MONTGOMERY
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Monitoring and Mitigation Plan for Groundwater Dependent Ecosystems and Water Wells

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1 INTRODUCTION

Montgomery & Associates (M&A) has prepared this Monitoring and Mitigation Plan at the request of the United States Forest Service (USFS) and in response to public issues raised during scoping and public and agency comment on the Draft Environmental Impact Statement (EIS) for the Resolution Copper mine and land exchange in the Copper Triangle, approximately 60 miles east of Phoenix, Arizona. The proposed Resolution Copper mine includes dewatering the mine area to allow safe access to the deposit (Resolution Copper, 2016). Groundwater Dependent Ecosystems (GDEs), which comprise seeps, springs, perennial stream reaches and wells that are supported, at least in part, by the regional groundwater system and may be impacted by mine dewatering activities (Garrett, 2018). This Monitoring and Mitigation Plan has been developed to minimize environmental impacts from the Resolution Copper mine by repairing, rehabilitating, restoring, or replacing the affected environment as specified for each GDE in the following sections. The plan has been incorporated into the proposed project design and is intended to be implemented under both the No Action and Action alternatives. A map of the GDEs is shown on Figure 1. GDEs are listed in Table 1 grouped by watershed.

The purpose of this document is to provide:

- A Monitoring Plan to track and assess impacts to each GDE
- Definition of triggers and associated actions to be taken by Resolution Copper to preserve GDEs
- Suggested mitigation measures to repair, rehabilitate, restore, or replace each GDE shown by monitoring to be impacted by mine dewatering

In response to comments on the Monitoring and Mitigation Plan included in the Final EIS (January Final EIS) withdrawn on March 1, 2021; this revised plan provides more specifics regarding when mitigations will be implemented.

Table 1. Groundwater Dependent Ecosystems

WATERSHED	GDE TYPE	SITE NAME
Queen Creek	Springs	Bitter Spring
		Bored Spring
		Hidden Spring
		Iberri Spring
		Kanes Spring
		McGinnel Mine Spring
		McGinnel Spring
		No Name Spring
		Rock Horizontal Spring
		Walker Spring
	Surface Water Reaches	QC 17.39 to 15.55
		Whitlow Ranch Dam Outlet
		AC 4.54 to 4.51
		AC 12.49 to 12.38
		TC 0.6 to TC 0.5
		TC1.06 to TC 1.01
	Communities	Superior
		Boyce Thompson Arboretum
Devils Canyon	Springs	DC 4.1E
		DC 6.1E
		DC 6.6W
		DC 8.2W
	Surface Water Reaches	DC 9.14 to 7.53
		DC 6.10 to 5.44
	Communities	Top of the World
Mineral Creek	Springs	Government Springs
		MC-3.4W
	Surface Water Reaches	MC-8.4C
		MC 6.9 to 1.6

QC – Queen Creek
AC – Arnett Creek
TC – Telegraph Canyon
DC – Devils Canyon
MC – Mineral Creek

2 OVERVIEW OF GROUNDWATER DEPENDENT ECOSYSTEM HYDROLOGY

There are 3 general sources of water for springs, seeps, surface water flows, and wells: 1) direct runoff of precipitation (either rain or snowmelt), 2) relatively small, local, perched groundwater systems, and 3) the regional groundwater system. GDEs include springs, seeps, surface water flows, and wells that are supported, at least in part, by regional groundwater. As discussed in the introduction, the GDEs included in this Monitoring and Mitigation Plan have been determined to be at risk of being impacted by mine dewatering (Garrett, 2018).

2.1 Springs and Seeps

Springs and seeps are broadly recognized as places where water emerges from the ground. For the purposes of this Monitoring Plan, springs and seeps are not differentiated. The following 4 generalized spring categories (Springer and Stevens, 2008) occur within the study area:

1. Rheocrene springs are flowing springs that emerge into 1 or more channels due to upwelling, a geologic contact, and/or a fault or fracture system (Figure 3A).
2. Hanging Gardens emerge along geologic contacts and seep, drip, or pour onto underlying walls. They typically emerge from unconfined aquifers and may contribute to shaping the canyon or rock wall from which they emerge. They often support unique local ecosystems (Figure 3B.)
3. Hillslope springs emerge from unconfined or confined aquifers on non-vertical hillslopes. They often have indistinct or multiple sources and may be associated with geologic contacts or fracture systems (Figure 3C).
4. Anthropogenic springs result from man-made controls, such as mine adit, pit, or tunnel (Figure 3D).

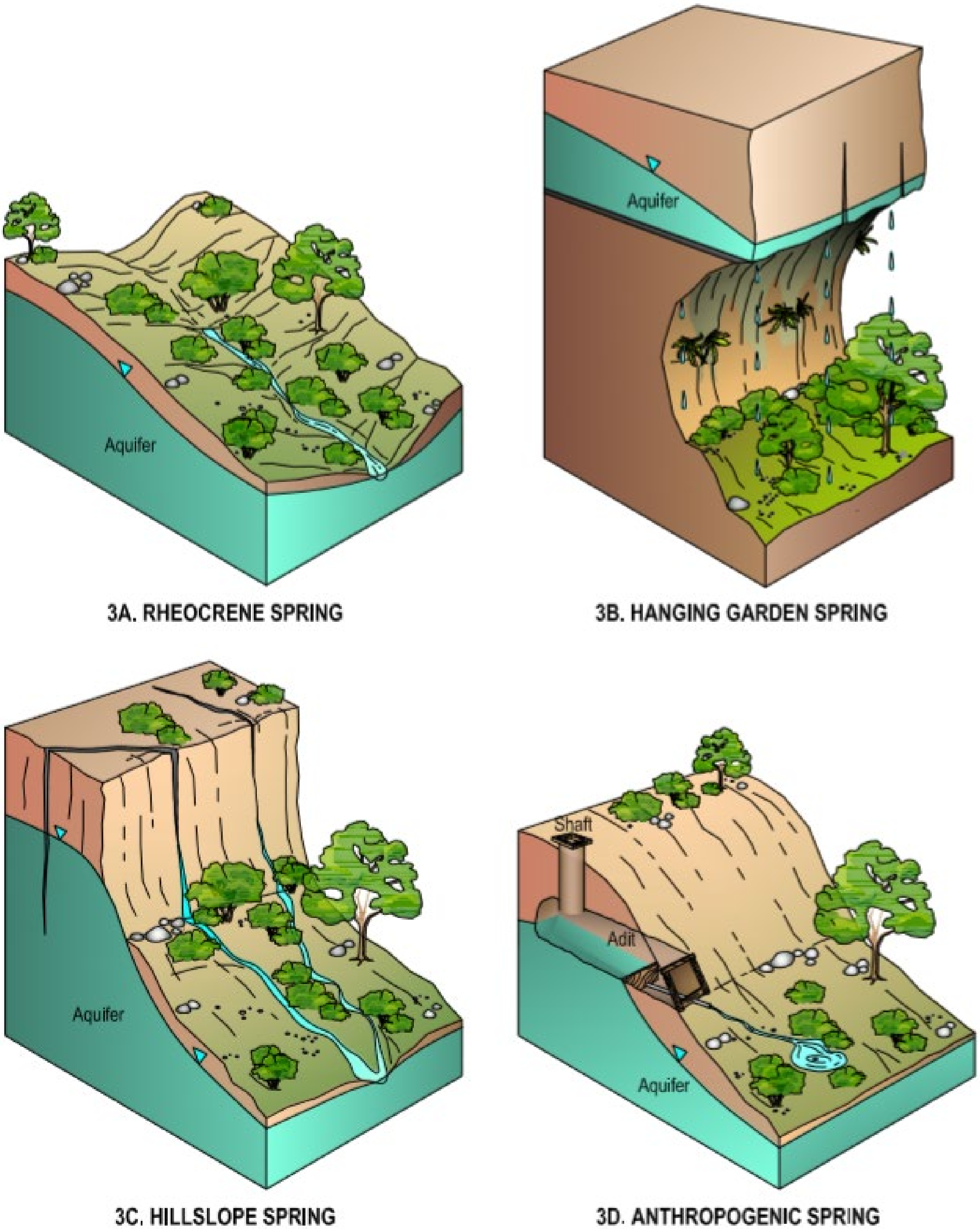

Figure 3. Conceptual Diagrams of 4 Spring Types Found within the Study Area

2.2 Groundwater-dependent Surface Water

Surface water occurs in channels, streams, creeks, rivers, and ephemeral washes and may include both running and standing water. Like springs and seeps, sources of surface water include direct runoff of precipitation or snowmelt, perched groundwater systems, and/or the regional groundwater system.

Groundwater can enter a surface water feature via several pathways: it can seep up from the base of the channel along a gaining reach, it can merge with the channel from a spring or seep along the bank, or it can seep in through fractures or joints in the bedrock. A reduction in groundwater levels will impact connected surface water features; they may dry up completely, have reduced discharge rates, or become smaller or seasonally present.

2.3 Groundwater Wells

Several groundwater wells are included in the list of GDEs. These wells are used by local communities for municipal, irrigation, and/or stock water supply. Water in these wells may be vulnerable to mining related drawdown of regional groundwater.

3 MONITORING PLAN

As mine dewatering occurs, the groundwater levels in the regional groundwater system are likely to be lowered and may reduce water available to GDEs. The intent of monitoring is to identify changes to the regional groundwater system and identify changes to GDEs.

The Monitoring Plan identifies monitoring locations, monitoring data types, and mitigation criteria for monitoring the condition of each GDE and regional groundwater levels between the mine area and each GDE to identify impacts from mining-related drawdown and if necessary, initiate mitigation. The location and purpose of monitoring for each GDE is shown in Table 2. All GDEs and monitoring locations are shown on Figure 2. A description of each GDE is provided in Appendix A. The following sections present a generalized description of each of the elements of the Monitoring Plan.

3.1 Monitoring Locations

Each GDE may have several monitoring locations (Table 2, Figure 2), each of which has a specific purpose as indicated in Table 2. Two types of monitoring locations are prescribed in this plan: groundwater observation wells and the GDEs themselves, which include springs, surface water, and water supply wells (Table 2).

3.2 Monitoring Data Types

Data are collected at the monitoring locations for each GDE to establish baseline conditions, document temporal changes, and implement mitigation actions if mining-related impacts are observed. Monitoring data include the following:

- Groundwater level
- Groundwater pressure
- Surface water level
- Presence of water (Inundation sensors)
- Flow rate
- Extent of saturated reach
- Phreatophyte area (ground-based inventory or remote sensing)
- Local/regional precipitation

Not all data types are relevant to all GDEs, and therefore are not required for all GDEs. Types of monitoring data required are based on the attributes of the GDE and the types of data that can be collected at the GDE. For example, monitoring the type and area of phreatophytes is required for all GDEs that have noted phreatophytic plants, but it is not part of the Monitoring Plan for GDEs that do not currently support phreatophyte communities. Monitoring data requirements for each GDE are listed in Table 2.

To document compliance with this Mitigation and Monitoring Plan, all monitoring data will be submitted to the United States Forest Service (USFS) on an annual basis consistent with the final USFS permit conditions. Monitoring reports will include all data and analysis from the prior year, climatic information, and trigger levels reached. Once the reports have been reviewed by the USFS, final monitor reports can be uploaded to the Resolution Copper Website and available for public use and review.

3.3 Mitigation Triggers

This plan specifies criteria for each GDE that will require RC to initiate mitigation (Table 3). Five trigger types have been identified to initiate mitigation.

Inundation Sensors

In the event that a site with measurable moisture at an inundation sensor experiences 1) lower than the calculated average during the monitoring period of record, 2) for more than two consecutive years, and 3) groundwater levels have declined in intervening groundwater monitoring wells located in the same hydrogeological unit as the GDE, a mitigation measure would be triggered, except if data demonstrate dewatering from the Project was not the cause of the impact.

Flow Rate

In the event that a site with measurable flow experiences a reduction in flow that is 1) lower than the calculated average during the monitoring period of record, 2) for more than two consecutive years, and 3) groundwater levels have declined in intervening groundwater monitoring wells located in the same hydrogeological unit as the GDE, a mitigation measure would be triggered except if data demonstrate dewatering from the Project was not the cause of the impact.

Saturated Length

In the event that a site groundwater dependent streamflow experiences a reduction in flowing length that is 1) lower than the calculated average during the monitoring period of record, 2) for more than two consecutive years, and 3) groundwater levels have declined in intervening groundwater monitoring wells located in the same hydrogeological unit as the GDE, a mitigation measure would be triggered except if data demonstrate dewatering from the Project was not the cause of the impact.

<u>Reduction to Phreatophytic Vegetation</u>

Implementation of a mitigation plan based on vegetation triggers would occur if it is determined that there is 1) a reduction of 25% or more of the phreatophytic vegetation area present at the surface water feature, 2) for four consecutive monitoring events over two years, and 3) groundwater levels have declined in intervening groundwater monitoring wells located in the same hydrogeological unit as the GDE, a mitigation measure would be triggered except if data demonstrate dewatering from the Project was not the cause of the impact.

4 MITIGATION PLAN

Mitigation measures are direct actions taken to offset the impact of mining-related groundwater drawdown on a GDE as part of the Mitigation Plan (Table 3). Not all of the mitigation measures described below are appropriate for all GDEs. Initial mitigation measures are specified for each GDE in Table 3 and may include 1 or more approaches. Additional baseline monitoring or improved understanding of site conditions may indicate that an alternative mitigation approach is more appropriate. Selection of more appropriate mitigations is considered acceptable provided they accomplish the goal of repairing, rehabilitating, restoring, or replacing the affected GDE or water supply wells. Because the Mitigation Plan may be updated, Table 3 identifies a preferred mitigation plan that would be implemented.

Mitigation plans are intended to restore water availability and GDE ecosystem services sustainably. For this reason, mitigation options identified in this plan are passive and restore water to the landscape, rather than consume water from the landscape. For example, the previous version of this Monitoring and Mitigation plan included wells that would pump shallow groundwater to the surface. This would have benefitted the ecosystem in the short term but also would have further removed groundwater from the landscape. In contrast, guzzlers harvest rainwater that would otherwise have evaporated and retain it on the landscape.

4.1 Rock Detention Structures

Rock Detention Structures (RDS) slow the movement of runoff in streams, increasing groundwater recharge and sedimentation while promoting the growth of riparian vegetation (DeBano and Heede, 1987; Gurnell, 1998). Beaver dams and rock outcrops are examples of naturally occurring infrastructure; human-constructed features can yield similar results. The most commonly used RDS are described below based on Norman and others (2022) and include check dams, gabions, 1 rock dams, and trincheras (Figure 4).

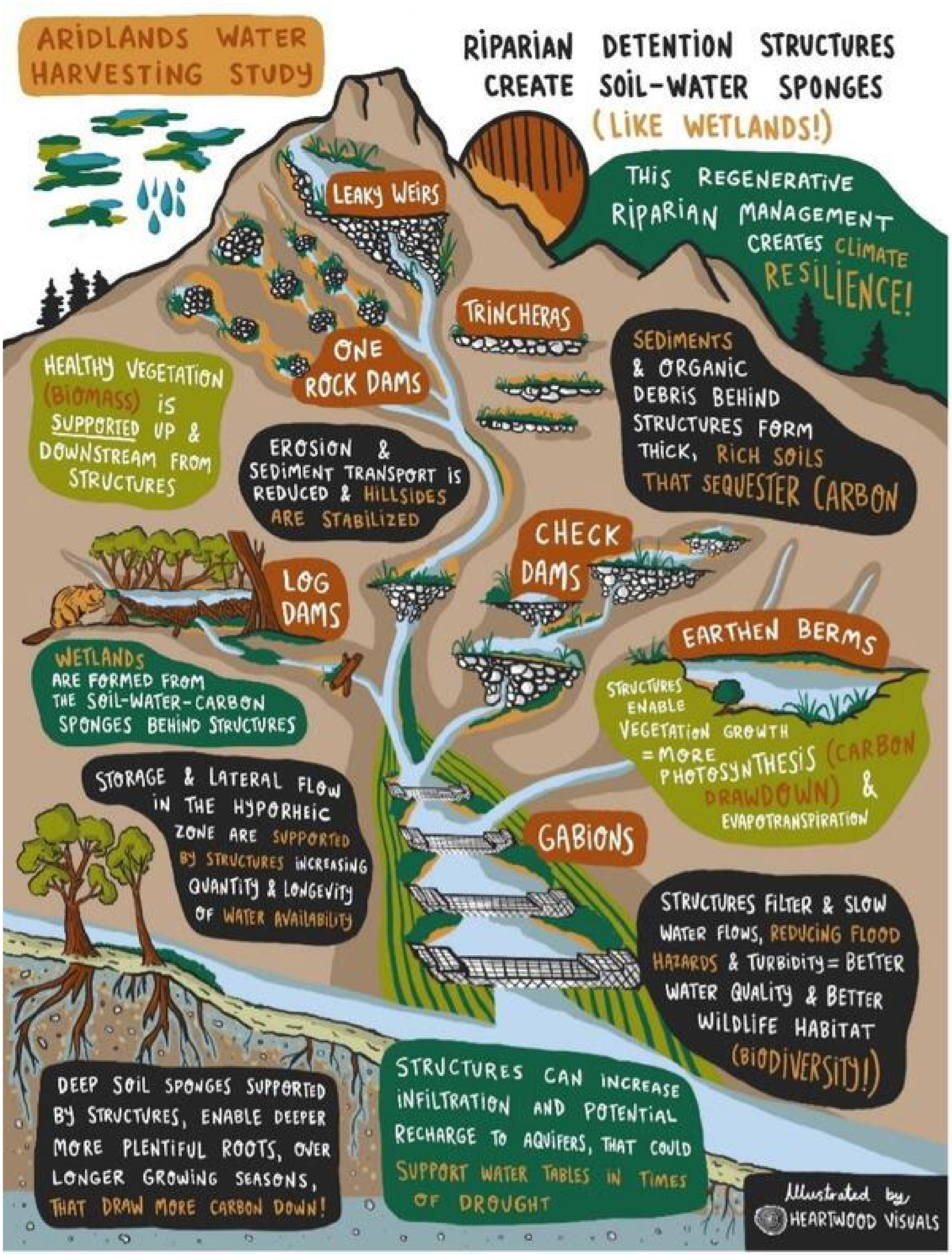

Figure 4. Natural Infrastructure for Drylands Illustration Reproduced with Permission from Heartwood Visuals

Norman and others (2015) compared streamflow in 2 watersheds in the Chiricahua Mountains of southern Arizona, one watershed had RDS and the other did not. RDS lowered peak runoff volumes while increasing total flow volumes, approximately doubled the runoff ratio (runoff/precipitation) in the treated watershed, and generated 28% more flow volume per unit area in the treated watershed (assumed to be due to increased baseflow).

RDS have been documented to restore perennial flow in ephemeral streams. Perennial flow returned to an ephemeral creek in Colorado following the installation of check dams (Heede and DeBano, 1984). A single dam less than 20 feet in length trapped sediment in Sheep Creek, Utah, and restored perennial flow (Ponce and Lindquist, 1990). Flows increased by 28% in an Arizona watershed treated with over 2,000 check dams compared to an adjacent untreated watershed (Norman and others, 2016).

RDS approaches all require careful site-specific planning and engineering to take advantage of natural drainage systems and to minimize impacts to the GDE. Prior to initiation of installation, detailed plans will be provided to the USFS to ensure proper and most effective placement.

4.2 Installation of a Guzzler

Guzzlers are relatively simple systems for harvesting rainwater for wildlife consumption (Figure 6). Guzzlers use an impermeable apron, typically installed on a slope, to collect rainwater which is then piped to a storage tank. A drinker allows wildlife and/or livestock to access water without trampling or further degrading the spring or water feature. Guzzlers are a highly effective method of providing water to animals.

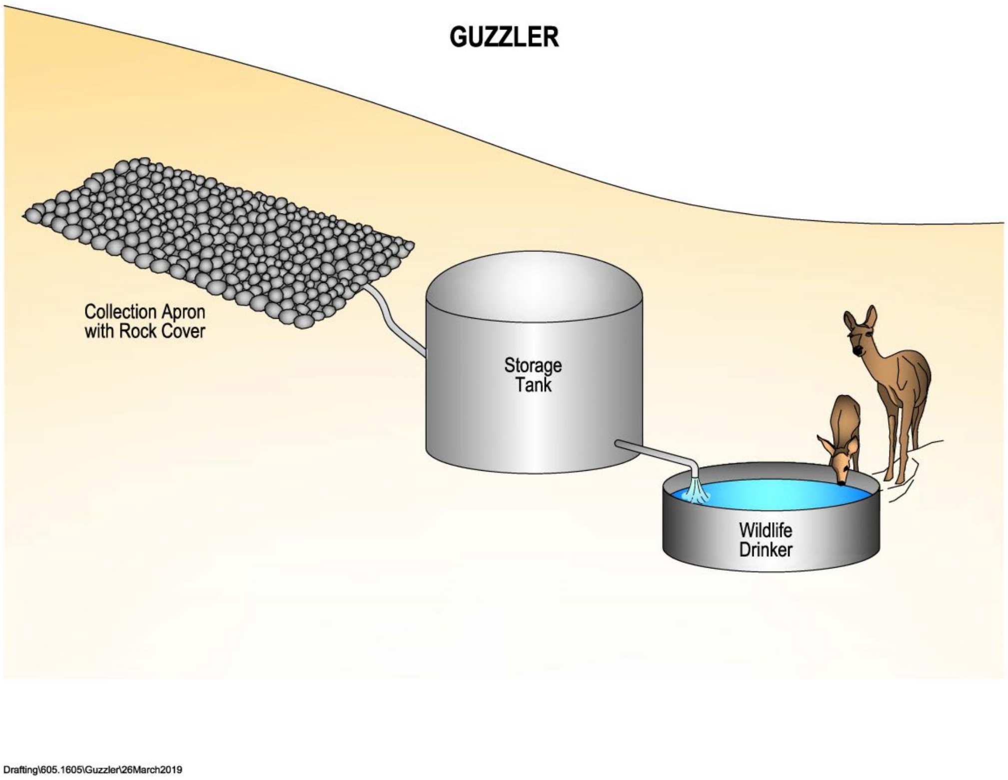

Figure 5. Conceptual Diagram of Guzzler, including Collection Apron, Storage Tank, and Wildlife Drinker

4.3 Alternative Water Supply

If no other water supply is available, alternative water supplies will be brought in from a non-local source. In this case, intercepted water from the Apache Leap tuff, Desert Wellfield, or Arizona Water Company would be the preferred alternative since it is the planned water supply for mine operations and current mine activities. Arizona Water Company supplies water to the Town of Superior.

5 REFERENCES

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Table 2. Monitoring Plan for Regional Groundwater Dependent Ecosystems, Resolution Copper

REGIONAL GROUNDWATER DEPENDENT ECOSYSTEM* (GDE)	Monitoring Location(s)	Purpose	Measurement Type	Monitoring Frequency	Reporting Frequency	Infrastructure Currently Existing?
QUEEN CREEK BASIN						
Springs						
Bitter Spring	DHRES-09	Indication that mining related drawdown may occur	Groundwater level	Daily	Annually	Yes
	Spring	GDE monitoring	Flow - manual measurement	Quarterly	Annually	N/A
	Vegetation area	GDE monitoring	Area and type of phreatophytes	Annually	Annually	N/A
	IS-01	GDE monitoring - Saturation of shallow subsurface	Inundation Sensor	Daily	Annually	No
Bored Spring	DHRES-13	Indication that mining related drawdown may occur	Groundwater level	Daily	Annually	Yes
	Spring	GDE monitoring	Flow - manual measurement	Quarterly	Annually	N/A
	Vegetation area	GDE monitoring	Area and type of phreatophytes	Annually	Annually	N/A
	IS-02	GDE monitoring - Saturation of shallow subsurface	Inundation Sensor	Daily	Annually	No
Hidden Spring	DHRES-13	Indication that mining related drawdown may occur	Groundwater level	Daily	Annually	Yes
	Spring	GDE monitoring	Flow - manual measurement	Quarterly	Annually	N/A
	Vegetation area	GDE monitoring	Area and type of phreatophytes	Annually	Annually	N/A
	IS-03	GDE monitoring - Saturation of shallow subsurface	Inundation Sensor	Daily	Annually	No
Iberri Spring	DHRES-09	Indication that mining related drawdown may occur	Groundwater level	Daily	Annually	Yes
	Spring	GDE monitoring	Flow - manual measurement	Quarterly	Annually	N/A
	Vegetation area	GDE monitoring	Area and type of phreatophytes	Annually	Annually	N/A
	IS-04	GDE monitoring - Saturation of shallow subsurface	Inundation Sensor	Daily	Annually	No
Kanes Spring	DHRES-6	Indication that mining related drawdown may occur	Groundwater level	Daily	Annually	Yes
	Spring	GDE monitoring	Flow - manual measurement	Quarterly	Annually	N/A
	Vegetation area	GDE monitoring	Area and type of phreatophytes	Annually	Annually	N/A
	IS-05	GDE monitoring - Saturation of shallow subsurface	Inundation Sensor	Daily	Annually	No
McGinnel Mine Spring	DHRES-09	Indication that mining related drawdown may occur	Groundwater level	Daily	Annually	No
	Spring	GDE monitoring	Flow - manual measurement	Quarterly	Annually	N/A
	IS-06	GDE monitoring - Saturation of shallow subsurface	Inundation Sensor	Daily	Annually	No
McGinnel Spring	DHRES-09	Indication that mining related drawdown may occur	Groundwater level	Daily	Annually	No
	Spring	GDE monitoring	Flow - manual measurement	Quarterly	Annually	N/A
	Vegetation area	GDE monitoring	Area and type of phreatophytes	Annually	Annually	N/A
	IS-07	GDE monitoring - Saturation of shallow subsurface	Inundation Sensor	Daily	Annually	No
No Name Spring	DS16-12	Indication that mining related drawdown may occur	Groundwater level	Daily	Annually	Yes
	Spring	GDE monitoring	Flow - visual estimate	Quarterly	Annually	N/A
	Vegetation area	GDE monitoring	Area and type of phreatophytes	Annually	Annually	N/A
	IS-08	GDE monitoring - Saturation of shallow subsurface	Inundation Sensor	Daily	Annually	No

Table 2. Monitoring Plan for Regional Groundwater Dependent Ecosystems, Resolution Copper

REGIONAL GROUNDWATER DEPENDENT ECOSYSTEM* (GDE)	Monitoring Location(s)	Purpose	Measurement Type	Monitoring Frequency	Reporting Frequency	Infrastructure Currently Existing?
Rock Horizontal Spring	DS16-12	Indication that mining related drawdown may occur	Groundwater level	Daily	Annually	No
	Spring	GDE monitoring	Flow - visual estimate	Quarterly	Annually	N/A
	Vegetation area	GDE monitoring	Area and type of phreatophytes	Annually	Annually	N/A
	IS-09	GDE monitoring - Saturation of shallow subsurface	Inundation Sensor	Daily	Annually	No
Walker Spring	DS16-14	Indication that mining related drawdown may occur	Groundwater level	Daily	Annually	No
	Spring	GDE monitoring	Flow - visual estimate	Quarterly	Annually	N/A
	Vegetation area	GDE monitoring	Area and type of phreatophytes	Annually	Annually	N/A
	IS-10	GDE monitoring - Saturation of shallow subsurface	Groundwater level	Daily	Annually	No
Surface Water						
QC 17.39 to 15.55	IMERYS discharge	GDE monitoring	Water Level (as proxy for stream flow)	Daily	Annually	No
	Superior Wastewater Treatment Plant discharge					
	Queen Creek flow	GDE monitoring	Water Level (as proxy for stream flow)	Daily	Annually	No
	Vegetation area	GDE monitoring	Area and type of phreatophytes	Annually	Annually	N/A
	Flowing length	GDE monitoring	Length of saturated reach	Quarterly	Annually	N/A
Whitlow Ranch Dam Outlet	DS17-17	Indication that mining related drawdown may occur	Groundwater level	Daily	Annually	Yes
	DHRES-16_743, DHRES-16_535; 55-919039 (near O Castleberry)	Confirmation of mining related drawdown	Groundwater level	Daily	Annually	Yes
	USGS Gage 09478500	GDE monitoring	Flow	Daily	Annually	Yes
AC 4.54 to 4.51	DHRES-16_535	Indication that mining related drawdown may occur	Groundwater level	Daily	Annually	Yes
	Arnet Creek reach	GDE monitoring	Water level (as proxy for stream flow)	Daily	Annually	No
	Vegetation area	GDE monitoring	Area and type of phreatophytes	Annually	Annually	N/A
	Flowing length	GDE monitoring	Length of saturated reach	Quarterly	Annually	N/A
	IS-11	GDE monitoring - Saturation of shallow subsurface	Inundation Sensor	Daily	Annually	No
AC 12.49 to 12.38	DHRES-06	Indication that mining related drawdown may occur	Groundwater level	Daily	Annually	Yes
	Arnet Creek reach	GDE monitoring	Water level (as proxy for stream flow)	Daily	Annually	No
	Vegetation area	GDE monitoring	Area and type of phreatophytes	Annually	Annually	N/A
	Flowing length	GDE monitoring	Length of saturated reach	Quarterly	Annually	N/A
	IS-12	GDE monitoring - Saturation of shallow subsurface	Inundation Sensor	Daily	Annually	No
TC 0.6 to TC 0.5	DHRES-16_535	Indication that mining related drawdown may occur	Groundwater level	Daily	Annually	Yes
	Telegraph Canyon reach	GDE monitoring	Water level (as proxy for stream flow)	Daily	Annually	No
	Vegetation area	GDE monitoring	Area and type of phreatophytes	Annually	Annually	N/A
	Flowing length	GDE monitoring	Length of saturated reach	Quarterly	Annually	N/A
	IS-13	GDE monitoring - Saturation of shallow subsurface	Inundation Sensor	Daily	Annually	No
TC1.06 to TC 1.01	DHRES-16_535	Indication that mining related drawdown may occur	Groundwater level	Daily	Annually	Yes
	Telegraph Canyon reach	GDE monitoring	Water level (as proxy for stream flow)	Daily	Annually	No
	Vegetation area	GDE monitoring	Area and type of phreatophytes	Annually	Annually	N/A
	Flowing length	GDE monitoring	Length of saturated reach	Quarterly	Annually	N/A
	IS-14	GDE monitoring - Saturation of shallow subsurface	Inundation Sensor	Daily	Annually	No

Table 2. Monitoring Plan for Regional Groundwater Dependent Ecosystems, Resolution Copper

REGIONAL GROUNDWATER DEPENDENT ECOSYSTEM* (GDE)	Monitoring Location(s)	Purpose	Measurement Type	Monitoring Frequency	Reporting Frequency	Infrastructure Currently Existing?
Wells						
Gallery Well	55-919039 (near O Castleberry)	Indication that mining related drawdown may occur	Groundwater level	Daily	Annually	Yes
	Gallery Well	Confirmation of mining related drawdown	Groundwater level	Daily	Annually	Yes
DHRES-16_743 (Local Superior Wells)	DHRES-16_743	Confirmation of mining related drawdown	Pressure	Daily	Annually	Yes
	Private Superior wells screened in Gila Conglomerate	Confirmation of mining related drawdown	Groundwater level	Daily	Annually	Yes
DEVILS CANYON BASIN						
Springs						
DC 4.1E	MJ-11	Indication that mining related drawdown may occur	Groundwater level	Daily	Annually	Yes
	Spring	GDE monitoring	Flow - visual estimate	Quarterly	Annually	N/A
	Vegetation area	GDE monitoring	Area and type of phreatophytes	Annually	Annually	N/A
	IS-15	GDE monitoring - Saturation of shallow subsurface	Inundation Sensor	Daily	Annually	No
DC 6.1E	MJ-11	Indication that mining related drawdown may occur	Groundwater level	Daily	Annually	Yes
	Spring	GDE monitoring	Flow - visual estimate	Quarterly	Annually	N/A
	Vegetation area	GDE monitoring	Area and type of phreatophytes	Annually	Annually	N/A
	IS-16	GDE monitoring - Saturation of shallow subsurface	Inundation Sensor	Daily	Annually	No
DC 6.6W	HRES-07	Indication that mining related drawdown may occur	Groundwater level	Daily	Annually	Yes
	Spring	GDE monitoring	Flow - visual estimate	Quarterly	Annually	N/A
	Vegetation area	GDE monitoring	Area and type of phreatophytes	Annually	Annually	N/A
	IS-17	GDE monitoring - Saturation of shallow subsurface	Inundation Sensor	Daily	Annually	No
DC 8.2W	HRES-07	Indication that mining related drawdown may occur	Groundwater level	Daily	Annually	Yes
	Spring	GDE monitoring	Flow - visual estimate	Quarterly	Annually	N/A
	Vegetation area	GDE monitoring	Area and type of phreatophytes	Annually	Annually	N/A
	IS-18	GDE monitoring - Saturation of shallow subsurface	Inundation Sensor	Daily	Annually	No
Surface Water						
DC 9.14 to 7.53	HRES-07	Indication that mining related drawdown may occur	Groundwater level	Daily	Annually	Yes
	DC 8.8C	GDE monitoring	Water level (as proxy for stream flow)	Daily	Annually	Yes
	DC 8.1C	GDE monitoring	Water level (as proxy for stream flow)	Daily	Annually	Yes
	Vegetation area	GDE monitoring	Area and type of phreatophytes	Annually	Annually	N/A
	Flowing length	GDE monitoring	Length of saturated reach	Quarterly	Annually	N/A
DC 6.10 to 5.44	MJ-11	Indication that mining related drawdown may occur	Groundwater level	Daily	Annually	Yes
	DC 5.5C	GDE monitoring	Water level (as proxy for stream flow)	Daily	Annually	Yes
	Vegetation area	GDE monitoring	Area and type of phreatophytes	Annually	Annually	N/A
	Flowing length	GDE monitoring	Length of saturated reach	Quarterly	Annually	N/A
Wells						
HRES-06	HRES-06	Indication that mining related drawdown may occur	Groundwater level	Daily	Annually	Yes
	Private Top-of-the-World wells screened in ALT	Confirmation of mining related drawdown	Groundwater level	Daily	Annually	Yes

Table 2. Monitoring Plan for Regional Groundwater Dependent Ecosystems, Resolution Copper

REGIONAL GROUNDWATER DEPENDENT ECOSYSTEM* (GDE)	Monitoring Location(s)	Purpose	Measurement Type	Monitoring Frequency	Reporting Frequency	Infrastructure Currently Existing?
MINERAL CREEK BASIN						
Springs						
Government Springs	HRES 10	Indication that mining related drawdown may occur	Groundwater level	Daily	Annually	Yes
	Spring	GDE monitoring	Flow - visual estimate	Quarterly	Annually	N/A
	IS-19	GDE monitoring - Saturation of shallow subsurface	Inundation Sensor	Daily	Annually	No
MC-3.4W	HRES-11	Indication that mining related drawdown may occur	Groundwater level	Daily	Annually	Yes
	Spring	GDE monitoring	Flow - visual estimate	Quarterly	Annually	N/A
	Vegetation area	GDE monitoring	Area and type of phreatophytes	Annually	Annually	N/A
	IS-20	GDE monitoring - Saturation of shallow subsurface	Inundation Sensor	Daily	Annually	No
Surface Water						
MC-8.4C	HRES-10	Indication that mining related drawdown may occur	Groundwater level	Daily	Annually	Yes
	Mineral Creek reach	GDE monitoring	Water level (as proxy for stream flow)	Daily	Annually	Yes
	Vegetation area	GDE monitoring	Area and type of phreatophytes	Annually	Annually	N/A
	Flowing length	GDE monitoring	Length of saturated reach	Quarterly	Annually	N/A
MC 6.9 to 1.6	HRES-11	Indication that mining related drawdown may occur	Groundwater level	Daily	Annually	Yes
	Upper Mineral	GDE monitoring	Water level (as proxy for stream flow)	Daily	Annually	Yes
	Lower Mineral	GDE monitoring	Water level (as proxy for stream flow)	Daily	Annually	Yes
	Vegetation area	GDE monitoring	Area and type of phreatophytes	Annually	Annually	N/A
	Flowing length	GDE monitoring	Length of saturated reach	Quarterly	Annually	N/A

Table 3. Mitigation Plan for Regional Groundwater Dependent Ecosystems, Resolution Copper

REGIONAL GROUNDWATER DEPENDENT ECOSYSTEM* (GDE)	ALTERNATE IDENTIFIER	REFERENCES	WATER USE				Trigger Types	PREFERRED MITIGATION PLAN	CONTINGENCY MITIGATION PLAN	EFFECTIVENESS OF SITE SPECIFIC MITIGATION PLAN	NEW DISTURBANCE FROM MITIGATION IMPLEMENTATION
			Human Consumption / Irrigation	Cattle / Wildlife Drinking	Aquatic	Vegetation / Ecological					
QUEEN CREEK BASIN **Springs**											
Bitter Spring	SK18-01	M&A 2017c		X	X	X	- Inundation sensor - Flow rate - Phreatophytic vegetation	Rock Detention Structures	Add well to augment flow	Effectiveness will be limited by size of contributing watershed and variability in future climate	Some road development may be required to access site.
Bored Spring		M&A 2012a M&A 2016b M&A 2017c		X	X	X	- Inundation sensor - Flow rate - Phreatophytic vegetation	Rock Detention Structures	Add well to augment flow	Effectiveness will be limited by size of contributing watershed and variability in future climate	Some road development may be required to access site.
Hidden Spring		M&A 2012a M&A 2016b M&A 2017c		X		X	- Inundation sensor - Flow rate - Phreatophytic vegetation	Rock Detention Structures	Add well to augment flow	Effectiveness will be limited by size of contributing watershed and variability in future climate	Some road development may be required to access site.
Iberri Spring		M&A 2017c		X	X	X	- Inundation sensor - Flow rate - Phreatophytic vegetation	Rock Detention Structures	Add well to augment flow	Effectiveness will be limited by size of contributing watershed and variability in future climate	Some road development may be required to access site.
Kanes Spring		M&A 2012a M&A 2016b M&A 2017c		X	X	X	- Inundation sensor - Flow rate - Phreatophytic vegetation	Rock Detention Structures	Add well to augment flow	Effectiveness will be limited by size of contributing watershed and variability in future climate	Some road development may be required to access site.
McGinnel Mine Spring		M&A 2018*		X			- Inundation sensor - Flow rate	Rock Detention Structures	Install well to augment flow near Cottonwood well; provide water to stock tank that currently receives water from spring	Effectiveness will be limited by size of contributing watershed and variability in future climate	Some road development may be required to access site.
McGinnel Spring		M&A 2018*		X		X	- Inundation sensor - Flow rate - Phreatophytic vegetation	Rock Detention Structures	Install guzzler	Effectiveness will be limited by size of contributing watershed and variability in future climate	Some road development may be required to access site.
No Name Spring		M&A 2017c M&A 2017e		X	X	X	- Inundation sensor - Flow rate - Phreatophytic vegetation	Rock Detention Structures	Add well to augment flow	Effectiveness will be limited by size of contributing watershed and variability in future climate	Some road development may be required to access site.
Rock Horizontal Spring		M&A 2018*		X	X	X	- Inundation sensor - Flow rate - Phreatophytic vegetation	Rock Detention Structures	Add well to augment flow	Effectiveness will be limited by size of contributing watershed and variability in future climate	Some road development may be required to access site.
Walker Spring		M&A 2017c		X	X	X	- Inundation sensor - Flow rate - Phreatophytic vegetation	Rock Detention Structures	Add well to augment flow	Effectiveness will be limited by size of contributing watershed and variability in future climate	Some road development may be required to access site.
Surface Water											
QC 17.39 to 15.55		M&A 2013b WestLand 2018		X	X	X	- Saturated Length - Flow rate - Phreatophytic vegetation	Rock Detention Structures	Work collaboratively with Town of Superior, Boyce Thompson Arboretum, and other local stakeholders to develop solution	Effectiveness will be limited by size of contributing watershed and variability in future climate	Some road development may be required to access site.
Whitlow Ranch Dam Outlet	USGS Stream Gage #09478500	M&A 2017e	X	X	X	X	- Flow rate - Phreatophytic vegetation	Work collaboratively with Town of Superior, Boyce Thompson Arboretum, Town of Queen Valley, and other local stakeholders to develop solution	Pump regional groundwater to augment flow consistent with AZPDES discharge permit requirements	To be determined	To be determined

Table 3. Mitigation Plan for Regional Groundwater Dependent Ecosystems, Resolution Copper

REGIONAL GROUNDWATER DEPENDENT ECOSYSTEM* (GDE)	ALTERNATE IDENTIFIER	REFERENCES	WATER USE				Trigger Types	PREFERRED MITIGATION PLAN	CONTINGENCY MITIGATION PLAN	EFFECTIVENESS OF SITE SPECIFIC MITIGATION PLAN	NEW DISTURBANCE FROM MITIGATION IMPLEMENTATION
			Human Consumption / Irrigation	Cattle / Wildlife Drinking	Aquatic	Vegetation / Ecological					
AC 4.54 to 4.51 (kilometers from confluence with Queen Creek)		M&A 2013b WestLand 2018		X	X	X	- Saturated Length - Flow rate - Phreatophytic vegetation	Rock Detention Structures	Drill well into shallow volcanic rock units	Effectiveness will be limited by size of contributing watershed and variability in future climate	Some road development may be required to access site.
AC 12.49 to 12.38		M&A 2012a WestLand 2018		X	X	X	- Saturated Length - Flow rate - Phreatophytic vegetation	Rock Detention Structures	Drill well into shallow volcanic rock units	Effectiveness will be limited by size of contributing watershed and variability in future climate	Some road development may be required to access site.
TC 0.6 to TC 0.5 (kilometers from confluence with Arnett Canyon)		M&A 2013b WestLand 2018		X	X	X	- Saturated Length - Flow rate - Phreatophytic vegetation	Rock Detention Structures	Drill well into shallow volcanic rock units	Effectiveness will be limited by size of contributing watershed and variability in future climate	Some road development may be required to access site.
TC1.06 to TC 1.01 (kilometers from confluence with Arnett Canyon)				X	X	X	- Saturated Length - Flow rate - Phreatophytic vegetation	Rock Detention Structures	Drill well into shallow volcanic rock units	Effectiveness will be limited by size of contributing watershed and variability in future climate	Some road development may be required to access site.
Wells											
Gallery Well		M&A 2013a M&A 2013b	X				- Water Level in Well	Drill new replacement well sized to produce quantity of water historically produced		Effective	None
DHRES-16_743 (Local Superior Wells)		M&A 2016a M&A 2017b	X				- Water Level in Well	Deepen or replace wells	Alternative Water Supply	Effective	None
DEVILS CANYON BASIN Springs											
DC 4.1E		M&A 2013b M&A 2016b M&A 2017a		X	X	X	- Inundation sensor - Flow rate - Phreatophytic vegetation	Rock Detention Structures	Add wells in Apache Leap Tuff aquifer to replace flow	Effectiveness will be limited by size of contributing watershed and variability in future climate	Some road development may be required to access site.
DC 6.1E		M&A 2013b M&A 2016b M&A 2017a		X	X	X	- Inundation sensor - Flow rate - Phreatophytic vegetation	Rock Detention Structures	Add wells in Apache Leap Tuff aquifer to replace flow	Effectiveness will be limited by size of contributing watershed and variability in future climate	Some road development may be required to access site.
DC 6.6W		M&A 2013b M&A 2016b M&A 2017a		X	X	X	- Inundation sensor - Flow rate - Phreatophytic vegetation	Rock Detention Structures	Add wells in Apache Leap Tuff aquifer to replace flow	Effectiveness will be limited by size of contributing watershed and variability in future climate	Some road development may be required to access site.
DC 8.2W		M&A 2013b M&A 2016b M&A 2017a		X	X	X	- Inundation sensor - Flow rate - Phreatophytic vegetation	Rock Detention Structures	Add wells in Apache Leap Tuff aquifer to replace flow	Effectiveness will be limited by size of contributing watershed and variability in future climate	Some road development may be required to access site.
Surface Water											
DC 9.14 to 7.53 (kilometers from confluence with Mineral Creek)		M&A 2013b M&A 2016b M&A 2017a		X	X	X	- Saturated Length - Flow rate - Phreatophytic vegetation	Rock Detention Structures	Add wells in Apache Leap Tuff aquifer to replace flow	Effectiveness will be limited by size of contributing watershed and variability in future climate	Some road development may be required to access site.
DC 6.10 to 5.44 (kilometers from confluence with Mineral Creek)		M&A 2013b M&A 2016b M&A 2017a		X	X	X	- Saturated Length - Flow rate - Phreatophytic vegetation	Rock Detention Structures	Add wells in Apache Leap Tuff aquifer to replace flow	Effectiveness will be limited by size of contributing watershed and variability in future climate	Some road development may be required to access site.

Table 3. Mitigation Plan for Regional Groundwater Dependent Ecosystems, Resolution Copper

REGIONAL GROUNDWATER DEPENDENT ECOSYSTEM* (GDE)	ALTERNATE IDENTIFIER	REFERENCES	WATER USE				Trigger Types	PREFERRED MITIGATION PLAN	CONTINGENCY MITIGATION PLAN	EFFECTIVENESS OF SITE SPECIFIC MITIGATION PLAN	NEW DISTURBANCE FROM MITIGATION IMPLEMENTATION
			Human Consumption / Irrigation	Cattle / Wildlife Drinking	Aquatic	Vegetation / Ecological					
Wells											
HRES-06		M&A 2012b M&A 2016b M&A 2017b	X				- Water Level in Well	Deepen or replace wells	Alternative Water Supply	Effective	None
MINERAL CREEK BASIN **Springs**											
Government Springs		M&A 2017a M&A 2013b M&A 2016b	X	X	X	X	- Inundation sensor - Flow rate - Phreatophytic vegetation	Rock Detention Structures	Add wells in Apache Leap Tuff aquifer to replace flow	Effectiveness will be limited by size of contributing watershed and variability in future climate	Some road development may be required to access site.
MC-3.4W		M&A 2017a M&A 2013b M&A 2016b WestLand 2018		X	X	X	- Inundation sensor - Flow rate - Phreatophytic vegetation	Rock Detention Structures	Add wells in Apache Leap Tuff aquifer to replace flow	Effectiveness will be limited by size of contributing watershed and variability in future climate	Some road development may be required to access site.
Surface Water											
MC-8.4 to 7.8 (kilometers from confluence with Devils Canyon)		M&A 2017a M&A 2013b M&A 2016b		X	X	X	- Saturated Length - Flow rate - Phreatophytic vegetation	Rock Detention Structures	Add wells in Apache Leap Tuff aquifer to replace flow	Effectiveness will be limited by size of contributing watershed and variability in future climate	Some road development may be required to access site.
MC 6.9 to 1.6		M&A 2017a M&A 2013b M&A 2016b		X	X	X	- Saturated Length - Flow rate - Phreatophytic vegetation	Rock Detention Structures	Add wells in Apache Leap Tuff aquifer to replace flow	Effectiveness will be limited by size of contributing watershed and variability in future climate	Some road development may be required to access site.

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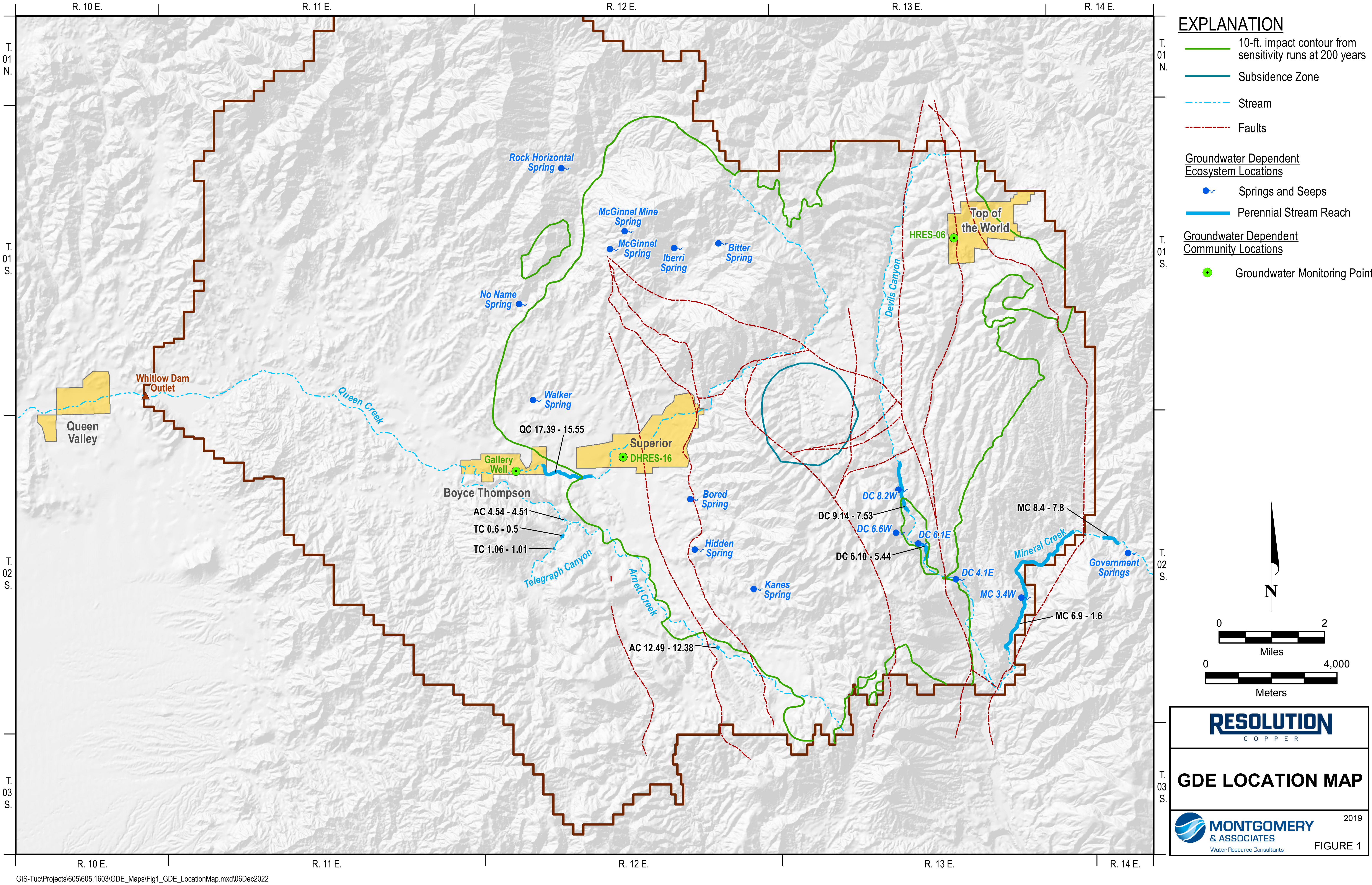
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T. 03 S.
EXPLANATION
10-ft. impact contour from sensitivity runs at 200 years
Subsidence Zone
Stream
Faults
Groundwater Dependent Ecosystem Locations
Springs and Seeps
Perennial Stream Reach
Groundwater Dependent Community Locations
Groundwater Monitoring Point
Rock Horizontal Spring
McGinnel Mine Spring
McGinnel Spring
Iberri Spring
Bitter Spring
No Name Spring
Top of the World
HRES-06
Devils Canyon
Whitlow Dam Outlet
Queen Creek
Queen Valley
Walker Spring
QC 17.39 - 15.55
Superior
DHRES-16
Gallery Well
Boyce Thompson
AC 4.54 - 4.51
TC 0.6 - 0.5
TC 1.06 - 1.01
Telegraph Canyon
Arnett Creek
Bored Spring
Hidden Spring
Kanes Spring
AC 12.49 - 12.38
DC 8.2W
DC 9.14 - 7.53
DC 6.6W
DC 6.1E
DC 6.10 - 5.44
DC 4.1E
MC 3.4W
MC 6.9 - 1.6
MC 8.4 - 7.8
Mineral Creek
Government Springs
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RESOLUTION
COPPER
GDE LOCATION MAP
MONTGOMERY & ASSOCIATES
Water Resource Consultants
2019
FIGURE 1
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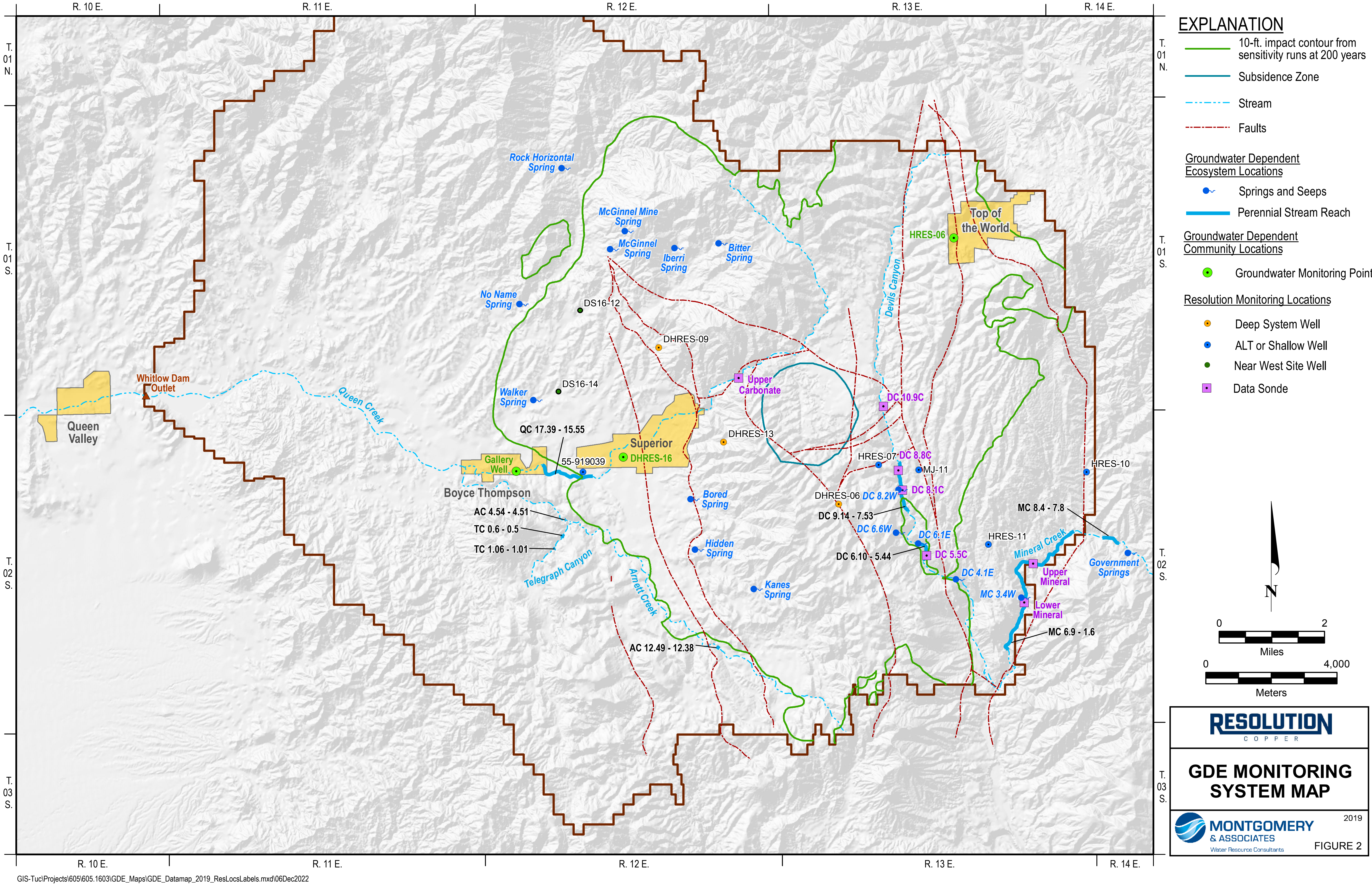


RESOLUTION COPPER

GDE MONITORING SYSTEM MAP

MONTGOMERY & ASSOCIATES Water Resource Consultants

2019

FIGURE 2

Appendix A: Descriptions of Groundwater Dependent Ecosystems

Springs and Seeps

Identification of springs and seeps in the Queen Creek, Devils Canyon, and Mineral Creek watersheds was accomplished as part of ongoing hydrological and biological baseline studies conducted by RC consultants and RC personnel during the period 2002 to present. Many springs/seeps were targeted for field verification based on locations shown on United States Geological Survey (USGS) topographic maps, or available in Arizona Department of Water Resources (ADWR) and Arizona State Land Department (ASLD) databases. Additional springs were identified during discussions with local ranchers and stakeholders. The remaining springs and seeps were identified during field transects along with analysis of high-resolution satellite imagery and aerial photography. Spring locations are shown on Figure 1.

Surface Water

Surface water monitoring is conducted in three principal watersheds within the Resolution Project study area: Devils Canyon, Upper Mineral Creek, and Queen Creek, including the Arnett Creek and Telegraph Canyon sub-basins (M&A 2013). Perennial reaches are shown on Figure 1.

Communities

Three communities within the study area are dependent on groundwater. The town of Superior and Boyce Thompson Arboretum are located within the Queen Creek watershed; the unincorporated community of Top of the World is located in upper Devils Canyon watershed. To ensure that mining-related drawdown doesn't result in reduced groundwater availability at these communities, a regional groundwater monitoring well has been established for each community (Table 2). A Monitoring Plan (Table 2) and a Mitigation Plan (Table 3) have been developed for each community, as described in the following sections.

Queen Creek Watershed - Springs

Bitter Spring

Bitter Spring is an intermittent rheocrene spring located in the channel of an unnamed tributary of Fortuna Wash in the Queen Creek basin. The spring discharges from

Precambrian quartzites at the downstream contact with Pinal Schist and Cretaceous quartz diorite.

A covered, hand-dug sump is located within the channel, approximately 800 feet downstream from the spring source. A solar powered submersible pump is installed in the sump and water is pumped to steel holding tank, which provides water to a cement stock trough. The spring and infrastructure is maintained by a local rancher.

Photograph A-1. Spring Sump with Solar Panel Powered Pump

Riparian plant species observed at Bitter Spring are toad rush and yellow monkey flower. Other plant species observed include oats, ragwort, plumeseed, Indian paintbrush, and poppy.

Photograph A-2. Bitter Spring, View of Bedrock in Streambed Surrounded by Herbaceous Vegetation, May 2017

Periodic monitoring of flow and water quality parameters for Bitter Spring has occurred since August 2012 (M&A, 2018a). Flow observations are summarized in Table A-1; flow estimates range from 0 – 0.5 gpm. Although flow estimates are sparse, flow likely varies seasonally and may periodically comprise both groundwater discharge and surface water runoff.

Table A-1. Summary of Flow Observations for Bitter Spring

Date	Time	Spring Flow		OBSERVATIONS
		Flow (gpm)	Method	
9-Aug-12	---	0	---	Developed spring; hand dug well in channel; depth to water 12.21 feet below top of wooden deck; solar panel and pump installed.
9-Sep-15	9:49	---	---	Murky
1-Dec-15	11:50	---	---	No visible flow; murky water in trough, clear from tank
17-Mar-16	11:30	---	---	Water is clear, comes from water tank. Trough is murky.
10-Jun-16	10:35	---	---	Clear water; heard tank fill up after discharging from spigot.
26-Jul-16	10:35	---	---	Water is flowing into trough. Water is clear from tap; water in trough is murky with green algae. Not able to detect natural flow.
11-Nov-16	12:00	---	---	Dissolved oxygen measurement was taken from 1 liter bottle.
29-Mar-17	11:30	---	---	Water is very clear; trough is filled 2/3 full. Dissolved oxygen measurement taken in 1 liter field bottle.
05-2017	---	---	---	Surface water present

Date	Time	Spring Flow		OBSERVATIONS
		Flow (gpm)	Method	
22-Jun-17	8:50	---	---	From spigot; clear
23-Jan-18	9:25	0.25 - 0.5	est.	Parameters measured in reach approximately 750 feet upstream from pit.
10-Apr-18	9:10	---	---	Parameters measured from tinaja at beginning of saturated reach approximately 750 feet upstream from pit. No observed flow.

gpm = gallons per minute

--- = unknown

Bored Spring

Bored Spring is an intermittent anthropogenic spring located in a small tributary of Pacific Canyon, immediately east of Arizona Highway 177 in the Queen Creek basin. Water seeps from the alluvium downslope from a diabase rock quarry. An area approximately 20 meters long by 5 meters wide is excavated below the seep, leading to a cement cattle trough that is plumbed into the spring. Historical records indicate that a well was drilled near this location and completed in diabase. Although this well has not been found, artesian flow from this well, or what remains of it, may represent a source of this spring.

Photograph A-3. Bored Spring View of Cement Trough and Overflow.
AZ Highway 177 Visible in Background, May 2017

Riparian plant species observed at Bored Spring are cattail, yellow monkey flower, and Goodding's willow. Other plant species observed include canyon ragweed, desert broom, yellow clover, and blue paloverde. Signs of javelina and mule deer have also been observed.

Photograph A-4. Bored Spring Discharge from Excavated Site Below Diabase Rock Quarry, 2017

Monitoring of flow and water quality parameters for Bored Spring has occurred since November 2002 (M&A, 2018A). Flow observations are summarized in Table A-2; flow estimates range from 0 – 1.3 gpm.

Table A-2. Summary of Flow Observations for Bored Spring

		Spring Flow		
Date	Time	Flow (gpm)	Method	OBSERVATIONS
1-Nov-02	---	---	---	No water present in 20-meter x 8-meter man-made spring with a cattle trough downstream
26-May-04	14:00	<0.1	estimated	
3-Nov-04	12:40	<0.1	estimated	
9-Feb-05	10:07	1.1	Bucket & Stop Watch	
3-May-05	13:40	1.3	---	
3-Aug-05	---	0.5	estimated	
21-Aug-08	---	0	---	Dry
13-Nov-08	10:30	<0.1	estimated	
12-Feb-09	8:15	<0.1	estimated	

Date	Time	Spring Flow		OBSERVATIONS
		Flow (gpm)	Method	
13-May-09	15:00	<0.1	estimated	
4-Aug-09	10:09	DRY	---	Dry
12-Feb-10	13:30	0.17	Bucket & Stop Watch	Abundant green algae
13-Jul-10	11:30	0	---	10 gallons in trough (stagnant)
9-Nov-10	11:30	0	---	No inflow to trough; water color brown
14-Feb-11	11:22	0	---	Trough full but no flow into it
13-May-11	10:45	1	estimated	Foul smelling water flowing over sides of through
7-May-12	13:00	1	estimated	
2-Jun-14	11:45	DRY	---	Dry
22-Aug-14	11:00	---	---	Trough filled with 5-10 gallons of what appears to be rain water. Stagnant, murky, green tint.
9-Mar-16	8:30	1	estimated	First time in 2 years seeing water in trough; approximately 1 gpm flow into trough from 1" pipe, source unknown; plumbed into hillside?
8-Jun-16	11:12	0	---	No inflow; stagnant water (thought to be rain water) 6" deep. Lots of bright green algae.
28-Jul-16	12:55	DRY	---	Dry
1-May-17	---	---	---	A stagnant pool of approximately 5-meter diameter, with cattle sign, is fringed by vegetation. A muddy stretch extends about 20 meter downstream from the pool. Water is piped into a cement trough, which was overflowing.

Hidden Spring

Hidden Spring is an intermittent rheocrene spring, located in an unnamed tributary to Arnett Creek, which is within the Queen Creek basin. The spring discharges from Paleozoic carbonates west of the Apache Leap escarpment. Travertine deposits are observed from active spring flow sites and former spring outlets. Spring water collects in an underground steel culvert and is plumbed to a drinker for stock and wildlife watering.

Photograph A-5. Hidden Spring, View of Spring Culvert with Netleaf Treetrunk in Foreground, May 2017

Riparian plant species observed at Hidden Spring are rabbitsfoot grass, yellow monkey flower, seepwillow, and Goodding's willow. Other plant species observed include jojoba, velvet mesquite, netleaf hackberry, and wolfberry.

Photograph A-6. Hidden Spring, View of Drinker with Herbaceous Vegetation Including Rabbitsfoot Grass, May 2017

Monitoring of flow and water quality parameters for Hidden Spring has occurred since November 2002 (M&A, 2018A). Flow observations are summarized in Table A-3; flow estimates range from 0 – 2 gpm.

Table A-3. Summary of Flow Observations for Hidden Spring

Date	Time	Spring Flow: Flow (gpm)	Spring Flow: Method	OBSERVATIONS
11-2002	---	---	---	Water present in caisson but none in drinker
15-May-03	17:00	0	---	
20-Aug-03	8:45	0	---	
3-Nov-03	10:30	<0.1	estimated	
9-Feb-04	12:10	<0.1	estimated	
24-May-04	9:00	<0.1	estimated	
4-Aug-04	8:55	<0.1	estimated	
3-Nov-04	11:20	<0.1	estimated	
9-Feb-05	11:50	<0.1	estimated	
3-May-05	12:15	1	estimated	
3-Aug-05	---	2	estimated	
19-Aug-08	8:30	<0.1	estimated	
6-Nov-08	9:30	<0.1	estimated	
10-Feb-09	13:00	<0.1	estimated	
12-May-09	14:15	<0.1	estimated	
4-Aug-09	9:00	---	---	
12-Feb-10	9:30	1.5	estimated	1-2 gpm coming out of outcrop
13-Jul-10	8:07	2	---	Clear with brown muddy bottom
17-Jul-10	15:02	---	---	Sample dipped from pool
9-Nov-10	10:45	0.1	estimated	
14-Feb-11	10:55	0.1	---	Trace Flow
05-2011	---	---	---	Water is present in caisson but none in drinker
13-May-11	10:25	DRY	---	Dry
9-Nov-11	10:45	---	---	
7-May-12	12:00	DRY	---	Dry
06-2012	---	---	---	Moisture evident in the soil but no standing or flowing water.
5-Jun-14	11:14	0.1	---	Unknown point of origin; clear; algal mats on surface (in tank).
22-Aug-14	10:25	0	---	Greenish tint; no algae floating in tank. No visible flow.
16-Oct-15	13:36	---	---	Slightly murky water; sampled from well under old metal top. Approximately 5 feet of water.
8-Mar-16	13:58	---	---	Water is clear; covered by an old steel plate; sampled from hand dug well.
6-Jun-16	14:40	<1	estimated	Murky; water dripping into trough from spigot <1 gpm
4-Aug-16	11:00	---	---	Water level in trough is very low - no flow to it. Upstream sump is filled approx. 1/2 way. Evidence of recent storm - everything is saturated; flow lines in mud. Took parameters and sample from sump. Syringed water from sump into bottles. Water is clear. No visible flow.
05-2017	---	---		Drinker is full and overflowing forming shallow stream for about 5 meters

Iberri Spring

Iberri Spring is an intermittent rheocrene spring located in the channel of Peachville Wash, within the Queen Creek basin. The spring discharges as multiple seeps from the fractures in the Peachville quartz diorite downstream from a large deposit of alluvium. Horizontal steel piping is embedded into the bedrock at the upper end of the seeps. Downstream from the spring discharge there is a 1.5 meter wide by 0.25 meter high concrete dam, likely evidence of former spring development.

Photograph A-7. Iberri Spring, View of Embedded Pipe, Near Upper End of Seeps.
Herbaceous Vegetation Including Yellow Monkeyflower and Oats, May 2017

A shallow hand dug well equipped with a solar pump is located upstream from the spring in Peachville Wash. This well likely taps shallow groundwater stored in the alluvial deposits. Plastic tubing leads upstream from the well to a storage tank and drinker.

Photograph A-8. Iberri Spring, View of Container and Drinker, May 2017

Riparian plant species observed at Iberri Spring are yellow monkey flower and seepwillow. Other plant species observed include oats and deergrass.

Iberri Spring has been monitored on three occasions since 2017 (M&A, 2018A). Flow observations are summarized in Table A-4.

Table A-4. Summary of Flow Observations for Iberri Spring

Date	Time	Spring Flow: Flow (gpm)	Spring Flow: Method	OBSERVATIONS
05-2017	---	---	---	Surface water present
23-Jan-18	17:05	---	---	No water presence at trough, pit, or channel. Dry conditions.
10-Apr-18	17:41	---	---	No water presence at trough, pit, or channel. Dry conditions.

Kane Spring

Kane Spring is an intermittent rheocrene spring located in the channel of an unnamed tributary of Arnett Creek in the Queen Creek basin. The spring discharges from bedding planes between strata of Paleozoic carbonates west of the Apache Leap escarpment. Spring flow is captured in several small tinajas and continues downstream where it disappears in alluvial deposits. A spring box and several generations of piping are evident near the source. .

Photograph A-9. Kane Spring, Spring Box, July 2010

Riparian plant species observed at Kane Spring are yellow monkey flower, swordleaf and grassleaf rush. Other plant species observed include: netleaf hackberry, desert broom, brickelbush, globemallow, jojoba, and velvet mesquite.

Photograph A-10. Kane Spring, View of Tinajas with Wetland Plant Swordleaf Rush, May 2017

Monitoring of flow and water quality parameters for Kane Spring has occurred since October 2002 (M&A, 2018a). Flow observations are summarized in Table A-5; flow estimates range from 0 – 0.6 gpm.

Table A-5. Summary of Flow Observations for Kane Spring

Date	Time	Spring Flow Flow (gpm)	Spring Flow Method	OBSERVATIONS
10-2002	---	---	---	Water present in 2.5-meter x 1 meter pool on bedrock below steep travertine drops
15-May-03	15:00	0	---	
20-Aug-03	8:00	0	---	
3-Nov-03	8:50	<0.1	---	
9-Feb-04	10:00	<0.1	---	
4-Aug-04	---	---	---	
3-Nov-04	8:50	---	---	
9-Feb-05	10:02	<0.1	---	
3-May-05	10:05	0.5	estimated	
3-Aug-05	8:05	0.1	estimated	
29-Aug-08	10:00	<0.1	---	
5-Nov-08	16:15	0.1	---	
10-Feb-09	15:30	0.6	---	
13-May-09	9:30	0.4	---	
4-Aug-09	7:48	---	---	~12 feet of ground saturation in a line trending down hill

Date	Time	Spring Flow		OBSERVATIONS
		Flow (gpm)	Method	
12-Feb-10	11:15	0.5	Bucket & Stop Watch	clean but site in shade ~60 degrees
13-Jul-10	9:40	0.01	Bucket & Stop Watch	
17-Jul-10	17:08	---	---	Dipped out of pool
9-Nov-10	9:23	0.2	Bucket & Stop Watch	
14-Feb-11	9:30	1	Bucket & Stop Watch	SC parameter taken from spring box
13-May-11	8:40	0.03	Bucket & Stop Watch	
7-May-12	10:10	0	---	New pipe connected
2-Jun-14	10:00	0.1	---	Very low flow from predominantly two seeps in wall
22-Aug-14	9:21	0.1	---	Green tint; 4 distinct seeps that flow into small pool (~5 gallons)
24-Nov-14	12:34	0.1	---	Very low flow; multiple seeps flowing into pool; minor algae
16-Oct-15	12:18	<0.1	---	Clear water; very low flow; lots of algae; 3 small seeps flowing into a pool that flows out into alluvium
8-Mar-16	12:30	---	---	Minor algae; multiple seeps along face of waterfall; sampled from pool (seeps too low flow <<1 gpm)
6-Jun-16	12:57	<1	estimated	~3 active seeps
28-Jul-16	11:30	0.5	---	Multiple seeps flowing; minor amount of bright green algae. Not enough water to collect for DO measurement.
05-2017	---	---	---	Flows, seeps, and pools present

McGinnel Spring

McGinnel Spring is a rheocrene spring of undetermined persistence located in the channel of an unnamed tributary of Whitford Canyon in the Queen Creek basin. The spring consists of a 3-foot diameter, 6.8-foot-deep sump lined with a corrugated steel culvert which is plumbed to a cement cattle trough roughly 600 feet to the southwest. The feature appears to be mostly supported by runoff water stored in alluvial channel deposits, with potentially some contribution from weathered schist bedrock.

Photograph A-11. Culvert Lined Pit at Mcginnel Spring, Shaded by Seepwillow, March 2018

The only riparian plant species observed at McGinnel Spring was seepwillow. Other plant species observed include giant saguaro, brittlebush, desert thorn, jojoba, mesquite, and yucca.

Photograph A-12. Cement Trough Plumbed to Mcginnel Spring Culvert, March 2018

McGinnel Spring has been surveyed on two occasions since 2018 (M&A, 2018a). Flow measurements are summarized on Table A-6. No flow has been observed at the spring source, however flow has been measured from the trough from 0 – 0.1 gpm.

Table A-6. Summary of Flow Observations for McGinnel Spring

Date	Time	Spring Flow		OBSERVATIONS
		Flow (gpm)	Method	
1-Mar-18	13:15	0.1	est.	Measured from valve flowing into cement trough
11-Apr-18	18:03	<0.01	est.	Measured from culvert lined pit

McGinnel Mine Spring

McGinnel Mine Spring is an intermittent anthropogenic spring located within an abandoned mine adit along FS Road 2389, approximately 1.5 miles from the Cottonwood Well in Whitford Canyon, Queen Creek basin. The mine adit is excavated in Pinal Schist on the western face of Peachville Mountain, more than 1,000 feet above the Whitford Canyon channel. The feature is likely supported by infiltration of stormwater runoff into the mine workings through the weathered schist surface. Standing water has been observed in the mine workings, retained by a 2-foot-tall wooden dam. Water is intentionally captured and stored in the mine and conveyed via a black polyethylene tubing to a small earthen cattle tank near the Cottonwood Well.

Photograph A-13. Mcginnel Mine Spring Entrance, Standing Water Present Along Floor, March 2018

No wetland plant species have been identified at this site. Other plant species identified in the vicinity include agave, cholla, mesquite, ocotillo, prickly pear, and sotol.

Photograph A-14. Water Dammed Near Entrance to Mine Adit, March 2018

McGinnel Mine Spring has been visited once in March 2018 (M&A, 2018a). Flow observations are given in Table A-7. No flow was measured exiting the mine adit.

Table A-7. Summary of Flow Observations for McGinnel Mine Spring

Date	Time	Spring Flow			
		Flow (gpm)	Method	Turbidity (NTUs)	OBSERVATIONS
1-Mar-18	14:00	---	---	---	Measured from pooled water at mine entrance

No Name Spring

No Name Spring is an intermittent rheocrene spring located in the channel of Whitford Canyon in the Queen Creek basin. Several seeps occur at contacts between the Dripping Springs quartzite and Pioneer shale, with the shale acting as the perching geologic unit. Substantial alluvial deposits occur in the channel upstream from the spring. No evidence of anthropogenic controls have been noted at this location.

Photograph A-15. No Name Spring, Beginning of Flowing Reach, Riparian Vegetation, June 2017

Riparian plant species identified at No Name Spring are seepwillow, toadrush, purplemat, yellow monkeyflower, saltcedar, cattail, and centaury. Other plant species observed included oats. Many aquatic invertebrates, birds, and mammal fauna have been observed at this location.

Periodic monitoring of flow and water quality parameters for No Name Spring has occurred since May 2017 (M&A, 2018a). Flow observations are summarized in Table A-8; flow has ranged from 0 – 3 gpm at this spring. Surface flow has been observed for more than 1,300 feet downstream from the spring before disappearing into the alluvial channel deposits.

Photograph A-16. Flowing Reach in Alluvial Channel Downstream from No Name Spring, June 2017

Table A-8. Summary of Flow Observations for No Name Spring

Date	Time	Spring Flow: Flow (gpm)	Spring Flow: Method	OBSERVATIONS
05-2017	---	---	---	Flow for approximately 500 meters
22-Jun-17	7:05	2-3	---	Clear; flow for approximately 1000 feet below spring
26-Sep-17	17:12	1-2	---	Clear; no odor; flow for approximately 400 meters
4-Dec-18	9:15	0.3	---	Clear; no odor; flow for approximately 400 meters
13-Mar-18	12:40	0.3	---	Clear, no odor; some rust colored moss/algae mats; flow for approximately 400 meters

Rock Horizontal Spring

Rock Horizontal Spring is an intermittent rheocrene spring located in the channel of Reavis Trail Canyon, within the Queen Creek basin. The spring flow surfaces from the alluvium upon entering a scoured granite narrows. Seepage has also been observed from joints in the granite canyon wall. Plastic hose and steel pipe downstream from the spring source are evidence of historical water source development at this spring location.

Photograph A-17. Rock Horizontal Spring, Flowing Through Granitic Slot Canyon, March 2018

Riparian plant species identified at Rock Horizontal Spring are seepwillow, deergrass, and cottonwood. Other plant species observed include hibiscus, hopbush, jojoba, fiddleneck, and mesquite. U.S. Forest Service Sensitive species include lowland leopard frog and Parish's Indian mallow. The area is frequented by cattle.

Photograph A-18. U.S. Forest Service Sensitive Species, Lowland Leopard from April 2018

Rock Horizontal Spring has only been monitored on two occasions starting in March 2018 (M&A, 2018a); flow observations are given in Table A-9. Flow has been measured between 0.1 – 0.5 gpm.

Table A-9. Summary of Flow Observations for Rock Horizontal

Date	Time	Spring Flow		OBSERVATIONS
		Flow (gpm)	Method	
1-Mar-18	8:38	0.5	est.	Measured from beginning of surface flow
11-Apr-18	9:00	<0.1	est.	Measured from beginning of surface flow

Walker Spring

Walker Spring is an intermittent flowing, rheocrene spring located in Happy Camp Canyon, within the Queen Creek Basin. The spring discharges from the Gila conglomerate and alluvium along both banks of the stream. Cemented layers within the Gila conglomerate act as the perching geologic unit.

Photograph A-19. Walker Spring, View of Conglomerate Bedrock Ledge Across Streambed, May 2017

Riparian plant species observed at Walker Spring are seepwillow, purple mat, and speedwell. Other plant species identified include canyon ragweed.


Photograph A-20. Walker Spring, Wetland Plant Purple Mat Growing in Wet Area of Channel, May 2017

Periodic monitoring of flow and water quality parameters for Walker Spring has occurred since May 2017 (M&A, 2018a). Flow observations are summarized in Table A-10; flow has ranged from 0 – 0.2 gpm at this spring. Flow has been observed downstream from the spring for up to 100 feet before disappearing into the alluvial channel deposits.

Table A-10. Summary of Flow Observations for Walker Spring

Date	Time	Spring Flow		OBSERVATIONS
		Flow (gpm)	Method	
1-May-17	---	---	---	Flow starts just below conglomerate ledge in streambed. Banks are saturated and seeping on both sides of the stream. Seeps, flows and pools present for approximately 30 meters.
30-Aug-17	14:30	0.2	---	Channel created to restrict water flow to small area for collection of sample; murky; very light-yellow tinge.
4-Dec-17	10:25	---	---	Moist ground but no standing or flowing water
12-Mar-18	9:03	---	---	Wash damp with two puddles; appear to be rain-related: larger puddle, approximately 3-4 gallons; yellow tinge; putrid odor; tadpoles; thin oily surface.
12-Mar-18	9:12	---	---	Wash damp with two puddles; appear to be rain-related; smaller puddle, approximately 50 feet downstream from above puddle; 0.5 gallon; odorless.
4-Jun-18	9:05	---	---	Dry

Queen Creek Watershed - Surface Water

Surface water occurrence surveys have been conducted in Queen Creek starting in 2002. The surveys indicate that Upper Queen Creek from the town of Superior to the headwaters flows chiefly in response to winter precipitation events. Shallow, seasonal groundwater systems are perched above the regional ALT aquifer and may sustain surface flow beyond the initial storm water pulse. The only continuously saturated reach along the main stem of Queen Creek is located downstream of the Town of Superior Waste Water Treatment Plant and the Harborlite perlite mine, where discharges from these two facilities maintain perennial flow in Queen Creek down to the Boyce Thompson Arboretum (Figure 1) (M&A 2017). This section is referred to as QC 17.39 to 15.55. Downstream of Boyce Thompson Arboretum Queen Creek is considered ephemeral.

Two other sub-basins within the Queen Creek watershed have perennial flowing reaches. Arnett creek has perennial surface flow from 4.54-4.51 and from 12.49 to 12.38 kilometers upstream from the confluence of Arnett Creek with Queen Creek. Telegraph Canyon has two small flowing reaches from 0.5 to 0.6 and 1.06 to 1.01 kilometers upstream from the confluence with Arnett Creek.

QC 17.39 to 15.55

QC 17.39 to 15.55, the perennial flowing reach of Queen Creek from the Town of Superior Waste Water Treatment Plant and the Harborlite perlite mine down to the Boyce Thompson Arboretum, is currently classified by the Arizona Department of Environmental Quality as effluent dependent. Flow in this reach is attributed primarily to discharge from these facilities; a stream camera and a transducer are installed in the Harborlite discharge canal to monitor dewatering schedule and estimate flow into Queen Creek. Seasonal storm water runoff also contributes to flow in this reach. Currently there is no evidence that this reach is supported by groundwater discharge from the regional aquifer (M&A 2017).

Photograph A-21. QC 17.39 To 15.55, View of Perennial Flowing Reach, September 2018

Along this reach the adjacent uplands are Arizona Upland Subdivision Sonoran Desert scrub. The vegetation along the portion of Queen Creek below the Superior Waste Water Treatment Plant is supported by effluent water and characteristic of Sonoran Riparian Deciduous Forest, represented by Fremont cottonwood and Goodding's Willow (WestLand 2018).

Whitlow Ranch Dam

Whitlow Ranch Dam is a flood control structure located on Queen Creek about 10 miles west from Superior **(Figures 1)**. The compacted-earthfill dam was completed in 1960 by the USACE to protect agricultural lands and communities in downstream areas from large damaging floods such as the one that occurred in 1954 (U.S. Army Corps of Engineers, 1975). The dam is situated at a narrow bedrock canyon, and represents the discharge point for all surface water runoff and underflow from upper Queen Creek in the Superior Basin. Discharge of surface water (and groundwater) through the dam occurs via a 5.5-foot diameter culvert (M&A 2013).

The USGS currently operates a stream gage to measure discharge from the outlet of Whitlow Ranch Dam (USGS #09478500 "Queen Creek below Whitlow Dam near Superior"). Queen Creek above the dam may sustain surface flow for several months after large runoff events; however the creek typically dries out during the late spring and early summer months. M&A installed a trail camera in late 2017 to monitoring occurrence of surface water flow in the main channel of Queen Creek, approximately 550 feet upstream from the base of the dam. Because little groundwater underflow out of the basin is likely to occur through volcanic rocks at the dam abutment or the underlying Pinal Schist, the Whitlow Ranch Dam is effectively the principal discharge point for groundwater underflow from the entire Superior Basin (M&A 2013).

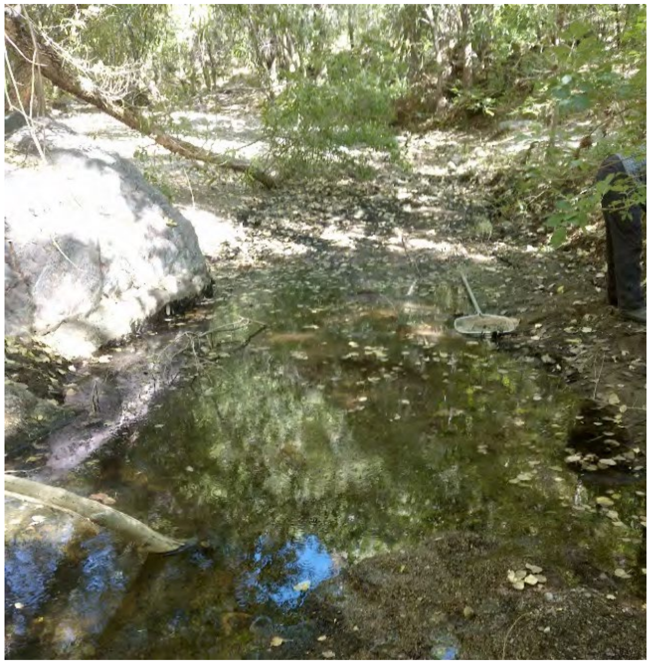
Photograph A-22. Whitlow Ranch Dam, View of Saltcedar and Freemont's Cottonwood, October 2017

Riparian plant species observed above Whitlow Ranch Dam include saltcedar, Goodding's Willow, and Freemont Cottonwood. Additional biological surveys of this area are recommended.

AC 4.54 to 4.51

A short stretch of flowing reach occurs in Arnett Creek, just below the confluence with Telegraph Canyon. This flowing reach is identified as AC 4.54-4.51 (Figure 1). The perennially flowing reach is supported by a spring, sometimes known as Thompson Spring (WestLand 2018), located within the Picketpost volcanic complex, which emerges above the streambed on a steep outcrop alcove. The spring discharge flows into the creek bed and continues to a pool about 400 meters downstream.

No monitoring instrumentation has been installed in Arnett Creek to monitor surface flow or water quality parameters. Occurrence surveys have been conducted in Arnett Creek by Golder, Resolution, and M&A intermittently since 2002, and AC 4.5C has been used as a surface water sampling location for intermittent sampling.


Photograph A-23. AC 4.54 To 4.51, Perennial Flowing Reach in Arnett Creek, 2017

Wetland plant species observed include: nutsedge, yellow monkeyflower, pale spikerush, and Goodding's Willow.

AC 12.49 to 12.38

This perennial flowing reach occurs in Arnett Creek along the Arizona Highway 177 (Figure 1). The reach coincides with Blue Spring, which discharges from a detached block of Apache Leap Tuff. Water upwells to the surface as alluvial cover pinches out, and flows perennially for 110 meters. There is no instrumentation installed in this reach to monitor surface flow.

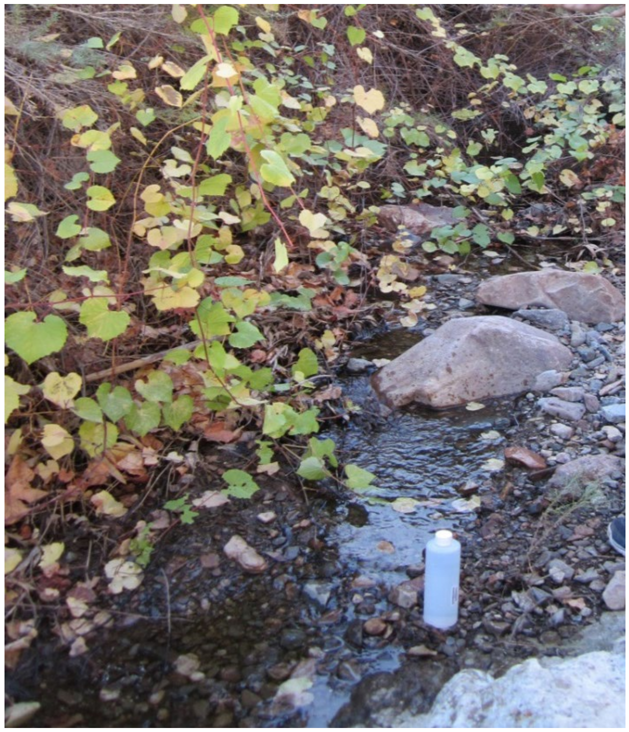
Wetland plant species observed include seepwillow and Goodding's Willow.


Photograph A-24. AC 12.49 To 12.38, Flowing Reach of Arnett Creek, Looking Upstream, February 2010

TC 0.6 to 0.5 and TC 1.06 to 1.01

Two perennial flowing reaches are located in Telegraph Canyon (Figure 1). Along these sections of the canyon the alluvial cover thins, forcing water to the surface where it flows along the streambed over volcanic outcrop. TC 0.5C has been used as a surface water sampling location during intermittent monitoring by M&A and Resolution, but no instrumentation has been installed in Telegraph Canyon to monitor surface water flow.

Wetland plant species observed at this location include: canyon grape, seepwillow, and nerium oldeander. Very dense vegetative cover result in major phreatophytic variations of surface water quantity and flow within this reach of the canyon.



Photograph A-25. TC 0.5C, Sampling Location, Canyon Grape Along Stream Bank, November 2013

Photograph A-26. TC 1.06 To 1.01, Flowing Reach Along Volcanic Outcrop and Nerium Oleander, November 2012

Queen Creek Watershed - Communities

Boyce Thompson Arboretum

Boyce Thompson Arboretum is a 323-acre arboretum and garden founded in 1924 by mining magnate Col. William Boyce Thompson (Figure 1). The gardens and facilities are open to the public, and operated by the Arizona State Parks in collaboration with the University of Arizona, and the Boyce Thompson Board. Water for the gardens and facilities is sourced from approximately ten wells in the regional groundwater system, ranging in well depth from 20 to 300 feet below land surface (ADWR 2019). Regional groundwater at this depth is hosted in alluvial deposits and volcanic rock. Water in the alluvial aquifer is derived from discharge of treated effluent from the Superior Waste Water Treatment Plant and the Harborlite Quarry, both of which discharge to the Queen Creek channel upstream of Boyce Thompson Arboretum. The Gallery Well (Figure 1) is designated to monitor regional groundwater levels, as outlined in the Monitoring Plan (Table 2). If mining-related drawdown is observed at the site, groundwater will be supplemented by drilling of a replacement well as described in the Mitigation Plan (Table 3).

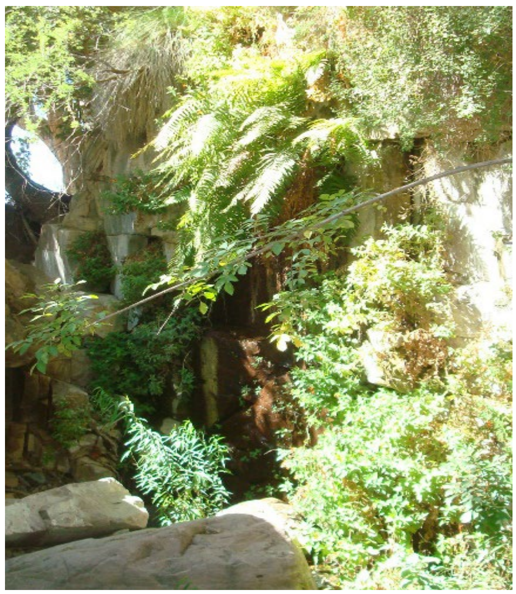
Superior

The town of Superior, AZ has a population of approximately 2,800 according to the 2010 census. The majority of the municipal water supply for Superior is sourced from the Desert Wellfield, outside of the study area. However, some residents use wells to supply groundwater for residential and other purposes in Superior. Most of these wells are screened in the Queen Creek Alluvial aquifer, which is a seasonally variable aquifer with limited connectivity to the regional aquifer. However, up to 35 groundwater wells potentially access regional groundwater and are screened between 50 and 760 feet below land surface (ADWR 2019). The regional aquifer at this depth is hosted in the upper Gila Conglomerate. Monitoring well DHRES-16_743 (Figure 1) will be used to monitor groundwater pressure in the regional aquifer as outlined in the Monitoring Plan (Table 2). If mining-related drawdown impacts water levels in the municipal area, water supply can be supplemented by deepening or replacing wells as outlined in the Mitigation Plan (Table 3).

Devils Canyon Watershed - Springs

DC 4.1E

DC 4.1E is a perennial hanging garden spring complex located in the lower reach of Devils Canyon. The springs discharge from the Apache Leap Tuff on the eastern wall of the canyon. Vertical fins in the cliff face suggest fracture control on spring discharge.



Photograph A-27. View of Hanging Garden at DC 4.1E Spring with Vegetation Growing from Canyon Wall, May 2011

Riparian plant species identified at DC 4.1E are Arizona ash, Arizona sycamore, Aravaipa woodfern, watercress, cattail, sedge, cardinal flower, and scarlet monkeyflower.

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Photograph A-28. DC 4.1E, View of Riparian Vegetation Growth along Hanging Garden Seeps, November 2002

Periodic monitoring of flow and water quality parameters for Spring DC4.1E has occurred since November 2002 (M&A, 2018a). Flow observations are summarized in Table A-11; flow estimates range from 0.1-3 gpm. Water discharges from the canyon wall over the 200-meter long complex before quickly infiltrating into the unconsolidated alluvial cover of the channel.

Table A-11. Summary of Flow Observations for Spring DC4.1W

Date	Team	Spring Flow		OBSERVATIONS
		Flow (gpm)	Method	
11-2002	WRI	---	---	Water emerges from a rock wall on east side of canyon for approximately 10 meters to a 1m by 8m pool. At this point the water submerges and does not re-emerge until 40 meters downstream. A few scattered pools are present 200 meters downstream from where the water reemerges.
21-May-03	GAI	---	---	
26-Aug-03	GAI	---	---	
11-Nov-03	GAI	---	---	
10-Feb-04	GAI	1.5	estimated	
05-2011	WRI	---	---	Water is present for 70 m in a series of small pools and seeps.
20-May-14	RC	1.5	---	Clear; multiple seeps coming out of wall
28-Aug-14	RC	3	---	Very clear; minor algae.
25-Nov-14	RC	1	---	Clear; 1-2 gpm

Date	Team	Spring Flow		OBSERVATIONS
		Flow (gpm)	Method	
16-Dec-15	RC	2	---	Very clear water; mineral deposits on wall.
24-May-16	RC	0.3	estimated	This location is not 4.1e; it was sampled approx. 0.9 km upstream; thus deemed 'DC 5.0' for this event. Could not find sample location at 4.1e. Site sampled near Westland game cameras. Dry creek; constant flow in spring.
15-Dec-16	RC	0.8	---	Clear; 2 main seeps (each with a hanging garden); approx. 0.5-1 gpm; sampled upstream from 2 main seeps
31-Mar-17	RC	0.1	---	Clear; multiple seeps flowing with main seep discharging ~0.1 gpm

DC 6.1E

DC 6.1E is an intermittent hanging garden spring that occurs on the east wall of Devils Canyon adjacent to the bottom pool of the “Crater Tanks.” The spring discharges from the Apache Leap Tuff on the east wall of the canyon. Water seeps from the megaspherulite zone of the tuff, which occurs above the vitrophyre subunit.

Photograph A-29. DC 6.1E, View of Hanging Garden Spring Seeping from Canyon Wall, June 2009

Riparian plant species observed at DC 6.1E are seepwillow, Fremont cottonwood, maidenhair fern, and chatterbox orchid. Other plant species observed include canyon grape and velvet ash.

Photograph A-30. View of Riparian Overstory at
Hanging Garden Spring, June 2009

Periodic monitoring of flow and water quality parameters for Spring DC6.1E has occurred since November 2002 (M&A, 2018a). Flow observations are summarized in Table A-12 flow estimates range from 0 – 6 gpm, with larger flows reported when stormwater runoff occurs. Water discharges from the canyon wall and flows into the colluvial substrate of large boulders.

Table A-12. Summary of Flow Observations for Spring DC6.6E

Date	Time	Spring Flow		OBSERVATIONS
		Flow (gpm)	Method	
11-2002	---	---	---	
5-Jun-03	8:44	---	---	
20-May-04	12:00	2	estimated	
23-Aug-04	10:05	0.8	---	
18-Nov-04	9:33	2	estimated	
28-Feb-05	10:31	0	---	
24-May-05	10:00	0.5	estimated	
23-Aug-05	12:30	0	---	
7-Aug-08	12:15	1	estimated	
6-Nov-08	11:30	0	---	
25-Feb-09	12:30	---	---	
20-May-09	12:00	3	---	
19-Mar-10	12:30	1.5	estimated	Flowing more than usual.
19-Oct-10	14:00	5	estimated	
10-Nov-10	13:00	80	estimated	
15-Aug-12	8:50	0	---	
26-Nov-12	11:55	---	---	

Date	Time	Spring Flow		OBSERVATIONS
		Flow (gpm)	Method	
16-Dec-15	10:04	1.5	---	Clear water; hanging garden closest to waterfall; series of seeps
22-Mar-16	10:30	---	---	Clear water with strong flow.
19-Jul-16	11:00	6	estimated	Clear; ~5-7 gpm

DC 6.6W

DC 6.6W is an intermittent rheocrene spring located in a small unnamed tributary to Devils Canyon, approximately 200 meters above the main channel of Devils Canyon. The spring discharges from the Apache Leap Tuff at the contact with the underlying Whitetail Conglomerate.

Photograph A-31. DC 6.6W, View of Pool Along Surface Water Flowing Reach, May 2011

Riparian plant species observed at DC 6.6W are seepwillow, yellow monkeyflower, Arizona sycamore, maidenhair fern, chatterbox orchid, swordleaf and grassleaf rush, and Aravaipa woodfern. Other plant species observed include: hollyleaf buckthorn and canyon grape.

Photograph A-32. DC 6.6W, View of Sensitive Wetland Plant Aravaipa Woodfern, May 2011

Periodic monitoring of flow and water quality parameters for Spring DC6.6W has occurred since October 2002 (M&A, 2018a). Flow observations are summarized in Table A-13; flows generally range from 0.5 - 2 gpm, with higher flows noted during storm water runoff events.

Table A-13. Summary of Flow Observations for Spring DC6.1W

Date	Time	Spring Flow		OBSERVATIONS
		Flow (gpm)	Method	
11-2002	---	---	---	Intermittent surface flows for approximately 60 meters before going subsurface, then re-emerges with minimal surface flow approximately 230 meters downstream.
29-May-03	9:21	0.5	---	
3-Sep-03	9:22	0.5	---	
4-Nov-03	9:23	1.5	estimated	
18-Feb-04	14:20	1.0	---	
5-May-04	8:30	0.5	estimated	
19-Aug-04	7:20	0.3	---	
29-May-03	14:30	0.5	---	
3-Sep-03	8:30	0.5	---	
4-Nov-03	10:00	1.5	estimated	
18-Feb-04	14:20	1.0	---	
5-May-04	8:30	0.5	estimated	
19-Aug-04	7:20	0.3	---	

Date	Time	Spring Flow		OBSERVATIONS
		Flow (gpm)	Method	
12-Nov-04	9:14	0.7	---	
16-Feb-05	10:15	32.5	1 " Flume	
17-May-05	8:20	0.5	estimated	
7-Sep-05	12:00	0	---	
05-2011	---	---	---	Water is present for 70 meters in a series of small pools and seeps.
4-May-12	11:30	2	estimated	
27-Feb-14	13:15	0.5	---	<1gpm; parameters taken in small pool on muddy ground.
25-Sep-14	12:36	0.1	---	Small pools in soil; clear; very low flow; pools in soil too small to measure DO.
7-Nov-14	12:15	1	estimated	Clear; muddy area; ~1 gpm. Not enough water for DO measurement.
23-Nov-15	13:11	---	---	Series of low flow puddles - some with clear water; some are stagnant looking. Had to dig out bigger pools and wait for water to settle before collecting sample.
17-Feb-16	14:12	0	---	Clear water; very little water (<<1 gpm); series of seeps in muddy terrain; extracted
23-Aug-16	13:48	---	---	Clear water; very little water (<<1 gpm); small pools with low flow

DC 8.2W

DC 8.2W is a perennial hillslope spring complex, located on the west side of Devils Canyon between Hackberry and Oak Canyons. DC 8.2W is the largest spring complex noted in Devils Canyon. There are two springs at this location approximately 20 meters apart, with flow connection to the main channel.

Photograph A-33. DC 8.2W, View Spring Discharge Pool Near Main Channel, October 2002

Riparian plant species observed at DC 8.2W are Arizona alder, Arizona sycamore, Bonpland's willow, buttonbush, yellow monkeyflower, and Aravaipa woodfern. Other plant species observed include velvet ash, blackberry, western poison ivy, and Virginia creeper.


Photograph A-34. DC 8.2W, View of Sensitive Plant Aravaipa Woodfern, May 2011

Periodic monitoring of flow and water quality parameters for Spring DC8.2W has occurred since October 2002 (M&A, 2018a). Flow observations are summarized in Table A-14; flow measurements range from 1 - 15 gpm. Groundwater discharges through fracturing in the Apache Leap Tuff, and emerges from under a large boulder and pools in several areas.

Table A-14. Summary of Flow Observations for Spring DC8.2W

Date	Time	Spring Flow		OBSERVATIONS
		Flow (gpm)	Method	
11-2002	---	---	---	The spring forms a 1 x 1 meter pool with a substantial amount of leaf litter
20-May-03	14:00	10.9	Cut-throat Flume	
21-Aug-03	8:00	---	---	
12-Nov-03	9:42	8.1	Cut-throat Flume	
17-Feb-04	13:10	10.9	Cut-throat Flume	
21-May-04	9:30	11.9	Cut-throat Flume	
16-Aug-04	8:55	9.0	Cut-throat Flume	
16-Nov-04	10:50	2.2	Cut-throat Flume	
15-Dec-04	9:31	---	---	
25-Feb-05	10:25	3	estimated	
30-Mar-05	10:49	---	---	
11-May-05	11:45	10	estimated	
28-Jun-05	10:01	---	---	
16-Aug-05	8:45	1	estimated	
19-Feb-08	13:30	---	---	
27-May-08	16:30	---	---	clear
6-Aug-08	9:30	---	---	
5-Nov-08	11:30	1	estimated	
2-Dec-08	10:45	---	---	
24-Feb-09	15:30	---	---	
03-2009	---	---	---	Pool flows into main channel
19-May-09	13:00	10.0	---	
10-Nov-10	9:45	<1	estimated	
05-2011	---	---	---	A series of four pools form from the source under a large boulder and flow 20 meters into the main channel.
20-May-11	9:45	0.1	---	
3-May-12	11:30	5	estimated	
14-Jun-13	14:18	5	---	
5-Aug-13	9:32	12	---	Clear
27-Feb-14	15:01	2	---	Water bubbles up clear from spring (1-3 gpm). Algae on surface of pool.
29-May-14	15:20	2	---	Clear

Date	Time	Spring Flow		OBSERVATIONS
		Flow (gpm)	Method	
3-Sep-14	12:27	5	---	Clear; inflow sounds like 5-7 gpm (under boulder).
21-Nov-14	12:11	5	---	Clear
14-Oct-15	12:03	15	---	Clear water.
19-Feb-16	10:31	---	---	Clear
21-Jun-16	11:12	---	---	Clear; steady flow.
23-Sep-16	10:15	5	estimated	Clear

Devils Canyon Watershed - Surface Water

The middle reach of Devils Canyon is dominated by outcrop of Tertiary Apache Leap Tuff. Occurrence surveys indicate that there are two continuously saturated reaches in Devils Canyon, from 9.14 to 7.53 and from 6.10 to 5.44 kilometers upstream of the confluence with Mineral Creek (Figure 1) (M&A 2017), referred to as "DC 9.14 to 7.53" and "DC 6.10 to 5.44," respectively. Analysis of hydrochemistry indicates that a portion of the flow in these reaches is supported by water discharged from the regional ALT aquifer. Water discharges from the Apache Leap Tuff at lithologic contacts, fractures, and faults along the canyon surfaces. This ALT aquifer water, combined with seasonally variable surface water runoff, supports the two perennial reaches.

Four surface water sampling locations in Devils Canyon have been instrumented with data sondes to continually monitor streamflow and water quality parameters:

- DC 10.9C – Located 10.9 kilometers upstream of the confluence with Mineral Creek on an ephemeral reach of Devils Canyon, adjacent to the proposed block cave area.
- DC 8.8C – Located within the upper perennial reach with extensive riparian vegetation.
- DC 8.1C – Located just downstream from the DC 8.2W spring, below the confluence with Oak Canyon.
- DC 5.5C – Located at the end of the DC 6.10 to 5.44 perennial reach.

DC 6.10 to 5.44

This perennial flowing reach occurs in Devils Canyon below the lower Crater Tank (Golder Associates, 2003). The reach begins at the hanging garden spring DC 6.1E at the contact of the megaspherelyte and vitorphyre units of the ALT with the Whitetail conglomerate (Tw). ALT water that is perched above the less permeable vitrophyre and the conglomerate discharges into the canyon from the eastern wall. Surface flow continues through the channel to the 5.44 km mark where it disappears into alluvial cover.

Photograph A-35. Hanging Garden Spring DC 6.1E, Start of Devils Canyon Lower Reach, February 2011

Surface water occurrence surveys have been conducted in the Devils Canyon study area starting in November 2002. Average discharge measured at DC 5.5C datasonde ranges from 0 to 0.204 cubic feet per second (cfs) per year since 2003 (M&A 2017).

Riparian plant species observed from DC 6.1 to 5.44 include seepwillow, Fremont cottonwood, maidenhair fern, and chatterbox orchid. Other plant species observed include canyon grape and velvet ash.

DC 9.14 to 7.53

This stretch of perennial flowing water in Devils Canyon begins just below the confluence with Rancho Rio Canyon. This perennial reach is believed to be structurally controlled by faulting along the southeast boundary of the Resolution graben. Water upwells from the ALT aquifer along the southwest-northeast striking fault that runs perpendicular to Devils Canyon. In addition to groundwater, streamflow is supported by surface water runoff from Upper Devils Canyon, as well as contributing side drainages: Rancho Rio Canyon, Hackberry Canyon, and Oak Canyon.

Photograph A-36. DC 9.14 To 7.53, Riparian Vegetation Includes Arizona Alder, Bonpland's Willow and Western Poison Ivy, May 2011

Surface water occurrence surveys have been conducted in the Devils Canyon study area starting in November 2002. Surface flow was quantified using the November 7-day low flow statistic, which is calculated as the minimum of the 7-day moving average streamflow, calculated during November. Average streamflow measured at DC 8.1C datasonde ranges from 0.002 to 0.051 cubic feet per second (cfs) since 2011, and from 0.024 to 0.688 cfs per year at DC 8.8 since 2002 (M&A 2017).

Riparian vegetation is extensive throughout this perennial reach. Wetland species include Arizona alder, Arizona Sycamore, Fremont Cottonwood, Bonpland's Willow, Goodding's Willow, seepwillow, yellow monkeyflower, buttonbush, western poison ivy, Virginia creeper, Aravaipa woodfern, and others (M&A 2018).

Devils Canyon Watershed - Communities

Top of the World

The community of Top of the World is located in upper Devils Canyon watershed (Figure 1), with a population of approximately 230 according to the 2010 census. Water supply for Top of the World is sourced from 29 local wells, screened in Apache Leap Tuff (ALT) from 300 to 1,000 feet below land surface (ADWR 2019). The current water level in the ALT near Top of the World is approximately 390 feet below land surface. Monitoring well HRES-06 (Figure 1) is designated in the Monitoring Plan (Table 2) to monitor water levels in the ALT aquifer. If mining-related drawdown is observed, water supply to the community will be augmented by deepening local wells as specified in the Mitigation Plan (Table 3).

Mineral Creek Watershed – Springs

Government Spring

Government Spring is a perennial rheocrene spring located in Mineral Creek, above the confluence with Lyon’s Fork. Several springs discharge from a brecciated outcrop of Apache Leap Tuff along the edge of the Mineral Creek floodplain. The main spring is contained in a large covered spring box in a horizontal tunnel excavated into the slope. Several other small spring boxes occur in the area. The spring supplies water for potable and irrigation supply for the Government Springs Ranch.

Photograph A-37. Entrance to the Government Springs Vault, September 2008

Photograph A-38. Government Spring, Developed and Covered Pit Located in Vault, September 2008

Plant species have not been cataloged at the Government Springs site.

Periodic monitoring of flow and water quality parameters for Government Springs has occurred since 2009 (M&A, 2016). Flow observations are summarized in Table A-14.

Table A-14. Summary of Flow Observations for Government Spring

		Spring Flow		
Date	Time	Flow (gpm)	Method	OBSERVATIONS
16-Dec-09	10:30	---	---	
18-Mar-10	12:00	3	---	
28-Feb-12	8:50	---	---	
22-Aug-12	9:00	---	---	
29-Aug-12	9:30	---	---	
11-Jun-13	8:51	---	---	
12-Aug-13	9:58	---	---	
31-Oct-13	8:48	---	---	Clear water - collected parameters even though sampling is no longer required at location.
23-Sep-14	8:15	0.1	Estimation	Clear, minor bits of debris (leaves, etc.). No noticeable inflow.
11-Nov-14	8:42	0	Estimation	Clear, no sound or sight of flow.
18-Nov-15	9:35	---	---	Clear water with no visible flow. Sampled by collecting in 2 gallon bucket tied to string
25-Feb-16	9:00	---	---	Depth to water in well is 2.5 feet deep. Water is clear, still, no visible flow.
22-Jun-16	11:35	0.1	Estimation	Clear with minor bugs crawling around enclosure, no visible flow, water level is substantially higher than last time. DTW is 15" - measured from bottom of cement on opening.
30-Sep-16	10:10	---	Estimation	Clear, minor algae floating on surface. No visible flow

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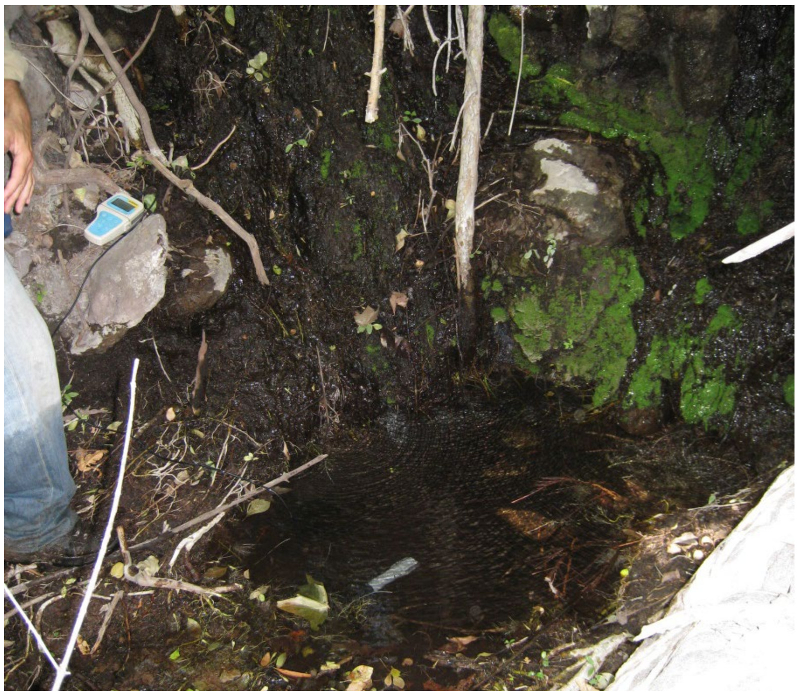
MC 3.4W

MC 3.4W, also known as Wet Leg Spring, is a perennial hillslope spring located in Mineral Creek. The spring discharges from the Apache Leap Tuff on the western side of the stream channel.



Photograph A-39. MC 3.4W, Water Seeping from TAL On Western Side of Mineral Creek, September 2008

Plant species have not been cataloged at the MC3.4W site.

Periodic monitoring of flow and water quality parameters for spring MC3.4W has occurred since 2009 (M&A, 2016). Flow observations are summarized in Table A-15.

Table A-15. Summary of Flow Observations for Government Spring

Date	Time	Spring Flow		OBSERVATIONS
		Flow (gpm)	Method	
6-Aug-09	13:30	2	Estimation	
15-Dec-09	13:10	---	---	
15-Feb-10	15:00	1	Estimation	
18-Mar-10	13:30	5	Estimation	Samples taken
4-Nov-10	15:45	7	Estimation	
24-Feb-11	9:46	---	---	
12-Aug-13	12:05	42	---	Previous flood 2 weeks ago 1000 gpm, clear current, frogs, minnows and brown algae
18-Feb-14	13:05	0.5	Estimation	Clear, very low flow, parameters taken in small pool in mud, dense green vegetation with audible spring behind.

Date	Time	Spring Flow		OBSERVATIONS
		Flow (gpm)	Method	
27-May-14	12:39	0.1	Estimation	Small puddles in soil below large amounts of vibrant vegetation. Soil is very saturated.
23-Sep-14	11:10	0.1	Estimation	Clear, small pools in soil, green vegetation (less green than last quarter). Not enough water for parameters.
11-Nov-14	11:33	2	Estimation	Clear, minor green vegetation on hillside.
18-Nov-15	14:20	2	Estimation	Clear water with green vegetation in area
25-Feb-16	16:30	1.5	Estimation	Clear water with bright green vegetation
28-Jun-16	15:38	0	Estimation	No flow - appears that June 10th storm destroyed spring.
20-Sep-16	13:25	0	Estimation	Evidence of past flow but none currently - moist ground, flow marks.
23-Jan-18	14:42	1	Estimation	Spring appears to be back to "normal" conditions, flowing at ~1 gpm from hillside into Mineral Creek; with bright green vegetation on hillside.

Mineral Creek Watershed - Surface Water

Mineral Creek from Government Springs to the confluence with Devils Canyon has two continuously flowing reaches identified by occurrence surveys (M&A 2017), one from 8.4 to 7.8 kilometers upstream form the confluence (MC 8.4 to 7.8) and another from 6.9 to 1.6 kilometers upstream of the confluence (MC 6.9 to 1.6). Surface water flow in Mineral Creek is understood to be a mix of groundwater from upper Mineral Creek Watershed, groundwater from the ALT aquifer, and precipitation-derived surface water runoff (M&A 2016).

Two surface water monitoring locations in Mineral Creek have been instrumented with data sondes to continually monitor streamflow and water quality parameters:

- Upper Mineral (MC 6.84) – Located below the confluence with Lyon's Fork near the beginning of the MC 6.9 to 1.6 reach of Mineral Creek.

- Lower Mineral (MC 3.3C) – Located in the lower stretch of the MC 6.9 to 1.6 reach, downstream from MC 3.4W spring.

MC 8.4 to 7.8

This perennial flowing reach begins below Government Springs Ranch and flows from 8.4 to 7.8 kilometers upstream of the confluence with Devils Canyon (Figure 1). The reach begins flowing from the alluvium where Apache Leap Tuff outcrops in the creek bed, and flows continually, or intermittently, for approximately 600 meters before seeping back into the channel alluvium. Sampling location MC 8.4C has been monitored since 2008 for surface water occurrence and surface water hydrochemistry.

Biological surveys specific to this reach have not been conducted.

Photograph A-40. MC 8.4 To 7.8, Water Flowing in Mineral Creek After Storm, July 2010

MC 6.9 to 1.6

This perennial reach of surface water flow is located in Mineral Creek from 6.9 to 1.6 kilometers upstream of the confluence with Devils Canyon, starting just above the confluence with Lyon's Fork wash, and continuing for 5.3 km downstream towards Big Box Dam (Figure 1). Sampling locations along this reach include MC 5.2C and MC 3.3C, and a pressure transducer (Lower Mineral) has been installed in a narrow channel of Apache Leap Tuff located at MC 3.3C to monitor surface water flow.

Surface water occurrence surveys have been conducted in the Mineral Creek study area starting in 2011. Average discharge measured at Upper Mineral datasonde ranges from 0 to 0.020 cubic feet per second (cfs), and from 0.05 to 4.01 cfs, since 2011 (M&A 2017).

Photograph A-41. Designated Location of Lower Mineral Datasonde, September 2008

Interior Riparian Deciduous Forest forms a canopy of Bonpland willow, Goodding's willow, velvet ash, Fremont cottonwood, Arizona sycamore, and Arizona walnut. No special-status plant species were observed. Wetland plants observed include pale spikerush, swordleaf rush, yellow monkeyflower, watercress, Arizona sycamore, Bonpland's willow, Goodding's willow, rabbitsfoot grass, western poison ivy, seepwillow, and speedwell (WestLand, 2018).

Photograph A-42. MC 6.9 To 1.6, Water Flowing in Mineral Creek Lower Reach, September 2008

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08 December 2022

Via email to: cory.brunsting@usda.gov

Cory Brunsting
US Forest Service
Supervisor's Office
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Phoenix, AZ 85006-2496

Subject: Resolution Copper Mining, LLC – Monitoring and Mitigation Plan for Groundwater Dependent Ecosystems and Water Wells for Final EIS

Dear Mr. Brunsting,

Enclosed for your review and consideration please see the Monitoring and Mitigation Plan for Groundwater Dependent Ecosystems and Water Wells in response to public issues raised during scoping and public and agency comment on the Draft Environmental Impact Statement.

Should you have any questions or require further information please do not hesitate to contact me.

Sincerely,

Willard Antone III
Senior Manager, Permitting and Approvals; Resolution Copper Company, as Manager of Resolution Copper Mining LLC

Enclosed: Monitoring and Mitigation Plan for Groundwater Dependent Ecosystems and Water Wells December 2022