Waste Rock Management at the Barrick Goldstrike Mine

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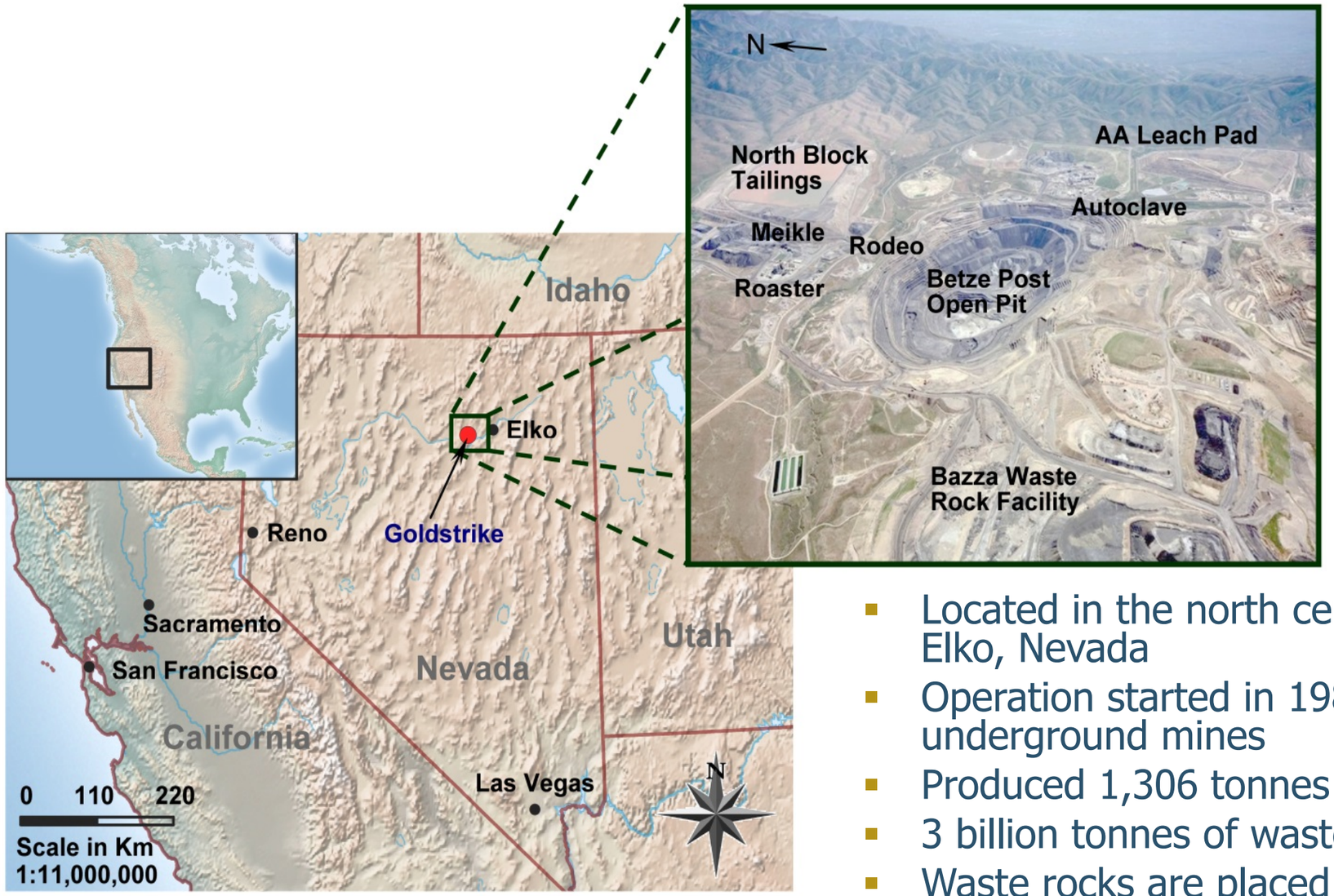
Outlines

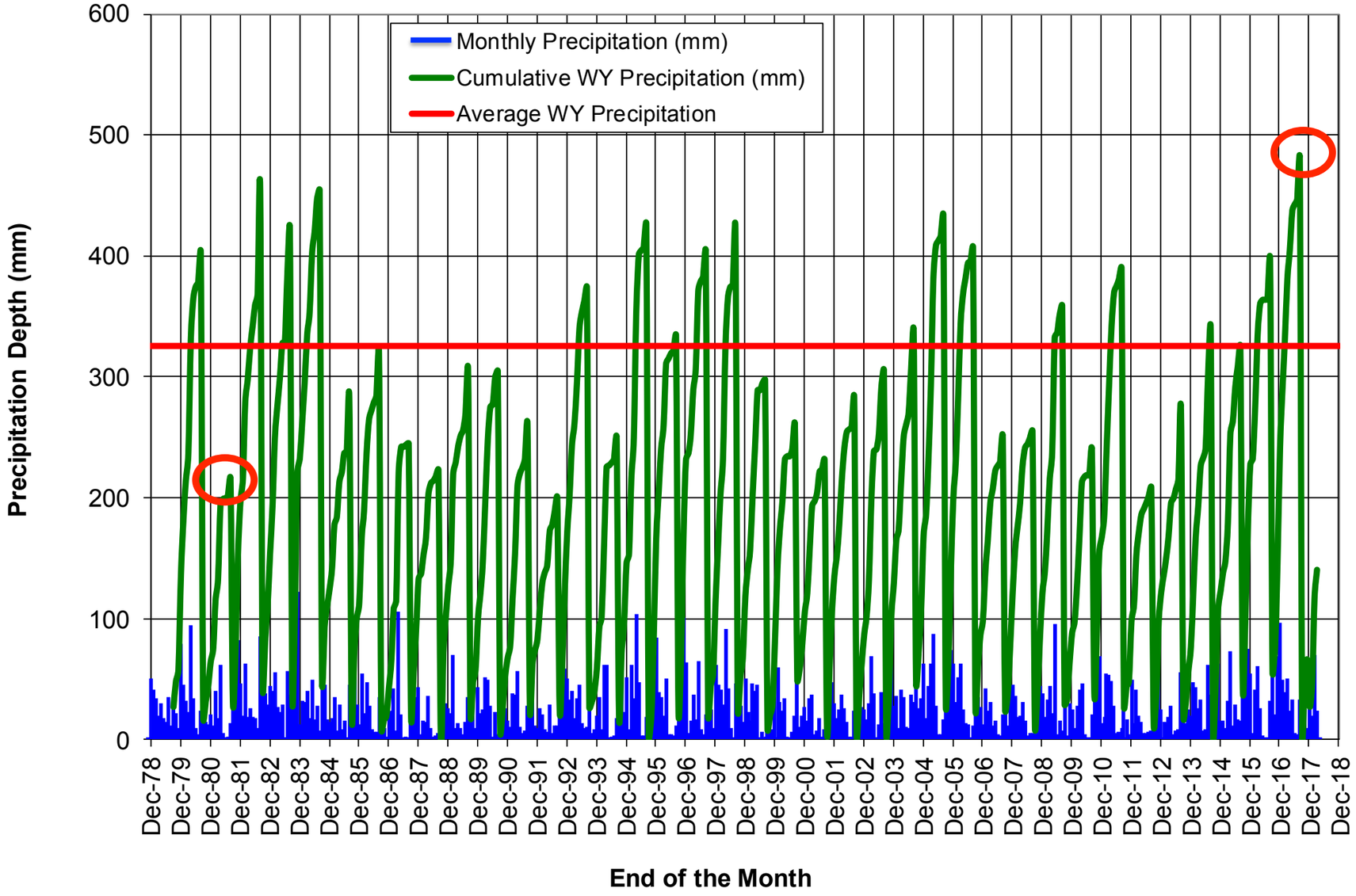
- Introduction
- Waste Rock Management Plan (WRMP)
- Cover Performance
- Conclusions

Introduction: Facility Description



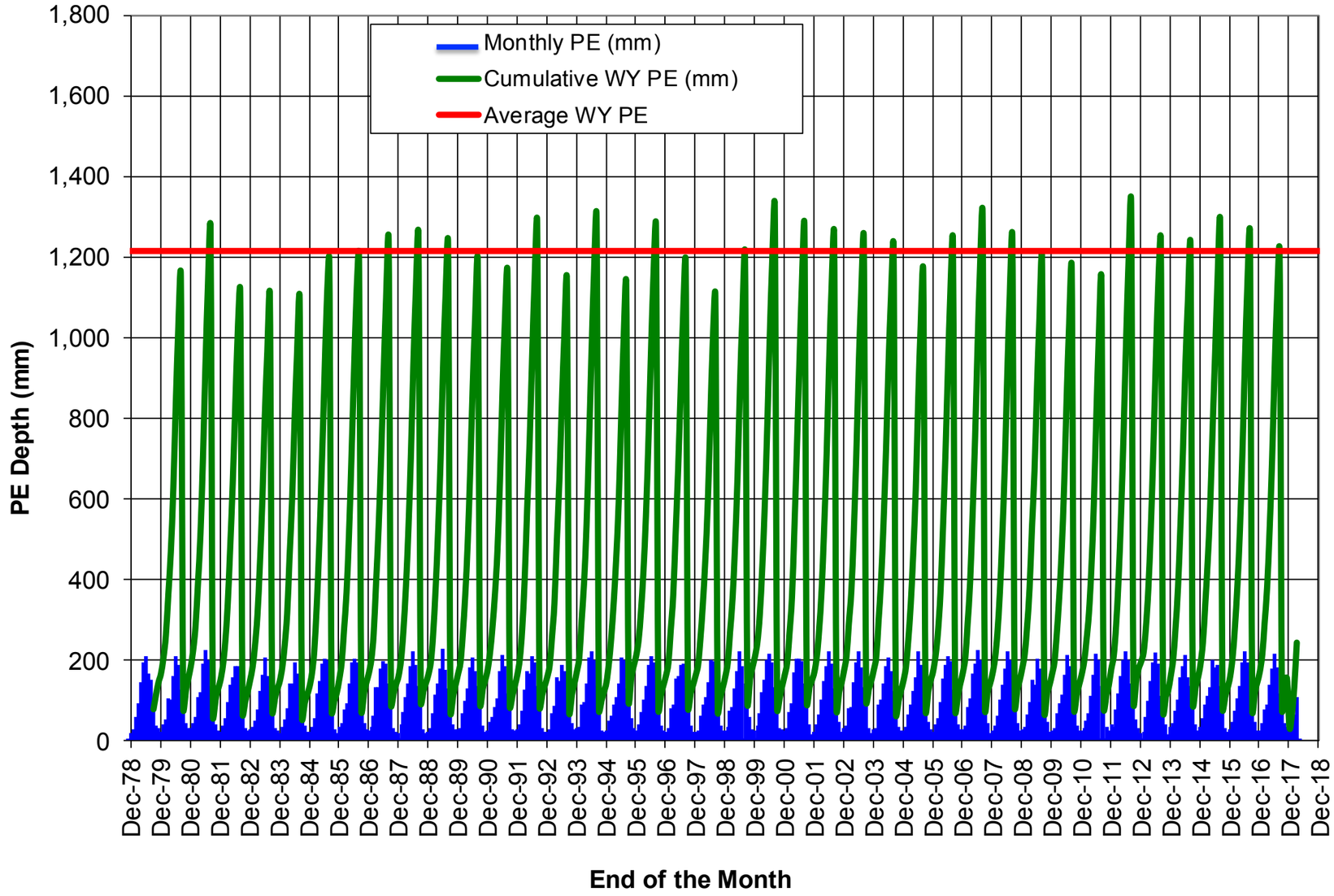
- Located in the north central Nevada, 61 km northwest of Elko, Nevada
- Operation started in 1987 with both open pits and underground mines
- Produced 1,306 tonnes (42 million ounces) of Gold
- 3 billion tonnes of waste rock produced thus far
- Waste rocks are placed in WRF, open pit and underground backfills, and tailings dams

Introduction: Climate Conditions (Precipitation)



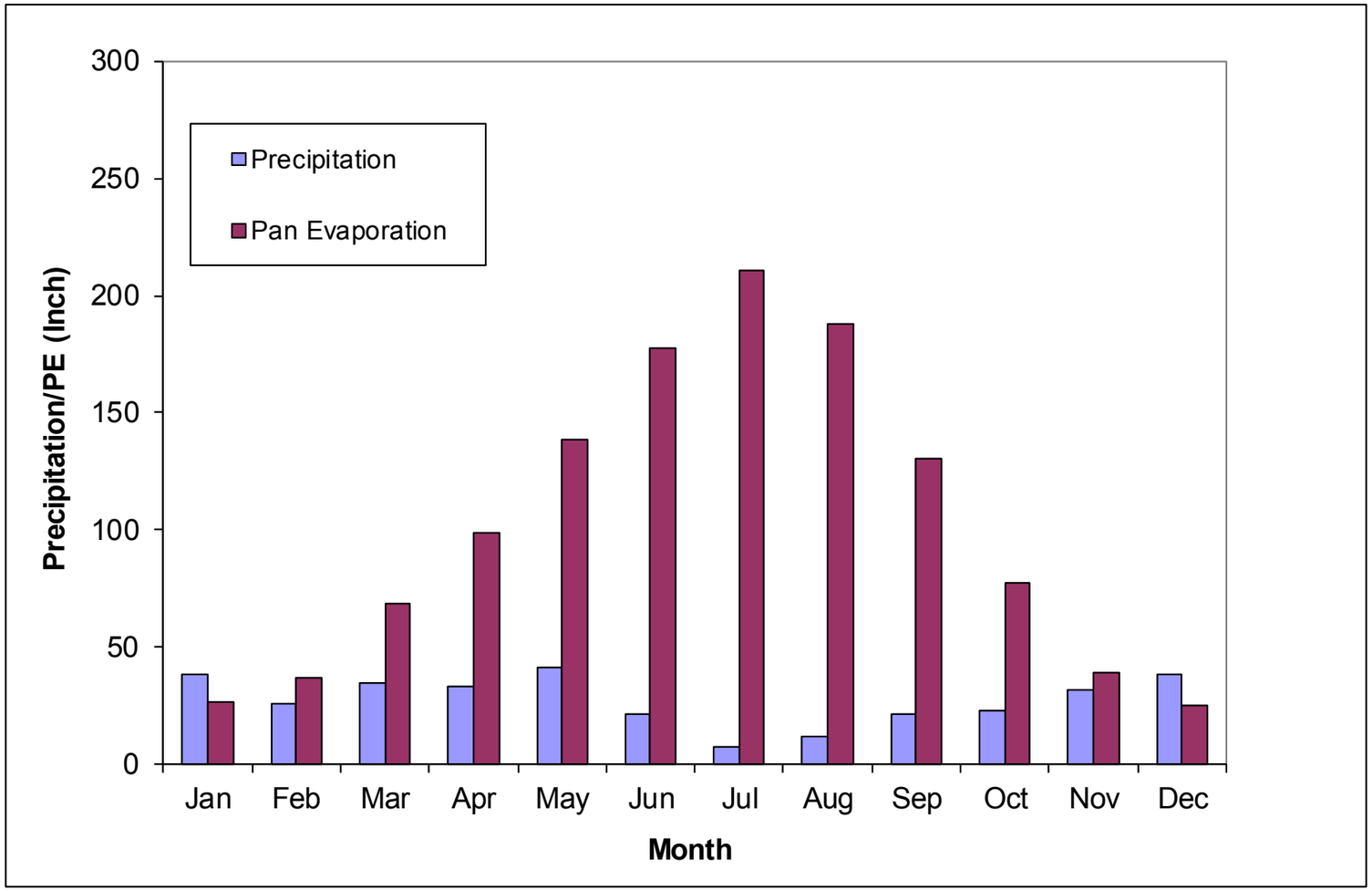
- Average Water Year (Oct – Sep) precipitation is 325 mm (215 – 480 mm)

Introduction: Climate Conditions (PET)



- Average Water Year (Oct – Sep) PET is 1,215 mm (with little difference)

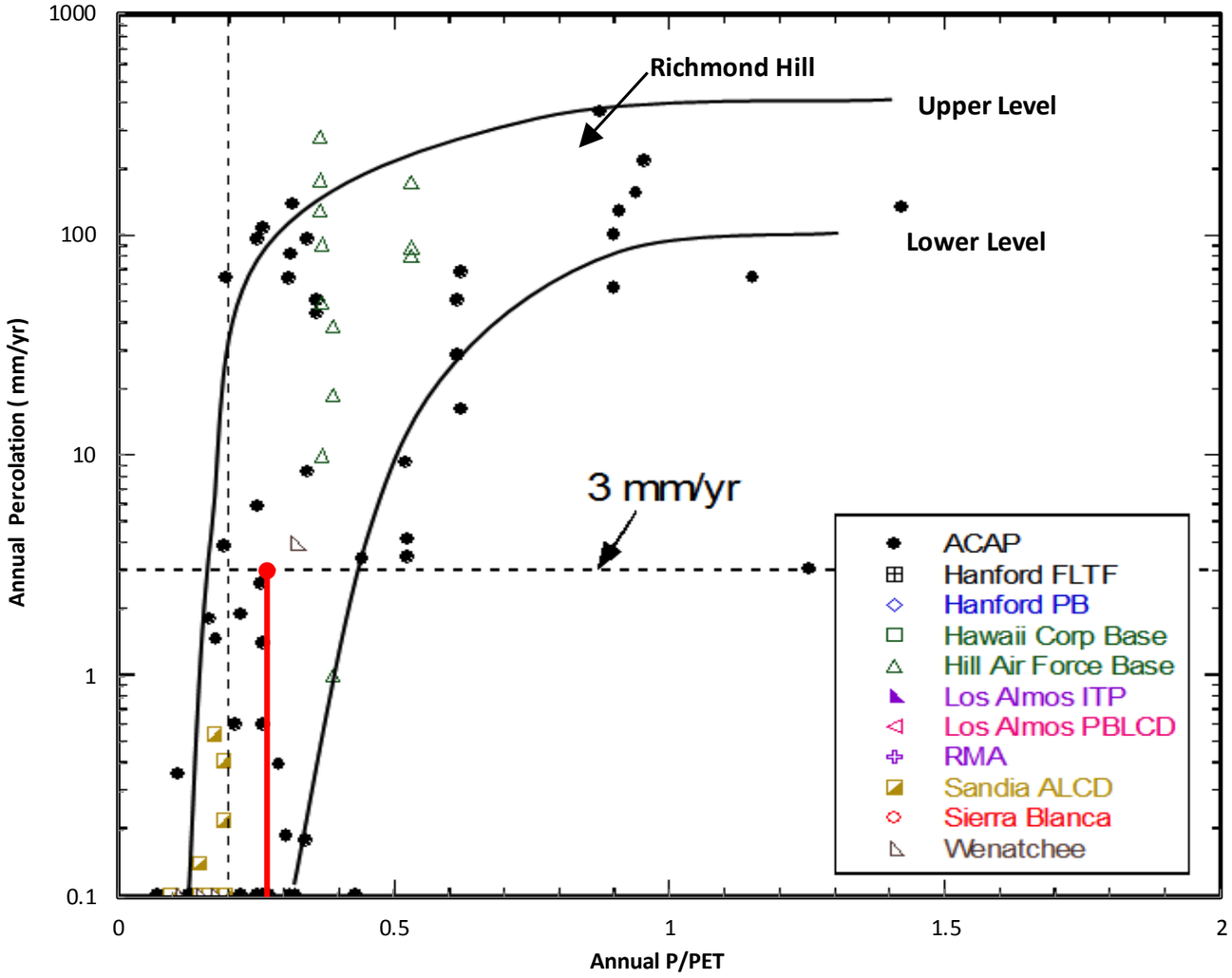
Introduction: Climate Conditions



Semi-arid region

- Average annual precipitation is 325 mm
- Average PET is 1,215 mm
- P/PET = 0.27 (or PET/P = 3.7)

Introduction: Climate Conditions



- P/PET = 0.27
- Cover system could effectively reduce percolation

Apiwantragoon P, Benson CH, Albright WH. 2015. Field Hydrology of Water Balance Covers for Waste Containment. J. Geotech. and Geoenvironmental Eng. 141 (2): 04014101-1-20. DOI: 10.1061/(ASCE)GT.1943-5606.0001195

WRMP: Geochemical Controls

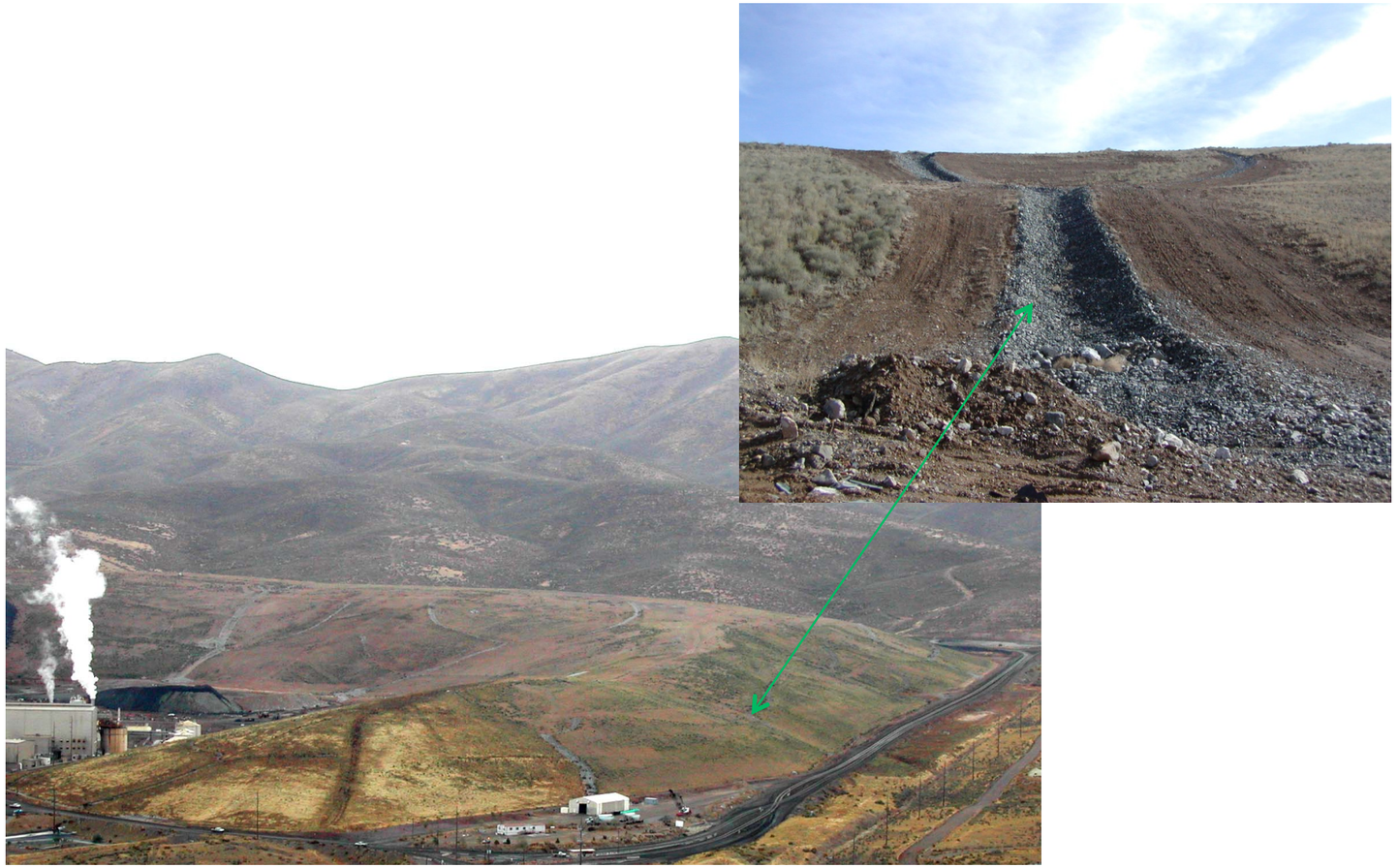
An extensive static and kinetic testing program was conducted to determine the balance of acid generation potential (AGP), acid neutralization potential (ANP), net neutralization potential (NNP, NNP = ANP-AGP):

- ~ 300,000 static tests
- Hundreds of kinetic humidity cell tests

PAG and non-PAG Separation criterion:

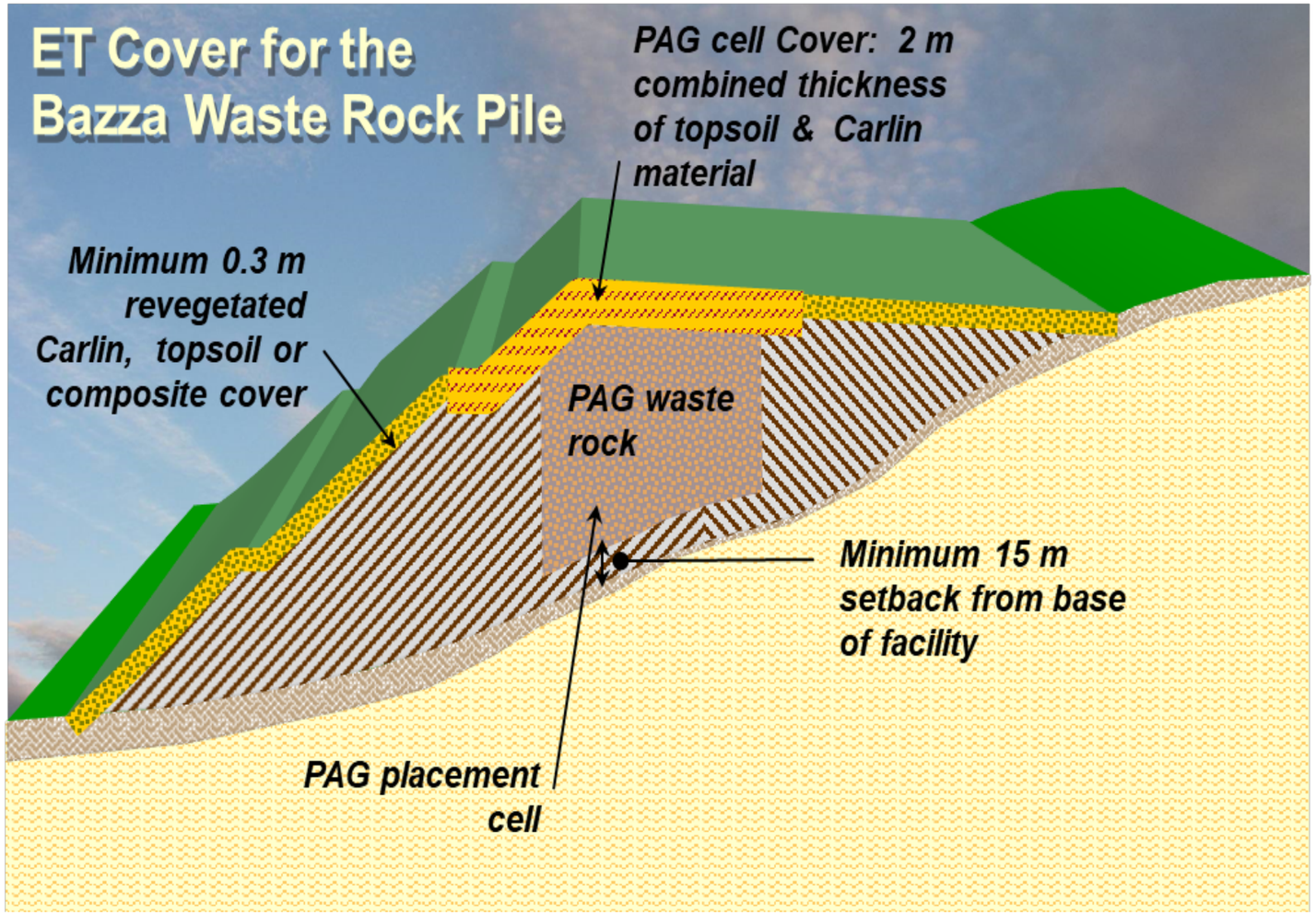
- PAG was defined as any non-ore material with NNP < 0 and greater than 0.3 % pyritic sulfur
- Non-PAG waste rock has NNP >0 or < 0.3 % pyritic sulfur

WRMP: Placement Controls



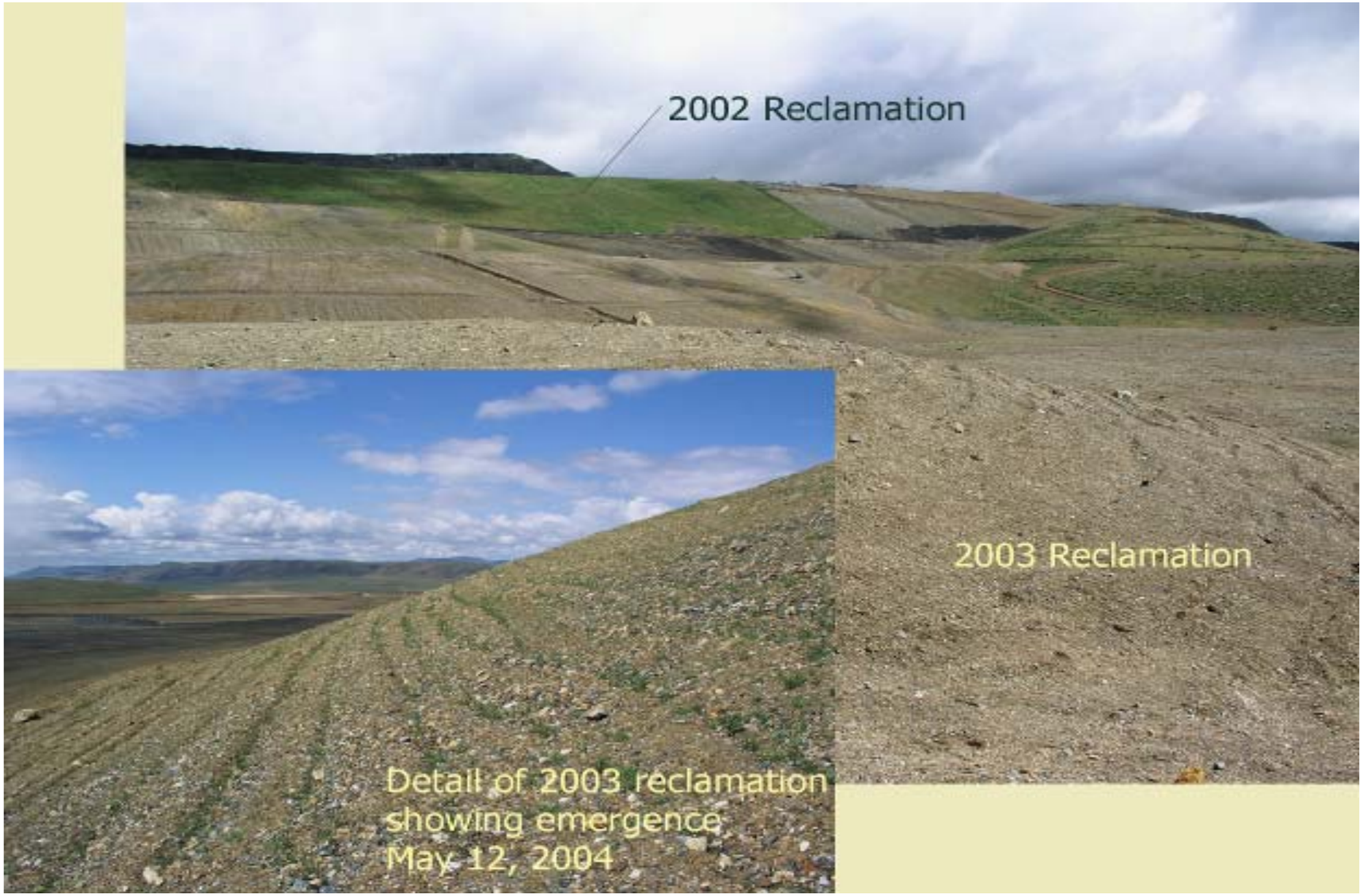
- Shaping the WRF to promote long-term geomorphic stability
- Integrating channel features into landforms to shorten runoff lengths
- Sizing channels and placing channel bed materials to promote runoff, long-term stability and reduce erosion
- Placing a soil cover that incorporates high water holding capacity and includes capillary breaks to reduce net infiltration of water and oxygen
- Establishment of perennial vegetation to meet post-mining land use objectives

WRMP: Placement Controls



- Use of a topsoil/Carlin cover to reduce or eliminate infiltration of water and oxygen
- Design of a thick cover system consisting of 2 m placed over PAG cells
- Use of a minimum of 0.30 m of cover for non-PAG areas
- Waste rock is selectively handled to avoid placement of PAG rock in the lower 15 m of the waste rock facility

WRMP: Concurrent Reclamation



Cover Performance: Vegetation

- Plant cover is 52% with 44% being derived from perennial species
- stable slopes and a sustainable plant community
- There was little to no erosion observed

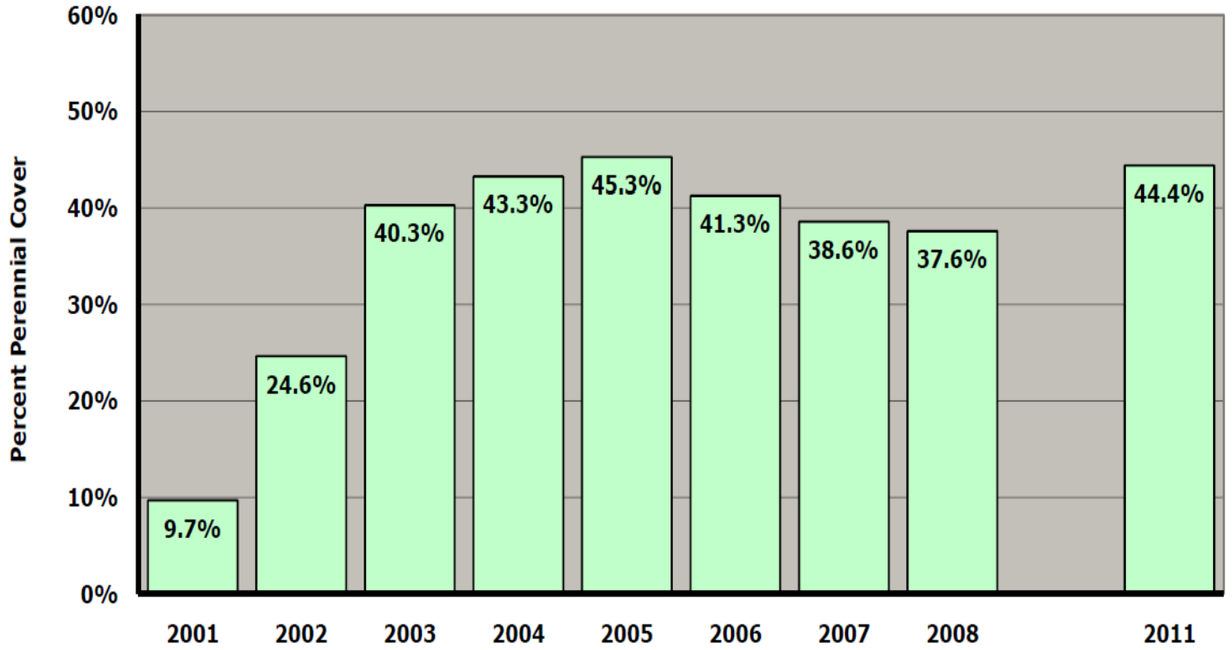


TABLE 1. Vegetation seed mix used for reclamation of the BGMI WRF.

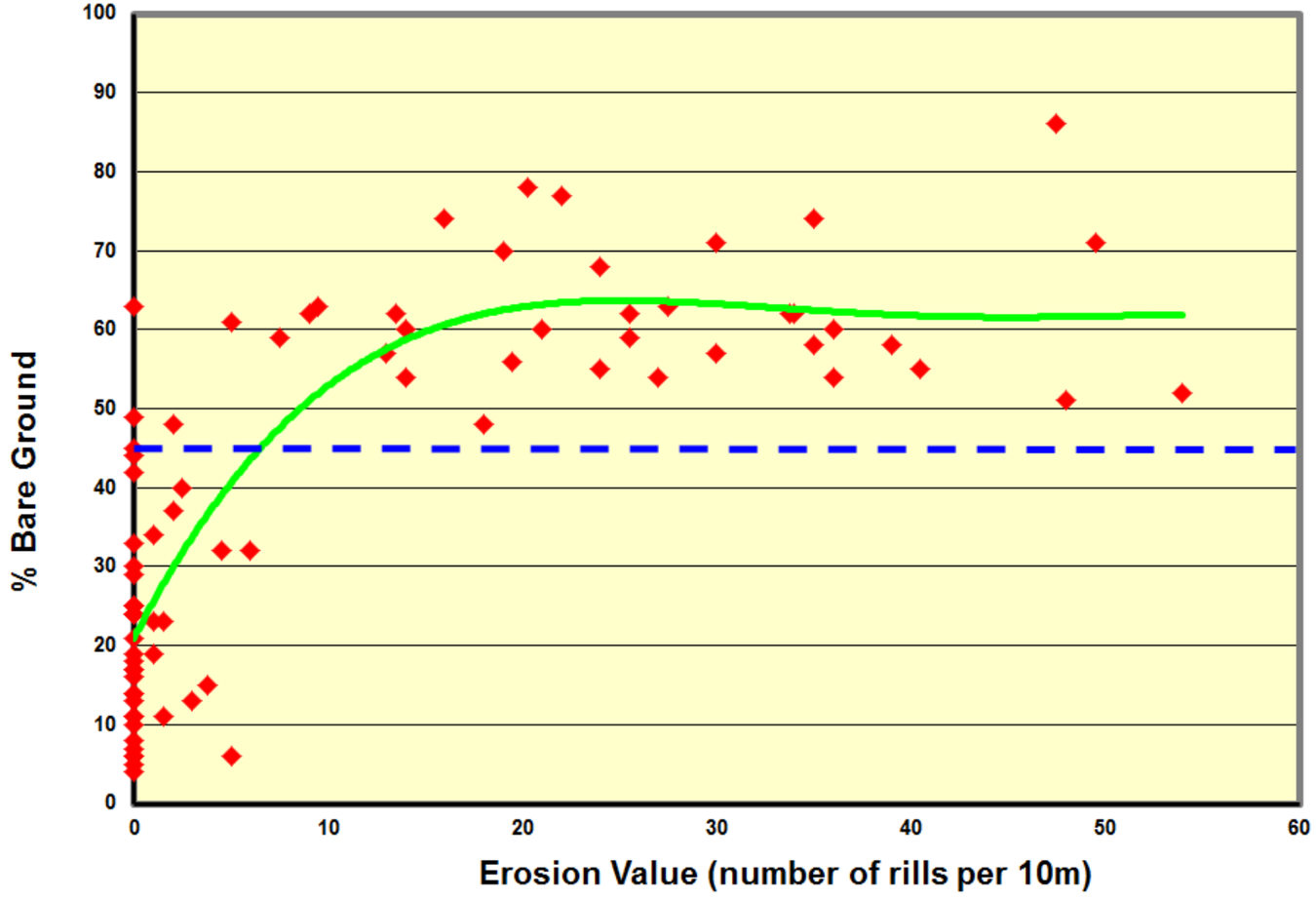
Perennial Grasses	***Forbs***	***Shrubs***
Great Basin Wildrye	Lewis Flax	Fourwing Saltbrush
Bluebunch Wheatgrass	Palmer Penstemon	Winterfat
Crested Wheatgrass	Small Burnet	Wyoming Big Sagebrush
Thickspike Wheatgrass	Forage Kochia	
Big Bluegrass		***Annual Nurse Crop***
Sandberg Bluegrass		Regreen (sterile Triticum x
Indian Ricegrass		Agropyron cross)

Cover Performance: Vegetation

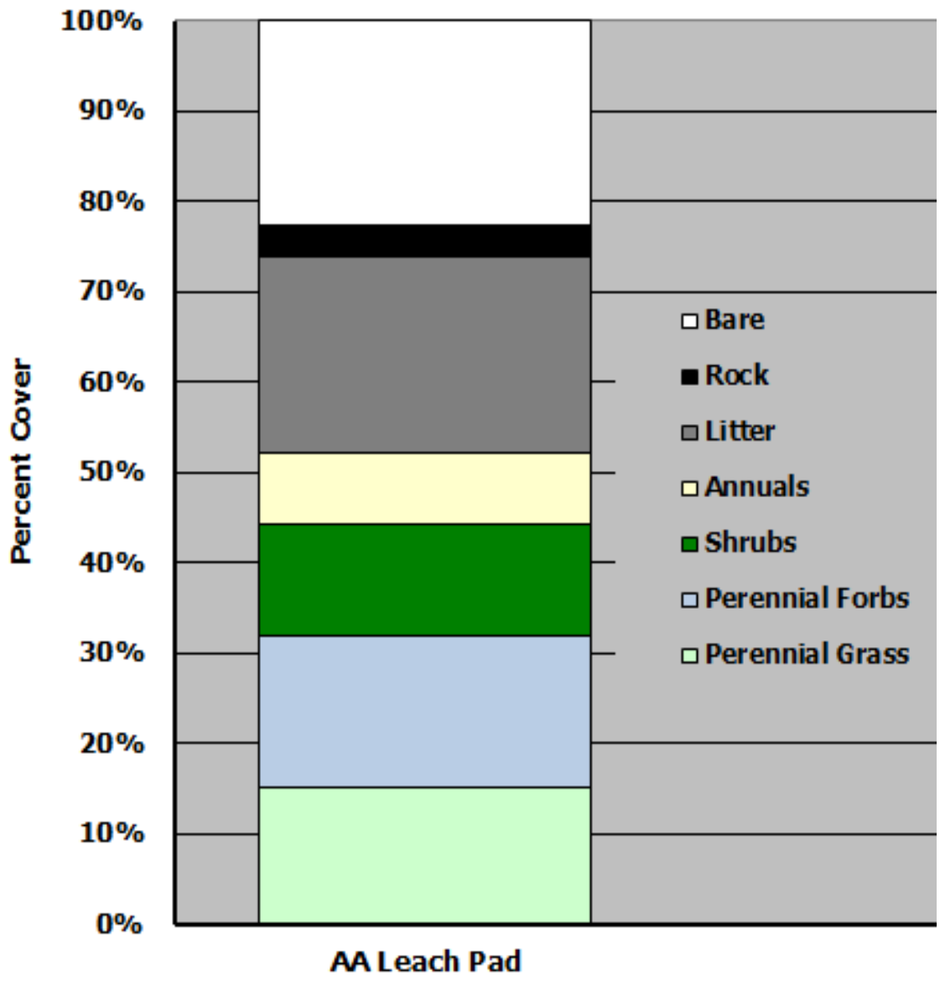
Grass and shrub cover on AA pad in 2001 - first year after seeding

Grass and shrub cover on AA pad in 2004 – four year after seeding

Cover Performance: Erosion vs. Bare Ground

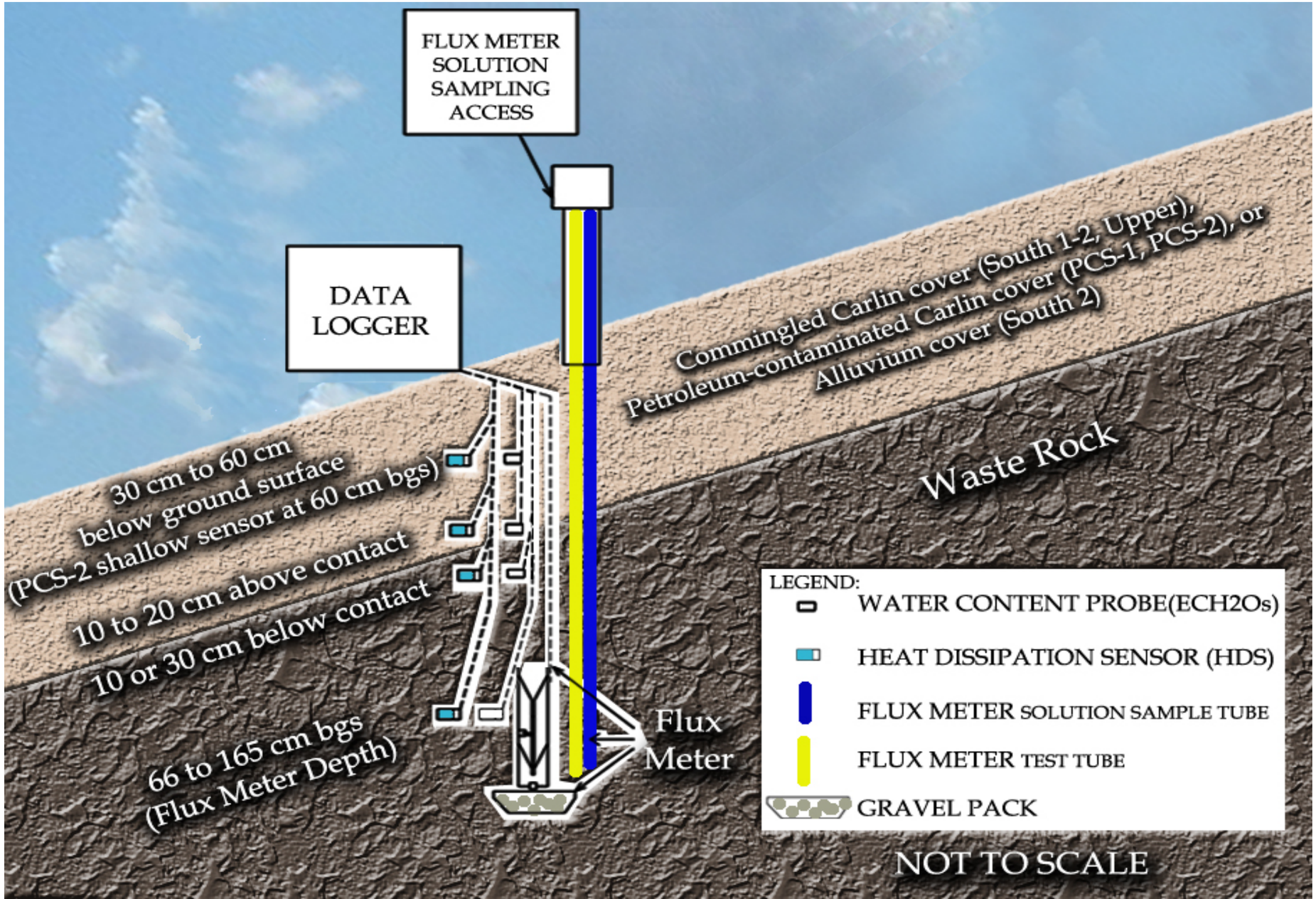


Average Coverage

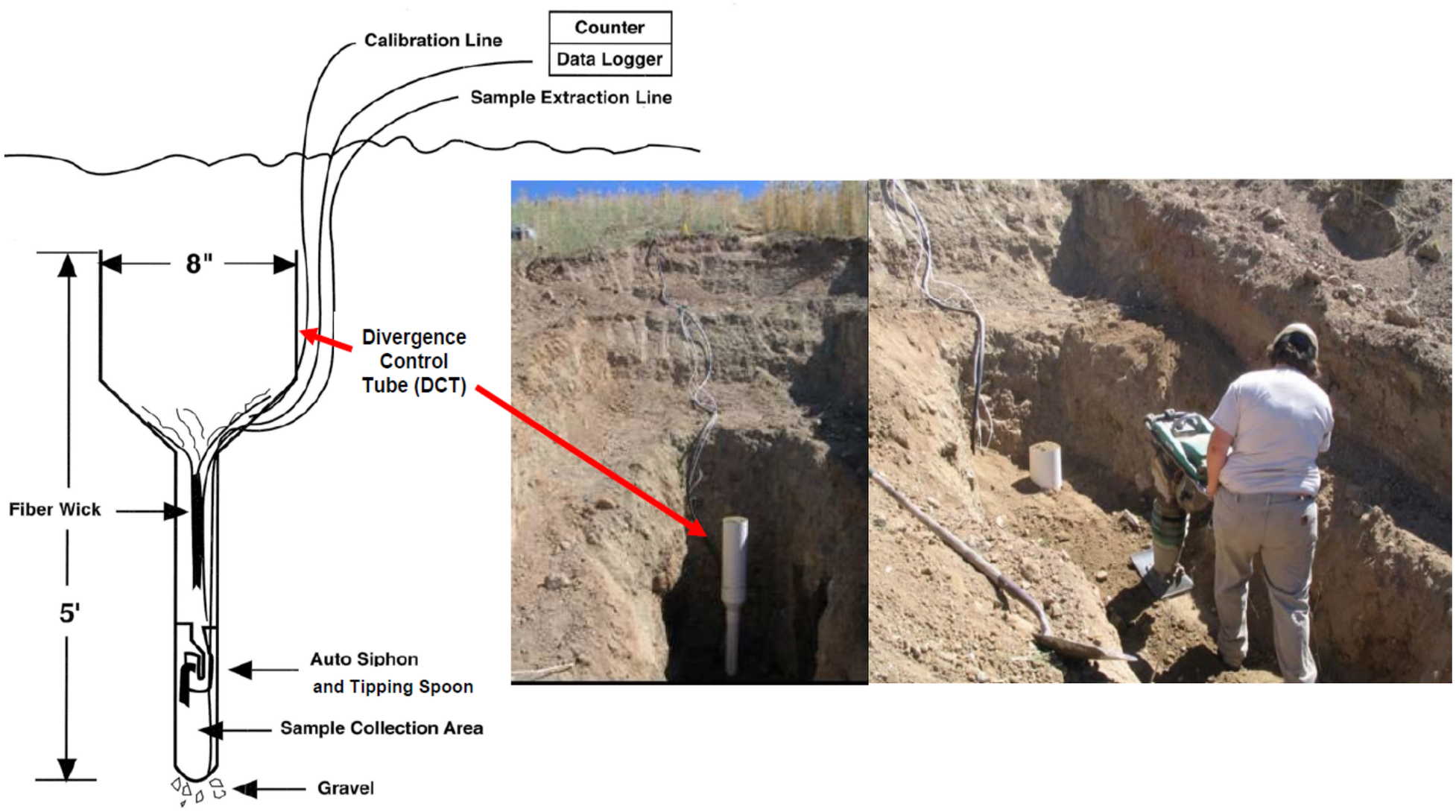


Cover Performance: Monitoring Locations

Cover Performance: Monitoring Profiles



Cover Performance: Monitoring (Water Flux Meter)



Cover Performance: Monitoring (In-Situ K_s)

Cover Performance: Net Percolation Evaluation

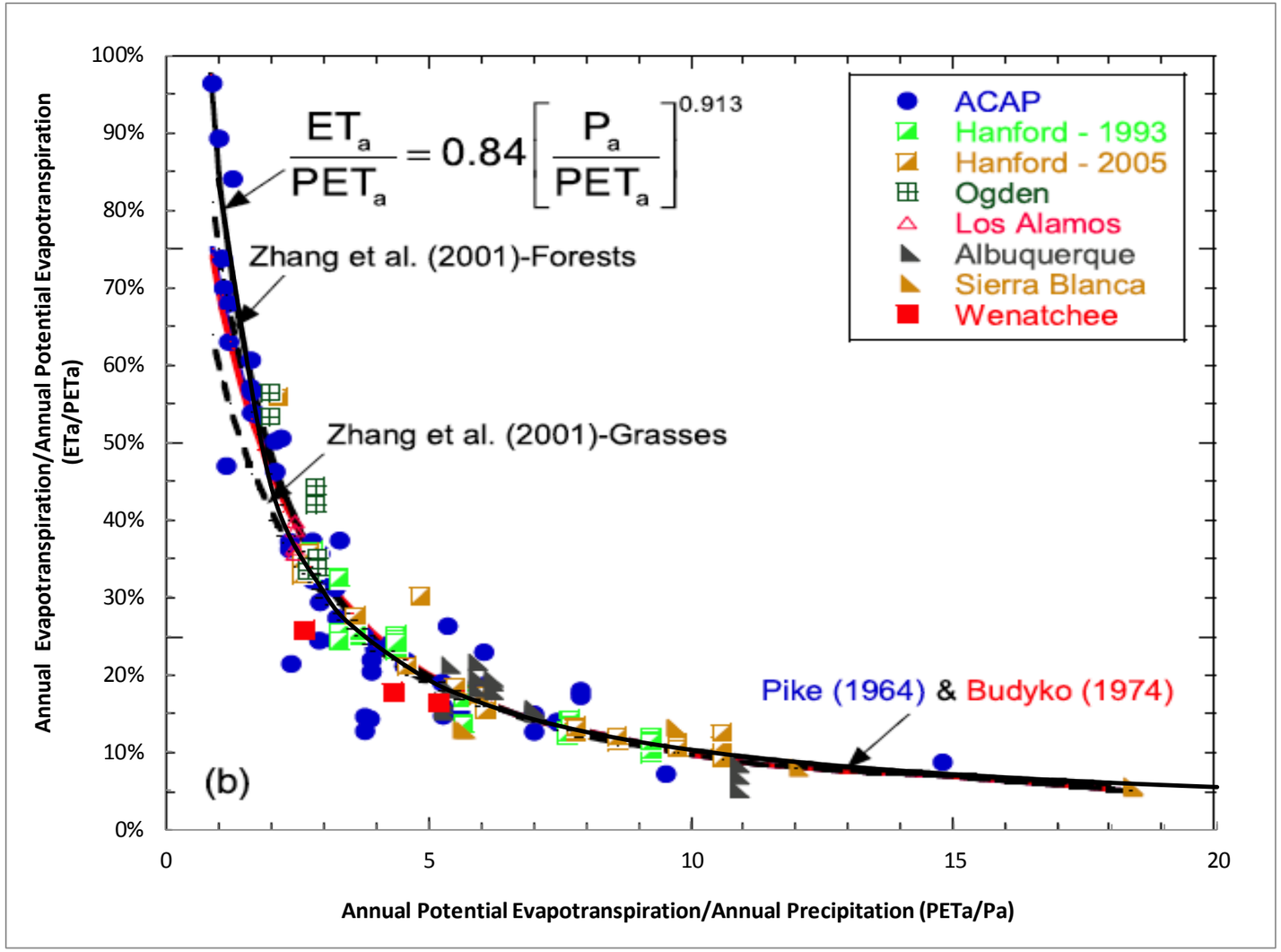
- Matric potential-based (MPB): Estimated for each monitoring station by calculating the one-dimensional vertical flux, using matric potential data measured from the two deepest functional HDSs combined with moisture retention characteristic and saturated and unsaturated hydraulic conductivity values

- Direct measured: Recorded by Water Flux Meters

Cover Performance: Net Percolation Results

- Average annual MPB net flux (2004-now) was approximately 11 mm (~ 3% of precipitation). Flux is low in most areas, with the greatest downward flux occurring during spring rains and snowmelt
- The average annual WFM-measured flux of all stations was 20 mm (~ 6% of precipitation)
- High percolation initially at several stations, as measured by WFM or as calculated by MPB, have decreased over time
- Observed decreases in flux with time may be due to vegetation mature
- Percolation flux only occurred during wet water years

Cover Performance: Net Percolation Results



Expected

- PET/P = 3.7
- ET/PET = 25%
- ET = 0.25 x 1,215 = 310 mm
- Percolation = P – ET = 325 – 310 = 15 mm

Observed

- 11 mm (MPB-Calculated) or 20 mm (WFM-measured)

Expected = Observed

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Conclusions

- The cover system proposed for the WRF at Goldstrike is expected to reduce deep percolation through the cover in the PAG cells to less < 20 mm/yr, comparable with natural groundwater recharge
- Deep percolation would flow into a thick mass of waste rock that is drier than field capacity, which would eliminate migration into unsaturated foundation materials until field capacity is reached
- If any seepage were to exit the WRF PAG cells in the long term, the underlying aquifer materials and groundwater are strongly alkaline and would tend to neutralize the small quantity of PAG impacted seepage
- After closure groundwater beneath the WRF mostly flows toward the open pit where the contribution of a small amount of waste rock seepage is not expected to have measurable effect on long-term water quality of the pit lake