# Groundwater Modeling to Support Water Management Decisions in Clarkdale, Arizona

PRESENTED AT THE UA WATER RESOURCES RESEARCH CENTER

BY

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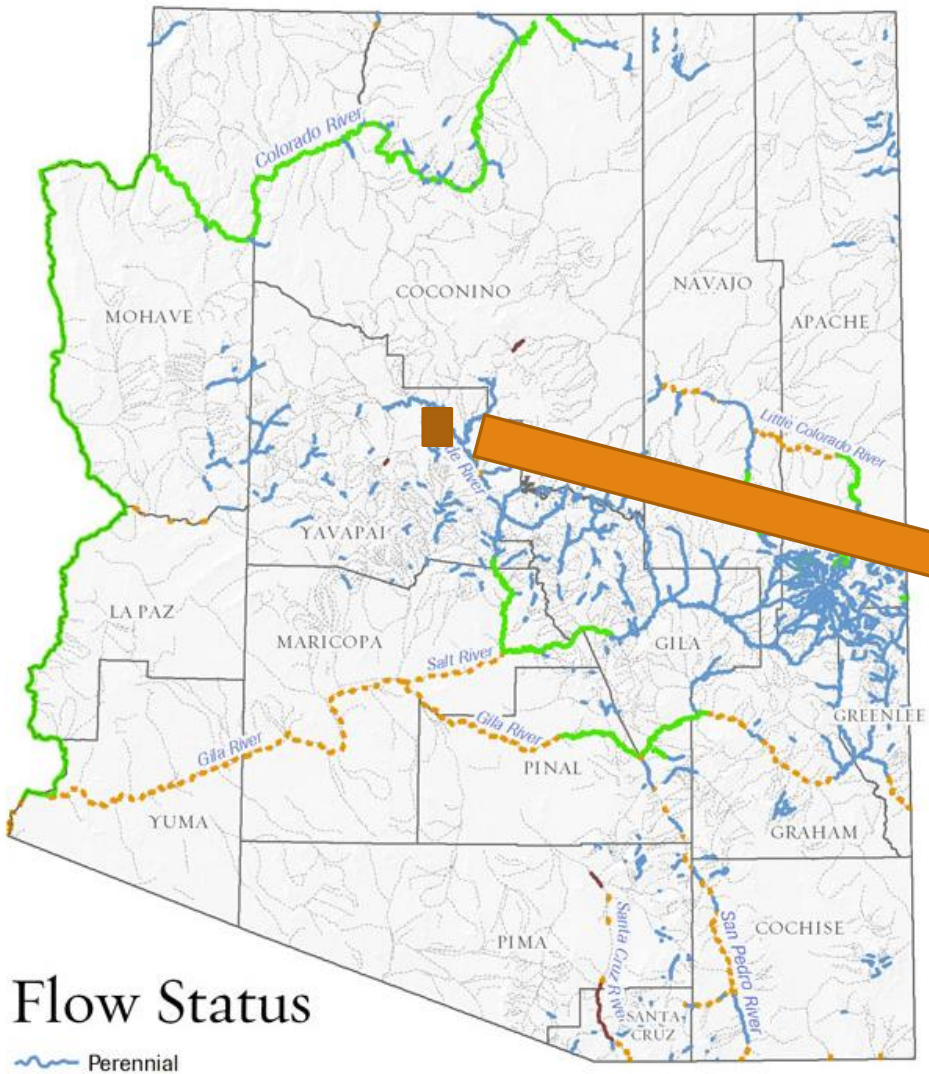
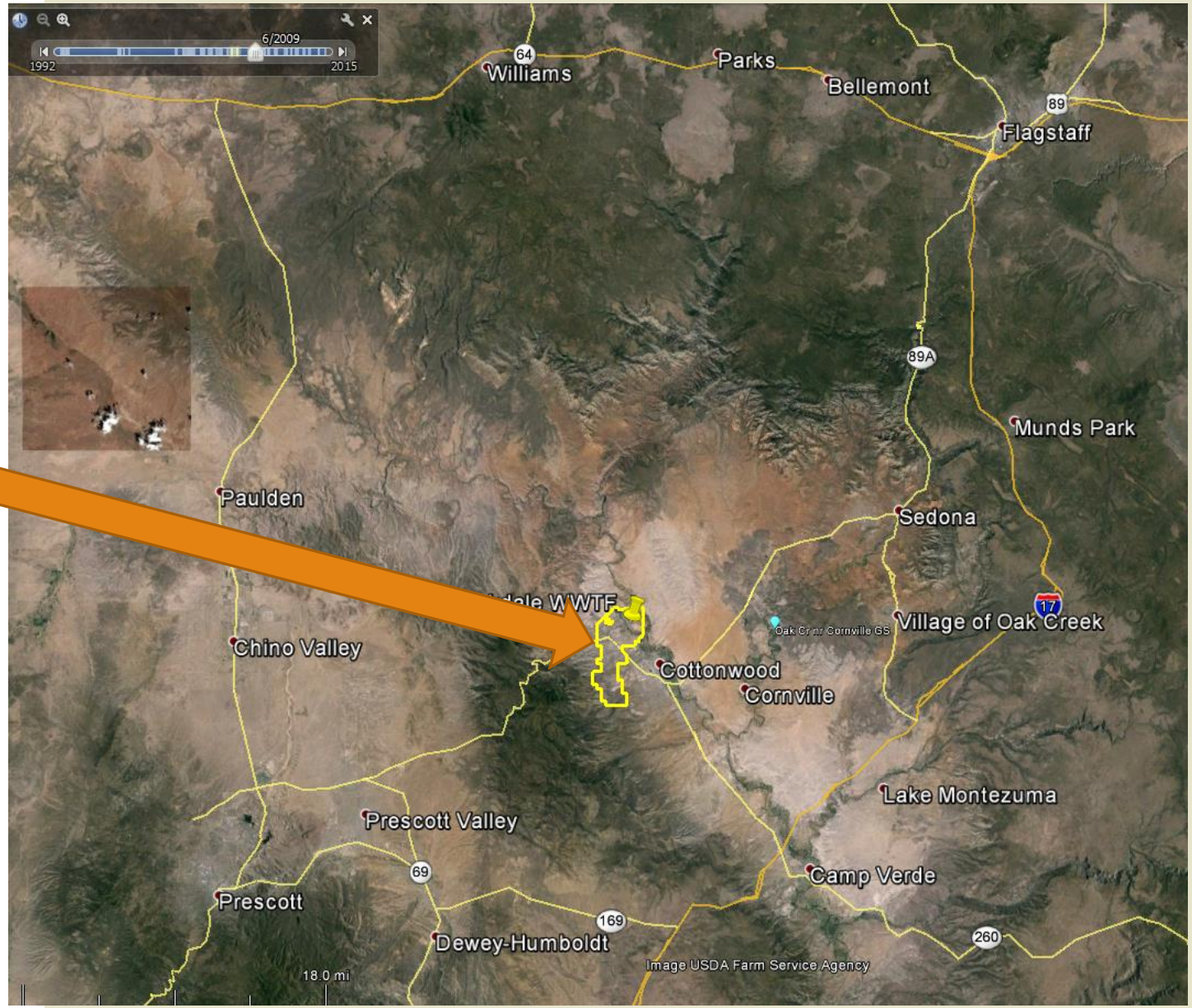
SEPTEMBER 21, 2016


Colorado River
COCONINO
NAVAJO
APACHE
MOHAVE
Little Colorado River
YAVAPAI
LA PAZ
MARICOPA
Salt River
GILA
GREENLEE
Gila River
PINAL
YUMA
GRAHAM
PIMA
COCHISE
Santa Cruz River
San Pedro River
SANTA CRUZ
Flow Status
Perennial
Formerly Perennial
Regulated
Effluent Dominated (May Be Formerly Perennial)
Intermittent or Ephemeral
The Nature Conservancy
Protecting nature. Preserving life.
Flow status data created from TNC Freshwater Assessment, available from azconservation.org

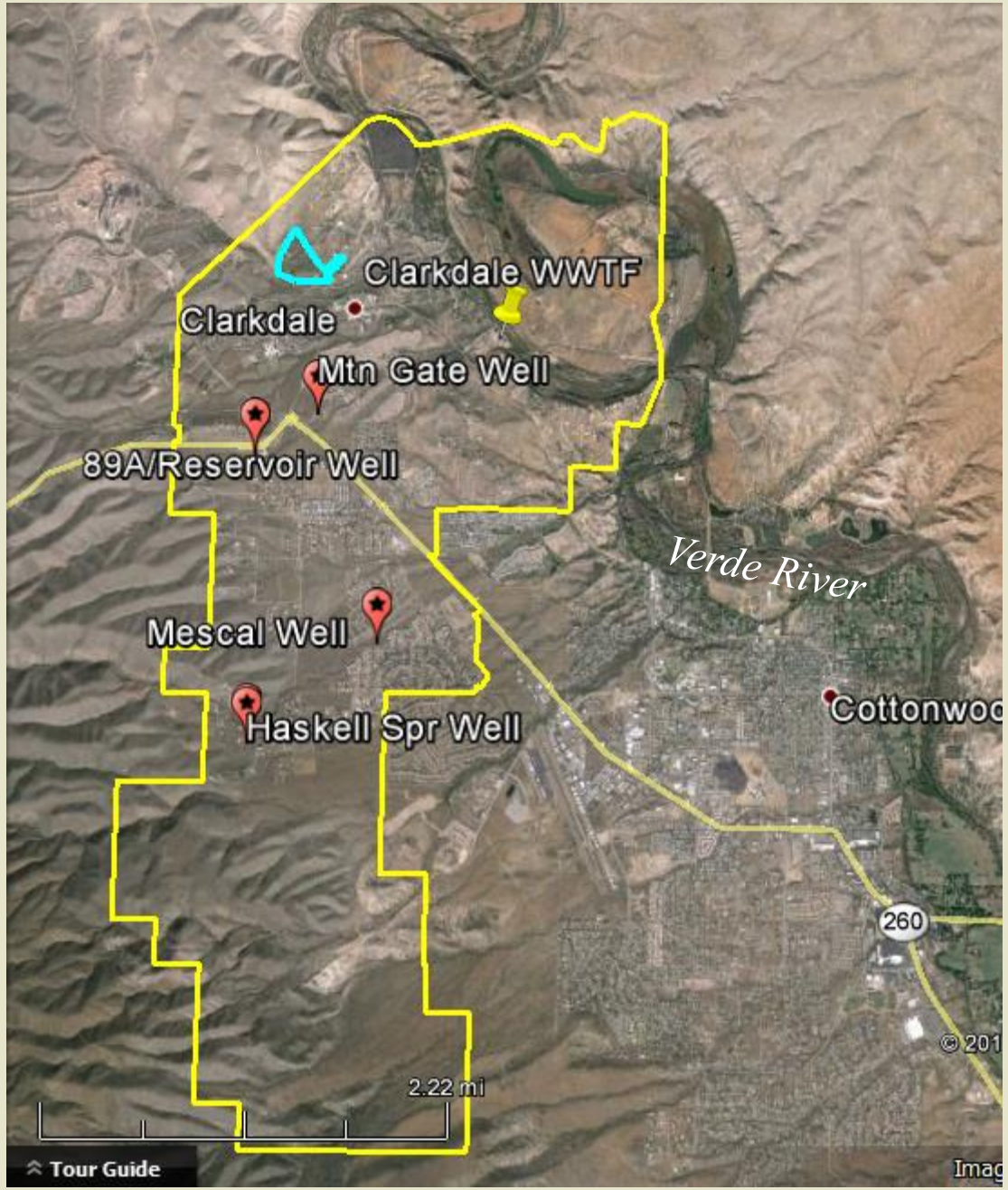

6/2009
1992
2015
Williams
Parks
Bellemont
Flagstaff
Munds Park
Sedona
Paulden
Chino Valley
Cottonwood
Cornville
Village of Oak Creek
Prescott Valley
Prescott
Dewey-Humboldt
Lake Montezuma
Camp Verde
18.0 mi
Image USDA Farm Service Agency

# Verde River Greenway

*photo source: verderivergreenway.org*

*photo courtesy of Doug von Gausig*

*photo courtesy of Doug von Gausig*

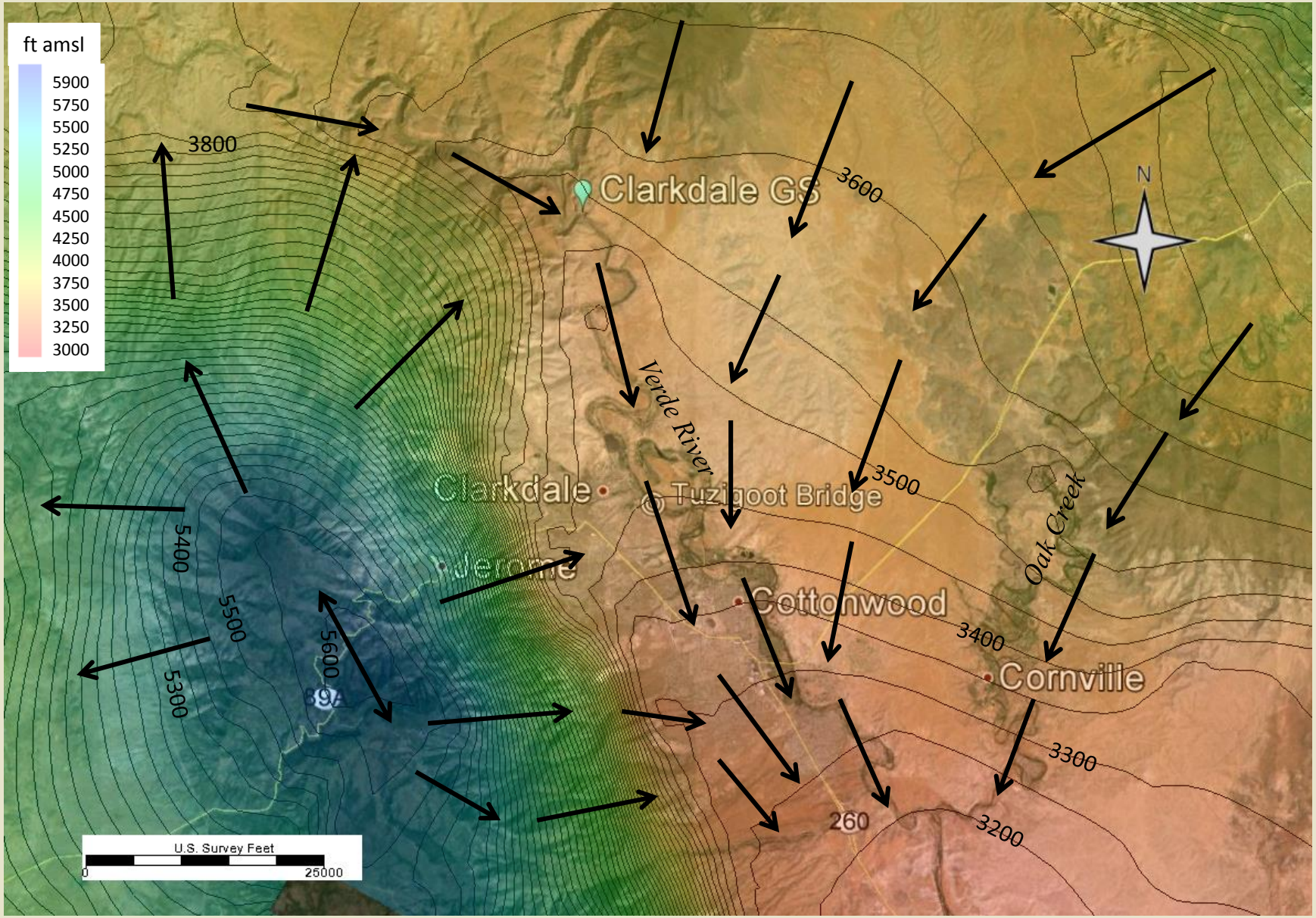



## Clarkdale, Arizona

- Population: 4,165
- 100% Groundwater-dependent
- Groundwater mining environment
- Class A+ Effluent

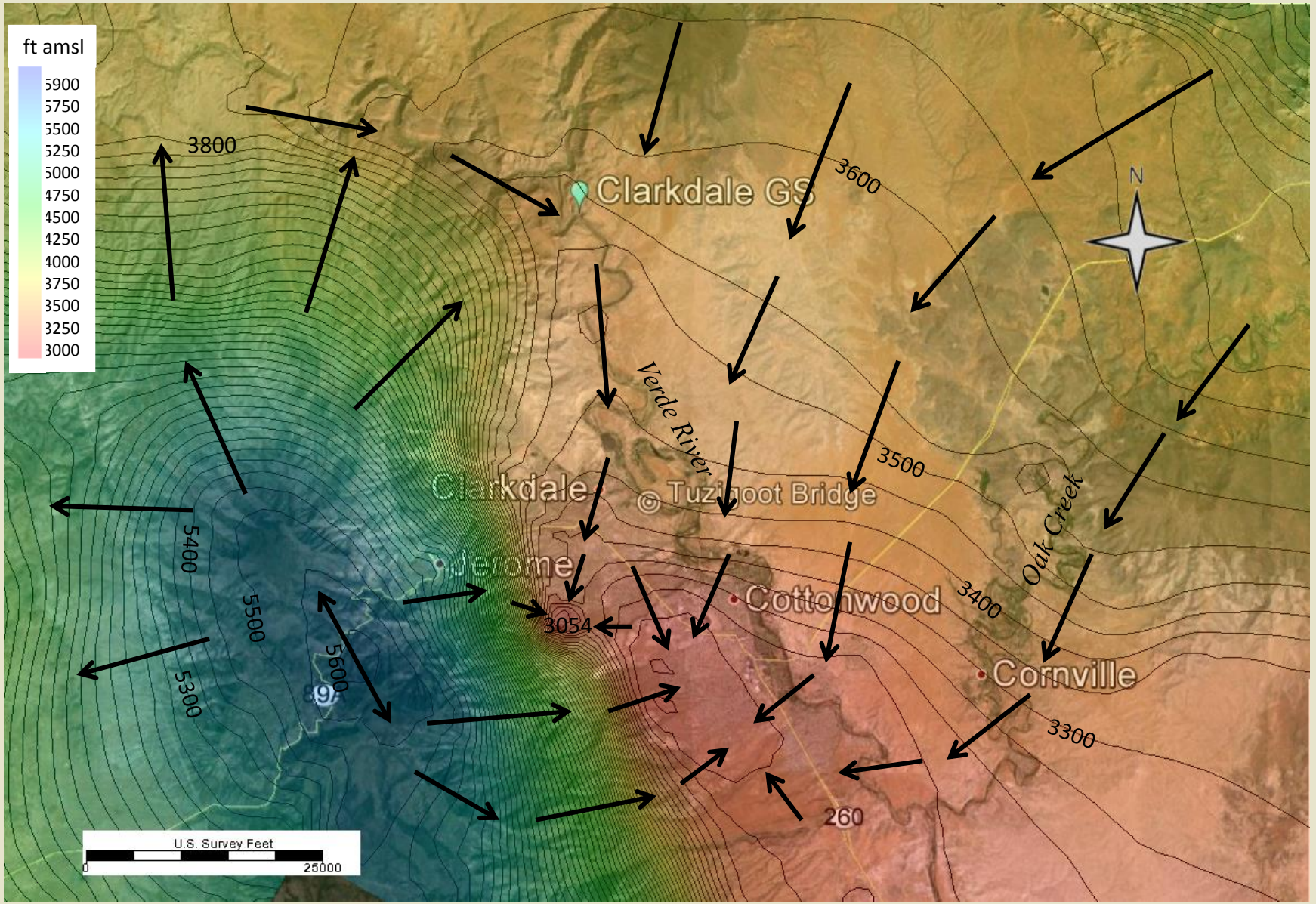
# Simulated Heads and Flow Paths – 1910

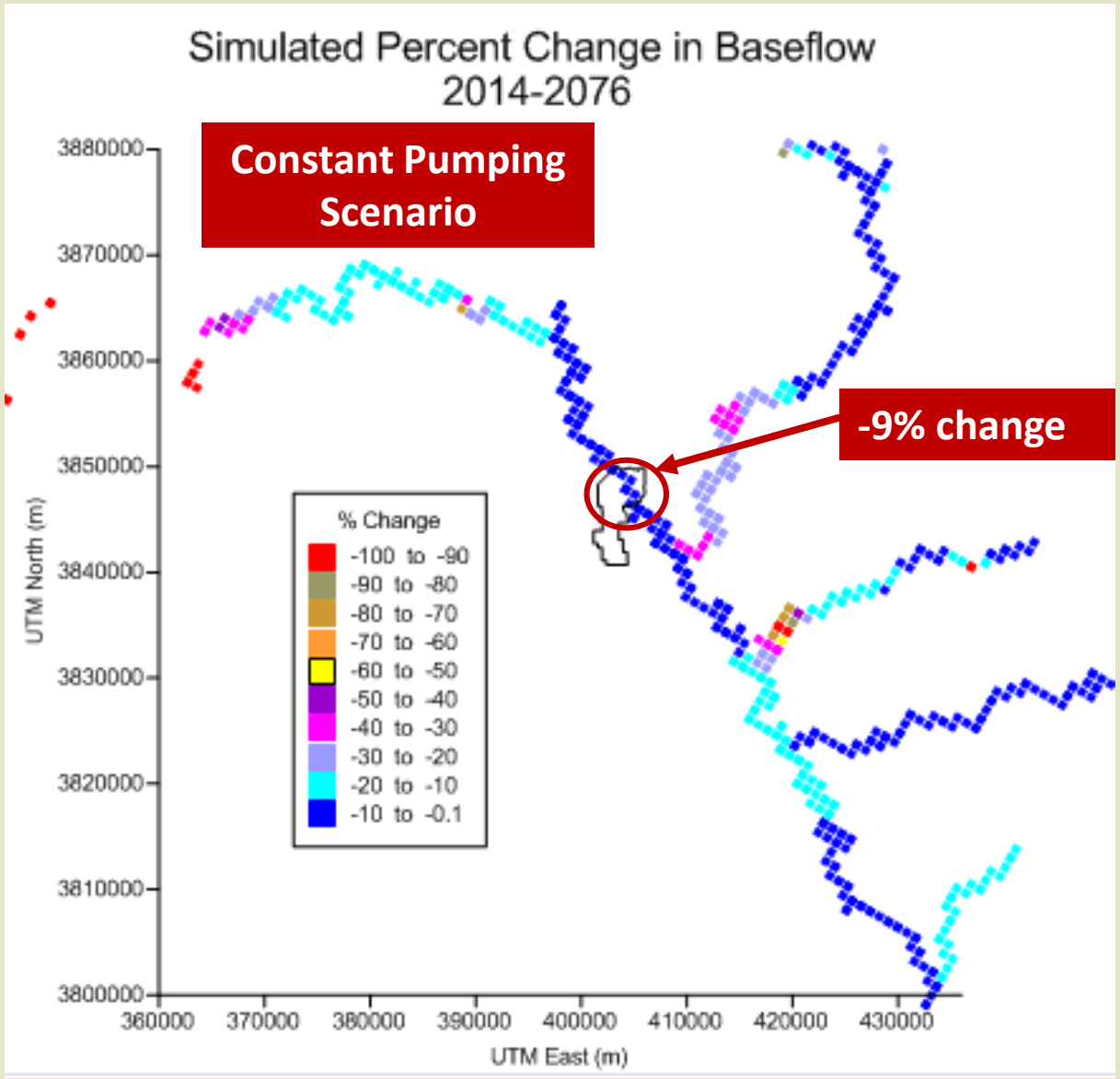
contour interval = 50 ft.

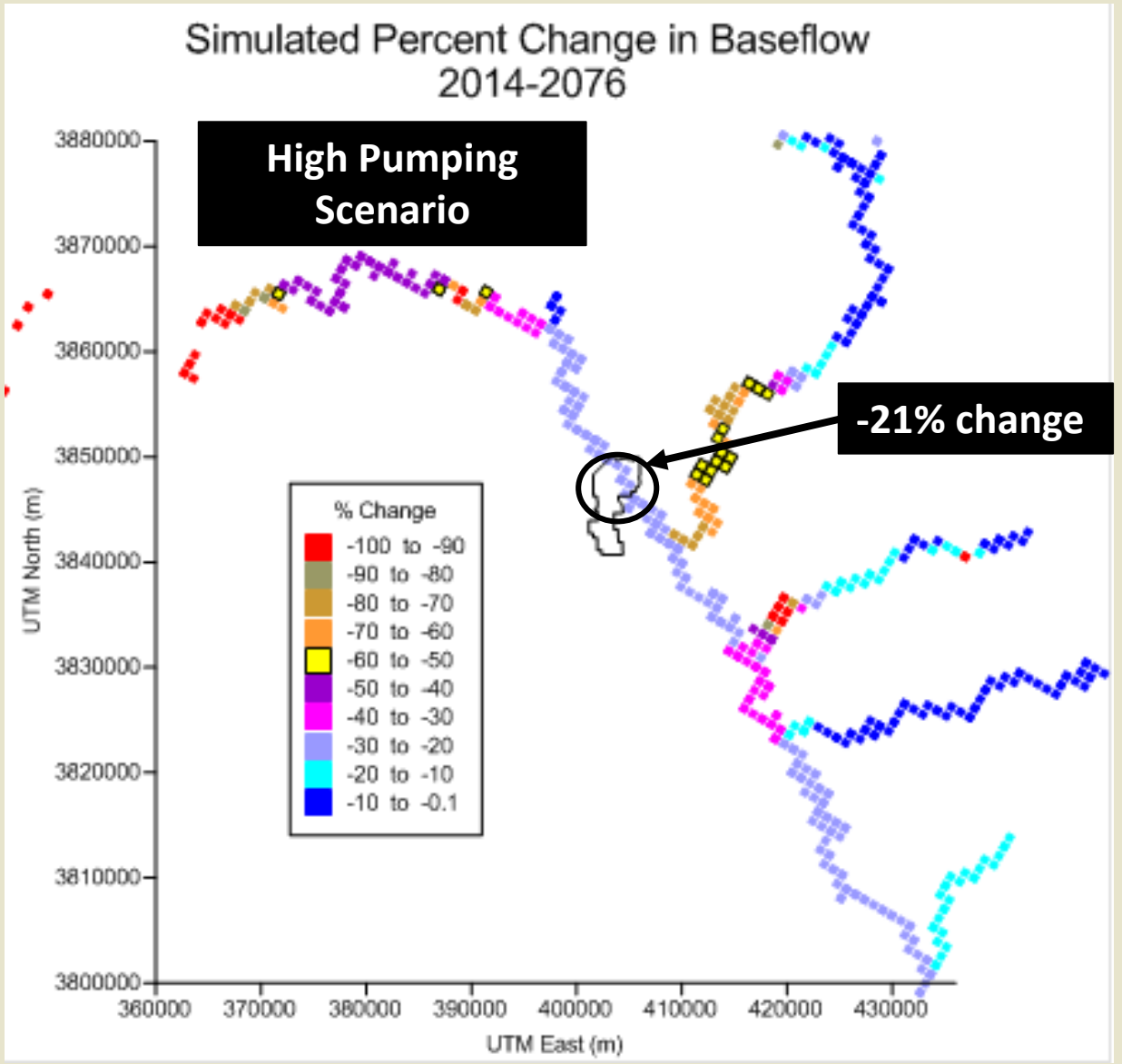


# Simulated Heads and Flow Paths – 2076

contour interval = 50 ft.

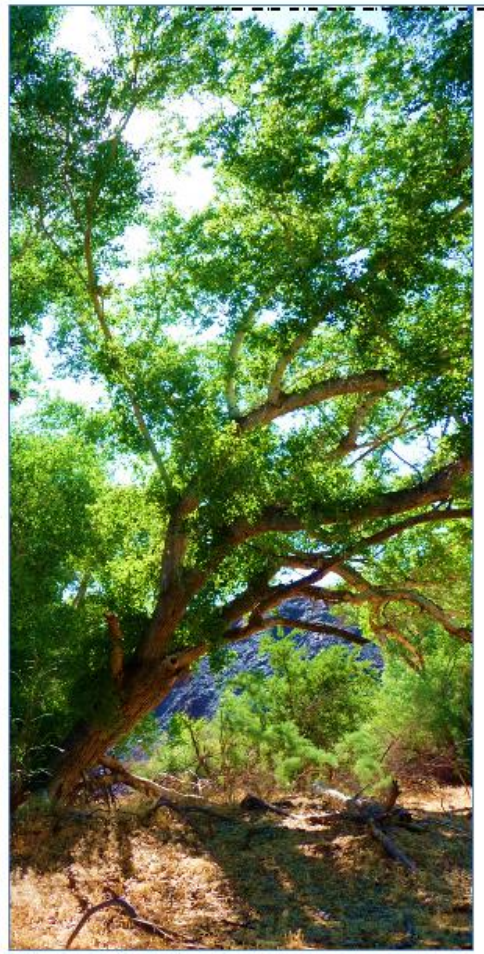



Simulated Percent Change in Baseflow
2014-2076
Constant Pumping Scenario
-9% change
% Change
-100 to -90
-90 to -80
-80 to -70
-70 to -60
-60 to -50
-50 to -40
-40 to -30
-30 to -20
-20 to -10
-10 to -0.1
UTM North (m)
UTM East (m)
3880000
3870000
3860000
3850000
3840000
3830000
3820000
3810000
3800000
360000
370000
380000
390000
400000
410000
420000
430000


Simulated Percent Change in Baseflow
2014-2076
High Pumping Scenario
-21% change
% Change
-100 to -90
-90 to -80
-80 to -70
-70 to -60
-60 to -50
-50 to -40
-40 to -30
-30 to -20
-20 to -10
-10 to -0.1
UTM North (m)
UTM East (m)
3880000
3870000
3860000
3850000
3840000
3830000
3820000
3810000
3800000
360000
370000
380000
390000
400000
410000
420000
430000

# Preconception:

Pumping-related stream depletions should be mitigated with near-stream recharge (MAR)

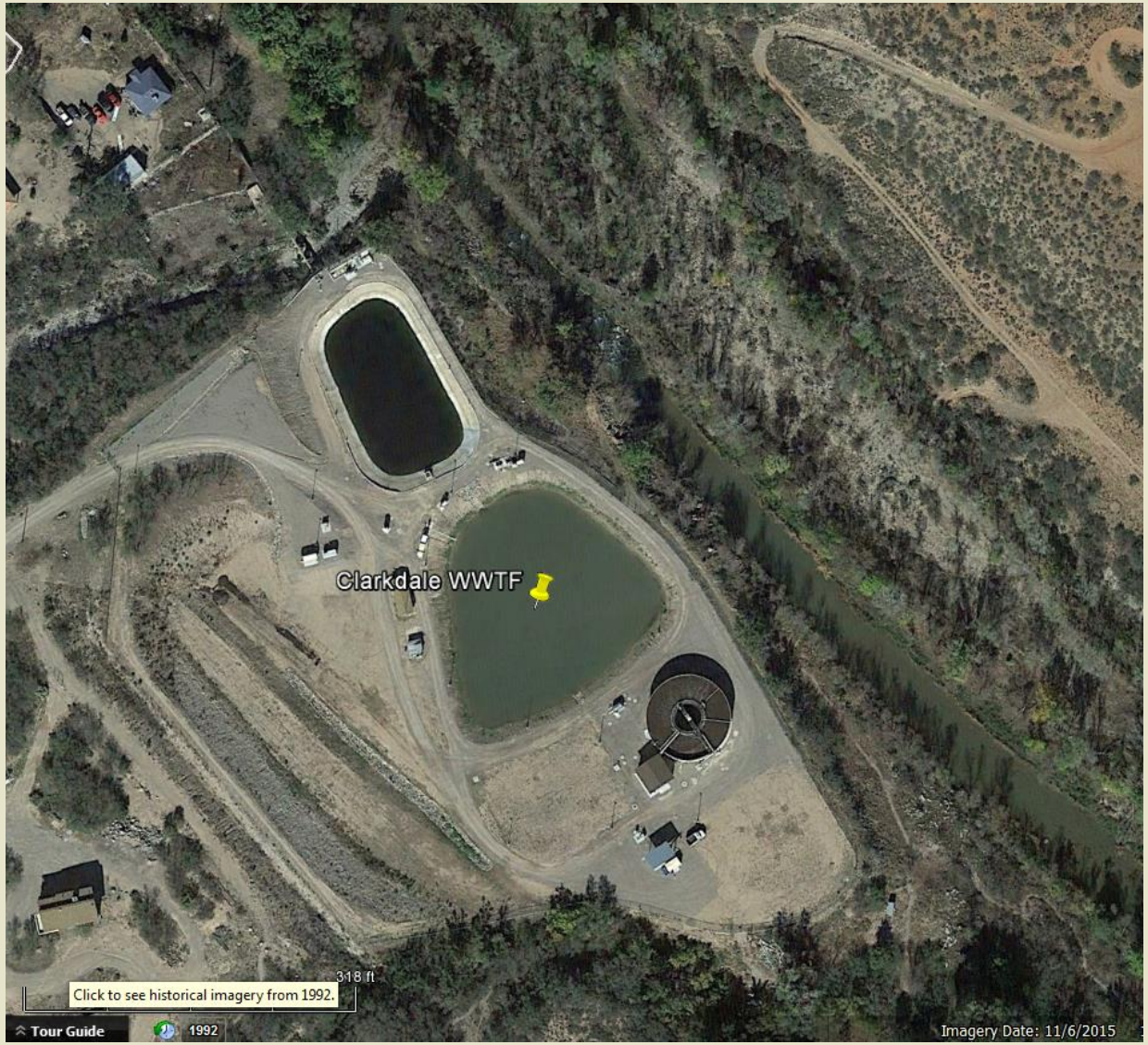


Clarkdale's

*Sustainable Community & Economic Development Plan*

July 2013

Accepted by Town Council June 25, 2013



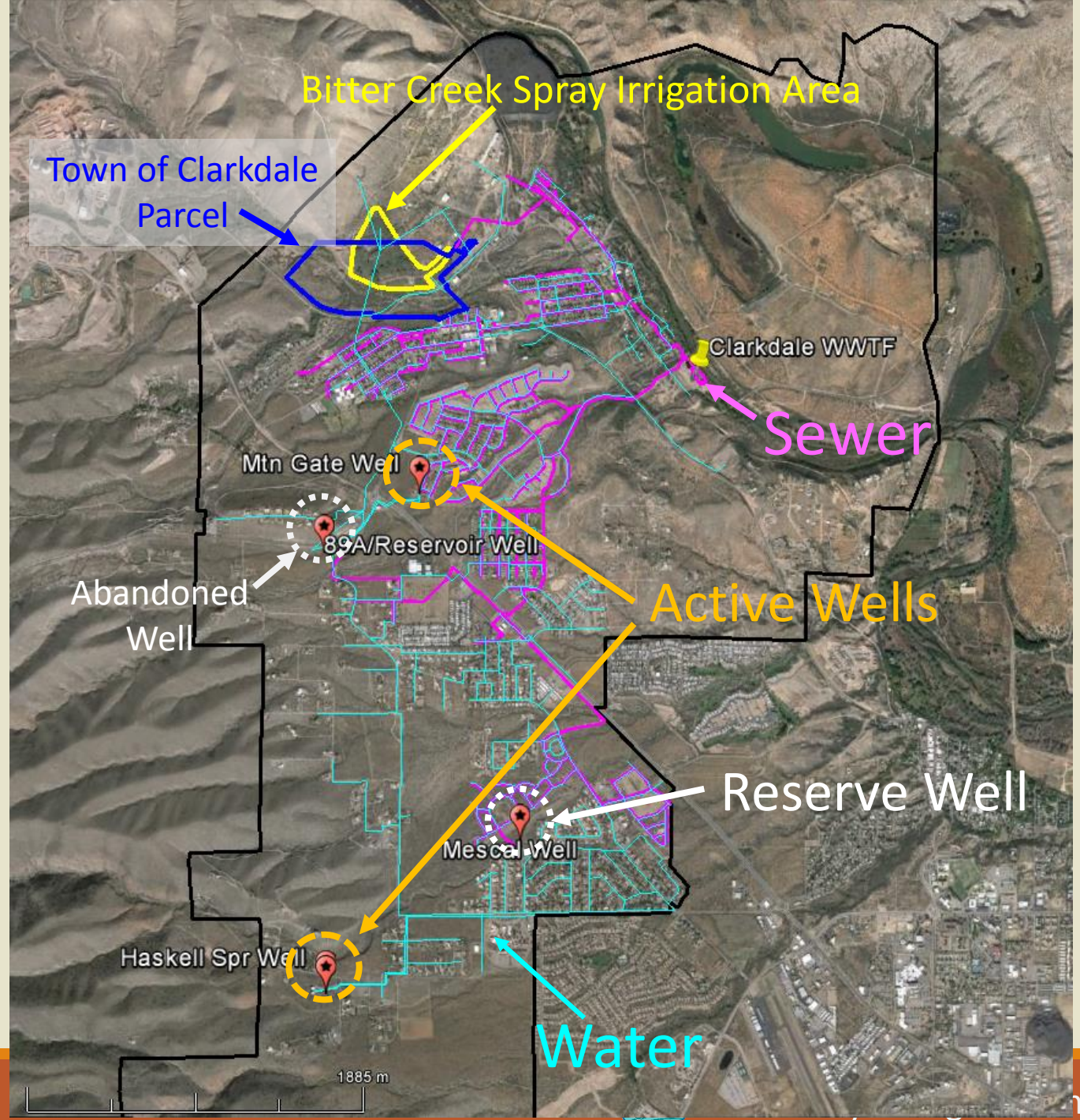

# But Really…..

**What is the Highest and Best Use for Clarkdale's High-Quality Treated Effluent?**

- Is there enough to make a difference in the Verde River?
- Is recharge compatible with ALL of the Town's long-term objectives?

# The Quest to Understand Clarkdale's Effluent: Present and Future

- How much of current effluent production is actually recharging the aquifer?
- What percentage of total demand is being treated, recharged?
  - Can that percentage be improved?
- What alternatives exist for using Clarkdale's Class A+ effluent?
  - What are the costs/benefits of those uses?




# Clarkdale's Water & Wastewater System

WATER SYSTEM

- Water Distribution Lines and Storage Tanks
- 2 Active Wells
- 1 Reserve Well
- 1 Abandoned Well

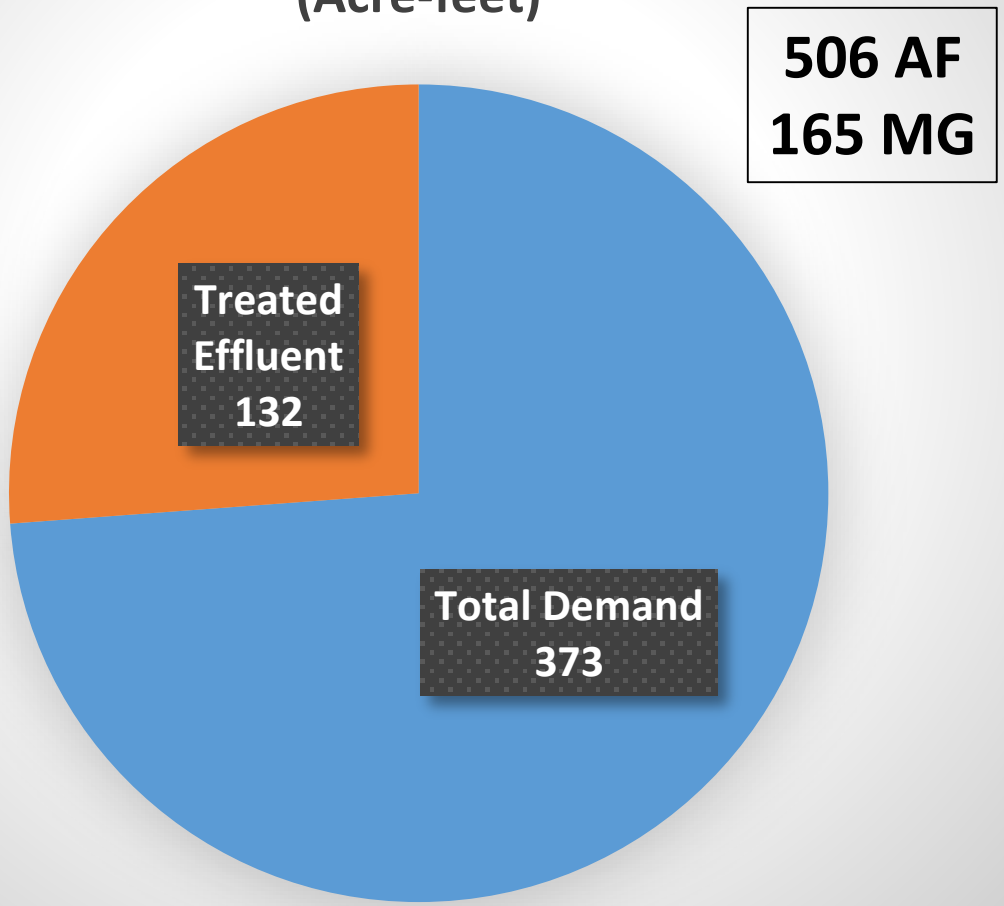
WASTEWATER SYSTEM

- Sewer Collection Lines
- Wastewater Treatment Facility (WWTF)
- Land Application Area (Bitter Cr.)

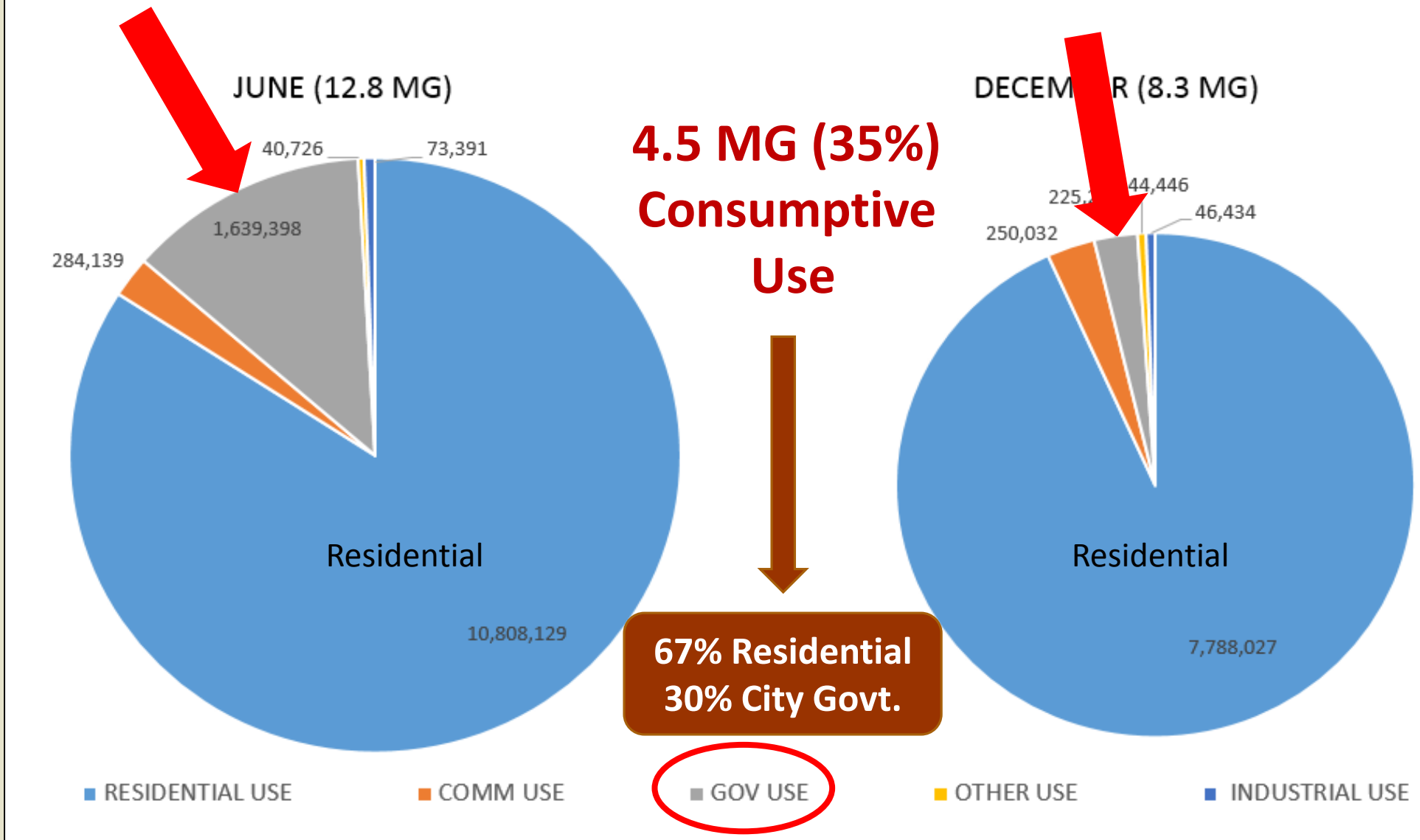
PRIVATE WELLS & SEPTIC TANKS

# 2014 Clarkdale Demand and Effluent Production

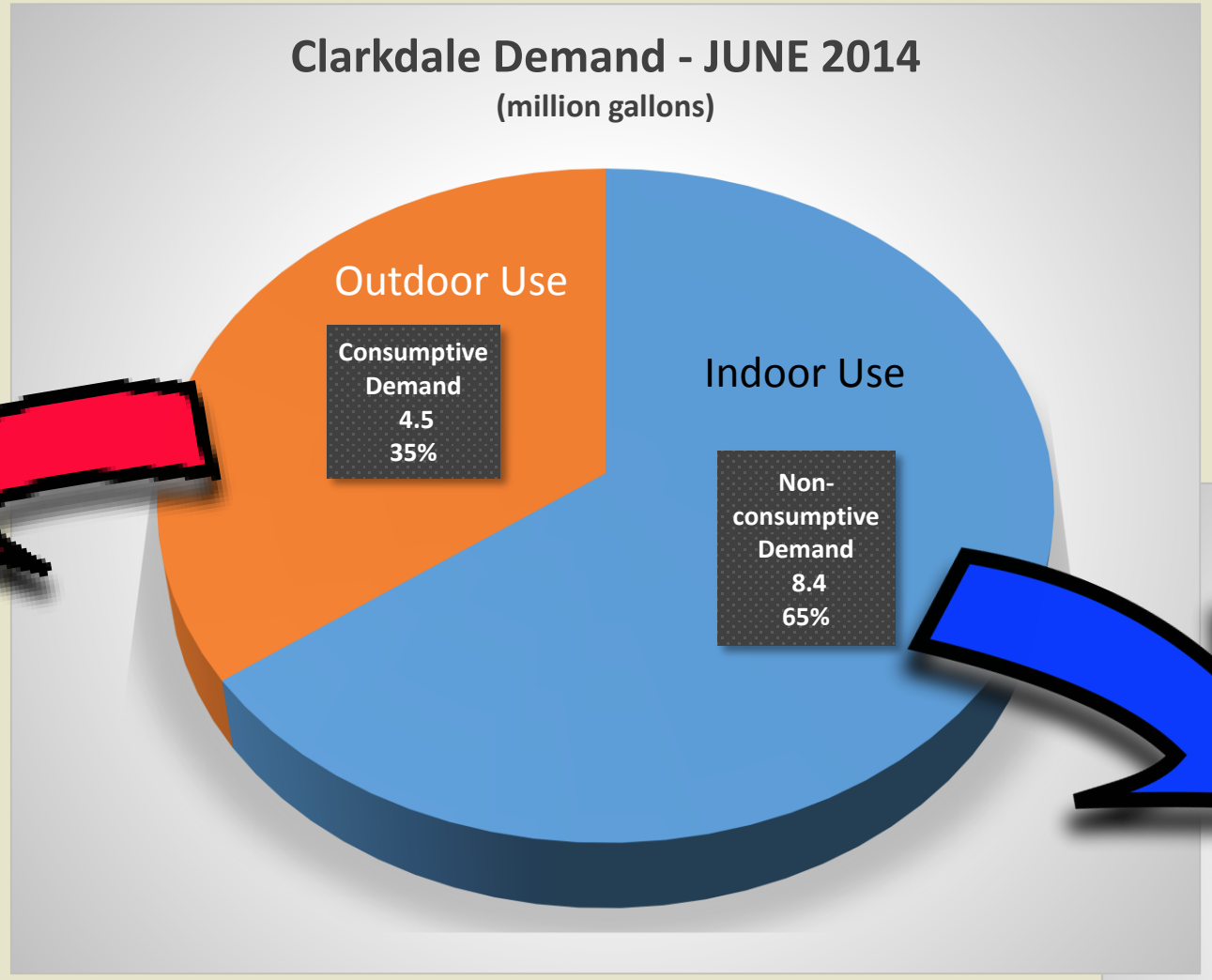
(Acre-feet)



# 2014 Total Clarkdale Demand by Sector

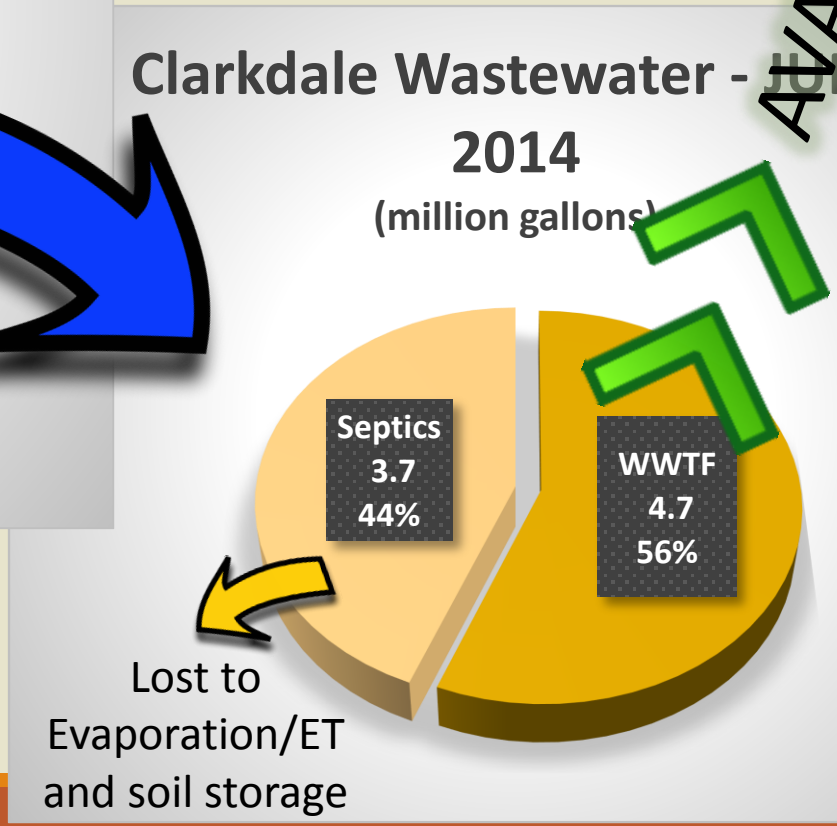


# Clarkdale's Water Budget




Lost to Evaporation/ET

AVAILABLE



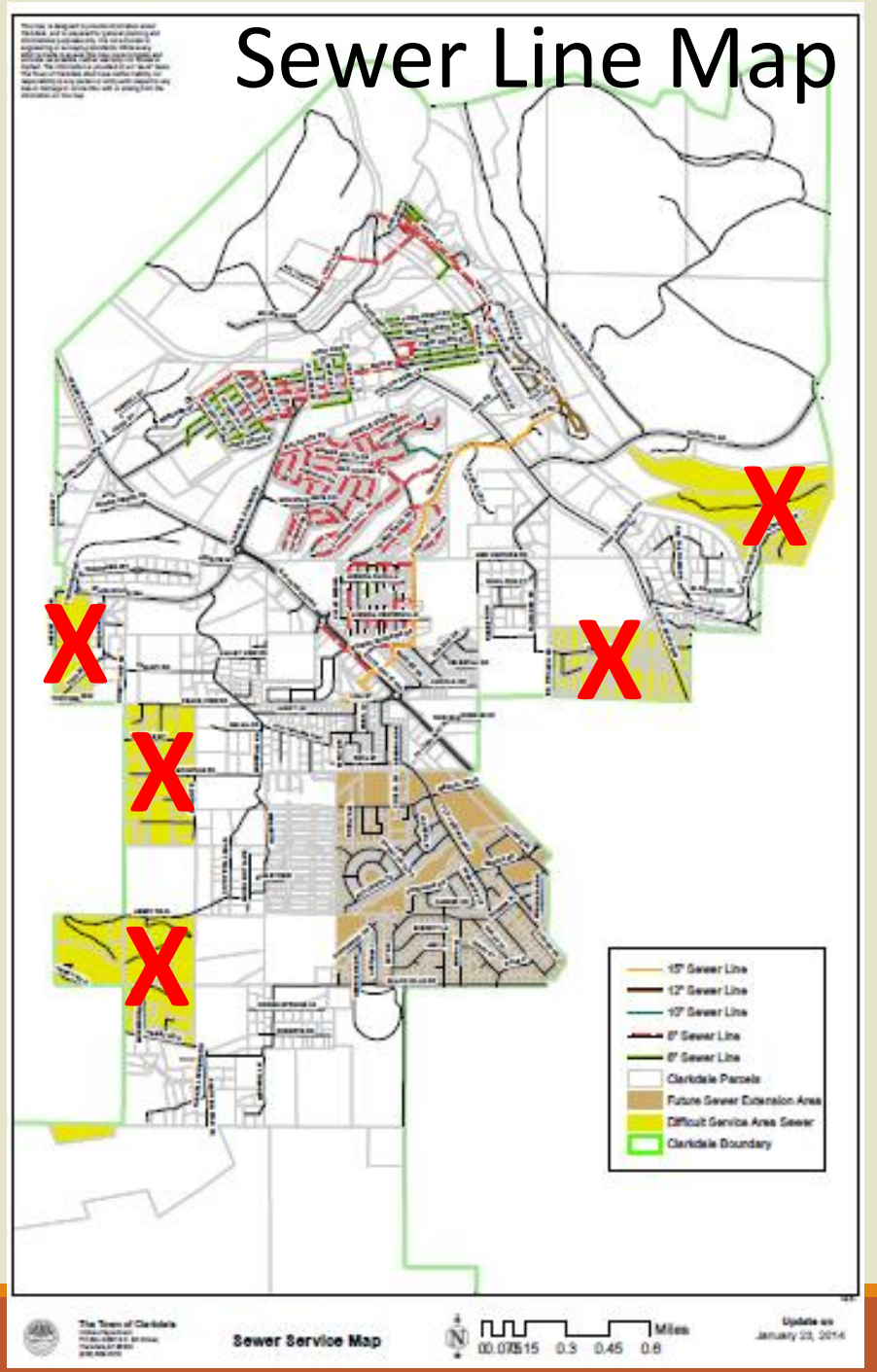

Lost to Evaporation/ET and soil storage

# Land Use Map

**Town of Clarkdale**
**Residential Property available for development**

| | Subdivision/Area | Platted | Number of Lots available for development | Undeveloped acres | Zoning | Residential Units per Acre | Maximum Residential Units |
|---|---|---|---|---|---|---|---|
| 1 | Haskell Springs Area | No | | 76 | R1-L | 1 | 76 |
| 2 | Abbey Road North | No | | 42 | R1-L | 1 | 42 |
| 3 | Vincent/Vinterra property north of Black Hills Drive | No | | 40 | R1-L | 1 | 40 |
| 4 | Haskell Springs Phase 3 | Yes | 150 | | R1 | | 150 |
| 5 | West of Minerich | No | | 50 | R1-L | 1 | 50 |
| 6 | Radley Subdivision | Yes | | 80 | R1 | 4 | 320 |
| 7 | Mescal Spur area | No | | 15 | R1 | 4 | 60 |
| 8 | Mountain north to Peaks View | No | | 30 | R1-L | 1 | 30 |
| 9 | Old Jerome Highway between Lemar & Kerrie Lee Road | No | | 7 | R1 | 4 | 28 |
| 10 | Classic Court | No | | 2.4 | R1 | 4 | 10 |
| 11 | Valley View area | No | | 8 | R1 | 4 | 32 |
| 12 | North of Peaks View | No | | 42 | R | 4 | 168 |
| 13 | Sienna Canyon Subdivision | | | 45 | R1 | 4 | 450 |
| 14 | Wildhorse Acres Subdivision | | 4 | | R1 | | 4 |
| 15 | West of Desert Sky | | | 34 | R1 | 4 | 136 |
| 16 | Along SR 89A to Clarkdale Parkway | No | | 44 | R1 | 4 | 176 |
| 17 | Panorama Subdivision | Yes | 5 | | | | 5 |
| 18 | YA Nation property west of Cement Plant Road | No | | 45 | R2 | 10 | 450 |
| 19 | North of SR 89A and west of Cement Plant Road | No | | 18 | R1 | 4 | 72 |
| 20 | Salt River PimaMaricopa (SRPM) Indian Community property east of Cement Plant Road (two parcels) | No | | 57 | R2 | 10 | 570 |
| 21 | SRPM property behind CJ School | No | | 18 | R1 | 4 | 72 |

# Sewer Line Map

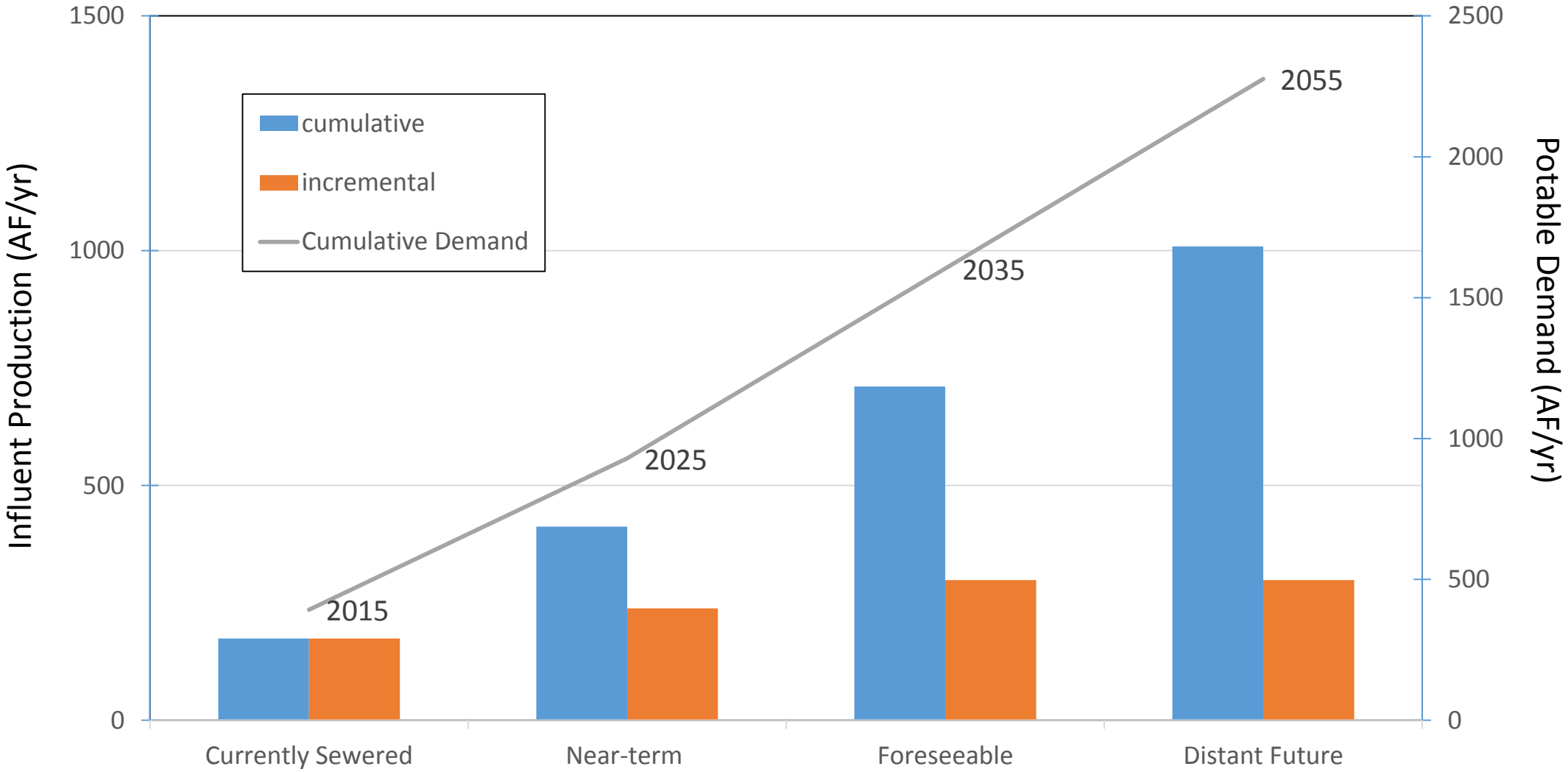


# Potential Residential Sewer Hook-ups in Clarkdale

| ID no. | Subdivision/Area | Likely to be Connected to Sewer | | | |
|---|---|---|---|---|---|
| | | Max Resid. Units | Soon | | |
| 7 | Mescal Spur area | 60 | X | | |
| 9 | Old Jerome Highway between Lemar & Kerrie Lee Road | 28 | X | | |
| 10 | Classic Court | 10 | X | | |
| 11 | Valley View area | 32 | X | | |
| 12 | North of Peaks View | 168 | X | | |
| 16 | Along SR 89A to Clarkdale Parkway | 176 | X | | |
| 21 | SRPM property behind CJ School | 72 | X | | |
| 22 | Mongini property west side of Clarkdale Pkwy | 80 | X | | |
| 23 | Rob Greene property east of Fire Station | 24 | X | | |
| 24 | DeBlanc property north of Patio Park | 28 | X | | |
| 25 | Tevis property east of Patio Park | 77 | X | | |
| 26 | East of Broadway between Main and Park | 23 | X | | |
| 27 | Rio Vista Subdivision | 25 | X | | |
| 33 | Mountain Gate | 393 | X | | |
| 34 | Crossroads | 233 | X | | |
| 6 | Radley Subdivision | 320 | | X | |
| 13 | Sienna Canyon Subdivision | 450 | | X | |
| 18 | YA Nation property west of Cement Plant RD | 450 | | X | |
| 20 | Salt River PimaMaricopa (SRPM) Indian Community property east of | 570 | | X | |
| 1 | Haskell Springs Area | 76 | | | X |
| 2 | Abbey Road North | 42 | | | X |
| 3 | Vincent/Vinterra property north of Black Hills Dr | 40 | | | X |
| 4 | Haskell Springs Phase 3 | 150 | | | X |
| 5 | West of Minerich | 50 | | | X |
| 8 | Mountain north to Peaks View | 30 | | | X |
| 14 | Wildhorse Acres Subdivision | 4 | | | X |
| 15 | West of Desert Sky | 136 | | | X |
| 17 | Panorama Subdivision | 5 | | | X |
| 19 | North of SR 89A and west of Cement Plant Rd | 72 | | | X |
| 28 | West of Broadway between Elks Lodge and Cottonwood boundary | 898 | | X | X |
| 29 | Palisades Subdivision | 8 | | | X |
| 30 | Paz & Cota | 190 | | | X |
| 31 | Bent River Area north | 22 | | | X |
| 32 | Bent River area south of El Ranch Rd | 66 | | | X |

| | Residential Unit |
|---|---|
| Near-term | 1429 |
| Foreseeable | 1790 |
| Distant Future | 1789 |
| | |
| Existing unsewered homes in platted subdivisions | 605 |
| Existing unsewered homes in metes and bounds subdivisions | 64 |
| Existing unswered homes - TOTAL | 669 |

# Projected Influent Production and Potable Demand



# Currently at Bitter Creek….

| Estimated Effluent Recharge (2014) | | |
|---|---|---|
| **Description** | **Value** | **Units** |
| Winter $ET_{0\ (Bowie)}$ | 0.93 | ft (Nov-Feb) |
| Recharge Area | 30 | acres |
| 2014 Annual Application Volume | 132 | AF over 30 ac |
| Annual Applic. Depth | 4.40 | ft |
| Estimated Winter Application Depth | 1.47 | ft (Nov-Feb) |
| Estimated Winter Recharge Depth (Applic. Depth - $ET_0$) | 0.53 | ft (Nov-Feb) |
| **Estimated Winter Recharge Volume (Recharge Depth * Area)** | **16.0** | **AF (Nov-Feb)** |
| Current Demand | 377 | AF/yr |
| % Effluent Recharged | 12.2% | |
| % Demand Recharged | 4.3% | |

USGS
science for a changing world

Prepared in cooperation with the Arizona Department of Water Resources and Yavapai County

# Regional Groundwater-Flow Model of the Redwall-Muav, Coconino, and Alluvial Basin Aquifer Systems of Northern and Central Arizona

Scientific Investigations Report 2010-5180, v. 1.1

U.S. Department of the Interior
U.S. Geological Survey

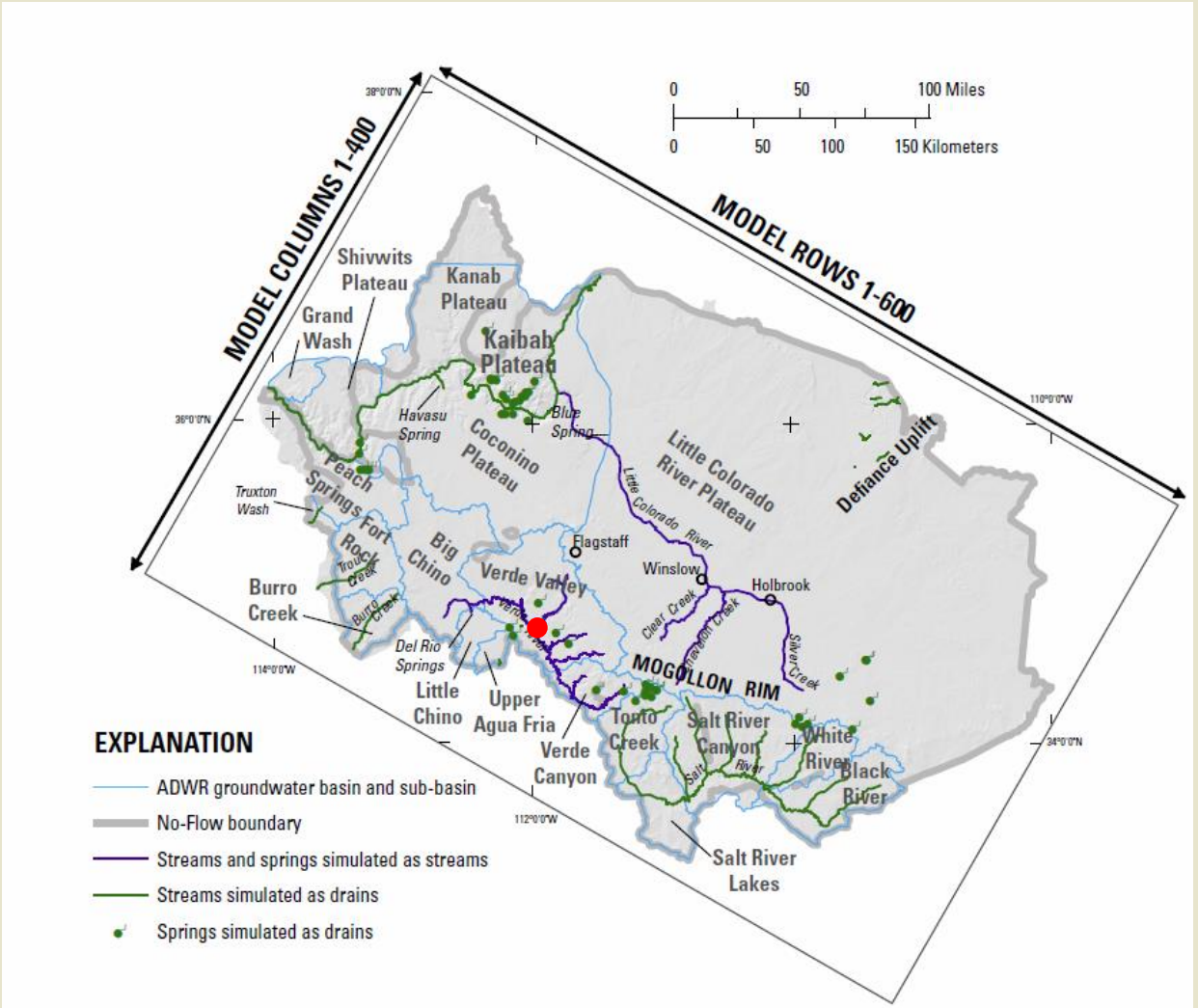
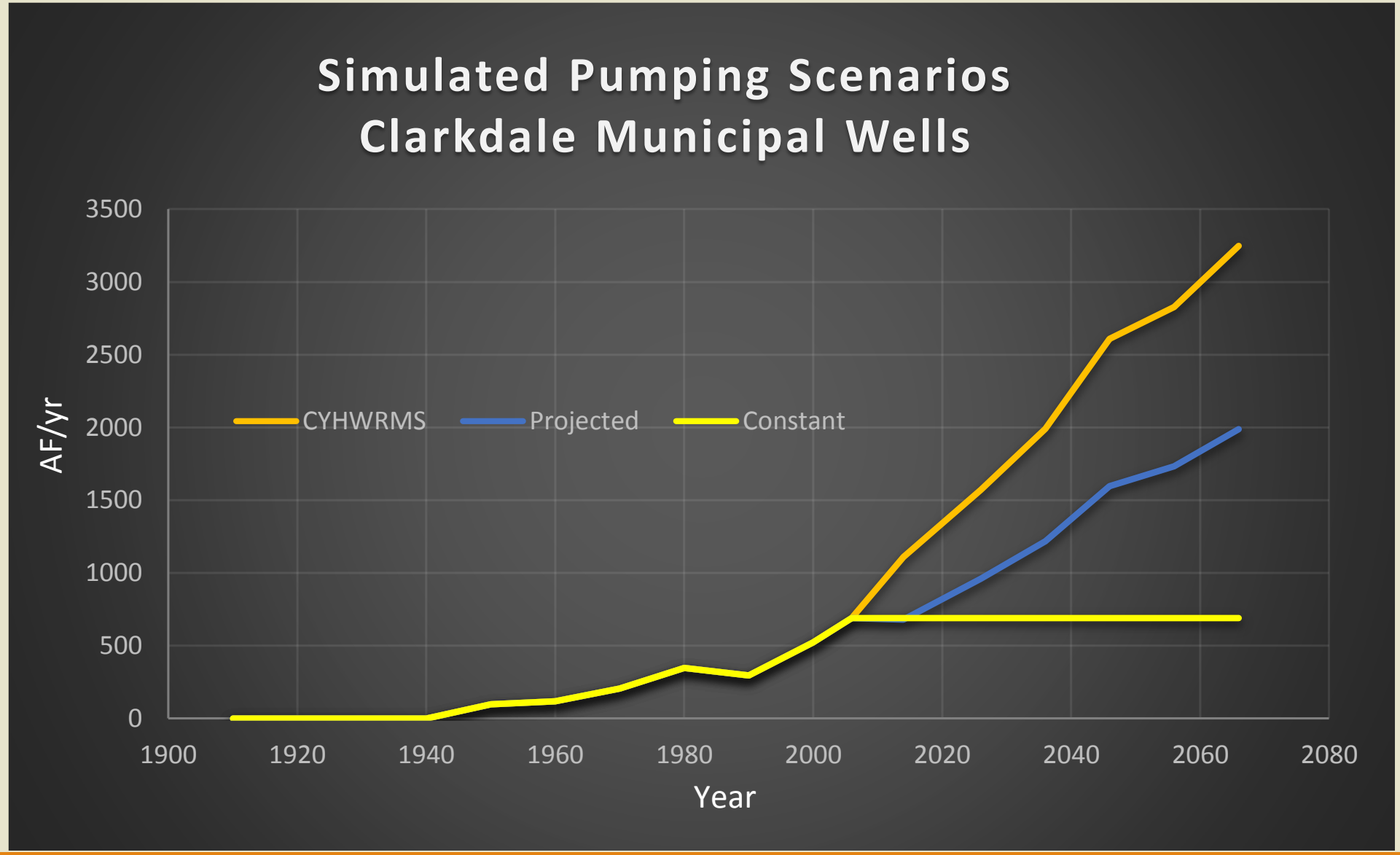


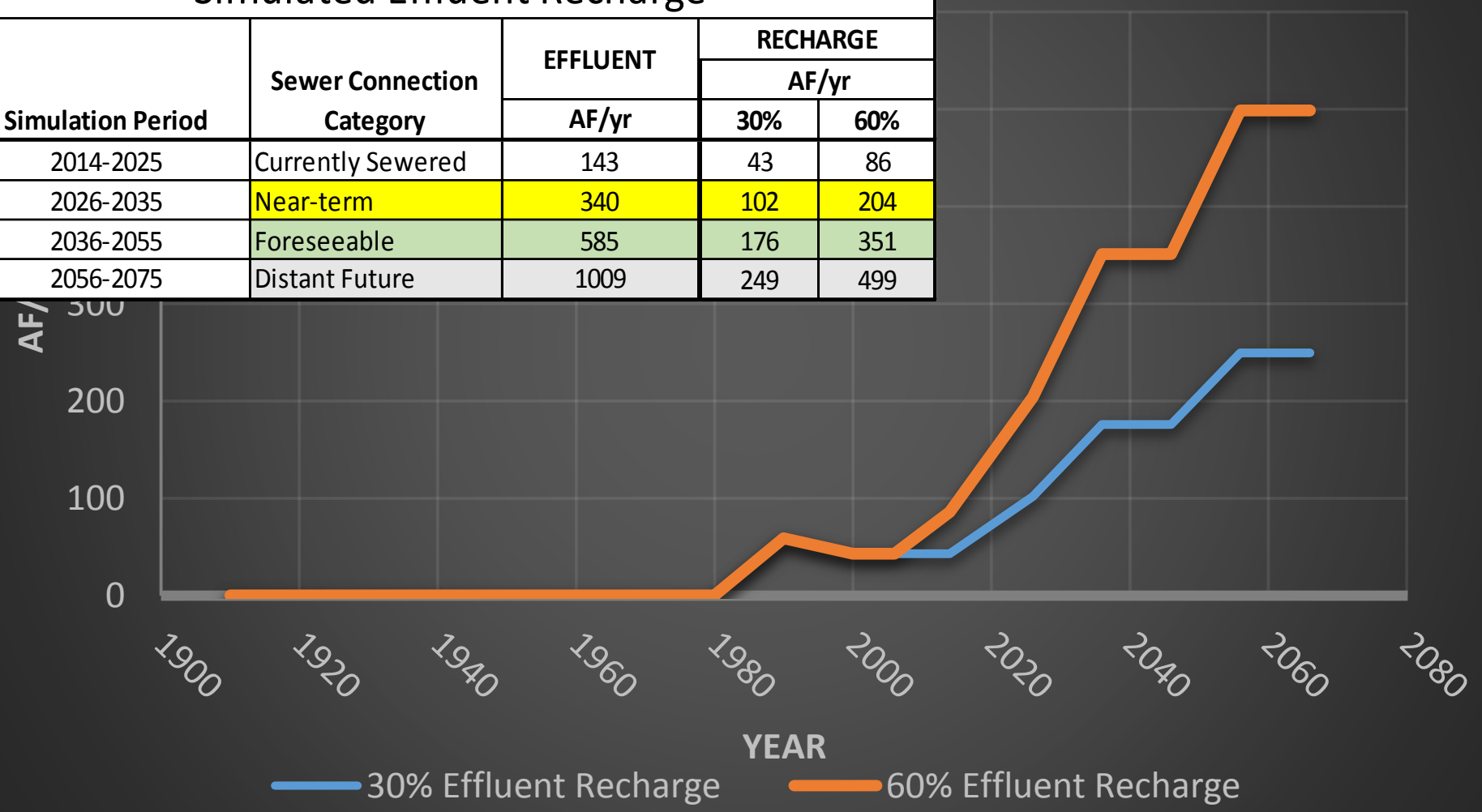

**Figure 11.** Boundary conditions for the Northern Arizona Regional Groundwater-Flow Model.

# Simulations to Test Impact of Direct Recharge of Effluent to the Aquifer

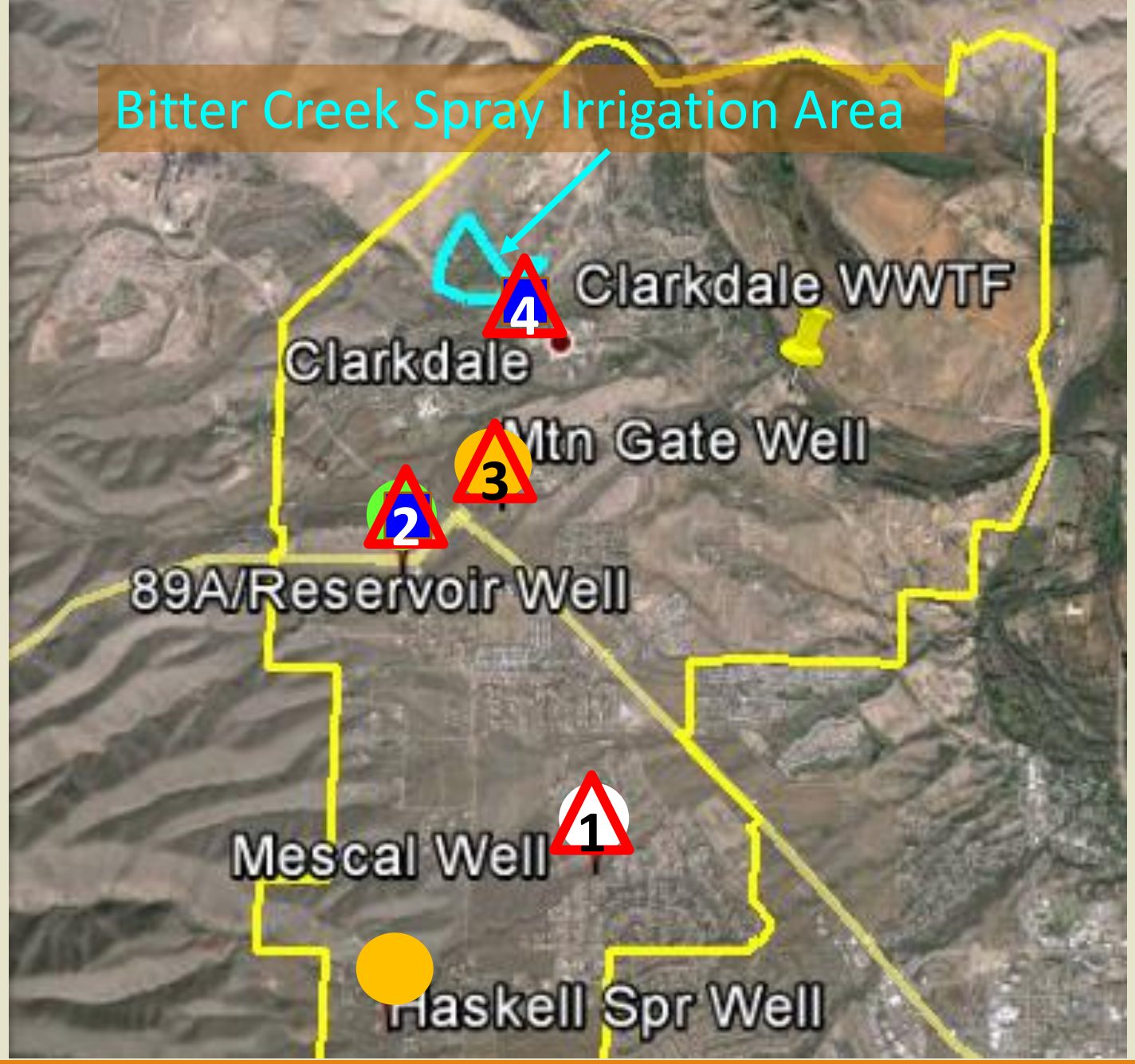


# Simulated Effluent Recharge

| Simulated Effluent Recharge | | | | |
|---|---|---|---|---|
| Simulation Period | Sewer Connection Category | EFFLUENT AF/yr | RECHARGE AF/yr 30% | RECHARGE AF/yr 60% |
| 2014-2025 | Currently Sewered | 143 | 43 | 86 |
| 2026-2035 | Near-term | 340 | 102 | 204 |
| 2036-2055 | Foreseeable | 585 | 176 | 351 |
| 2056-2075 | Distant Future | 1009 | 249 | 499 |

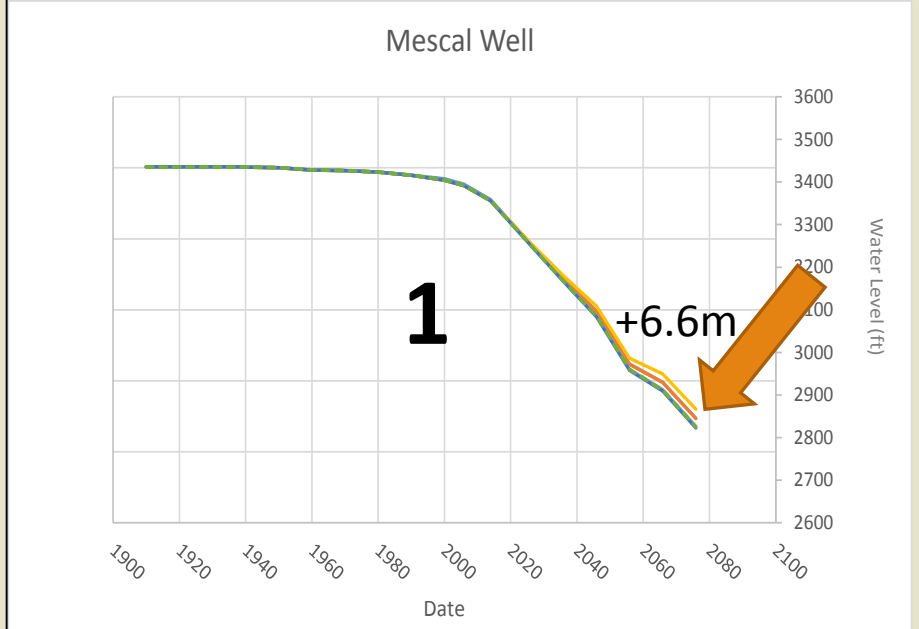


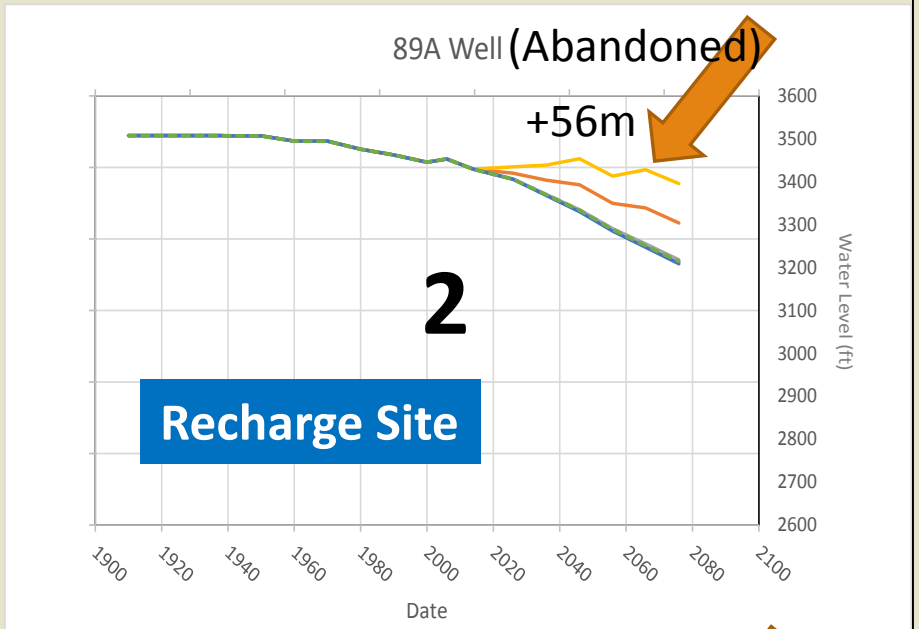

What if effluent recharge could be increased to 30% or 60% of demand instead of today's 4%?

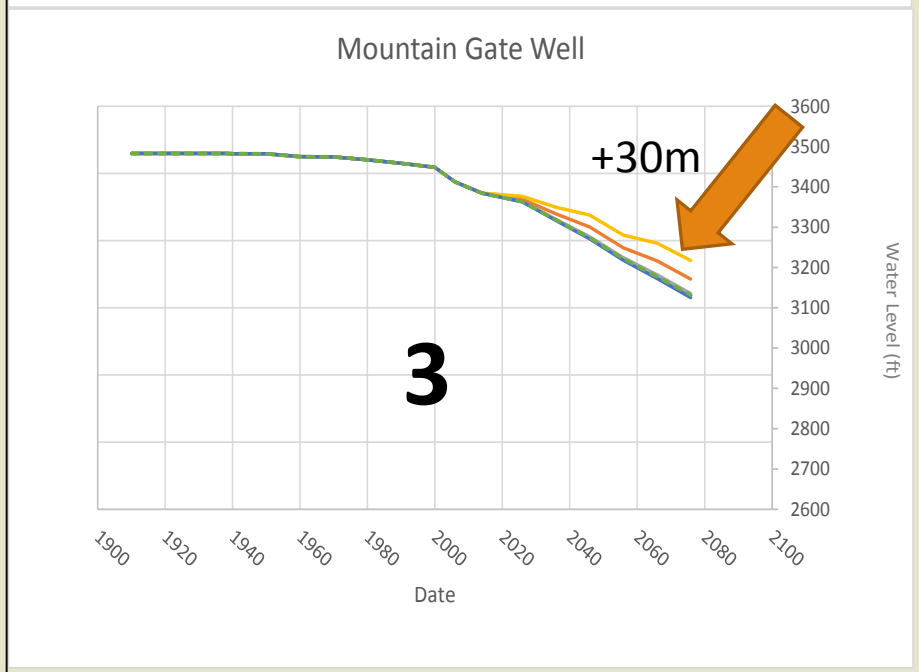


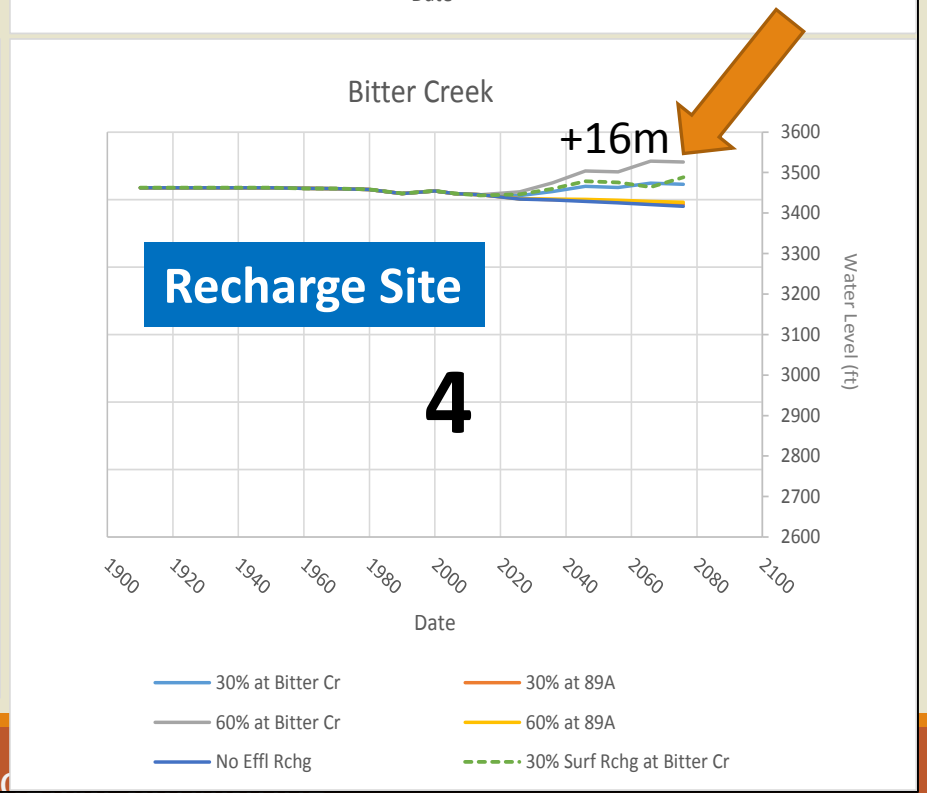

Simulated Recharge

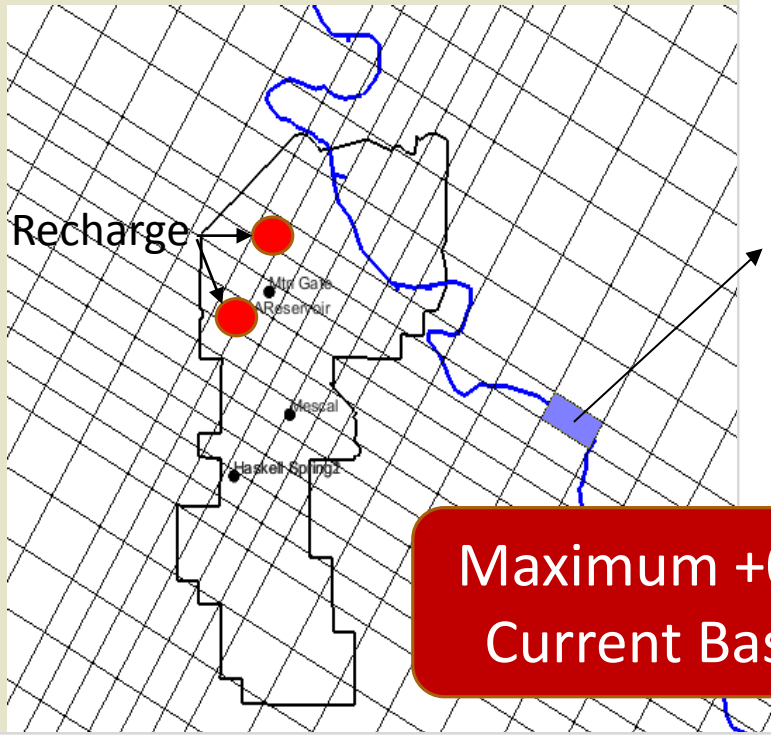
1 Head Observation Point

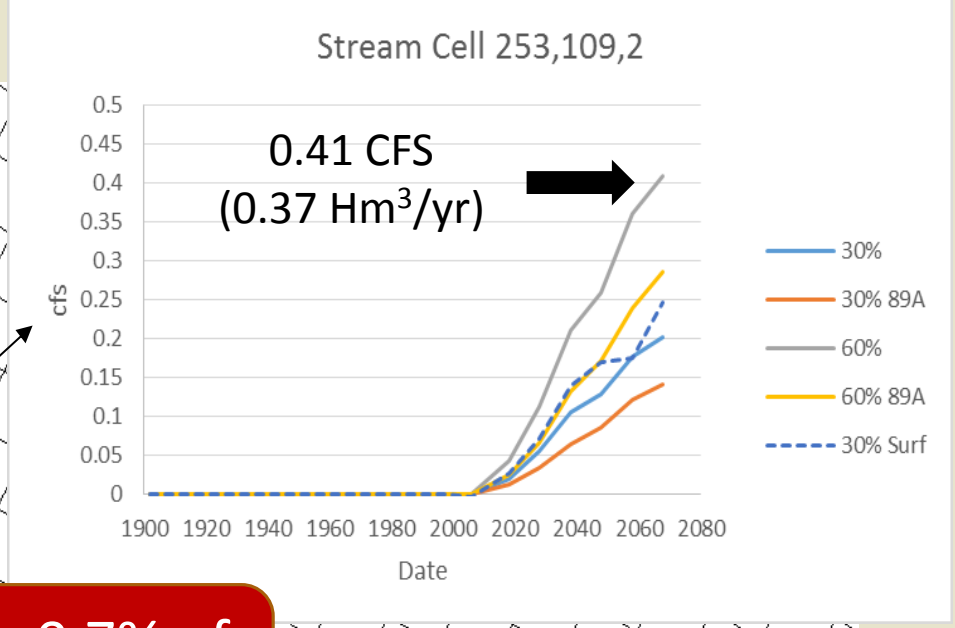

Mescal Well
1
+6.6m
Water Level (ft)
Date


89A Well (Abandoned)
+56m
2
Recharge Site
Water Level (ft)
Date


Mountain Gate Well
+30m
3
Water Level (ft)
Date

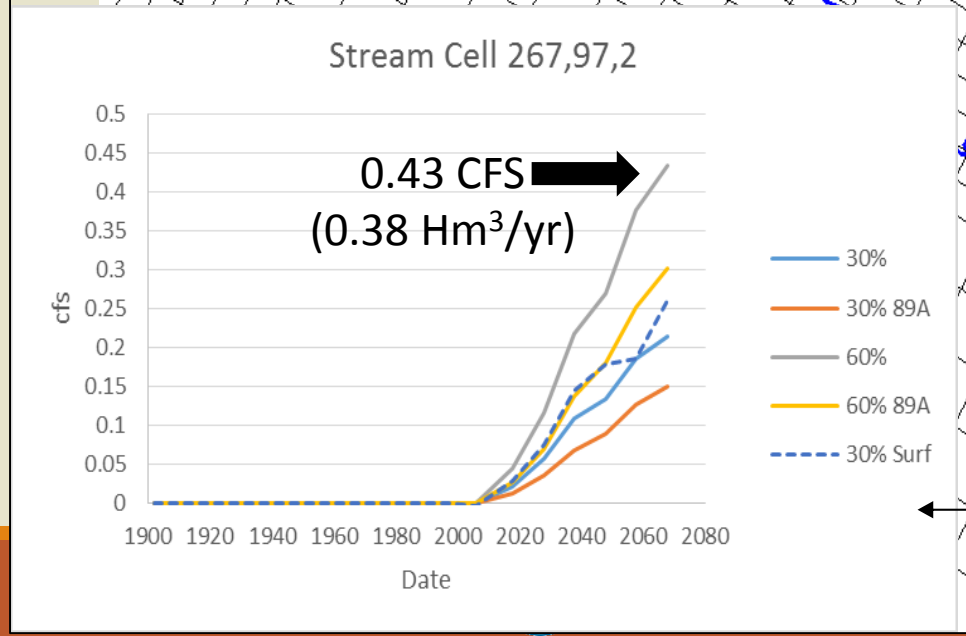

Bitter Creek
+16m
Recharge Site
4
Water Level (ft)
Date
30% at Bitter Cr
30% at 89A
60% at Bitter Cr
60% at 89A
No Effl Rchg
30% Surf Rchg at Bitter Cr



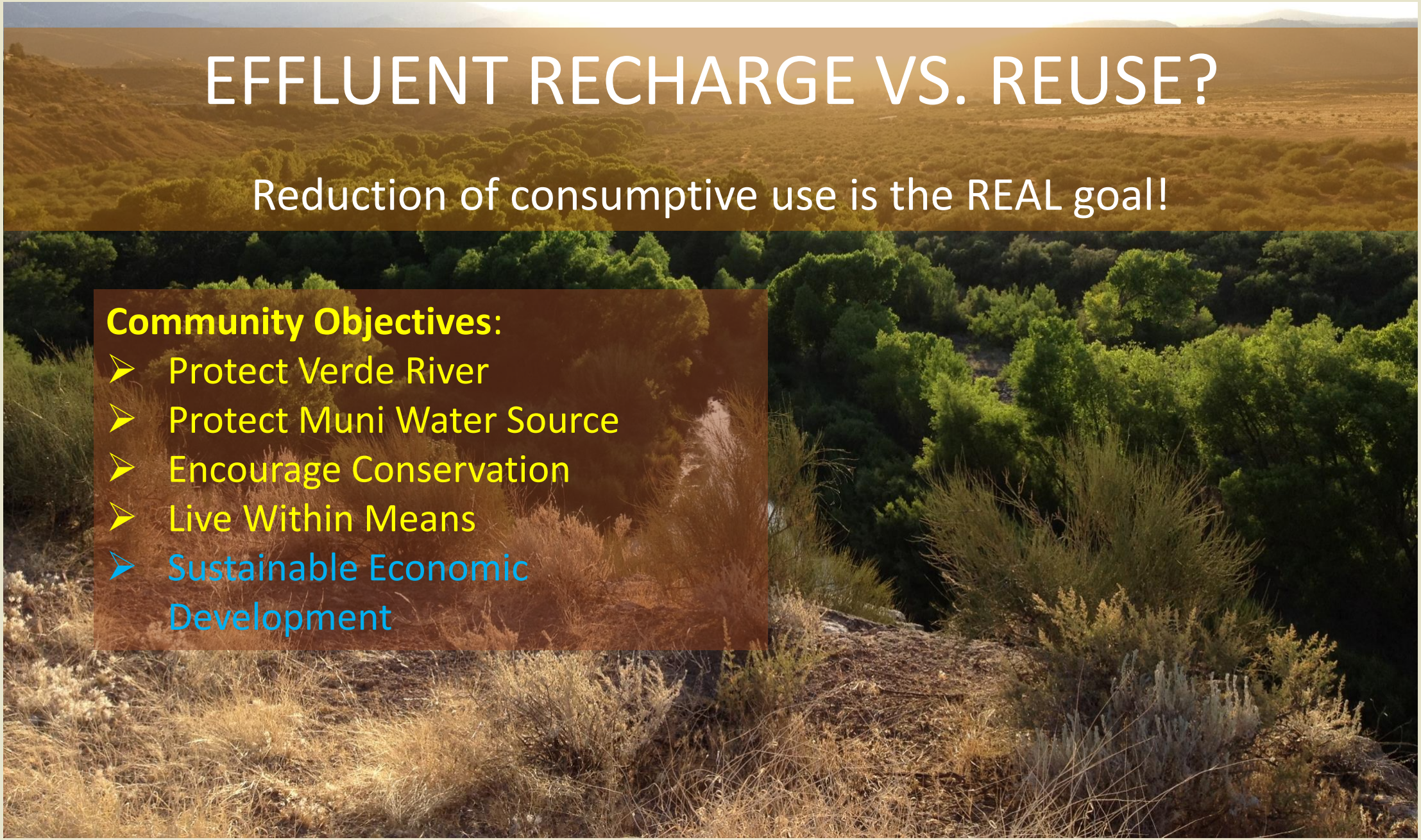

Maximum +0.7% of Current Baseflow

Simulated Difference In Baseflow from No-effluent Recharge Scenario



# EFFLUENT RECHARGE VS. REUSE?

Reduction of consumptive use is the REAL goal!



**Community Objectives**:

- Protect Verde River
- Protect Muni Water Source
- Encourage Conservation
- Live Within Means
- Sustainable Economic Development

# Effluent Reuse Costs and Benefits

| COSTS | BENEFITS |
|---|---|
| Infrastructure modifications (eg, purple pipes, lift stations, meters, recharge basins, injection wells) | Reduced consumptive use of potable water |
| APP permit modification for reuse | Lower O&M on production well infrastructure |
| Additional treatment (dechlorination, polishing) for some uses | Slower rate of aquifer depletion |
| Potentially reduced recharge at Bitter Creek site | Reduced impact to Verde River from pumping wells |
| ◊ | Potential revenue from lease of recharge site for agricultural and/or industrial purposes |
| ◊ | Potential revenue from lease/sale of effluent for industrial and/or agricultural purposes |
| ◊ | Alignment with Sustainable Clarkdale initiative |

# Moving Forward

EFFLUENT MANAGEMENT APPROACH

# Refined Objectives:

- ❑ Make better use of treated effluent
  1. Purple pipes to City parks
  2. Economic development at Bitter Creek
  3. Increased recharge efficiency

- ❑ Explore potential to extend sewer system

***MAR is NOT the top priority***

# RECOMMENDATIONS

Starting Now:

- Pursue business relationships with wine growers.
- Contact ADEQ regarding APP modification to allow beneficial reuse.
- Plan for “purple pipes” to water city parks.

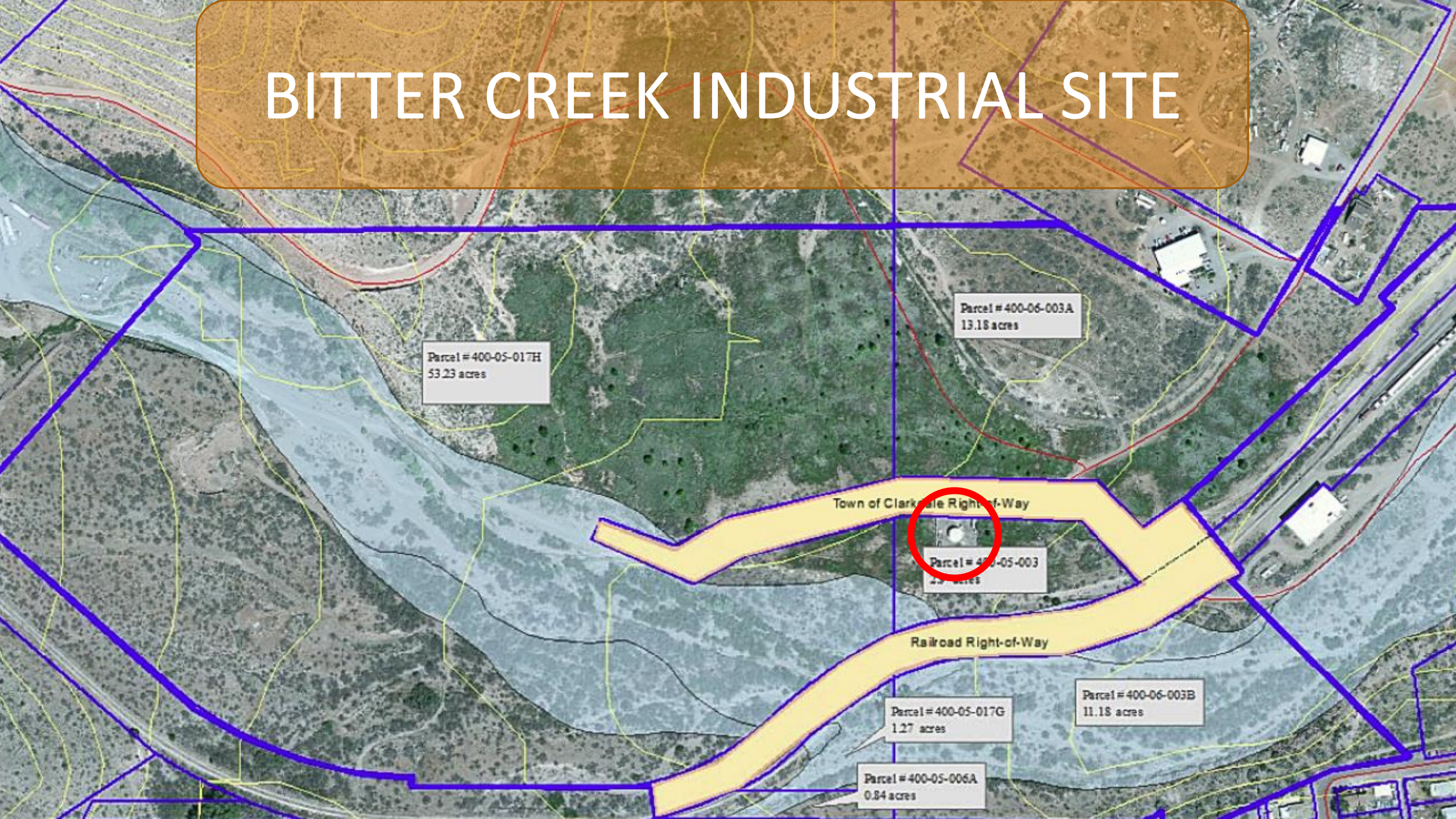
*Along the path to full effluent reuse, excess effluent should be managed for maximum recharge to the groundwater system.*

- ❑ Shrink the area receiving spray irrigation at the Bitter Creek site.
- ❑ Conduct a site investigation for rapid infiltration basins at the Bitter Creek site.

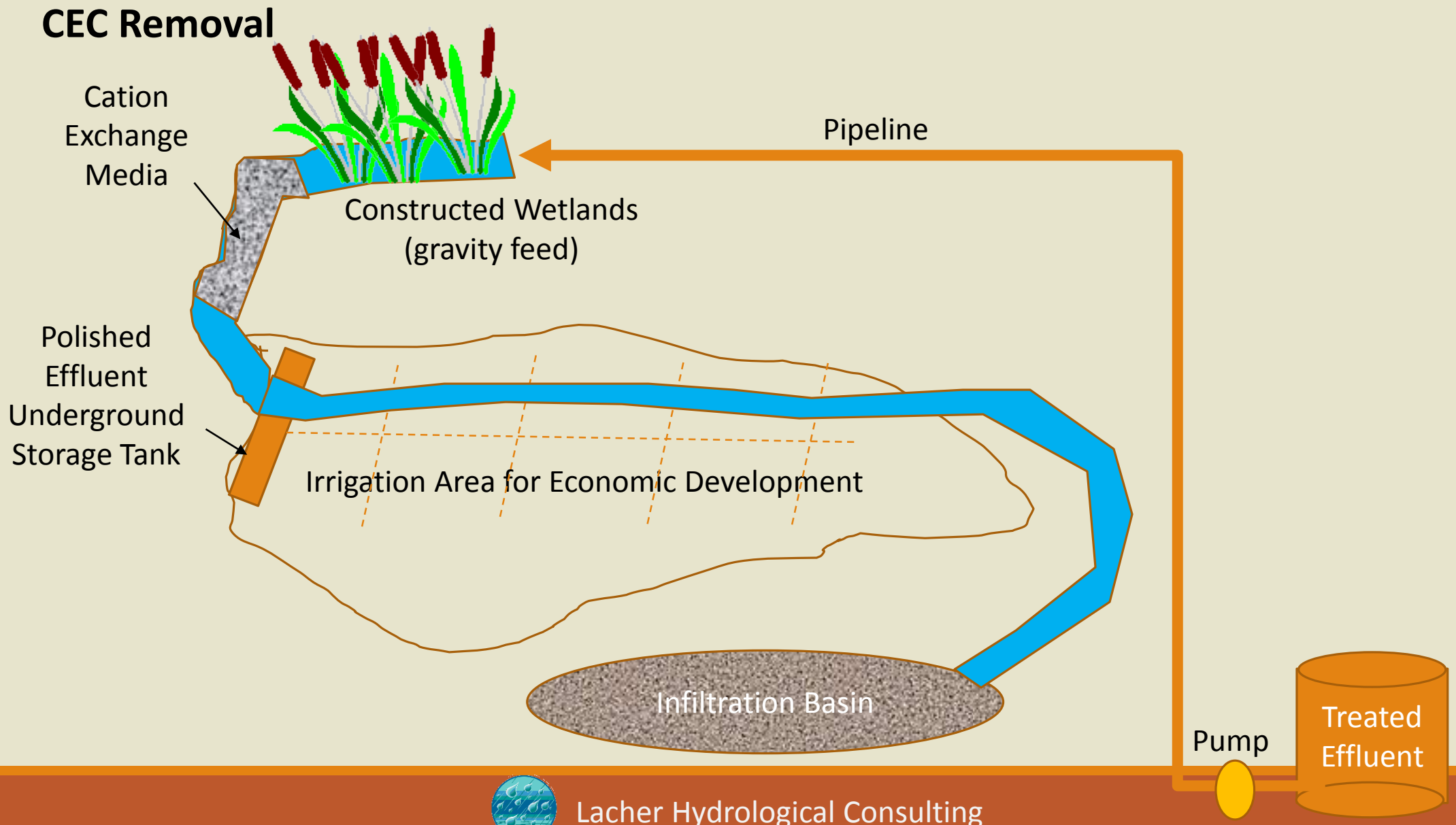
*As business development opportunities for effluent reuse evolve, determining the value of treated effluent will become critical.*

- ❑ Conduct a cost-benefit analysis for sewering existing unsewered and “difficult to sewer” areas.
- ❑ Develop a long-term funding strategy to support ongoing wastewater collection and reuse infrastructure.

# BITTER CREEK INDUSTRIAL SITE



# One Conceptual Reuse Plan




Cation
Exchange
Media
Pipeline
Constructed Wetlands
(gravity feed)
Polished
Effluent
Underground
Storage Tank
Irrigation Area for
Economic Development
Infiltration
Basin
226 m
Google earth

# Bitter Creek Industrial Area

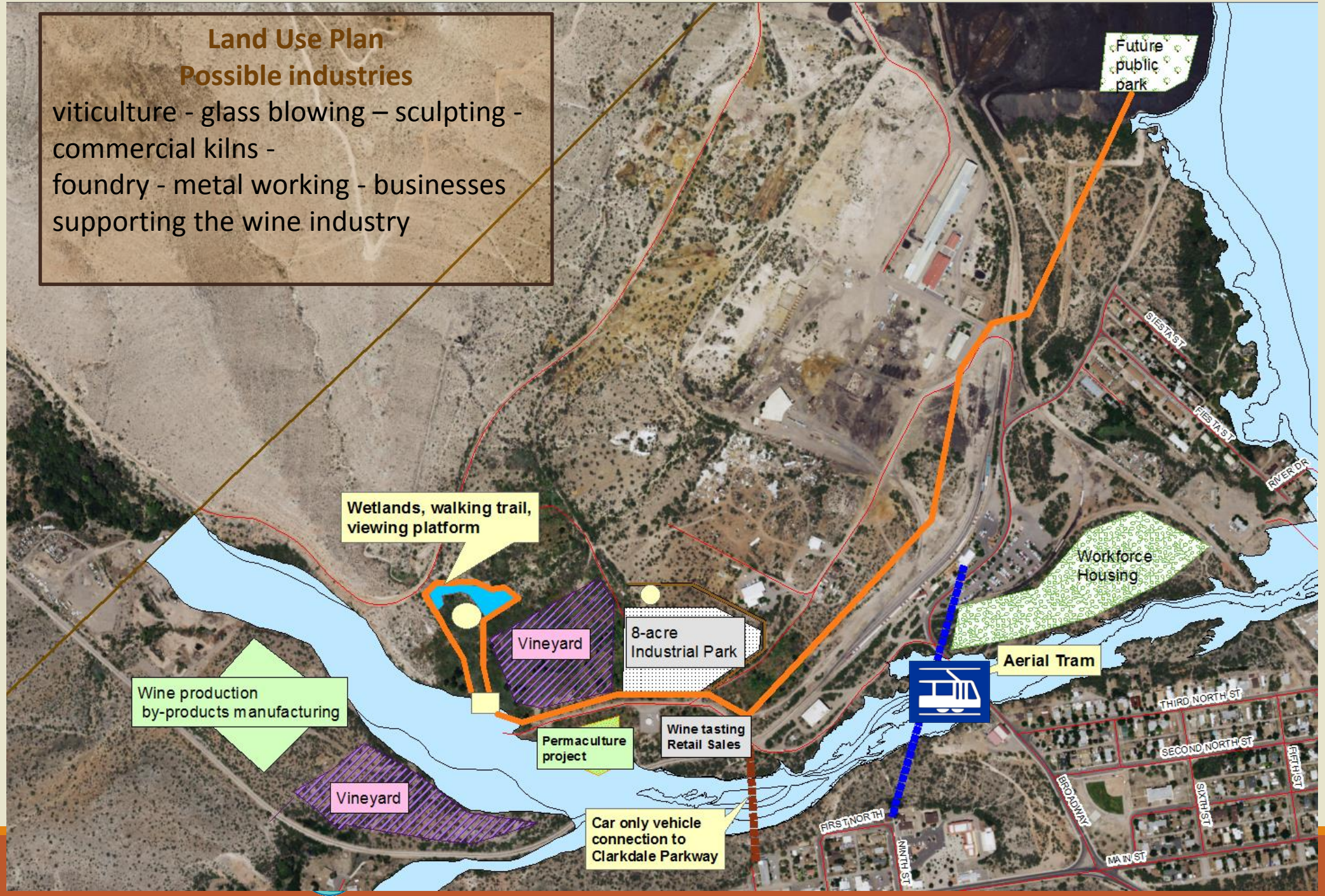
## Focus Area Plan

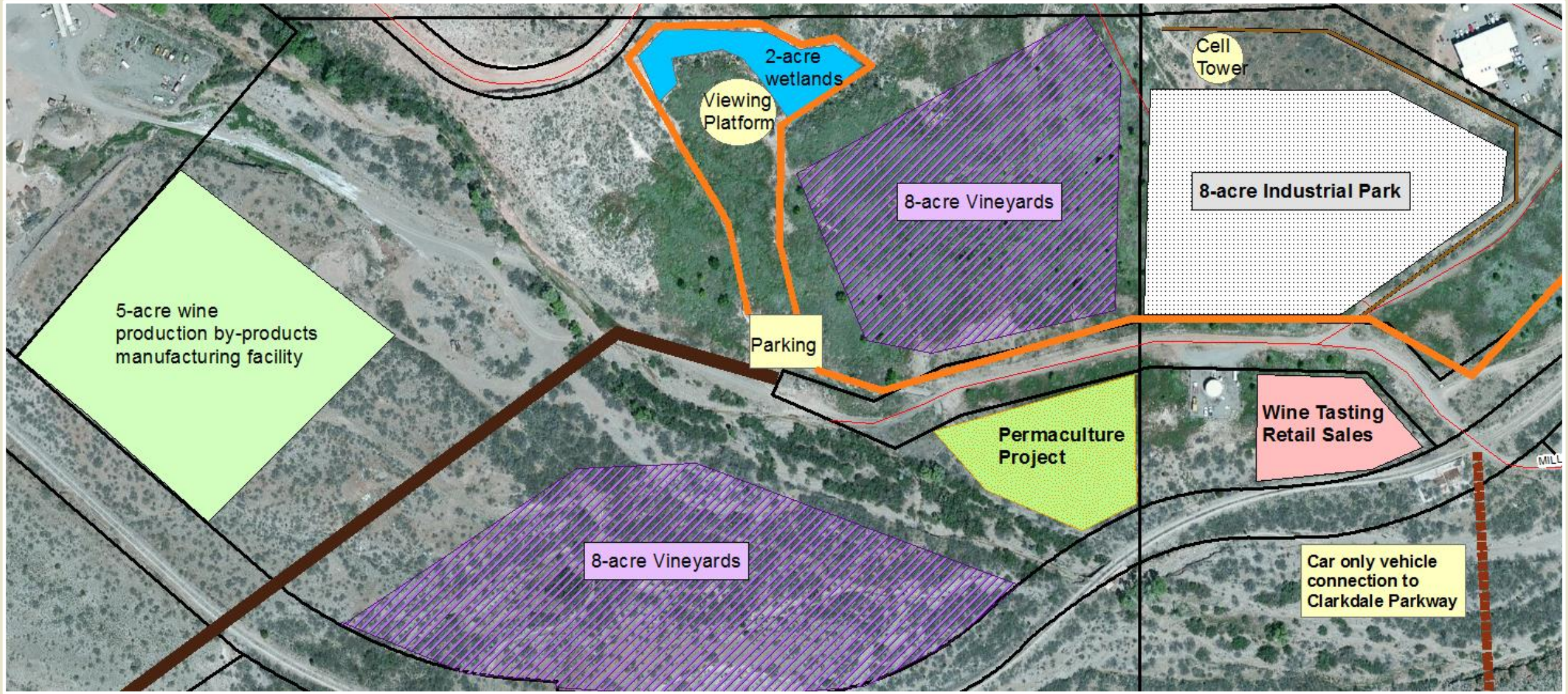
*Draft*

# The Plan

- Goal:

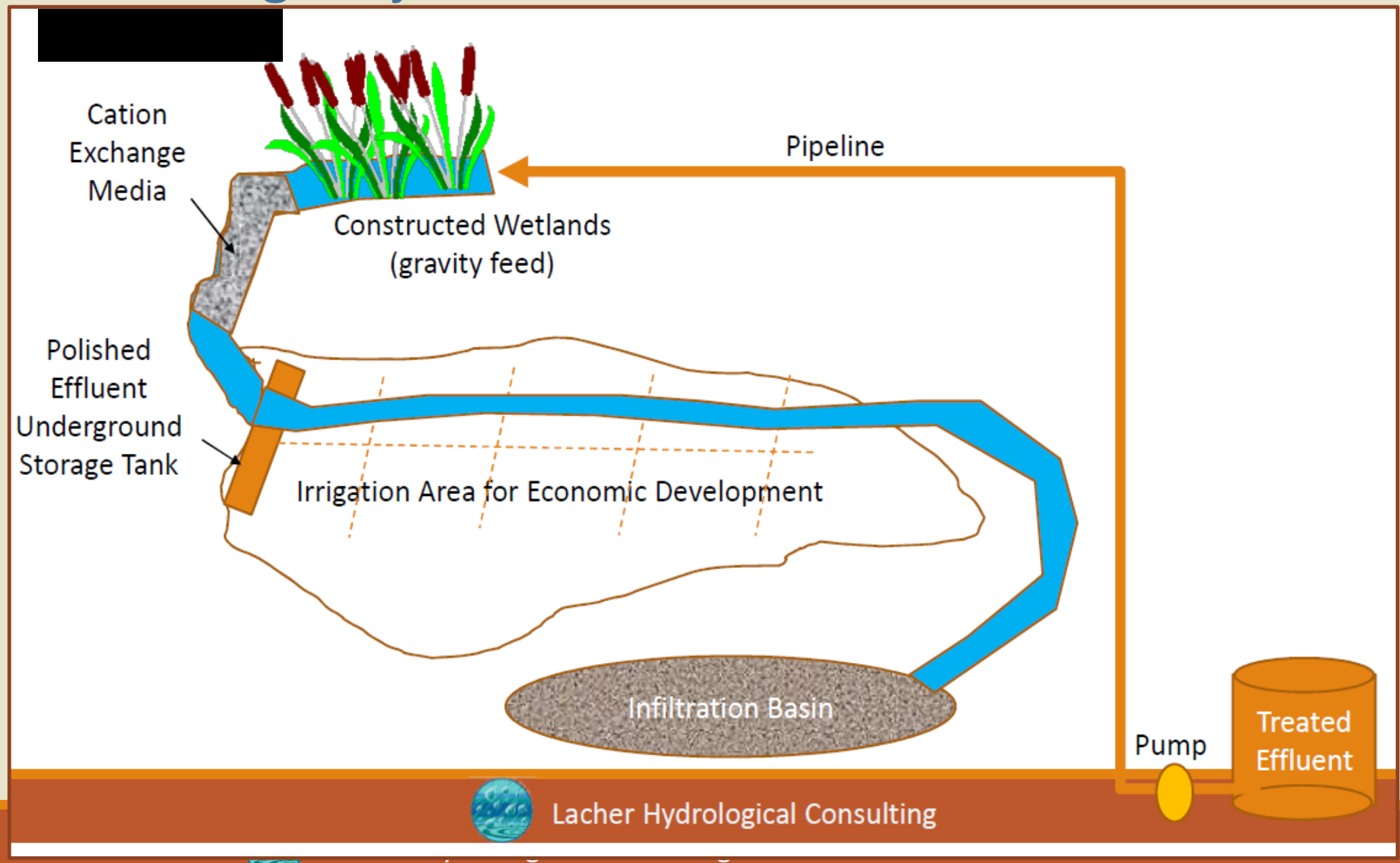
**Development within the Bitter Creek Industrial Focus Area will provide a variety of innovative economic expansion opportunities encouraging partnerships focusing on sustainable industrial development.**


Land Use Plan
Possible industries
viticulture - glass blowing – sculpting -
commercial kilns -
foundry - metal working - businesses
supporting the wine industry
Future public park
Wetlands, walking trail, viewing platform
Vineyard
8-acre Industrial Park
Workforce Housing
Aerial Tram
Wine production by-products manufacturing
Permaculture project
Wine tasting Retail Sales
Vineyard
Car only vehicle connection to Clarkdale Parkway
SIESTA ST
FIESTA ST
RIVER DR
THIRD NORTH ST
SECOND NORTH ST
FIFTH ST
SIXTH ST
BROADWAY
FIRST NORTH
NINTH ST
MAIN ST


2-acre wetlands
Viewing Platform
Cell Tower
8-acre Industrial Park
8-acre Vineyards
5-acre wine production by-products manufacturing facility
Parking
Permaculture Project
Wine Tasting Retail Sales
8-acre Vineyards
Car only vehicle connection to Clarkdale Parkway


Original Route
Alternate Route 1
Alternate Route 2
Bridge across wash
MILLER ROAD
BUS STOP
BROADWAY
AMS System
STOP
Construct Intersection
CEMENT PLANT RD
FIRST NORTH
MAIN ST
NINTH ST
TENTH ST
FIRST SOUTH ST
HOLLOW REED

# Water Polishing Project



# Thank you!

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