reaches in Cienega Creek.

Watershed Yield

Various calculations have been made in previous literature concerning the amount of water leaving the area watersheds as runoff. These analyses were made solely on the Barrel and Scholefield Canyon watersheds, which form a total watershed area of approximately 9,000 acres. Estimates of flow leaving these watersheds as runoff range from 900 to 1,500 acre-feet per year (Hargis and Harshbarger n.d. [1978]). At existing conditions, the average annual runoff from contributing watersheds associated with the project area to the point of concentration (USGS gage no. 09484580) is estimated to be 1,407 acre-feet (Krizek 2010c).

Stream Flow

Flow monitoring at seeps and springs and in washes is an ongoing activity in and around the project area. Runoff from the drainage areas to the point of concentration at USGS gage no. 09484580 is typically intermittent and of short duration. Historic peak flow data exist for Barrel Canyon from 1962 through 1976, and there are daily stream flow data after January 23, 2009 (U.S. Geological Survey 2010). The maximum peak flows in major drainages on the project area are related to episodic heavy thunderstorm precipitation during the summer months; all peak flows in Barrel Canyon occurred during the months of July through September. Peak flows recorded annually from 1962 through 1976 at Barrel Canyon range from approximately 150 cubic feet per second to nearly 2,000 cubic feet per second (table 80). The available 2009 flow data indicate that Barrel Canyon is an ephemeral drainage, with only occasional flow. At existing conditions, the 100-year flood peak at the point of concentration (USGS gage no. 09484580) is estimated to be 8,072 cubic feet per second (Krizek 2010c).

Table 80. Annual peak flows in Barrel Canyon at SR 83 bridge, 1962 to 1976

Year	Date Peak Flow Occurred	Peak Stage Height (feet)	Peak Flow (cubic feet per second)
1962	Unknown	2.54	140
1963	Unknown	2.57	145
1964	September 10, 1964	4.78	879
1965	September 8, 1965	3.64	480
1966	Unknown	2.97	260
1967	September 1967	3.04	323
1968	July 26, 1968	6.15	1,600
1969	July 23, 1969	1.7	<15
1970	July 20, 1970	5.6	1,350
1971	August 1971	6.87	1,900
1972	July 1972	2.92	240
1973	Unknown	1.23	<10
1974	September 21, 1974	5.64	1,350
1975	September 13, 1975	4.6	980
1976	August 1976	5.24	1,100

Source: USGS (2010).

Note: Data are from USGS gage no. 09484580.

The Pima Association of Governments has been monitoring stream flow in Cienega Creek Natural Preserve downstream of the project area along lower Davidson Canyon since 2005 and along lower Cienega Creek since 1993 (Pima Association of Governments 2012). Monitoring in lower Davidson Canyon extends 4.3 miles downstream from a spring south of I-10 (presumably Reach 2 Spring; see the “Seeps, Springs, and Riparian Areas” resource section in this chapter) and consists of recording the presence/absence of stream flow (also known as “wet/dry mapping”). For this method, the length of the channel is walked, the locations of flows are recorded, and the extent of stream flow is mapped and measured. Monitoring efforts along lower Cienega Creek begin where it crosses I-10 and continue 9 miles downstream to Pantano Dam. Cienega Creek surface water quantity monitoring includes wet/dry mapping as well as monthly stream flow volumetric measurements taken manually with a flow meter.

The Pima Association of Governments performs wet/dry mapping of Davidson Canyon on a quarterly basis. Since monitoring began, September has consistently been the quarter with the longest-flowing reach; for the 2009 to 2010 monitoring year, it was the only quarter in which flow was observed. Along Cienega Creek, a perennial reach occurs just up- and downstream of its confluence with Davidson Canyon. The Pima Association of Governments (2012) reported that for the 2009 to 2010 monitoring year, stream flow along this perennial reach ranged from a low of 0.08 cubic feet per second in September 2009 to 1.07 cubic feet per second in March 2010. Historically, the annual mean stream flow along this perennial reach has declined since 1994 (table 81), and the average total length of surface flow in the Cienega Creek Preserve has also decreased over time since 1975.

Table 81. Annual mean stream flows in Cienega Creek below the confluence with Davidson Canyon, 1994 to 2010

Year	Annual Mean Stream Flow (cubic feet per second)
1994	1.87
1995	1.31
1996	1.09
1997	1.34
1998	1.15
1999	1.32
2000	1.15
2001	1.72
2002	1.37
2003	0.70
2004	0.65
2005	0.49
2006	0.72
2007	1.06
2008	0.99
2009	1.16
2010	0.39

Source: Pima Association of Governments (2010).

Note: Data are from Marsh Station stream flow monitoring site.

Available surface flow data from four USGS stream gages located in the vicinity of the project area were obtained using the online National Water Information System Web Interface (U.S. Geological Survey 2013c). The gages are located at:

- Cienega Creek near Sonoita (gage no. 09484550). This gage is located in a perennial section of Upper Cienega Creek and is also referenced in the “Groundwater Quantity” resource section of this chapter.
- Cienega Creek near Pantano (gage no. 09484560). This gage is located in an intermittent or ephemeral part of Lower Cienega Creek, several miles above the confluence with Davidson Canyon, and is also referenced in the “Groundwater Quantity” resource section of this chapter.
- Pantano Wash near Vail (gage no. 09484600). This gage is located at the confluence of Cienega Creek with Pantano Wash, downstream of the confluence with Davidson Canyon, at the boundary of the analysis area.
- Davidson Canyon Wash near Vail (gage no. 09484590). This gage is located within the reach of lower Davidson Canyon that is designated an Outstanding Arizona Water, between Reach 2 Spring and the confluence with Cienega Creek.

Data were compiled using the data set containing mean discharge for each month of data collected during the period of record for each location. Median, minimum, and maximum of the means were then determined by month for each location. A summary of the data is presented in tables 82 through 85.

Table 82. Surface water flow at Cienega Creek near Sonoita, Arizona

Monthly Mean Flow (in cubic feet per second), Cienega Creek near Sonoita, Arizona, Gage No. 09484550, Period of Record 2001 to 2011												
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
2001	–	–	–	–	–	–	–	–	0.97	0.89	0.96	1.10
2002	1.33	1.51	1.51	1.26	0.69	0.33	0.60	1.28	0.37	0.36	0.56	0.77
2003	0.82	0.90	0.93	0.70	0.45	0.22	1.41	2.97	0.46	0.74	0.72	0.84
2004	0.94	1.15	1.26	1.04	0.52	0.27	0.90	1.75	0.31	0.45	0.60	0.65
2005	0.76	0.80	0.80	0.69	0.40	0.24	0.61	7.76	0.71	0.31	0.42	0.63
2006	0.75	0.79	0.79	0.63	0.43	0.23	6.73	15.40	18.10	0.48	0.65	0.77
2007	0.84	0.88	0.97	0.70	0.41	0.22	30.10	8.41	1.19	0.42	0.58	0.79
2008	0.87	0.94	0.96	0.72	0.42	0.65	32.70	1.97	0.53	0.59	0.82	0.96
2009	1.20	1.37	1.29	0.93	0.46	0.30	1.25	0.62	1.01	0.37	0.55	0.81
2010	3.34	1.12	1.02	0.74	0.07	0.07	5.72	12.10	0.59	0.45	0.62	0.85
2011	0.94	0.98	1.00	0.83	0.53	0.27	0.43	0.39	6.90	–	–	–
Median	0.90	0.96	0.98	0.73	0.44	0.25	1.33	2.47	0.71	0.45	0.61	0.80
Minimum	0.75	0.79	0.79	0.63	0.07	0.07	0.43	0.39	0.31	0.31	0.42	0.63
Maximum	3.34	1.51	1.51	1.26	0.69	0.65	32.70	15.40	18.10	0.89	0.96	1.10

Source: USGS (2013c).

Note:

– = No data available.

Table 83. Surface water flow at Cienega Creek near Pantano, Arizona

Monthly Mean Flow (in cubic feet per second), Cienega Creek near Pantano, Arizona, Gage No. 09484560, Period of Record 1968 to 1975												
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1968	–	–	0	0	0	0	16.70	9.45	0	0	0.002	0
1969	0	0	0	0	0	0	6.15	2.10	1.63	0	0	0
1970	0	0	0	0	0	2.58	4.22	14.60	7.96	0	0	0
1971	0	0	0	0	0	0	3.59	38.90	2.44	1.96	0	0
1972	0	0	0	0	0	0	2.57	1.86	12.60	0.18	0	0
1973	0	7.94	1.33	0	0	0	3.21	0	0	0	0	0
1974	0.02	0	0	0	0	0	53.80	6.35	13.40	0	0	0
1975	0	0	0	0	0	0	0.21	0	6.37	–	–	–
Median	0	0	0	0	0	0	3.91	4.23	4.41	0	0	0
Minimum	0	0	0	0	0	0	0.21	0	0	0	0	0
Maximum	0.019	7.94	1.33	0	0	2.58	53.80	38.90	13.40	1.96	0.002	0

Source: USGS (2013c).
Note:
– = No data available.

Table 84. Surface water flow at Pantano Wash near Vail, Arizona

Monthly Mean Flow (in cubic feet per second), Pantano Wash near Vail, Arizona, Gage No. 09484600, Period of Record 1959 to 1974 and 1989 to 2011												
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1959	–	–	–	–	–	–	–	–	–	6.50	1.11	1.40
1960	17.70	3.17	2.25	1.61	1.55	1.33	4.08	23.10	2.97	3.22	1.34	1.70
1961	2.40	1.44	1.60	1.51	1.37	1.01	8.40	47.60	14.80	1.33	1.52	2.09
1962	5.15	1.73	1.70	1.31	1.25	1.10	3.43	3.45	9.08	1.18	1.21	1.11
1963	1.00	1.04	1.00	0.87	1.00	0.91	9.14	88.60	16.30	1.36	1.44	1.42
1964	1.52	1.98	1.36	1.75	1.32	1.18	21.90	15.30	105.00	2.55	2.34	2.50
1965	1.82	2.10	2.02	1.65	1.95	1.25	4.51	7.39	10.60	0.42	0.90	50.30
1966	2.79	36.30	3.19	2.68	1.46	0.96	13.70	38.70	10.50	2.91	2.26	5.16
1967	2.68	3.59	2.56	2.03	1.54	1.80	49.60	14.60	12.80	6.67	2.97	43.30
1968	3.25	3.56	6.67	3.31	1.45	1.75	18.60	15.10	1.59	1.14	1.53	2.72
1969	2.58	2.79	2.74	2.21	0.96	0.53	3.23	4.15	2.90	0.67	1.06	0.86
1970	0.89	1.04	0.86	0.92	1.38	2.57	25.60	19.30	5.18	0.97	0.42	0.90
1971	0.90	1.05	1.62	1.05	0.46	0.31	2.86	92.60	11.00	4.62	2.29	1.85
1972	1.78	1.56	1.54	1.15	0.74	0.79	3.25	2.36	8.94	1.79	1.17	1.97
1973	1.48	14.20	18.20	5.16	1.78	0.44	2.38	0.52	0.16	0.10	0.10	0.10
1974	0.10	0.10	0.12	0.32	0.19	0.07	21.80	6.86	11.20	–	–	–
1989	–	–	–	–	–	–	–	–	–	1.14	0.27	0.28
1990	0.81	1.03	2.24	3.81	1.48	3.63	47.20	23.40	7.22	1.51	1.47	1.88
1991	2.25	2.58	9.15	4.94	1.84	2.55	1.45	0.96	0.60	0.52	0.56	1.12
1992	0.81	1.74	3.70	3.53	1.28	1.00	5.22	7.74	1.20	0.66	0.76	3.12
1993	110.90	9.31	5.03	2.36	1.86	1.14	6.39	10.40	2.54	0.93	0.75	1.22
1994	1.60	1.70	1.66	1.52	1.41	0.89	0.78	1.54	7.58	0.68	1.42	16.40
1995	22.20	11.50	4.97	2.16	1.52	0.97	0.66	2.15	0.94	0.27	0.42	0.49

Monthly Mean Flow (in cubic feet per second), Pantano Wash near Vail, Arizona, Gage No. 09484600, Period of Record 1959 to 1974 and 1989 to 2011

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1996	0.52	0.79	0.72	0.61	0.43	0.56	8.32	15.90	14.90	1.34	0.83	1.13
1997	1.23	1.02	0.84	0.85	0.38	0.21	0.22	5.88	3.29	0.28	0.78	4.44
1998	0.71	75.10	21.20	12.00	1.31	0.89	47.30	26.30	2.26	0.47	0.70	1.23
1999	0.74	0.57	0.41	0.57	0.41	0.29	41.10	5.22	5.71	0.62	0.51	0.64
2000	0.52	0.44	0.55	0.55	0.24	20.80	1.90	23.70	0.93	45.60	38.70	2.61
2001	2.85	2.17	2.48	1.68	1.21	1.00	9.73	18.00	0.96	1.09	0.56	0.84
2002	0.78	1.32	1.48	1.58	0.79	0.10	1.12	9.14	6.64	0.37	0.14	0.11
2003	0.09	0.34	0.54	0.50	0.36	0.08	12.60	10.50	1.02	2.11	0.22	0.24
2004	0.33	0.49	1.20	0.64	2.62	0.75	10.60	13.60	0.65	0.40	0.44	0.43
2005	0.28	0.23	0.39	0.46	1.50	0.13	6.58	24.50	7.26	0.40	0.39	0.37
2006	0.25	0.13	0.12	0.29	1.42	3.83	82.50	27.00	14.20	0.75	0.93	0.89
2007	1.04	0.66	3.51	0.72	0.56	1.80	62.70	48.30	1.86	0.72	0.80	2.45
2008	3.78	0.70	0.45	0.42	0.36	1.63	55.60	26.40	1.21	0.77	0.60	0.77
2009	1.47	1.29	1.56	0.50	0.27	0.40	0.26	0.28	0.79	0.14	0.11	0.09
2010	0.12	2.80	10.30	0.53	0.19	0.09	17.30	14.80	0.13	0.12	0.11	0.17
2011	0.21	0.22	0.17	0.18	0.22	0.12	37.30	3.30	19.20	–	–	–
Median	1.23	1.44	1.62	1.31	1.28	0.96	8.40	14.60	5.18	0.93	0.80	1.22
Minimum	0.09	0.10	0.12	0.18	0.19	0.07	0.22	0.28	0.13	0.10	0.10	0.09
Maximum	110.90	75.10	21.20	12.00	2.62	20.80	82.50	92.60	105.00	45.60	38.70	50.30

Source: USGS (2013c).

Note:

– = No data available.

Table 85. Surface water flow at Davidson Canyon Wash near Vail, Arizona

Monthly Mean Flow (in cubic feet per second), Davidson Canyon Wash near Vail, Arizona, Gage No. 09484590, Period of Record 1968 to 1975												
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1968	–	0.63	0.63	0.52	0.41	0.32	5.08	6.21	0.80	0.71	0.95	1.36
1969	0.74	0.72	0.76	0.52	0.47	0.23	0.32	0.99	0.01	0	0	0
1970	0	0	0	0	0	0	11.10	5.85	0.01	0	0	0.006
1971	0	0.05	0.21	0.13	0.03	0	0	11.20	2.01	0.002	0	0.24
1972	0.02	0	0	0	0	0	0	0	4.02	0.003	0	0
1973	0	0	0.008	0	0	0	0	0	0	0	0	0
1974	0	0	0	0	0	0	2.85	1.64	8.02	0.003	0	0
1975	0	0	0	0	0	0	0.51	1.27	1.63		–	–
Median	0	0	0.004	0	0	0	0.41	1.46	1.22	0.002	0	0
Minimum	0	0	0	0	0	0	0	0	0	0	0	0
Maximum	0.74	0.72	0.76	0.52	0.47	0.32	11.10	11.20	8.02	0.71	0.95	1.36

Source: USGS (2013c).

Note:

– = No data available.

Cienega Creek near the Sonoita gage has a period of record from 2001 to 2011. Data indicate that this reach of Cienega Creek is perennial; no months in the period of record were recorded with no flow.

The period of record for Cienega Creek near the Pantano gage is February 1968 to September 1975. Greater variability is evident in these data, compared with the upstream gage, with the median monthly mean ranging from no flow to 4.4 cubic feet per second. The largest flows occur in July and August, with the highest in July 1974, when the monthly mean flow was recorded at 53.8 cubic feet per second. Flow characteristics suggest that this reach is ephemeral or intermittent.

The Pantano Wash gage has the longest period of record, from 1959 to 2011. This is a perennial stream reach; the median monthly mean ranges from 0.798 cubic feet per second in October to 18.88 cubic feet per second in August.

The period of record for the Davidson Canyon Wash gage is February 1968 to September 1975; this gage is no longer in service. The range of mean monthly flow at this location corresponds to the monsoon season, with the highest occurring in August (11.2 cubic feet per second) and the lowest occurring in June just before summer monsoon season (0.318 cubic feet per second). The data also show the temporal variability of flow at this location, with many months of no flow. This reach of Davidson Canyon appears to be perennial for some periods of time (such as in 1968) but is more properly termed an intermittent stream.

Surface Water Trends

The Pima Association of Governments reports on conditions within the Pima County Natural Preserve, which encompasses a large portion of Lower Cienega Creek both above and below the confluence with Davidson Canyon. Stream flow monitoring (wet/dry mapping) has occurred since 1984 (Pima Association of Governments 2012). The percentage of Cienega Creek that flows in this area is cyclical but has steadily decreased since monitoring began in 1984. Since 1999, drought monitoring has been conducted, and measurements in June 2011 indicate that this portion of Cienega Creek has the least amount of flow yet observed, with only 13 percent of the stream exhibiting flowing or standing water.

Surface Water Rights Onsite

Surface water rights within the project area associated with Rosemont Copper include those located on deeded land, as well as those located on Coronado National Forest land, as summarized in table 86. Identified surface water rights filed with the ADWR include diversions from 10 springs (including Questa, Horse Pasture, McCleary, and Rosemont Springs) and multiple diversions from six washes (including Wasp, Barrel, and McCleary Canyons). Priority and validity of these surface water rights have not yet been determined through the General Stream Adjudication.

Table 86. Summary of onsite surface water rights associated with the project area

General Location	Water Right Number	Name of Water Source	Cadastral Location
Deeded/Fee Lands	33-93235.2	Questa Spring	D-18-16 27dd
Deeded/Fee Lands	33-93236.2	Horse Pasture Spring	D-18-16 15aa
Deeded/Fee Lands	33-93277.1	Barrel Canyon	D-18-16 29ba
Deeded/Fee Lands	33-93278.1	McCleary Canyon	D-18-16 19cc
Deeded/Fee Lands	33-93279.1	Wasp Canyon	D-18-16 29cd
Deeded/Fee Lands	33-96516.0	Wasp Canyon	D-18-15 36ab
Deeded/Fee Lands	36-25948.1	Rosemont Spring	D-18-16 32bc

General Location	Water Right Number	Name of Water Source	Cadastral Location
Deeded/Fee Lands	36-25954	Unnamed Spring	D-18-15 23ba
Coronado National Forest	38-93308.1	Unnamed Wash	D-18-16 33cc
Coronado National Forest	38-93309.1	Unnamed Wash	D-18-16 34bc
Coronado National Forest	38-93310.1	Unnamed Wash	D-18-15 25dd
Coronado National Forest	36-25911	Wasp Canyon	D-18-15 D-18-16
Coronado National Forest	36-25912	McCleary Canyon	D-18-16
Coronado National Forest	36-25945	McCleary Spring	D-18-16 30ab
Coronado National Forest	36-25946	Unnamed Spring	D-18-16 30cd
Coronado National Forest	36-25947	Unnamed Spring	D-18-16 30cd
Coronado National Forest	36-25950	Unnamed Spring	D-18-16 21bc
Coronado National Forest	36-25951	Unnamed Spring	D-18-16 29ab
Coronado National Forest	36-25956	Unnamed Spring	D-18-16 19cd

Source: Pearce (2007).

Surface Water Rights Offsite

Offsite surface water rights that could be impacted include any surface rights where surface water/groundwater exchange occurs, which could include diversions from springs or washes but generally not from stock tanks. Table 87 summarizes the surface water rights (excluding stock tanks) that are located outside the footprint of the project but still within the influence of groundwater drawdown. Data were obtained from the ADWR Statement of Claimant database. Priority and validity of these surface water rights have not yet been determined through the General Stream Adjudication.

Table 87. Summary of offsite surface water rights within the area of groundwater drawdown

Name on Water Right	Number of Water Rights
Coronado National Forest	80
ASARCO	28
Ocotillo Ranches Inc.	26
BLM	21
ASLD	20
Robinson	17
Bowman	15
Lauderbach	10
Barchas	6
McCain	5
Maldonado	4
Andrada Properties	3
Cote	3
Zeagler	3
Adler	2
Coronado Investments Inc.	2

Name on Water Right	Number of Water Rights
Stewart Title and Trust No. 1460	2
Arizona Game and Fish Commission	1
Boschert	1
Carbone	1
Garrett	1
Harm	1
Hickman	1
Hillman	1
Keim	1
Martin	1
Montgomery	1
Moore	1
Nikrasch	1
Prieve	1
Robinson Cattle LLC	1
Snow	1

Source: ADWR (2005).

Stock Tanks

Ongoing grazing activities and associated stock tank development and maintenance occur on and around the project area. Stock tanks associated with the project include those located on deeded land, on Coronado National Forest land, or downstream in the Davidson Canyon watershed, as summarized in table 88. Data were obtained from the Coronado, ADWR Surface Water Rights and Statement of Claimant databases, and USGS topographic maps. The water source that feeds these stock ponds varies. Most commonly, the stock ponds are constructed earthen berms within drainages that impound surface runoff. There are several stock ponds in the project area that are known to be fed by springs and that have been developed with concrete structures to capture spring flow (WestLand Resources Inc. 2010a).

Table 88. Summary of stock tanks associated with the project area

ID	Watershed	Water Right Number	Name of Water Source	Cadastral Location
1	Barrel Canyon	38-24457	Barrel Tank[‡]	D-19-16 06dd
2	Wasp Canyon	38-26056	Upper Barrel Tank[†]	D-18-15 25dc
3	Barrel Canyon	38-57582	Stock Tank*	D-19-16 06ab
4	Barrel Canyon	38-40329	North Basin Tank*	D-19-16 05bc
5	Barrel Canyon	38-62329	South Basin 4 Tank*	D-19-16 06dd
6	Barrel Canyon	38-62339	North Basin Tank 2[‡]	D-19-16 05bc
7	Upper Barrel Canyon	38-70161	East Dam Header Tank*	D-18-16 29ac
8	Upper Barrel Canyon	38-70775	North Dam Header Tank*	D-18-16 29ac
9	Barrel Canyon	38-70799	Unnamed Stock Tank*	D-19-16 05bc
10	Wasp Canyon	38-70881	Section 25*	D-18-15 25dd
11	Davidson Wash	38-63384	4th of July Tank*	D17-17 30ab

ID	Watershed	Water Right Number	Name of Water Source	Cadastral Location
12	Davidson Wash	38-66914	Unnamed Stock Tank*	D17-17 30cd
13	Davidson Wash	Not available	Unnamed Tank[‡]	D-17-16 36a
14	Davidson Wash	Not available	Unnamed Tank[‡]	D-17-17 07b
15	East Barrel Canyon	38-70879	Section 33 Tank	D-18-16 33cc
16	East Barrel Canyon	38-26061	Dirt Tank[†‡]	D-18-16 33cc
17	East Barrel Canyon	38-49861	Section 33 Tank*	D-18-16 33cc
18	Barrel Canyon	Coronado National Forest	Unnamed Tank[‡]	D-18-16 32c
19	McCleary Canyon	38-26053	McCleary Tank[†]	D-18-16 30bb
20	McCleary Canyon	Asarco	Unnamed Stock Pond[†]	D-18-16 19cc
21	Barrel Canyon	Not available	East Dam Tank[‡]	D-18-16 28ac
22, 23	Box Canyon	Not available	Unnamed Tank[§] (2 tanks)	D-19-15 01da
24	Davidson Canyon	Not available	Unnamed Tank[§]	D-18-16 01ab

Note: The "Biological Resources" resource section references two stock tanks by name: Lower Stock Tank and East Dam Tank. East Dam Tank (#21) is identified in the table above. It is not clear which tank corresponds to Lower Stock Tank, which is located within the area of the mine pit. It likely corresponds to either Upper Barrel Tank (#2) or Section 25 Tank (#10).

* Data are from ADWR (2011b) Surface Water Filings database.

[†] Data are from ADWR (2005) Statement of Claimant database.

[‡] Data are from USGS Map/Geographic Names Information System (2013a; 2013b).

[§] Data are from Forest Service (2011).

Environmental Consequences

This section presents only impacts associated with surface water quantity. Impacts to seeps, springs, and riparian habitat as well as potential changes in perennial flow status are discussed in the "Seeps, Springs, and Riparian Areas" resource section of this chapter.

Direct and Indirect Effects of Each Alternative

Specific impacts analyzed for each alternative include surface water peak flows, average annual surface water flow volume, and number of stock tanks both directly and indirectly impacted. Surface water flows from the project area were calculated in both cubic feet per second and acre-feet per year for the USGS gage located by the SR 83 bridge.

Overview of Stormwater Management

Public comments indicated that the DEIS did not provide an adequate overall picture for stormwater management. In addition, substantial work has been conducted since the DEIS to redesign stormwater management for the preferred alternative to improve downstream water availability. The purpose of the following description is to provide a comprehensive comparison between the redesigned Barrel Alternative and the stormwater management for the other alternatives.

Redesign of the Barrel Alternative

During public comment, several cooperating agencies, including the EPA and the USACE, expressed concerns over postclosure stormwater management as it was described in the DEIS. Primary points of concern included the storage of stormwater on the top and benches of the tailings and waste rock facilities; the amount of water being removed in perpetuity from the upper reaches of the watershed, with a resulting serious impact to downstream riparian resources; and the use of flow-through drains beneath the tailings and waste rock facilities.

In response to these concerns, the Coronado requested that Rosemont Copper undertake a redesign of postclosure stormwater management for the Barrel Alternative. As a result, a revised stormwater management plan was developed for the Barrel Alternative, and it has been analyzed in the FEIS (Tetra Tech 2012).

Barrel Alternative—Stormwater Management during Premining and Active Mining Phases

Stormwater is necessarily handled differently during premining and active mining, compared with postclosure. During active mining, certain areas of the mine site are required to be zero discharge under the multisector general stormwater permit, which has been obtained by Rosemont Copper (coverage was granted to Rosemont Copper by ADEQ on February 7, 2013). These include any areas in which stormwater comes into contact with ore stockpiles or processing facilities. Runoff from tailings is allowed to be released under the stormwater permit, but Rosemont Copper is choosing not to allow this to protect water quality. The maximum loss of runoff to the watershed occurs during the first 10 years of active mining when runoff from these areas is retained onsite and recycled as process water. During this period, the loss of runoff would vary but is likely to approach a reduction in annual average runoff of about 30 to 40 percent, compared with undeveloped baseline conditions (SWCA Environmental Consultants 2013a).

Where possible, diversions have minimized the amount of water required to be retained by routing stormwater around these process areas. Specifically, during active mining the runoff from the area above the plant site is sent downstream using a permanent diversion channel that directs water into upper McCleary Canyon instead of onto the plant site. A similar diversion exists to the west of the pit. However, runoff from this area is not able to discharge downstream and is generally retained and allowed to infiltrate as recharge into the subsurface in several ponds at the toe of the waste rock facility.

The mine design incorporates concurrent reclamation. A perimeter waste rock buttress would be built around the waste rock and tailings facilities. As this buttress is completed, the surface would be reclaimed and revegetated. Concurrent reclamation means that the revegetation of the waste rock buttress would start taking place while active mining is still occurring; in fact, concurrent reclamation would begin to occur by the end of the first year of active mining. As the surface is revegetated and stabilized, stormwater would begin to be released downstream rather than being retained onsite. Therefore, the amount of runoff lost to the watershed would be gradually reduced as areas are closed or capped with waste rock and reclaimed.

A large portion of the waste rock buttresses that surround the tailings facility and the waste rock facility itself would be concurrently reclaimed by year 10 of the active mining phase; these areas would begin to discharge water downstream as concurrent reclamation is completed. The upper benches and tops of the waste rock and tailings facilities would be reclaimed beginning in year 16 of the active mining phase but not completely reclaimed until the mine is fully closed.

During active mining, several areas would not discharge downstream. Runoff in the vicinity of the pit itself would be retained in the pit or, before development of the pit, in stormwater ponds. Runoff from the plant site would be retained in stormwater or process ponds and recycled as process water. Runoff from tailings facilities, prior to capping and reclamation, would also be retained in various ways and would not be allowed to discharge. Tailings runoff would be at times necessarily stored on top of the tailings facility during active mining and allowed to evaporate; when there are large volumes of ponded water present, the ponded stormwater on the tailings facility can be actively pumped off and recycled as process water.

Barrel Alternative—Stormwater Management after Closure

The redesign of stormwater management undertaken for the Barrel Alternative focused primarily on postclosure conditions. Previously, postclosure stormwater ponds on the top of the tailings and waste rock piles were designed to retain the 1,000-year, 24-hour storm event, and stormwater ponds on the benches of the waste rock and tailings were designed to retain the 500-year, 24-hour storm event. With the redesign, these ponds have been eliminated. Instead, the waste rock and tailings facilities shed all runoff, which is designed to flow laterally along benches until reaching several concrete drop structures, at which point the runoff would be discharged either into the natural washes (Barrel Canyon or a tributary) or into a diversion channel that would carry runoff along the toe of the waste rock and tailings facilities. The diversion channel would then discharge that runoff into the natural washes. Adjacent to the waste rock and tailings facilities, the plant site would be regraded and reclaimed, and a diversion channel would be constructed to allow discharge of stormwater from the plant site into upper McCleary Canyon.

By eliminating the stormwater retention ponds, substantially more postclosure runoff would be retained in the watershed. Previously, annual average postclosure runoff from the mine was reduced by approximately 34 percent, compared with undeveloped baseline conditions. With the redesign, annual average postclosure runoff from the mine is reduced by only 17 percent, compared with undeveloped baseline conditions.

There are still several areas (the mine pit itself and diversions to the west of the mine pit) that would not discharge downstream in perpetuity. All precipitation falling within and near the pit would be retained in the pit. The diversion channel west of the pit would collect precipitation in stormwater retention ponds along the southern toe of the waste rock facility and would be allowed to infiltrate as aquifer recharge, but it would not be able to flow downstream as surface water due to topography.

Previously, the stormwater design for the Barrel Alternative also made use of flow-through drains located under the waste rock and tailings facilities. In the redesign, these flow-through drains were removed from the Barrel Alternative because of concerns about long-term maintenance and possible intermingling of tailings seepage with stormwater. These flow-through drains would theoretically have allowed stormwater from the plant site and west of the pit to continue flowing downstream; in reality, that stormwater would have likely infiltrated into and recharged the aquifer rather than continuing as surface flow.

Postclosure, all runoff from the closed and reclaimed waste rock and tailings facilities and the plant site would be allowed to discharge downstream. Only two general areas of the mine site would not discharge runoff downstream. These include the mine pit itself and diversions to the west of the mine pit.

Stormwater Management for the Phased Tailings, Barrel Trail, and Scholefield-McCleary Alternatives

Stormwater management for the Phased Tailings, Barrel Trail, and Scholefield-McCleary Alternatives is similar to that analyzed in the DEIS and similar to the Barrel Alternative before it was redesigned. During premining, active mining, and postclosure phases, stormwater would be stored on top of and on the benches of the waste rock and tailings facilities and would not be discharged downstream except in extreme events. While concurrent reclamation would still occur, it would not facilitate any stormwater passing downstream. Runoff from the plant site and the diversion west of the open pit would also be retained onsite. These three alternatives would all maintain flow from above the plant site by diverting it into upper McCleary Canyon during both active mining and postclosure.

Flow-through drains are still part of the stormwater management of the Phased Tailings and Barrel Trail Alternatives and would allow at least infiltration of retained water from the plant site, if not direct surface runoff. The Scholefield-McCleary Alternative has no flow-through drains. As identified in the DEIS, these stormwater management schemes would reduce average annual postclosure runoff by approximately 42 percent for the Barrel Trail Alternative, by 44 percent for the Phased Tailings Alternative, and by 23 percent for the Scholefield-McCleary Alternative, compared with undeveloped baseline conditions.

Stormwater Management for the Proposed Action

The proposed action handles stormwater entirely differently from the other action alternatives. Runoff under the proposed action would be largely allowed to discharge downstream, similar to the redesign of the Barrel Alternative. However, much of the stormwater management relied on a feature known as the central drain. Designed as a vertical chimney drain as well as a flow-through underdrain, the central drain was considered problematic because of the potential for discharge of stormwater into the tailings and waste rock facilities and the concern that this would result in greater potential for seepage. The central drain concept was dropped during the development of the other alternatives.

As identified in the DEIS, the proposed action would reduce average annual postclosure runoff by approximately 46 percent, compared with undeveloped baseline conditions.

No Action Alternative

Under baseline conditions (no action), surface water within the project area will continue to consist solely of stock tanks or ephemeral flows that occur as the result of precipitation events. The no action alternative would result in no further impacts to the quantity of surface water resources. Grazing will continue. Stock tanks will continue to be monitored and maintained for use by stock and wildlife. The use of surface water for recreation and/or stock watering would likely increase relative to the predicted increase in population growth and residential development. Ephemeral washes on the project area will continue to flow in response to precipitation. Climate change will continue over time. Anticipated decreases in winter precipitation would decrease the occurrence of ephemeral flows, and the anticipated increase in the frequency of heavy rains would create higher peak flows with a greater potential for flooding.

Impacts Common to All Action Alternatives

For each action alternative, as mining operations progress over time, ephemeral stormwater flows from the project area would change, primarily as a result of the retention of water from certain portions of the mine and from changes in surface topography and characteristics from disturbed areas, such as the pit, operating facilities, and tailings and waste rock facilities.

All of the action alternatives would result in alteration of the natural surface hydrology. Impacts related to surface water quantity that are common to all action alternatives include the modification of stormwater peak flows, modification to overall runoff volume from the watersheds, and direct loss of stock tanks. The direct loss of springs through dewatering or surface disturbance and the direct loss of riparian areas are discussed in the "Seeps, Springs, and Riparian Areas" resource section of this chapter. Changes in erosion potential that would result from changes in ephemeral flows are assessed in the "Surface Water Quality" resource section of this chapter.

Direct impacts to stock tanks and indirect impacts to downstream stock tanks (see figure 62) and other beneficial uses would occur under all action alternatives and are discussed below. Postclosure stormwater management techniques differ by alternative; therefore, reductions in runoff and peak flow are analyzed for each alternative in turn.

While the analysis area for surface water quantity includes the various connected actions beyond the project area, such as the power line, water pipeline, Arizona National Scenic Trail reroute, primary access road, and utility maintenance road, disturbance in these areas would not result in any retention of surface water flow. While a change in surface characteristics, such as loss of vegetation or paving of the road, could change runoff characteristics, this change was determined to be relatively minor and similar among all action alternatives.

Proposed Action and Action Alternatives

Direct Loss of Stock Tanks by Surface Disturbance

Stock tanks would be directly lost as a result of surface disturbance under all alternatives except for the no action alternative. Based on a review of USGS topographic maps and ADWR database (Arizona Department of Water Resources 2011b), expected stock tank losses per action alternative range from eight to 19 and are summarized in table 89.

Table 89. Direct impacts to stock tanks by alternative

Alternative	Stock Tanks Lost	Names of Stock Tanks (ID)	Estimated Total Capacity Lost per Alternative (acre-feet per year)
No action	0	Not applicable	Not applicable
Proposed action	11	Barrel Tank (1) Upper Barrel Tank (2) North Basin Tank (4) South Basin 4 Tank (5) North Basin Tank 2 (6) East Dam Header Tank (7) North Dam Header Tank (8) Section 25 (10) 3 Unnamed Tanks (3, 9, 18)	66

Alternative	Stock Tanks Lost	Names of Stock Tanks (ID)	Estimated Total Capacity Lost per Alternative (acre-feet per year)
Phased Tailings	11	Barrel Tank (1) Upper Barrel Tank (2) North Basin Tank (4) South Basin 4 Tank (5) North Basin Tank 2 (6) East Dam Header Tank (7) North Dam Header Tank (8) Section 25 (10) 3 Unnamed Tanks (3, 9, 18)	66
Barrel	15	Barrel Tank (1) Upper Barrel Tank (2) North Basin Tank (4) South basin 4 Tank (5) North Basin Tank 2 (6) East Dam Header Tank (7) North Dam Header Tank (8) Section 25 (10) Dirt Tank (16) McCleary Tank (19) 2 Section 33 Tanks (15, 17) 3 Unnamed Tanks (3, 9, 18)	90
Barrel Trail	15	Barrel Tank (1) Upper Barrel Tank (2) North Basin Tank (4) South basin 4 Tank (5) North Basin Tank 2 (6) East Dam Header Tank (7) North Dam Header Tank (8) Section 25 (10) Dirt Tank (16) East Dam Tank (21) 2 Section 33 Tanks (15, 17) 3 Unnamed Tanks (3, 9, 18)	90
Scholefield-McCleary	5	Upper Barrel Tank (2) Unnamed Tank (3) East Dam Header Tank (7) North Dam Header Tank (8) Section 25 Tank (10)	30

The capacity of each individual stock tank has not been measured, but ADWR (2011b) records indicate that stock tanks in the project area each use from approximately 0.1 to 6.0 acre-feet of water per year. Assuming that all the stock tanks directly impacted by the project area have the capacity to hold the maximum 6.0 acre-feet of water per year, the estimated maximum total capacity lost per alternative would range from 30 acre-feet per year for the Scholefield-McCleary Alternative to 90 acre-feet per year for the Barrel and Barrel Trail Alternatives.

Direct Loss of Stormwater Flows to Downstream Beneficial Uses

Each action alternative incorporates various design features to maintain flow from undisturbed areas above the mine operations and to manage stormwater runoff (see chapter 2 and the alternatives discussion later in this resource section). Much of the runoff from the proposed action would not be retained onsite but instead would be allowed to discharge downstream via a central drain feature using a vertical chimney and underdrain. Conversely, runoff from Phased Tailings, Barrel Trail, and Scholefield-McCleary Alternatives would be stored on top of and on the benches of the waste rock and tailings facilities and would not be discharged downstream except in extreme events. For the Phased Tailings and Barrel Trail Alternatives, only flow-through drains would allow infiltration and direct runoff of retained water from the plant site. For the Barrel Alternative, stormwater retention ponds were eliminated from the benches of the waste rock and tailings facilities. Instead, runoff would be shed from these facilities and then routed to wrap around diversion channels and discharge into the natural washes. Redesign of the Barrel Alternative stormwater management plan has resulted in this alternative's having the largest area contributing to runoff and thus allowing the largest amount of runoff to be retained in the watershed.

Postclosure stormwater peak flows and volume for all action alternatives were modeled using the USACE computer program Hydrologic Engineering Center Hydrologic Modeling System, Version 3.4 (Chee 2010; Krizek 2010a, 2010b, 2010c, 2010d). Modeling results were validated using the USGS Bulletin 17B statistical analysis and Region 13 Regional Regression Equation. The direct effects on stormwater peak flows and volume would be proportionate to the drainage area available for contributing to runoff for each alternative, which would vary by action alternative (table 90). Table 90 provides a summary of the alternatives and their impacts on various watersheds; details are presented for each action alternative.

Table 90. Impacts to postclosure surface runoff by alternative

Alternative	Contributing Drainage Area (square miles)	Watersheds with Major Impacts	Change in Average Annual Postclosure Runoff Volume
No action	14	Not applicable	Not applicable
Proposed action	6.82	Barrel, McCleary, Wasp	Reduced by 45.8% from baseline
Phased Tailings	7.06	Barrel, McCleary (delayed 10 years), Wasp	Reduced by 44.3% from baseline
Barrel	11.326	Barrel, McCleary, Wasp	Reduced by 17.2% from baseline
Barrel Trail	7.56	Barrel, McCleary, Wasp	Reduced by 42% from baseline
Scholefield-McCleary	10.35	Barrel, Wasp, Scholefield	Reduced by 22.8% from baseline

Farther downstream from the project area, the impact from disturbed areas would attenuate as the contributing watershed becomes larger. The average annual runoff for lower Davidson Canyon Wash at its confluence with Cienega Creek was modeled for the proposed action using regression equations. Model results show that runoff for the proposed action is predicted to be reduced from 514 acre-feet for existing conditions to 464 acre-feet for postmine conditions, which is slightly less than a 10 percent reduction once postmine conditions are considered (Zeller 2011a). Runoff estimates at the confluence of Davidson Canyon Wash and Cienega Creek were not modeled for the remaining action alternatives; however, they can be approximated based on the model results for the proposed action (Tetra Tech 2010a). Stormwater flow in the Davidson Canyon watershed is estimated to be reduced by 4.3 percent; for the remaining action alternatives, stormwater flow in the Davidson Canyon watershed is estimated to be reduced by 5.7 to 11.1 percent (SWCA Environmental Consultants 2012).

With respect to modification of stormwater peak flows and volume, reductions in runoff are primarily important because they indirectly impact the water availability for downstream use. Ephemeral flows, such as those found throughout the project area, are of importance: (1) to downstream user surface water rights; (2) for sustaining riparian vegetation; (3) for livestock and wildlife; (4) in some cases to supply spring flow; and (5) for groundwater recharge in the channel. This section addresses the downstream users; indirect impacts from reduced stormwater flow to wildlife are discussed in the "Biological Resources" resource section of this chapter. Indirect impacts to livestock are discussed in the "Livestock Grazing" resource section of this chapter. Indirect impacts to riparian vegetation and springs, including several springs in Davidson Canyon (Reach 2 Spring, Escondido Spring) believed to rely on ephemeral flows stored in shallow alluvial sediments, are discussed in the "Seeps, Springs, and Riparian Areas" resource section of this chapter.

Indirect Impacts to Offsite Surface Water Rights

With respect to downstream users, because of the flashy nature of ephemeral flows, in-channel storage such as a reservoir or stock tank would be required in order to use any significant amount of ephemeral flow. No reservoirs are located within the analysis area; however, there are stock tanks located on the downstream channels that would be impacted under all action alternatives. Modification of stormwater peak flows and volume is also important for erosion potential and threat to property and human health and safety.

An offsite surface water right can be indirectly impacted by the project in one of two ways: (1) by a reduction in stormwater runoff in the channel if the water right is located in the main stem of Davidson Canyon; or (2) in a situation in which the surface water right has surface water/groundwater exchange such as at a spring or perennial reach of a stream. Based on the expected minimal reductions in stormflow by the time it exits Davidson Canyon (4.3 to 11.1 percent), surface water rights beyond Davidson Canyon are unlikely to be impacted by changes in surface water hydrology in the project area. For the most part, in-channel surface water rights consist of stock tanks, which are discussed separately below. Other than stock tanks, there are an additional 262 offsite surface water rights (see table 87) within the area of groundwater drawdown that could possibly be indirectly impacted by the project. Of these, 47 percent of the surface water right holders are public agencies: the Coronado, BLM (water rights primarily associated with the Las Cienegas National Conservation Area), ASLD, and AGFD. Other offsite water rights holders include mines, cattle companies, and individuals.

Some water sources would be impacted, as described in the "Seeps, Springs, and Riparian Areas" resource section of this chapter. Whether surface water rights associated with these water sources would be impacted is not possible to determine from a regulatory standpoint; both priority and validity of these surface water rights have not yet been determined through the General Stream Adjudication of the Gila River.

Indirect Impacts to Downstream Stock Tanks

Based on the ADWR surface water filing database (Arizona Department of Water Resources 2011b), all surface water filings in Davidson Canyon downstream of the project area are stock tanks. Downstream stock tanks would be indirectly impacted under all action alternatives as a result of a reduction in ephemeral storm flows from the project area. The stock tanks impacted are shown in table 91.

Table 91. Indirect impacts to downstream stock tanks

Alternative	Watershed	ID	Name of Water Source	Cadastral Location
Proposed action and Phased Tailings	Barrel Canyon	21	East Dam Tank	D-18-16 28ac
Scholefield-McCleary	Barrel Canyon	18	Unnamed tank	D-18-16 32c
All action alternatives	Davidson Canyon	14	Unnamed tank	D-17-17 07b
All action alternatives	Davidson Canyon	13	Unnamed tank	D-17-16 36a
All action alternatives	Davidson Canyon	11	4th of July Tank	D-17-17 03ab
All action alternatives	Davidson Canyon	24	Unnamed tank	D-18-16 01ab
All action alternatives	Davidson Canyon	12	Unnamed stock tank	D-17-17 03cd

All action alternatives would indirectly impact five downstream stock tanks in Davidson Canyon. Three of the action alternatives (proposed action, Phased Tailings, and Scholefield-McCleary) would indirectly impact one additional downstream stock tank in Barrel Canyon.

Surface water in stock tanks is collected both by the direct input of precipitation into the tank and by runoff from the upstream drainage. Given the high spatial variability of precipitation in this region, surface water runoff contributing to a stock tank could come from just a portion of the upstream drainage or could come from the entire drainage. The capacity of each individual stock tank that would be indirectly impacted is not known; however, ADWR (Arizona Department of Water Resources 2011b) records indicate that stock tanks indirectly impacted downstream of the project area each use approximately 0.1 to 14.6 acre-feet of water per year. Assuming that all stock tanks indirectly impacted by the project have the capacity to hold 14.6 acre-feet per year, an estimate of total capacity lost is 73 acre-feet per year for two action alternatives (Barrel and Barrel Trail) and 87.6 acre-feet per year for the remaining three action alternatives (proposed action, Phased Tailings, and Scholefield-McCleary).

The proposed action would indirectly impact a total of six downstream stock tanks. Considering that the average annual runoff of storm flow from the proposed action is 762 acre-feet (table 92), and assuming that all runoff would be from the entire upstream drainage, it would take a small portion of the total flow (approximately 11.5 percent) to fill all of the impacted stock tanks. The Barrel Alternative would indirectly impact five downstream stock tanks, and it would take 6.3 percent of the average annual runoff to fill all downstream stock tanks to capacity. For the remaining action alternatives, the requirement of total flow to fill the impacted stock tanks would be 7.8 to 11.2 percent.

Because flow volumes from each action alternative would be more than sufficient to fill downstream stock tanks that would be indirectly impacted by any action alternative, and because there is a high likelihood that these stock tanks could be filled from more localized precipitation instead of runoff from the project area, this impact to downstream users is considered insignificant.

Indirect Impacts to Aquifer Recharge

One source of aquifer recharge is the infiltration of runoff through coarse alluvial sediments along ephemeral stream channels like Barrel Canyon and Davidson Canyon. Reduction in surface water flow could result in a reduction in recharge to the aquifer through these alluvial stream channels and/or bank storage. The amount of water currently recharged through alluvial channels is unknown, and the effect of reductions in runoff on aquifer recharge cannot be quantified.

Proposed Action

The proposed action would have a total of 4,387 acres within the security fenceline. The majority of disturbance would occur in Barrel, Wasp, McCleary, and Scholefield Canyons. Surface water management facilities include stormwater basins and diversions around the facility to convey storm events that occur in undisturbed areas upgradient of the pit, operating facilities, waste rock, and tailings facilities. These diversion structures would place the water into a central drain intended to provide hydraulic connection between the upgradient side of the project area and the downgradient side; therefore, runoff from any watershed area located upgradient of the proposed action is expected to arrive at the USGS gaging station (Krizek 2010c). Permanent diversion structures are designed to carry at least the 100-year, 24-hour storm event; drainage features to transfer stormwater from the top of the dry-stack tailings are designed to carry the 500-year, 24-hour storm; and stormwater control basins on top of the wide benches in the waste rock facility are designed to contain storm flows up to the 500-year, 24-hour storm event (Krizek 2010c; Tetra Tech 2010c).

Table 92 summarizes the modeled watershed yield from baseline conditions and under the proposed action.

Table 92. Summary of expected changes to postclosure stormwater flow under the proposed action

Condition	Discharge Area (square miles)	100-Year, 24-Hour Peak Flows (cubic feet per second)	Average Annual Volumes (acre-feet)	Change in Postclosure 100-Year, 24-Hour Peak Flows (percent)	Percent Change in Postclosure Average Annual Volumes (percent)
Baseline*	14	8,072	1,407	Not applicable	Not applicable
Proposed action*	6.82	3,785	762	−53.1	−45.8

Source: Krizek (2010c).

* At point of concentration: USGS gage no. 09484580.

Phased Tailings Alternative

The Phased Tailings Alternative would have a total of 4,308 acres within the security fenceline. This allows the tailings to be stored in two separate phases, effectively isolating the tailings footprint to an area of Barrel Canyon and leaving McCleary Canyon open for a period of approximately 10 years after the start of active mining.

Stormwater controls include basins and diversions around the facility to convey storm events that occur upgradient of the pit, operating facilities, waste rock facility, and tailings facility. Surface water drainage channels would be placed every 100 feet of vertical rise on the outer slopes of the dry-stack tailings and waste rock facilities. Stormwater would flow to stilling pools/drop-structures, natural ground, or stormwater basins. Drop structures located on the east side of the dry-stack tailings facility would drain to the USGS gaging station facility. Other diversion structures would place the water into a retention pond; therefore, runoff from any watershed located upgradient of the Phased Tailings Alternative is not expected to arrive at the USGS gaging station (Krizek 2010a). Permanent diversion structures would be designed to carry at least the 100-year, 24-hour storm event; the top of the dry-stack tailings and stormwater control basins in the waste rock facility are expected to contain storm flows up to the 500-year, 24-hour storm event.

Table 93 summarizes the modeled watershed yield from baseline conditions and under the Phased Tailings Alternative.

Table 93. Summary of expected changes to postclosure stormwater flow under Phased Tailings Alternative

Condition	Discharge Area (square miles)	100-Year, 24-Hour Peak Flows (cubic feet per second)	Average Annual Volumes (acre-feet)	Change in Postclosure 100-Year, 24-Hour Peak Flows (percent)	Percent Change in Postclosure Average Annual Volumes
Baseline*	14	8,072	1,407	Not applicable	Not applicable
Phased Tailings*	7.06	4,044	784	−49.9	−44.3

Source: Krizek (2010a).

* At point of concentration: USGS gage no. 09484580.

Barrel Alternative

The Barrel Alternative has a total of 4,228 acres within the security fenceline. Stormwater management features have been redesigned for this alternative and now include stormwater diversion features that allow for more surface water runoff to the watershed after closure. Further, there would be no flow-through drains beneath the tailings and waste rock facilities and no storage of stormwater on their tops or benches postclosure.

During premining and active mining and as required by stormwater discharge permits, no stormwater that comes into contact with ore stockpiles, tailings, or processing facilities would be allowed to discharge offsite. Operational stormwater storage is designed for the 500-year, 24-hour storm (Tetra Tech 2012). Runoff from the area above the plant site would be maintained using a permanent diversion channel to direct water into upper McCleary Canyon instead of onto the plant site. Water from the diversion channel would pass under the primary access road through culverts designed to carry the 100-year, 24-hour rainfall event; larger flows would pass over the road. A similar diversion west of the pit would direct runoff to several retention ponds at the toe of the waste rock facility, where it would be allowed to infiltrate.

The maximum loss of runoff to the watershed would occur during the first 10 years of active mining, when runoff from these areas would be retained onsite and recycled as process water; during this period, the loss of runoff to the watershed would vary but is likely to approach a reduction in annual average runoff of about 30 to 40 percent, compared with undeveloped baseline conditions. Because reclamation would occur concurrently during active mining, the amount of runoff to the watershed would gradually be increased as areas are closed or capped with waste rock and reclaimed. By year 10 of active mining, portions of the waste rock buttresses that surround the tailings facility and the waste rock facility itself would be reclaimed, and by year 16 of active mining reclamation would begin on the upper benches and tops of the waste rock and tailings facilities.

Postclosure, all runoff from the closed and reclaimed waste rock and tailings facilities and the plant site would be allowed to discharge downstream. Only two general areas of the mine site would not discharge runoff downstream: the mine pit itself and diversions to the west of the mine pit. The tops of the waste rock and tailings facilities would be graded to discharge stormwater to the lower benches, flowing laterally along the benches until reaching several concrete drop structures, at which point the runoff would either be discharged into natural washes (Barrel Canyon or a tributary) or discharged into a diversion channel along the toe of the waste rock and tailings facilities and then discharged into natural washes. Channels and drop structures are designed to carry the 1,000-year, 24-hour peak flow.

Table 94 summarizes the modeled watershed yield from baseline conditions and under the Barrel Alternative conditions.

Table 94. Summary of expected changes to postclosure stormwater flow under Barrel Alternative

Condition	Discharge Area (square miles)	100-Year, 24-Hour Peak Flows (cubic feet per second)	Average Annual Volumes (acre-feet)	Change in Postclosure 100-Year, 24-Hour Peak Flows (percent)	Percent Change in Postclosure Average Annual Volumes
Baseline*	14	8,072	1,404	Not applicable	Not applicable
Barrel Alternative*	11.326	6,293	1,162	−22.0	−17.2

Source: Krizek (2010b).
* At point of concentration: USGS gage no. 09484580.

Barrel Trail Alternative

The Barrel Trail Alternative would have a total of 4,688 acres within the security fenceline. Under this alternative, the dry-stack tailings and waste rock would be confined to Barrel Canyon and an unnamed tributary of Barrel Canyon. The majority of disturbance for this alternative would occur in Barrel, Wasp, McCleary, and Scholefield Canyons.

Stormwater controls for this alternative include basins and diversions around the facility to convey storm events upgradient of the pit, operating facilities, waste rock facility, and tailings facility. The largest stormwater control feature associated with this alternative is the new Barrel Canyon drainage. Its alignment runs between the dry-stack tailings facility and the waste rock facility. This drainage feature would be stepped, with sloping channel segments and stilling pools, and the channel would be designed to convey stormwater runoff from the reclaimed surface. The south side of the waste rock facility would retain runoff detention basins for the 500-year, 24-hour event. Volumes exceeding that would be routed down the waste rock slopes to sediment basin. The east side of the waste rock facility would have a ridge running adjacent to SR 83 that would serve as a drainage divide for the benches. Stormwater on the east side of the ridge would eventually flow to the USGS gaging station. Stormwater controls associated with the dry-stack tailings facility would consist of drainage benches and drop structures; pooling on top surfaces of the facility would be limited. Stormwater runoff from the pit diversion channel south of the open pit is expected to be retained between the toe of the waste rock facility and an adjacent natural ridge and would not drain to the USGS gaging station (Chee 2010).

Table 95 summarizes the modeled watershed yield from baseline conditions and under the Barrel Trail Alternative.

Table 95. Summary of expected changes to postclosure stormwater flow under Barrel Trail Alternative

Condition	Discharge Area (square miles)	100-Year, 24-Hour Peak Flows (cubic feet per second)	Average Annual Volumes (acre-feet)	Change in Postclosure 100-Year, 24-Hour Peak Flows (percent)	Percent Change in Postclosure Average Annual Volumes
Baseline*	14	8,072	1,407	Not applicable	Not applicable
Barrel Trail Alternative*	7.56	4,845	816	−40.0	−42.0

Source: Chee (2010).

* At point of concentration: USGS gage no. 09484580.

Scholefield-McCleary Alternative

The Scholefield-McCleary Alternative would have a total of 5,045 acres within the security fenceline. For this alternative, the dry-stack tailings would be located entirely within Scholefield Canyon, and waste rock would be located outside canyon bottoms within McCleary Canyon and between Wasp and Barrel Canyons. The majority of disturbance for this alternative would occur in the four major drainages (Barrel, Wasp, McCleary, and Scholefield Canyons). Stormwater controls for this alternative include basins and diversions around the facility to convey storm events upgradient of the pit, operating facilities, waste rock facility, and tailings facility. Surface water drainage benches would be placed every 100 feet of vertical rise on the outer slopes of the dry-stack tailings and waste rock facilities. Stormwater would flow to stilling pools/drop structures or to natural ground. A portion of the diversion channel would route stormwater runoff around the plant site area to Barrel Canyon Wash, which would eventually drain to the USGS gaging station. Stormwater from drainage benches and pit diversion would drain to the USGS gaging station as well. Stormwater from other runoff from any watershed located upgradient of the Scholefield-McCleary Alternative is not expected to arrive at the USGS gaging station (Krizek 2010d). Permanent diversion structures would be designed to carry at least the 100-year, 24-hour storm event; the top of the dry-stack tailings and stormwater control basins in the waste rock facility are expected to contain storm flows up to the 500-year, 24-hour storm event.

Table 96 summarizes the modeled watershed yield from baseline conditions and under the Scholefield-McCleary Alternative.

Table 96. Summary of expected changes to postclosure stormwater flow under Scholefield-McCleary Alternative

Condition	Discharge Area (square miles)	100-Year, 24-Hour Peak Flows (cubic feet per second)	Average Annual Volumes (acre-feet)	Change in Postclosure 100-Year, 24-Hour Peak Flows (percent)	Percent Change in Postclosure Average Annual Volumes
Baseline*	14	8,072	1,407	Not applicable	Not applicable
Scholefield-McCleary Alternative*	10.35	5,689	1,086	−29.5	−22.8

Source: Krizek (2010d).

* At point of concentration: USGS gage no. 09484580.

Cumulative Effects

As outlined in the chapter 3 introduction, cumulative impacts of past and present actions are identified and analyzed in the "Affected Environment" part of each resource section, including for "Surface Water Quantity." This cumulative effects discussion addresses the cumulative impacts of the action alternatives and any applicable reasonably foreseeable actions as identified on the Coronado ID team's list of reasonably foreseeable future actions, provided in the introduction to chapter 3.

The analysis area for cumulative effects on surface water quantity includes all the sub-watersheds in the vicinity of the project and the watersheds of Davidson, Box, and Sycamore Canyons (figure 63). The following reasonably foreseeable actions from that list were determined to contribute to a cumulative impact to surface water quantity:

- The BLM proposes to approve an MPO to expand the Andrada Mine limestone quarry in the Davidson Canyon drainage system north and northeast of the Santa Rita Mountains. The Andrada Mine is located approximately 4 miles from the Tucson, Arizona, city limits and 1 mile from the Vail, Arizona, city limits.
- In May 2010, a lease was granted to Charles Seel for mining purposes for 240 acres of ASLD State Trust land (from State land commissioner) in Section 29, Township 17 South, Range 17 East, adjacent to CalPortland leases in Davidson Canyon. There are no known plans to explore for or develop mineral resources on this lease in the foreseeable future.
- The Forest Service proposes to add, decommission, close, and change designation of roads in the NFSR database and prohibit off-road motorized travel for dispersed camping in certain areas on the Nogales Ranger District.

Cumulatively, road construction near or on the Coronado National Forest, along with the construction of the Rosemont Copper Project, would have long-term, adverse impacts on surface water quantity, whereas road decommissioning or prohibiting off-road motorized travel would have long-term, favorable impacts on surface water quantity. Favorable impacts however, would likely be partially offset by the addition of new roads in the area, including the new road segments proposed as part of the Rosemont Copper Project. Expansion of the limestone quarries in lower Davidson Canyon could further reduce surface water quantity beyond the reductions expected under the action alternatives, depending on surface water management plans for those facilities. However, because the area is relatively small, compared with the watershed, and would be required by the ASLD to be reclaimed after the mine is closed, the additional impacts to surface water quantity would be minimal and localized.

Climate Change

As discussed earlier in this chapter, climate change in the desert Southwest is predicted to bring about higher mean annual temperatures over the next 100 years, along with less winter precipitation, an increase in extreme rainstorms and flooding, and longer periods of drought. The extent to which these predictions will occur is uncertain, and the overall difference in the amount of annual precipitation is impossible to accurately quantify. However, in general, predicted changes in weather patterns could have an effect on the quantity of stormwater that is stored at the surface and available for beneficial use.

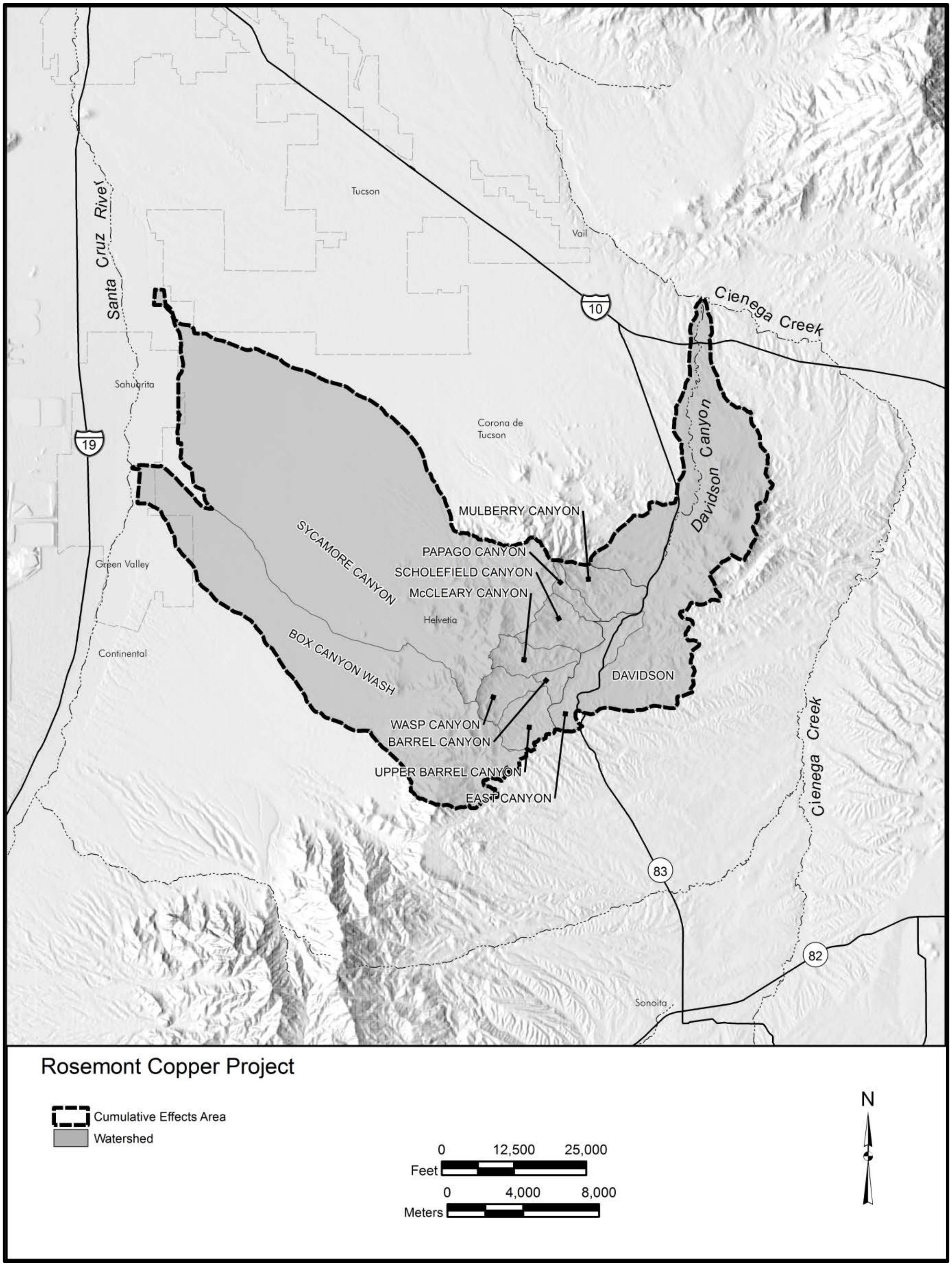

Figure 63. Analysis area for cumulative effects – surface water quantity

Winter storms typically are frontal systems that produce gentle rainfall over a wide spatial extent, allowing for more of the precipitation to be stored at the surface. A decrease in winter rainfall would mean a decrease in the volume of surface water flow and resulting surface storage. In contrast, an increase in more extreme rainstorms would create higher volumes of surface flow passing through the ephemeral channels in a shorter period of time, thus limiting the occurrences of low, steady flows that would be more conducive to surface storage. With regard to higher temperatures and longer periods of drought, ephemeral surface water would be more likely to evaporate and dry up at a faster rate.

Mitigation Effectiveness

Mitigation and Monitoring – Forest Service

- **Growth media salvage and application.** In order to support reclamation activities, soil and other growth media would be salvaged, stored, and applied to the surface of the perimeter waste rock buttress and waste rock and tailings facilities in order to facilitate revegetation.
- **Revegetation of disturbed areas with native species.** Reclamation efforts would include revegetation of native grasses, forbs, shrubs, and trees on areas disturbed by mining and mine related activities. Revegetation would include detecting and treating of invasive weed species.
- **Concurrent placement of perimeter buttress.** Placement of the perimeter buttress would allow reclamation activities to take place earlier, concurrent with mine operations.
- **Location, design, and operation of facilities and structures intended to route stormwater around the mine and into downstream drainages.** Various stormwater diversion channels and location of facilities have been designed and located in order to maintain flow downstream as much as possible and avoid contact of stormwater with processing facilities and ore stockpiles.
- **Stormwater diversion for Barrel Alternative designed to route more stormwater into downstream drainages postclosure.** Following publication of the DEIS, the Coronado undertook an effort to apply the concepts of geomorphic reclamation to the Barrel Alternative. The result is a design that would route more stormwater into downstream drainages postclosure than previous designs.
- **Purchasing of water rights to be used for compensating for impacts in the Cienega Creek watershed.** This mitigation measure involves a suite of actions that involve purchasing, severing, and transferring existing senior water rights on Lower Cienega Creek. The water rights would be transferred to appropriate entities to become in-stream flow rights on Lower and Upper Cienega Creek. Additional actions would include the discharge of water below Pantano Dam, which would be expected to enhance and support riparian areas, and retirement of a groundwater pumping well near to Lower Cienega Creek.
- **Spring, seep, and constructed/enhanced waters monitoring.** A suite of selected seeps and springs has been monitored for baseline conditions since 2007 and would be monitored to identify any impacts that may occur due to dewatering of the regional aquifer in the vicinity of the mine pit. Specific seeps and springs included in this monitoring are listed in appendix B.
- **Recordation of a restrictive easement on private land parcels in Davidson Canyon to compensate for impacts to WUS and provide other benefits.** Rosemont Copper would record restrictive covenants to preclude real estate development and similar land use activities. Managed grazing, cultural, and some low-impact public use (hiking, bird watching,

minor forms of hunting) would be allowed in some locations. These lands total 383 acres and include portions of ephemeral wash, riparian habitat in Davidson Canyon, Barrel Canyon, and Mulberry Canyon, upland buffer habitat adjacent to riparian areas, and three springs.

- **Plant site location and design adjustments to reduce impacts to biological resources.** The entire plant site is sited and designed to reduce its size and overall footprint and to use gravity instead of pumping to move process water where possible.
- **Construction, management, and maintenance of water features to reduce potential impacts to wildlife and livestock from reduced flow in seeps, springs, surface water, and groundwater.** Seven specific existing water features, including stock ponds, would be enhanced and managed for sustainability of surface water. In addition, up to 23 additional water features would be constructed or managed if needed based on impacts observed in the field. While considered primarily mitigation for impacts to biological resources, this would also mitigate effects on surface water resources and riparian resources.
- **Conveyance of private Sonoita Creek Ranch parcel to an in lieu fee sponsor.** Rosemont would purchase the 1,200-acre Sonoita Creek Ranch and an estimated 590 acre-feet per annum of certificated water rights, and convey the property and the water rights to a Corps-approved In Lieu Fee (ILF) sponsor. The land and water rights would establish the resource framework and opportunity for the development of an ILF project, which would include the discontinuation of agriculture irrigation and the use of the perennial flows from Monkey Spring to establish wetland and riparian habitat. The parcel includes open water, forested wetland and riparian habitat, upland habitat adjacent to riparian habitat, seasonal ponds, semidesert grassland, and ephemeral drainages.
- **Establishment of the Cienega Creek Watershed Conservation Fund, to be used for future mitigation to in the Cienega Creek watershed.** Rosemont Copper would establish an endowment and provide $2,000,000 of funding. This fund would essentially be established as a resource to help restore the watershed to a functioning ecosystem and as a mechanism to promote adaptive management and allow flexibility in mitigation to achieve desired outcomes in light of future uncertainties.
- **Monitoring to determine impacts from pit dewatering on downstream sites in Barrel and Davidson Canyons.** Monitoring would be conducted of surface water, alluvial groundwater, and deeper groundwater at sites in Barrel and Davidson Canyons. Several locations have already been installed and are being actively monitored, whereas others would require access from landowners.
- **Periodic validation and rerun of groundwater model throughout life of mine.** This measure would involve basic data collection of water levels, meteorological data, and water balance components, which would allow the predictions of groundwater impacts to be revised based on actual hydrologic observations. Specific wells to be monitored are listed in appendix B.
- **Removal of unneeded facilities during closure.** These facilities include buildings, the plant site, some roads, the perimeter and security fence, power supply line, piping systems, and water supply pipeline. The plant site would be recontoured and revegetated with native vegetation. Building foundations would either be removed or broken up and buried. Reclamation and revegetation of this area would minimize erosion and allow stormwater flow to be returned to the watershed.

Mitigation and Monitoring – Other Regulatory and Permitting Agencies

- **Power line and waterline locations.** The final location of the power line as considered by the ACC was the shortest route, minimizing soil disturbance.
- **Paving of mine roads.** Paving of certain roads with the mine is required under the air quality permits and would also serve to reduce the potential for erosion of soil from disturbed road areas.
- **Processing and placement of tailings to reduce water content and overall footprint.** The use of dry-stack tailings instead of traditional slurry tailings would allow for a much smaller footprint for the tailings facility, minimizing soil disturbance.
- **Implementation of stormwater pollution prevention plan.** Required under the stormwater permit for the mine, implementation of the stormwater pollution prevention plan would include use of structural sediment controls and best management practices intended to minimize the potential for erosion from the mine site.

Mitigation and Monitoring – Rosemont Copper

- **Continued operation and data gathering of USGS flow gage that would provide data for surface water flows downstream of the mine site.** Rosemont Copper would annually fund the USGS to operate and maintain the existing flow gage at Barrel Canyon.

Conclusion of Mitigation Effectiveness

Most of the mitigation measures listed above are associated with design features. Some of the design features would reduce the overall footprint of structures or create large stormwater diversions that would directly route stormwater around operations, which in turn would reduce the impact to surface water quantity by allowing more surface water to flow downstream. Other types of design features such as those associated with road paving or revegetation of disturbed areas would also improve surface water quantity by allowing more water to flow downstream as soon as possible during the active mining phase. Removal of unneeded facilities during closure would allow these areas to be revegetated and allow surface water to flow downstream postclosure. These mitigation measures are effective at minimizing reductions to surface water quantity within the analysis area.

The most effective mitigation involves the redesign of the Barrel Alternative, where eliminating retention ponds and using wraparound storm diversions to discharge flow into the natural channels successfully improves the postclosure runoff by reducing it from 34 to 17 percent. Concurrent reclamation would allow water to be released downstream as quickly as possible during the active mine life.

Best management practices associated with implementation of the stormwater pollution prevention plan, required under the stormwater permit for the mine, would effectively maintain the flow of surface water in existing drainages. Power lines would be constructed aboveground, and power poles are not expected to be placed in washes. Access roads would be constructed in a manner that allows stormwater to pass through culverts or dip crossings. Where feasible, once construction is complete, washes would be restored to preconstruction contours. Water pipelines would be buried underground. When pipelines cross a wash or are in the vicinity of a wash, construction would be such that they do not impede surface water flow.

Rosemont Copper has committed to replacement of water features (WestLand Resources Inc. 2012) and has identified improvements to existing stock tanks and the establishment of new stock tanks with surface water sources for livestock and wildlife. Rosemont Copper would establish a long-term management/maintenance fund for the proposed improvements and additions to water sources, which are proposed to be placed throughout the surrounding landscape, encompassing more than 28 square miles in the Santa Rita and Sierrita Mountains. Proposed improvements to existing tanks would involve renovations such as removal of sediments to increase the tank volume and soil compaction in the tank basin or installation of impervious liners to decrease infiltration. New stock tanks would include water source features such as ground-level tanks and wildlife guzzlers, which would replace surface water resources lost. However, none would be located in the area of analysis for surface waters, and therefore they would be ineffective at mitigating the loss of surface water quantity within the analysis area. Yet, these water features may be effective at mitigating other resources, such as water sources for livestock grazing (see the “Livestock Grazing” resource section), wildlife habitat (see the “Biological Resources” resource section), and riparian habitat (see the “Seeps, Springs, and Riparian Areas” resource section) and would be effective at providing new surface waters outside the analysis area.

As part of the CWA 404 permit requirements, a restrictive covenant would be recorded on 574 acres downstream of the project area in lower Davidson Canyon. This would effectively mitigate impacts to surface water quantity by protecting approximately 8,000 feet of ephemeral wash in Davidson, Barrel, and Mulberry Canyons and restricting land use to low-impact uses such as hiking, bird watching, and managed grazing. Recordation of a similar restrictive covenant associated with Sonoita Creek Ranch would be effective at mitigating impacts to surface waters but would be outside the area of analysis for surface waters.

The purchase of senior surface water rights on Cienega Creek and conversion of these water rights into in-stream flow rights would be effective at providing legal protection to Cienega Creek that would help compensate for any potential impacts to surface water. While it is outside the analysis area for surface waters, discharge of water below Pantano Dam would also be effective at creating or maintaining surface waters in the region. The effectiveness of the Cienega Creek conservation fund would depend on the nature of the projects funded, but in general projects would be expected to be beneficial to surface waters within the area.

In addition to the mitigation measures described above, which would effectively avoid, minimize, reduce, rectify, or compensate for impacts, a suite of monitoring measures is also proposed or required under permits. These measures generally would not be effective as mitigation but rather would provide a means for monitoring potential changes to surface waters within the analysis area.