

CUMULATIVE HYDROLOGIC IMPACT ASSESSMENT

of the

Peabody Western Coal Company

Kayenta Mine Complex



United States Department of the Interior
Office of Surface Mining Reclamation and Enforcement
Western Region

September 2016

TABLE OF CONTENTS

1	INTRODUCTION.....	9
1.1	Regulatory Environment	11
1.1.1	CHIA Revision Purpose	11
1.1.2	Cumulative Impact Area	13
1.1.3	Material Damage to the Hydrologic Balance	14
1.1.4	Material Damage Criteria.....	14
1.2	Kayenta Mine Complex Background	14
2	DELINEATION OF CUMULATIVE IMPACT AREA.....	18
2.1	Surface Water Cumulative Impact Area	18
2.1.1	Downstream Impact Potential	20
2.1.2	Surface Water Impact Areas	20
2.2	Groundwater Cumulative Impact Area	23
2.2.1	Mesa Verde Group	23
2.2.2	D and N Aquifers	27
3	WATER RESOURCE USES AND DESIGNATIONS.....	29
3.1	Domestic Water Supply	29
3.2	Industrial Supply Water	29
3.3	Agricultural Water Supply	31
3.4	Livestock Watering	31
3.5	Secondary Human Contact and Partial Body Contact.....	32
3.6	Primary Contact Ceremonial.....	32
3.7	Aquatic Wildlife Habitat and Fish Consumption	32
3.8	Groundwater Recharge.....	32
4	BASELINE HYDROLOGIC CONDITIONS	33
4.1	Surface Water.....	33
4.1.1	Surface Water Regulatory Requirements	33
4.1.2	Surface Water Baseline Quantity	34
4.1.3	Surface Water Baseline Quality	37
4.2	Groundwater.....	40
4.2.1	Groundwater Regulatory Requirements.....	40
4.2.2	Alluvium	40
4.2.2.1	Alluvial Baseline Quantity	43
4.2.2.2	Alluvial Baseline Quality	45
4.2.3	Wepo Formation.....	47

4.2.3.1	Wepo Formation Baseline Quantity	49
4.2.3.2	Wepo Baseline Quality.....	50
4.2.4	D Aquifer	53
4.2.4.1	D aquifer Baseline Quantity	53
4.2.4.2	Dakota Aquifer Baseline Quality	55
4.2.5	N Aquifer	60
4.2.5.1	N Aquifer Baseline Quantity.....	60
4.2.5.2	N Aquifer Baseline Quality.....	60
5	HYDROLOGIC IMPACT ASSESSMENTS	67
5.1	Surface Water.....	67
5.1.1	Surface Water Monitoring Program.....	67
5.1.2	Surface Water Quantity.....	68
5.1.2.1	Impact Potential to Existing and Foreseeable Uses.....	68
5.1.2.2	Surface Water Quantity Material Damage Threshold and Limit	72
5.1.3	Surface Water Quality.....	72
5.1.3.1	Surface Water Quality Monitoring Program.....	72
5.1.3.2	Impact Potential to Existing and Foreseeable Uses.....	72
5.1.3.3	Surface Water Quality Material Damage Threshold and Limit	79
5.2	Groundwater.....	80
5.2.1	Alluvium	80
5.2.1.1	Alluvial Quantity.....	80
5.2.1.1.1	Alluvial Quantity Monitoring Program.....	80
5.2.1.1.2	Alluvial Quantity Impact Potential to Existing and Foreseeable Uses	81
5.2.1.1.3	Alluvial Quantity Material Damage.....	82
5.2.1.2	Alluvial Quality.....	83
5.2.1.2.1	Alluvial Quality Monitoring Program.....	83
5.2.1.2.2	Alluvial Quality Impact Potential to Existing and Foreseeable Uses	83
5.2.1.2.3	Alluvial Quality Material Damage	84
5.2.2	Wepo Formation.....	87
5.2.2.1	Wepo Formation Quantity.....	87
5.2.2.1.1	Wepo Formation Quantity Monitoring Program.....	88
5.2.2.1.2	Wepo Formation Quantity Impact Potential	88
5.2.2.1.3	Wepo Formation Quantity Material Damage.....	88
5.2.2.2	Wepo Formation Quality.....	89
5.2.2.2.1	Wepo Formation Quality Monitoring Program.....	89
5.2.2.2.2	Wepo Formation Quality Impact Potential	89

5.2.2.2.3	Wepo Formation Quality Material Damage.....	92
5.2.3	D aquifer.....	93
5.2.3.1	D aquifer Quantity.....	93
5.2.3.1.1	D aquifer Quantity Material Damage.....	94
5.2.3.2	D aquifer Quality Material Damage.....	94
5.2.4	N aquifer.....	96
5.2.4.1	N aquifer Quantity.....	97
5.2.4.1.1	N aquifer Quantity Monitoring Program.....	98
5.2.4.1.2	Transient Modeling.....	101
5.2.4.1.3	N aquifer Impact Potential to Existing and Foreseeable Uses	102
5.2.4.1.4	N aquifer Quantity Material Damage.....	108
5.2.4.2	Navajo Aquifer Quality.....	109
5.2.4.2.1	N aquifer Quality Monitoring Program.....	110
5.2.4.2.2	N aquifer Quality Impact Potential to Existing and Foreseeable Uses	113
5.2.4.2.3	N aquifer Quality Material Damage.....	115
6	WORKS CITED.....	116

Appendix A - Material Damage Criteria: Confined N aquifer Wells

Appendix B - Regional Monitoring Program Evaluation

LIST OF FIGURES	5
LIST OF TABLES	6
LIST OF ACRONYMS AND ABBREVIATIONS	7

LIST OF FIGURES

Figure 1: Kayenta Mine Complex Location Map (BOR, 2016, Figure 3.7-3).....	16
Figure 2: Kayenta Mine Complex Coal Resource Areas (BOR, 2016, Figure 1-5).....	17
Figure 3: Mining and Reclamation Operations in the Little Colorado River Watershed.....	19
Figure 4: Moenkopi and Dinnebito Surface Water Monitoring Locations	21
Figure 5: Moenkopi and Dinnebito Surface Water Cumulative Impact Areas, Kayenta Mine Complex ...	22
Figure 6: Stratigraphic Sequence of the Black Mesa Area (Macy and Unema, 2014).....	24
Figure 7: Black Mesa Area Surface Geology, Northeastern Arizona (Nations et. al., 2000)	25
Figure 8: Wepo Formation and Alluvium Cumulative Impact Area, Kayenta Mine Complex	26
Figure 9: D aquifer and N aquifer Cumulative Impact Area, Kayenta Mine Complex	28
Figure 10: Well System Monitored, Black Mesa, Northeastern Arizona (Macy and Unema, 2014).....	30
Figure 11: PWCC Surface Water Monitoring Locations (BOR, 2016, Figure WR-1.1)	36
Figure 12: Comparison of Upstream and Downstream TDS Surface Water Quality Data for Baseflow and Stormwater flow (1986-2004).....	38
Figure 13: PWCC Alluvial Water Monitoring Locations (BOR, 2016, Figure WR-4.1)	39
Figure 14: Seismic Refraction Evaluation Locations for Alluvium, Kayenta Mine Complex.....	42
Figure 15: Alluvial Aquifer Test Results, Kayenta Mine Complex.....	44
Figure 16: Wepo and Spoil Monitoring Wells, Kayenta Mine Complex (BOR, 2016, Figure WR-5.3)....	48
Figure 17: Wepo Formation in N-6 with minor offset (photos by OSMRE, 5-25-2005)	49
Figure 18: Wepo Aquifer Transmissivities, Kayenta Mine Complex.....	51
Figure 19: Black Mesa D and N aquifer Extents (BOR, 2016, Figure WR-8.5).....	54
Figure 20: D aquifer (Layer 3) and N aquifer (Layer 5) Steady State Target Water Level Locations, Black Mesa, Arizona (PWCC, 2016)	56
Figure 21: D aquifer Steady State Potentiometric Surface, Black Mesa, Arizona (PWCC, 2016).....	57
Figure 22: Hydraulic Head Difference Between the D and N Aquifers, Black Mesa, Arizona (PWCC, 1999)	58
Figure 23: Approximate area where groundwater leakage likely occurs between the D and N aquifers in the southern part of Black Mesa (Truini and Macy, 2006)	59
Figure 24: Confined N aquifer Conditions, Black Mesa, Arizona (BOR, 2016, Figure WR-8.11).....	61
Figure 25: Average Annual Groundwater Recharge, Black Mesa, Arizona (PWCC, v.11, ch.18, 2016) ..	62
Figure 26: D aquifer (Layer 3) and N aquifer (Layer 5) Simulated Spring Locations, Black Mesa, Arizona (PWCC, v.11, ch.18, 2016).....	61
Figure 27: N aquifer Steady State Potentiometric Surface, Black Mesa, Arizona (PWCC, v.11, ch.18, 2016)	64
Figure 28: N aquifer Water Quality Type, 2012 Results (Macy and Unema, 2014)	65
Figure 29: Dinnebito CIA Acres Managed with Impoundments, Kayenta Mine Complex	69
Figure 30: Moenkopi CIA Acres Managed with Impoundments, Kayenta Mine Complex	69
Figure 31: Blue Canyon on Moenkopi Wash (photo by OSMRE, 11-8-2002).....	71
Figure 32: Downstream Surface Water TDS Concentrations, Kayenta Mine Complex (1986-2010).....	78
Figure 33: TDS Concentrations (1986-2015), Upstream Alluvial Monitoring Locations	86
Figure 34: TDS Concentrations (1986-2015), Downstream Alluvial Monitoring Locations	86
Figure 35: Wepo Background Wells and Spoil Median Concentration for Major Cations	90
Figure 36: Wepo Background Wells and Spoil Median Concentration for Major Anions	91
Figure 37: Wepo Background Wells and Spoil Median Concentration for TDS.....	92
Figure 38: Groundwater Model Simulated D aquifer Drawdown in 2005 and 2012 (PWCC, v.11, ch.18, 2016)	95
Figure 39: N aquifer level changes from the pre-stress period to 2012 (Macy and Unema, 2014)	100
Figure 40: Measured (Black) and Model Simulated (Blue) Water Level at BM-6 (PWCC, v.11, ch. 18, Attachment IV, Figure 3.4-1, 2016).....	101

LIST OF FIGURES (continued)

Figure 41: Simulated N aquifer Drawdown – 2005 and 2012; PWCC and Community Pumping (PWCC, v.11, ch.18, Attachment IV, 2016).....	103
Figure 42: TDS Concentration in PWCC NAV Wells (2001-2015).....	112
Figure 43: Chloride Concentraions in PWCC NAV Wells (2001-2015).....	112
Figure 44: Sulfate Concentrations in PWCC NAV Wells (2001-2015)	113
Figure 45: Arsenic Concentrations in PWCC NAV Wells (2011-2015).....	113
Figure 46: Boron Concentration in PWCC NAV Wells (2011-2015).....	114
Figure 47: Selenium Concentration in PWCC NAV Wells (2011-2015).....	114

LIST OF TABLES

Table 1: Kayenta Mine Complex Material Damage Assessment Summary.....	10
Table 2: Storm water sample ranges for upstream locations, Kayenta Mine Complex (1986-2010).	39
Table 3: Alluvial water quality sample ranges for upstream locations, Kayenta Mine Complex (1986-2010).	46
Table 4: Wepo Formation water quality sample ranges for background locations, Kayenta Mine Complex (1986-2010).....	52
Table 5: Hopi Tribe Water Resources Program 2008 Water Quality Standards (Hopi Tribe, 2011)	74
Table 6: NNEPA Water Quality Program 2007 Surface Water Quality Standards (NNEPA, 2009)	75
Table 7: Storm water sample ranges for downstream locations, Kayenta Mine Complex (1986-2010)	76
Table 8: Alluvial Quantity Outflow Calculations for Primary Washes (2002).....	81
Table 9: Downstream Alluvial Water Quality Summary (1986-2010), Kayenta Minw Complex.....	85
Table 10: PWCC Pumping Wells Screened Aquifer Zone (feet) (PWCC, v.11, Ch.15, 2016)	94
Table 11: Simulated Stream Discharge Reductions (cfs) Due to PWCC Pumping (PWCC, v.11, Ch.18, Attachment IV, Table 3.2-3, 2016)	105
Table 12: Discharge Reductions for Springs Simulated as Streams (cfs) Due to Pumping (PWCC, v.11, ch.18, Attachment IV, Table 3.2-3, 2016)	106

List of Acronyms and Abbreviations

3D Model	regional three-dimensional numerical flow model of D and N aquifers
ac-ft	acre-feet
AgL	agricultural livestock watering
AgI	agricultural irrigation water
AgWS	agricultural water supply
ALJ	administrative law judge
A&W _e	aquatic and wildlife - ephemeral
A&WHbt	aquatic and wildlife habitat
BIA	Bureau of Indian Affairs
BOR	Bureau of Reclamation
C aquifer	Coconino aquifer
CCL	Candidate Contaminant List
cfs	cubic feet per second
CHIA	cumulative hydrologic impact assessment
CIA	cumulative impact area
CFR	Code of Federal Regulations
CG	crest gage
CWA	clean water act
D aquifer	Dakota aquifer
DWS	domestic water supply
EA	environmental assessment
EIS	environmental impact statement
ft/sec	feet per second
FC	fish consumption
FR	federal register
gpd/ft	gallons per day per foot

GWR	groundwater recharge
HTWQS	Hopi Tribe water quality standards
HUC	hydrologic unit code
KMC	Kayenta Mine Complex
LW	livestock watering
MAD	Median Absolute Deviation
MDL	method detection limit
mg/L	milligrams per liter
mi ²	square miles
N aquifer	Navajo aquifer
NNSWQS	Navajo Nation surface water quality standards
NPDES	National Pollutant Discharge Elimination System
OSMRE	Office of Surface Mining Reclamation and Enforcement
PAP	permit application package
PBC	partial body contact
PCC	Primary Contact Ceremonial
PHC	Probable Hydrologic Consequences
PWCC	Peabody Western Coal Company
PWS	public water supply
ROD	Record of Decision
ScHC	secondary human contact
SMCRA	Surface Mining Control and Reclamation Act
TDS	total dissolved solids
TSS	total suspended solids
µg/L	micrograms per liter
USEPA	United States Environmental Protection Agency
USGS	United States Geologic Survey
WRP	Water Resource Program