Floodplain Analysis and Conceptual Levee Alignment along the Gila River

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Project Description

- **Project Location:** Duncan, Arizona
- **Problem:** The Town of Duncan rests in the floodplain of the Gila River and does not have adequate flood protection
- **Objectives**
  - Analyze existing floodplain model
  - Create a current floodplain model
  - Propose a levee alignment that will be able to protect Duncan
  - Must meet requirements set by the Code of Federal Regulations Section 65.10

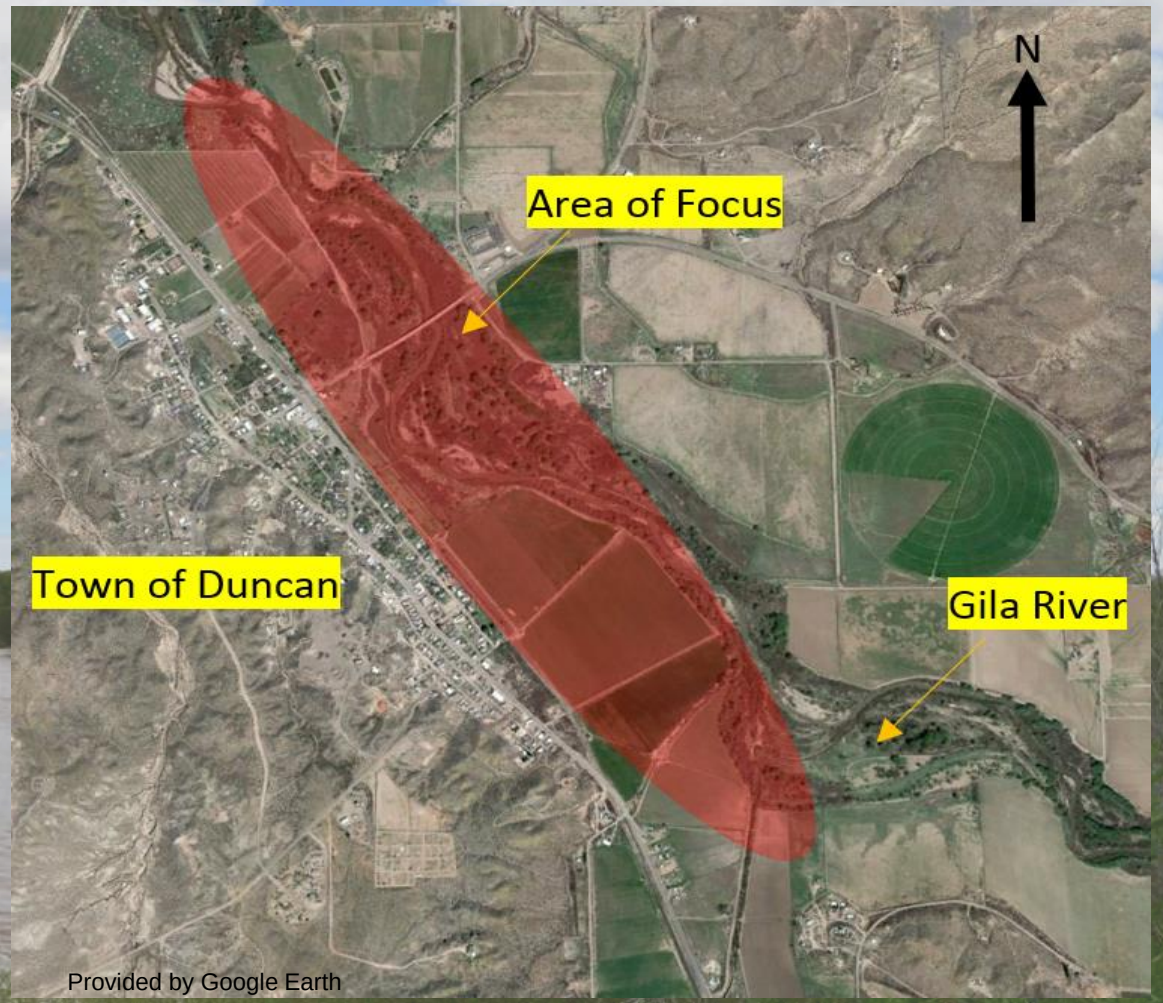
Provided by: https://upload.wikimedia.org/wikipedia/commons/7/76/Gilarivermap.png

Project Background

- **Project Location:** Duncan, Arizona
- **Current Flood Protection**
  - Agricultural dike in place
    - Not a levee
  - Does not protect against the 100 year flood
  - Overtopping begins around 24,000 cfs
  - The entire downtown area can experience flooding

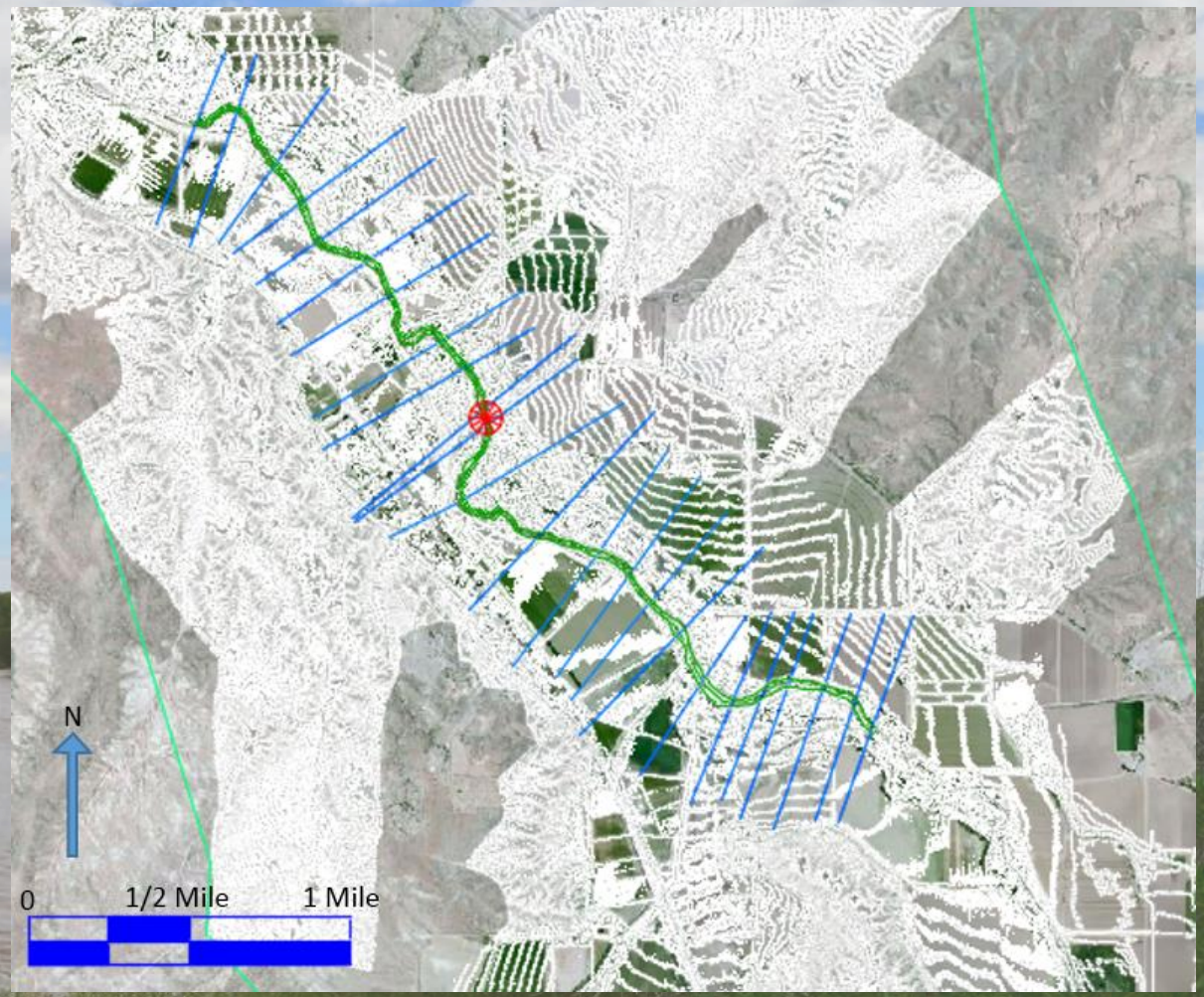
Client Expectations

- **Client**
  - Philip Ronnerud, Greenlee County Engineer
- **Client's Expectations**
  - Create various HEC-RAS models that will be used to choose an alignment for the new levee
- **Deliverables**
  - Effective Model
  - Corrected Effective Model
  - Proposed Conditions Models



Data Collection

- **Hydraulics and Hydrology**
  - Previous flood studies
  - Client requested 48,000 cfs be used for 100 year flood
- **LiDAR Data**
  - Provided by client
  - Used in Civil 3D to determine elevations for cross sections and the Gila River reach
- **Regulations**
  - Code of Federal Regulations 65.10
  - Flood Insurance Study Guidelines and Specifications for Study Contractors

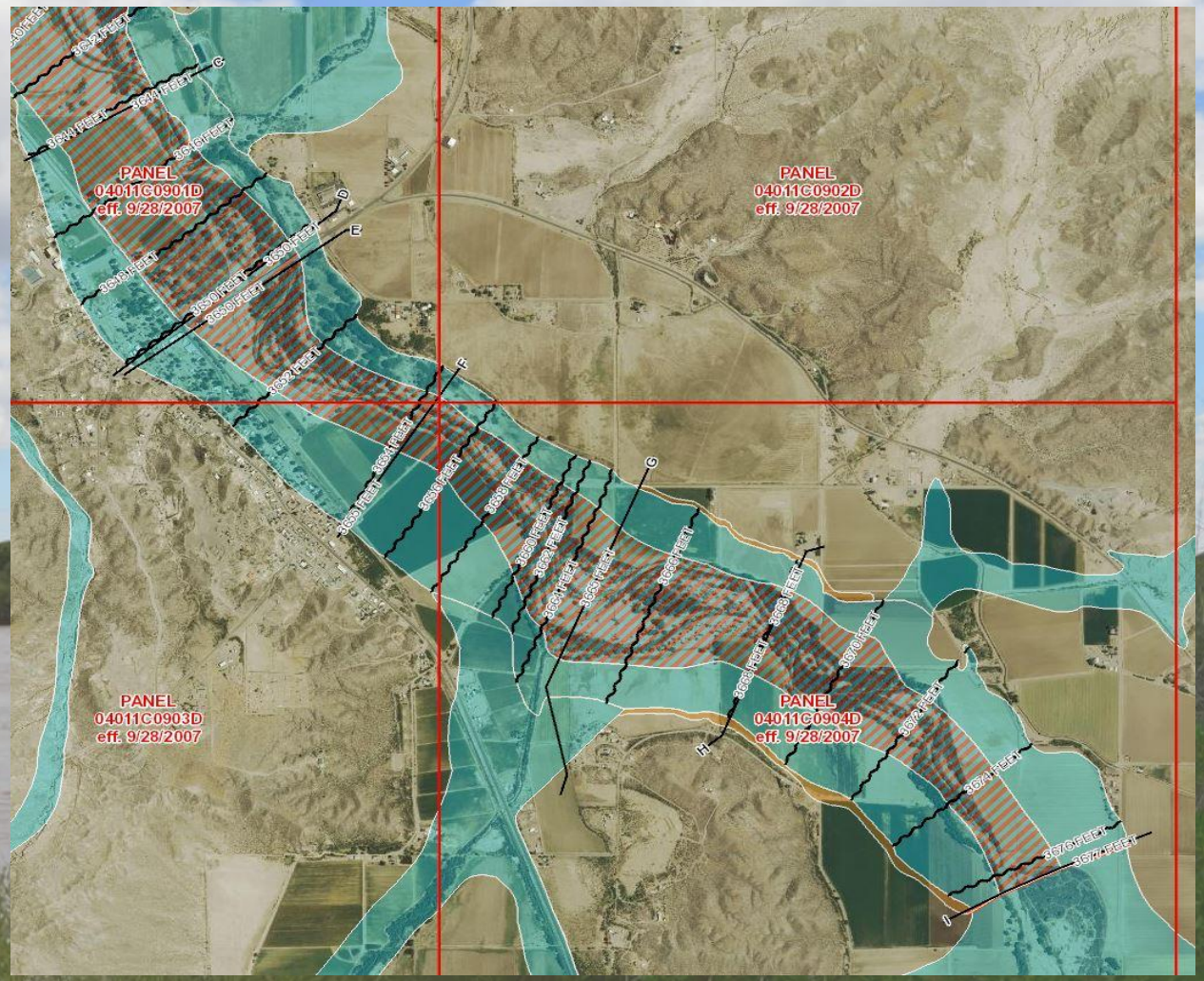


Data Collection

- **Field Visit**
  - Met with client and outside advisor to see project location and past flood damage
- **Made observations on:**
  - Agricultural dike in place
  - Potential tie in locations for proposed levee
  - Vegetation in floodplain
  - Important infrastructure

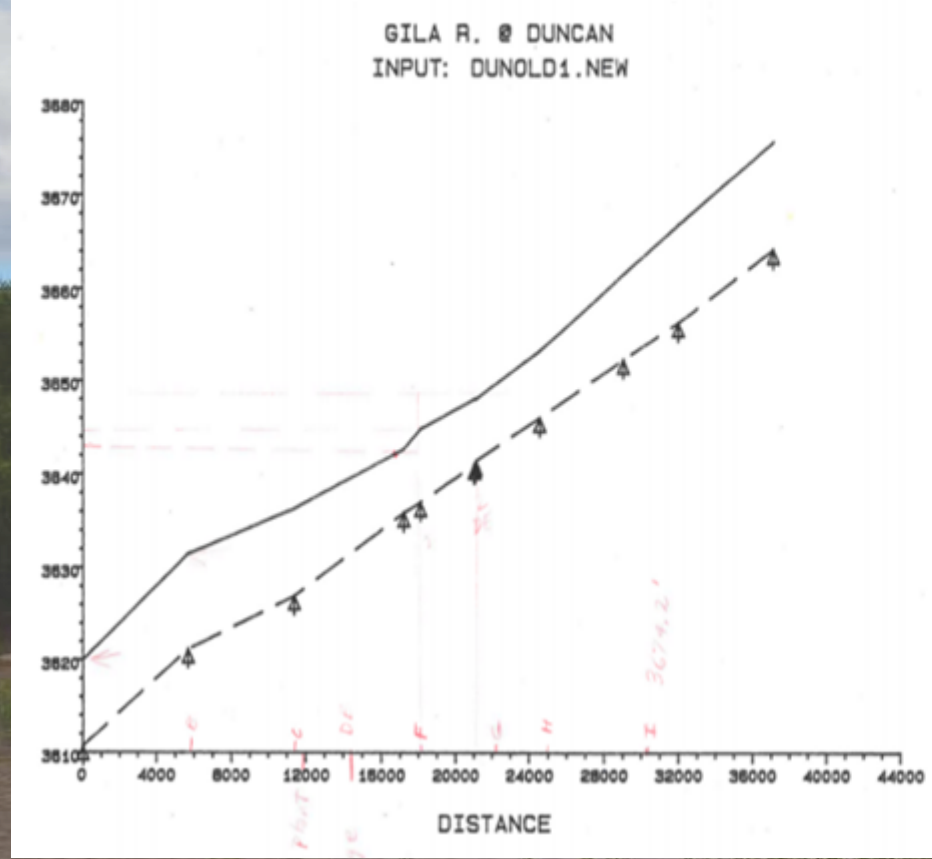
Effective Model

- **Task**
  - Recreate existing floodplain model produced by FEMA in 1976
- **Purpose**
  - Ensure existing model is accurate and that correct testing methods are being followed
- **Procedures**
  - Input provided HEC-2 data from original model into HEC-RAS
  - Run HEC-RAS model under same flow conditions (28,500 cfs) to match original results

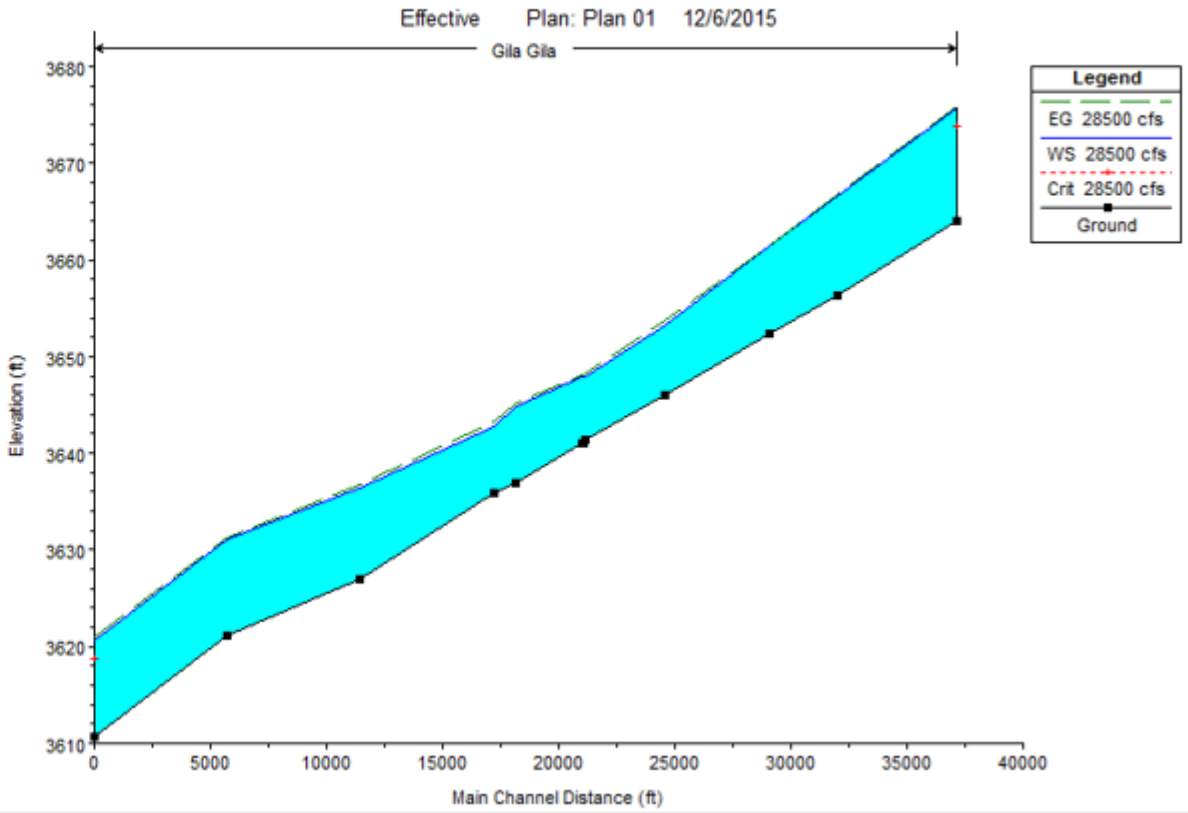


Effective Model

Hec-2 Model from 1976

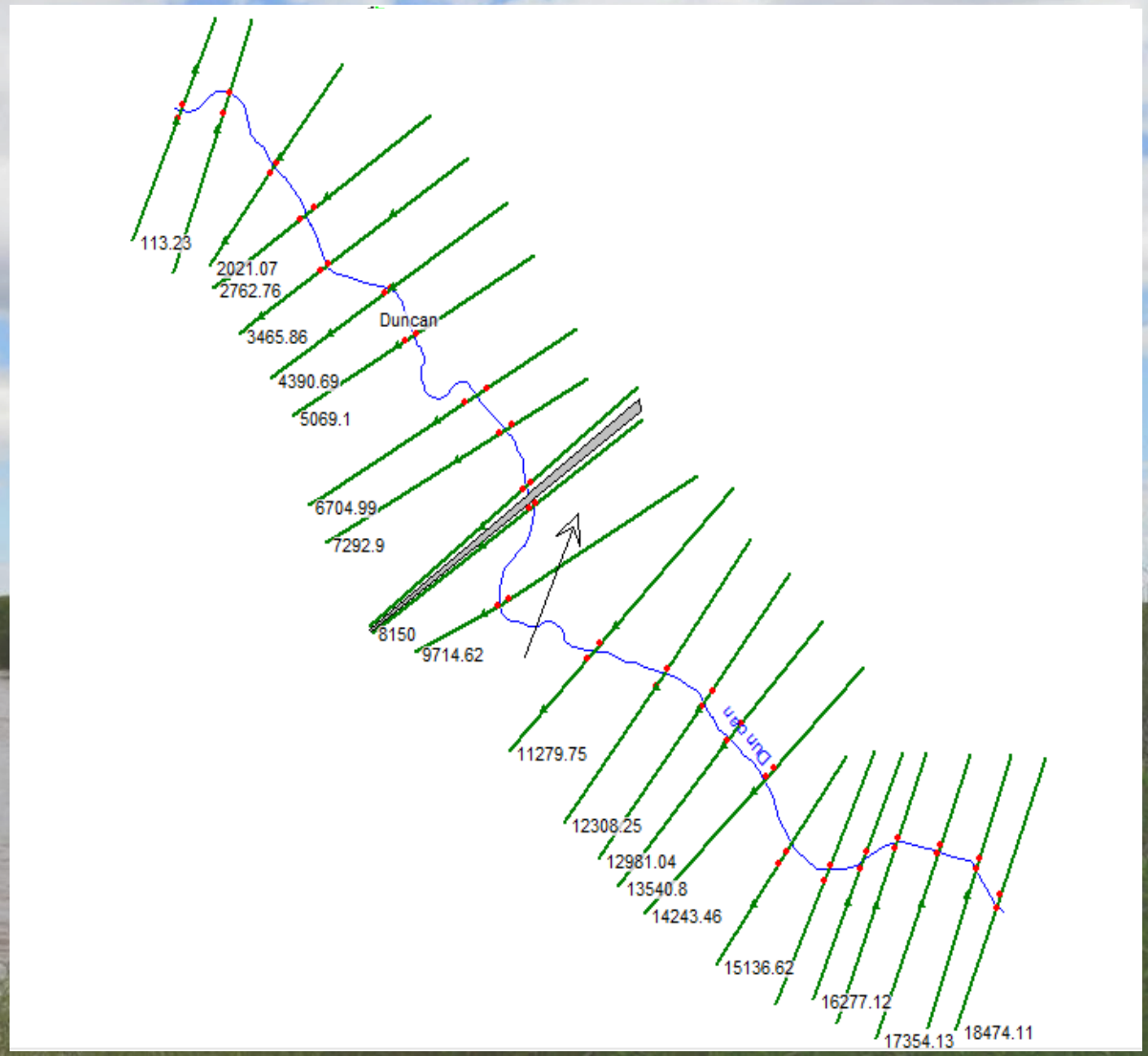


Recreated Version in HEC-RAS



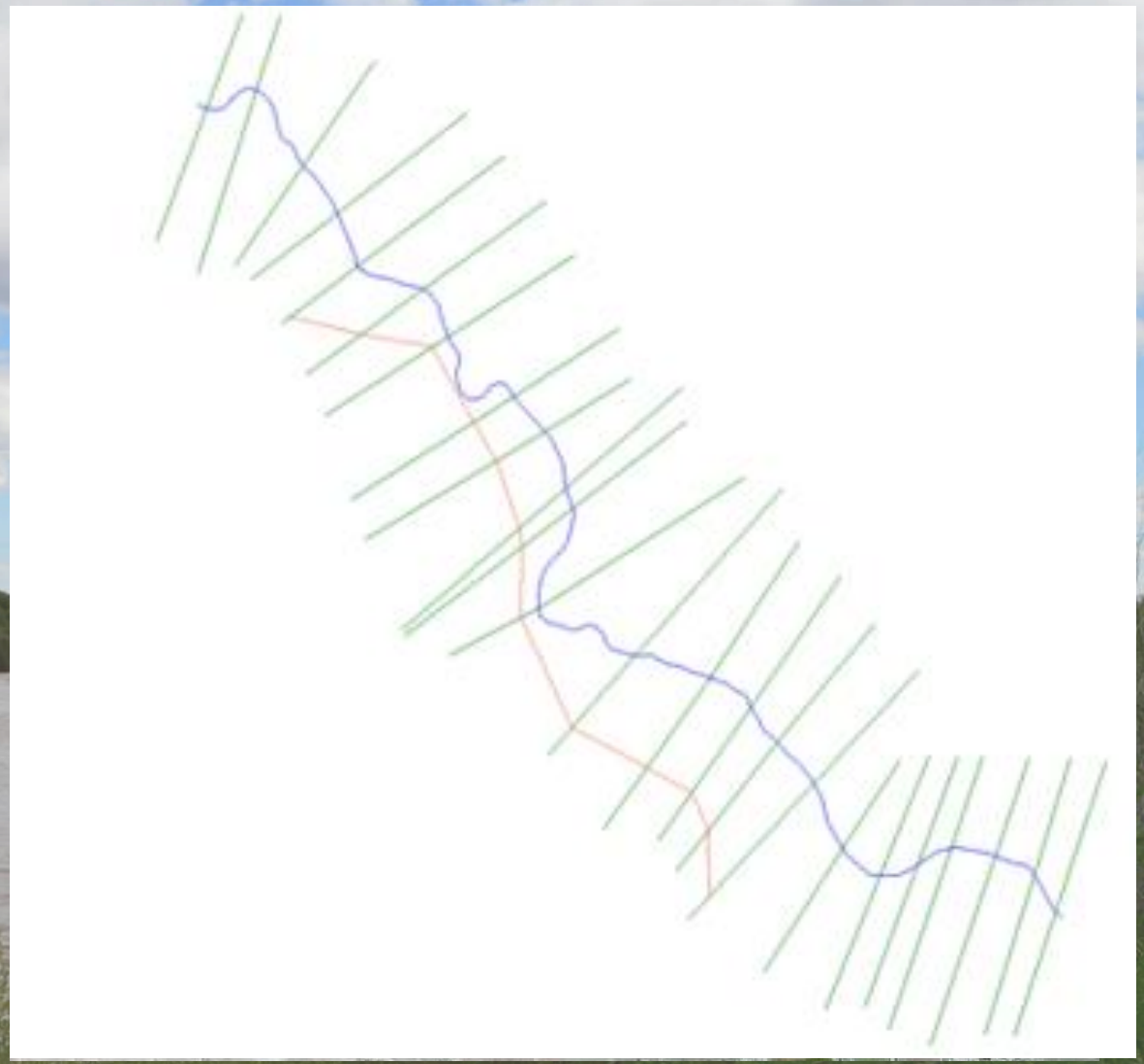
Corrected Effective Model

- **Task**
  - Create floodplain model that reflects current topography
- **Purpose**
  - Provides insight to the flood risks of Duncan
- **Procedures**
  - Export cross sections and topography data from Civil 3D to HEC-RAS
  - Determine Manning's Roughness Coefficient values
  - Run HEC-RAS model with various flow conditions
    - 100 year flow: 48,000 cfs
    - Storm of Record: 58,700 cfs



Proposed Conditions Model

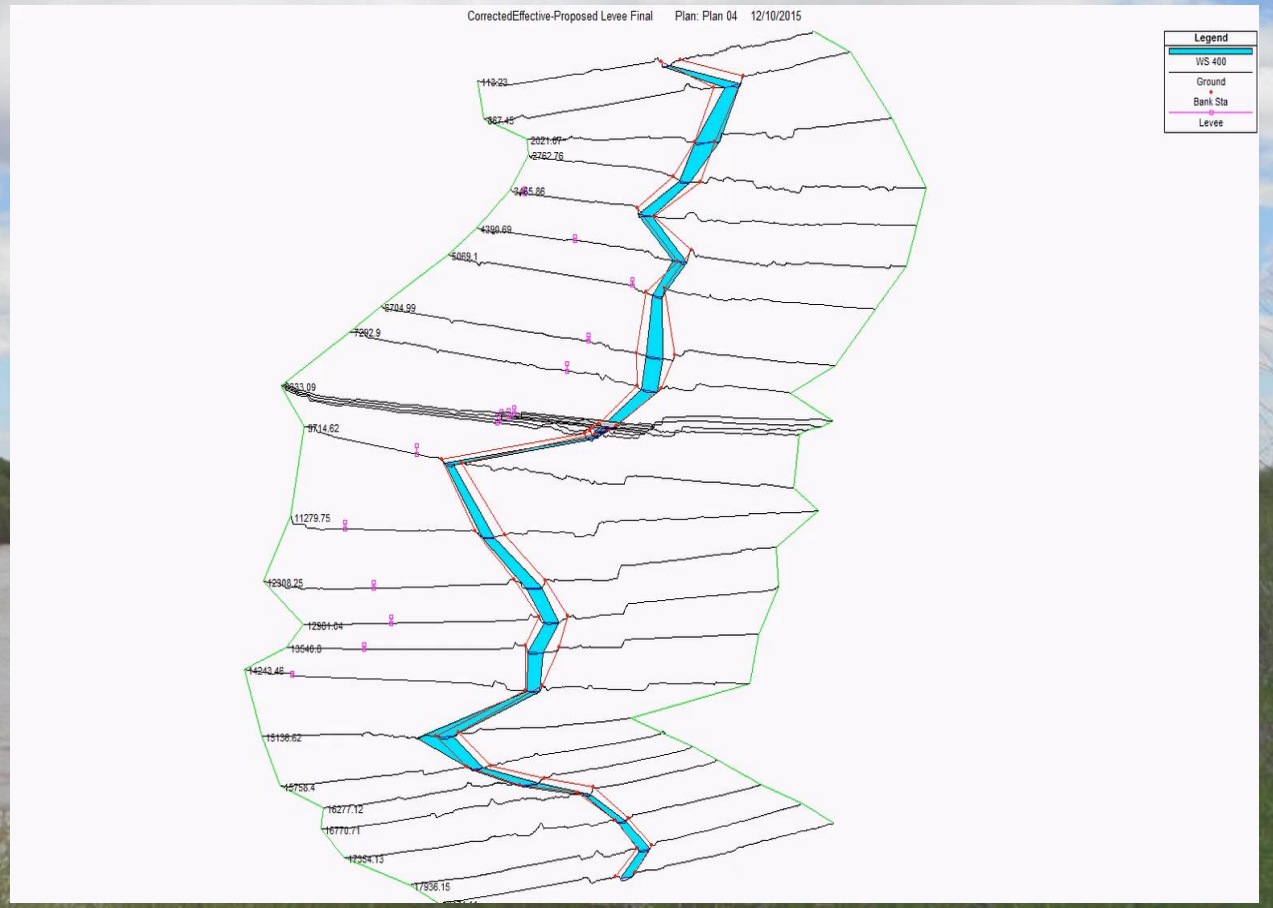
- **Task**
  - Develop levee alignment and analyze its impact to flooding conditions
- **Purpose**
  - Provides insight to Duncan community on how to control Gila River flooding
- **Procedures**
  - Use corrected effective model information
  - Determine most suitable alignment and height specification for levee



Model Comparison

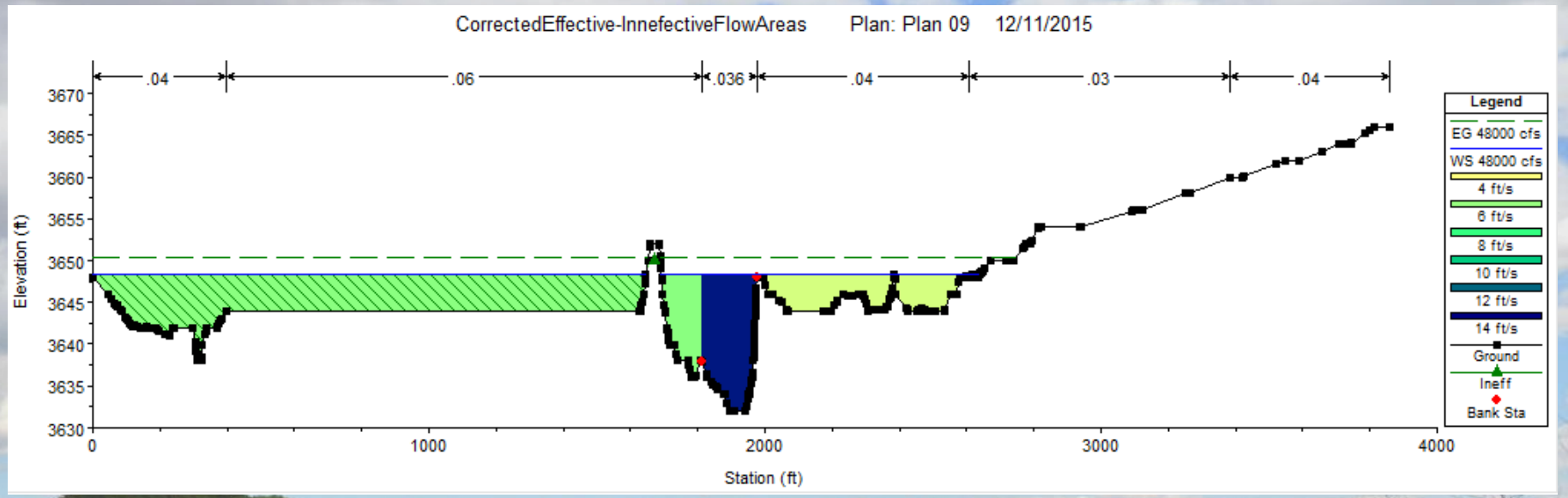
Corrected Effective Model at 48,000 cfs

Proposed Conditions Model at 48,000 cfs



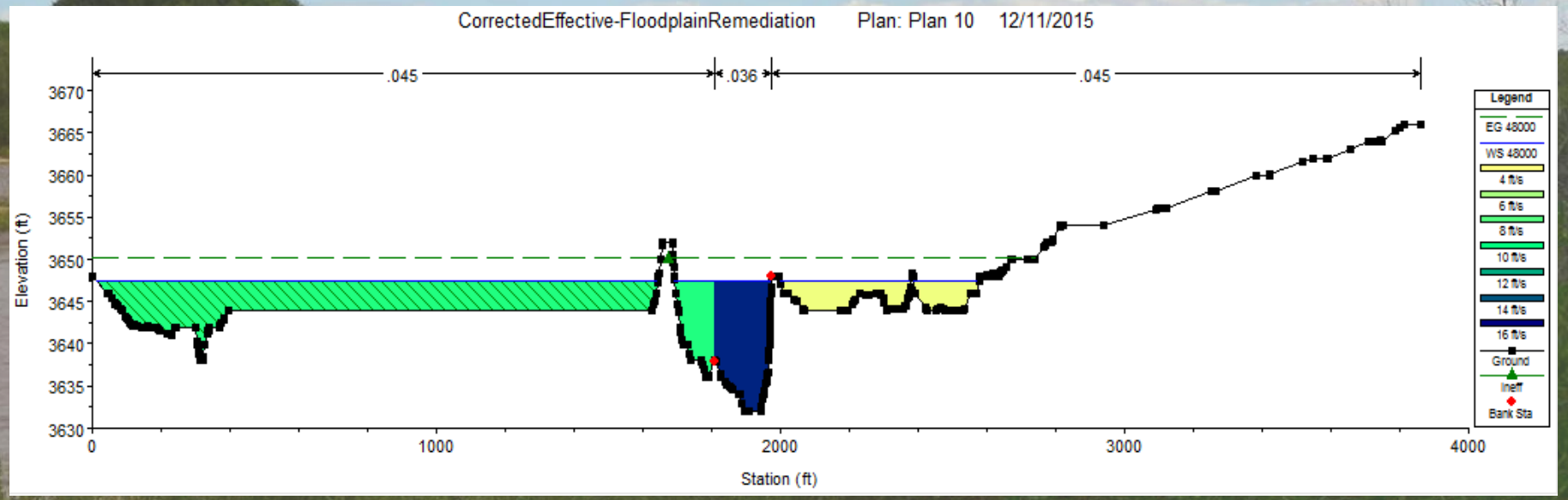
Alternative Proposed Conditions

Existing Conditions



Floodplain Restoration

Soil Excavation

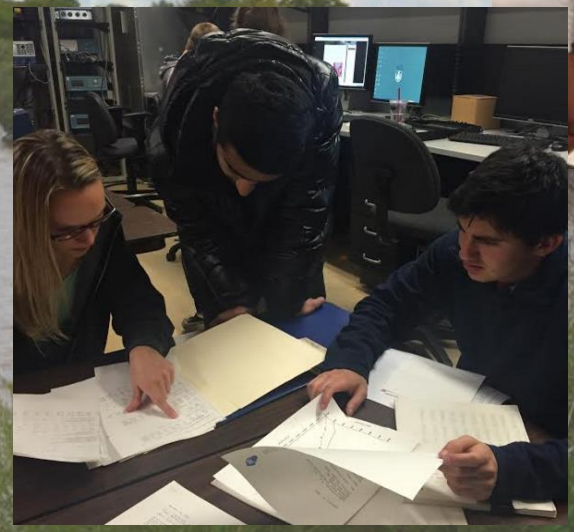


Summary of Project Costs

Personnel	Hours	Price per hour ($/hr)	Total Price ($)
Senior Engineer (SENG)	91	95.00	8,645.00
Professional Engineer (PE)	121	55.00	6,655.00
Engineer In Training (EIT)	156	35.00	5,460.00
Intern	247	20.00	4,940.00
Total Hours	615	**TOTAL COST ($)**	**25,700.00**

Conclusion

- **Project Purpose**
  - Update floodplain boundaries of Gila River in Duncan, AZ
  - Inform community of flood risk
  - Propose 1.9 mile long levee alignment to protect the Town of Duncan
- **Further Recommendations**
  - Floodplain remediation
  - Continuation of floodplain analysis
  - Detailed levee design
- **Project's Future**
  - Spring 2016 NAU Capstone Project



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Client of Project, Greenlee County Engineer

Charles M. Schlinger, Ph.D., P.E., R.G., P.Gp.
Technical Advisor

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[9]	FEMA, "Flood Map Service Center," 28 September 2007. [Online]. Available: https://msc.fema.gov/portal/search?AddressQuery=Duncan%2C%20Arizona. [Accessed 1 February 2007]. [Accessed 1 February 2015].
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Thank You

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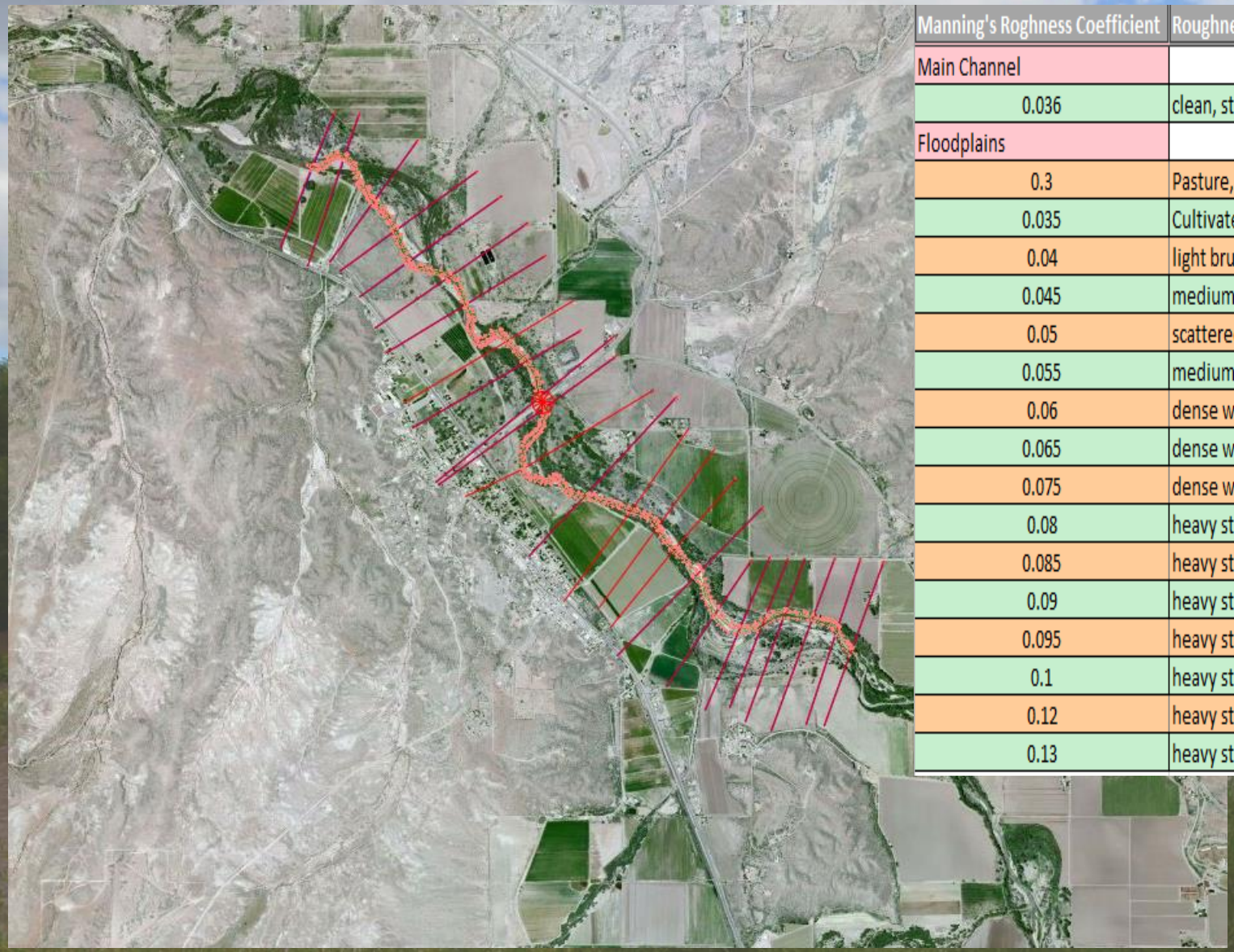
Additional Explanation



Manning's Roghness Coefficient	Roughness Description
Main Channel	
0.036	clean, straight, full stage, no rifts or deep pools, But more stones and weeds
Floodplains	
0.3	Pasture, no brush, short grass
0.035	Cultivated areas, mature field crops
0.04	light brush and trees
0.045	medium to dense brush
0.05	scattered brush, heavy weeds
0.055	medium to dense brush
0.06	dense willows, summer, straight, but with heavy growth of sprouts
0.065	dense willows, summer, straight, but with heavy growth of sprouts
0.075	dense willows, summer, straight, but with heavy growth of sprouts
0.08	heavy stand of timber, a few down trees, little undergrowth, flood stage below branches
0.085	heavy stand of timber, a few down trees, little undergrowth, flood stage below branches
0.09	heavy stand of timber, a few down trees, little undergrowth, flood stage below branches
0.095	heavy stand of timber, a few down trees, little undergrowth, flood stage below branches
0.1	heavy stand of timber, a few down trees, little undergrowth with flood stage reaching branches
0.12	heavy stand of timber, a few down trees, little undergrowth with flood stage reaching branches
0.13	heavy stand of timber, a few down trees, little undergrowth with flood stage reaching branches

Additional Explanation

COMMUNITY NAME	INITIAL IDENTIFICATION	FLOOD HAZARD BOUNDARY MAP REVISION DATE(S)	FLOOD INSURANCE RATE MAP EFFECTIVE DATE	FLOOD INSURANCE RATE MAP REVISION DATE(S)
Clifton, Town of	June 7, 1974	March 25, 1977	March 1, 1984	N/A
Duncan, Town of	September 13, 1974	December 5, 1975	August 2, 1982	N/A
Greenlee County (Unincorporated Areas)	October 25, 1977	N/A	July 18, 1985	September 4, 1987

TABLE 9

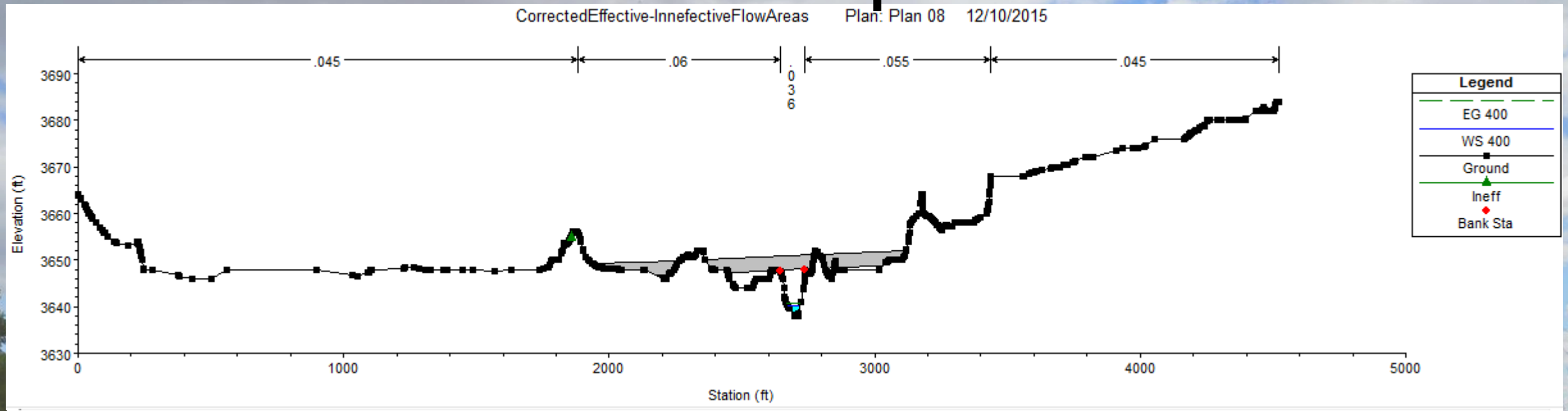
FEDERAL EMERGENCY MANAGEMENT AGENCY

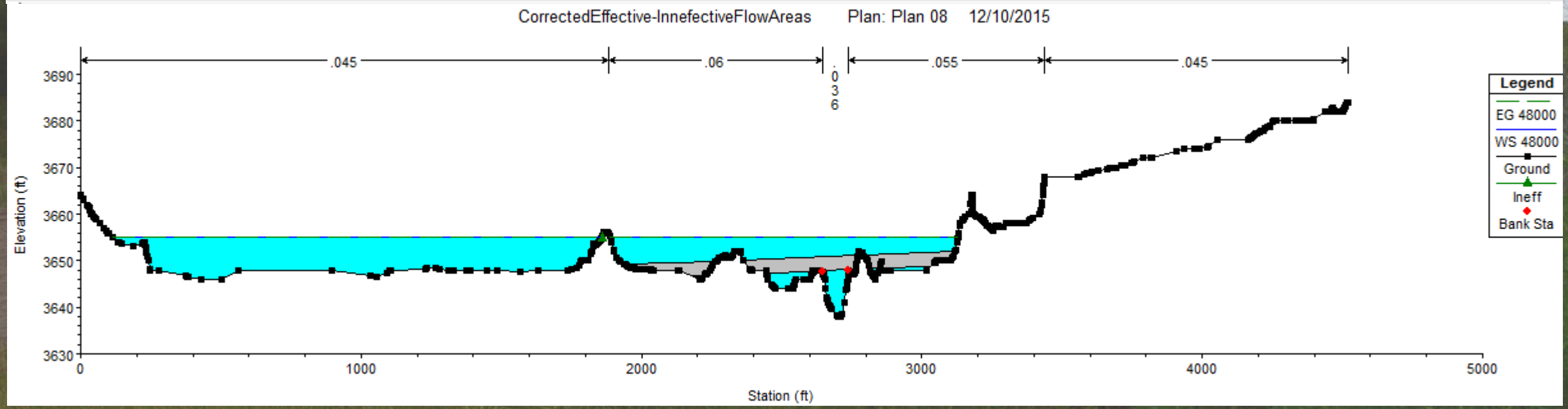
GREENLEE COUNTY, AZ

AND INCORPORATED AREAS

COMMUNITY MAP HISTORY

Additional Explanation





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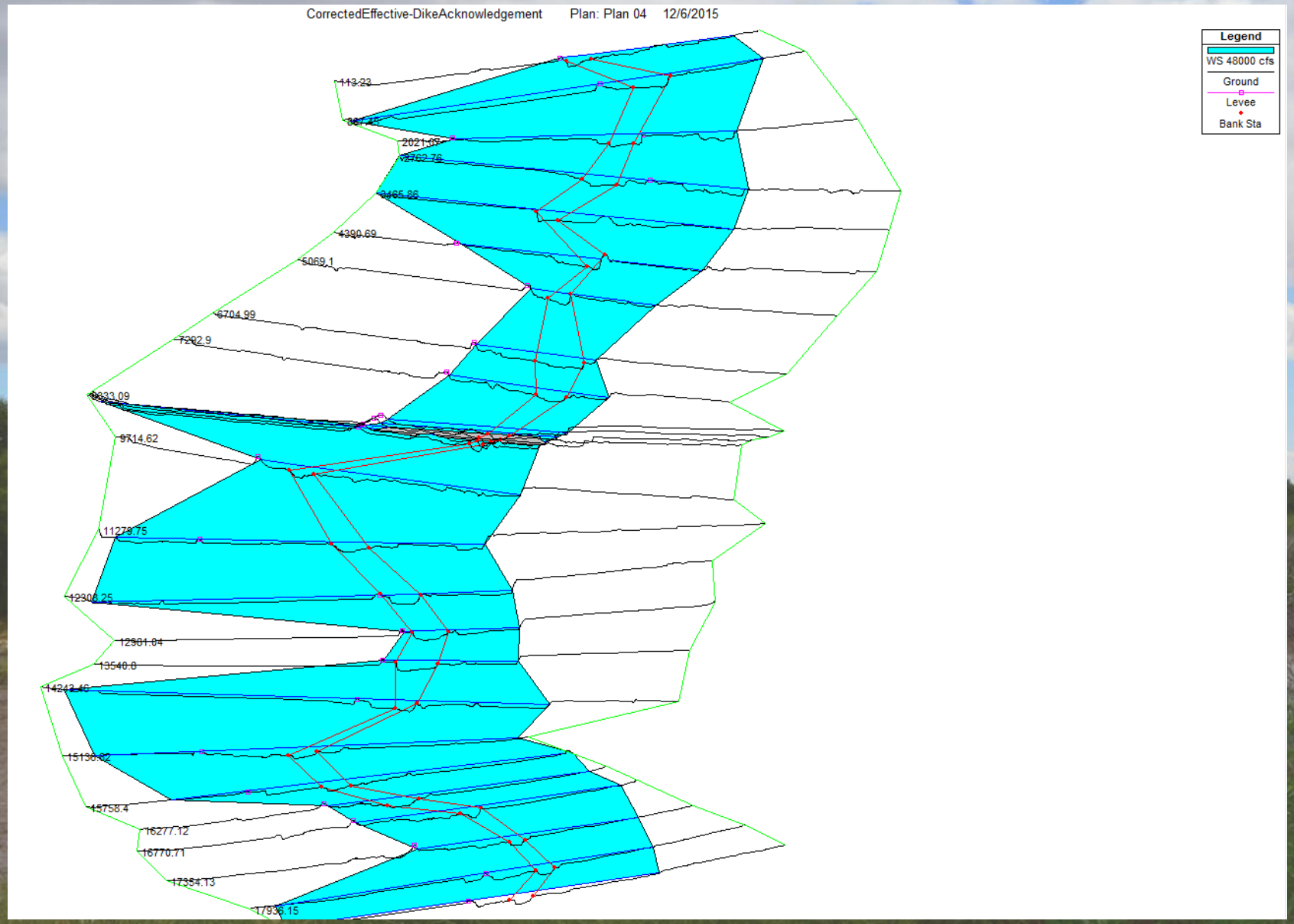

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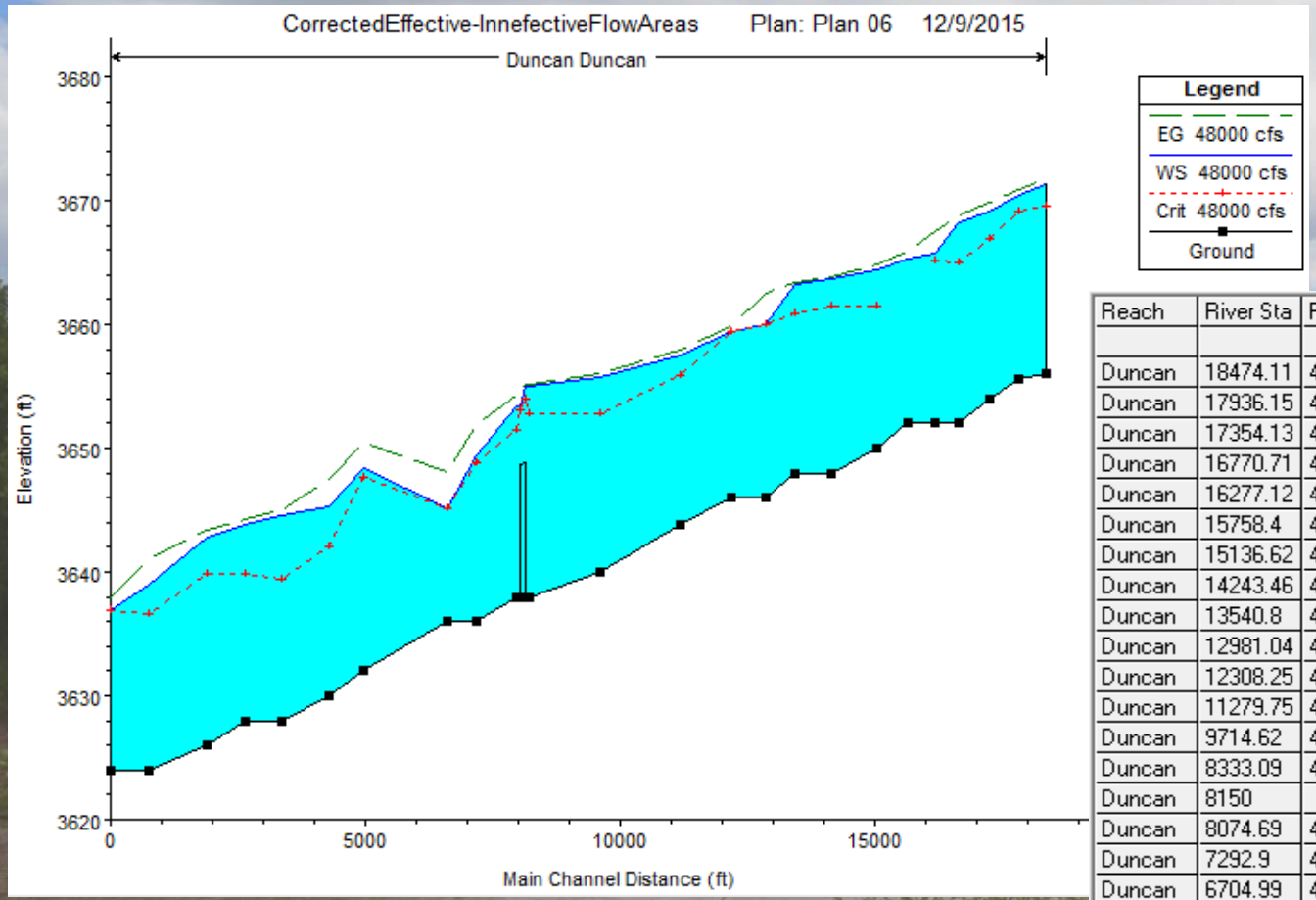

Reach	River Sta	Profile	Q Total	Min Ch El	W.S. Elev	Crit W.S.	E.G. Elev	E.G. Slope	Vel Chnl	Flow Area	Top Width	Froude # Chl
			(cfs)	(ft)	(ft)	(ft)	(ft)	(ft/ft)	(ft/s)	(sq ft)	(ft)	
Duncan	18474.11	48000	48000.00	3656.00	3671.29	3669.49	3671.74	0.001350	8.00	12436.13	2673.23	0.40
Duncan	17936.15	48000	48000.00	3655.61	3670.40	3669.08	3670.94	0.001601	9.13	12151.00	2726.40	0.44
Duncan	17354.13	48000	48000.00	3654.00	3669.07	3666.88	3669.90	0.001945	10.09	8761.83	3016.41	0.49
Duncan	16770.71	48000	48000.00	3652.00	3668.21	3665.02	3668.76	0.001699	8.78	11048.86	3234.97	0.45
Duncan	16277.12	48000	48000.00	3652.00	3665.67	3665.20	3667.50	0.003467	12.82	8129.53	2758.82	0.65
Duncan	15758.4	48000	48000.00	3652.00	3665.31		3665.87	0.001755	8.71	13496.29	2703.48	0.46
Duncan	15136.62	48000	48000.00	3650.00	3664.44	3661.50	3664.92	0.001272	7.84	15173.85	3035.98	0.39
Duncan	14243.46	48000	48000.00	3648.00	3663.61	3661.51	3663.89	0.000918	6.74	15150.97	3069.34	0.33
Duncan	13540.8	48000	48000.00	3648.00	3663.22	3660.88	3663.40	0.000489	4.86	19776.64	2954.72	0.24
Duncan	12981.04	48000	48000.00	3646.00	3659.99	3659.99	3662.51	0.005455	14.21	4293.32	2758.37	0.79
Duncan	12308.25	48000	48000.00	3646.00	3659.47	3659.47	3659.88	0.001595	7.44	14552.60	2789.73	0.42
Duncan	11279.75	48000	48000.00	3643.84	3657.52	3655.95	3657.92	0.001290	7.25	12887.83	2469.75	0.39
Duncan	9714.62	48000	48000.00	3640.00	3655.67	3652.77	3656.09	0.001057	7.22	10836.84	2825.09	0.36
Duncan	8333.09	48000	48000.00	3638.00	3655.04	3652.76	3655.15	0.000396	4.62	20925.27	2982.82	0.22
Duncan	8150		Bridge									
Duncan	8074.69	48000	48000.00	3637.95	3653.38	3651.50	3654.26	0.001879	10.21	8160.52	3014.81	0.49
Duncan	7292.9	48000	48000.00	3636.00	3649.48	3648.79	3651.90	0.004684	14.34	5546.70	2935.05	0.75
Duncan	6704.99	48000	48000.00	3636.00	3645.15	3645.15	3648.13	0.008937	15.06	4023.76	2222.11	0.96
Duncan	5069.1	48000	48000.00	3632.00	3648.39	3647.62	3650.39	0.003403	13.55	5497.10	2593.69	0.64
Duncan	4390.69	48000	48000.00	3630.00	3645.28	3641.99	3647.43	0.005693	16.33	5263.94	2463.19	0.81
Duncan	3465.86	48000	48000.00	3628.00	3644.63	3639.34	3645.06	0.001032	7.41	11236.33	2469.69	0.35
Duncan	2762.76	48000	48000.00	3628.00	3643.79	3639.89	3644.28	0.001184	7.55	12803.12	2564.99	0.36
Duncan	2021.07	48000	48000.00	3626.00	3642.81	3639.87	3643.42	0.001110	8.41	12013.01	2248.67	0.38
Duncan	867.45	48000	48000.00	3624.00	3639.02	3636.68	3641.10	0.003836	12.61	4896.37	2589.25	0.67
Duncan	113.23	48000	48000.00	3624.00	3636.95	3636.95	3637.98	0.003553	11.23	8294.49	2469.58	0.63

Additional Explanation

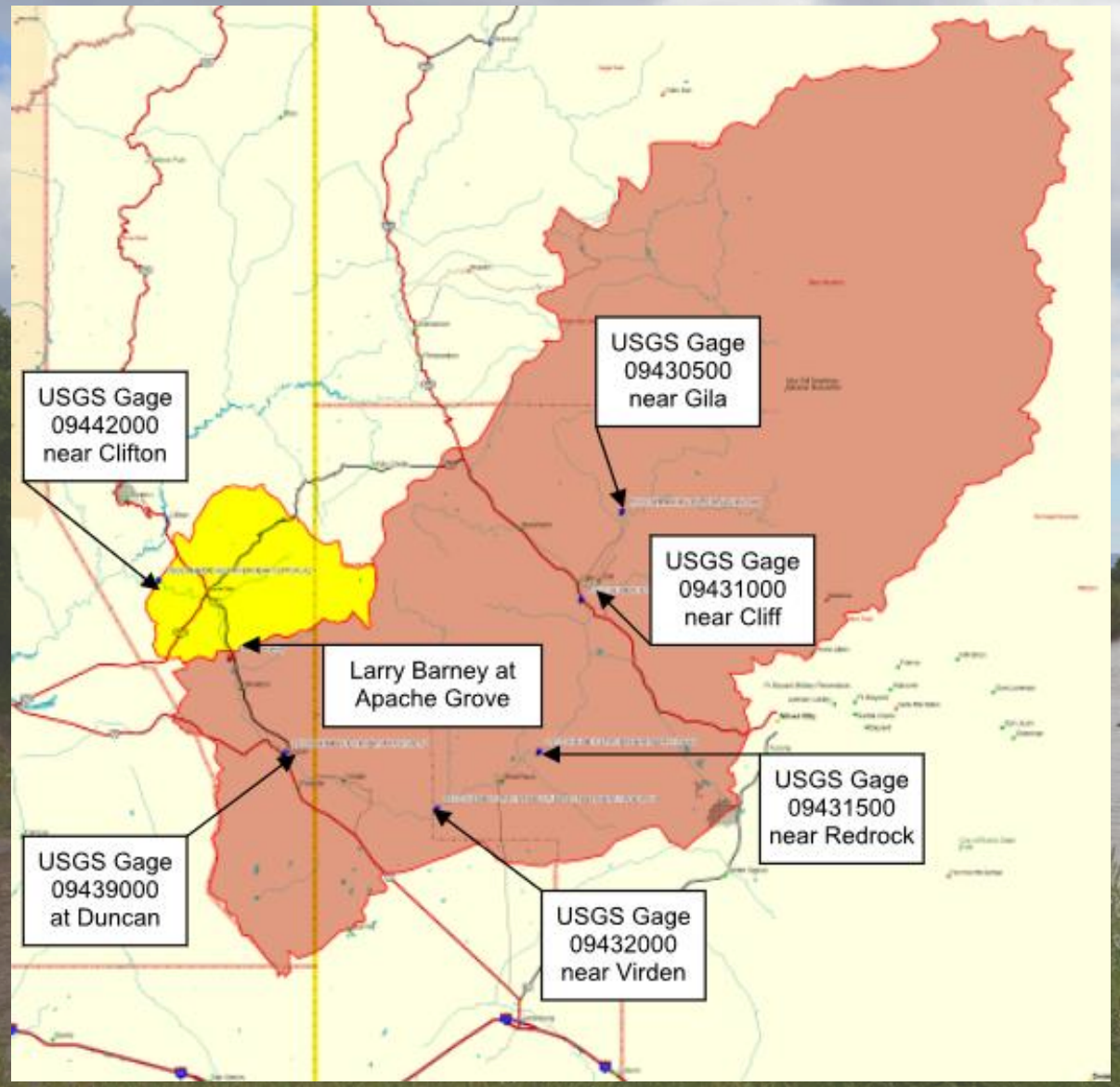

Table 1 Flood Frequency Analysis for the Gila River

Flood frequency analysis results for the Virden and Clifton USGS Gages and flood estimates for the project site.

	USGS Gage #9432000 (1)	USGS Gage #9442000 (1)	Project Site	
RECURRENCE INTERVALS	GILA RIVER BELOW BLUE CREEK, NEAR VIRDEN, NM (Watershed = 3,203 mi^2)	GILA RIVER NEAR CLIFTON, AZ (Watershed = 4,010 mi^2)	APACHE GROVE (Watershed = 3,769 mi^2)	
$Q_{1.25}$	2,410	2,820	2,650	(2)
$Q_{1.5}$	3,600	4,030	3,790	(2)
Q_2	5,440	5,870	5,520	(2)
Q_5	12,100	12,400	12,400	(3)
Q_{10}	18,200	18,300	18,300	(3)
Q_{25}	28,100	27,900	28,100	(3)
Q_{50}	37,000	36,800	37,000	(3)
Q_{100}	47,400	47,100	47,400	(3)

Additional Explanation

- **1870s**: Duncan is established
- **1945**: Research of Dam sites along upper Gila River (Army Corps of Engineers)
- **1972**: Levees overtopped and eroded-27,200 cfs: Non-agriculture damages= 1.5 million
- **1975**: Flood Boundary Map Revision Date
- **1978:** 58,700 CFS $3 million in damage (ADWR)
- **1979**: Evaluation of feasibility for designing a 2 mile levee system to protect Duncan (Corps of Engineers)- Turned down due to unfavorable project economics
- **1980**: After flood, the Soil Conservation Service restored damaged levees through the Emergency Watershed Protection Program
- **1981** ADWR Reconnaissance Report of potential levee design plan(s) of 7.5/2.3(+1.9 miles to protect sewage plant) mile reach along Gila River. Objective is to provide the maximum degree of protection at the least possible cost
- **1988** HEC2 ADWR Analysis of Gila River
- **1990** HEC2 ADWR Analysis of Gila River
- **2001-2003** USBR Geomorphic study hydraulic model input files (HEC-RAS)
- **Feb 2005:**Claims Coordinating Office (CCO) meeting for Greenlee Countywide DFIRM and FIS
- **Feb 2007**: Final DFIRM and FIS meeting
- **2012:** Airborne Lidar Survey of Southeast Arizona 164 square miles (Kimley-Horne)
- **2015** 100 Year flow is updated from 28,500 cfs to 47,400 cfs