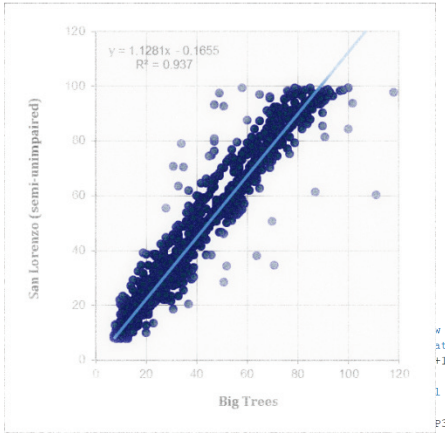
City of Santa Cruz HCP

Hydrologic Modeling Support

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Balance Hydrologics, Inc.

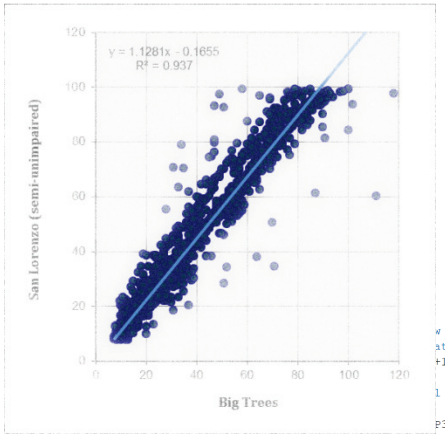
Presentation Overview

1. Review basic work objectives
2. Review procedures used to develop hydrologic data:
   - Data development and other items
   - Model application
3. Review model framework
4. Questions

City of Santa Cruz HCP

Review Basic Work

Objectives

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Technical Role

To support the project team in identifying (*modeling*) the availability of water for habitat and water supply under HCP and projected climate change conditions

Liddell, Laguna, Majors & San Lorenzo

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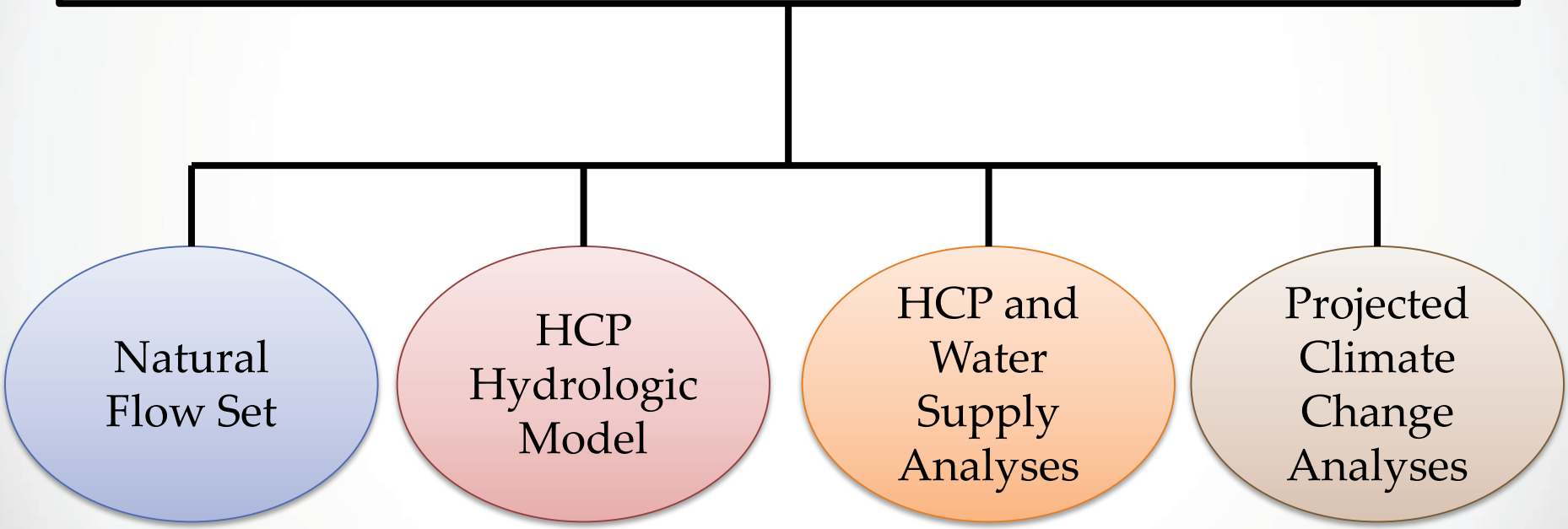

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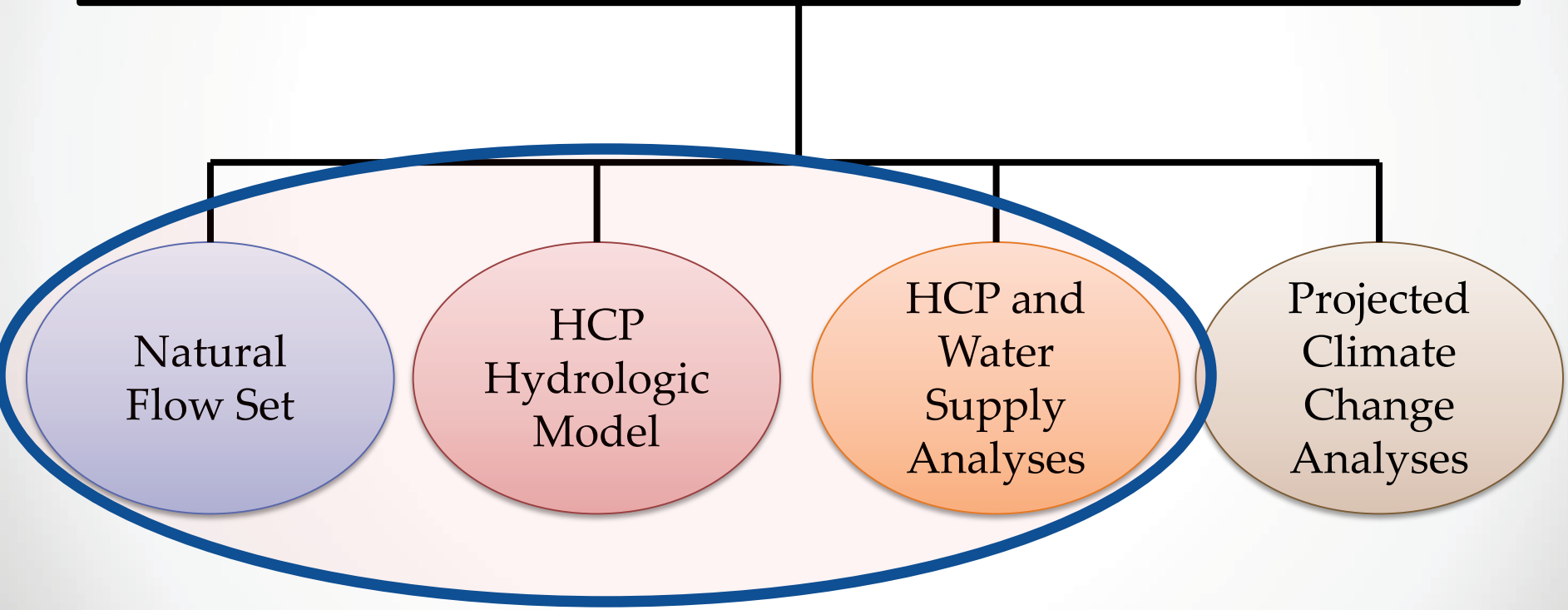


Specific Objectives

- Develop records of 'natural' mean daily flow **upstream of diversions** and within the **anadromous reaches** of source streams
  - Period of record: water years (WY) **1936 - 2009**

Specific Objectives

- Develop records of mean daily flow upstream of diversions and within the anadromous reaches of source streams
  - Period of record: water years (WY) 1936 - 2009
- Develop defensible hydrologic models
  - Tailored to periods of low-flow (May – October)
  - Tailored to periods of drought
  - Make allowances for known diversions (City and others)
  - Run tests to assess upstream/downstream hydrologic connectivity
  - Evaluate model performance vs. gaged data sets
  - Track expected trajectory in source streams and minimize |error|

HCP Hydrologic Model

Specific Objectives

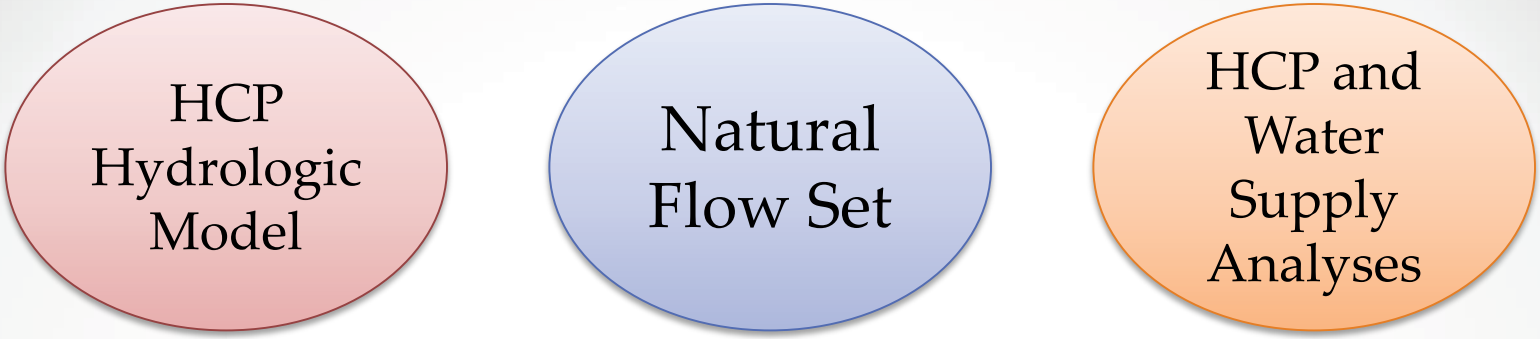
- Develop model platform to efficiently evaluate scenarios and alternatives
  - MS Excel VBA
  - MatLab
- Develop records of mean daily flow within reaches of anadromy under HCP flow rules
- Develop records of mean daily flow available for production at the points of diversion

→ WY 1936 - 2009

HCP and Water Supply Analyses

Specific Objectives

- Provide datasets for direct input into *Confluence®* to complete water supply analyses
  - Natural flow sets
  - Flow available for production upstream of diversions
- Provide datasets for completion of HCP effects analysis
  - Use HCP Hydrology results to compute residual flows

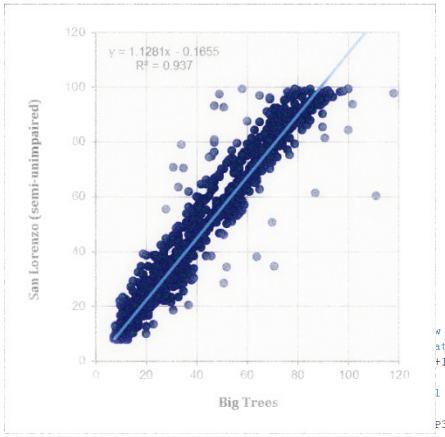


Present working product the result of lots of collaboration and troubleshooting by others Jeff, Gary, Chris, DFW

City of Santa Cruz HCP

Review Hydrologic Data Development

1. Brief History
2. Data development
3. Other items

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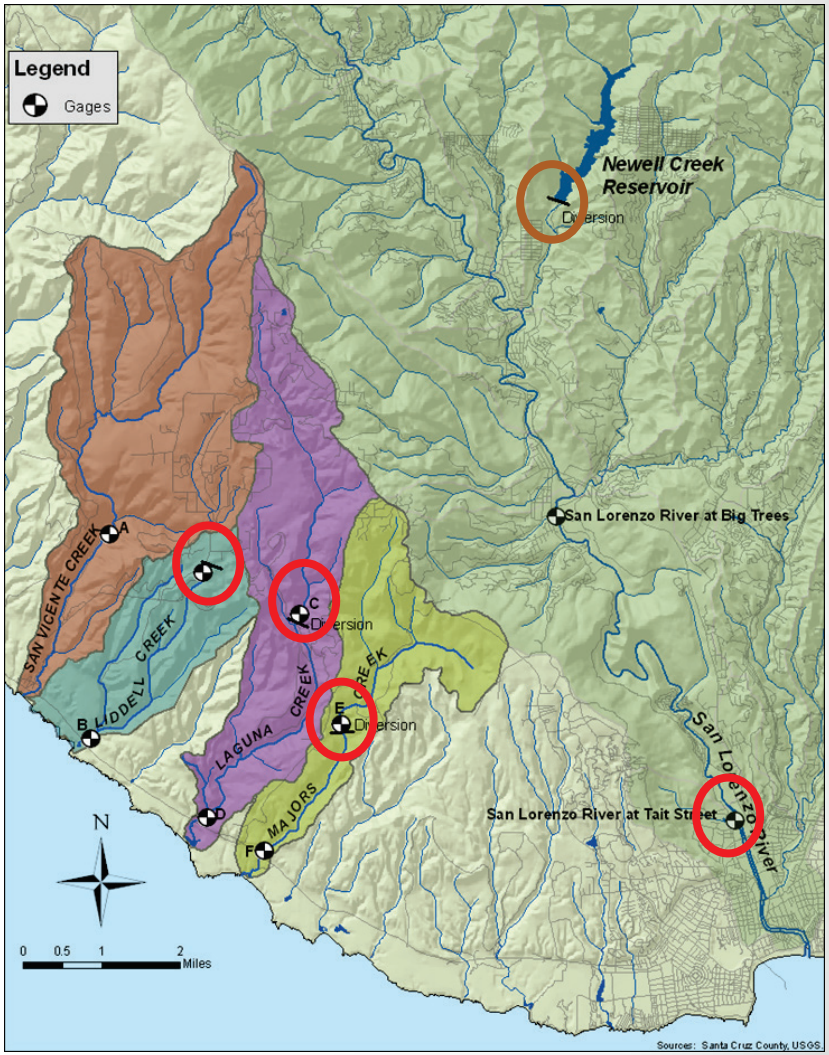
Brief History

1. Integrated Water Management Plan – late 1990's
   - ❖ Developed in-stream natural flow estimates for all sources upstream points of diversion



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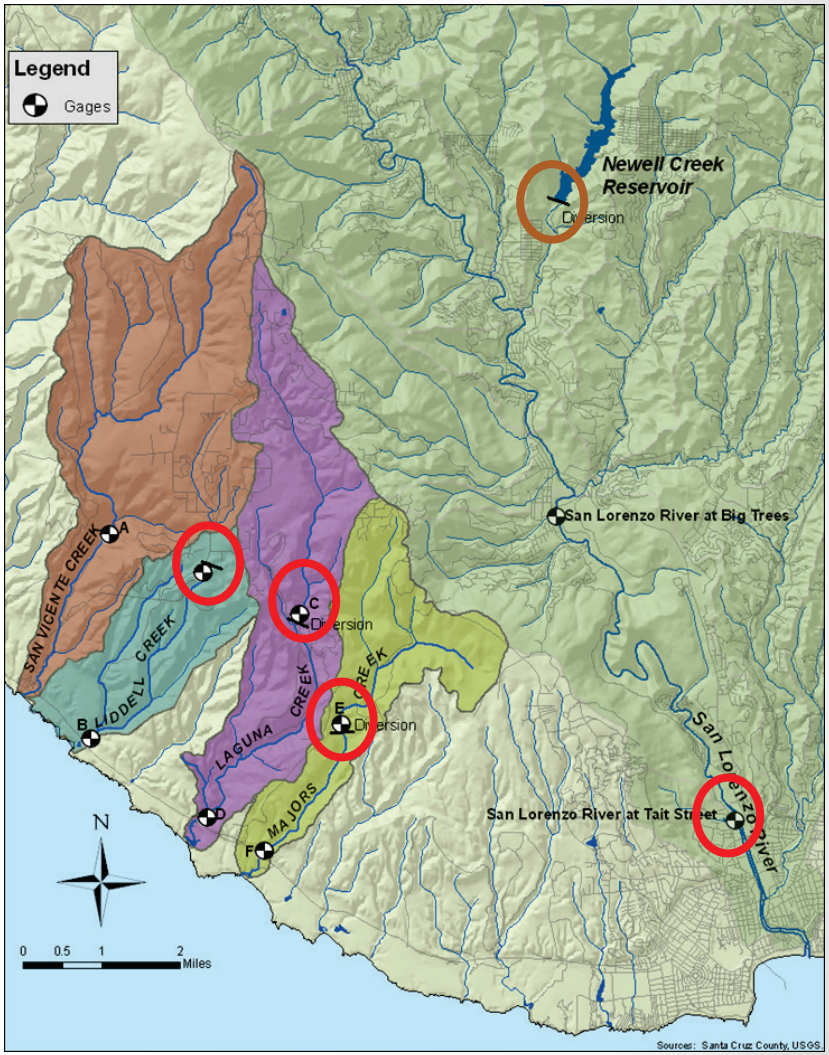

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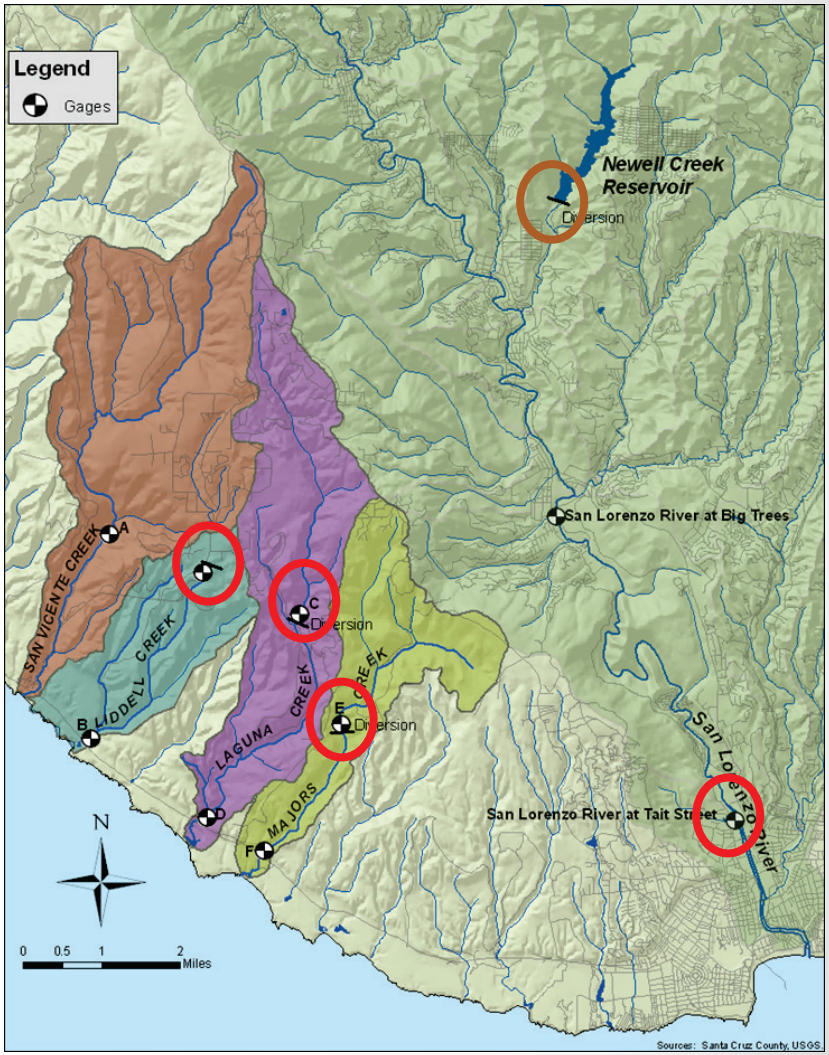

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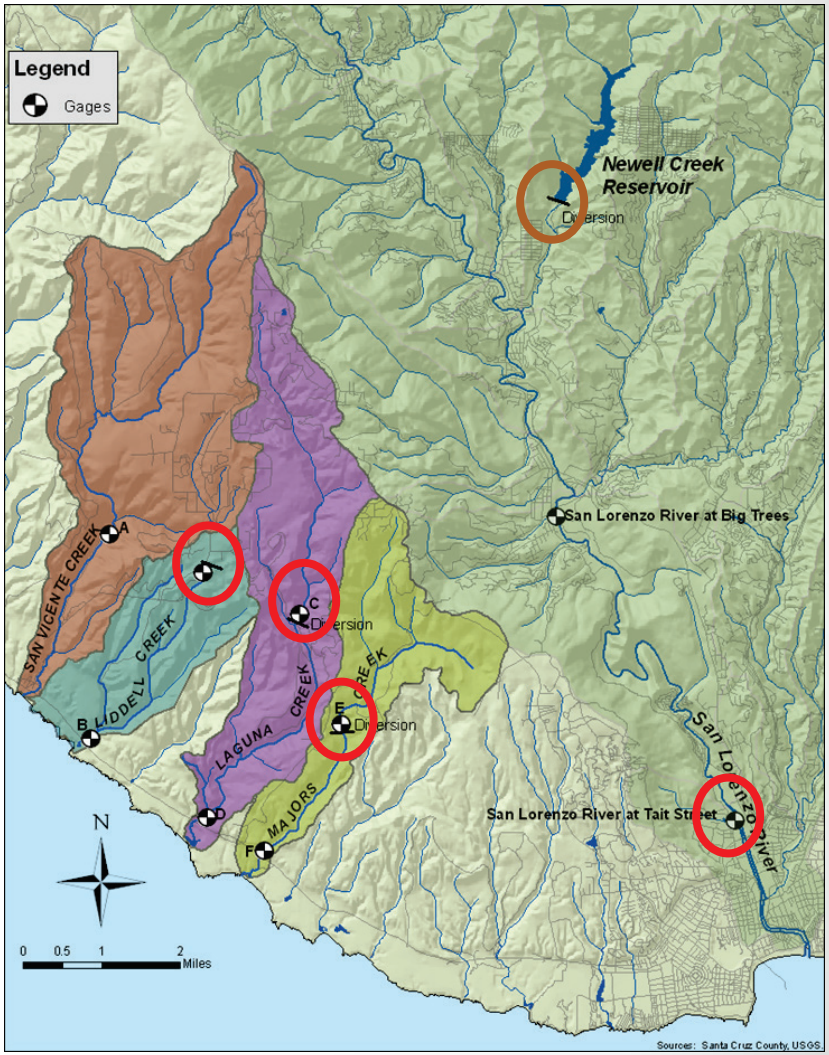
1. IWP natural flow data
   - ❖ Based on watershed model (HSPF – Hydrological Simulation Program Fortran)
   - ❖ Developed prior to the City's extensive gaging program was developed
   - ❖ Does a reasonably good job of simulating flows
   - ❖ Tends to overestimate low-flows and high-flows as parameterized
   - ❖ Data components within records not fully consistent and sources unclear



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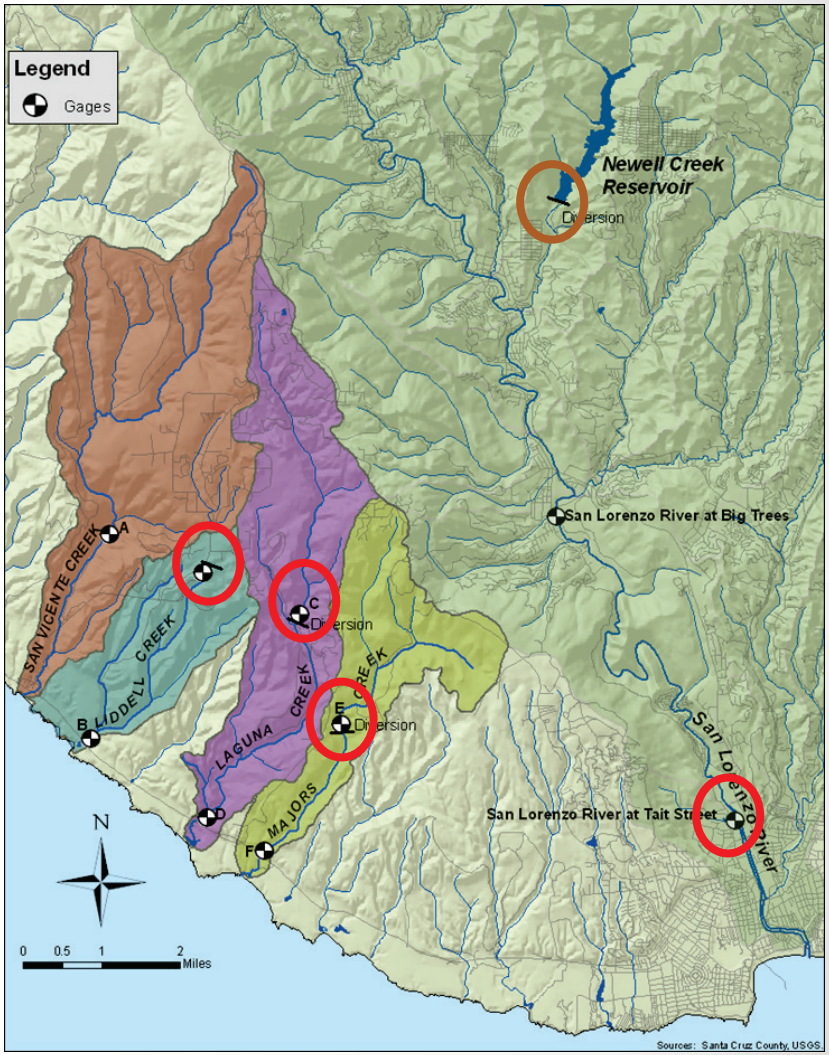

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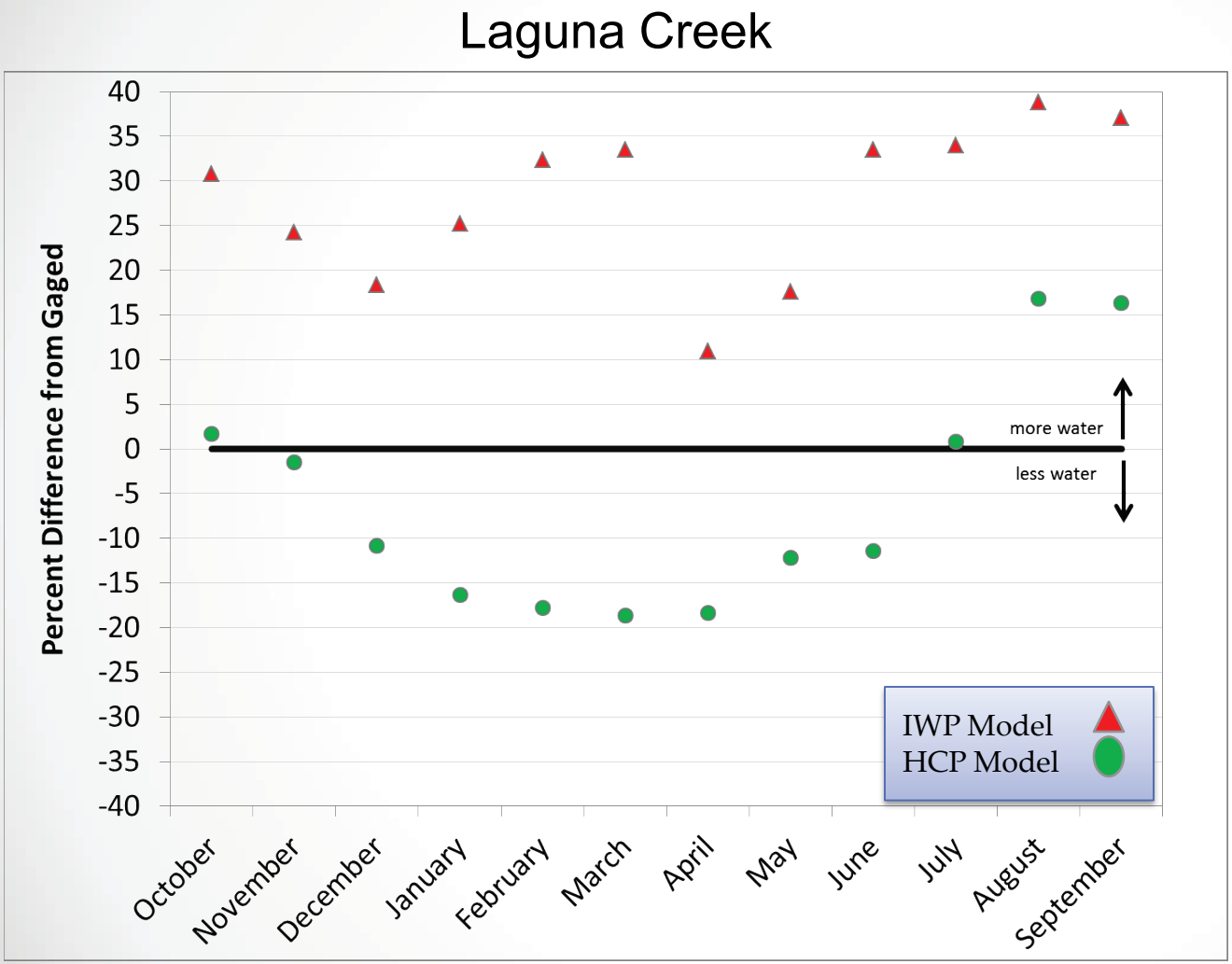

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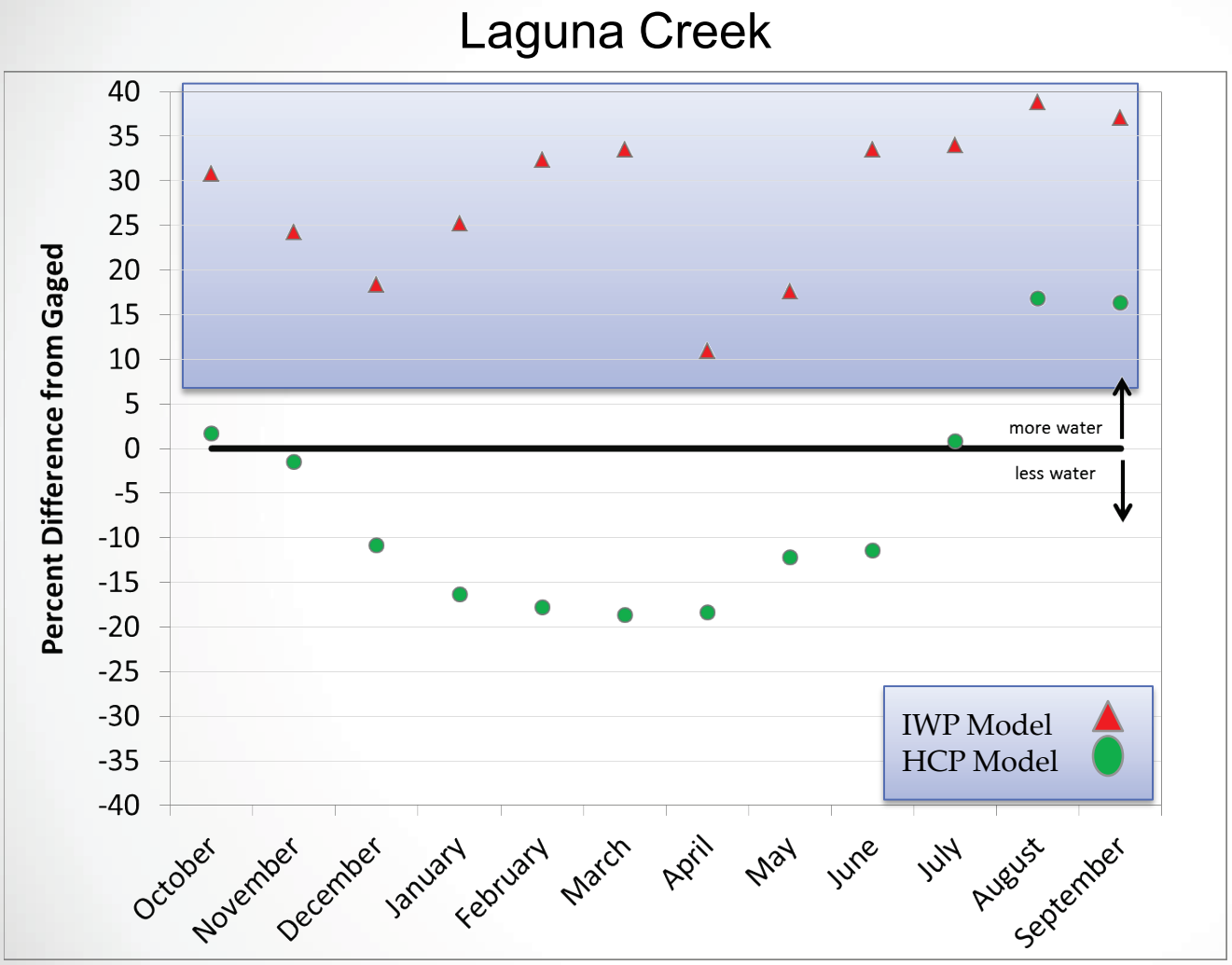

IWP model simulates wetter than gaged results across all months

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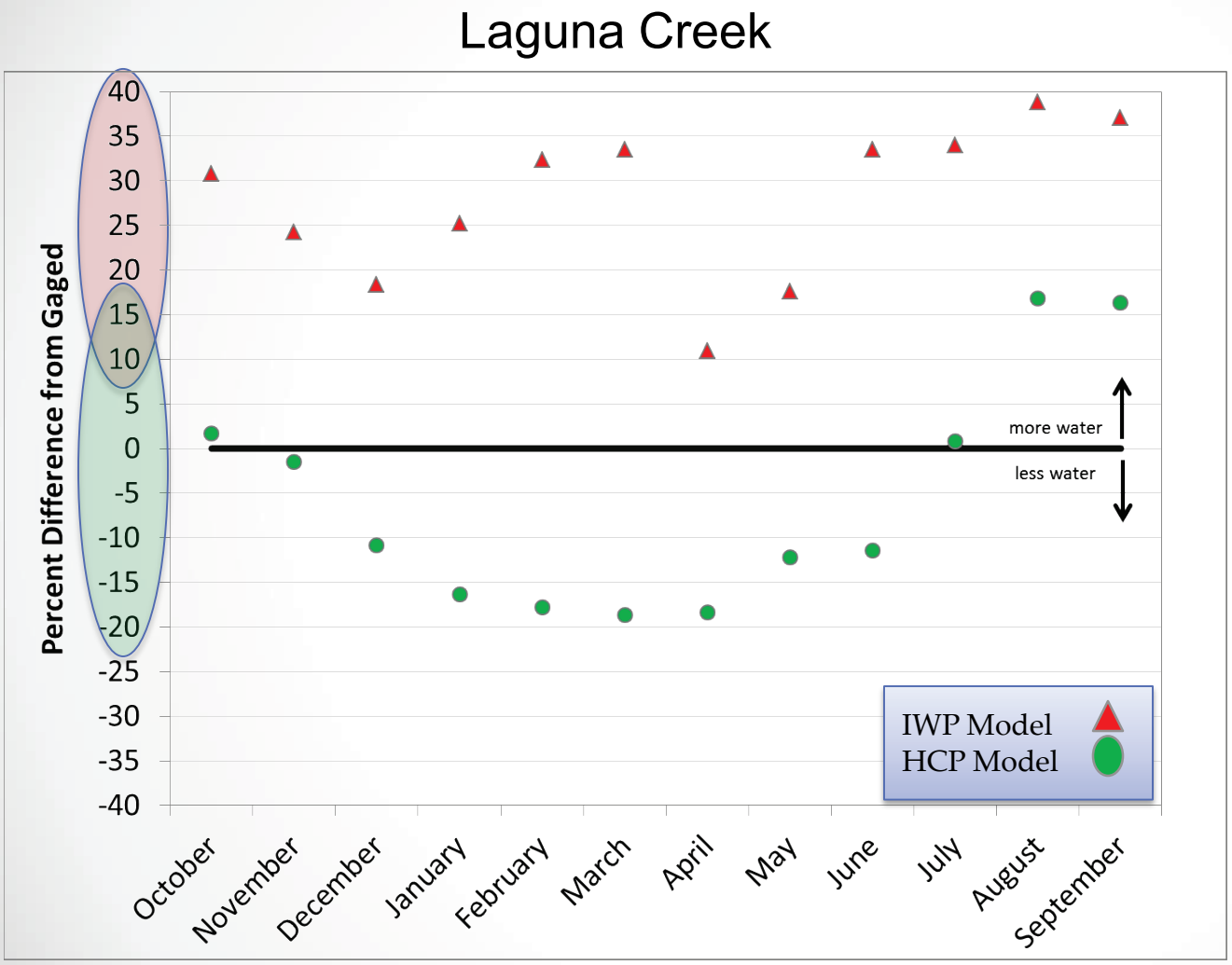

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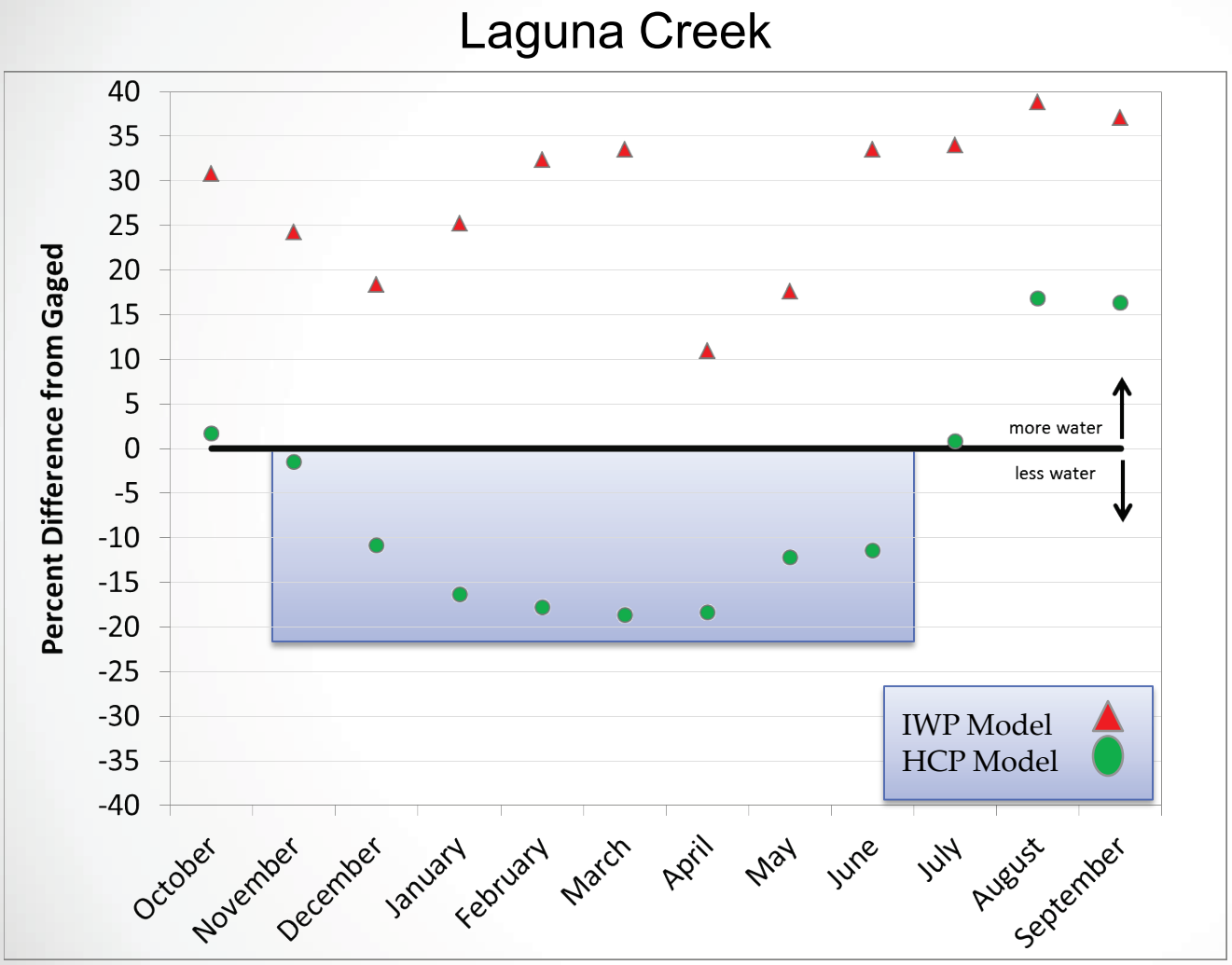

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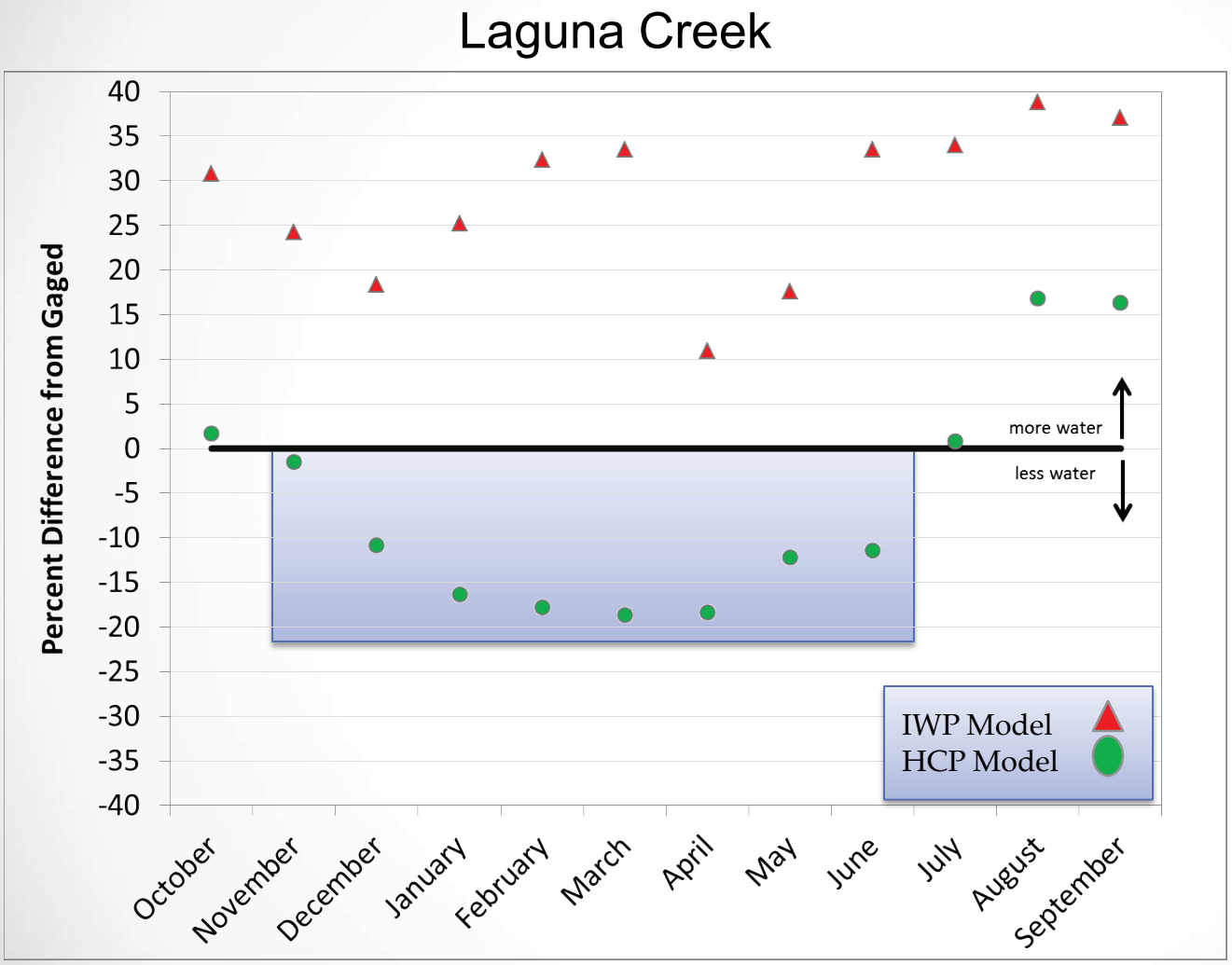

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City of Santa Cruz HCP

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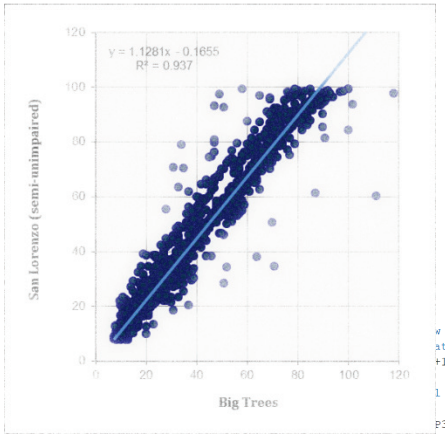


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Model Assumptions

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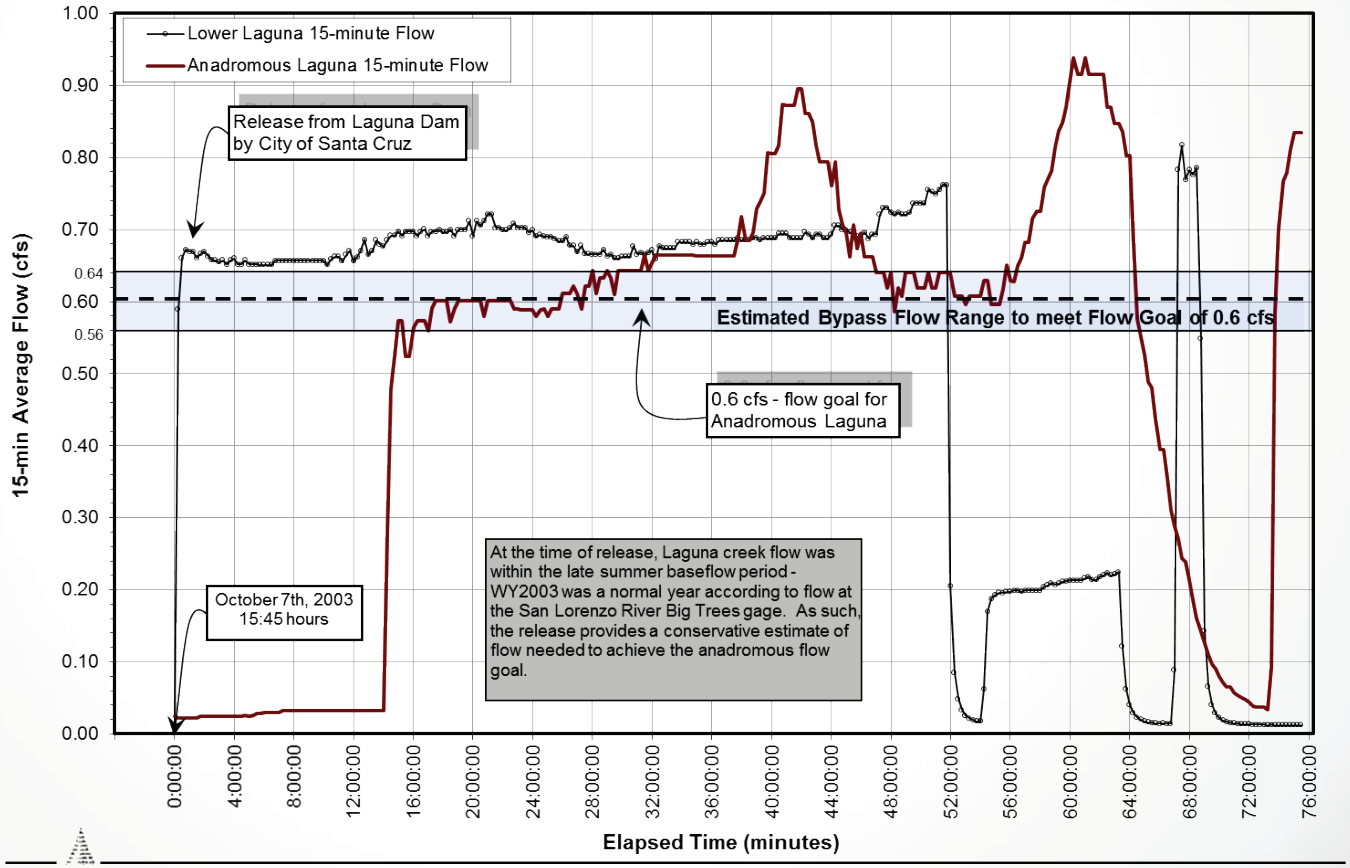

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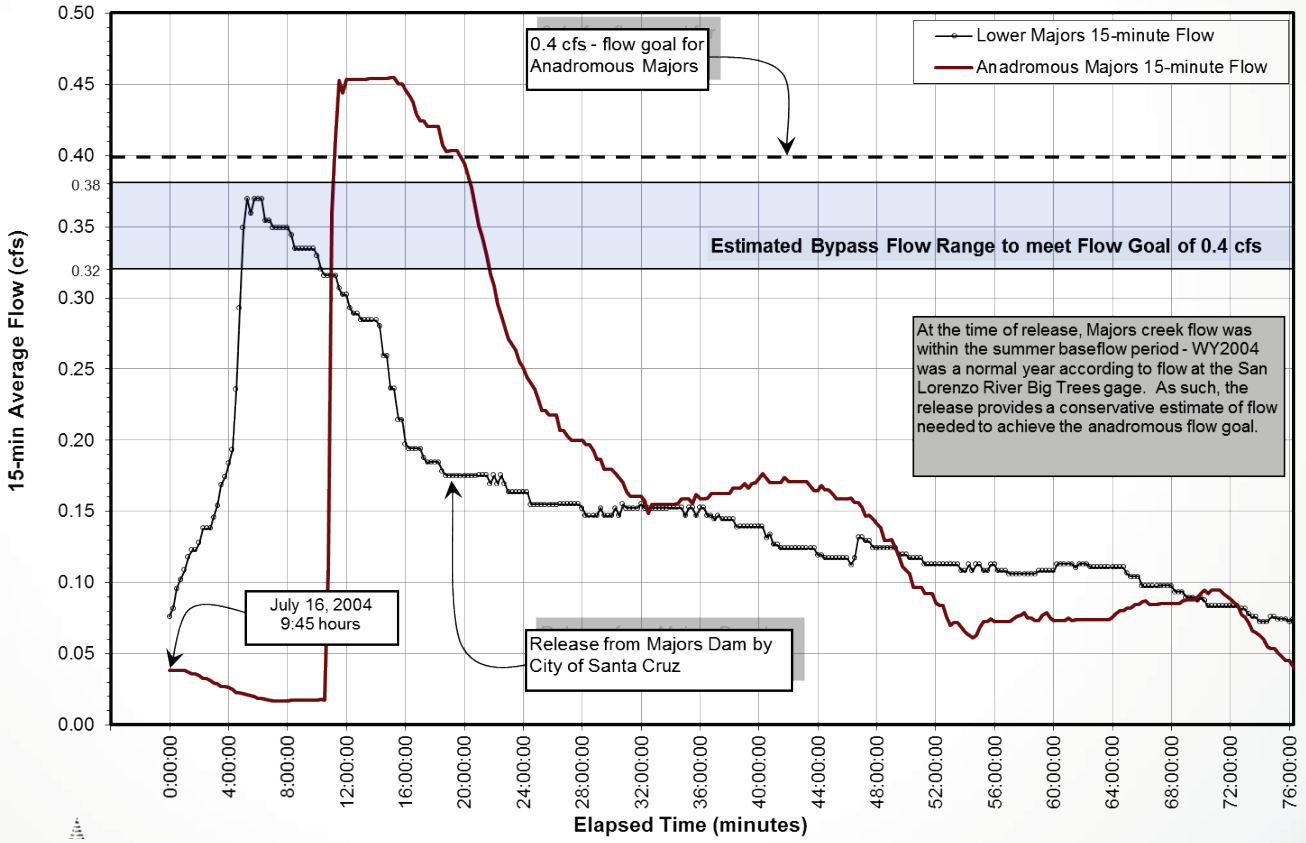

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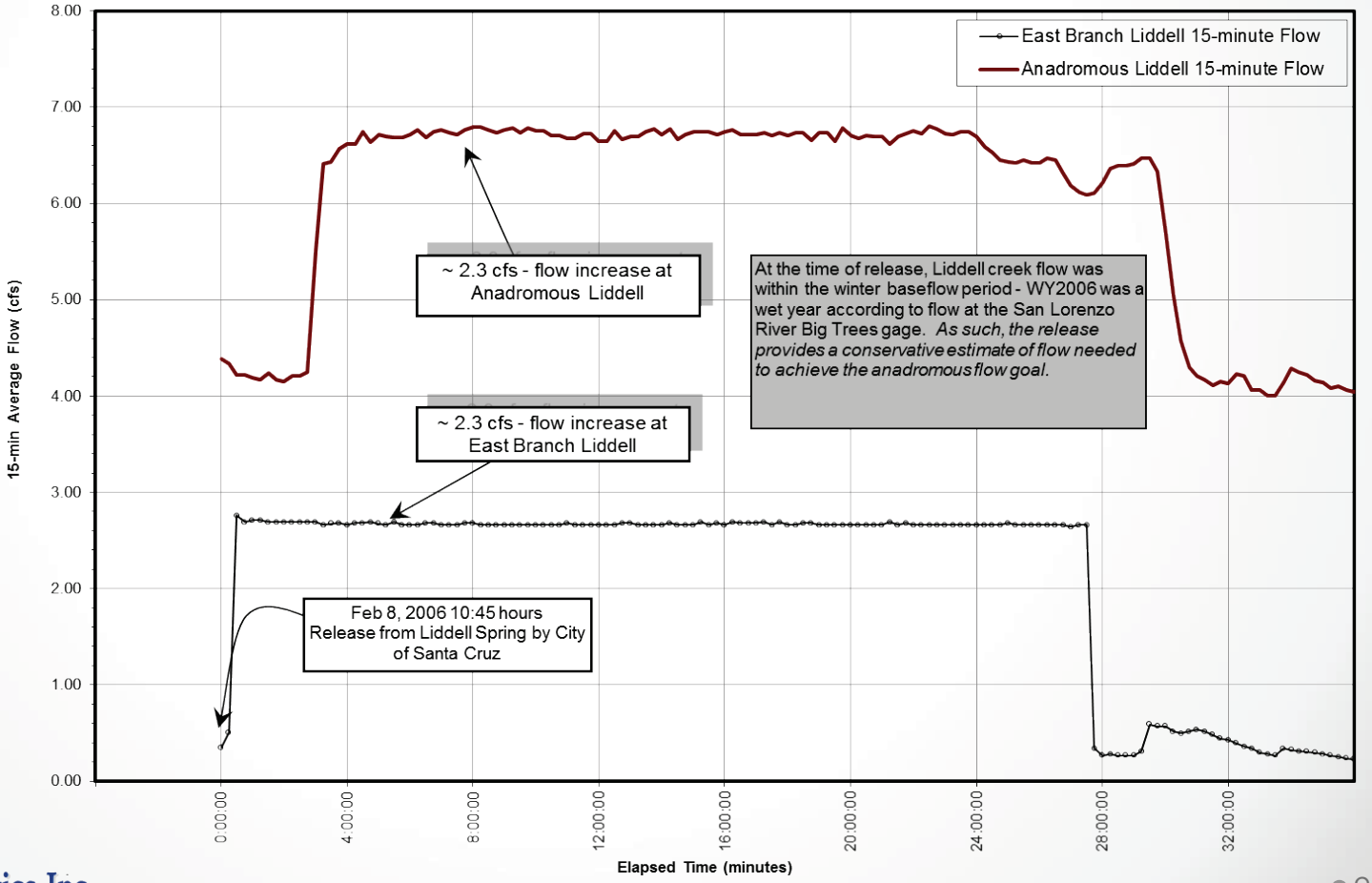

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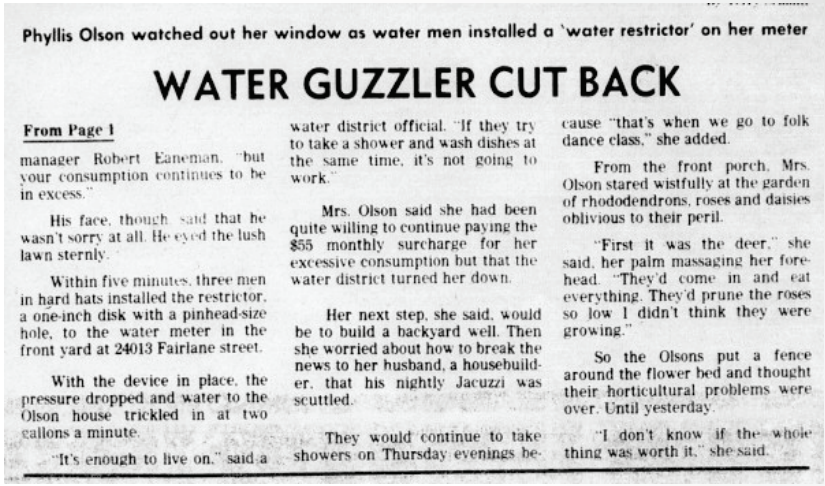
3. Present hydrologic character of basins will describe character of conditions in the future
   - ❖ 1:1 translation from upstream of diversion to anadromy
   - ❖ General hydrologic response to storms
   - ❖ No new major water withdraws downstream of City diversions

Primary Challenges

1. Lack of gaging records on the northcoast streams during the WY1977 drought



Phyllis Olson watched out her window as water men installed a 'water restrictor' on her meter

WATER GUZZLER CUT BACK

From Page 1

manager Robert Eaneman, "but your consumption continues to be in excess."

His face, though, said that he wasn't sorry at all. He eyed the lush lawn sternly.

Within five minutes, three men in hard hats installed the restrictor, a one-inch disk with a pinhead-size hole, to the water meter in the front yard at 24013 Fairlane street.

With the device in place, the pressure dropped and water to the Olson house trickled in at two gallons a minute.

"It's enough to live on," said a water district official. "If they try to take a shower and wash dishes at the same time, it's not going to work."

Mrs. Olson said she had been quite willing to continue paying the $55 monthly surcharge for her excessive consumption but that the water district turned her down.

Her next step, she said, would be to build a backyard well. Then she worried about how to break the news to her husband, a housebuilder, that his nightly Jacuzzi was scuttled.

They would continue to take showers on Thursday evenings because "that's when we go to folk dance class," she added.

From the front porch, Mrs. Olson stared wistfully at the garden of rhododendrons, roses and daisies oblivious to their peril.

"First it was the deer," she said, her palm massaging her forehead. "They'd come in and eat everything. They'd prune the roses so low I didn't think they were growing."

So the Olsons put a fence around the flower bed and thought their horticultural problems were over. Until yesterday.

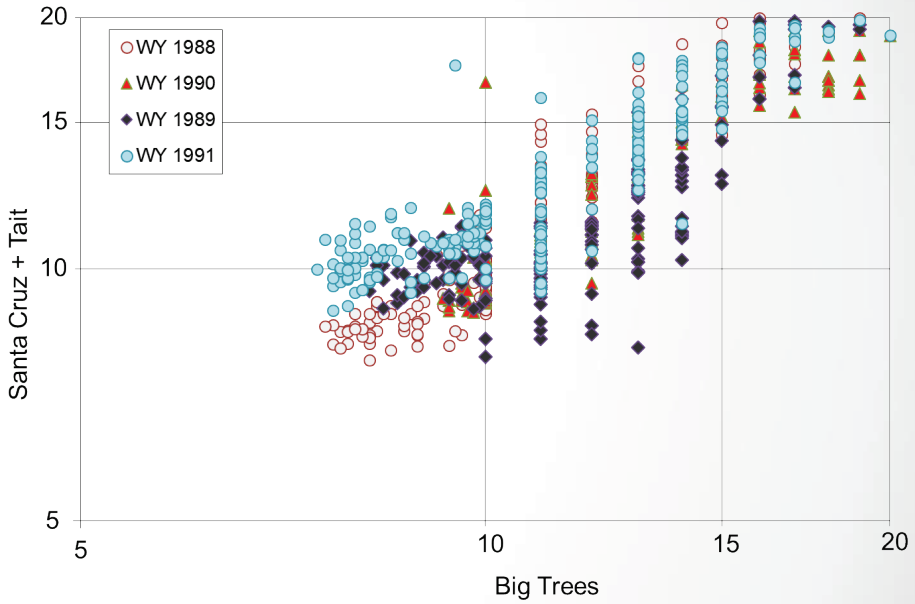
"I don't know if the whole thing was worth it," she said.

Source: sfgate.com

Primary Challenges

1. Lack of gaging records on the northcoast streams during the WY1977 drought

2. Non-systematic variability in streamflows on all sources during low-flows and droughts

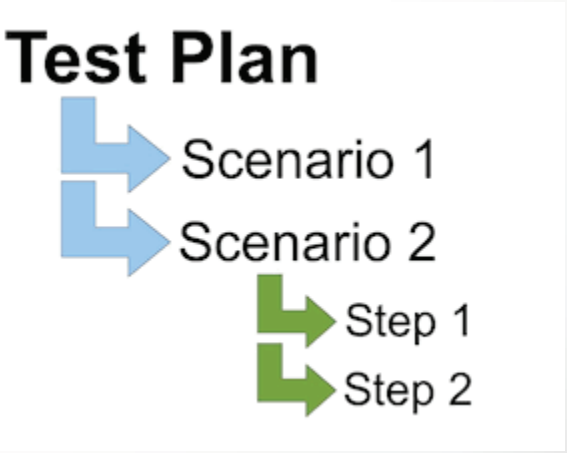


Primary Challenges

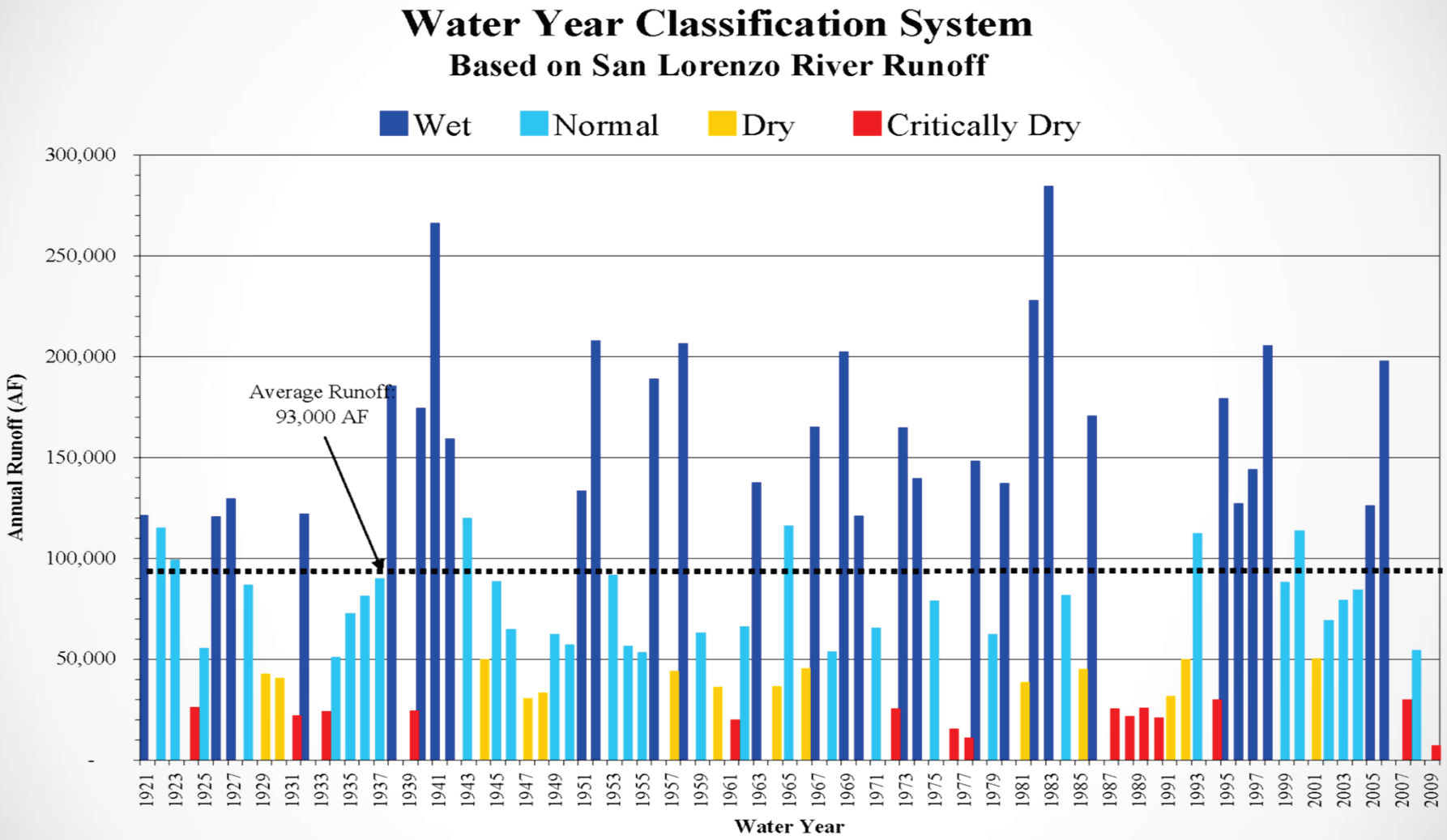
1. Lack of gaging records on the northcoast streams during the WY1977 drought

2. Non-systematic variability in streamflows on all sources during low-flows and droughts

3. Build a tool that is flexible and reasonably representative of known conditions

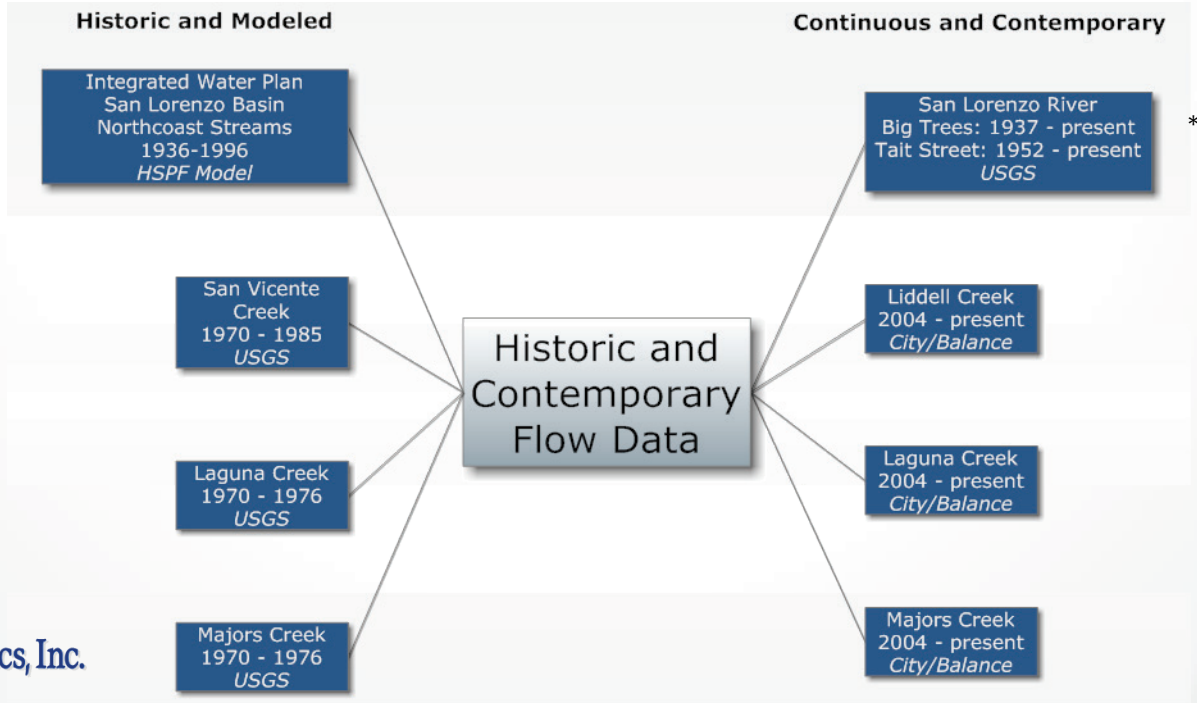


Analysis Period

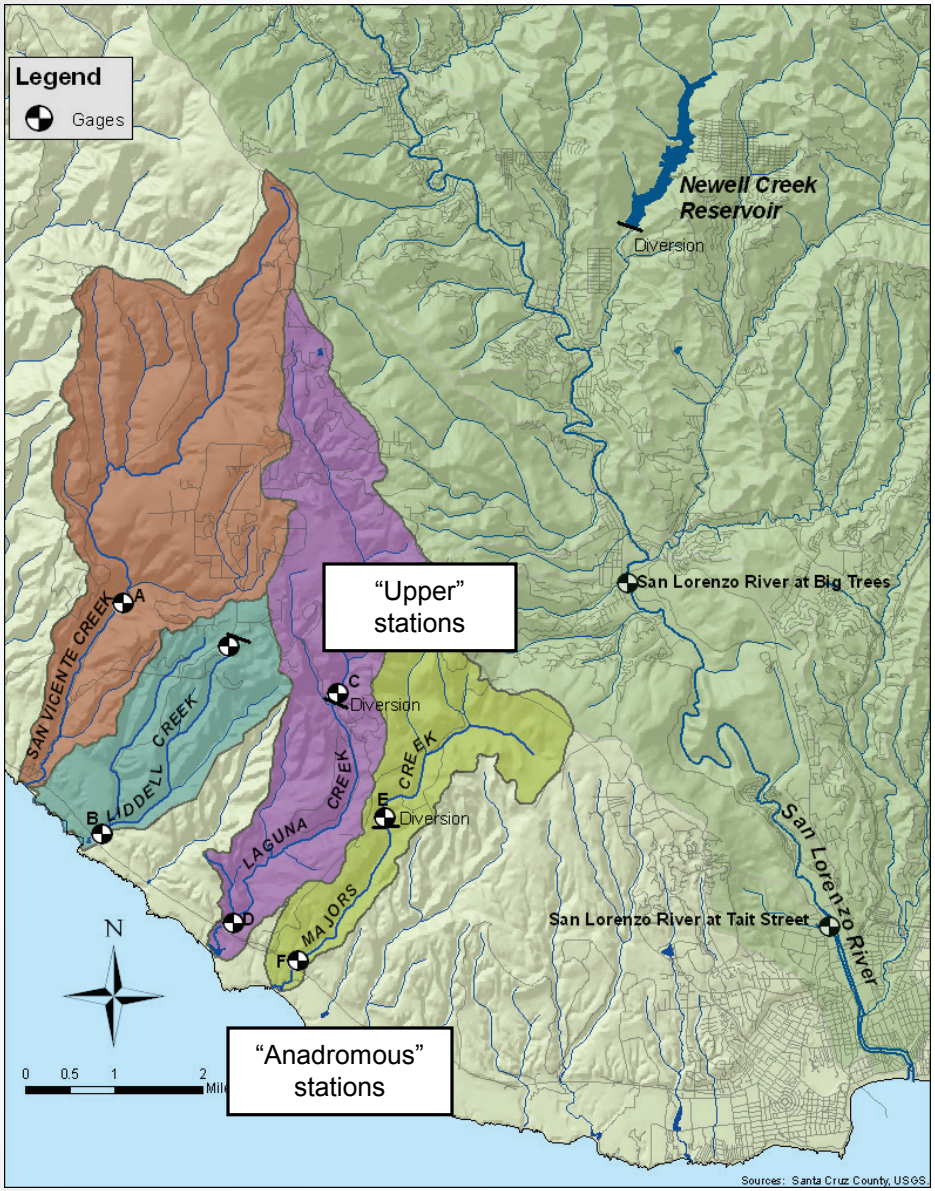


Data Development

1. Compile all historic and contemporary flow data for:
   - San Lorenzo River: Big Trees (USGS) and Santa Cruz (USGS)
   - San Vicente Creek: Nr Davenport (USGS)
   - Laguna and Majors Creeks: US of diversions (USGS) + (CSC)
   - Liddell, Laguna and Majors Creeks: Anadromy (CSC)
   - Liddell Spring (CSC)



* note: tait st. record missing WY '61-'87



Hydro Records Locations

USGS Stations:

- San Lorenzo
  - Big Trees
  - Tait St.
- North Coast
  - San Vicente
  - Laguna
  - Majors

City of S.C. Stations:

- Upper and Anad. Liddell
- Upper and Anad. Laguna
- Upper and Anad. Majors

Data Development

2. Establish San Lorenzo River at Big Trees (BT) as our "period of record" control station
   - Longest continuously running stream gage in the region (**WY1936 – present**)
   - Primary water supply source for the City
   - Very good gage control – records are excellent

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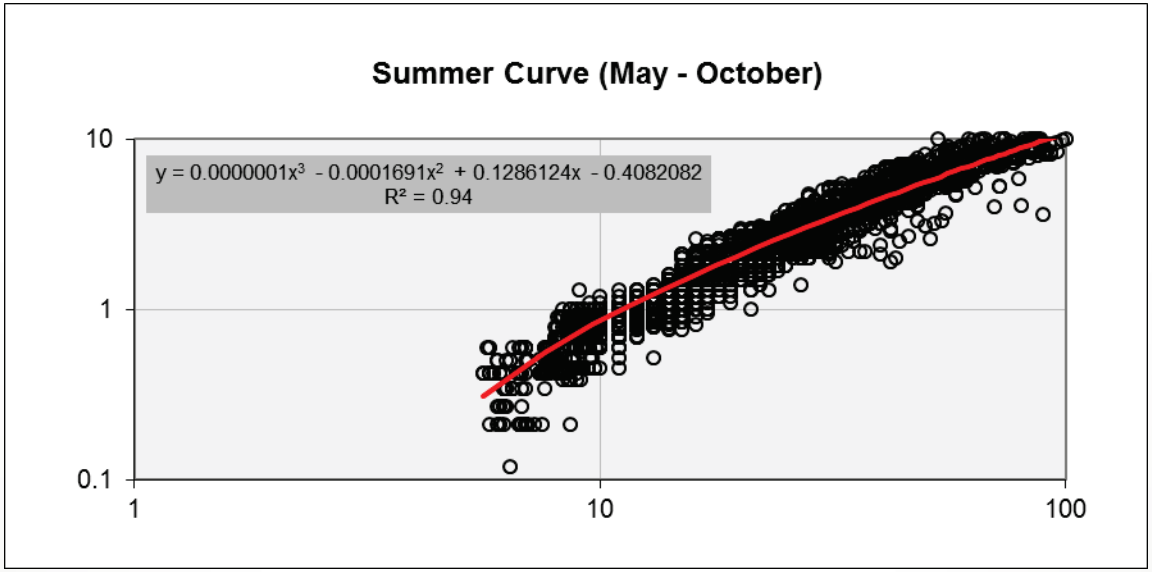
Records for other source streams can be extended to the analysis period of record with the Big Trees data using separate regression models for low-flow and mid- to high-flow conditions

Data Development

3. Extend San Vicente Creek (SVC) USGS record to the BT period of record using inter-basin regression model (*hybrid record)
   - Longest continuously running stream gage on the northcoast for the analysis period of record (**WY1970 – 1985**)
   - Hydrogeologic context similar to Laguna and Liddell Creeks



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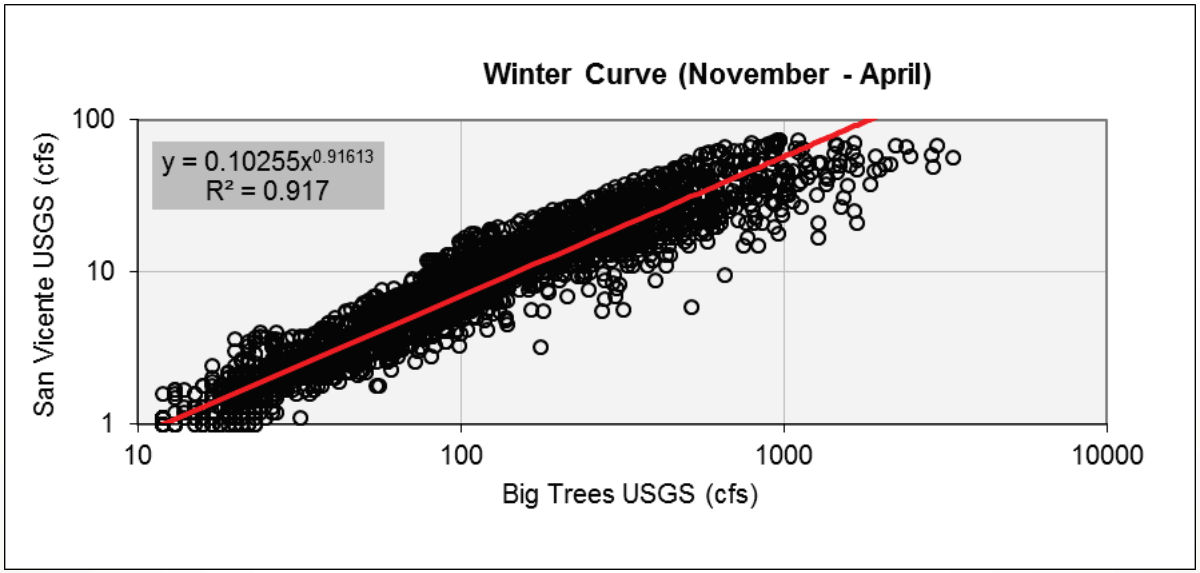

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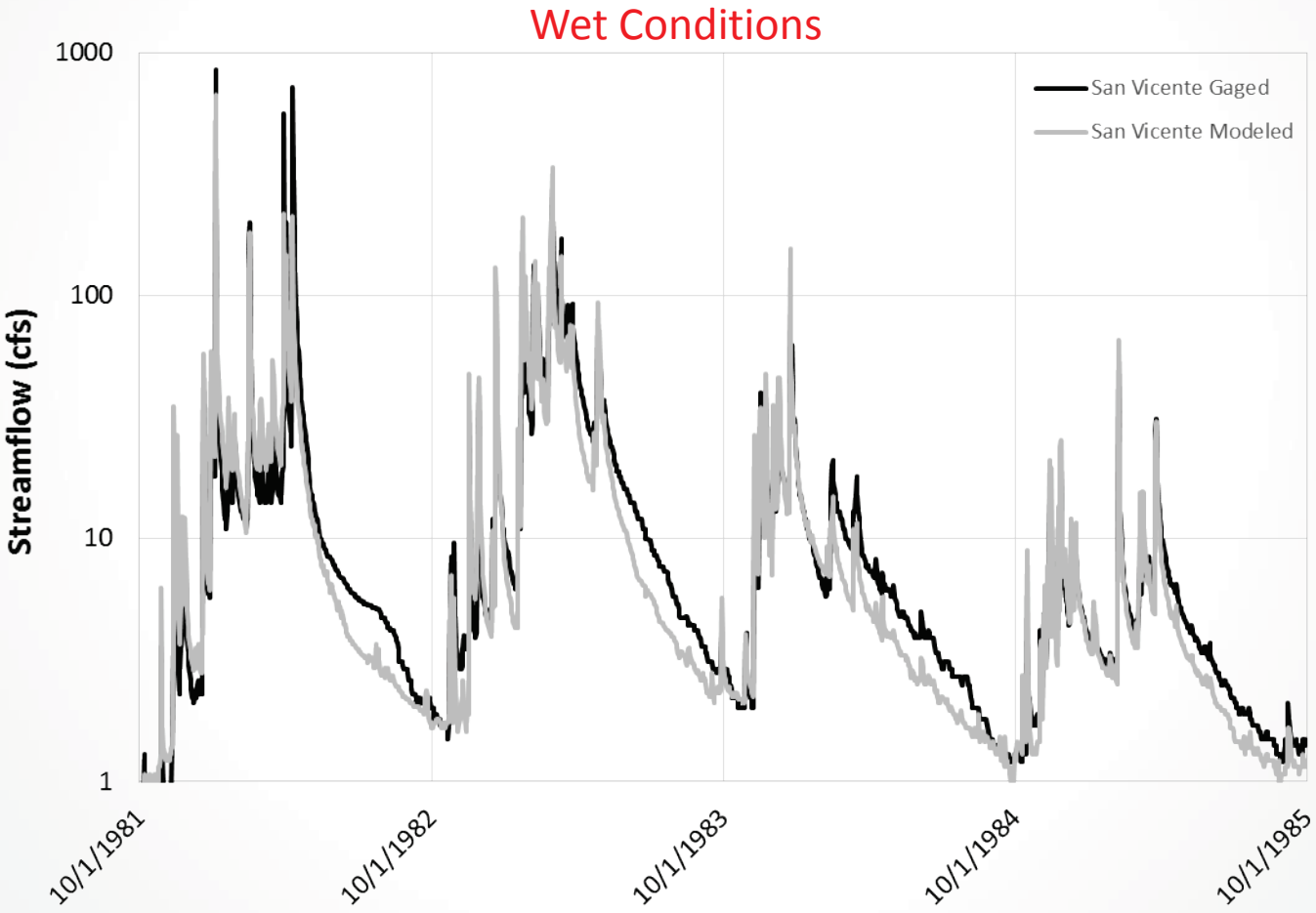

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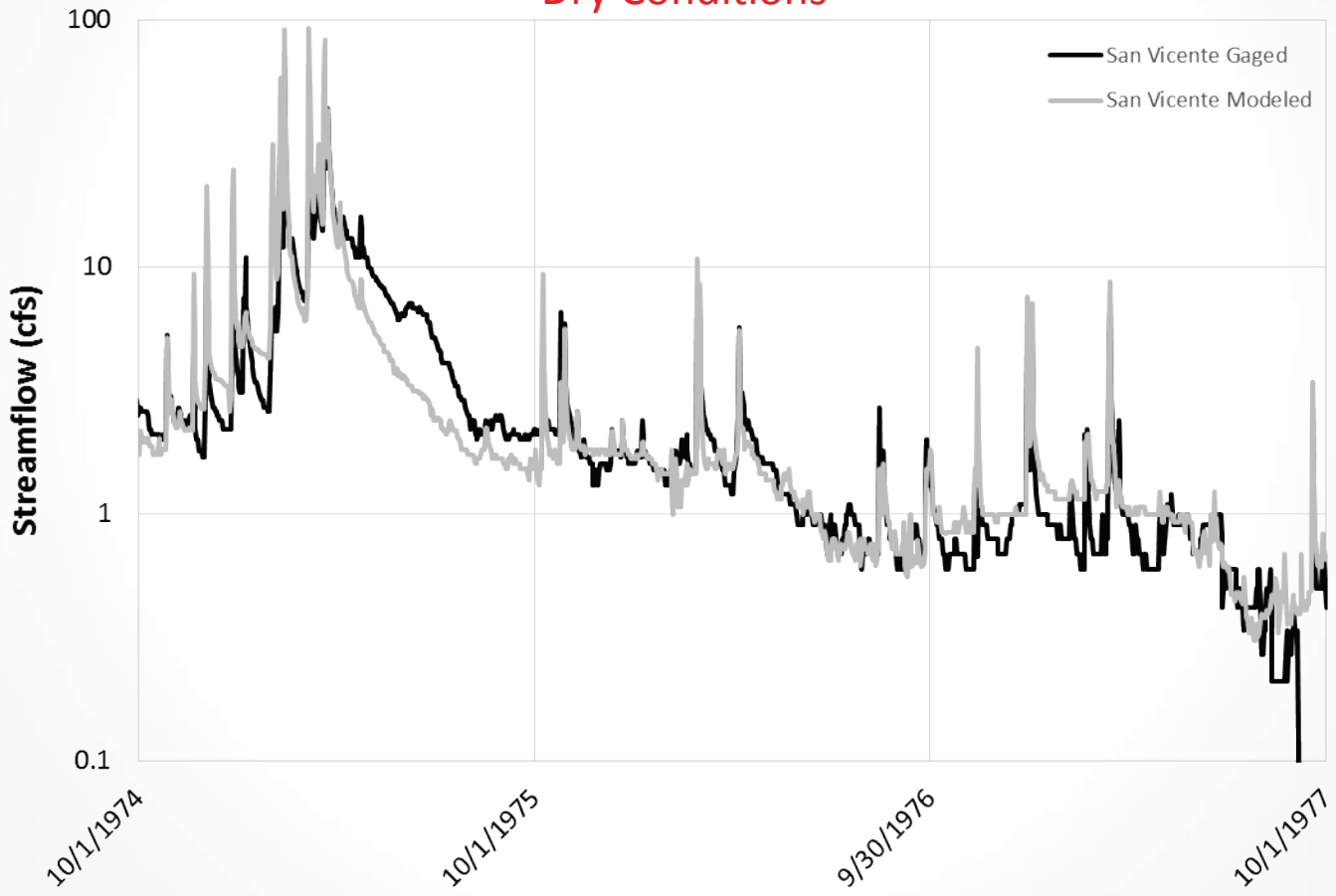
Dry Conditions



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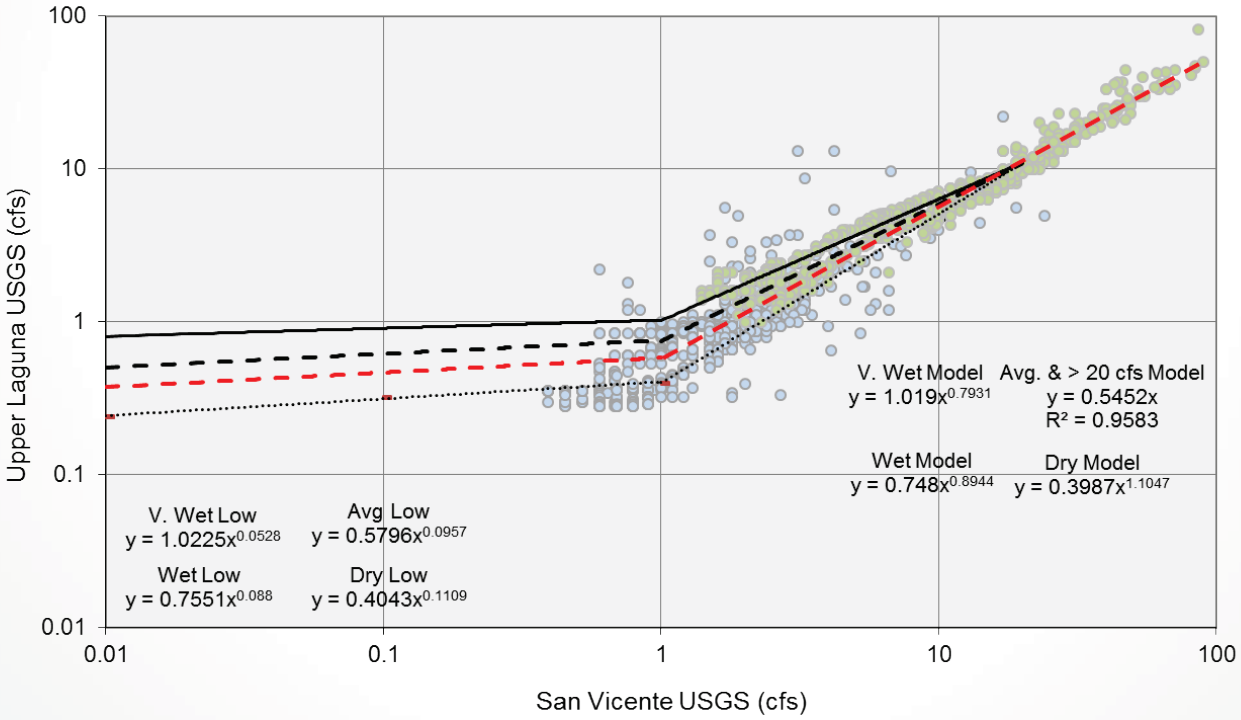
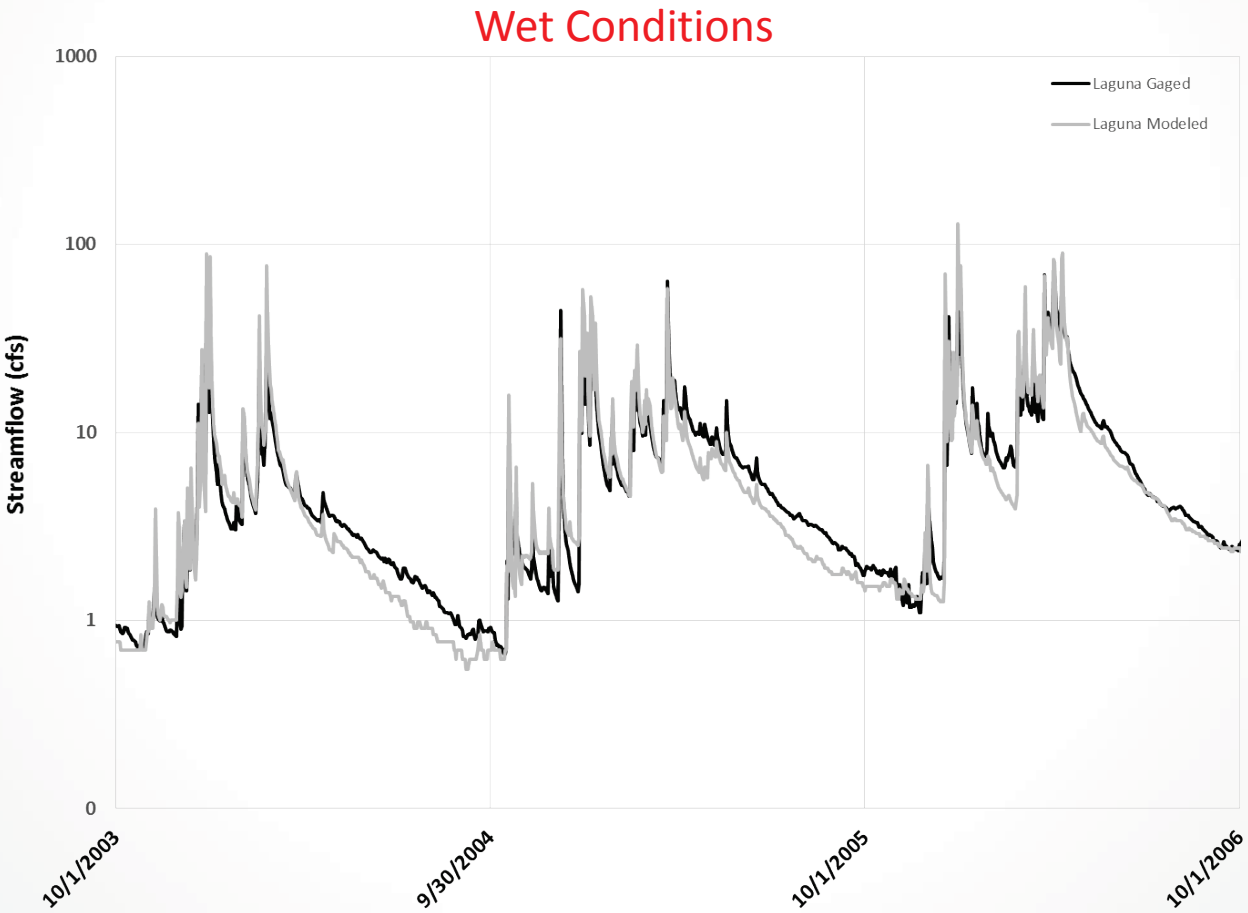
Data Development

4. Utilize the "hybrid" SVC record to build analogues record for Laguna Creek upstream of diversion
   - ❖ Applied a more detailed modeling approach – developed low-flow models based on hydrologic condition – thought toward driest cond.



Data Development

4. Utilize the “hybrid” SVC record to build analogues record for Laguna Creek upstream of diversion



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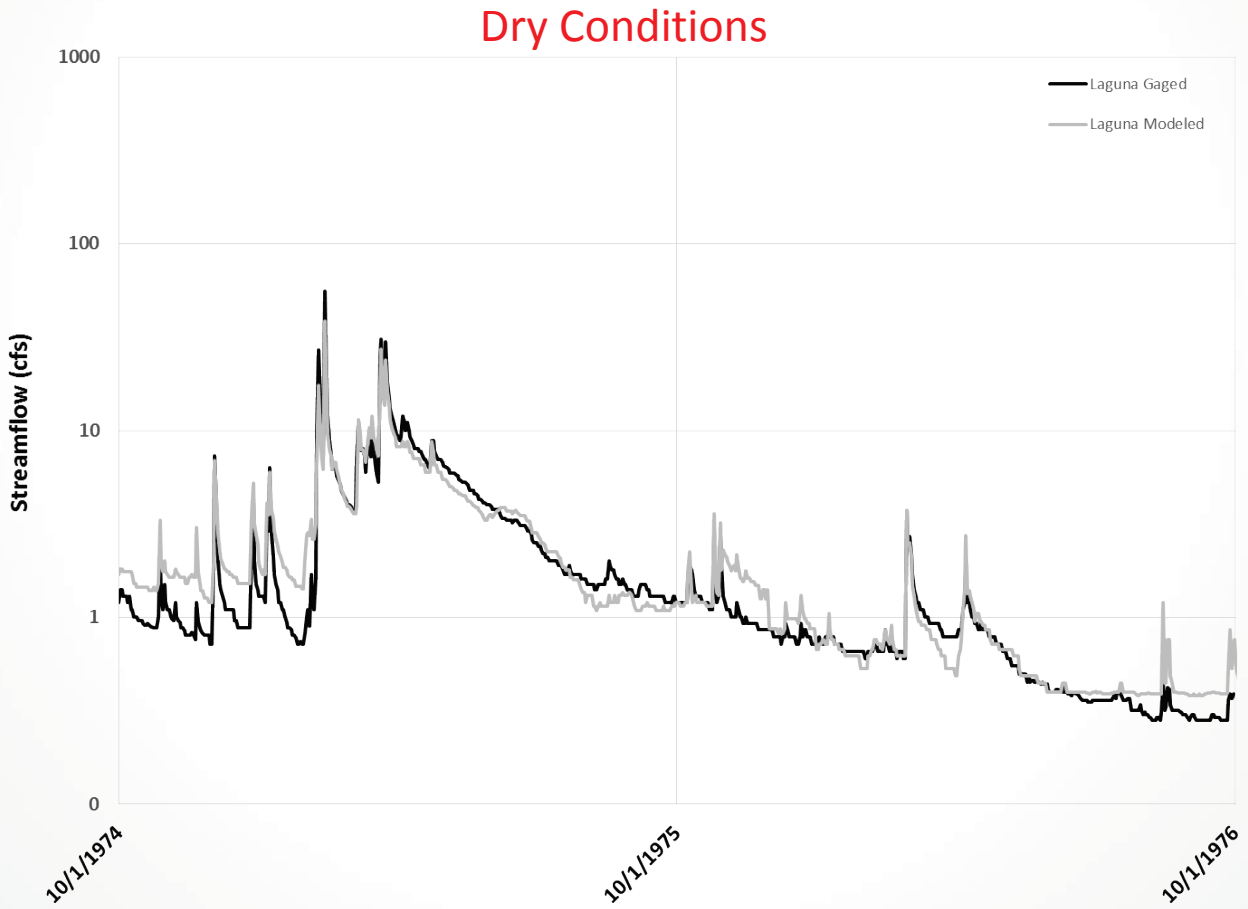
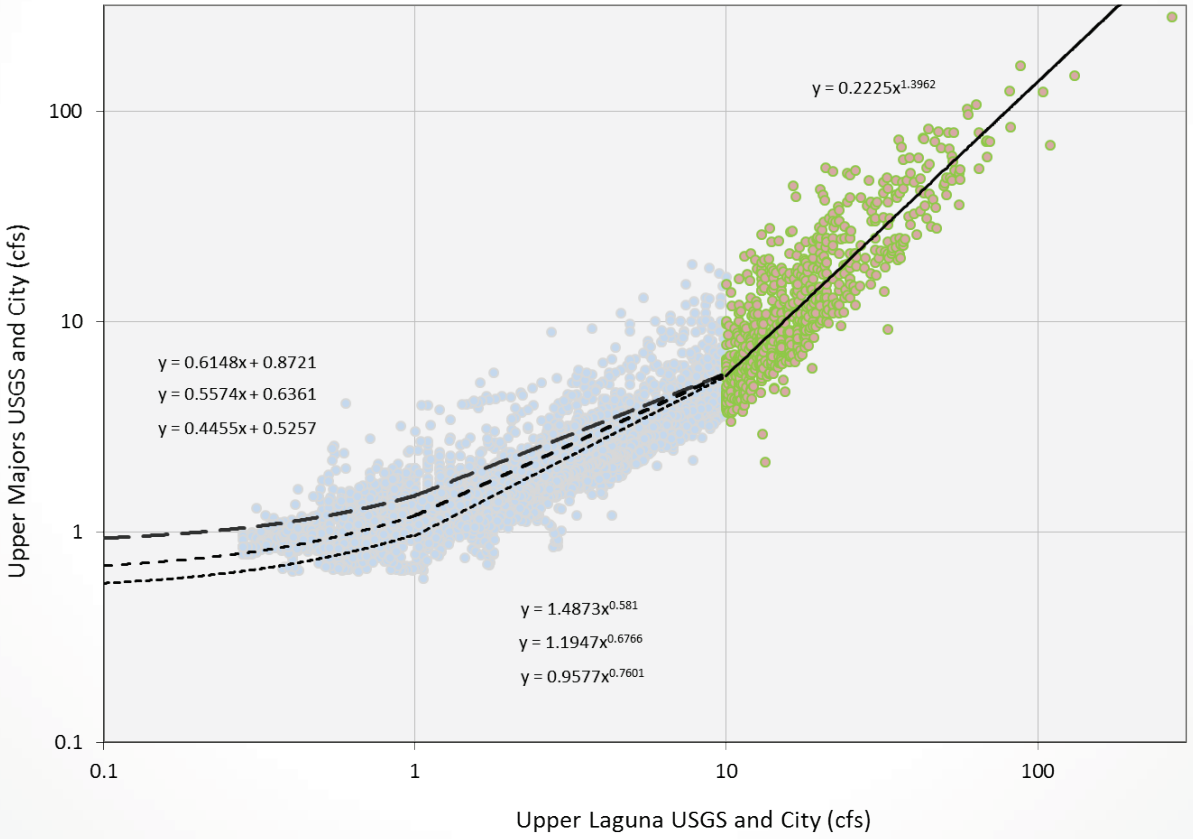


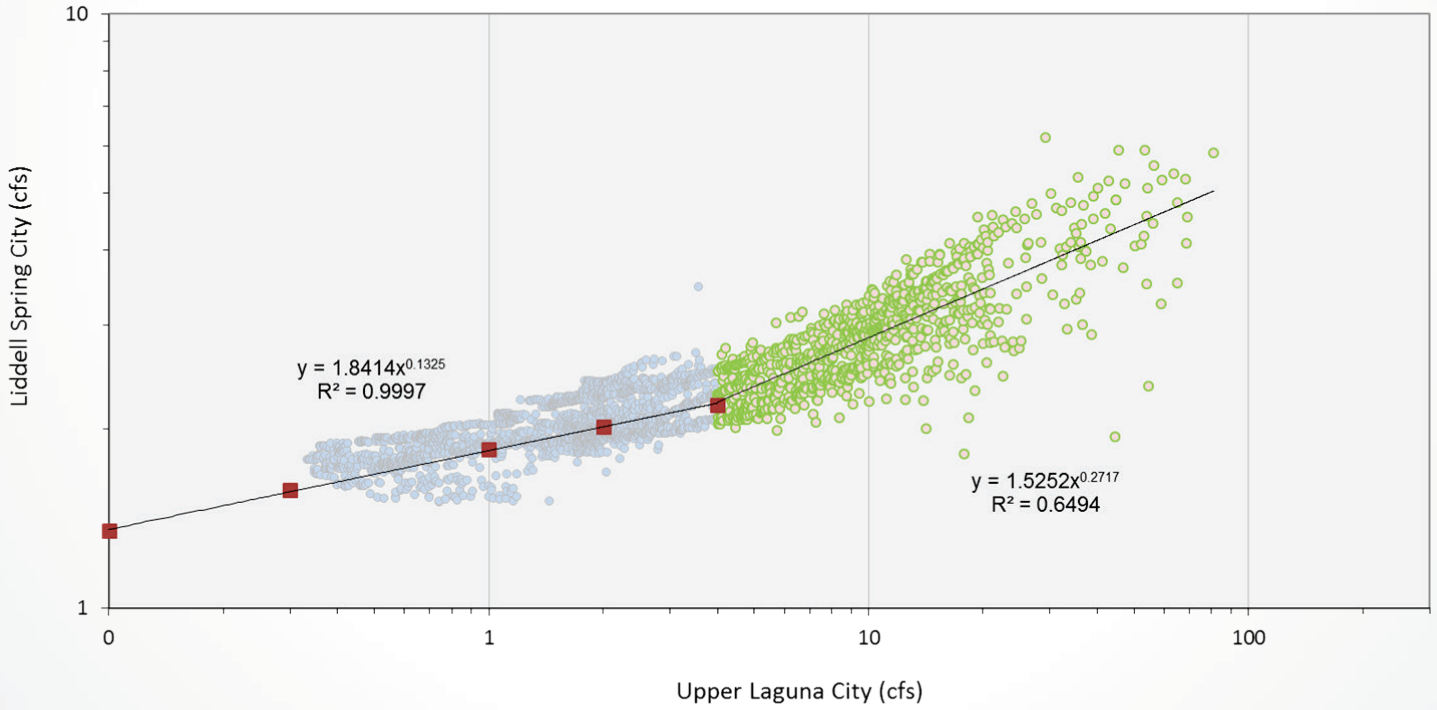
Data Development

5. Utilize the “hybrid” Laguna record to build analogues record for Majors Creeks upstream of diversion



Data Development

6. Utilize the “hybrid” Upper Laguna record to build an analogues record for Liddell Spring using inter-basin regression model (*hybrid)



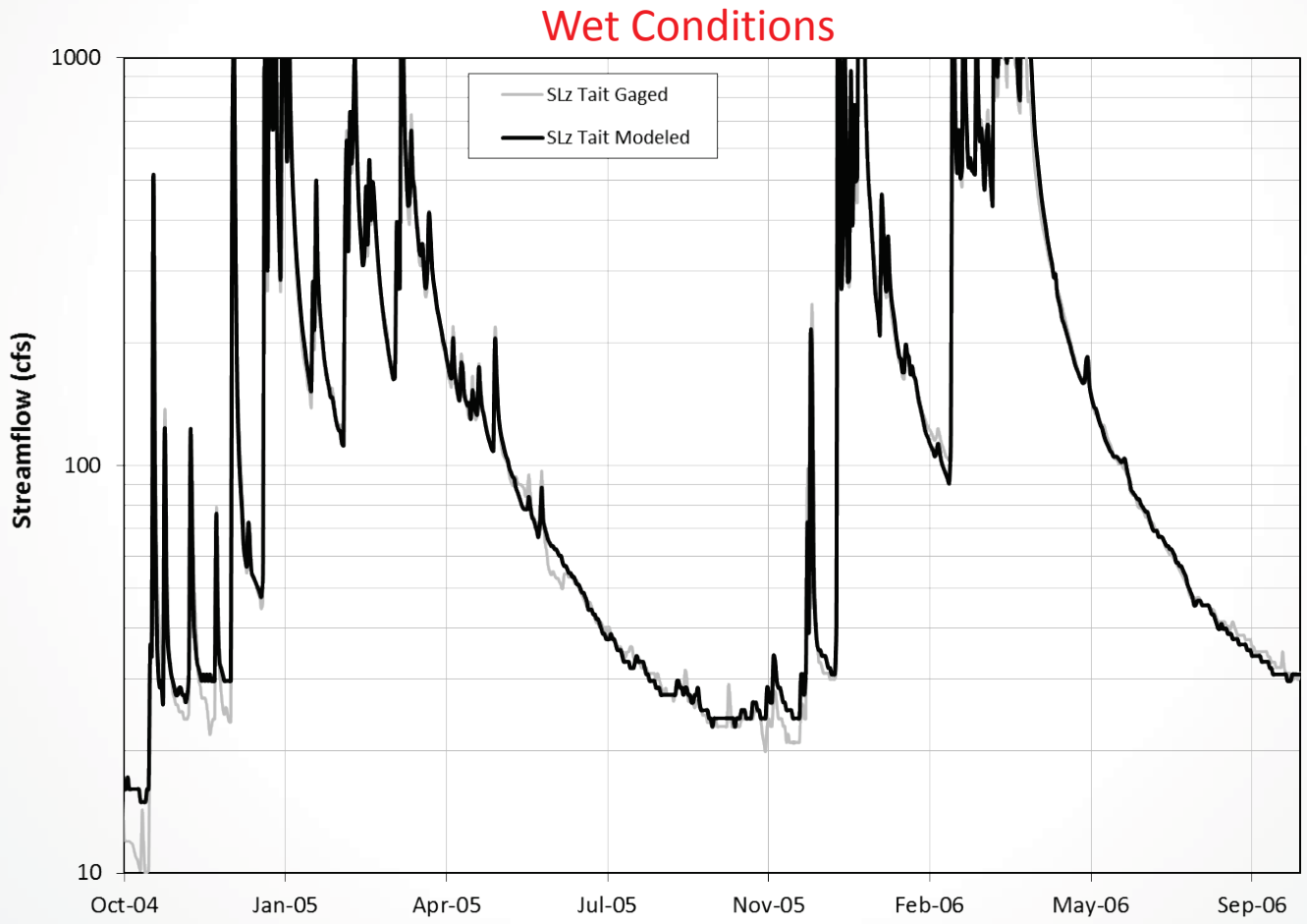
Data Development

Now ready to build flow records on Laguna, Majors and Liddell **upstream of the diversion** points for the analysis period.

Next we need to prepare to build records for the **anadromous reaches.** We use a similar approach as that presented above, except we focus on intra-basin regression models built with the City gaging records.

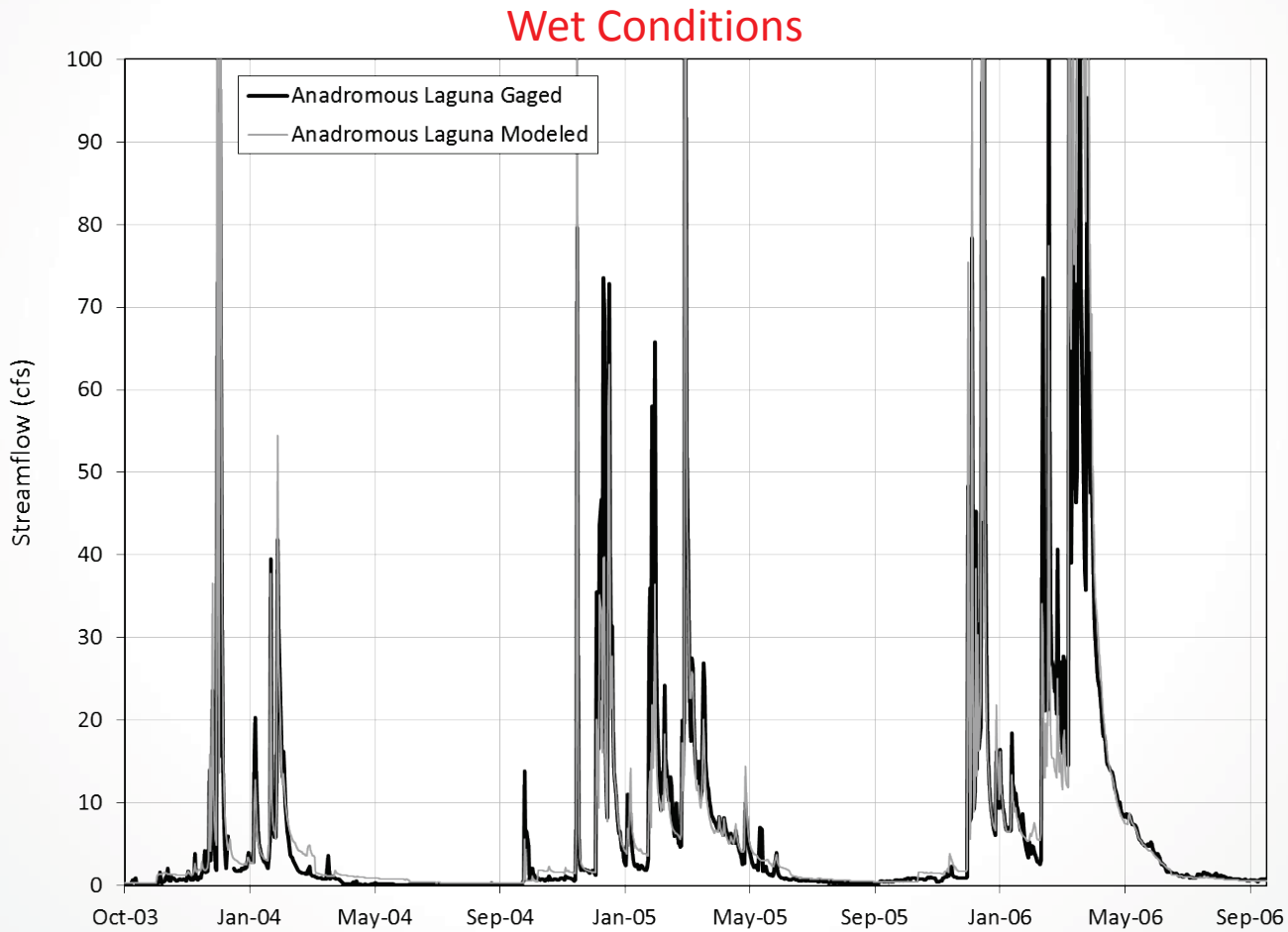
Data Development

7. Anadromous records – San Lorenzo Tait (*hybrid)



Data Development

7. Anadromous records – Laguna (*hybrid)



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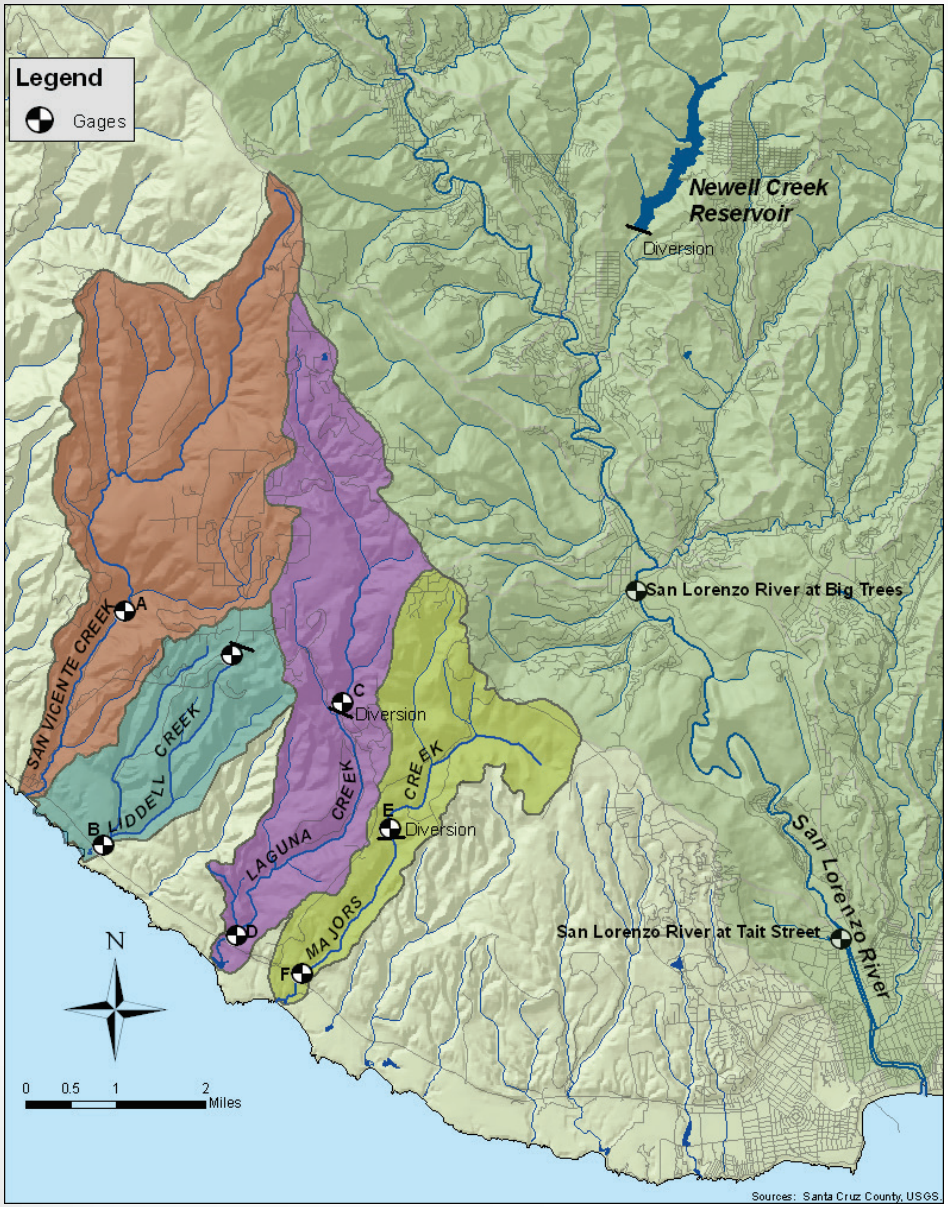


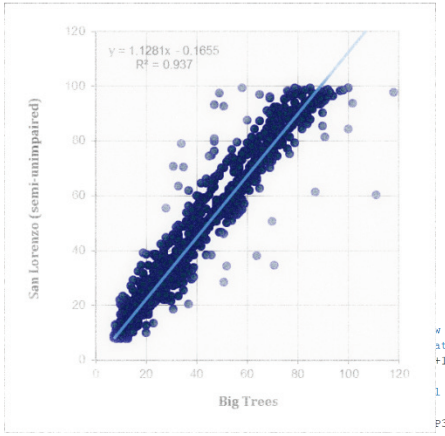
The end result are records of mean daily flow (mdf) for the all anadromous reaches and reaches upstream of City diversions for the period of record WY1936 - 2009.

Newell Creek flows are taken as the IWP simulated flows.

City of Santa Cruz HCP

Review Hydrologic Data Development

1. Brief History
2. Data development
3. Other items

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+1,4) < MJAMig(1,1)

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Data Development

other considerations

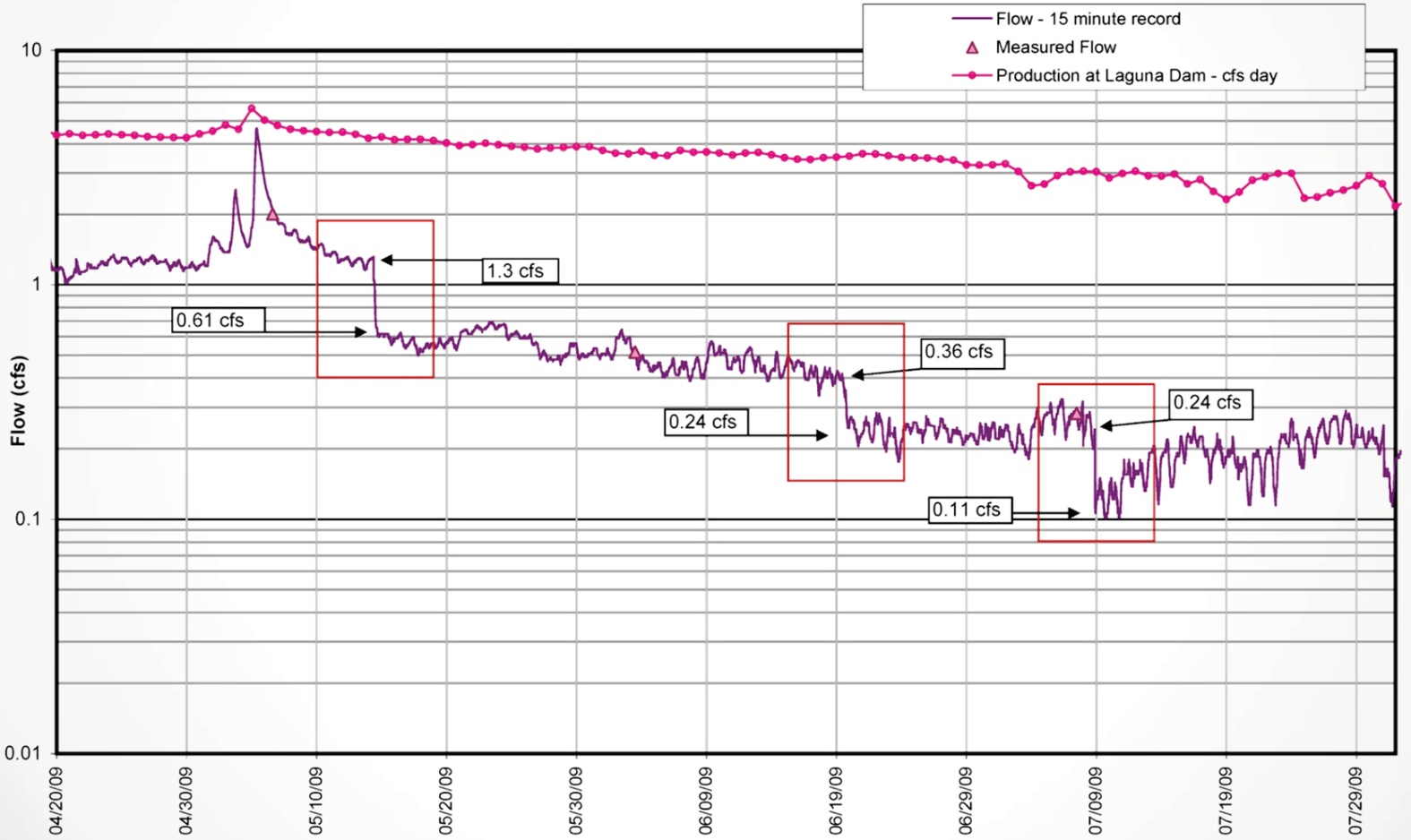
- City production is known at the monthly time step – conversion to the daily time step was done by simple arithmetic.
  - This carries with it the assumption that production was constant for any given month (this comes into play when we compute “natural” flows

Data Development

other considerations

- Private diversion records are unknown and a conservative estimate of diversion was applied:
  - Laguna Creek: 0.25 cfs
  - Majors Creek: 0.20 cfs
  - No additions necessary for SLR or Liddell
- Actual private diversion rates can be higher than our conservative estimate

Sample of loss of flow at Anadromous Laguna station



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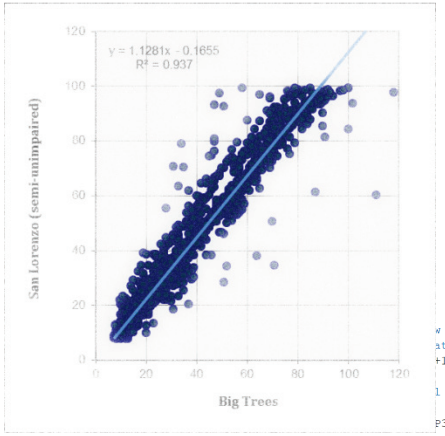
Data Development

other considerations

- Tributary inflows:
  - Tributary inflows on all four source streams are largely unknown.
  - But this is not is not as bad as it sounds because we have stream gage records to work with to estimate these tributary inputs, once the records are properly adjusted for City water supply diversion.
    - ✓ Northcoast records 10+ years
    - ✓ SLR 25+ years
  - Also keep in mind that our intra-basin regression models implicitly reflect tributary inputs (which is one reason why we went this route to begin with).

City of Santa Cruz HCP

Review Model Framework

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Balance Hydrologics, Inc.

HCP Hydrology Model

1. Hydrology Model uses data for the period 1936-2009 to step through the HCP flow goals (i.e. habitat flows) for each source stream in order to identify the flow available for production at the sources.
   - ❖ HCP Hydrology Model is simply a hydrologic decision tool
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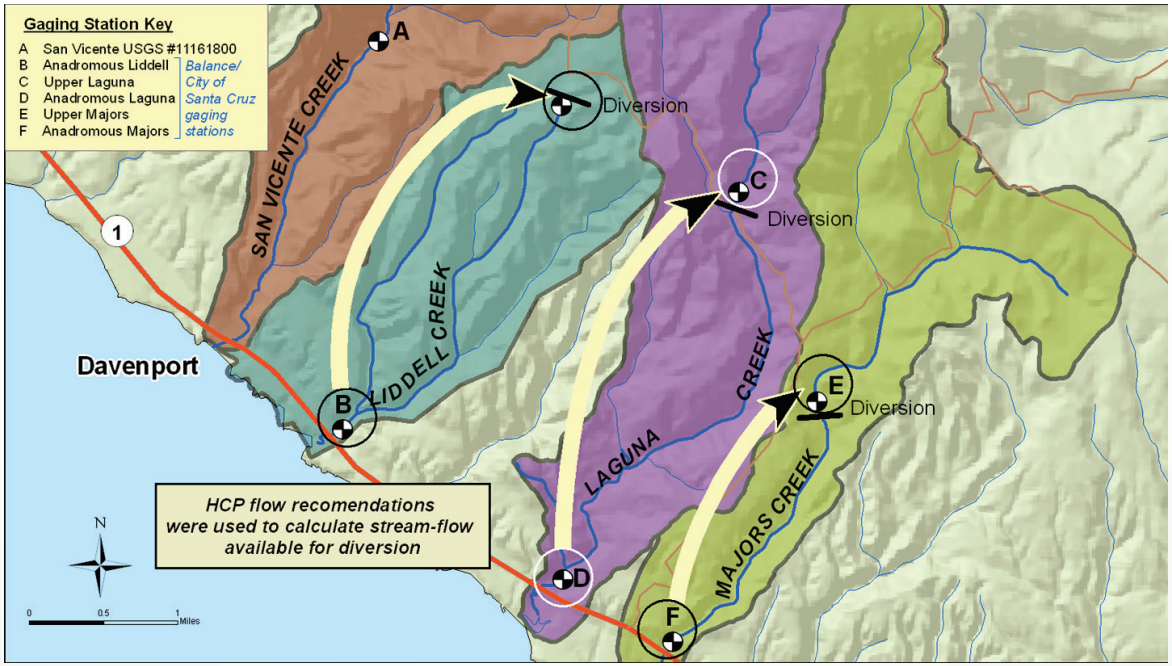

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2. Flow goals are described by a set of rules which specifies when a goal is to be in effect:

Laguna:

Rearing: 2 cfs at all times
Migration minimum- adult: 10.6 cfs, whenever daily average flow (absent City diversion) is at or exceeds minimum adult migration flows for one day from December through March.
Spawning: 9.4 cfs for 14 days following migration event from January through May
Incubation: 4 cfs for 61 days following last day of spawning event or until May 31, whichever comes first.
Smolt flows- 0-80% exceedence: 3.8 cfs continuous January-May
Smolt flows- 80-100% exceedence: 3.8 cfs or suspend City diversion for 3 consecutive days a week in March, April, and May

Sample HCP Flow Rules

		Minimum Flow at Laguna Creek Anadromous Gage								
		Rearing Baseflow					Migration		Spawning	
	Exception Minimum	Exceedence Category 5 80-100%	Exceedence Category 4 60-80%	Exceedence Category 3 40-60%	Exceedence Category 2 20-40%	Exceedence Category 1 0-20%	Adult	Smolt Migration	Spawn	Incubate
Jan	0.6	1.1	1.4	3.7	4.8	6.5	15.5		9.4	4
Feb	0.9	1	1.9	4.9	5.8	6.5	15.5		9.4	4
Mar	1.2	1.1	2.1	4.5	5.8	6.5	15.5		9.4	4
Apr	0.4	1.2	2	2.8	4.1	6.3	15.5	3.8	9.4	4
May	0.4	0.8	1.7	2.6	3.5	4.9		3.8	9.4	4
Jun	0.3	0.6	1.1	1.7	2.4	3.5				
Jul	0.1	0.3	0.4	1	1.5	2.4				
Aug	0.1	0.2	0.3	0.8	1.1	1.7				
Sep	0.1	0.2	0.4	0.7	1	1.4				
Oct	0.4	0.6	0.7	1.2	1.4	1.7				
Nov	0.4	0.8	0.9	1.7	1.9	2.4				
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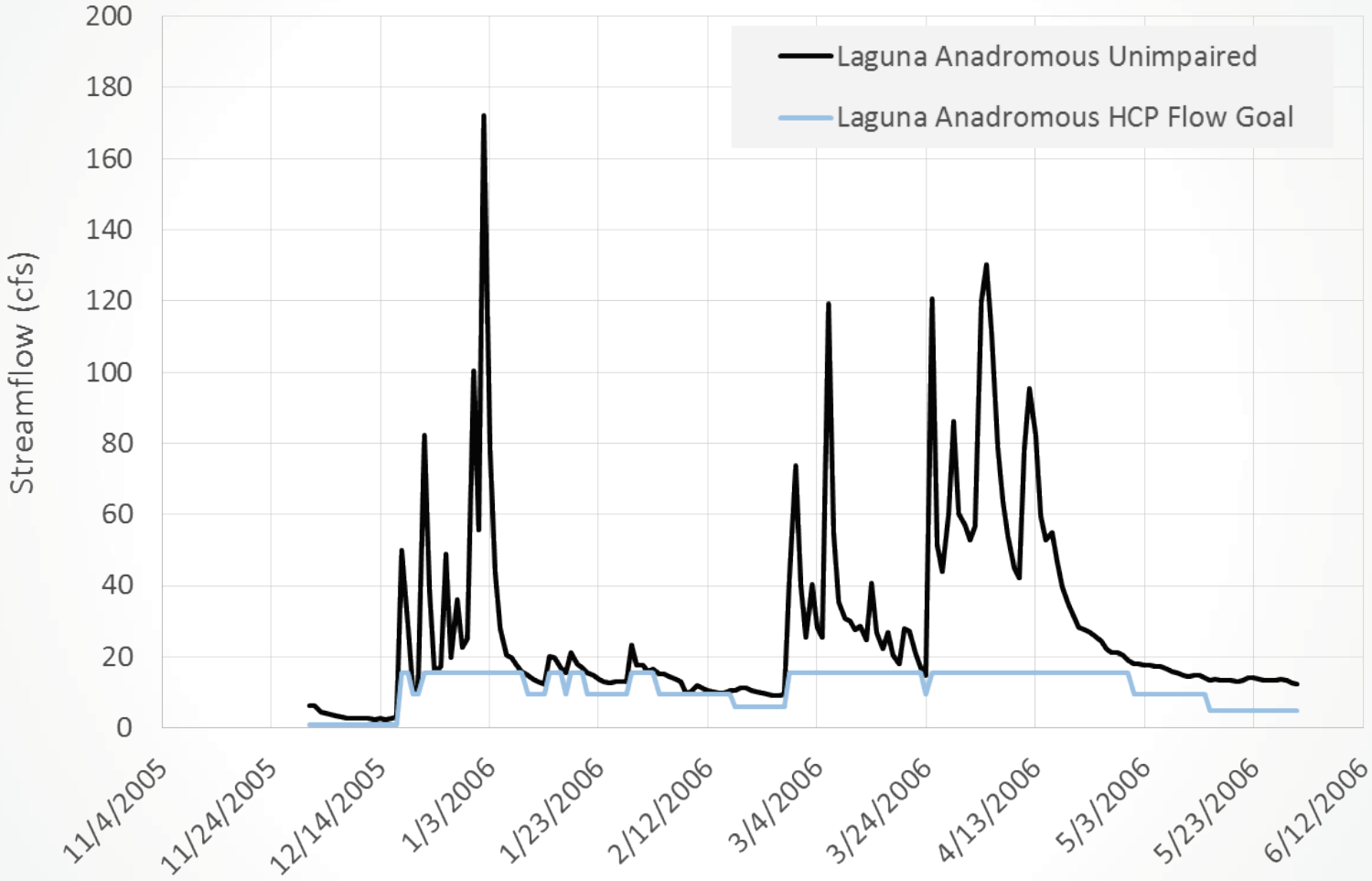

Flow Available for Supply

1. Assign the proper flow goal for the anadromous reach (trickiest part of the modeling)

Flow Available for Supply

1. Assign the proper flow goal for the anadromous reach (trickiest part of the modeling)
2. Now complete the basic flow accounting (northcoast):

$Q_{nana} < or > Q_{fg}$

< yields no potential production at point of diversion

> yields an additional query

$Q_{nud} > or < Q_{nana} - Q_{fg}$

> yields potential production at point of diversion up to Q_{nud}

< potential production at point of diversion = Q_{nud}

Flow Available for Supply

3. Flow accounting for the SLR is handled a bit differently to be more consistent with how *Confluence* views the various model nodes.

HCP Hydrology Model

WORKED EXAMPLE: taken straight from our model output

San Lorenzo River at Tait St.: Jan. 4th, 2007 (avg. year):

Big Trees UI:	37 cfs
Tributary Inputs:	3.89 cfs
sum:	40.89 cfs

This is what we have to work with on 1/4/2007

PX Legal Bypass: ~~20 cfs~~

HCP flow goal (bf): 25.2 cfs

so 11.8 cfs at BT potentially available at Tait for prod.

37-25.2 = 11.8 cfs

This sets the deal on 1/4/2007

Thus: potential Tait Production = 11.8 + 3.89 = 15.69 cfs

HCP Hydrology Model

WORKED EXAMPLE: taken straight from our model output

San Lorenzo River at Tait St.: June 4th, 2005 (wet year):

Big Trees UI:	73 cfs
Tributary Inputs:	16.92 cfs
sum:	89.92 cfs

This is what we have to work with on 6/4/2005

PX Legal Bypass: 0 cfs

so 54.9 cfs at BT potentially available at Tait for prod.

73-18.1 = 54.9 cfs

HCP flow goal (bf): 18.1 cfs

This sets the deal on 6/4/2005

Thus: potential Tait Production = 54.9 + 16.92 = 71.82 cfs

HCP Hydrology Model

WORKED EXAMPLE: taken straight from our model output

San Lorenzo River at Tait St.: August 4th, 2005 (wet year):

Big Trees UI:	32 cfs
Tributary Inputs:	3.88 cfs
sum:	35.88 cfs

This is what we have to work with on 8/4/2005

PX Legal Bypass: 0 cfs

so 23 cfs at BT potentially available at Tait for prod.

32-9 = 23 cfs

HCP flow goal (bf): 9 cfs

This sets the deal on 8/4/2005

Thus: potential Tait Production = 23 + 3.88 = 26.88 cfs

HCP Hydrology Model

1. The calculations for Liddell, Laguna and Majors follow the exact same procedure.

```
% If the flow the day after is less than the
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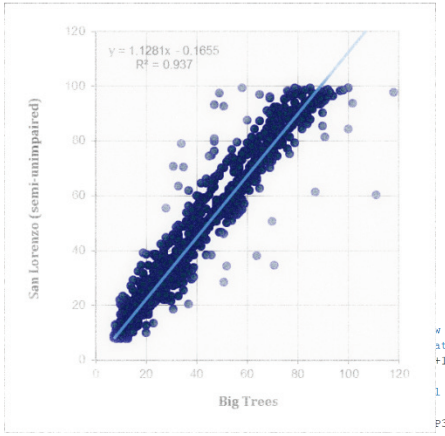
5. Working internally to frame potential climate change effects to habitat flows and water supply*

Questions and Discussion

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