City of Fort Bragg

Water Supply Model

Development, Functionality and Model Results

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Water Model History

The water model was first built in early 2014, by Bonnie Lampley of Lawrence and Associates, located in Shasta Lake, CA. Numerous iterations occurred with Terry Jo Barber, Sergio Fuentes, and myself. A Special City Council Water Workshop was held on January 5, 2016, where Sergio gave a brief demo of the Water Model, as it was at that time.

I worked with Bonnie from August 2017 to September of 2018, when I took over the functionality myself. I am confident that we are as close to the “real world” as we can get, with the information we have.

Historic data as input to model

DAY	DAILY PRECIP		DAILY EVAP		NOYO	NEWMAN	SIMPSON/ WATERFALL
Period for model is water years 1974 - 2013; this period encompasses most recent drought periods	From Fort Bragg Station 5N, U.S. Climatedata		Based on ET of North Coast basins, converted to evap (ET/1.25); monthly data converted to daily by dividing the monthly value by the # days/month		1973-1994, est. from 2008-2013; 1994-2015, average daily from City's meters		
	INCHES	FEET	INCHES	FEET	GPM	GPM	GPM
10/1/1973	0.00	0.000	0.004	0.0004	298	315	141
10/2/1973	0.02	0.002	0.004	0.0004	298	315	141
10/3/1973	0.00	0.000	0.004	0.0004	298	315	141

"Raw" tide data from CeNCOOS (Central & Northern California Ocean Observatory System)

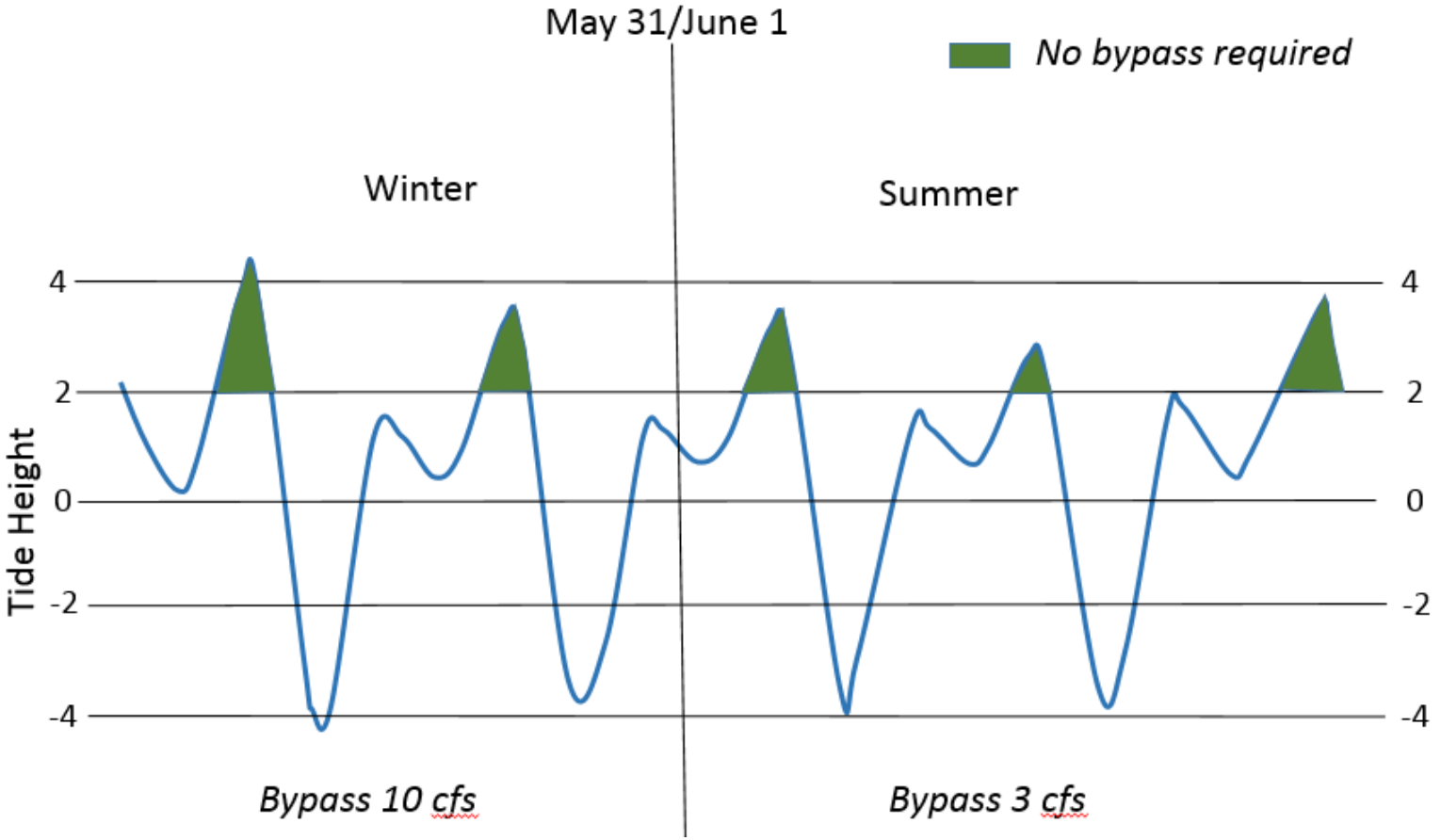
RAW DATA FROM CeNCOOS

10/01/1973 Mon	03:45AM PDT	4.2 H	10/01/1973 Mon	08:15AM PDT	2.9 L	10/01/1973 Mon	02:28PM PDT	5.4 H	10/01/1973 Mon	09:39PM PDT	0.4 L
10/02/1973 Tue	04:53AM PDT	4.0 H	10/02/1973 Tue	09:03AM PDT	3.1 L	10/02/1973 Tue	03:14PM PDT	5.1 H	10/02/1973 Tue	10:39PM PDT	0.6 L
10/03/1973 Wed	06:09AM PDT	3.9 H	10/03/1973 Wed	10:08AM PDT	3.3 L	10/03/1973 Wed	04:13PM PDT	4.9 H	10/03/1973 Wed	11:43PM PDT	0.8 L
10/04/1973 Thu	07:19AM PDT	4.0 H	10/04/1973 Thu	11:31AM PDT	3.3 L	10/04/1973 Thu	05:24PM PDT	4.7 H			
10/05/1973 Thu	12:45AM PDT	0.8 L	10/05/1973 Fri	08:09AM PDT	4.2 H	10/05/1973 Fri	12:51AM PDT	3.1 L	10/05/1973 Fri	06:38PM PDT	4.7 H
10/06/1973 Sat	01:38AM PDT	0.8 L	10/06/1973 Sat	08:46AM PDT	4.4 H	10/06/1973 Sat	01:53PM PDT	2.7 L	10/06/1973 Sat	07:44PM PDT	4.7 H
10/07/1973 Sun	02:23AM PDT	0.8 L	10/07/1973 Sun	09:16AM PDT	4.7 H	10/07/1973 Sun	02:42PM PDT	2.3 L	10/07/1973 Sun	08:41PM PDT	4.9 H

10/01/1973 Mon 03:45AM PDT 4.2 H 10/01/1973 Mon 08:15AM PDT 2.9 L 10/01/1973 Mon 02:28PM PDT 5.4 H 10/01/1973 Mon 09:39PM PDT 0.4 L

Noyo Diversion Order 1998 Amendment

"For the protection of fish and fish habitat, whenever the tide elevation at the mouth of the Noyo River is equal to or less than +2.0', Permittee shall maintain in the streambed immediately below the point of diversion a minimum flow of 10 cfs or the natural flow of the stream, whichever is less, for the period of October 1 through May 31, and 3 cfs or the natural flow of the stream, whichever is less, for the period June 1 through September 30.



“Raw” tide data from CeNCOOS (Central & Northern California Ocean Observatory System)

10/01/1973 Mon 03:45AM PDT	4.2 H	10/01/1973 Mon 08:15AM PDT	2.9 L	10/01/1973 Mon 02:28PM PDT	5.4 H	10/01/1973 Mon 09:39PM PDT	0.4 L

This part of the model “counts” the hours (rounded to increments of 6 or 8, for 4 or 3 tides/day, respectively) that the tide is above 2’, 5’, and 6.7’ (King Tide)

	PARSE VALUES				COUNT HOURS >2				COUNT HOURS >5				COUNT HOURS >6.7				SUM HRS >2	SUM HRS >5	SUM HRS >6.7
10/1/1973	4.2	2.9	5.4	0.4	6	6	6	0	0	0	6	0	0	0	0	0	18	6	0
10/2/1973	4	3.1	5.1	0.6	6	6	6	0	0	0	6	0	0	0	0	0	18	6	0
10/3/1973	3.9	3.3	4.9	0.8	6	6	6	0	0	0	0	0	0	0	0	0	18	0	0
10/4/1973	4	3.3	4.7	#N/A	8	8	8	0	0	0	0	0	0	0	0	0	24	0	0
10/5/1973	0.8	4.2	3.1	4.7	0	6	6	6	0	0	0	0	0	0	0	0	18	0	0
10/6/1973	0.8	4.4	2.7	4.7	0	6	6	6	0	0	0	0	0	0	0	0	18	0	0
10/7/1973	0.8	4.7	2.3	4.9	0	6	6	6	0	0	0	0	0	0	0	0	18	0	0
10/8/1973	0.8	5	1.7	5	0	6	0	6	0	6	0	6	0	0	0	0	12	12	0
10/9/1973	0.9	5.3	1.2	5	0	6	0	6	0	6	0	6	0	0	0	0	12	12	0
10/10/1973	1.1	5.6	0.6	5.1	0	6	0	6	0	6	0	6	0	0	0	0	12	12	0
10/11/1973	1.3	5.9	0	5	0	6	0	6	0	6	0	6	0	0	0	0	12	12	0
10/12/1973	1.6	6.2	-0.4	#N/A	0	8	0	0	0	8	0	0	0	0	0	0	8	8	0
10/13/1973	4.9	1.9	6.4	-0.7	6	0	6	0	0	0	6	0	0	0	0	0	12	6	0

% of “constrained” flow available for use (User_Input)
In this case 75% of the flow

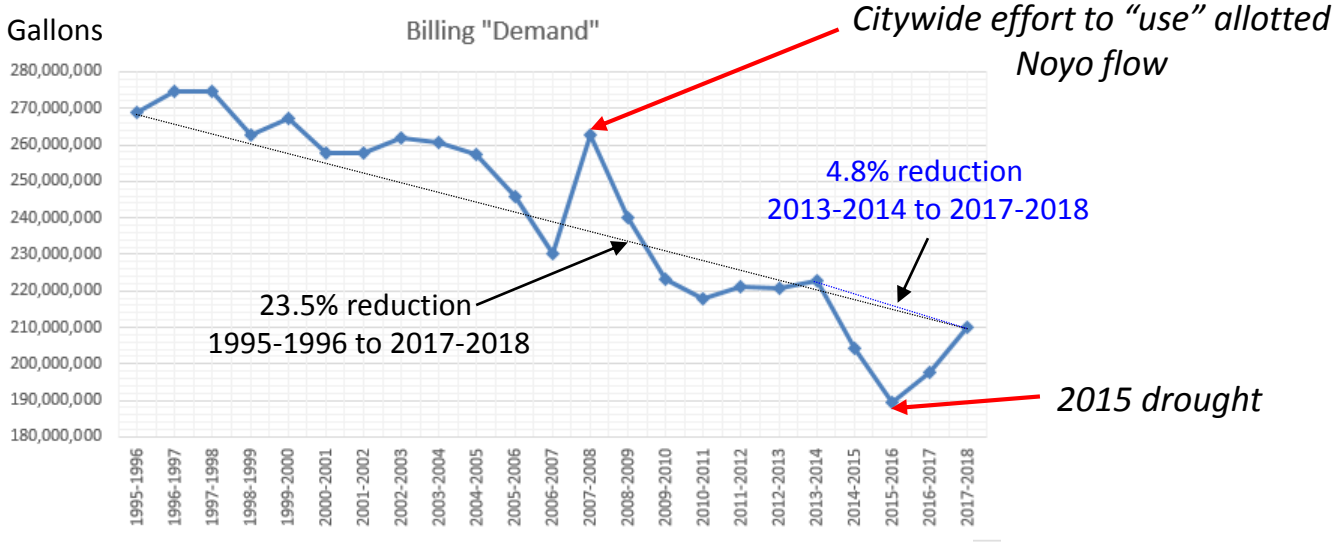
“Constrained” source volumes

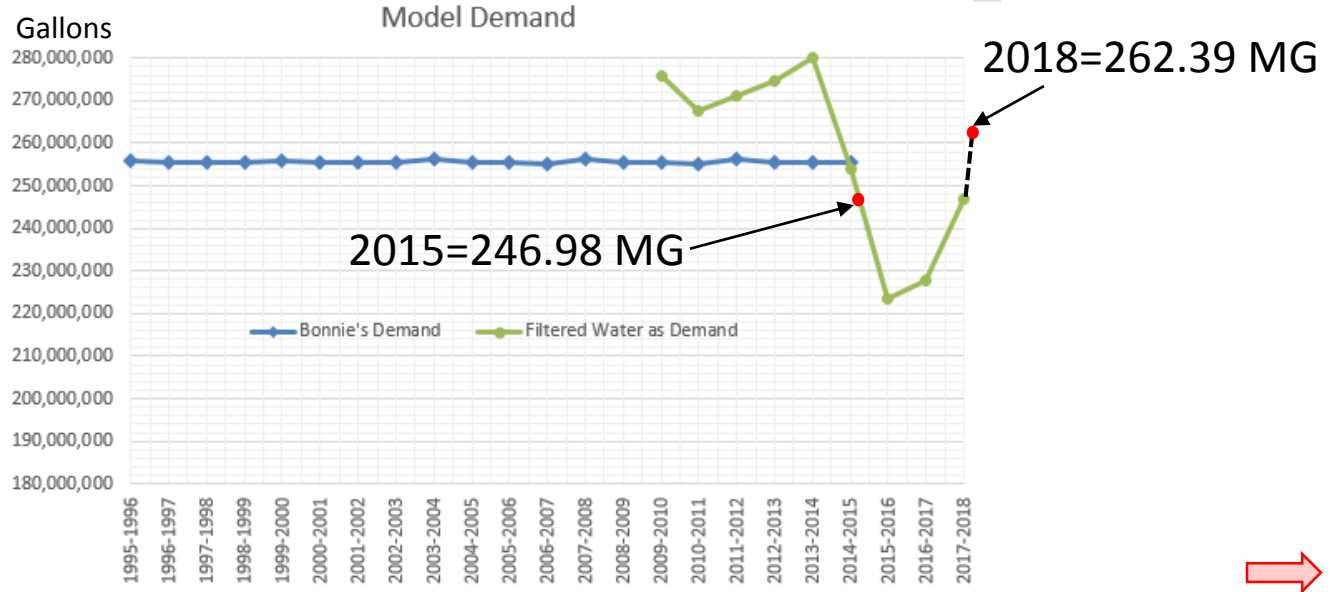
Day	REVISED NEWMAN	REVISED WATERFALL	REVISED NOYO
	AF/DAY	(AF/DAY)	(AF/DAY)
	NOT TO EXCEED FLOW OF 0.99 AF/DAY	From Data sheet, converted to af/day - reduced by chosen %, less amount to remain	From Data sheet Diane Calc (Max 5.95 AF)
10/1/1973	0.990	0.47	4.46
10/2/1973	0.990	0.47	4.46
10/3/1973	0.990	0.47	4.46
10/4/1973	0.990	0.47	5.95
10/5/1973	0.990	0.47	4.46
10/6/1973	0.990	0.47	5.95
10/7/1973	0.990	0.47	5.95
10/8/1973	0.990	0.47	5.95
10/9/1973	0.990	0.47	5.95
10/10/1973	0.990	0.47	5.95

WATERFALL RESTRICTED	WATERFALL RESTRICTED
NOT TO EXCEED 1.325 AF/DAY (299.82 GPM)	constrained by user amount
AF	AF
0.62	0.47
0.62	0.47
0.62	0.47
0.62	0.47

Historic Demand Trends

Day	Beginning Volume (AF)	City Demand (AF/DAY)
	From end of previous day	From Data sheet - converted to af/day - multiplied by growth factor if used
7/30/2015	64.6	3.3
7/31/2015	64.6	3.1
8/1/2015	64.6	3.0
8/2/2015	64.6	2.8
8/3/2015	64.6	3.3
8/4/2015	64.6	3.0
8/5/2015	64.6	3.0





2015 calendar year metered **billing** is 195,544,404 Gallons
2015 calendar year metered **filtered** is 246,979,900 Gallons
2017-2018 Fiscal year metered **filtered** is 246,742,000 Gallons
2018 calendar year metered **filtered** is 262,390,000 Gallons

User Interface (User_Input Tab)

Model Constants:

Existing Newman Reservoir	0.9	acre-feet
New Summers Lane Reservoir	**44.3**	**acre-feet**
Raw Water Storage	9.2	acre-feet
Finished Water Storage	10.1	acre-feet
Groundwater availability (maximum, non-drought)	0.4	acre-feet per day
Water Alert Trigger	Raw water source capacity at least 10% above demand	

Adjust flow %

Use Summers Lane Reservoir

Model Input Adjustments You Can Make:

Reduce Noyo flow?	100%	<-- as percent of measured flow
Amount of flow that must remain in Noyo River?	10	<-- amount to leave in Noyo, Oct 1 - May 31 (cfs)
	3	<-- amount to leave in Noyo, Jun 1 - Sep 30 (cfs)
Height of tide that controls pumping?	2.0	<-- height of tide that controls pumping (feet)
Reduce Newman Gulch flow?	100%	<-- percent of historic measured flow
Reduce Waterfall Gulch flow?	100%	<-- percent of historic measured withdrawal
Amount of flow that must remain in Waterfall G.?	0.0	<-- enter amount to leave in Waterfall G. (cfs) (enter 0.000001 to ignore factor)
Use new Summers Lane Reservoir?	n	<-- enter Y or N
Use evaporation on raw water storage?	0.00	<-- approximate daily amount in acre-feet
Use evaporation reduction device on new reservoir?	0%	<-- percent reduction due to device
Adjust daily precipitation?	100%	<-- percent change from historic values
Increase City demand? If using 2015 graphs, demand is for 2015	100%	<-- **percent of 2015 production**
Use groundwater from former park site?	N	<-- Y or N
Groundwater pumpage? (200 gpm original)	100	<-- as total gallons per minute from well field

Adjust volume of bypass
We now bypass 25% of flow at Waterfall Gulch

Increase demand from 2015

What is a Water Emergency?

Ordinance of 1/25/2016 reads that a Water Emergency is declared when “the City is unable to maintain a 10% buffer between its ability to replenish water in its storage tanks and the total daily demand for water”.

Stage 1 is defined as 10% goal of reducing water usage

Stage 2 is defined as 20% goal of reducing water usage

Stage 3 is defined as 30% goal of reducing water usage

Stage 4 is defined as “all available water sources cannot provide sufficient flow for water users or cannot maintain adequate flows or pressures for fire-fighting; and the conservation measures required by a Stage 1, Stage 2, and Stage 3 water emergency are no longer adequate to address the water shortage”.

The Model automatically calculates a **Water Alert**, when demand exceeds 90% of supply, and **Stage 4**, when supply is exhausted. **Stage 1** Water Emergency will be determined by evaluation of daily model results.

Determining Stage 1 Water Emergency Criteria for Fall of 2015

Summers Lane holds 44.3 AF. If it is 98% full, that equates to 43.4 AF. 11% drawdown leaves a volume of 38.6 AF. Added to the other storage (20.2) equals ***58.8 AF***
With the reservoir full, ***we don't reach Stage 1 until we increase demand by 6%.***

Increase City demand? If using 2015 graphs, demand is for 2015 — 106% <-- percent of 2015 production

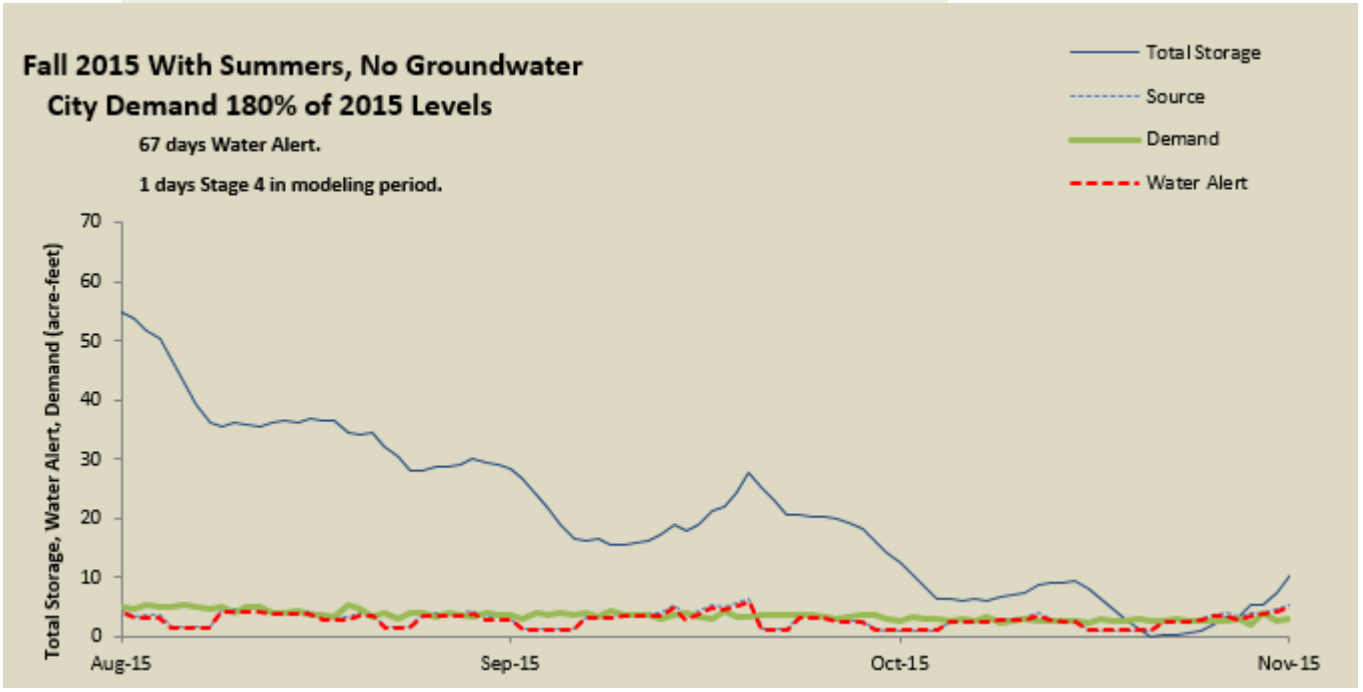
Day	Beginning Volume	City Demand	Newman	REVISED NEWMAN	REVISED WATERFALL	REVISED NOYO	Summers Withdrawl (if used)	FINAL ENDING VOLUME
	(AF)	(AF/DAY)	(AF/DAY)	AF/DAY	(AF/DAY)	(AF/DAY)	(AF/DAY)	(AF/DAY)
	From end of previous day	From Data sheet - converted to af/day - multiplied by growth factor if used	From Data sheet, converted to af/day, reduced by User Input %	NOT TO EXCEED FLOW OF 0.99 AF/DAY	From Data sheet, converted to af/day - reduced by chosen %, less amount to remain	From Data sheet Diane Calc (Max 5.95 AF)	Amount to be drawn from reservoir if needed (when used)	Final Ending Volume
8/5/2015	64.6	3.0	1.4	0.990	0.55	0.00	1.44	63.1
8/6/2015	63.1	3.1	1.4	0.990	0.55	0.00	1.60	61.5
8/7/2015	61.5	3.0	1.4	0.990	0.55	0.00	1.47	60.1
8/8/2015	60.1	2.8	1.4	0.990	0.55	0.00	1.29	58.8
8/9/2015	58.8	3.1	1.4	0.990	0.55	3.19	0.00	60.4
8/10/2015	60.4	2.3	1.4	0.990	0.55	3.12	0.00	62.8
8/11/2015	62.8	3.0	1.4	0.990	0.55	3.16	0.00	64.5
8/12/2015	64.5	2.9	1.4	0.990	0.55	3.05	0.00	64.6

Stage 4 Criteria 2015

Day	Beginning Volume (AF) From end of previous day
10/21/2015	3.1
10/22/2015	1.3
10/23/2015	0.0
10/24/2015	0.3
10/25/2015	0.3

Model Input Adjustments You Can Make:

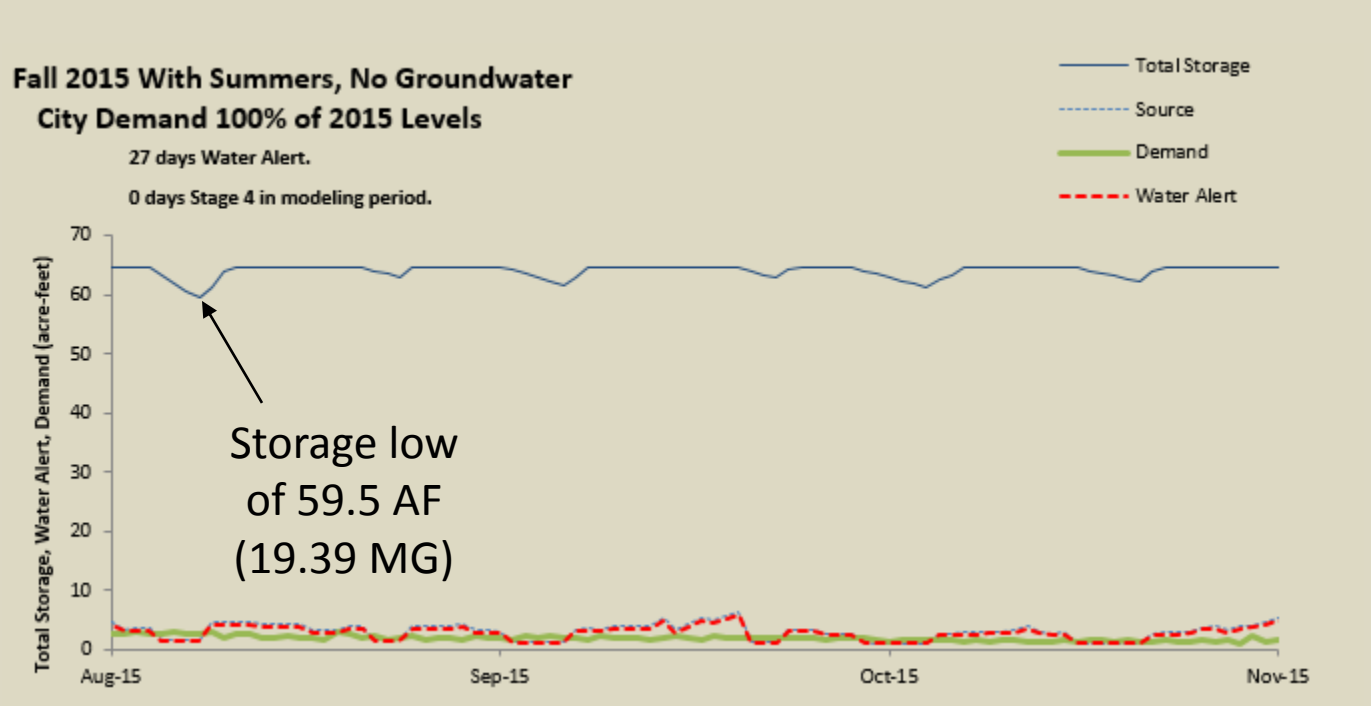
Reduce Noyo flow?	100%	<-- as percent of measured flow
Amount of flow that must remain in Noyo River?	10	<-- amount to leave in Noyo, Oct 1 - May 31 (cfs)
	3	<-- amount to leave in Noyo, Jun 1 - Sep 30 (cfs)
Height of tide that controls pumping?	2.0	<-- height of tide that controls pumping (feet)
Reduce Newman Gulch flow?	100%	<-- percent of historic measured flow
Reduce Waterfall Gulch flow?	75%	<-- percent of historic measured withdrawal
Amount of flow that must remain in Waterfall G.?	0.0	<-- enter amount to leave in Waterfall G. (cfs) (enter 0.000001 to ignore factor)
Use new Summers Lane Reservoir?	y	<-- enter Y or N
Use evaporation on raw water storage?	0.00	<-- approximate daily amount in acre-feet
Use evaporation reduction device on new reservoir?	0%	<-- percent reduction due to device
Adjust daily precipitation?	100%	<-- percent change from historic values
Increase City demand? If using 2015 graphs, demand is for 2015	**180.1%**	**<-- percent of 2015 production**
Use groundwater from former park site?	N	<-- Y or N
Groundwater pumpage? (200 gpm original)	100	<-- as total gallons per minute from well field



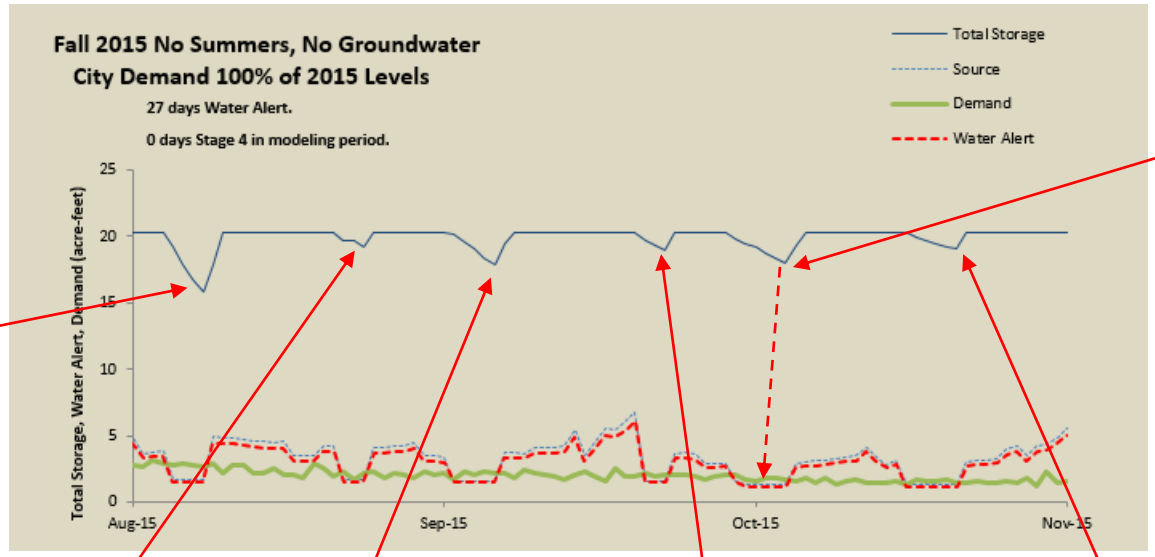
Example run with Summers Lane Reservoir

Model Input Adjustments You Can Make:

Reduce Noyo flow?	100%	<-- as percent of measured flow
Amount of flow that must remain in Noyo River?	10	<-- amount to leave in Noyo, Oct 1 - May 31 (cfs)
	3	<-- amount to leave in Noyo, Jun 1 - Sep 30 (cfs)
Height of tide that controls pumping?	2.0	<-- height of tide that controls pumping (feet)
Reduce Newman Gulch flow?	100%	<-- percent of historic measured flow
Reduce Waterfall Gulch flow?	75%	<-- percent of historic measured withdrawal
Amount of flow that must remain in Waterfall G.?	0.0	<-- enter amount to leave in Waterfall G. (cfs) (enter 0.000001 to ignore factor)
Use new Summers Lane Reservoir?	y	<-- enter Y or N
Use evaporation on raw water storage?	0.00	<-- approximate daily amount in acre-feet
Use evaporation reduction device on new reservoir?	0%	<-- percent reduction due to device
Adjust daily precipitation?	100%	<-- percent change from historic values
Increase City demand? If using 2015 graphs, demand is for 2015	100%	**<-- percent of 2015 production**
Use groundwater from former park site?	N	<-- Y or N
Groundwater pumpage? (200 gpm original)	100	<-- as total gallons per minute from well field



Ground truth - Fall of 2015 without Summers Lane, 100% of Waterfall Gulch



Date	AF
8/1/2015	20.3
8/2/2015	20.3
8/3/2015	20.3
8/4/2015	20.3
8/5/2015	20.3
8/6/2015	19.2
8/7/2015	17.9
8/8/2015	16.8
8/9/2015	15.9
8/10/2015	17.9
8/11/2015	20.3
8/12/2015	20.3
8/13/2015	20.3
8/14/2015	20.3
8/15/2015	20.3
8/16/2015	20.3
8/17/2015	20.3
8/18/2015	20.3
8/19/2015	20.3
8/20/2015	20.3
8/21/2015	20.3
8/22/2015	20.3
8/23/2015	19.7
8/24/2015	19.7
8/25/2015	19.2
8/26/2015	20.3
8/27/2015	20.3
8/28/2015	20.3
8/29/2015	20.3
8/30/2015	20.3
8/31/2015	20.3

Date	AF
9/1/2015	20.3
9/2/2015	20.3
9/3/2015	20.2
9/4/2015	19.5
9/5/2015	19.1
9/6/2015	18.4
9/7/2015	17.9
9/8/2015	19.4
9/9/2015	20.3
9/10/2015	20.3
9/11/2015	20.3
9/12/2015	20.3
9/13/2015	20.3
9/14/2015	20.3
9/15/2015	20.3

Date	AF
9/16/2015	20.3
9/17/2015	20.3
9/18/2015	20.3
9/19/2015	20.3
9/20/2015	20.3
9/21/2015	20.3
9/22/2015	19.7
9/23/2015	19.4
9/24/2015	18.9
9/25/2015	20.3
9/26/2015	20.3
9/27/2015	20.3
9/28/2015	20.3
9/29/2015	20.3
9/30/2015	20.3

Date	AF
10/1/2015	19.8
10/2/2015	19.4
10/3/2015	19.3
10/4/2015	18.8
10/5/2015	18.4
10/6/2015	18.0
10/7/2015	19.3
10/8/2015	20.3
10/9/2015	20.3
10/10/2015	20.3
10/11/2015	20.3
10/12/2015	20.3
10/13/2015	20.3
10/14/2015	20.3
10/15/2015	20.3
10/16/2015	20.3
10/17/2015	20.3
10/18/2015	20.3
10/19/2015	19.9
10/20/2015	19.7
10/21/2015	19.5
10/22/2015	19.2
10/23/2015	19.1
10/24/2015	20.3
10/25/2015	20.3
10/26/2015	20.3
10/27/2015	20.3
10/28/2015	20.3
10/29/2015	20.3
10/30/2015	20.3
10/31/2015	20.3

If the model was set up to determine the Stage 1 automatically, it would have counted 6 days. If the City declared Stage 1 on the first day we hit or fell below 18 AF (8/7), and continue until there were no more days below 18 AF for the fall (10/7), Stage 1 would have been declared for 61 days (from 8/7-10/6)

Maximum Drought Water Supply – Reserve 5 MG Storage

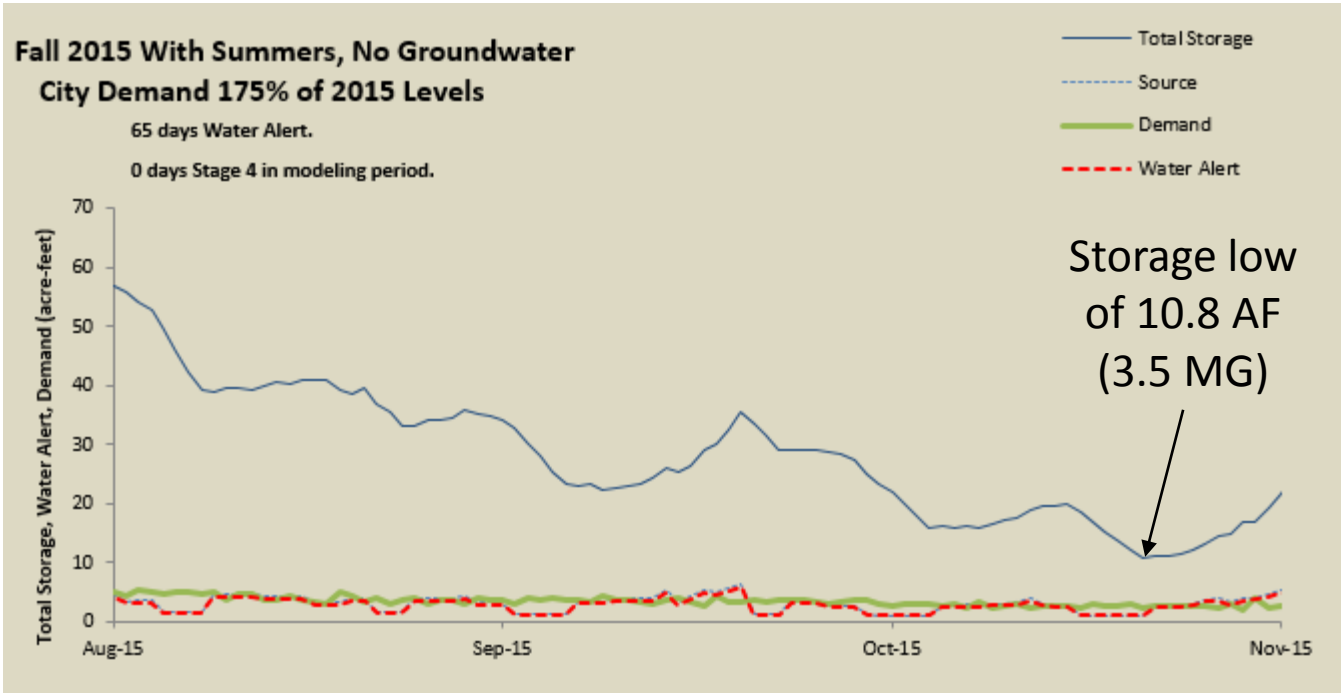
Day	Beginning Volume (AF)
	From end of previous day
10/20/2015	15.4
10/21/2015	13.9
10/22/2015	12.1
10/23/2015	10.8
10/24/2015	11.1
10/25/2015	11.2
10/26/2015	11.6

10.8 AF = 3.5 MG
New Tank = 1.5 MG

Model Input Adjustments You Can Make:

Reduce Noyo flow?	100%	<-- as percent of measured flow
Amount of flow that must remain in Noyo River?	10	<-- amount to leave in Noyo, Oct 1 - May 31 (cfs)
	3	<-- amount to leave in Noyo, Jun 1 - Sep 30 (cfs)
Height of tide that controls pumping?	2.0	<-- height of tide that controls pumping (feet)
Reduce Newman Gulch flow?	100%	<-- percent of historic measured flow
Reduce Waterfall Gulch flow?	75%	<-- percent of historic measured withdrawal
Amount of flow that must remain in Waterfall G.?	0.0	<-- enter amount to leave in Waterfall G. (cfs) (enter 0.000001 to ignore factor)
Use new Summers Lane Reservoir?	y	<-- enter Y or N
Use evaporation on raw water storage?	0.00	<-- approximate daily amount in acre-feet
Use evaporation reduction device on new reservoir?	0%	<-- percent reduction due to device
Adjust daily precipitation?	100%	<-- percent change from historic values
Increase City demand? If using 2015 graphs, demand is for 2015	**174.8%**	**<-- percent of 2015 production**
Use groundwater from former park site?	N	<-- Y or N
Groundwater pumpage? (200 gpm original)	100	<-- as total gallons per minute from well field

74.8% growth = 431 MG



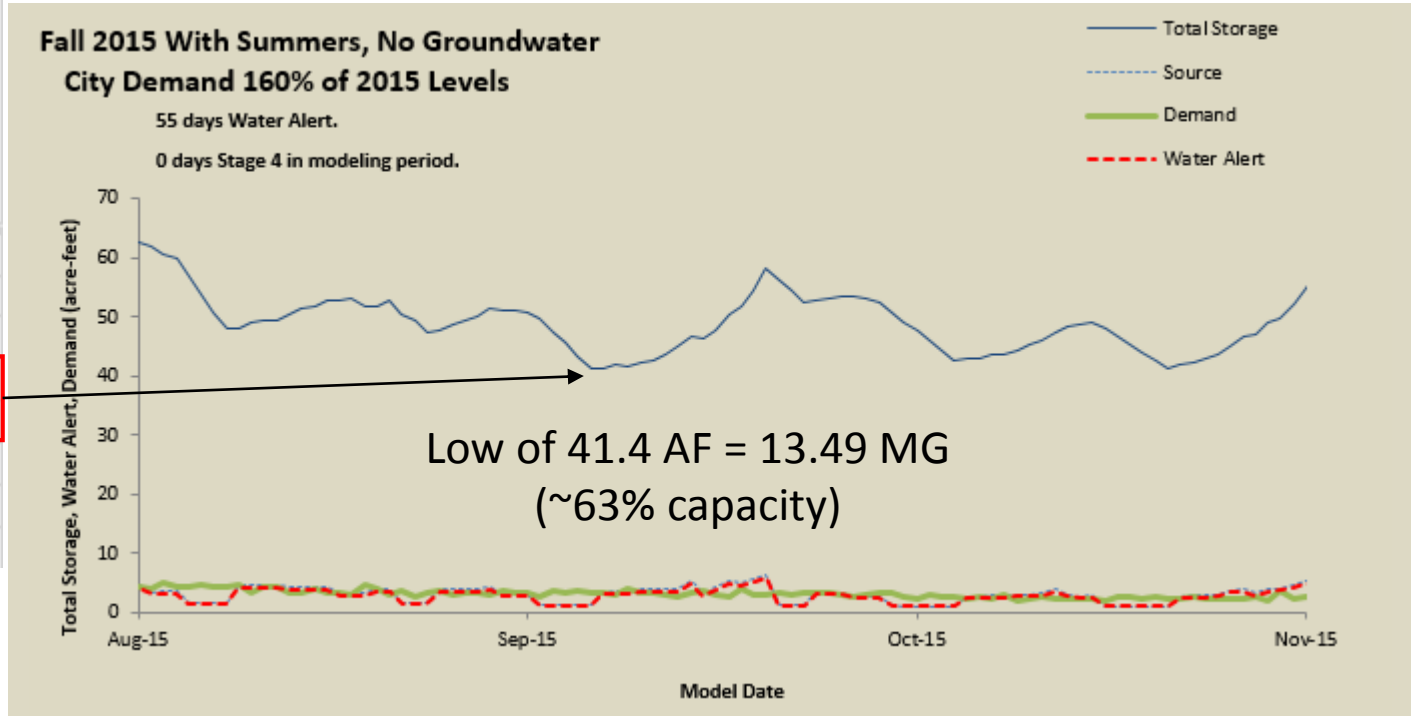
60% Growth Analysis

Model Input Adjustments You Can Make:

Reduce Noyo flow?	100%	<-- as percent of measured flow
Amount of flow that must remain in Noyo River?	10	<-- amount to leave in Noyo, Oct 1 - May 31 (cfs)
	3	<-- amount to leave in Noyo, Jun 1 - Sep 30 (cfs)
Height of tide that controls pumping?	2.0	<-- height of tide that controls pumping (feet)
Reduce Newman Gulch flow?	100%	<-- percent of historic measured flow
Reduce Waterfall Gulch flow?	75%	<-- percent of historic measured withdrawal
Amount of flow that must remain in Waterfall G.?	0.0	<-- enter amount to leave in Waterfall G. (cfs) (enter 0.000001 to ignore factor)
Use new Summers Lane Reservoir?	y	<-- enter Y or N
Use evaporation on raw water storage?	0.00	<-- approximate daily amount in acre-feet
Use evaporation reduction device on new reservoir?	0%	<-- percent reduction due to device
Adjust daily precipitation?	100%	<-- percent change from historic values
Increase City demand? If using 2015 graphs, demand is for 2015	160%	**<-- percent of 2015 production**
Use groundwater from former park site?	N	<-- Y or N
Groundwater pumpage? (200 gpm original)	100	<-- as total gallons per minute from well field

60% growth = 395 MG

Day	Beginning Volume (AF) — From end of previous day
9/4/2015	47.4
9/5/2015	45.6
9/6/2015	43.4
9/7/2015	41.4
9/8/2015	41.4
9/9/2015	42.0
9/10/2015	41.6
9/11/2015	42.1



Low of 41.4 AF = 13.49 MG
(~63% capacity)

Live Demo

What parameters would you like me to use?

Back Up Slides

Historic Noyo flow and daily intake calculations - Winter

	100%														
DAY	NOYO FLOW		AMOUNT TO LEAVE IN NOYO	TIDES (TIME >2')	TIDES (TIME >5')	TIDES (TIME >6.7')	CHECK IF NOYO PUMPING POSSIBLE BASED ON QUALITY								NOYO RESTRICTED BY TIDES
Period for model is water years 1974 - 2013; this period encompasses most recent drought periods	From USGS 11468500 Noyo R. Near Fort Bragg; flow reduced at choice of user (column G) **Yellow is revised per USGS, the following BOLD data was added**			Tide data from CeNCOOS, Fort Bragg Landing Station; hours/day tides >2' estimated from tide data	Tide data from CeNCOOS, Fort Bragg Landing Station; hours/day tides >5' estimated from tide data	Tide data from CeNCOOS, Fort Bragg Landing Station; hours/day tides >6.7' estimated from tide data	If tide is >5' at any time during the day and flow is < 1 OR if tide >6.7' and flow is < 2.5 cfs, then Noyo offline (0 = offline, 1 = ok to pump)	**Manage flows in winter with bypass, Tide <2' 10 cfs bypass required**	**Constrain to max 3 CFS**	**Manage flows in summer with bypass, Tide <2' - 3 cfs bypass required**	**Constrain to max 3 CFS**	**Flow rate when tide ≤2' (sum of previous 2 constrained)**	**Total available flow during tide ≤2'**	**Total available flow when tide >2'**	**Total Noyo flow for 24 hour period (sum of below and above 2' tide in AF) MAX 5.95**
	CFS	CFS	CFS	HRS	HRS	HRS	0=King Tide	CFS	CFS	CFS	CFS	CFS	CF	CF	AF
10/1/1973	7.6	7.6	10.0	18	6	0	1	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0**	**194,400**	**4.46**
10/2/1973	7.2	7.2	10.0	18	6	0	1	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0**	**194,400**	**4.46**
10/3/1973	7.2	7.2	10.0	18	0	0	1	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0**	**194,400**	**4.46**
10/4/1973	6.8	6.8	10.0	24	0	0	1	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0**	**259,200**	**5.95**
10/5/1973	6.8	6.8	10.0	18	0	0	1	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0**	**194,400**	**4.46**
10/6/1973	17.0	17.0	10.0	18	0	0	1	**7.0**	**3.0**	**0.0**	**0.0**	**3.0**	**64,800**	**194,400**	**5.95**
10/7/1973	60.0	60.0	10.0	18	0	0	1	**50.0**	**3.0**	**0.0**	**0.0**	**3.0**	**64,800**	**194,400**	**5.95**
10/8/1973	33.0	33.0	10.0	12	12	0	1	**23.0**	**3.0**	**0.0**	**0.0**	**3.0**	**129,600**	**129,600**	**5.95**
10/9/1973	21.0	21.0	10.0	12	12	0	1	**11.0**	**3.0**	**0.0**	**0.0**	**3.0**	**129,600**	**129,600**	**5.95**

10/1/73 – flow of 7.6 cfs – must bypass 10 cfs when tide =<2’ so only pump when tide >2’. Tide >2’ for 18 hours so 7.6 * 3600 (seconds/hour) * 18 = 194,400 CF or 4.46 AF

10/8/73 – flow of 33 cfs – must bypass 10 cfs when tide =<2’ but still have 23 cfs available when tide >2’. Tide <2’ for 12 hours. Can only pump 3 cfs max, so 3 * 3600 (seconds/hour) * 12 = 129,600 CF. Will also pump 3 cfs for 12 hours that tide is >=2’ so another 129,600 CF. The sum is 259,200 CF, or 5.95 AF, which is our current daily maximum.

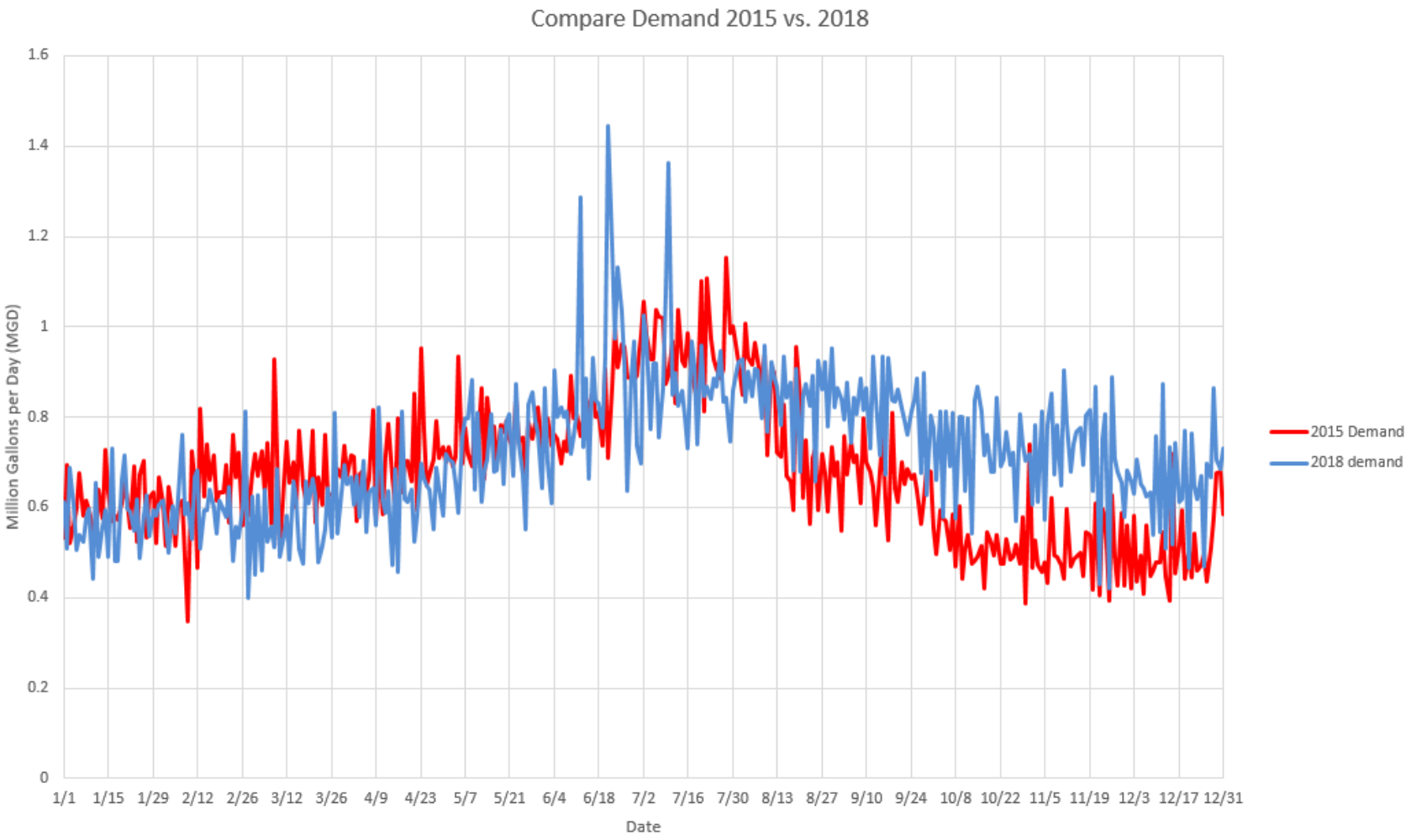
Historic Noyo flow and daily intake calculations - Summer

DAY	NOYO FLOW		AMOUNT TO LEAVE IN NOYO	TIDES (TIME >2')	TIDES (TIME >5')	TIDES (TIME >6.7')	CHECK IF NOYO PUMPING POSSIBLE BASED ON QUALITY								NOYO RESTRICTED BY TIDES
Period for model is water years 1974 - 2013; this period encompasses most recent drought periods	From USGS 11468500 Noyo R. Near Fort Bragg; flow reduced at choice of user (column G) **Yellow is revised per USGS, the following BOLD data was added**			Tide data from CeNCOOS, Fort Bragg Landing Station; hours/day tides >2' estimated from tide data	Tide data from CeNCOOS, Fort Bragg Landing Station; hours/day tides >5' estimated from tide data	Tide data from CeNCOOS, Fort Bragg Landing Station; hours/day tides >6.7' estimated from tide data	If tide is >5' at any time during the day and flow is < 1 OR if tide >6.7' and flow is < 2.5 cfs, then Noyo offline (0 = offline, 1 = ok to pump)	Manage flows in winter with bypass, Tide <2' 10 cfs bypass required	Constrain to max 3 CFS	Manage flows in summer with bypass, Tide <2' - 3 cfs bypass required	Constrain to max 3 CFS	Flow rate when tide ≤2' (sum of previous 2 constrained)	Total available flow during tide ≤2'	Total available flow when tide >2'	Total Noyo flow for 24 hour period (sum of below and above 2' tide in AF) MAX 5.95
	CFS	CFS	CFS	HRS	HRS	HRS	0=King Tide	CFS	CFS	CFS	CFS	CFS	CF	CF	AF
9/8/1977	0.8	0.8	3.0	18	6	0	0	0.0	0.0	0.0	0.0	0.0	0	0	0.00
9/9/1977	1.5	1.5	3.0	18	6	0	1	0.0	0.0	0.0	0.0	0.0	0	97,200	2.23
9/10/1977	0.8	0.8	3.0	18	6	0	0	0.0	0.0	0.0	0.0	0.0	0	0	0.00
9/11/1977	1.3	1.3	3.0	12	12	0	1	0.0	0.0	0.0	0.0	0.0	0	56,160	1.29
9/12/1977	0.9	0.9	3.0	12	12	0	0	0.0	0.0	0.0	0.0	0.0	0	0	0.00
9/13/1977	1.0	1.0	3.0	8	8	0	1	0.0	0.0	0.0	0.0	0.0	0	28,800	0.66
9/14/1977	1.5	1.5	3.0	12	12	0	1	0.0	0.0	0.0	0.0	0.0	0	64,800	1.49
9/15/1977	1.3	1.3	3.0	12	12	0	1	0.0	0.0	0.0	0.0	0.0	0	56,160	1.29
9/16/1977	2.0	2.0	3.0	12	12	0	1	0.0	0.0	0.0	0.0	0.0	0	86,400	1.98
9/17/1977	2.8	2.8	3.0	12	6	0	1	0.0	0.0	0.0	0.0	0.0	0	120,960	2.78
9/18/1977	4.5	4.5	3.0	18	6	0	1	0.0	0.0	1.5	1.5	1.5	32,400	194,400	5.21
9/19/1977	19.0	19.0	3.0	18	6	0	1	0.0	0.0	16.0	3.0	3.0	64,800	194,400	5.95
9/20/1977	17.0	17.0	3.0	24	8	0	1	0.0	0.0	14.0	3.0	3.0	0	259,200	5.95

9/8/77 – flow of 0.8 cfs – but have King Tide (Tide>6.7', flow<3cfs) so the model neglects the entire day.

19/11/77 – flow of 1.3 cfs – must bypass 3 cfs when tide =<2' so only pump when tide >2'. Tide >2' for 12 hours so 1.3 * 3600 (seconds/hour) * 12 = 56,160 CF or 1.29 AF

9/18/77 – flow of 4.5 cfs – must bypass 3 cfs when tide =<2' but still have 1.5 cfs available when tide <=2'. Tide <=2' for 6 hours so 1.5 * 3600 (seconds/hour) * 6 = 32,400 CF. Will also pump 3 cfs for 18 hours that tide is >=2' so another 194,400 CF. The sum is 226,800 CF, or 5.21 AF.


Compare Demand 2015 vs. 2018
Million Gallons per Day (MGD)
1.6
1.4
1.2
1
0.8
0.6
0.4
0.2
0
1/1 1/15 1/29 2/12 2/26 3/12 3/26 4/9 4/23 5/7 5/21 6/4 6/18 7/2 7/16 7/30 8/13 8/27 9/10 9/24 10/8 10/22 11/5 11/19 12/3 12/17 12/31
Date
2015 Demand
2018 demand

Example run with Summers Lane Reservoir

Calcs Tab

Day	Beginning Volume	City Demand	Newman	REVISED NEWMAN	REVISED WATERFALL	REVISED NOYO	Summers Withdrawl (if used)	FINAL ENDING VOLUME	Daily Flow	Ending Volume	Ending Volume	Water Alert?	Sum of inflows	Water Alert criteria
	(AF)	(AF/DAY)	(AF/DAY)	AF/DAY	(AF/DAY)	(AF/DAY)	(AF/DAY)	(AF/DAY)	AF/DAY		(AF)		(AF)	(AF)
	From end of previous day	From Data sheet - converted to af/day - multiplied by growth factor if used	From Data sheet, converted to af/day, reduced by User Input %	NOT TO EXCEED FLOW OF 0.99 AF/DAY	From Data sheet, converted to af/day - reduced by chosen %, less amount to remain	From Data sheet Diane Calc (Max 5.95 AF)	Amount to be drawn from reservoir if needed (when used)	Final Ending Volume	daily inflow less demand	Beginning volume - city + total inflow - NO RESERVOIR	Beginning volume - city + total inflow - WHEN USING RESERVOIR	Water Alert 1=yes , 0 if not	Sum of Waterfall+ Noyo+Newman Max 8.265 AF	Water Alert Criteria (90% of inflow)
7/31/2015	64.6	3.0	1.8	0.990	0.56	3.21	0.00	64.6	1.80	0.0	64.6	0.0	4.75	4.3
8/1/2015	64.6	2.8	1.4	0.990	0.55	3.15	0.00	64.6	1.86	0.0	64.6	0.0	4.70	4.2
8/2/2015	64.6	2.6	1.4	0.990	0.55	1.91	0.00	64.6	0.84	0.0	64.6	0.0	3.45	3.1
8/3/2015	64.6	3.1	1.4	0.990	0.55	2.07	0.00	64.6	0.52	0.0	64.6	0.0	3.61	3.2
8/4/2015	64.6	2.9	1.4	0.990	0.55	2.13	0.00	64.6	0.82	0.0	64.6	0.0	3.67	3.3
8/5/2015	64.6	2.8	1.4	0.990	0.55	0.00	1.27	63.3	-1.27	0.0	63.3	1.0	1.54	1.4
8/6/2015	63.3	3.0	1.4	0.990	0.55	0.00	1.42	61.9	-1.42	0.0	61.9	1.0	1.54	1.4
8/7/2015	61.9	2.8	1.4	0.990	0.55	0.00	1.30	60.6	-1.30	0.0	60.6	1.0	1.54	1.4
8/8/2015	60.6	2.7	1.4	0.990	0.55	0.00	1.13	59.5	-1.13	0.0	59.5	1.0	1.54	1.4
8/9/2015	59.5	2.9	1.4	0.990	0.55	3.19	0.00	61.3	1.84	0.0	61.3	0.0	4.73	4.3
8/10/2015	61.3	2.2	1.4	0.990	0.55	3.12	0.00	63.8	2.47	0.0	63.8	0.0	4.66	4.2

Data Tab

DAY	NOYO FLOW	AMOUNT TO LEAVE IN NOYO	TIDES (TIME >2')	TIDES (TIME >5')	TIDES (TIME >6.7')	CHECK IF NOYO PUMPING POSSIBLE BASED ON QUALITY								NOYO RESTRICTED BY TIDES
Period for model is water years 1974 - 2013; this period encompasses most recent drought periods	From USGS 11468500 Noyo R. Near Fort Bragg; flow reduced at choice of user (column G) **Yellow is revised per USGS, the following BOLD data was added**		Tide data from CeNCOOS, Fort Bragg Landing Station; hours/day tides >2' estimated from tide data	Tide data from CeNCOOS, Fort Bragg Landing Station; hours/day tides >5' estimated from tide data	Tide data from CeNCOOS, Fort Bragg Landing Station; hours/day tides >6.7' estimated from tide data	If tide is >5' at any time during the day and flow is < 1 OR if tide >6.7' and flow is < 2.5 cfs, then Noyo offline (0 = offline, 1 = ok to pump)	Manage flows in winter with bypass, Tide <2' 10 cfs bypass required	Constrain to max 3 CFS	Manage flows in summer with bypass, Tide <2' - 3 cfs bypass required	Constrain to max 3 CFS	Flow rate when tide ≤2' (sum of previous 2 constrained)	Total available flow during tide ≤2'	Total available flow when tide >2'	Total Noyo flow for 24 hour period (sum of below and above 2' tide in AF) MAX 5.95
	CFS	CFS	CFS	HRS	HRS	HRS	0=King Tide	CFS	CFS	CFS	CFS	CFS	CF	CF	AF
7/31/2015	2.14	2.1	3.0	18.1	12.5	0.0	1	0.0	0.0	0.0	0.0	0.0	0	139,699	3.21
8/1/2015	2.06	2.1	3.0	18.5	6.9	0.0	1	0.0	0.0	0.0	0.0	0.0	0	137,320	3.15
8/2/2015	1.99	2.0	3.0	11.6	11.6	0.0	1	0.0	0.0	0.0	0.0	0.0	0	82,983	1.91
8/3/2015	1.99	2.0	3.0	12.6	12.6	0.0	1	0.0	0.0	0.0	0.0	0.0	0	90,028	2.07
8/4/2015	2.05	2.1	3.0	12.5	12.5	0.0	1	0.0	0.0	0.0	0.0	0.0	0	92,619	2.13
8/5/2015	2.15	2.2	3.0	12.5	12.5	6.2	0	0.0	0.0	0.0	0.0	0.0	0	0	0.00
8/6/2015	2.15	2.2	3.0	12.5	12.5	6.1	0	0.0	0.0	0.0	0.0	0.0	0	0	0.00
8/7/2015	2.19	2.2	3.0	6.0	6.0	6.0	0	0.0	0.0	0.0	0.0	0.0	0	0	0.00
8/8/2015	2.26	2.3	3.0	17.7	12.5	5.9	0	0.0	0.0	0.0	0.0	0.0	0	0	0.00
8/9/2015	2.19	2.2	3.0	17.6	12.5	0.0	1	0.0	0.0	0.0	0.0	0.0	0	138,890	3.19
8/10/2015	2.15	2.2	3.0	17.6	5.8	0.0	1	0.0	0.0	0.0	0.0	0.0	0	135,966	3.12

Ground truth - Fall of 2015 without Summers Lane, 100% of Waterfall Gulch

Storage without Summers Lane is 20.25 AF. An 11% drawdown equates to a volume of 18.0 AF.

We hit the Stage 1 criteria on 8/7 with a low of 17.9 AF. Storage is full again from 8/11-8/22. We hit another low of 19.2 AF on 8/25. Storage is full again from 8/26-9/2. A low of 17.9 AF is encountered on 9/7. Storage is full again 9/9-9/21. A low of 18.9 is encountered on 9/24. Storage is full again 9/25-9/30. A low of 18.0 is encountered on 10/6. Storage is full again 10/8-10/18. A low of 19.1 is encountered on 10/23. Storage is full again on 10/24.

If the model was set up to determine the Stage 1 automatically, it would have counted 6 days at Stage 1. If the City declared Stage 1 on the first day we hit the 18 AF (8/7), and continue until there were no more days below 18 AF for the year (10/7), Stage 1 would have been declared for 61 days (from 8/7-10/6)

The City declared a Stage 1 water emergency at City Council on 8/10/2015. Stage 3 was declared at City Council on 9/30. On 10/26 Council issued the non-emergency water conservation ordinance. On 11/9 City Council resolution confirmed the continued existence of a local drought emergency. On 11/23 the Stage 3 was lowered to a Stage 1 or Stage 2. The Water Workshop was held on 1/5/2016. On 1/25 a new water conservation ordinance was passed, and we reconfirmed a drought emergency monthly throughout 2016.