

## 2 DELINEATION OF CUMULATIVE IMPACT AREA

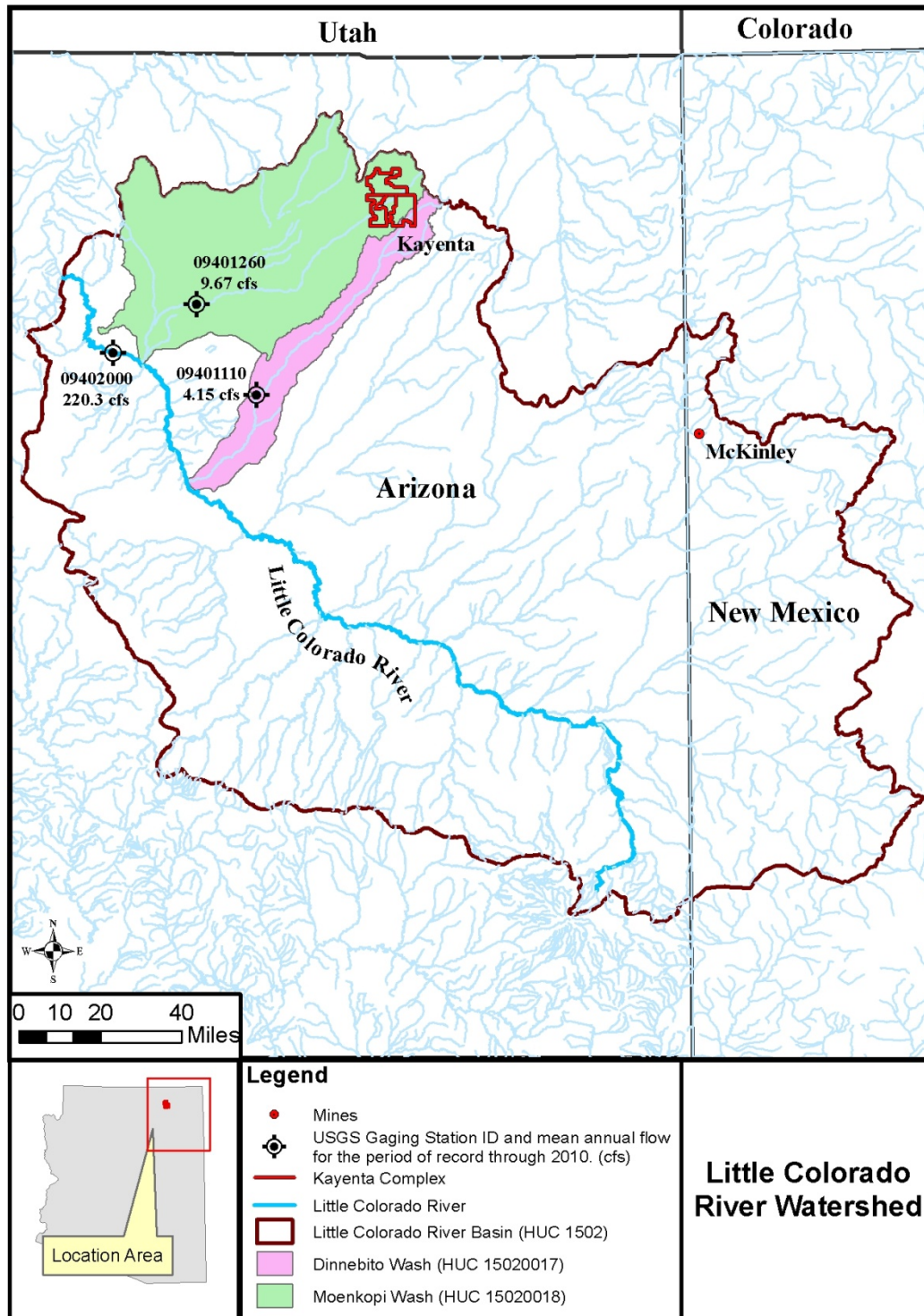
A CIA is defined at 30 CFR § 701.5 as, “. . . the area, including the permit area, within which impacts resulting from the proposed operation may interact with the impacts of all anticipated mining on surface- and ground-water systems.” A CIA considers an area where impacts from the coal mining operation, in combination with additional coal mining operations, may cause material damage. Material damage considers quantifiable adverse degradation or reduction of surface or ground waters outside the permit area, resulting in the inability to utilize water resources for existing or reasonably foreseeable uses. CIA delineation for the Kayenta Complex consists of both surface water and groundwater delineations, with impact areas delineated for both surface and ground waters based upon the resource extent and potential use impacts.

### 2.1 Surface Water Cumulative Impact Area

The United States is divided into 21 surface water regions, and further sub-divided into 221 sub-regions (USGS, 1987). Sub-regions are further sub-divided into 378 hydrologic accounting units, and finally a fourth level of classification, 2264 cataloging units. The subdivisions provide a mechanism to classify each hydrologic unit by a unique hydrologic unit code (HUC) consisting of two to eight digits based on the four levels of classification in the hydrologic unit system. The Little Colorado River sub-region encompasses 29,900 square miles, and assigned a HUC of 1502. The Little Colorado River 1502 is sub-divided into 18 cataloging units. Kayenta Complex mining and reclamation operations occur in 2 of the 18 cataloging units: Dinnebito Wash (HUC 15020017) and Moenkopi Wash (HUC 15020018). Dinnebito Wash and Moenkopi Wash discharge to the Little Colorado River at two independent downstream locations (Figure 1). Since mining operations at the Kayenta Complex are the only existing or proposed coal operations in either Moenkopi Wash (HUC 15020018) or Dinnebito Wash (HUC 15020017), surface water impacts will not be cumulative with other coal mining operations unless the impacts extend to the Little Colorado River.

McKinley Mine, located in the Upper Puerco Watershed (HUC 15020006), and the Kayenta Complex are the only active coal mining and reclamation operations in the Little Colorado (HUC 1502) (Figure 3). McKinley Mine is approximately 190 stream miles from the first point McKinley Mine impacts could become cumulative with Kayenta Complex impacts at the confluence of the Little Colorado River and Dinnebito Wash. McKinley Mine ceased coal production in December 2009, and is currently completing final reclamation.

Figure 3 presents the mean annual flow measured on Dinnebito Wash (station 09401110), Moenkopi Wash (station 09401260), and the Little Colorado River (station 09402000). Compared to the mean annual flow at station 09402000, mean annual flow at stations 09401110 and 09401260 are 1.8- and 4.3-percent respectively, of the Little Colorado River flow measured at station 09401260. Based on the spatial separation of McKinley Mine from the Little Colorado River and Dinnebito Wash confluence, and the magnitude of mean annual surface flow on the Little Colorado River compared to contributing flow volumes, make it impracticable to distinguish potential coal mine water quality impacts at the confluence of the Little Colorado River and Dinnebito Wash. Therefore, the McKinley Mine is excluded from the Kayenta Complex CIA, and a smaller watershed area for assessment of probable hydrologic impacts attributed to the Kayenta Complex operations will be delineated.



**Figure 3: Mining Operations in the Little Colorado River Watershed**

### **2.1.1 Downstream Impact Potential**

Approximately 30 stream miles downstream of the Kayenta Complex, Rocky Ridge is the only community along the main channel of Dinnebito Wash. Historically, an attempt was made to dam Dinnebito Wash at Rocky Ridge and impound storm flow water for potential use. Currently, only remnants of the Dinnebito Dam remain, and there are no structures or equipment indicating Dinnebito Wash is utilized for irrigation water at Rocky Ridge (OSMRE, 2011a).

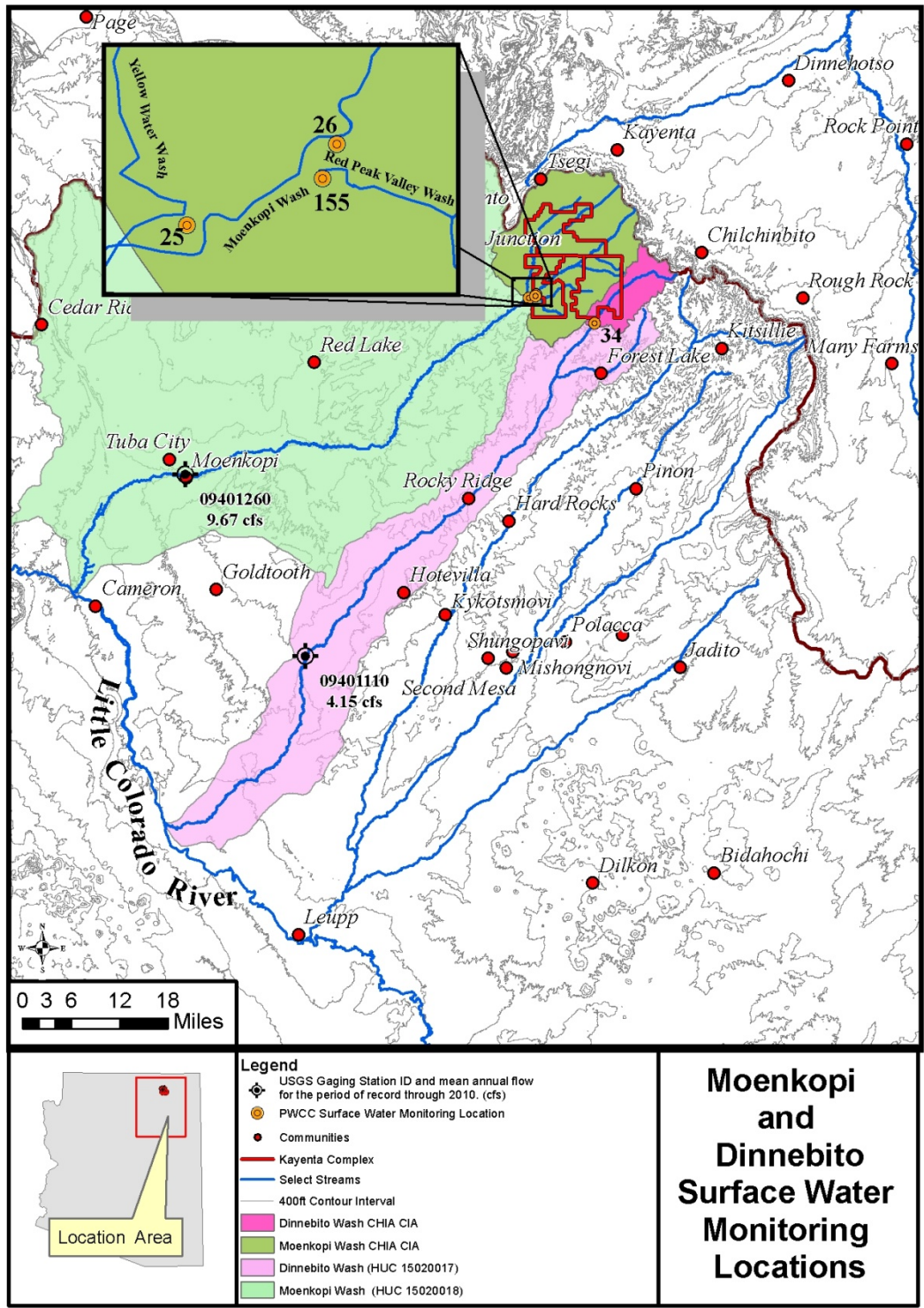
Moenkopi is the only community along the main channel of Moenkopi Wash, approximately 70 stream miles downstream of the PWCC permit area. At this area, Moenkopi residents may dig pits in the Moenkopi alluvium for agricultural irrigation on fields adjacent to Moenkopi Wash (OSMRE, 2011b). The pits are dug in the channel alluvium until the pits remain saturated. The shallow alluvial water may be pumped from in-channel pits during the growing season in order to reduce the amount of sediment extracted with the irrigation water. Suspended sediment generated during storm flow events precludes farmers in the Moenkopi area from utilizing flowing storm water directly on the crop fields. The high sediment loads transported during storm flow events create problems with the pumping equipment, as well as limits the productivity of the crop if the fine silt is applied over the field.

OSMRE recognizes that subflow in the Moenkopi Wash alluvium is part of the hydrologic balance and important to local farmers in the Moenkopi community, and potentially Rocky Ridge. Subflow in the alluvium is part of the flow system, and a decrease in surface water flow contribution to the hydrologic system may affect subflow and ultimately surface water use (OSMRE, 2011b).

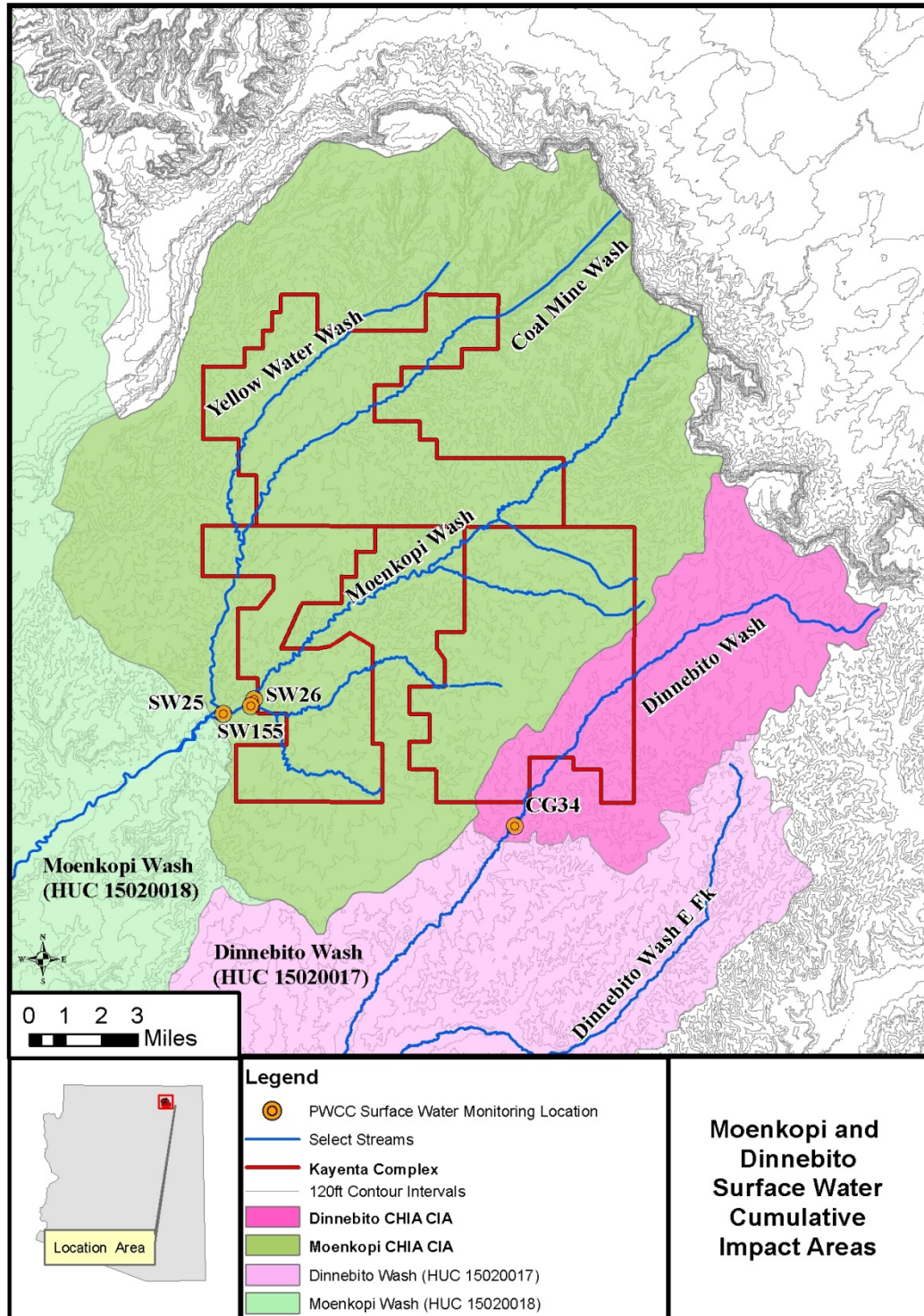
### **2.1.2 Surface Water Impact Areas**

Mining and reclamation operations on the Kayenta Complex occur in the headwater areas of Dinnebito Wash (HUC 15020017) and Moenkopi Wash (HUC 15020018), which are tributary to the Little Colorado River (Figure 3). Moenkopi Wash (HUC 15020018) drains an area of 2,635 square miles (mi<sup>2</sup>), and Dinnebito Wash (HUC 15020017) drains an area of 743 mi<sup>2</sup> before discharging to the Little Colorado River. The United States Geological Survey (USGS) maintains a gaging station on both Moenkopi Wash (station No. 09401260) and Dinnebito Wash (station No. 09401110) (Figure 3). Gaging station 09401260 has a continuous period of record at the same location beginning in 1977, and the continuous period of record for gaging station 09401110 began in 1993. The Moenkopi Wash gaging station is located approximately 1-2 miles from the area local farmers dig pits in the alluvium. The Dinnebito Wash gaging station is approximately 30 stream miles downstream from Rocky Ridge.

USGS gaging stations 09401260 and 09401110 provide valuable information on the hydrology of the Moenkopi and Dinnebito watersheds. However, the watershed areas monitored by the two gaging stations cannot be used exclusively to assess surface water quantity and quality impacts of the Kayenta Complex due to the size of the watershed monitored. Surface water impacts from the Kayenta Complex are most effectively evaluated using monitoring information close to the permit area. PWCC collects surface water quality and quantity information at locations 25, 26, 34, and 155 (Figure 4). Therefore, OSMRE has delineated two surface water areas for hydrologic impact assessment: one for Moenkopi Wash (253 mi<sup>2</sup>) one for Dinnebito Wash (51 mi<sup>2</sup>) (Figure 5). The Moenkopi Wash CIA will use information from monitoring locations 25, 26, and 155 near the downgradient permit boundary on Moenkopi Wash for mine impact assessment. The Dinnebito Wash CIA will use information from monitoring location 34 near the downgradient permit boundary on Dinnebito Wash for mine impact assessment.



**Figure 4: Moenkopi and Dinnebito Surface Water Monitoring Locations**



**Figure 5: Moenkopi and Dinnebito Surface Water Cumulative Impact Areas, Kayenta Complex**

## 2.2 Ground Water Cumulative Impact Area

Kayenta Complex mining operations occur in the Wepo Formation of the Mesa Verde Group (Figure 6). The Yale Point sandstone is above the Wepo Formation and present between the eastern boundary of the Kayenta Complex and the rim of Black Mesa. The Yale Point Sandstone is recharged by direct precipitation and will either discharge to stream channels above the Kayenta Complex or recharge the underlying Wepo Formation. The Toreva Formation of the Mesa Verde Group underlies the Wepo Formation. Geologic mapping indicates that the Wepo Formation is discontinuous over the areal extent of Black Mesa, varies in thickness from 130-740 feet where present, and intertongues with the overlying Yale Point Sandstone on the northeastern mesa rim and underlying Toreva Formation (Repenning and Page, 1956).

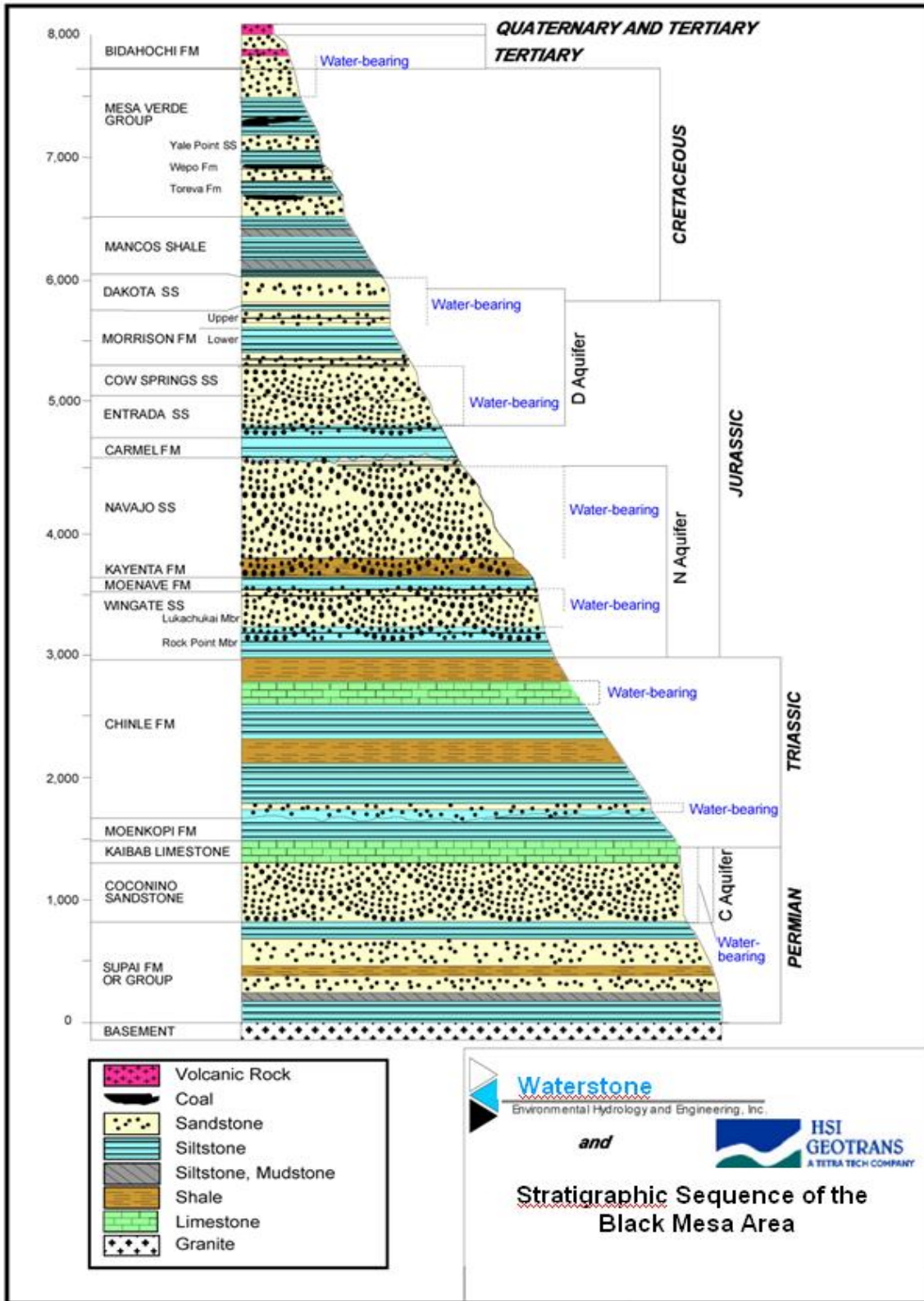
The Black Mesa area has three regional aquifer systems: Dakota aquifer (D aquifer), Navajo aquifer (N aquifer), and Coconino aquifer (C aquifer) (Figure 6). The D Aquifer is separated from the Mesa Verde Group by the Mancos Shale (Figure 7). The D aquifer and N aquifer are separated by the siltstone Carmel Formation. The PWCC water supply wellfield withdraws water from wells screened in the D aquifer and N aquifer systems. The N aquifer system is the deepest water bearing zone to be potentially affected by the mining operation water supply wellfield; confined below by the Chinle Formation. The Chinle Formation separates the N aquifer from the C aquifer.

### 2.2.1 Mesa Verde Group

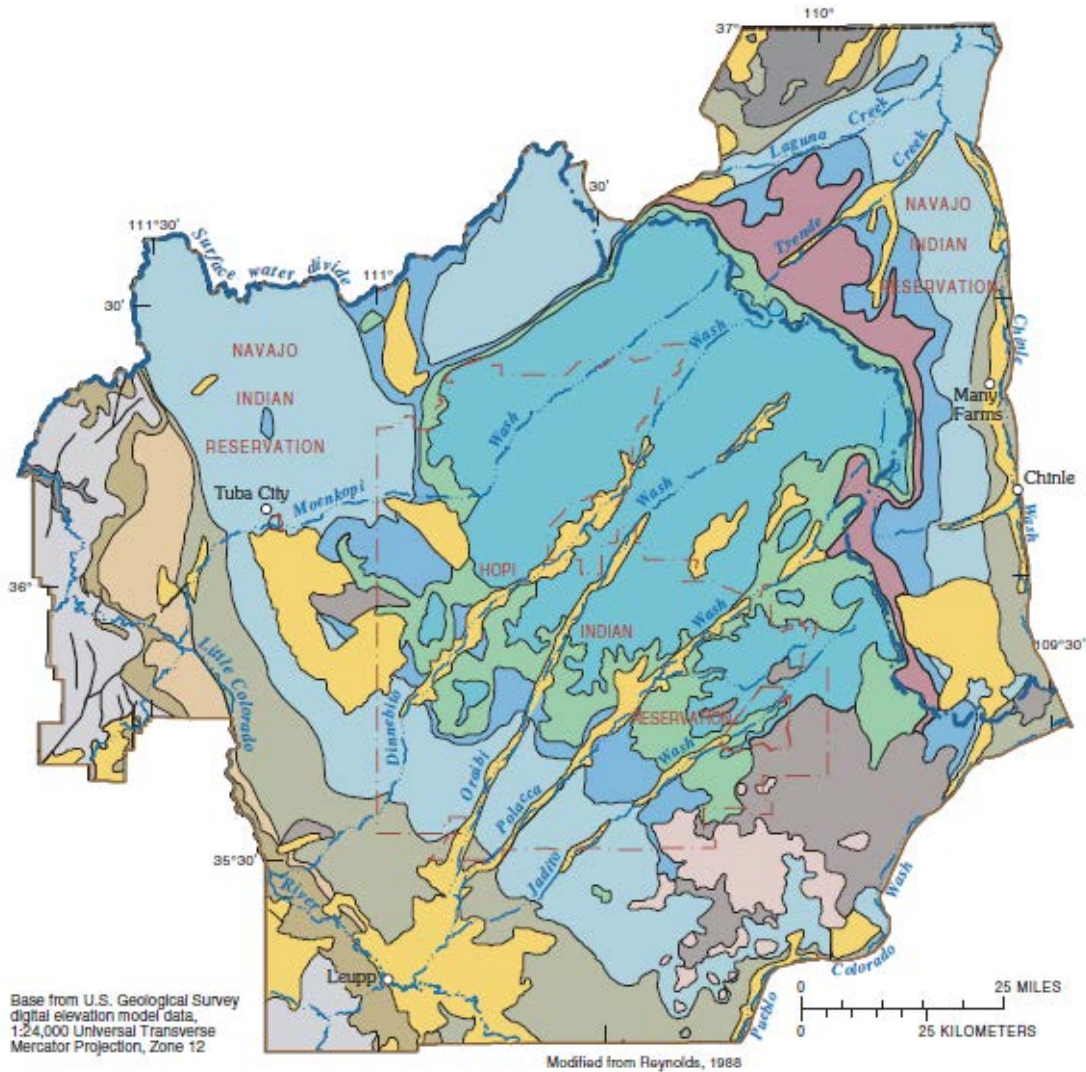
The Yale Point sandstone may discharge at outcrop areas above the Kayenta Complex and will not be influenced by mining operations. There are no known use locations of water in the Yale Point sandstone northeast of the permit area. Lithologic drill logs of the Wepo Formation indicate water yielding units consisting of single sandstone beds, multiple sandstone beds which are hydraulically connected, fractured coal seams, and sandy shales of limited extent (PWCC, v.1, ch.4, 2011). Historical and existing use locations of Wepo Formation water have been identified within the permit and adjacent area (Figure 8). The Toreva Formation is not disturbed during mining operations, and there are no water use locations within the permit or adjacent area. Therefore, delineation of the CIA for the Mesa Verde Group will focus on the Wepo Formation.

The Wepo Formation is completely incised by Moenkopi Wash near the southwest corner of the permit area where the Mancos Shale is exposed at the surface. Therefore, water quantity and quality impacts cannot propagate past the exposed area prior to impact detection at surface water monitoring stations 25, 26, and 155. Additionally, a Wepo water level contour map indicates that the water level contours generally mimic the surface topography (PWCC, v.9, ch.15, 2011), flowing to discharge areas where the alluvial washes incise the Wepo Formation. Geologic and hydrologic mapping were applied to delineate the CIA for the Wepo Formation. Since the Wepo Formation is in hydrologic communication with the alluvial washes, alluvial aquifers are included in the CIA.

The Wepo Formation CIA is bound to the west by Yellow Water Wash, and to the southeast by Dinnebito Wash. The Wepo Formation CIA also includes the upgradient sides of mine areas N-7/8, N-9, N-11, N-14, J-21, and any historical or existing use location in the adjacent area. Water level contours for the Wepo Formation south of the Kayenta Complex indicate that ground water flow is from the east to the discharge zone in Moenkopi Wash west of the Kayenta Complex; therefore, the southern extent of the CIA has been delineated parallel to the Wepo flow paths (Figure 8).



**Figure 6: Stratigraphic Sequence of the Black Mesa Area (PWCC, 1999)**

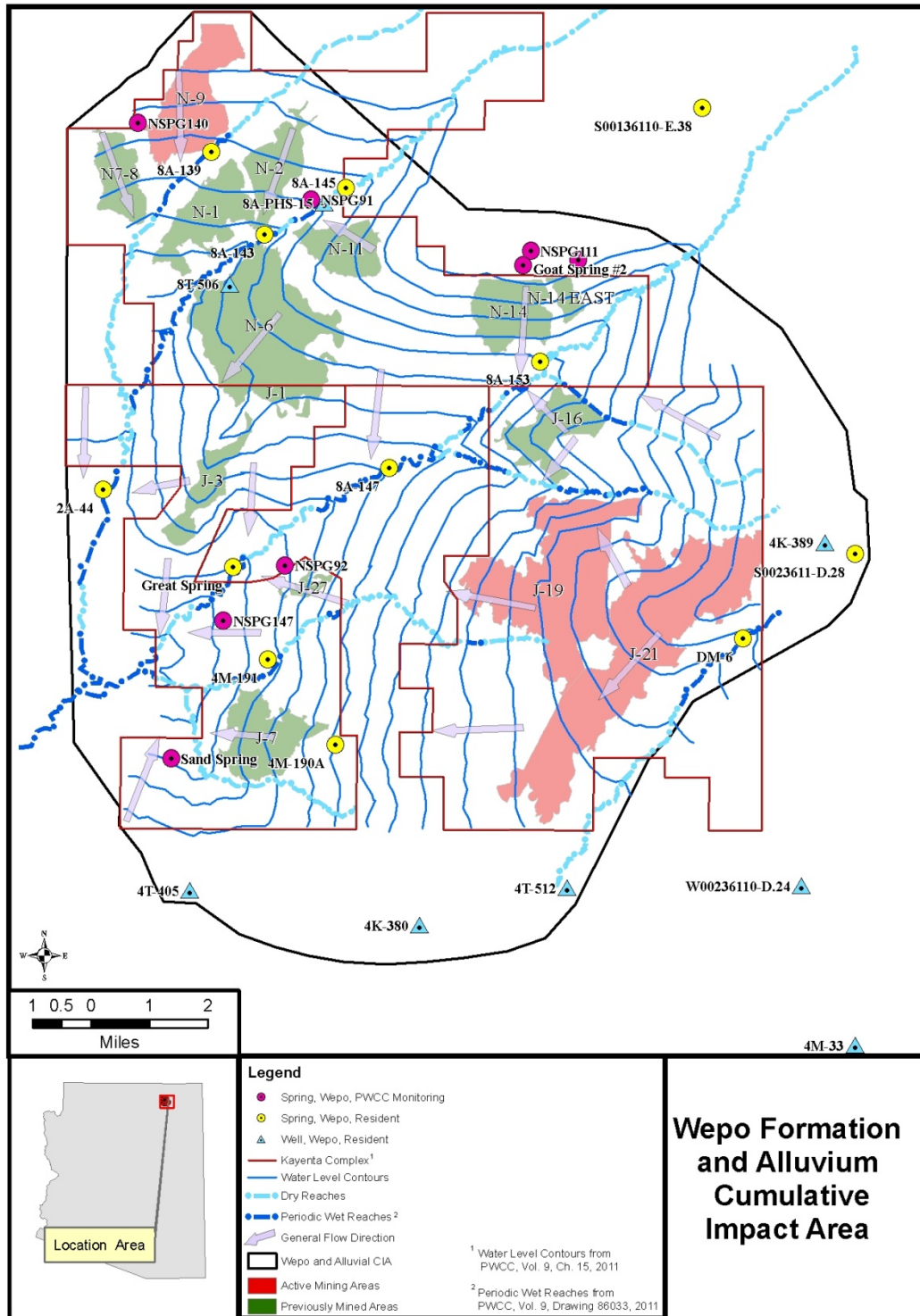


EXPLANATION

	SEDIMENTARY DEPOSITS	— QUATERNARY
	VOLCANIC ROCKS—Basaltic flows	} TERTIARY
	BIDAHOCHI FORMATION	
	MESA VERDE GROUP—Includes Yale Point Sandstone, Wepo Formation, and Toreva Formation	} CRETACEOUS
	MANCOS SHALE AND DAKOTA SANDSTONE	
	MORRISON FORMATION	} JURASSIC
	SAN RAFAEL GROUP—Includes Entrada Sandstone and Carmel Formation	
	GLEN CANYON GROUP—Includes the Navajo Sandstone, Kayenta Formation, and the Wingate Sandstone,	} TRIASSIC
	SHINARUMP MEMBER OF THE CHINLE FORMATION	
	CHINLE FORMATION	} PERMIAN
	MOENKOPI FORMATION	
	KAIBAB FORMATION, TOROWEAP FORMATION, AND COCONINO SANDSTONE	} PERMIAN/PENNSYLVANIAN
	HERMIT SHALE, SUPAI GROUP, AND DE CHELLY SANDSTONE	
	GEOLOGIC CONTACT	
	FAULT	

**Figure 7: Black Mesa Area Surface Geology, Northeastern Arizona (Truini and Longworth, 2003)**



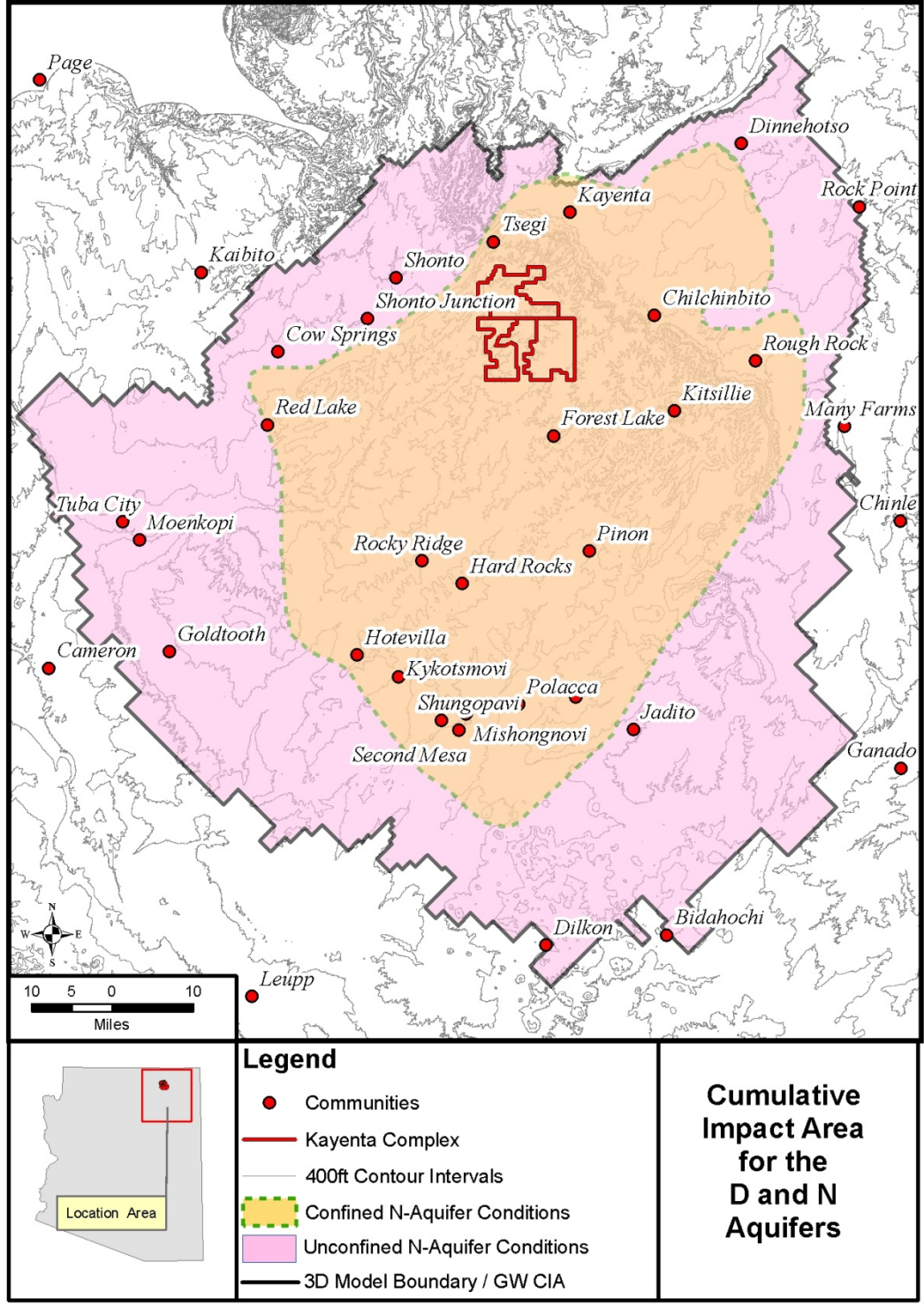


**Figure 8: Wepo Formation and Alluvium Cumulative Impact Area, Kayenta Complex**

## 2.2.2 D and N Aquifers

In 1999, PWCC completed a report that presented a regional three-dimensional numerical model of the Black Mesa Basin groundwater flow system (hereinafter, the “3D Model”) (PWCC, 1999). The 3D Model represents the most comprehensive compilation and evaluation of geologic and hydrologic data for the purpose of evaluating the effects of PWCC pumping of the D and N aquifers. The 3D Model considers the cumulative effect of all groundwater use from PWCC, Navajo Nation, and Hopi community pumping centers on the aquifers and associated surface flows. The 3D Model was calibrated using data collected through 1996, and 3D Model predictions were validated against field measured water levels from 1996-2005, and again in 2010 including 2006-2009 data, which assists in determining the appropriateness of utilizing the 3D Model for predictive purposes (PWCC, v.11, ch.18, 2011). The model validation and previous calibrations to field data demonstrate that the 3D Model is an appropriate tool for assessing PWCC water quantity impacts from groundwater pumping at the PWCC wellfield. OSMRE relies on the 3D Model for water resource impact predictions, and will reference summary statements and conclusions throughout this assessment supported by the 3D Model report. The 3D Model boundary is considered the CIA for the D and N aquifers (Figure 9).

The 3D Model boundary is described in the 3D Model report (PWCC, 1999). It is based on the lateral extent of rocks comprising the N aquifer as well as hydrologic features. The lateral extent of the N aquifer bounds the 3D Model on the west, south, and southeast (Figure 7). From Cedar Ridge to near Bidahochi, north toward the vicinity of Round Rock; this boundary is a no-flow boundary (PWCC, 1999). East of the Kayenta Complex, Chinle Wash is a hydrologic boundary, and is a discharge area for flow both east and west of Chinle Wash (PWCC, 1999). “The northern boundary is placed along the interpreted groundwater divide that extends eastward from Cedar Ridge to Preston Mesa, northeastward to Skeleton Mesa east of Kaibito to the Shonto Plateau. The boundary then extends southeastward east of Tsegi Canyon to a point where it is defined by the northern extent of the Wingate hydrostratigraphic unit along the Comb Ridge monocline” (PWCC, 1999).



**Figure 9: D aquifer and N aquifer Cumulative Impact Area, Kayenta Complex**