A case study of stormwater diversion for groundwater recharge

David A. Jaffe, PhD, PE, BC.WRE

Emma Erickson, PE

West Yost

Floodplain Management Association Annual Conference

September 2025

Sacramento, California

FMA40

40TH ANNIVERSARY

FLOODPLAIN MANAGEMENT ASSOCIATION

CELEBRATING 40 YEARS OF SAFER AND MORE RESILIENT FLOODPLAINS

SEPTEMBER 2-5, 2025 | SACRAMENTO, CA

35 YEARS Of Excellence WEST YOST

Challenges

- **Primary challenge** - large quantities of runoff are available to recharge during storm events, but

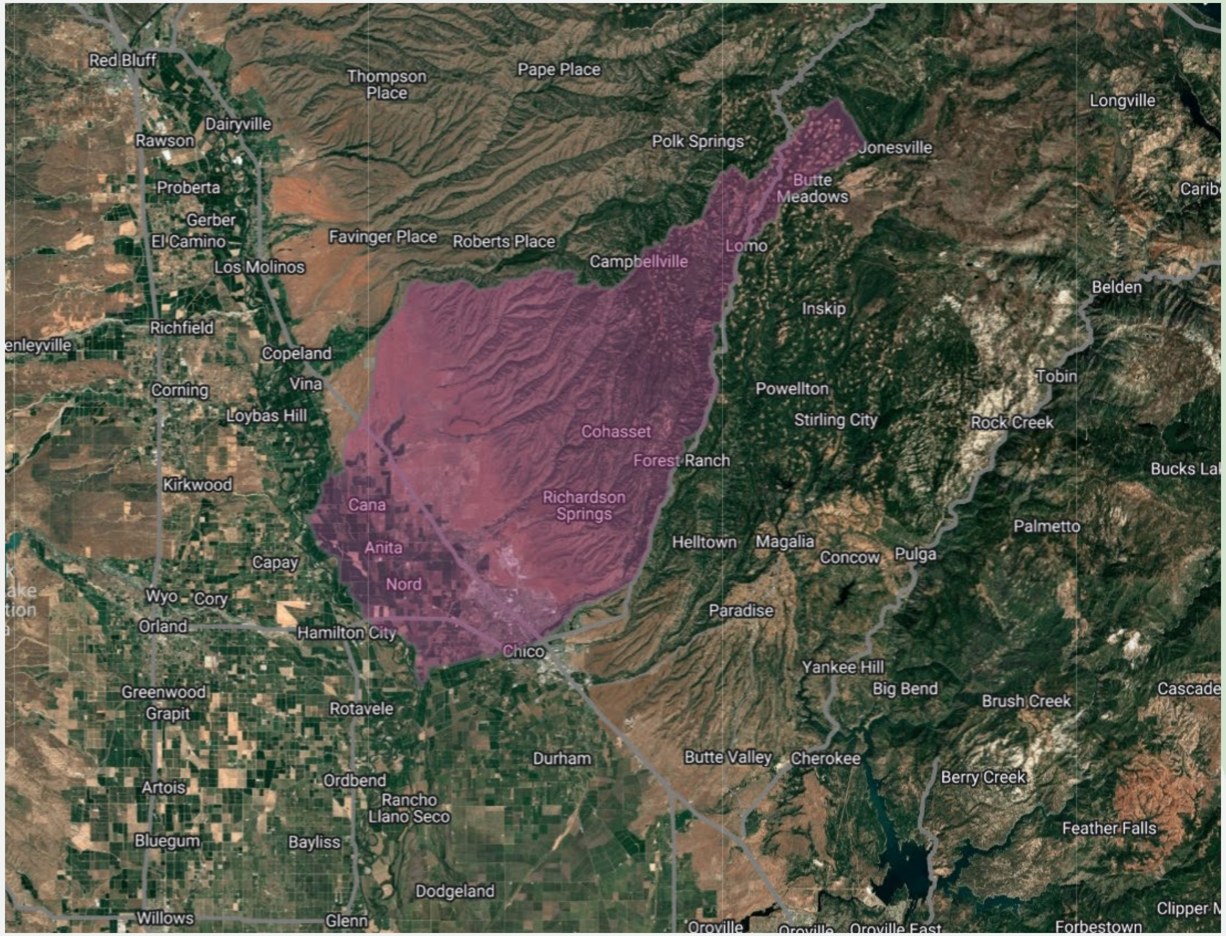
Channel discharge: cubic feet per second

Infiltration (sandy bed): inches per hour

- **Other challenges** - low permeability soils, soil saturation, shallow groundwater table, relatively low storage basin volume.

Solution case study – Lindo Channel

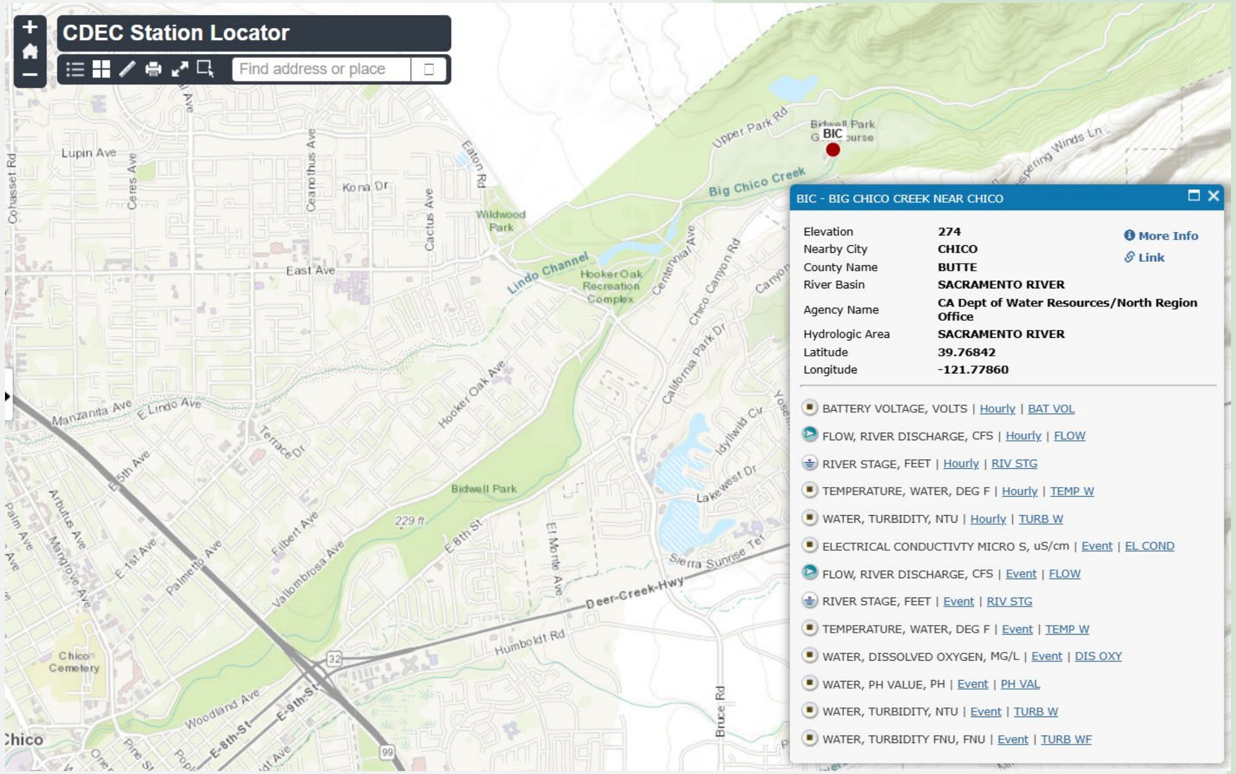
- The present study examines the effectiveness of diversions during frequent runoff events to recharge groundwater.
- Lindo Channel, Chico, California
- Natural intermittent overflow channel from Big Chico Creek in the Chico Fan.
- USACE completed flood control program in study area in 1965.



- Source: Sacramento Watershed Program

Approach

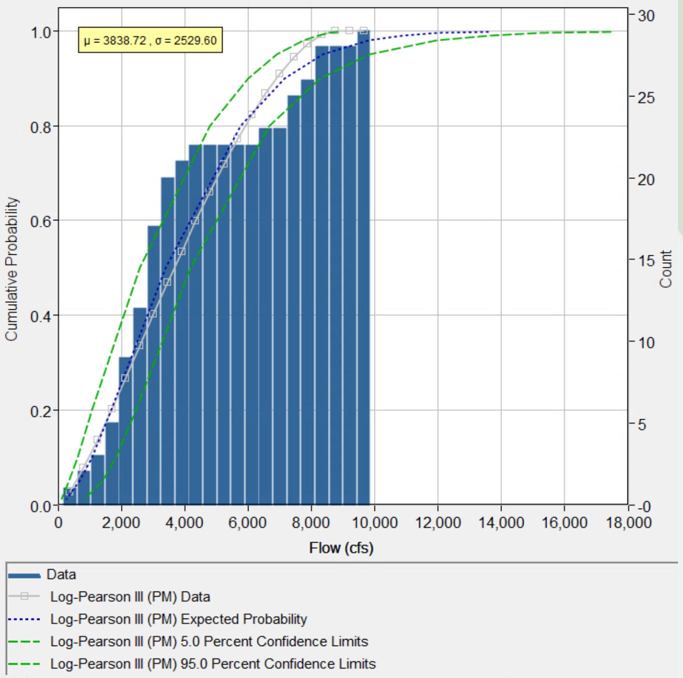
- Ecological flows assessment (not described here)
- Flood flow frequency analysis at BIC
- Flow split two-dimensional numerical modeling at Big Chico/Lindo
- Lindo Channel one-dimensional numerical modeling
- Infiltration calculations
- Concurrent hydrogeologic analysis



- Source: CDEC

Flood flow frequency analysis

- BIC gage
- 28 years of record (1997-present)
- HEC-SSP (Bulletin 17C)
- Discharges for 1-, 2-, 5- and 10-year return periods
- Log-Pearson III distribution vs. Gumbel distribution
- Representative historical runoff event selected for each return period event for numerical modeling



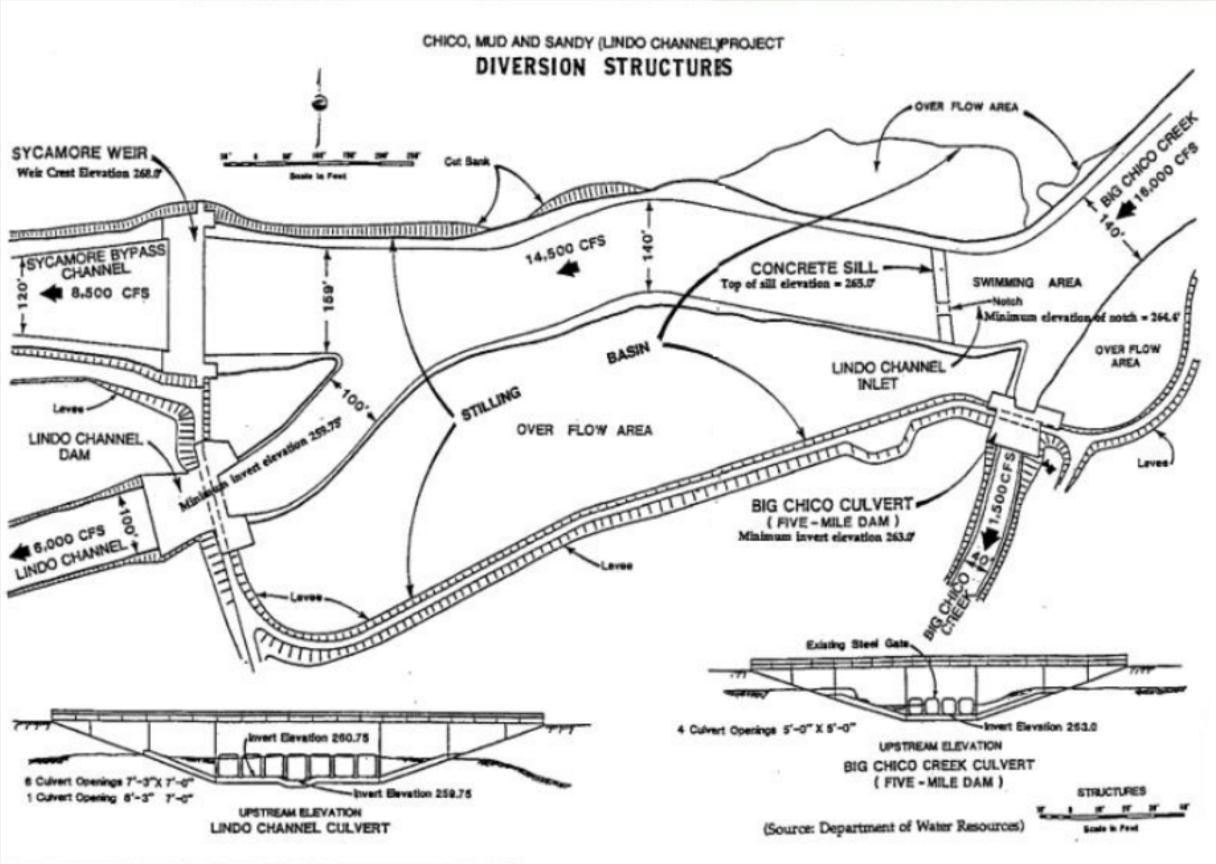
Frequency Curves

Percent Chance Exceedance	Median Curve Flow in cfs	Expected Probability Flow in cfs
0.2	8521.5	13602.6
0.5	8399.0	12007.5
1.0	8248.3	10889.1
2.0	8017.7	9810.7
5.0	7513.9	8359.6
10.0	6887.5	7151.8
20.0	5912.3	5751.4
50.0	3672.5	3392.3
80.0	1693.5	1684.5
90.0	986.5	1070.5
95.0	585.5	694.7
99.0	181.5	257.9

35 YEARS Of Excellence WEST YOST

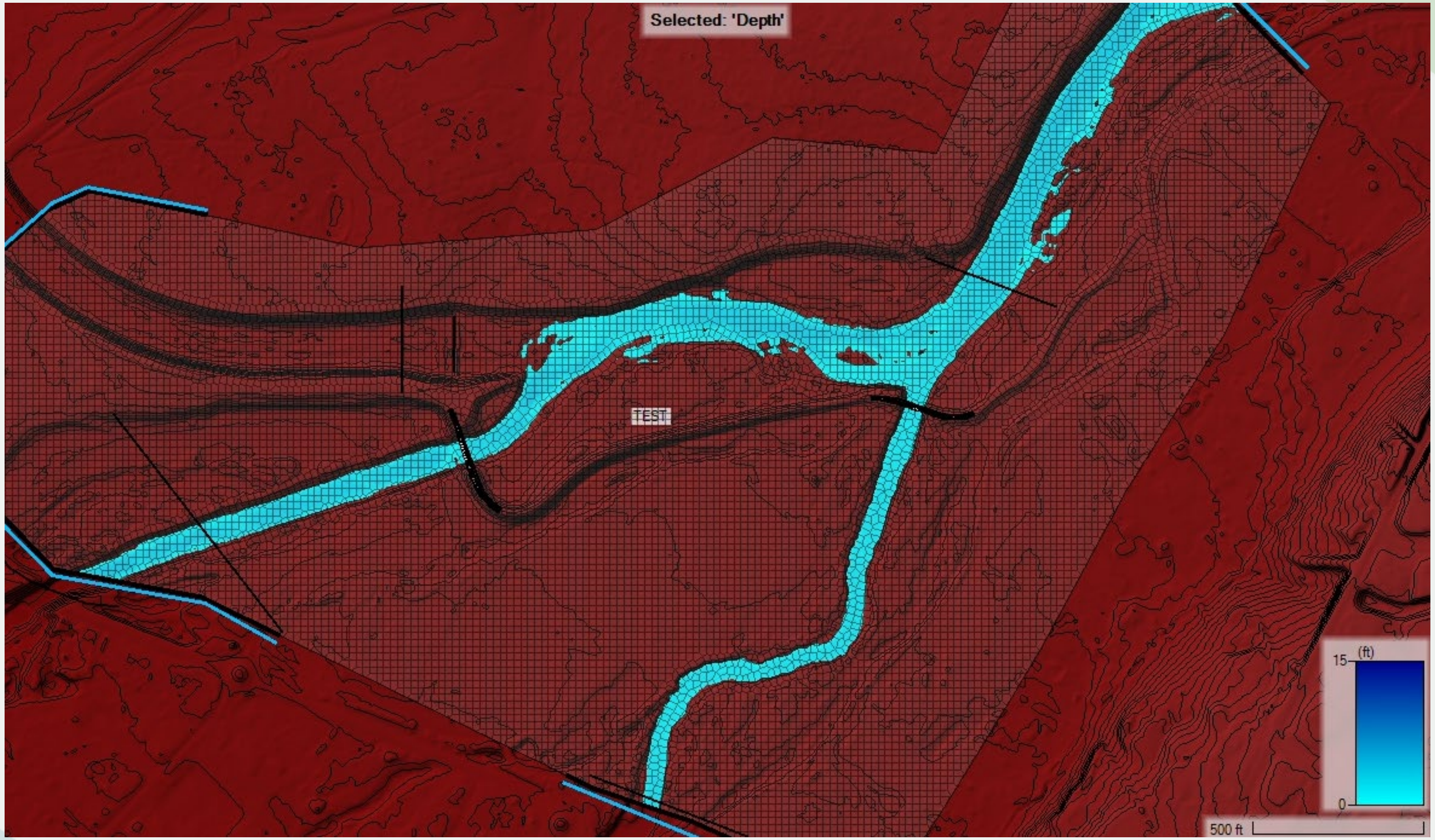
2D flow split modeling

- HEC-RAS
- Two terrains: existing and as-built
- Hydrology from HEC-SSP
- **Goal** – determine flow distribution between Big Chico (main channel), Lindo (distributary) and overflow channel (Sycamore Bypass).

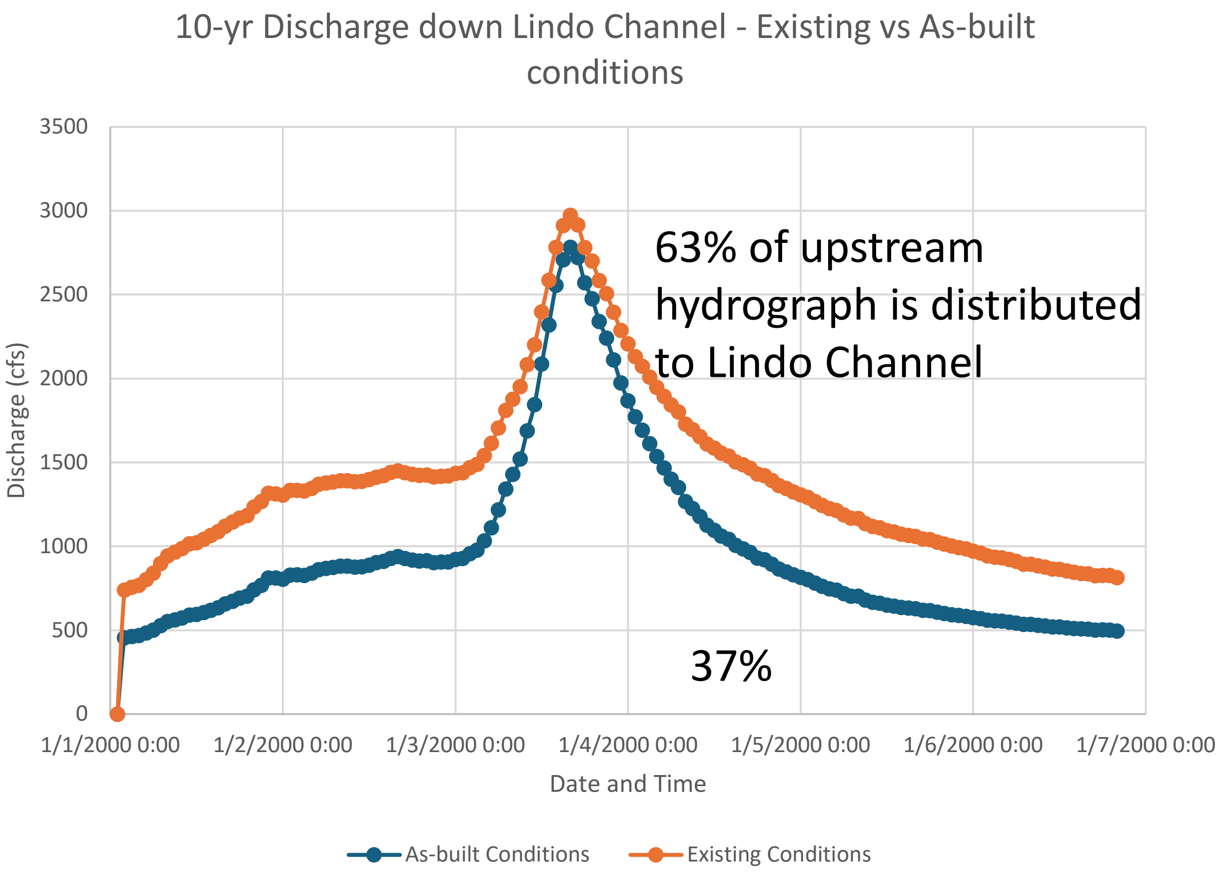


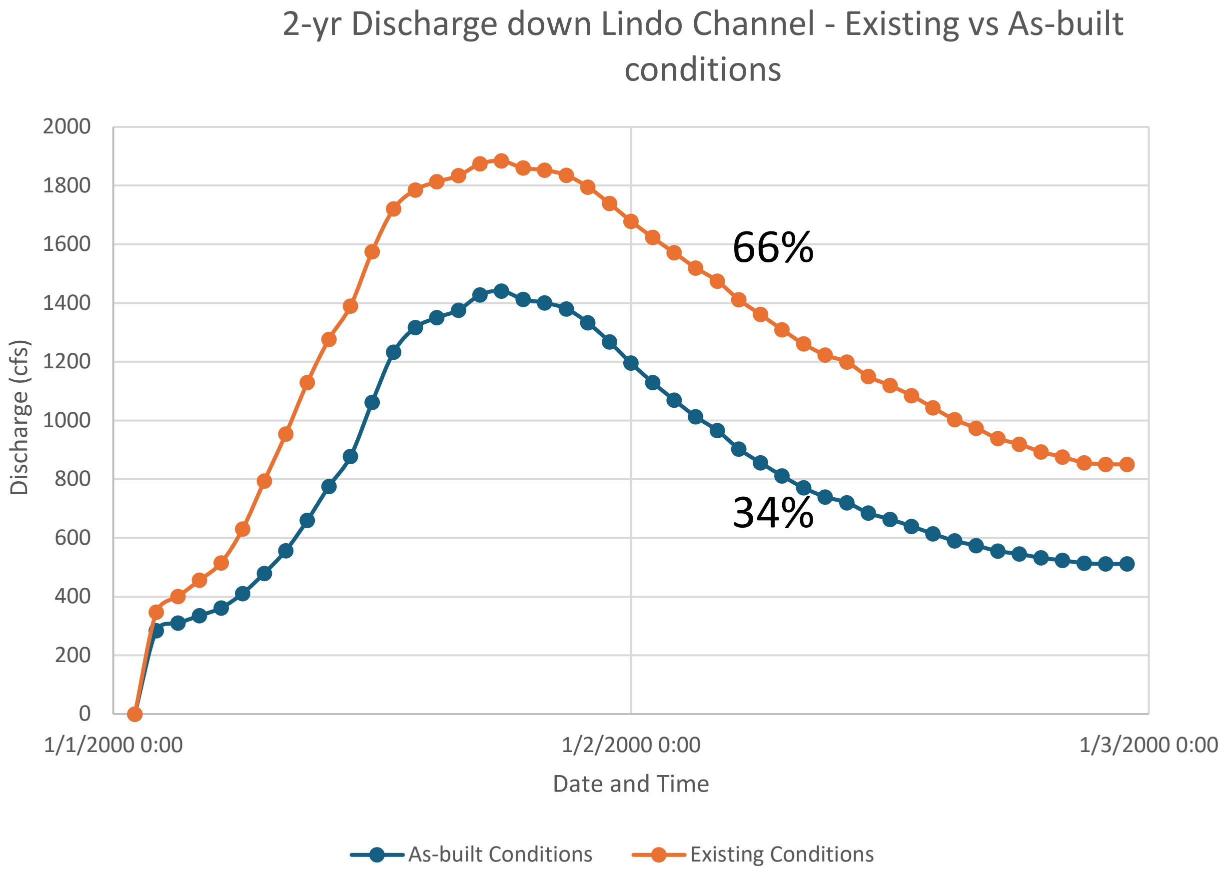
- Source: City of Chico

Lindo Channel 2D flow split model



Flow split model Hydrographs

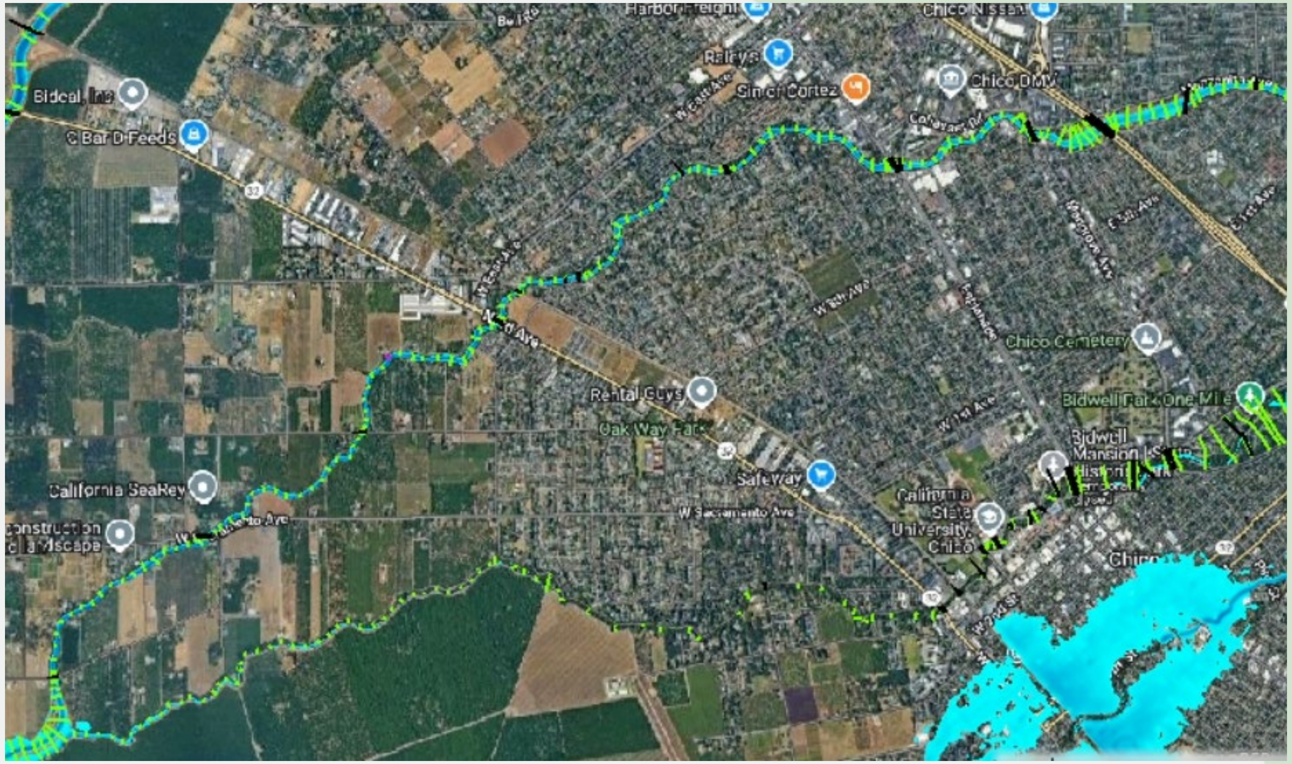




1D Lindo Channel modeling

- 1D HEC-RAS Model developed by others
- 1D modeling goal is to determine top width and wetted perimeter for each section along the channel between Highway 99 and the Big Chico confluence at each model time step
- Area available for infiltration is:

$$A = RL^{*}\ WP \text{ (or B)}$$



Hydrogeologic testing

- Impervious layer upstream of Highway 99 (data/model review)
- Testing and monitoring on-going (domestic well monitoring)
- Preliminary comparisons between runoff events and observed well response (early 2025)
- Infiltrometer testing indicated range of 50-300 feet/day

Infiltration calculations

- Python script written to organize results from HEC-RAS
- Volume = A Δt IR
- Assumptions: no saturated soils, constant infiltration rate in space, constant infiltration rate in time, sufficiently low groundwater table, no anisotropy
- Did not use other methods (i.e., Green-Ampt) which require calibration
- Calculations use 1 inch/hour

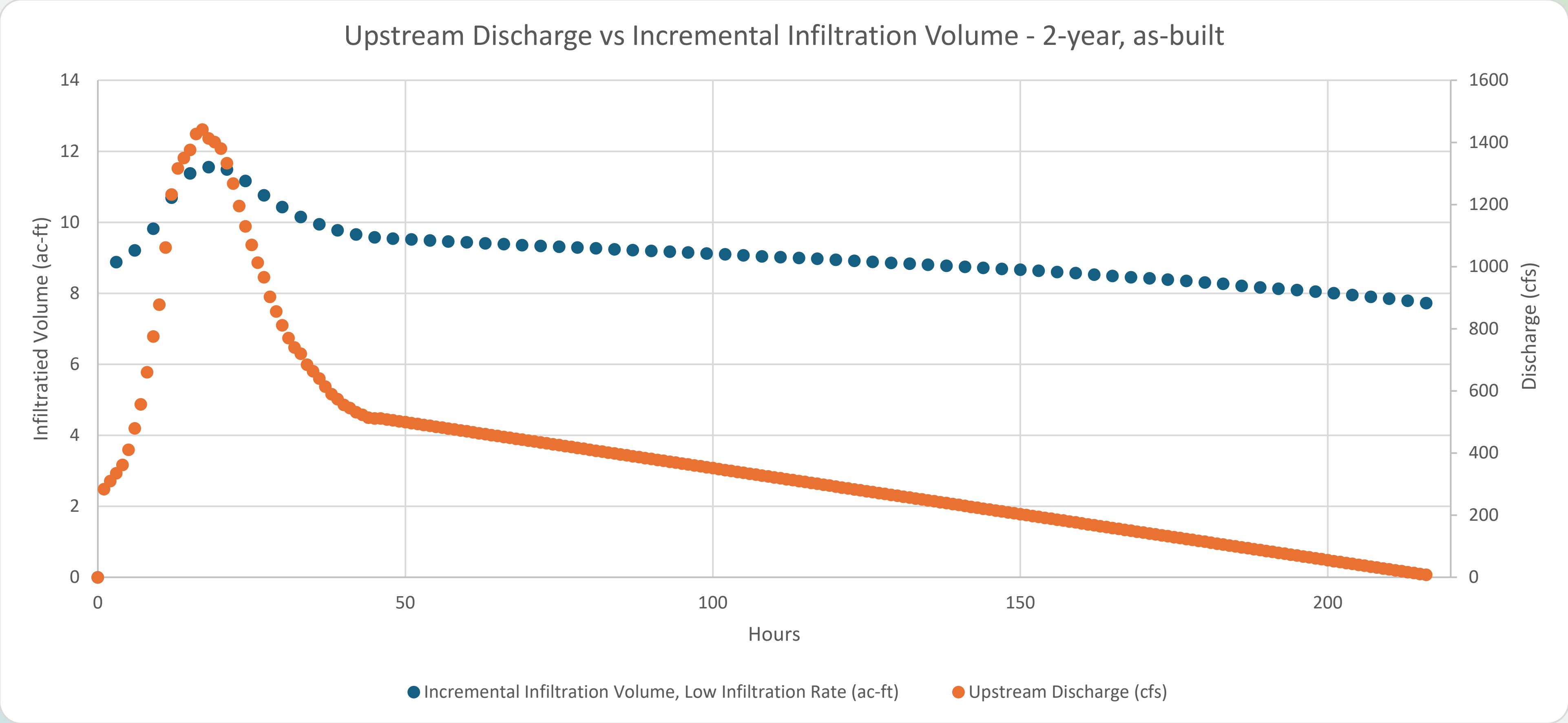
	Varies with Discharge					
River Station	Top Width (ft)	Length of Channel (ft)	Time Step (s)	Infiltration Rate (ft/s)	Area (ft2)	Infiltration Volume (ac-ft)
5.49	61.5	114	10800	2.31481E-05	=H4*F4	0.040

River Station	Top Width (ft)	Length of Channel (ft)	Time Step (s)	Infiltration Rate (ft/s)	Area (ft2)	Infiltration Volume (ac-ft)
5.49	61.5	114	10800	2.31481E-05	7000.9	=(O4*I4*J4)/43560

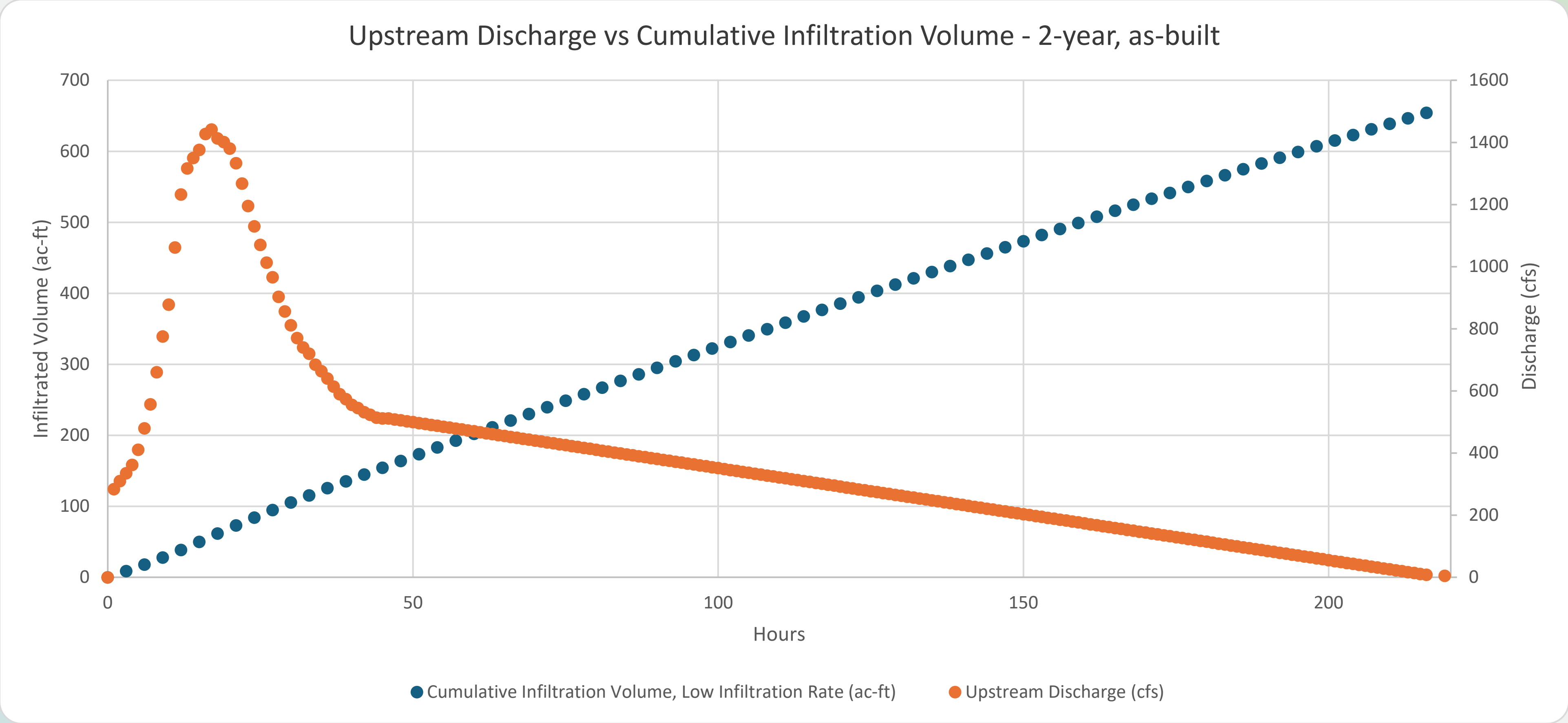
Σ Infiltration Volume at each River Station at one Time Step = Total Infiltration Volume at Time Step

Σ Infiltration Volume at Each Time Step = Total Infiltration Volume during Storm Event

Results – 2-year, as-built

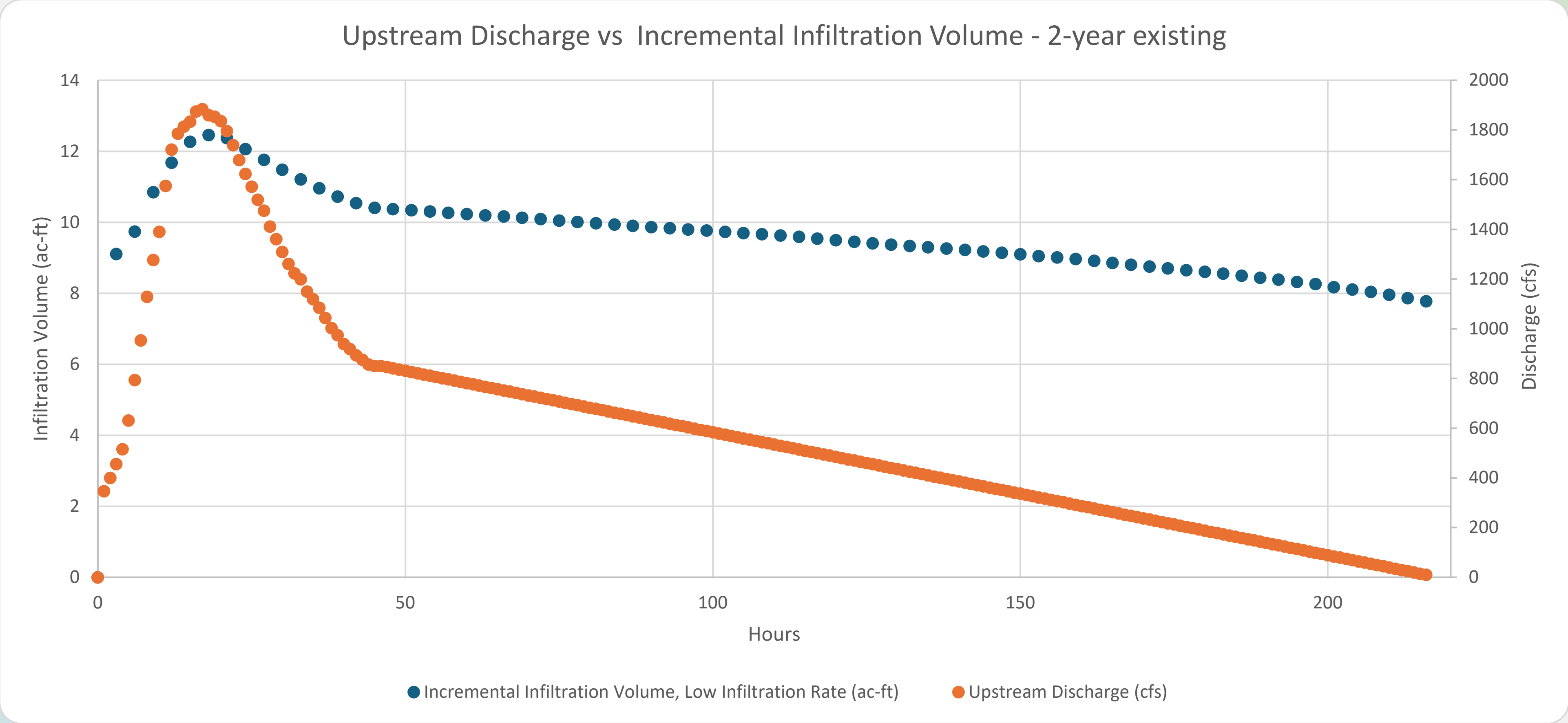


Results – 2-year, as-built, cont.

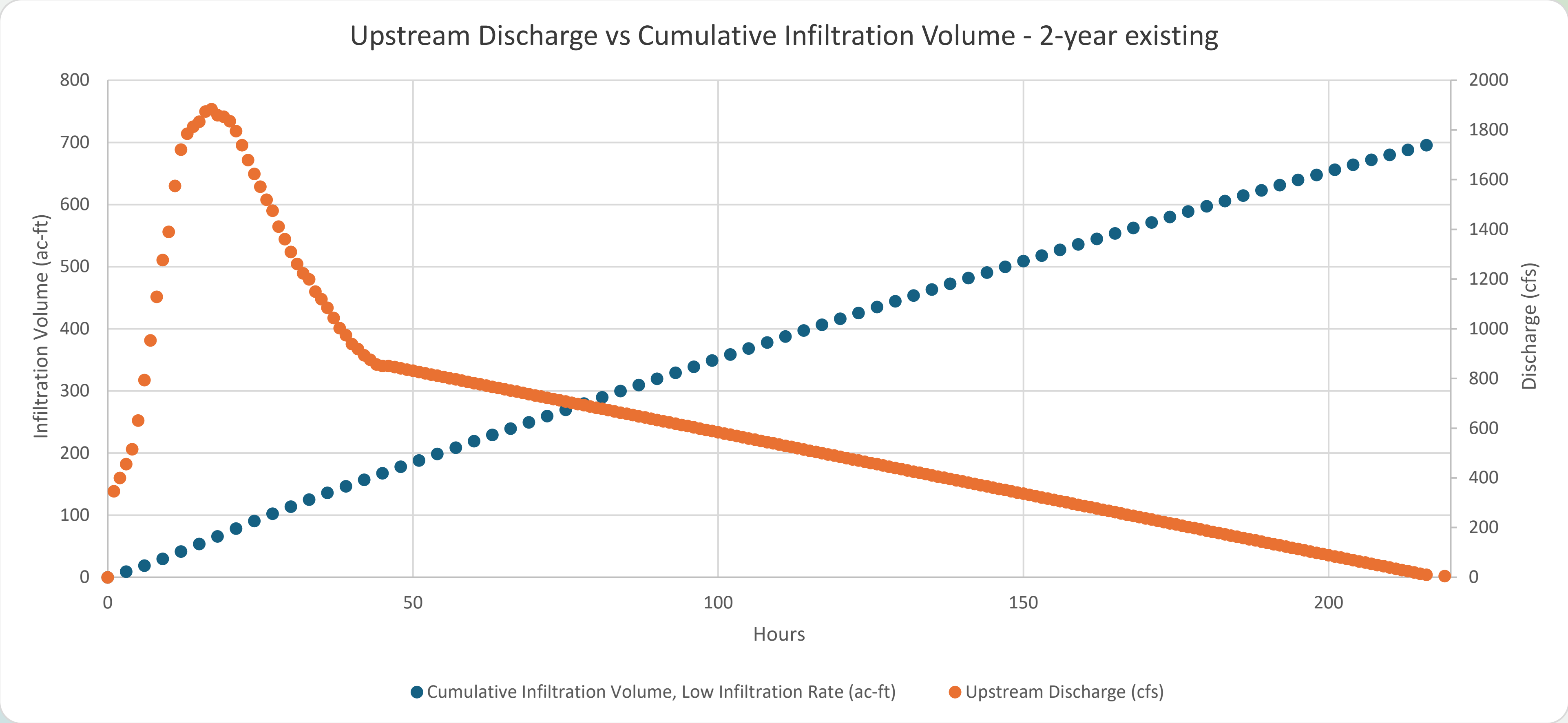


WEST YOST 35 YEARS Of Excellence

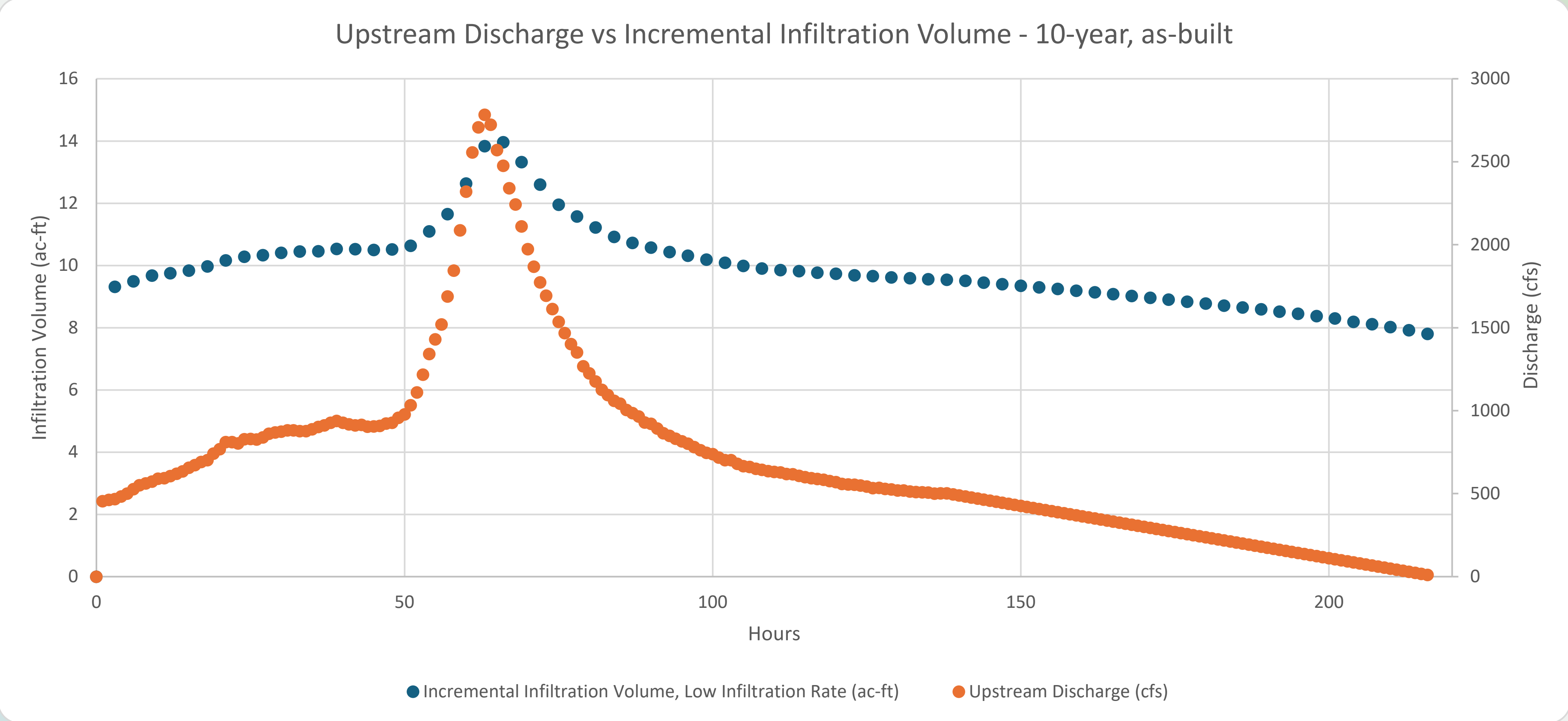
Results – 2-year, existing



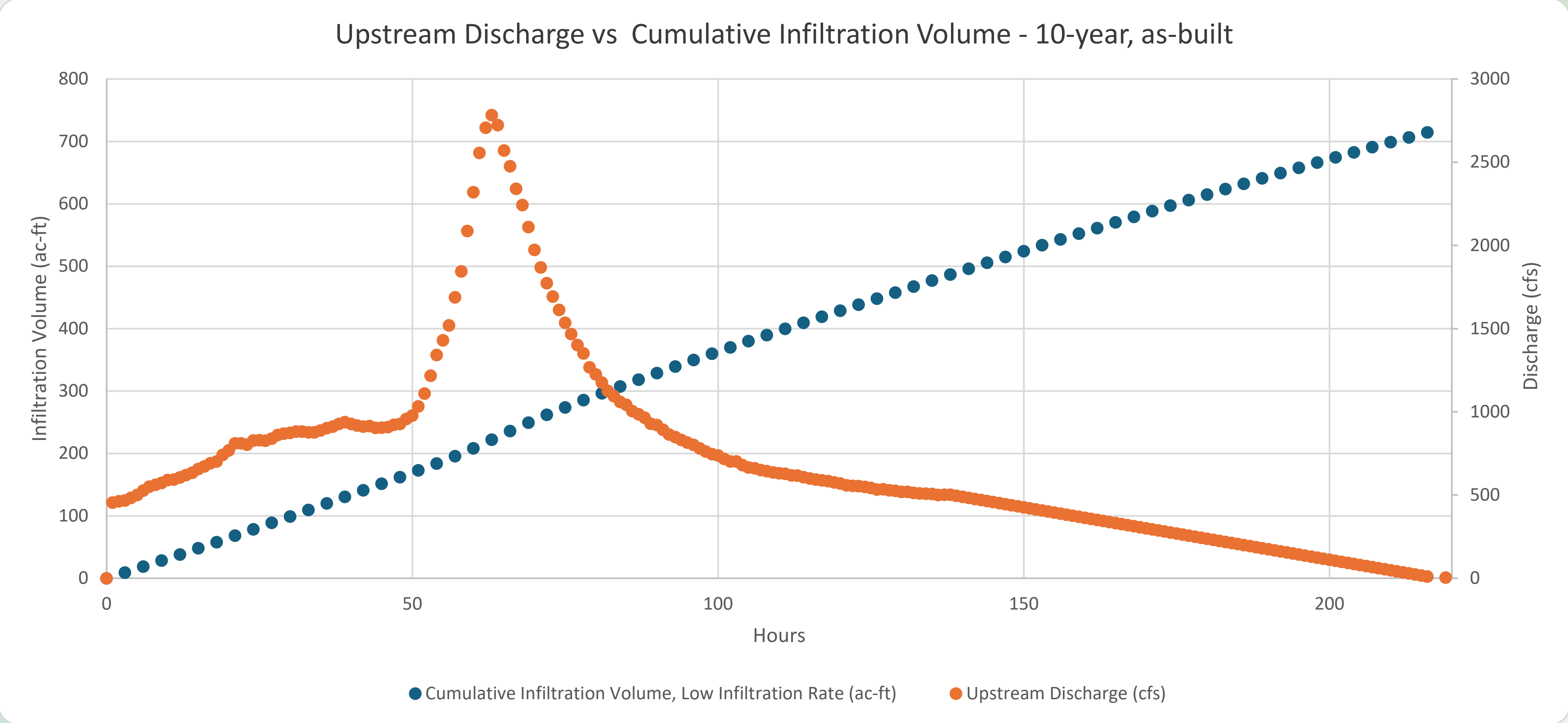
Results – 2-year, existing, cont.



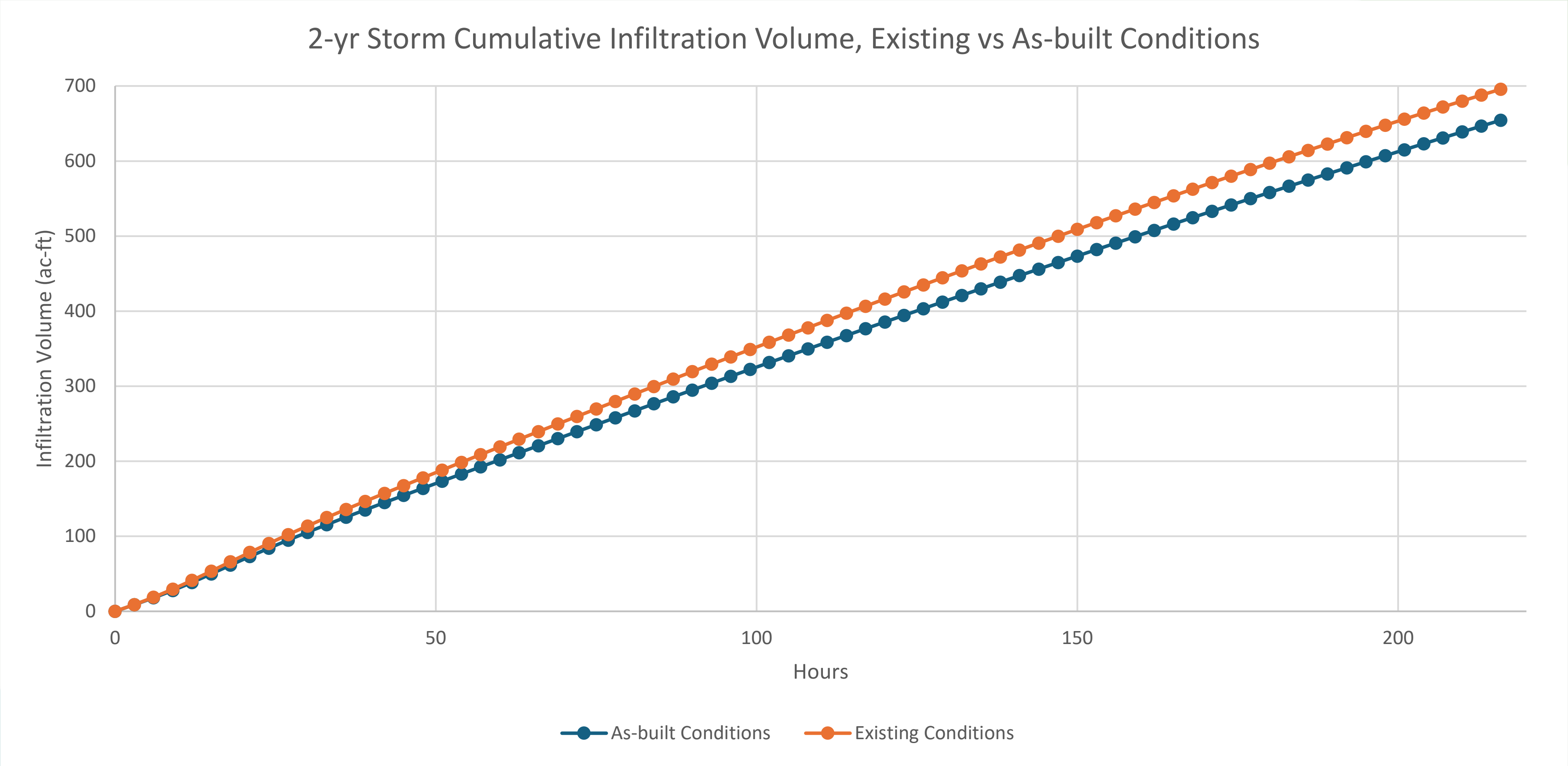
Results – 10-year, as-built



Results – 10-year, as-built, cont.

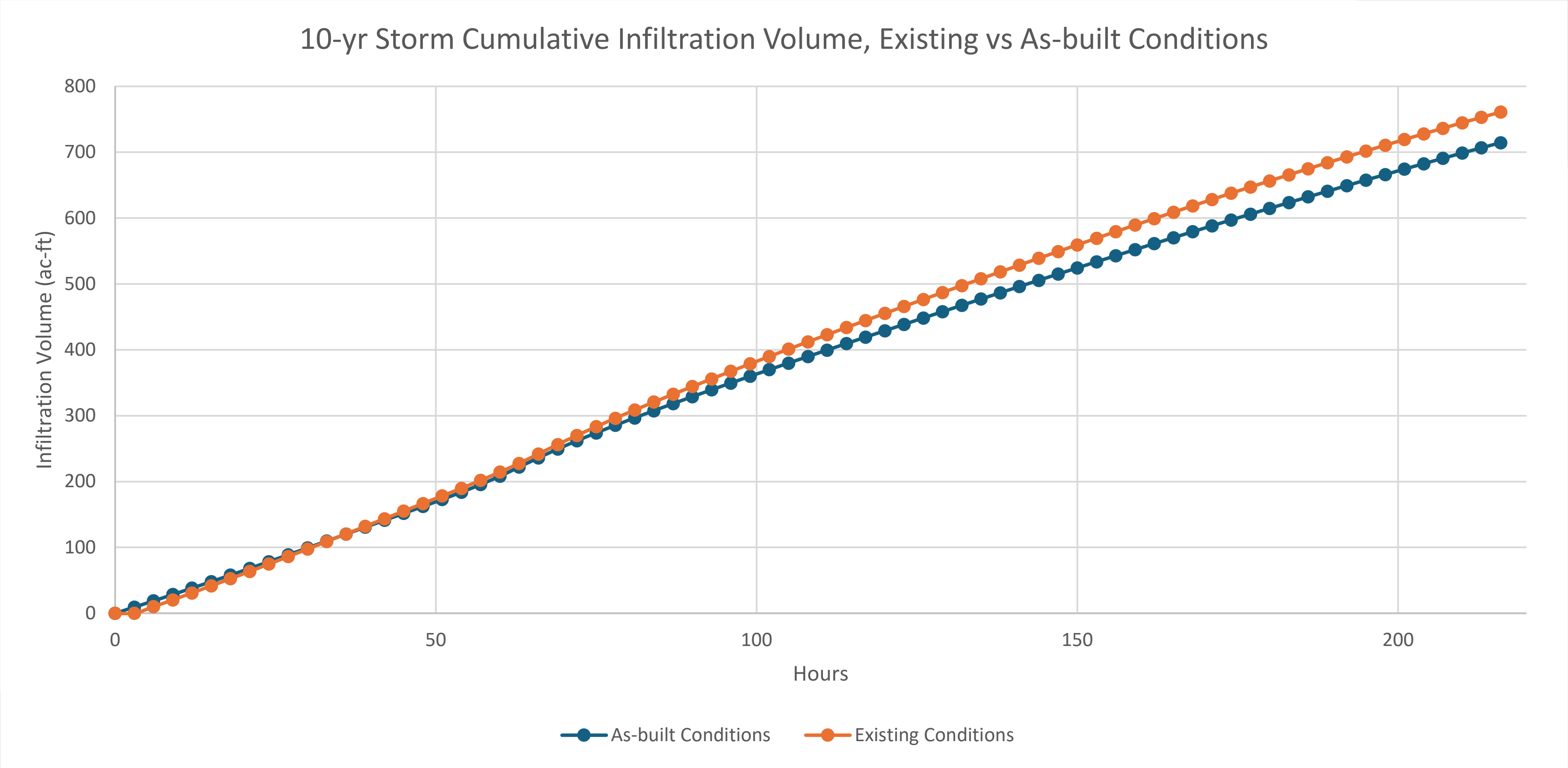


Results – 2-year, existing vs. as-built



Δ=-0.067, 1867 ACFT

Results – 10-year, existing vs. as-built



Δ=-0.078, 2300 ACFT

35 YEARS Of Excellence WEST YOST

Takeaways

- Infiltration in-stream provides a valuable source of groundwater recharge
- Modeling indicates in-stream divisions can substantially increase groundwater recharge when considering more frequent, lower discharge storm events
- Modeling indicates that in-stream diversions of frequent events can infiltrate groundwater more efficiently than storage basins in some systems
- Long infiltration times for small, frequent runoff events are more efficient for recharge design than scalping high volumes for large, less frequent runoff events**
- Hydrogeologic testing is on-going to support these findings

Acknowledgements

- Christina Buck – Butte County
- Rebecca (Becky) Fairbanks – Butte County/Vina GSA
- David Kehn – City of Chico
- Kamie Loeser – Butte County
- Joe Turner – Geosyntec
- Mike van den Enden – Geosyntec

- This project was graciously funded by SGM grant VX0005

35 YEARS Of Excellence WEST YOST

THANK YOU

Today's Presentation

David Jaffe LinkedIn