APPENDIX B – Yield Modelling

CONJUNCTIVE USE AND WATER TRANSFERS – PHASE II (TASK 6)

Proposition 84

Department of Water Resources

Integrated Regional Water Management Planning Grant

Northern Santa Cruz County Integrated Regional Water Management

Agreement No. 4600009400

May 2015

Prepared by:

Santa Cruz County Environmental Health Services

Submitted to:

Regional Water Management Foundation

Department of Water Resources

Appendix B – Yield Modeling

- Fiske, Water Transfer Project: Long-Term Analysis Scenario 1 (June 1, 2012)
- Fiske, Phase 2 Water Transfer Project Draft Task 2 Technical Memorandum: Utilization of Tait Street Capacity (June 11, 2012)
- Fiske, Phase 2 Water Transfer Project Draft Task 3 Technical memorandum: Potential Transfers with Unlimited Tait Street Capacity (June 20, 2013)
- Fiske, Water Transfer Project: Long-Term Analysis Scenario 2 (Revised) (June 22, 2012)
- Fiske, Water Transfer Project: Long-Term Analysis Scenarios 3 and 4 (June 25, 2012)
- Fiske, Water Transfer Project: Long-Term Analysis Scenario 5: GHWTP Improvements (July 2, 2012)
- Fiske, Final Water Transfer Project Results Summary (July 6, 2012)
- Fiske, Phase 2 Water Transfer Analysis: Task 1 Results (Second Revision) (May 22, 2013)
- Fiske, February 12, 2014, Volumetric Shortage Analysis for Water Transfer Project
- Akel Engineering Group, February 19, 2014, City of Santa Cruz Water Department and Soquel creek Water District Intertie Capacity Analysis

GARY FISKE AND ASSOCIATES, INC.
Water Resources Planning and Management

Date: June 1, 2012
From: Gary Fiske
To: Linette Almond, John Ricker
Re: Water Transfer Project: Long-Term Analysis Scenario 1

This memo reports the results of the first of 4 scenarios to be analyzed as part of Task 2, the long-term analysis. Scenario 1 assumes current infrastructure[1] and water rights. The remaining scenarios look at various water rights and infrastructure changes.

The long-term analysis examines how much of the existing demands of the Scotts Valley, San Lorenzo Valley, and Soquel Creek Water Districts in the off-peak months (November-April) will be able to be met by surplus Santa Cruz supply in the year 2030. As in the short-term analysis, water will be transferred only on days when Santa Cruz Water Department demands are fully met. The transfers will be of volumes that can be diverted from the San Lorenzo River at the Tait Street diversion on such days.

Assumptions

Other than the assumption of unlimited treatment capacity at Graham Hill, all supply, demand, facility, and operational parameters for the City of Santa Cruz system are consistent with those used in the recent Integrated Water Plan update. Available flows are assumed to be Tier 3, as developed in the ongoing HCP negotiation process.

The intertie capacities between Santa Cruz and the other districts are assumed to be unlimited.

Monthly demands for each of the three agencies are assumed to be the five-year average of 2006-07 through 2010-11 well production.[2] The San Lorenzo Valley demands are combined with those of Scotts Valley. Throughout the remainder of this memo, these combined demands are referred to as "Scotts Valley." The demands are shown in Table 1.

Scotts Valley demands are served first. On any day, Soquel Creek Service Area 1 demand is only served if there is surplus supply after serving all of that day's Scotts Valley demand.

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[1] As discussed below, the exceptions to this are the Graham Hill Water Treatment Plant and the Soquel Creek intertie, both of which are assumed to not be capacity-limited.

[2] For Soquel Creek, these are the wells serving Service Area 1.The Soquel Creek and San Lorenzo Valley averages for the months of November-February also include actual well production for 2011-12. For Scotts Valley, the November-January averages include 2011-12.

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Table 1. Assumed Monthly Demands (millions of gallons)

Month	Scotts Valley	Soquel Creek (SA1)
November	42.8	39.6
December	38.7	36.1
January	37.2	35.6
February	33.8	32.2
March	40.3	37.4
April	48.3	41.9
TOTAL	**241.1**	**222.7**

Averages and Distributions of Water Transfer Volumes

Table 2 shows the 2030 monthly average Scotts Valley and Soquel Creek transfers across all hydrologic years.

Table 2. 2030 Monthly Average Transfers Across All Hydrologic Years (millions of gallons)

Month	Scotts Valley Transfer Volume	Soquel Creek Transfer Volume	Total Transfer Volume
November	21.4	6.0	27.4
December	11.9	5.5	17.4
January	14.0	8.5	22.5
February	15.9	10.6	26.5
March	23.6	15.0	38.6
April	25.0	10.0	35.0
TOTAL	**111.8**	**55.6**	**167.4**

Figure 1 shows the duration curves for the annual transfers.

Table 3 shows the average transfers for each hydrologic year type, and Figures 2-5 show the transfer duration curves for each year type.

Figure 1

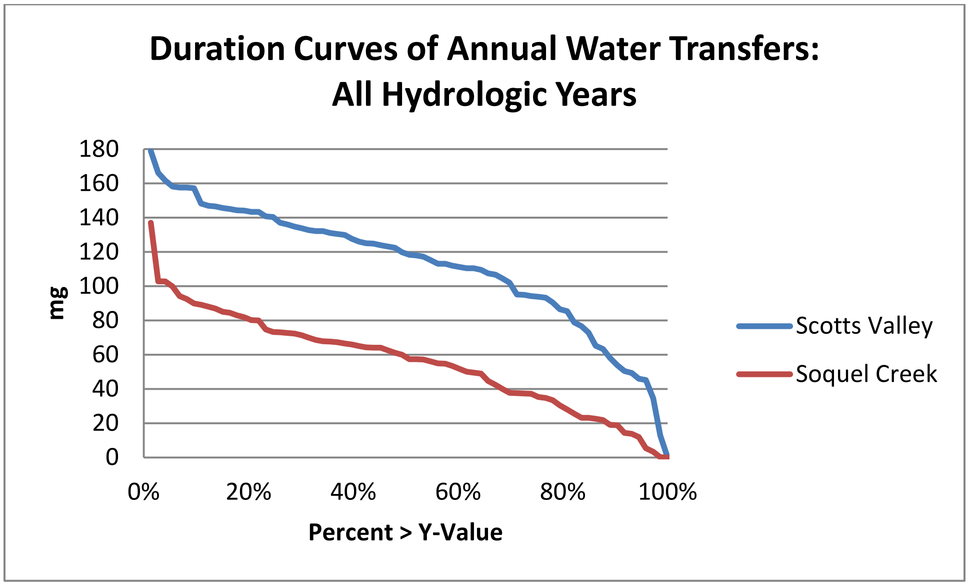


Table 3. 2030 Annual Average Transfers by Hydrologic Year Type (mg)

Year Type	Scotts Valley	Soquel Creek	Total
Critically Dry	74.5	30.7	105.2
Dry	87.7	31.4	119.1
Normal	127.9	58.2	186.1
Wet	125.3	76.7	202.0
Average	**111.8**	**55.6**	**167.4**

Figure 2

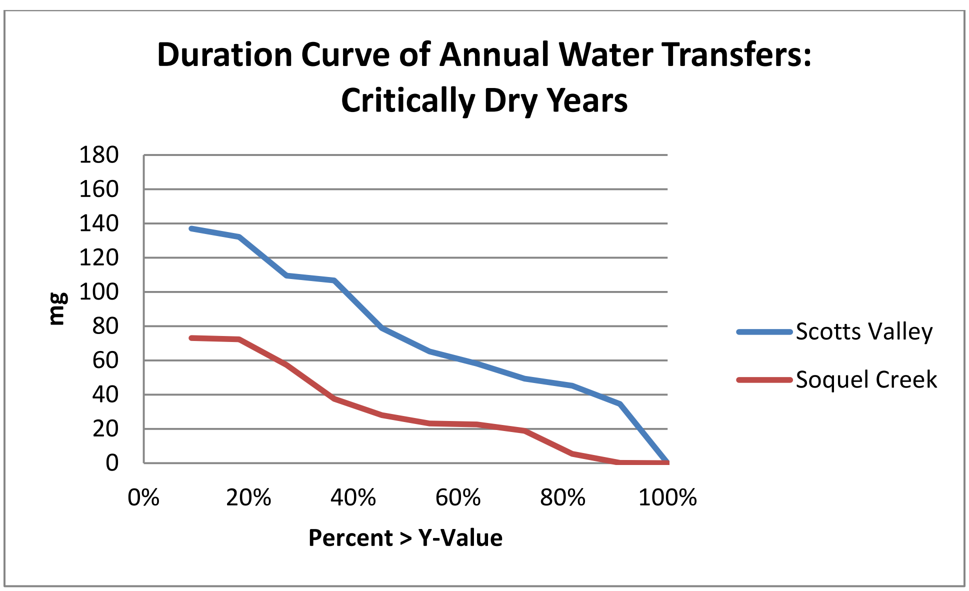


Figure 3

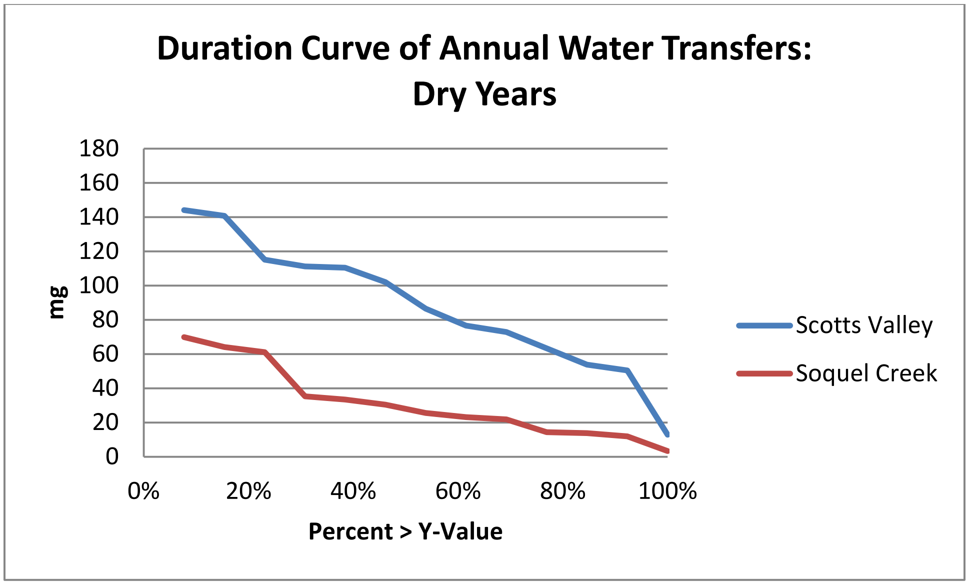


Figure 4

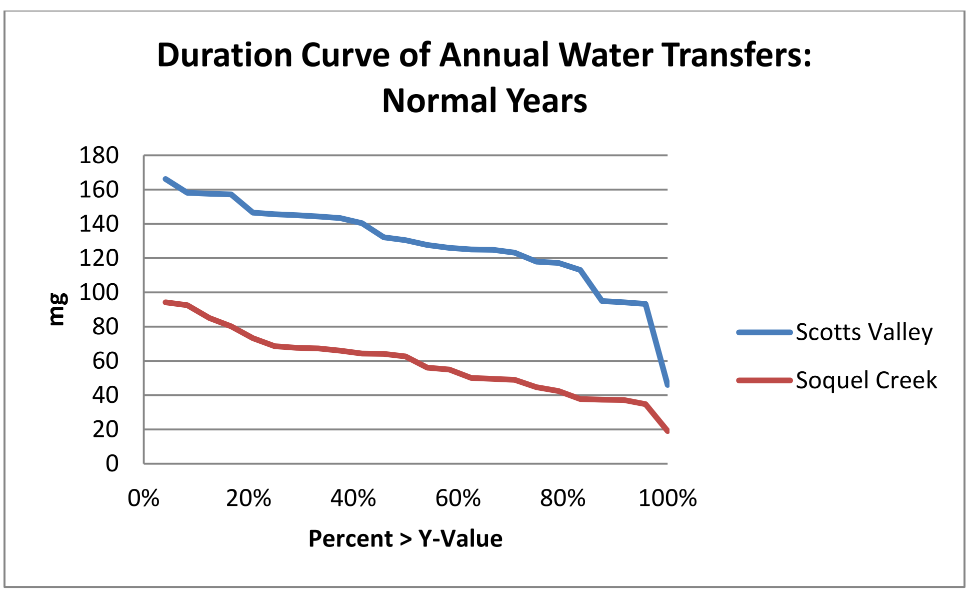
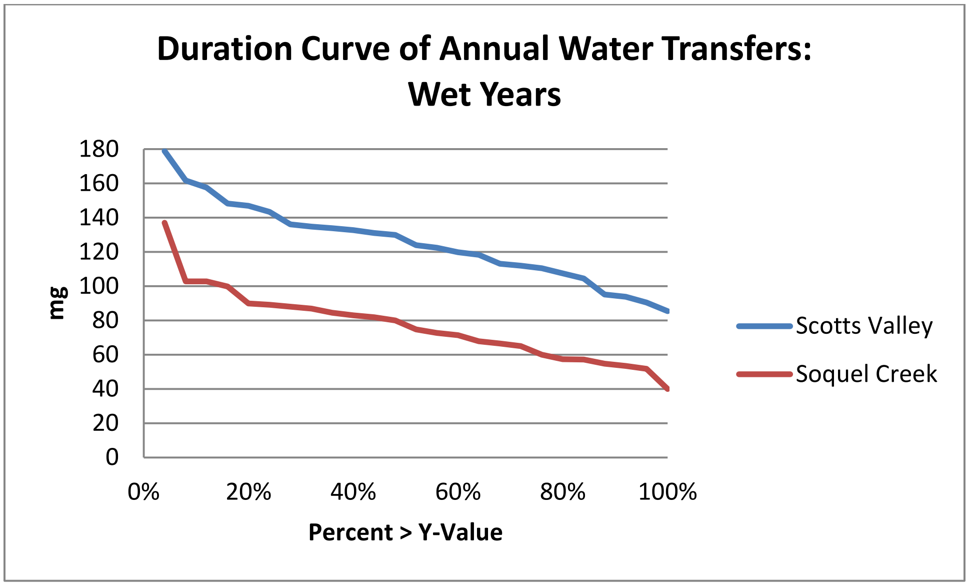


Figure 5



Source Production

Table 4 shows the monthly average added production at Tait Street required to serve Scotts Valley and Soquel Creek demands.[3]

Table 4. 2030 Monthly Average Added Production at Tait Street to Serve Scotts Valley and Soquel Creek (millions of gallons)

Month	Base	With Transfers	Added Tait St. Production
November	140.8	164.6	23.8
December	127.3	144.7	17.4
January	126.4	149.0	22.5
February	106.7	133.2	26.5
March	121.0	159.6	38.6
April	152.4	187.1	34.7
TOTAL	**774.7**	**938.2**	**163.6**

[3] As explained in the April 26 memo, the slight differences between the added Tait St production of this table and the transfer volumes of Table 2**Error! Reference source not found.** are due to local storage fill.

Surplus Supply

Given these production levels, how much surplus supply is there available at Tait Street to potentially meet other external demands? For our purposes, surplus supply on any day is defined as:

> *The excess of the maximum potential Tait Street diversion over the volume that has already been diverted to meet Santa Cruz, Scotts Valley, and Soquel Creek demands. The maximum potential diversion is the minimum of the available flow at Tait Street and the capacity of the Tait Street diversion (11.52 cfs). On days when there are no turbidity constraints at Tait St., the available flow at Tait Street is the Tier 3 Big Trees flow less the diversion at Felton plus the Tier 3 tributary inflows between Felton and Tait Street. On days when Tait St. is shut down due to turbidity, the Tait St. available flow is zero.*

Based on this definition, Table 5 shows the expected November-April surplus supply.

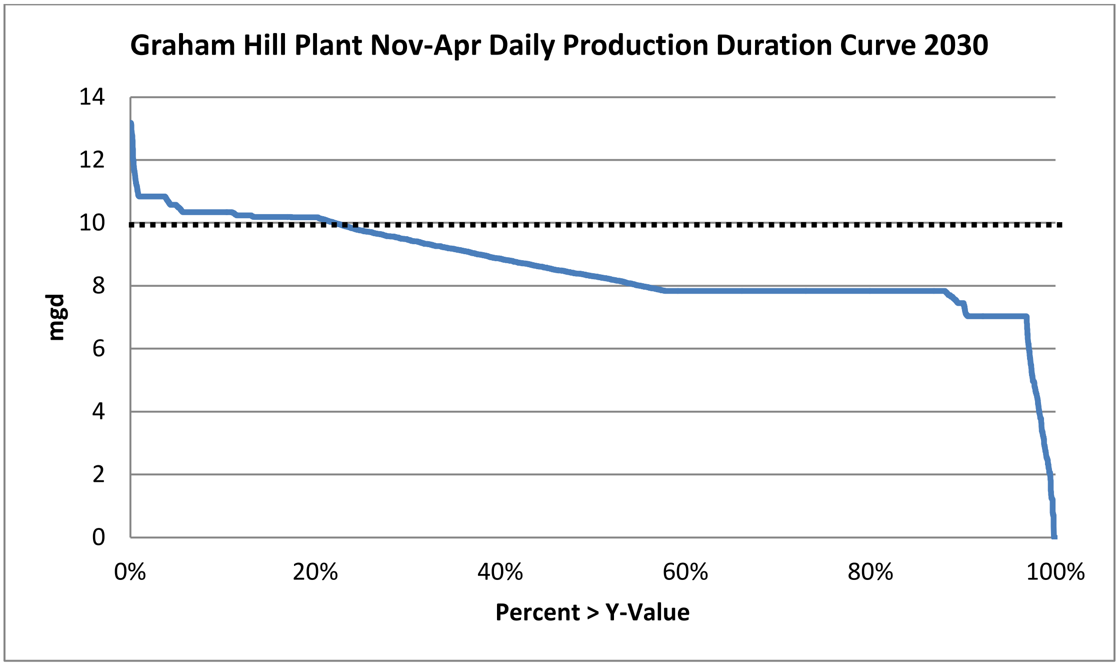
Table 5. Expected 2030 November-April Surplus Supply at Tait Street (millions of gallons)

Year Type	Surplus Supply
Critically Dry	14
Dry	18
Normal	44
Wet	83
Average	**48**

Treatment Plant Capacity Requirements

Figure 6 shows the duration curve of the Graham Hill treatment plant production required to accomplish the transfers depicted in the tables and charts above.

Figure 6



The chart shows that treatment plant usage exceeds the current 10 mgd capacity on approximately 20% of days. The key question is the extent to which the total 167 mg average annual transfer shown in Table 2 is reduced due to this constraint. It turns out that the expected annual transfer is reduced by about 9% to 151 mg. Put another way, an investment in treatment plant expansion would, at most, result in added annual transfers of about 16 million gallons.

Transmission Capacity Requirements

Figure 7 shows the duration curve for the transmission loadings to move water from the treatment plant to yield the combined transfer volumes discussed above. Figure 8 shows the duration curve for the transmission loadings to Scotts Valley, while Figure 9 shows the loadings to Soquel Creek.[4]

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[4] The duration curve in Figure 7 is less than the sum of the two district-specific curves due to the non-coincidence of the daily demands.

Figure 7

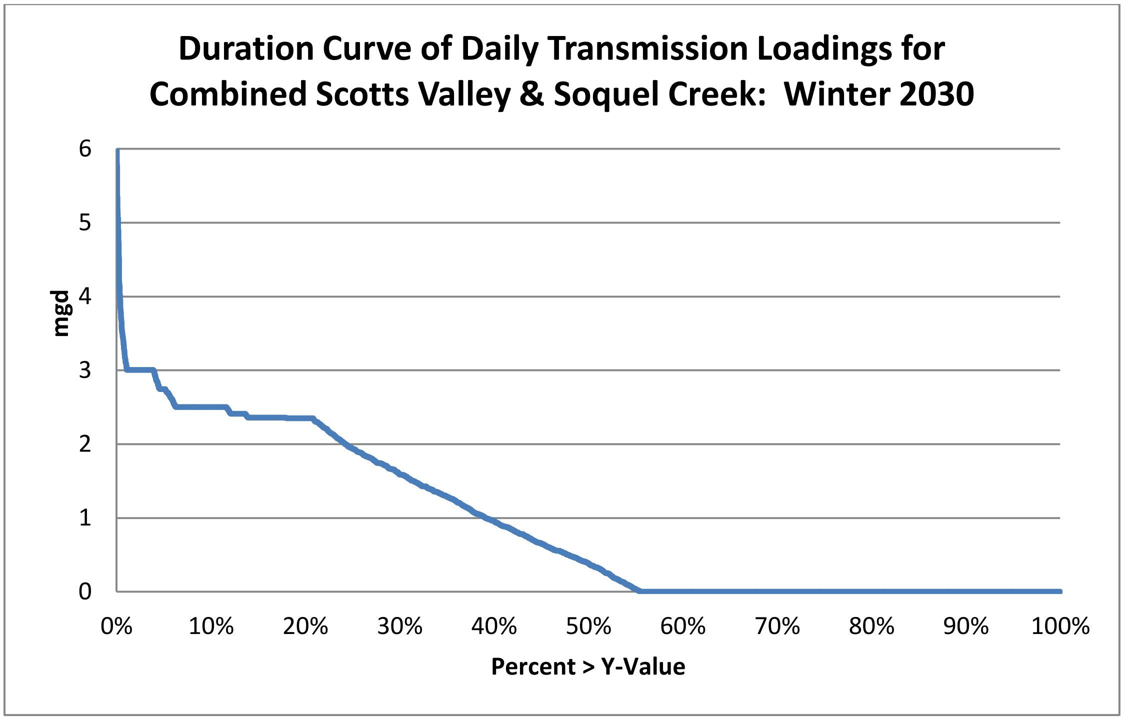


Figure 8

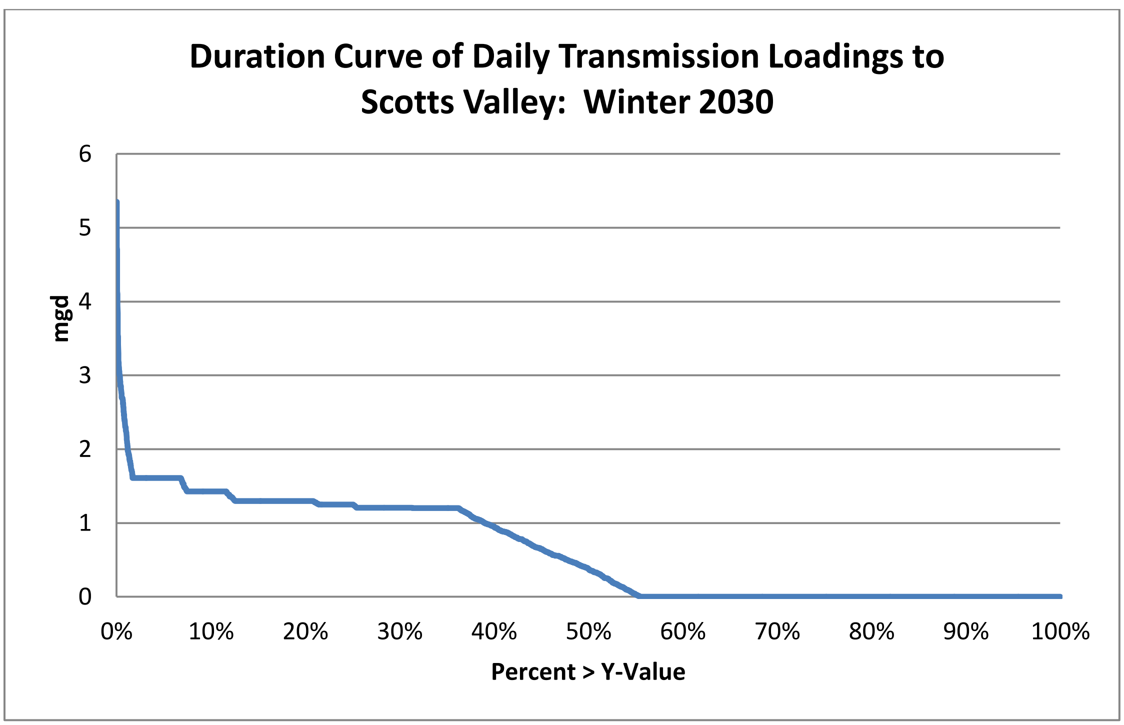
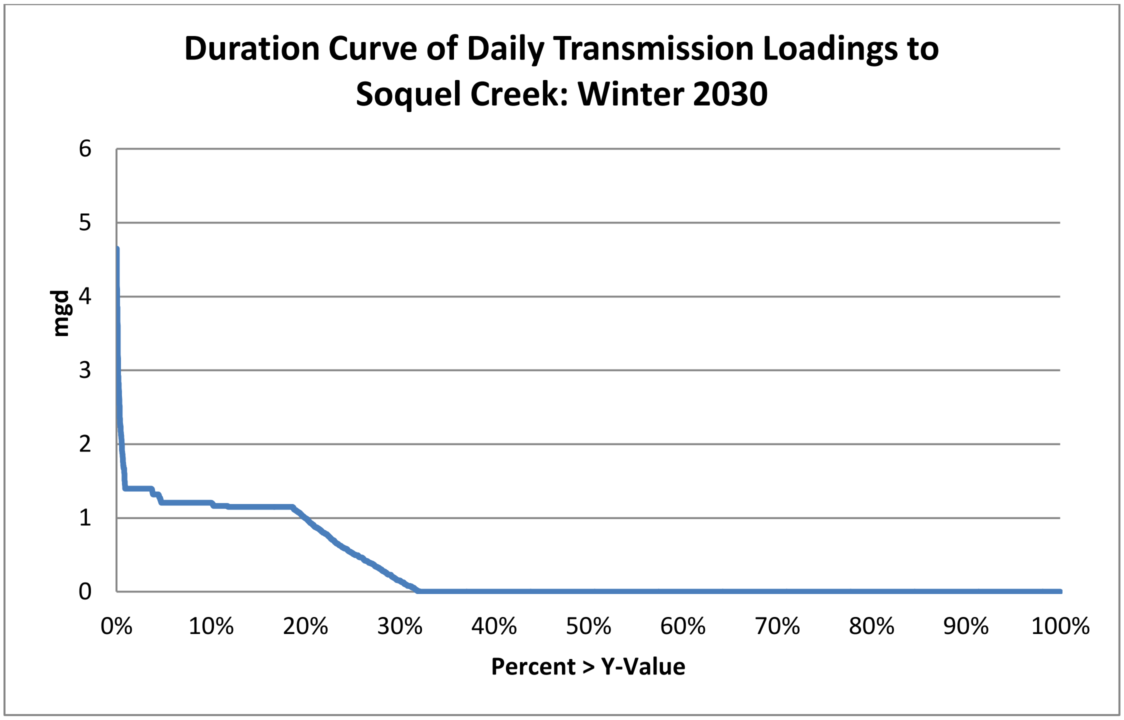


Figure 9


Duration Curve of Daily Transmission Loadings to Soquel Creek: Winter 2030
mgd
6
5
4
3
2
1
0
0%
10%
20%
30%
40%
50%
60%
70%
80%
90%
100%
Percent > Y-Value

GARY FISKE AND ASSOCIATES, INC.
Water Resources Planning and Management

Date: June 11, 2013
From: Gary Fiske
To: Linette Almond, John Ricker
Re: Phase 2 Water Transfer Project Draft Task 2 Technical Memorandum: Utilization of Tait Street Capacity

This memorandum reports on the results of the Task 2 analysis. Task 2 breaks down the utilization of the current 7.44 mgd Tait Street diversion into off-peak season production to serve Santa Cruz Water Department demands and to serve district transfers. The results that follow are all based on Scenario 1a (current infrastructure and water rights) and Tier 3 available flows.

Tait Street Production: All Hydrologic Years

Figures 1-5 show duration curves of daily Tait St. production in the off-peak months (November-April) over all years of the 73-year hydrologic record. Each figure shows the distribution of daily production required to serve the different demands as follows:

- Figure 1: Santa Cruz Water Department (SCWD) only
- Figure 2: SCWD demand plus both districts
- Figure 3: Both districts only
- Figure 4: Scotts Valley only
- Figure 5: Soquel Creek only

Note that the curves are not additive because of non-coincidence.

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Figure 1

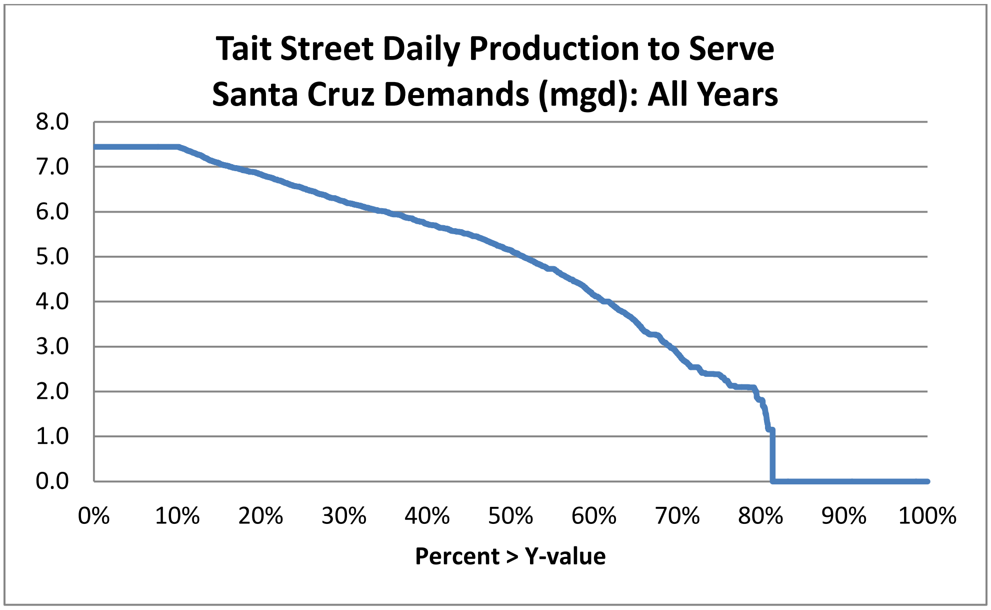


Figure 2

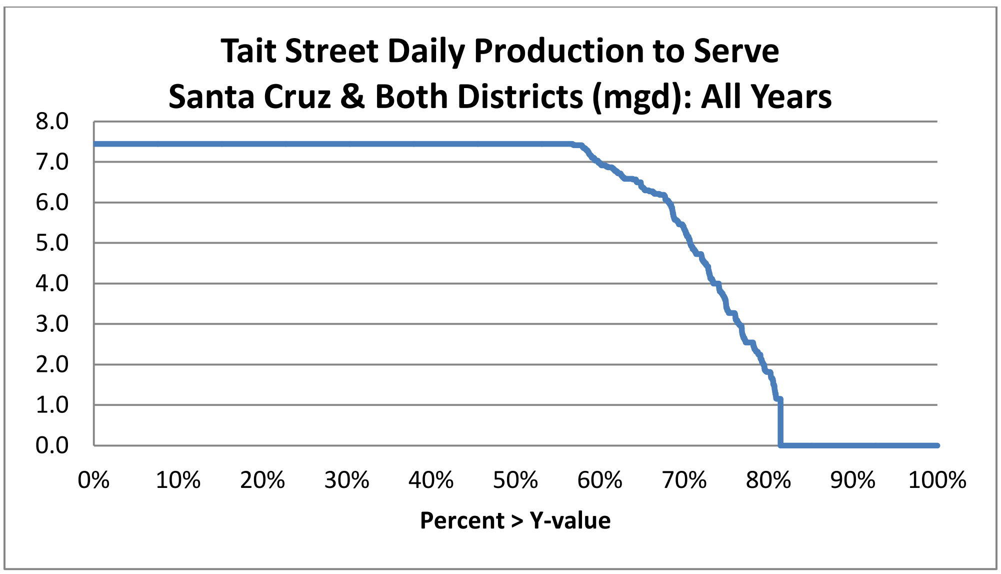


Figure 3

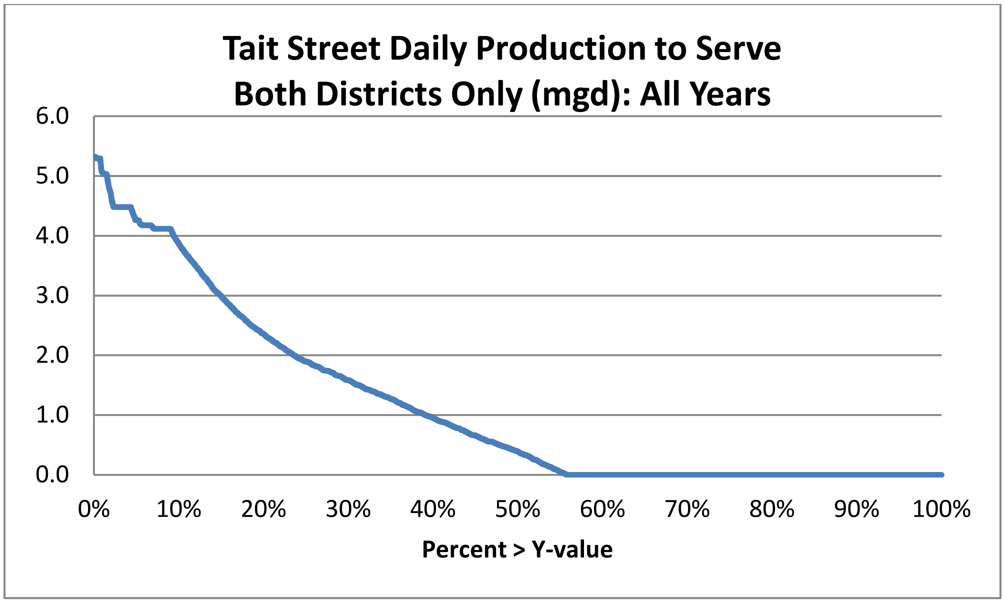


Figure 4

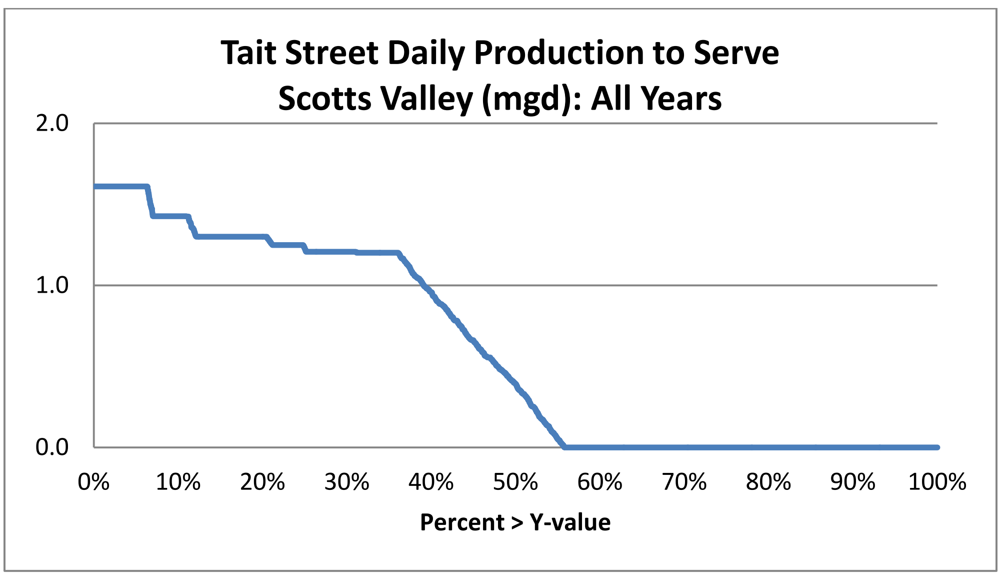
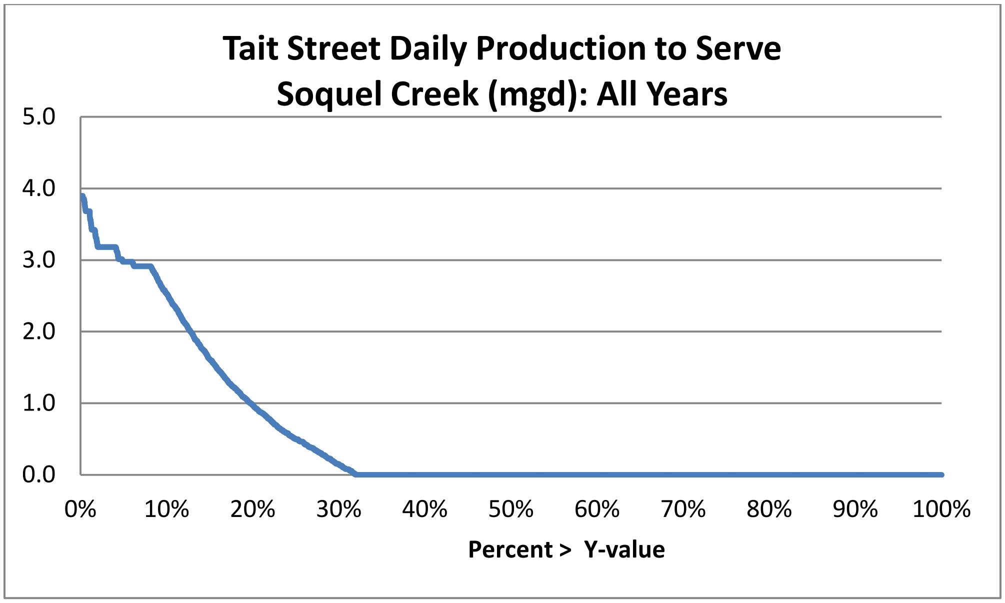


Figure 5



One thing that stands out from the above charts is that, while Tait Street operates at full capacity on only about 10% of the winter days if only Santa Cruz demand must be served, that figure shoots up to 57% if water is also being transferred to the districts. This suggests that transfers are constrained by the current Tait capacity and could be increased if that capacity was increased. This issue will be explicitly addressed in Task 3.

In addition, with current Tait capacity, no Scotts Valley demand is served on 45% of days; for Soquel Creek, that figure rises to 68%.

Tait Street Production by Year Type

This section presents charts that compare the distributions of off-peak season Tait daily production for each of the four hydrologic year types.

Figure 6

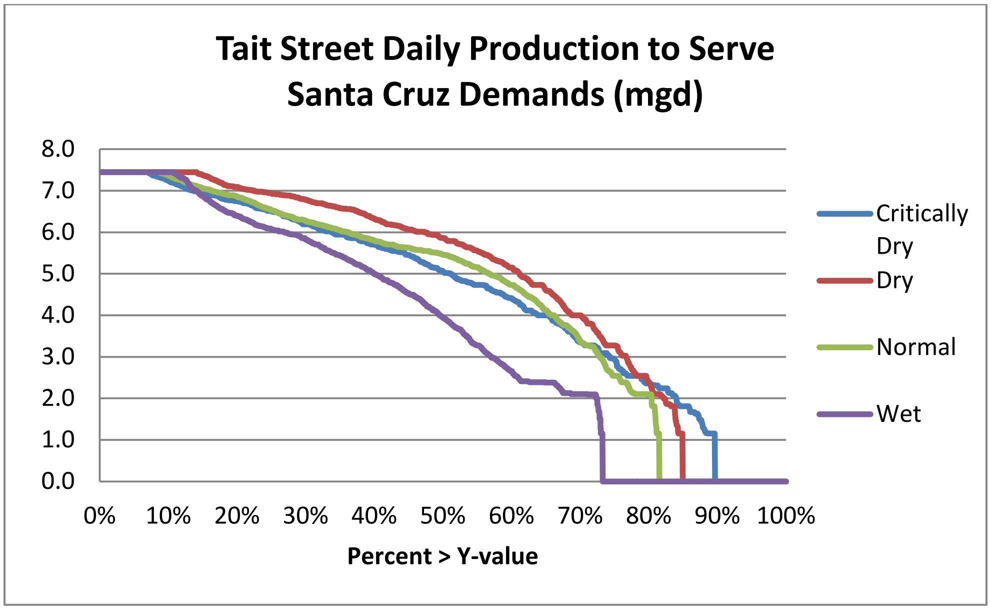


Figure 7

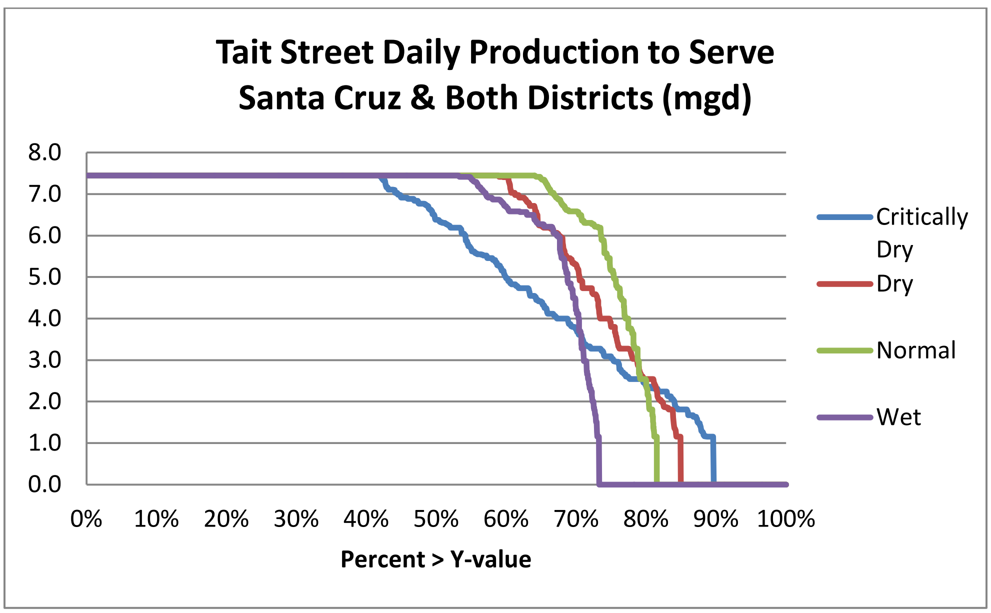


Figure 8

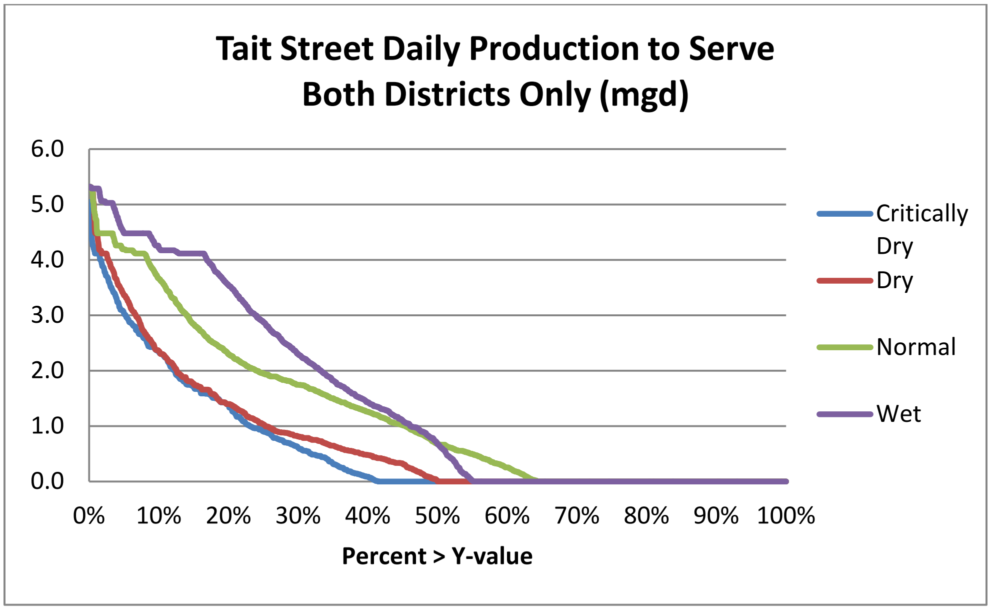


Figure 9

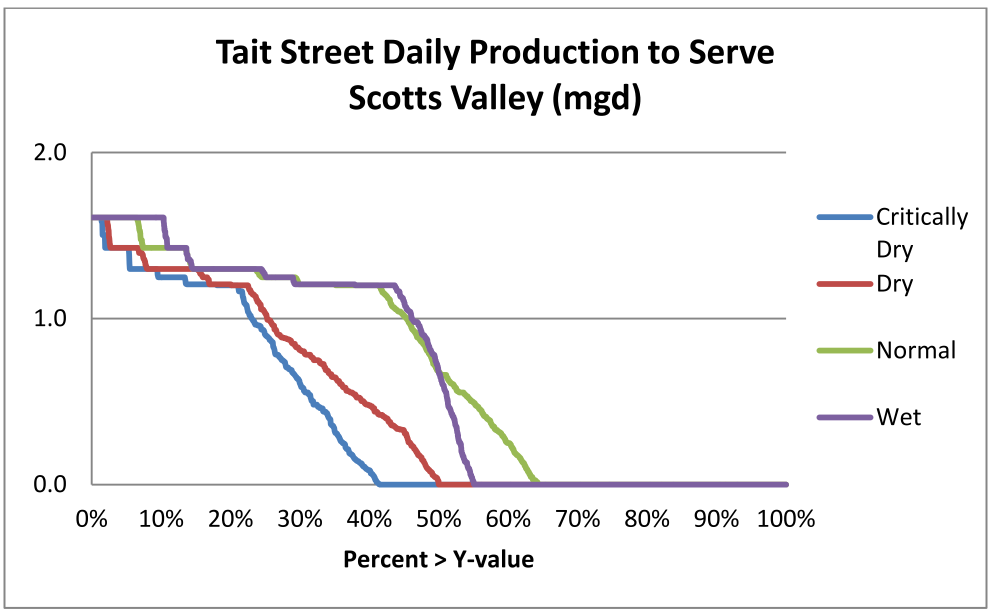
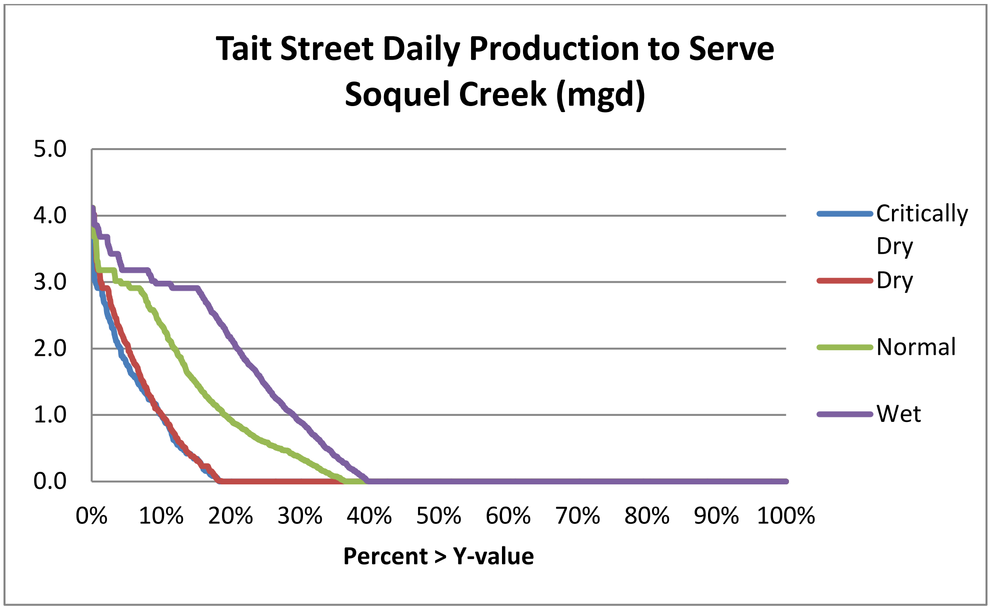


Figure 10



The patterns are similar to what we see in Figures 1-5. It is, however, interesting to compare the year-type distributions as we move from serving only Santa Cruz demands (Figure 6) through the other figures. When only Santa Cruz demands are being served, Tait production is smallest in wet years because more demand is met from the North Coast supplies. As the charts incorporate district demands, which can only be served from Tait, the relative position of the curves moves more toward replicating the San Lorenzo River availability in the four year types. Thus, Figure 10 shows that Soquel Creek is best served in wet years and receives the least supply in dry and critically-dry years (in 80% of those years, Soquel Creek receives no supply).

These relationships are also illustrated in Table 1, which compares the average off-peak season Tait production to serve different demands across the year types.

Table 1. Average Off-Peak Season Tait Street Production (mg)

DEMAND SERVED	HYDROLOGIC YEAR TYPE				
	Critically Dry	Dry	Normal	Wet	All
Santa Cruz Only	823	879	812	663	**775**
Santa Cruz & Both Districts	936	1010	1033	930	**979**
Both Districts Only	112	131	221	267	**204**
Scotts Valley	70	84	125	121	**108**
Soquel Creek	41	46	95	144	**95**

GARY FISKE AND ASSOCIATES, INC.
Water Resources Planning and Management

Date: June 20, 2013
From: Gary Fiske
To: Linette Almond, John Ricker
Re: Phase 2 Water Transfer Project Draft Task 3 Technical Memorandum: Potential Transfers with Unlimited Tait Street Capacity

This memorandum reports on the results of the Task 3 analysis. Recall that Task 2 broke down the utilization of the current 7.45 mgd Tait Street diversion into production to serve Santa Cruz Water Department demands and to serve district transfers. Task 3 extends that analysis by relaxing the Tait Street capacity constraint, and examining the off-peak-season volumes that could be transferred to Scotts Valley and Soquel Creek if the capacity of the Tait Street diversion was unlimited.

This task addresses the following questions:

- If Tait Street capacity were not limited to the current level, what is the distribution of daily Tait Street production in the off-peak months (November-April) to serve Santa Cruz demands and to serve the demands of each of the two districts?

- How do these distributions differ for the four year-type categories?

- How much would the Tait Street capacity have to increase to serve the maximum possible portion of off-peak season demands of the two districts?

Note that it is assumed that, as Tait Street capacity is increased, so also are the water rights and the transmission capacity between Tait Street and the treatment plant. In addition, the current assumed 10 mgd off-peak capacity of the Graham Hill plant would also have to increase. (The final section of this memo shows the distribution of required daily treatment plant production.)

As was the case for Task 2, the results that follow all assume Tier 3 available flows.

Tait Street Production: All Hydrologic Years

Figures 1-5 compare the duration curves of daily off-peak season Tait St. production over all years of the 73-year hydrologic record to the analogous curves developed in Task 2. Each figure shows the distribution of daily production required to serve different demands as follows:

- Figure 1: Santa Cruz Water Department (SCWD) only
- Figure 2: SCWD plus both districts
- Figure 3: Both districts only
- Figure 4: Scotts Valley only
- Figure 5: Soquel Creek only

Note that the curves are not additive because of non-coincidence.

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Figure 1

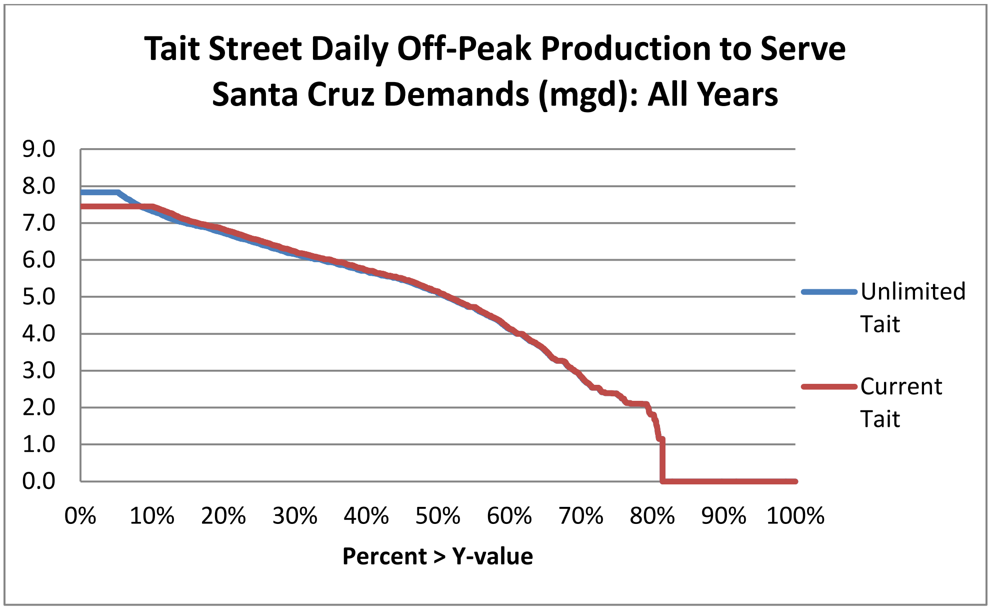


Figure 2

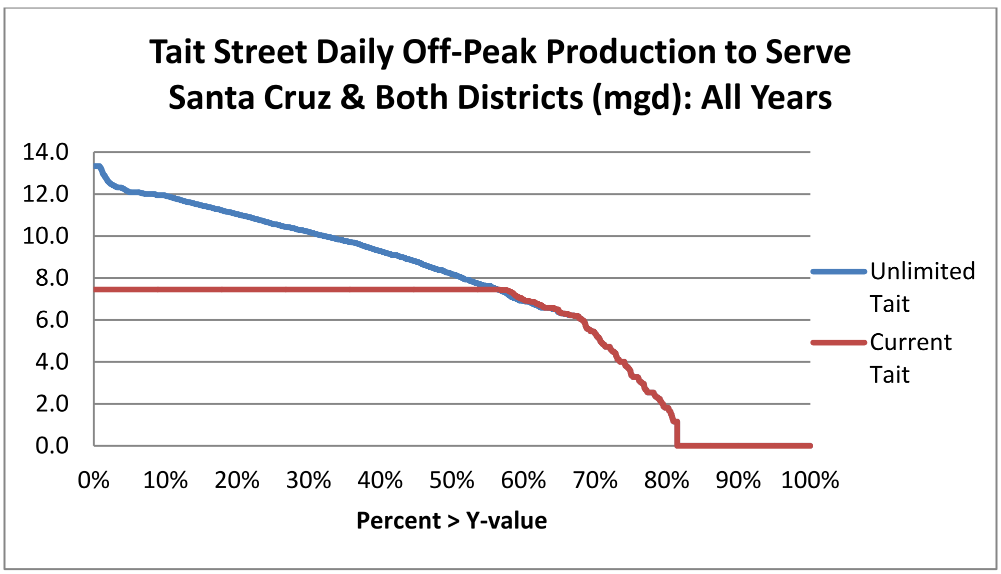


Figure 3

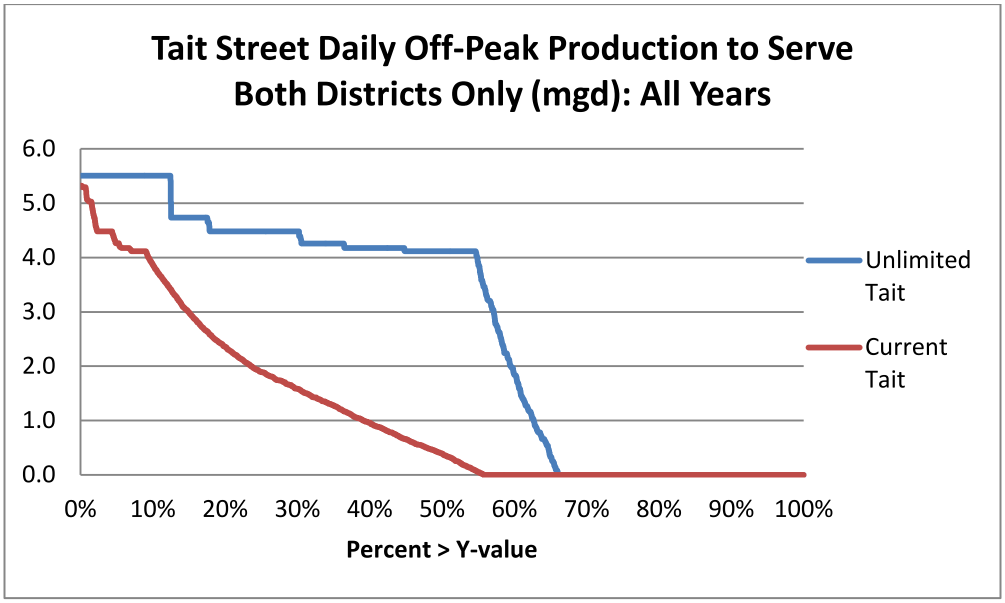


Figure 4

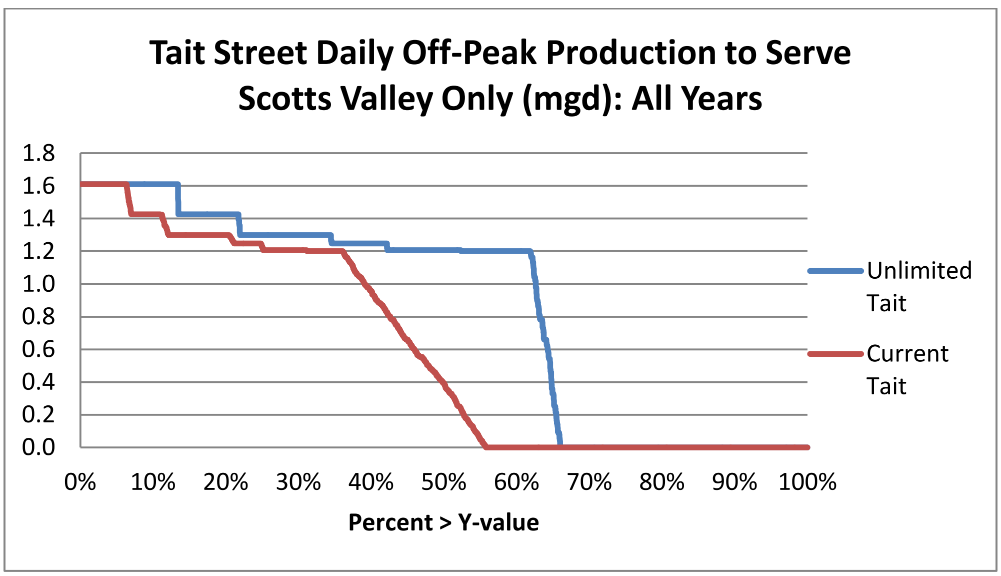
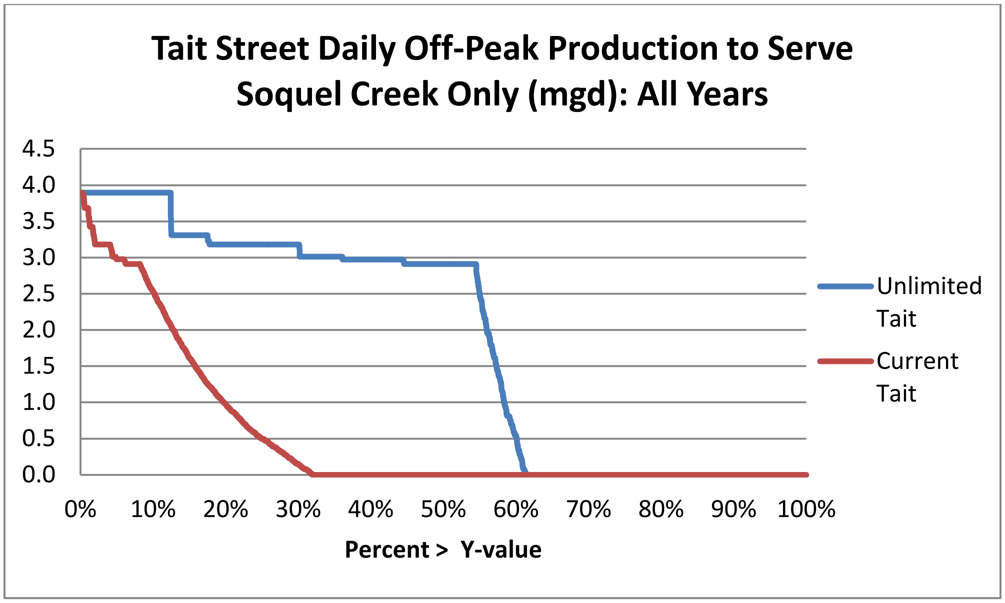


Figure 5



Added Tait Street capacity has very little impact on production to meet Santa Cruz demands. The Santa Cruz off-peak season demand in 2030 is 7.83 mgd, which is not much higher than the current 7.45 mgd capacity. Moreover, the only days on which Tait Street may produce that much are those days when there is no North Coast production.

However, added capacity at Tait Street does result in significantly higher transfer volumes. As Figure 2 shows, the Tait Street capacity would need to increase to about 13.3 mgd (20.6 cfs) to serve the maximum possible portion of district demands. The marked increase in Tait production to serve the different demands is illustrated in Table 1. The last two rows of the table also show the percent of total seasonal demand for each district that is served.

Table 1. Average Annual Tait Street Production (mg)

DEMAND SERVED	Current Tait Capacity (7.4 mgd)	Increased Tait Capacity (13.3 mgd)
Santa Cruz Only	775	778
Santa Cruz & Both Districts	979	1266
Both Districts Only	204	488
Scotts Valley	108 (45%)	154 (64%)
Soquel Creek	95 (16%)	333 (57%)

Tait Street Production by Year Type

The charts of this section compare the distributions of off-peak season Tait daily production for each of the four hydrologic year types, assuming the added Tait Street capacity. Since showing the comparable

Task 2 distributions on the same charts would render the charts unreadable, each of the Task 2 charts is displayed directly under the comparable Task 3 chart to facilitate comparison.

Figure 6 (Increased Tait Capacity)

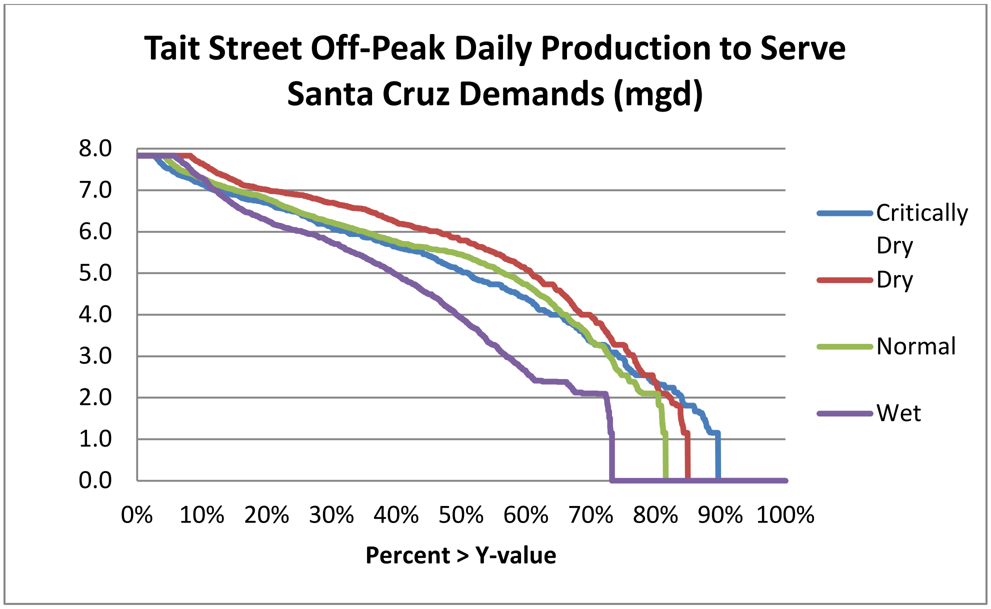


Figure 6a (Current Tait Capacity)

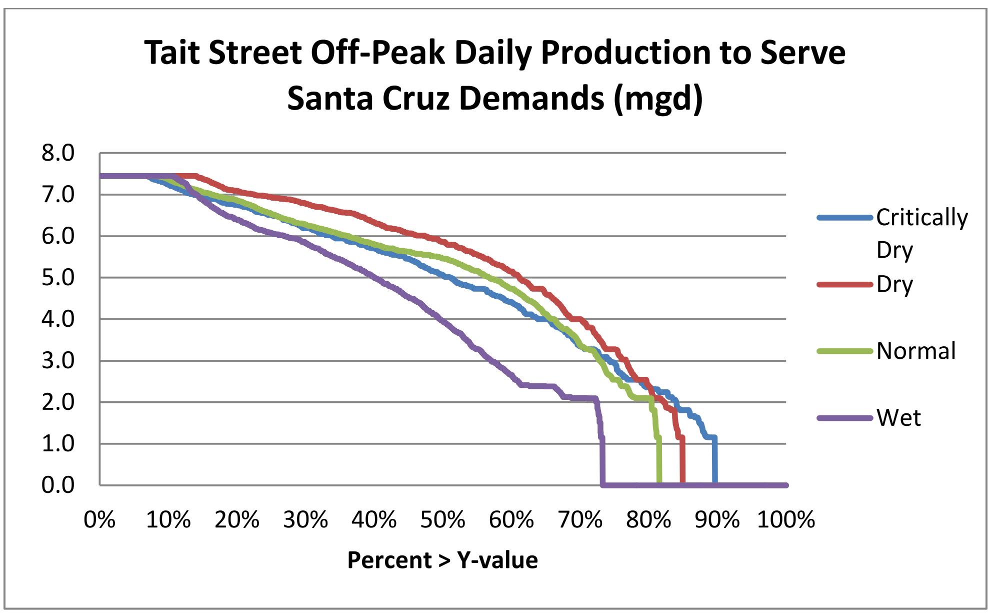


Figure 7 (Increased Tait Capacity)

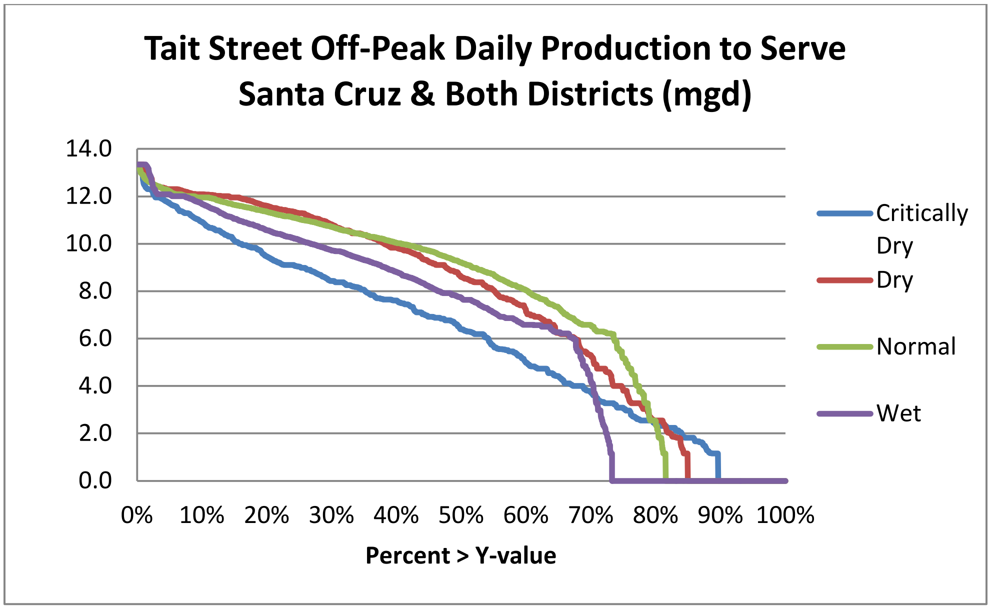


Figure 7a (Current Tait Capacity)

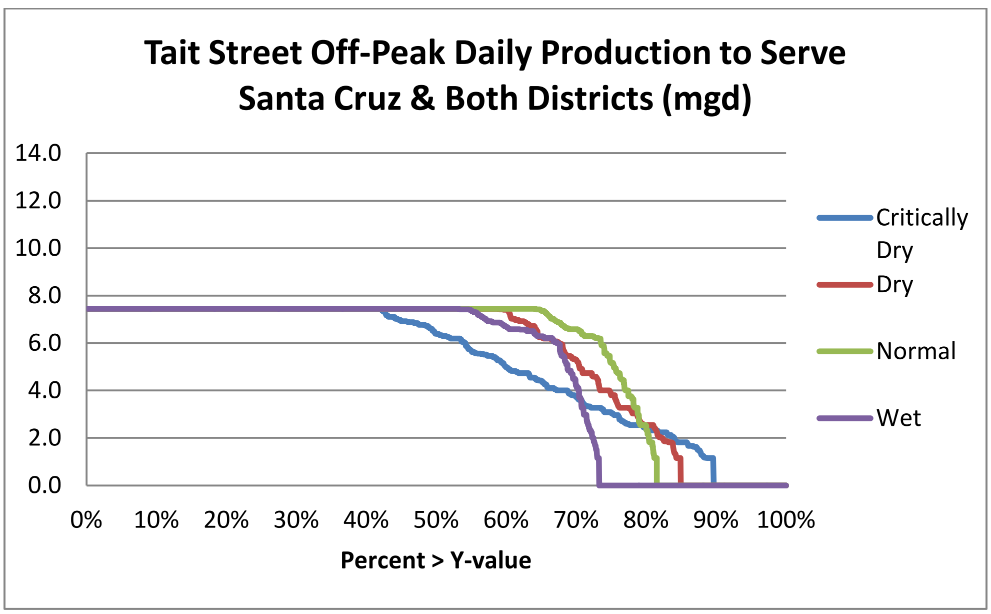


Figure 8 (Increased Tait Capacity)

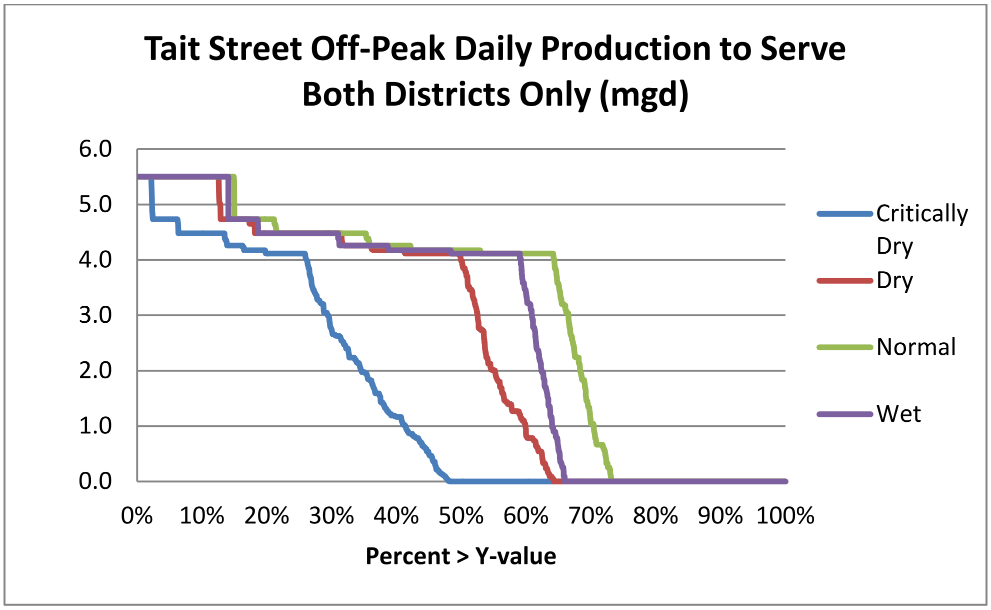


Figure 8a (Current Tait Capacity)

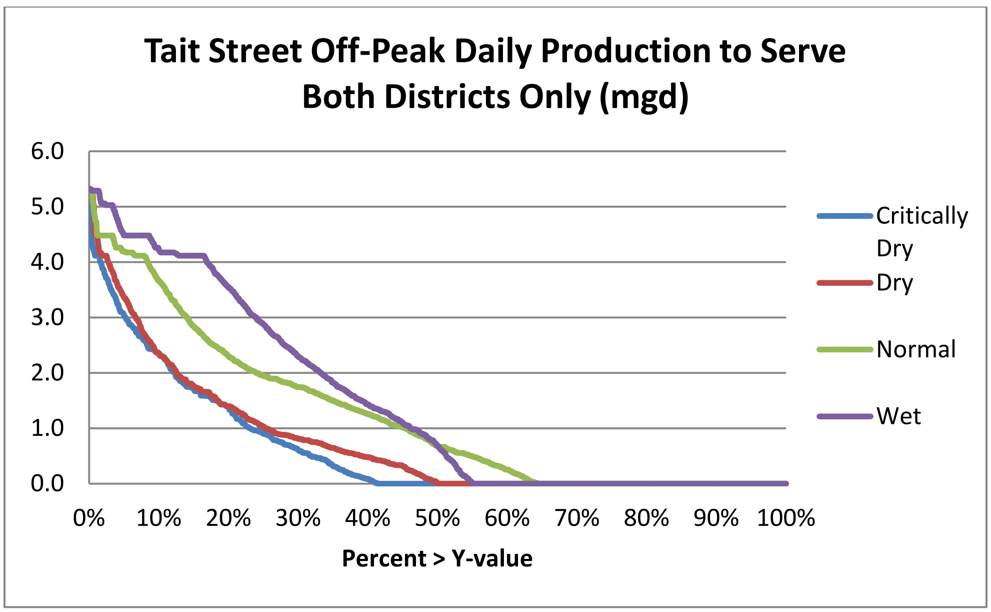


Figure 9 (Increased Tait Capacity)

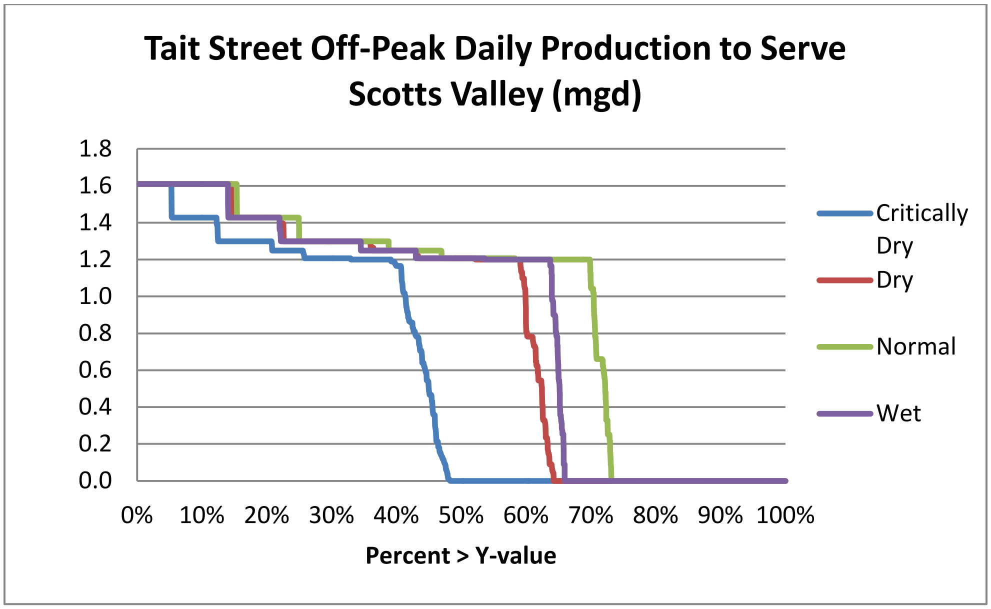


Figure 9a (Current Tait Capacity)

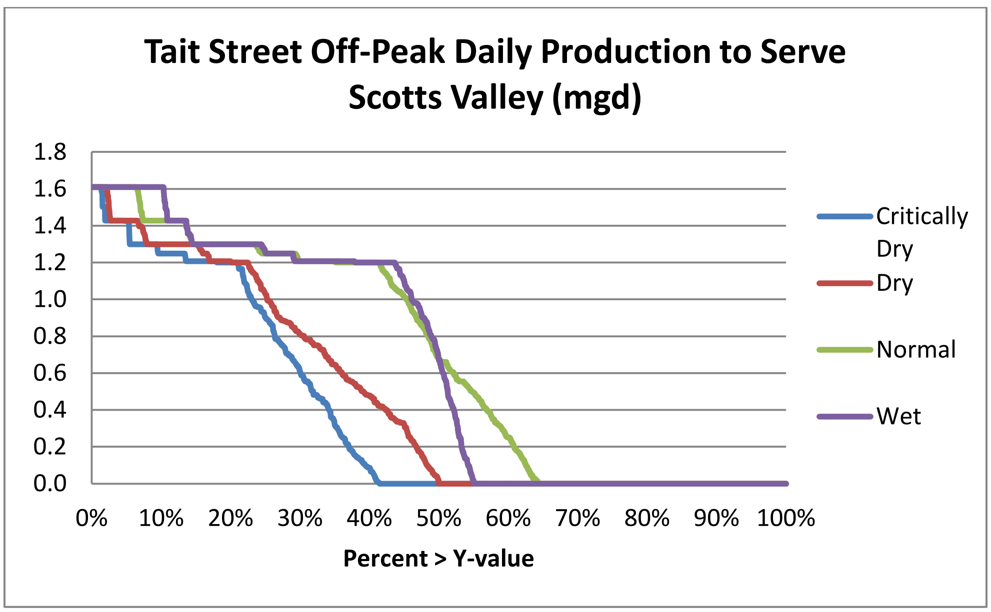


Figure 10 (Increased Tait Capacity)

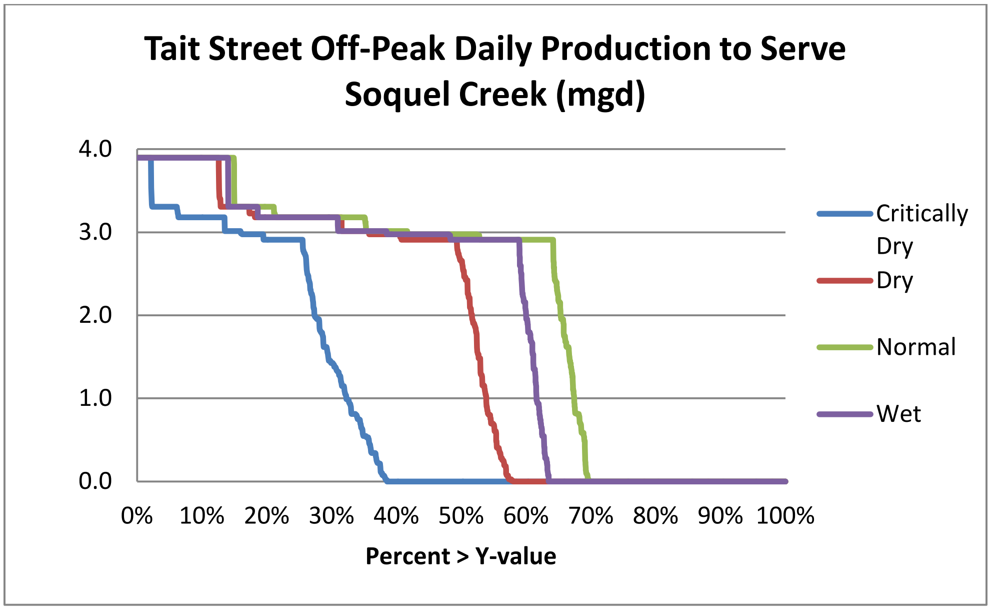


Figure 10a (Current Tait Capacity)

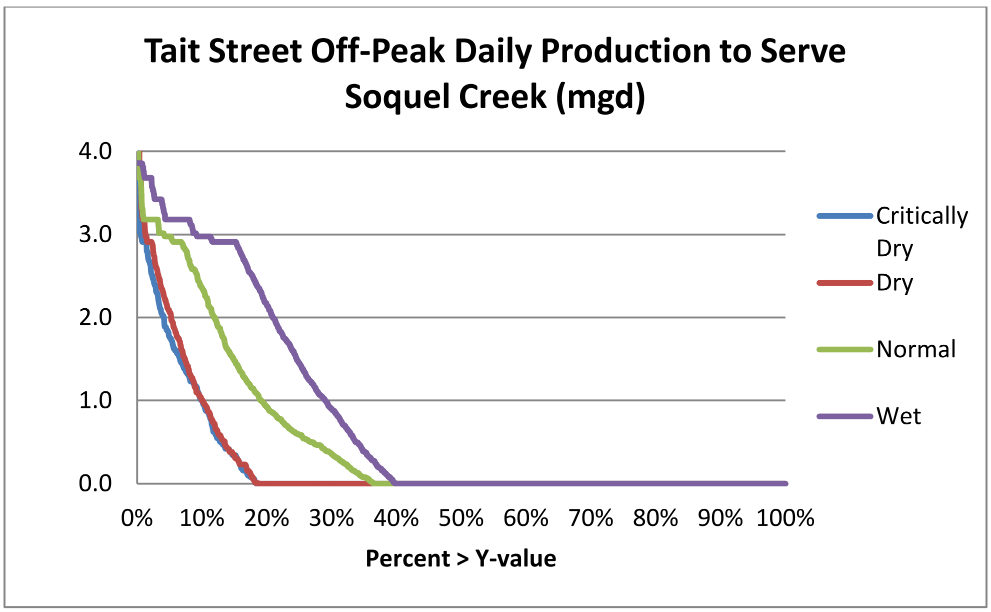


Table 2 compares the average off-peak season Tait production to serve different demands across the year types. Table 2a shows the comparable figures from Task 2.

Table 2. Average Off-Peak Season Tait Street Production (mg) (Increased Tait Capacity)

DEMAND SERVED	HYDROLOGIC YEAR TYPE				
	Critically Dry	Dry	Normal	Wet	All
Santa Cruz Only	823	879	812	663	**778**
Santa Cruz & Both Districts	1102	1345	1378	1179	**1262**
Both Districts Only	278	464	566	517	**488**
Scotts Valley	105	151	174	158	**154**
Soquel Creek	173	313	392	358	**333**

Table 2a. Average Off-Peak Season Tait Street Production (mg) (Current Tait Capacity)

DEMAND SERVED	HYDROLOGIC YEAR TYPE				
	Critically Dry	Dry	Normal	Wet	All
Santa Cruz Only	823	879	812	663	**775**
Santa Cruz & Both Districts	936	1010	1033	930	**979**
Both Districts Only	112	131	221	267	**204**
Scotts Valley	70	84	125	121	**108**
Soquel Creek	41	46	95	144	**95**

GHWTP Production

The added production at Tait Street requires increased utilization of the treatment plant. Figure 11 compares the distributions of off-peak season daily production at the treatment plant with current and increased Tait Street capacity. The current 10 mgd off-peak season GHWTP capacity is shown on the chart.

Figure 11

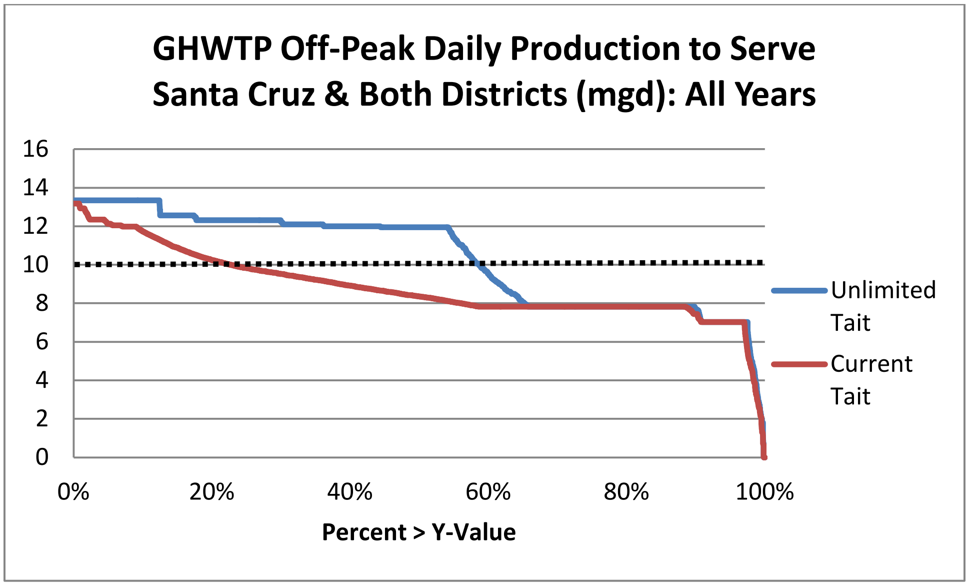


Table 3 shows the percentage of days that the current 10 mgd winter plant capacity limits transfers and the expected volume reduction in the annual combined transfer to the two districts due to this capacity limitation.

Table 3. Impacts of Current GHWTP Capacity on Potential Transfer Volumes

Scenario	Percentage of Days Exceeding 10 mgd	Expected Reduction in Expected Annual Transfer	
		Volume (mg)	Percentage of Potential Transfer
Current Tait Capacity	22%	59	28%
Unlimited Tait Capacity	59%	246	50%

If the Tait Street capacity was increased without a concurrent increase of the off-peak treatment plant capacity, the potential transfer volumes would be limited by the plant on almost 3 of 5 off-peak season days, and the average annual transfer volume would be reduced by half.

Date: June 22, 2012
From: Gary Fiske
To: Linette Almond, John Ricker
Re: Water Transfer Project: Long-Term Analysis Scenario 2 (REVISED)

This memo reports the results of the second of 4 scenarios to be analyzed as part of Task 2, the long-term analysis. Whereas Scenario 1 assumed current infrastructure and water rights, Scenario 2 assumes the necessary changes in infrastructure and water rights to enable direct diversion from Felton to the Graham Hill Water Treatment Plant. This includes lifting the 3,000 AF annual diversion limit at Felton.

The analysis and other key assumptions are substantially the same as described in the June 1 Scenario 1 memo; the key difference is that the Scotts Valley and Soquel Creek demands can now be served from Felton as well as Tait Street. This memo is in much the same format as the earlier one, with many of the tables directly comparing the Scenario 1 and 2 results in order to highlight the changes attributable to allowing Felton direct diversion. The Scotts Valley and Soquel Creek Service Area 1 demands are once again as shown in Table 1.

Table 1. Assumed Monthly Demands (millions of gallons)

Month	Scotts Valley	Soquel Creek (SA1)
November	42.8	39.6
December	38.7	36.1
January	37.2	35.6
February	33.8	32.2
March	40.3	37.4
April	48.3	41.9
TOTAL	**241.1**	**222.7**

Averages and Distributions of Water Transfer Volumes

Table 2 compares the Scenario 2 2030 monthly average Scotts Valley and Soquel Creek transfers across all hydrologic years to the corresponding transfers under Scenario 1. Not surprisingly, the Scenario 2 transfers are significantly higher. Table 3 shows the average transfers for each hydrologic year type.

Figure 1 shows the duration curves across all hydrologic years for the Scenario 2 annual transfers, and Figures 2-5 show the transfer duration curves for each year type.

Table 2. 2030 Monthly Average Transfers Across All Hydrologic Years (millions of gallons)

Month	Scotts Valley Transfer Volume		Soquel Creek Transfer Volume		Total Transfer Volume	
	Scen 1	Scen 2	Scen 1	Scen 2	Scen 1	Scen 2
November	21.4	21.4	6.0	8.5	27.4	29.9
December	11.9	19.0	5.5	13.8	17.4	32.8
January	14.0	22.5	8.5	18.5	22.5	40.9
February	15.9	21.6	10.6	20.6	26.5	42.2
March	23.6	29.9	15.0	27.0	38.6	56.9
April	25.0	38.9	10.0	32.3	35.0	71.2
TOTAL	**111.8**	**153.3**	**55.6**	**120.7**	**167.4**	**274.0**

Table 3. 2030 Annual Average Transfers by Hydrologic Year Type (mg)

Year Type	Scotts Valley		Soquel Creek		Total	
	Scen 1	Scen 2	Scen 1	Scen 2	Scen 1	Scen 2
Critically Dry	74.5	109.3	30.7	67.1	105.2	176.5
Dry	87.7	150.3	31.4	112.0	119.1	262.3
Normal	127.9	169.9	58.2	139.2	186.1	309.1
Wet	125.3	156.1	76.7	133.3	202.0	289.3
Average	**111.8**	**153.3**	**55.6**	**120.7**	**167.4**	**274.0**

Figure 1

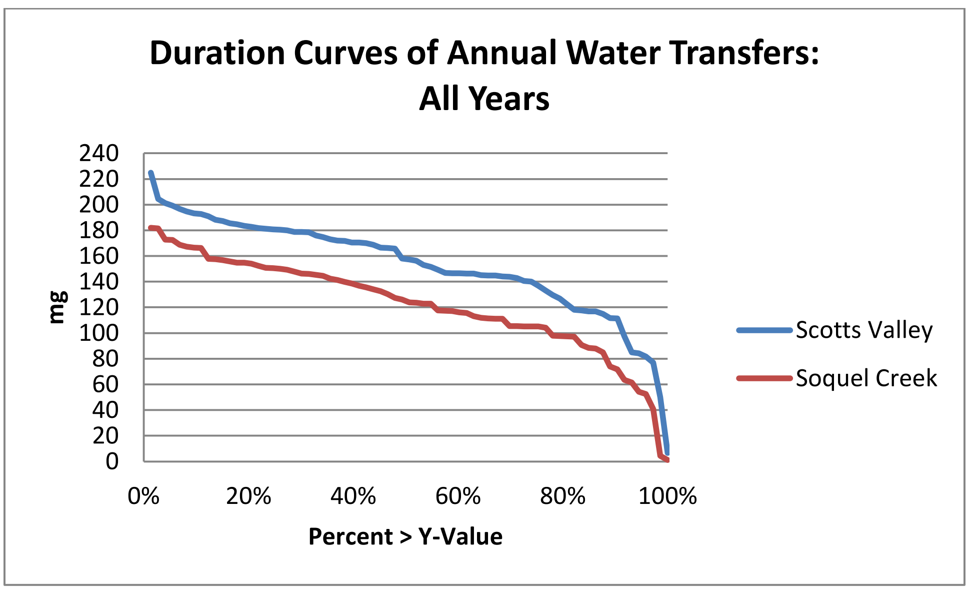


Figure 2

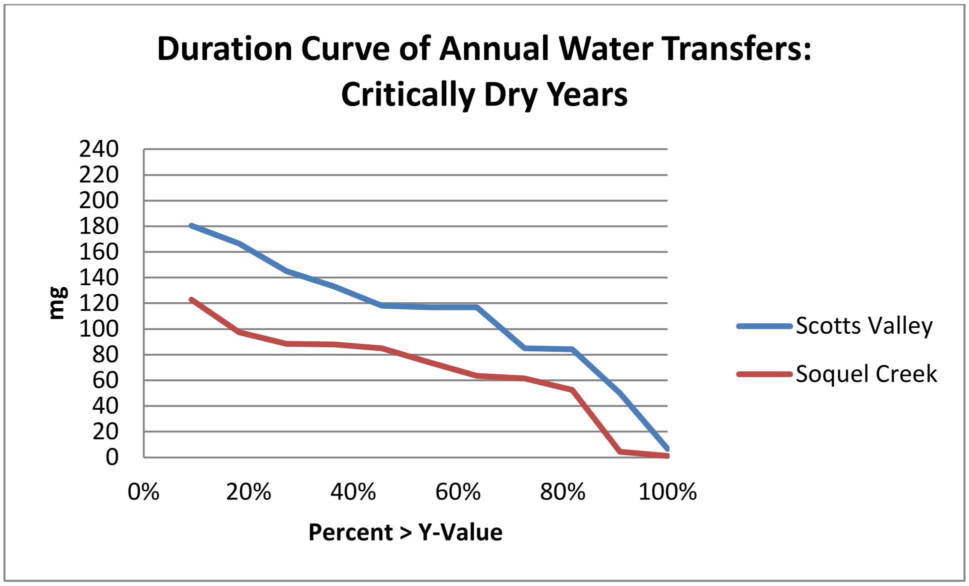


Figure 3

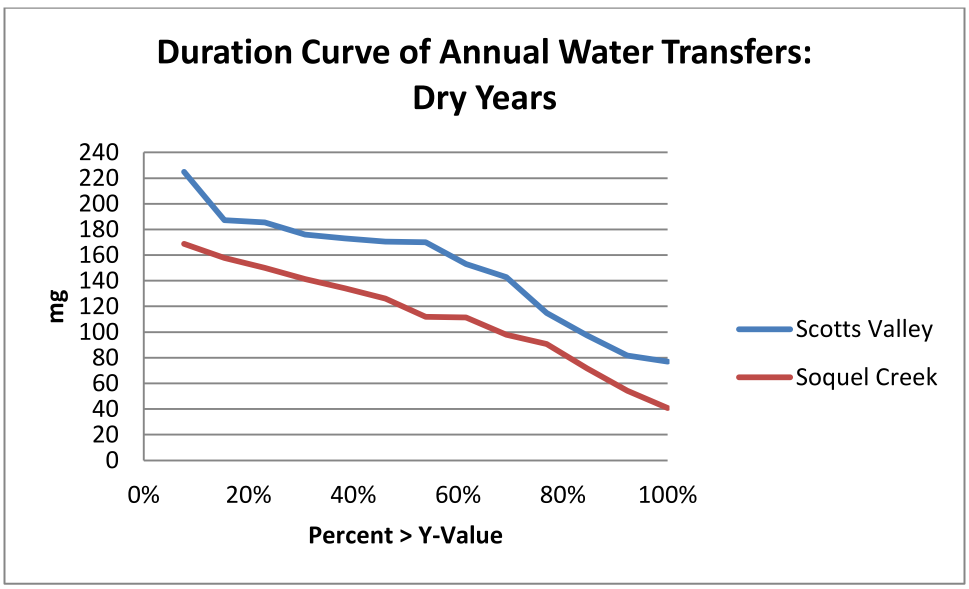


Figure 4

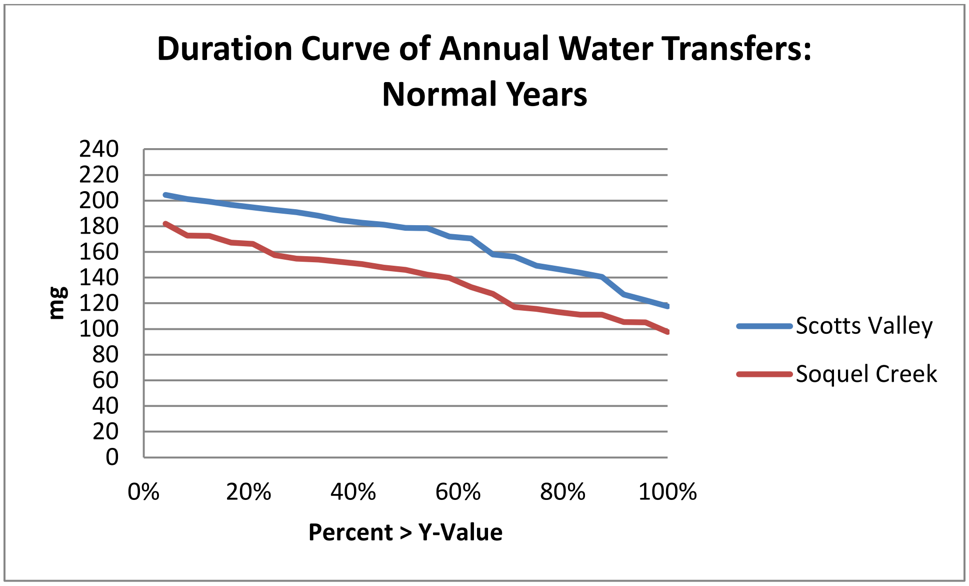
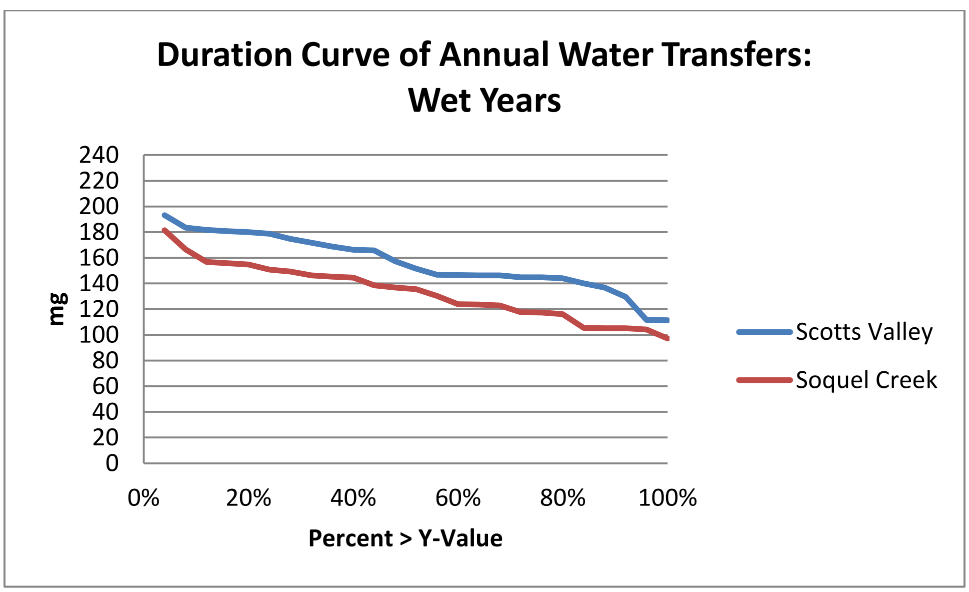


Figure 5



Source Production

Table 4 shows the monthly average combined added production at Tait Street and Felton required to serve Scotts Valley and Soquel Creek demands.

Table 4. 2030 Monthly Average Added Production at Tait Street & Felton to Serve Scotts Valley and Soquel Creek (millions of gallons)

Month	Base (No Direct Div)	With Transfers		Added Production	
		Scen 1	Scen 2	Scen 1	Scen 2
November	157.9	181.1	187.9	23.1	29.9
December	158.4	174.1	191.1	15.7	32.8
January	158.6	180.3	199.6	21.7	40.9
February	134.3	160.2	176.5	25.9	42.2
March	151.2	189.8	208.2	38.5	56.9
April	173.5	208.0	244.7	34.6	71.2
TOTAL	**933.9**	**1093.5**	**1208.0**	**159.6**	**274.0**

Surplus Supply

Given these production levels, how much surplus supply is there available at Tait Street and/or Felton to potentially meet other external demands? For our purposes, surplus supply at Tait Street on any day is defined as:

> *The excess of the maximum potential Tait Street diversion over the volume that has already been diverted to meet Santa Cruz, Scotts Valley, and Soquel Creek demands. The maximum potential diversion is the minimum of the available flow at Tait Street and the capacity of the Tait Street diversion (11.52 cfs). On days when there are no turbidity constraints at Tait St., the available flow at Tait Street is the Tier 3 Big Trees flow less the diversion at Felton plus the tributary inflows between Felton and Tait Street. On days when Tait St. is shut down due to turbidity, the Tait St. available flow is zero.*

To this must be added the daily incremental surplus available at Felton, which is defined as:

> *The minimum of the excess net flow at Tait Street and the unused Felton capacity. The excess net flow at Tait St. is the amount (if any) by which the Tait St. available flow, as defined above, exceeds the Tait Street diversion capacity (11.52 cfs). The unused Felton capacity is the difference between the Felton capacity (13.7 cfs) and the daily Felton diversion.*

Based on this definition, Table 5 shows the expected November-April surplus supply. The additional diversion capacity at Felton ensures that there is substantial unused capacity at Felton and Tait Street which, on days of sufficient flow, would be available to serve other demand. The Scenario 2 surplus is thus substantially larger than Scenario 1.

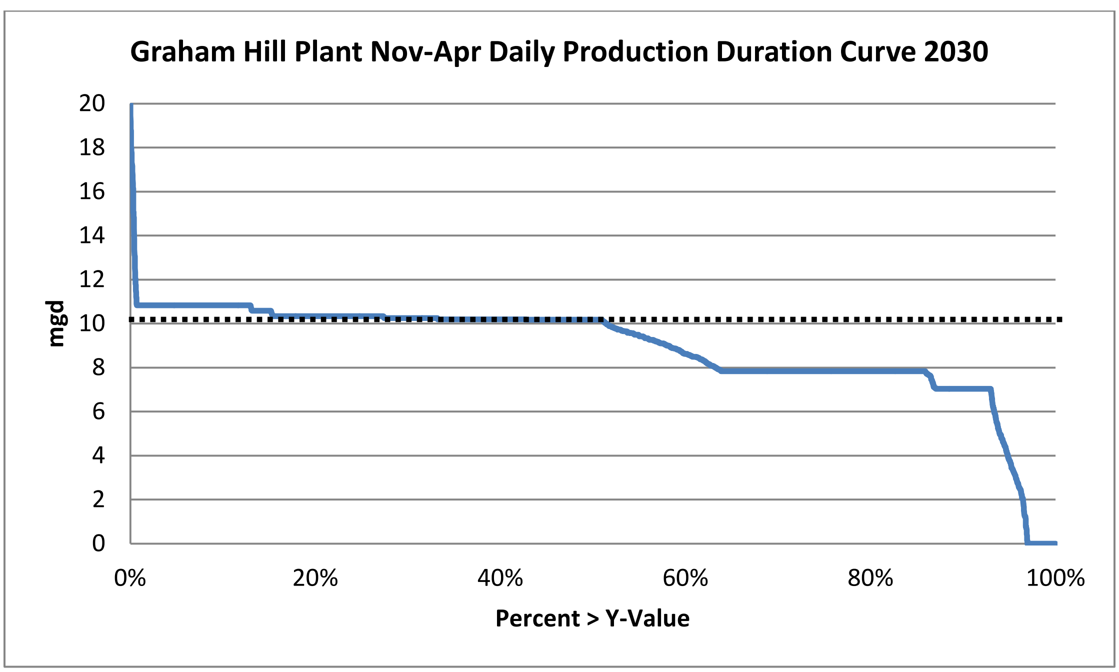
Table 5. Expected 2030 November-April Surplus Supply at Tait Street (millions of gallons)

Year Type	Surplus Supply	
	Scen 1	Scen 2
Critically Dry	14	270
Dry	18	555
Normal	44	838
Wet	83	890
Average	**48**	**720**

Treatment Plant Capacity Requirements

Figure 6 shows the Scenario 2 duration curve of Graham Hill treatment plant production required to accomplish the transfers depicted in the tables and charts above. The chart shows that treatment plant usage exceeds the current 10 mgd capacity on more than 50% of days. Constraining the plant capacity to this level would reduce the total 274 mg average annual transfer shown in Table 2 by about 16% to 230 mg. Put another way, an investment in treatment plant expansion would, at most, result in additional average annual transfers of about 44 million gallons.

Figure 6



Transmission Capacity Requirements

Figure 7 shows the Scenario 2 duration curve for the required transmission capacity to move water from the treatment plant to yield the combined transfer volumes discussed above. Figure 8 shows the duration curve for the required transmission capacity to Scotts Valley, while Figure 9 shows the required capacity to Soquel Creek.

Figure 7

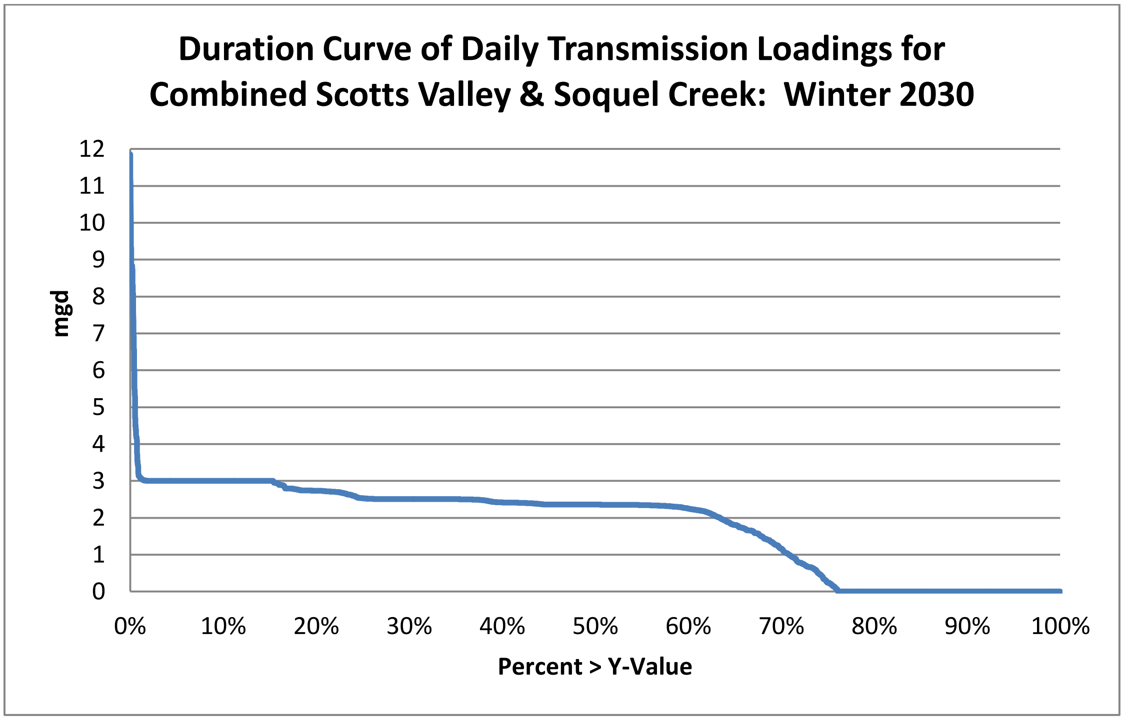


Figure 8

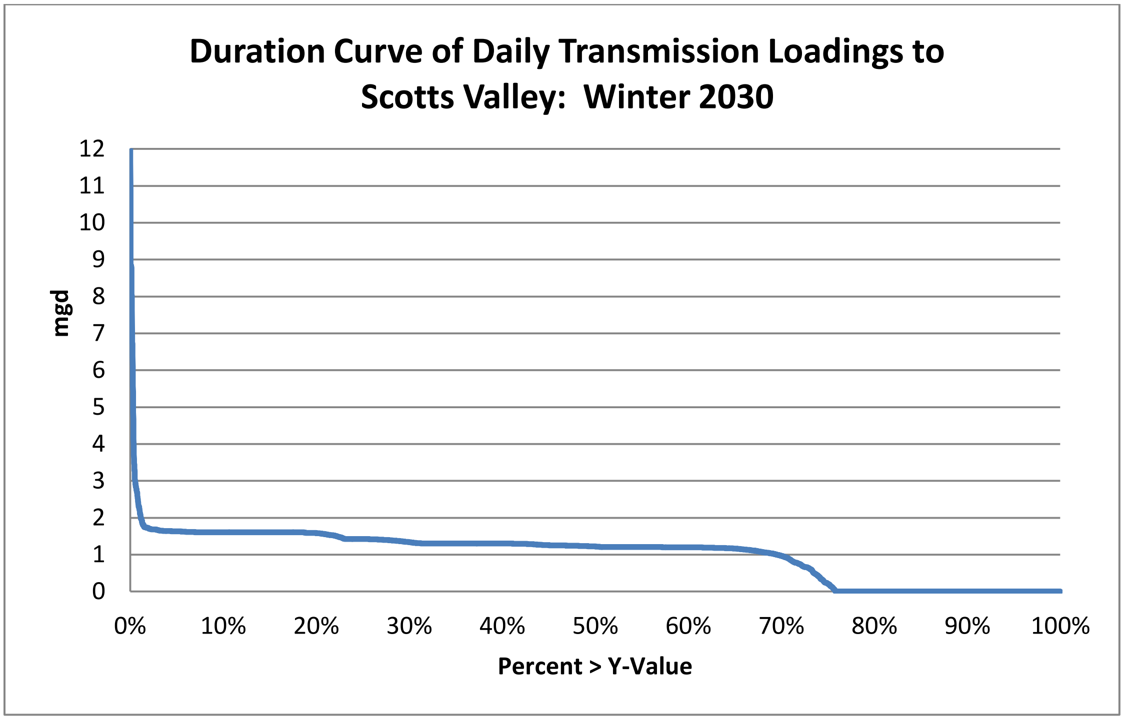
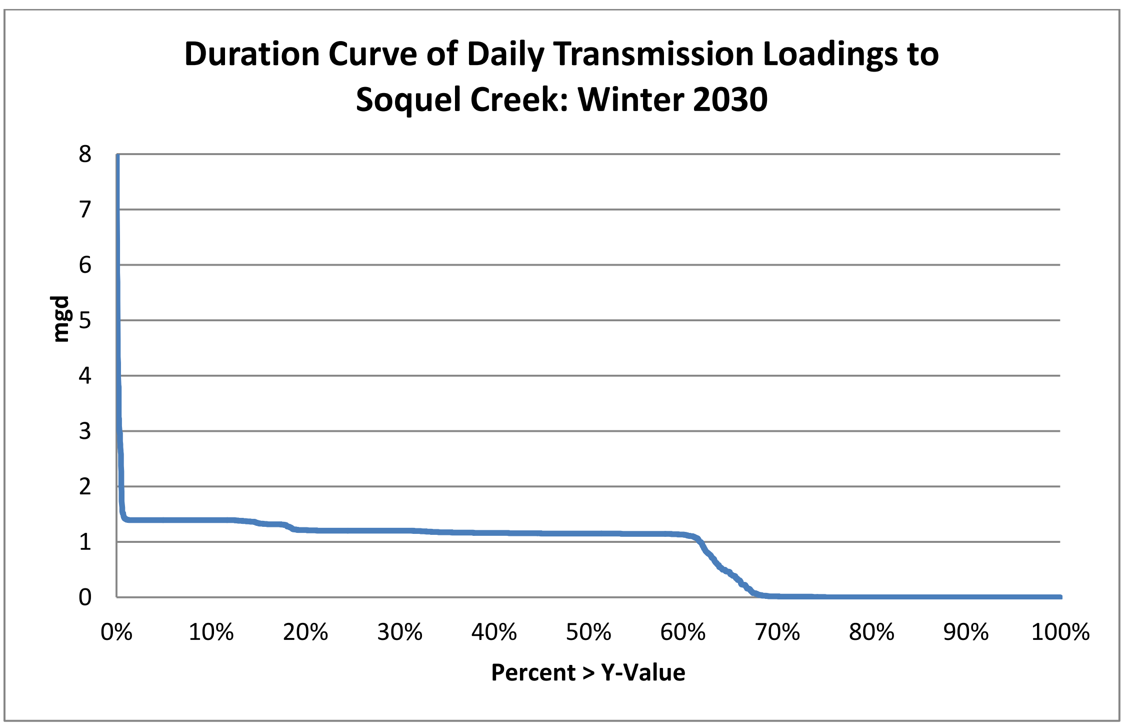


Figure 9



GARY FISKE AND ASSOCIATES, INC.
Water Resources Planning and Management

Date: June 25, 2012
From: Gary Fiske
To: Linette Almond, John Ricker
Re: Water Transfer Project: Long-Term Analysis Scenarios 3 and 4

This memo reports the results of the third and fourth scenarios to be analyzed as part of Task 2, the long-term analysis. Originally, Scenario 3 was to examine "remov[ing] water rights constraints at Felton and Loch Lomond." However, Scenario 2 has already removed the water right constraint that limits annual Felton diversions to 3,000 AF. Moreover, the diversion rights at Felton exceed the physical diversion capacity in all but one month (September), so removing them would have no impact on water transfers to Scotts Valley and Soquel Creek. The only other water right that is feasible to remove is the 3,200 AF annual Loch Lomond withdrawal limit. But that would also have no impact on transfers.

Therefore, based on discussions with Linette, Scenario 3 was redefined as a modification of Scenario 2 which increased the Felton diversion capacity from its current 13.7 cfs to match the 20 cfs water right.[1]

It turns out that, on all winter days, there is currently more than sufficient combined capacity at Felton and Tait Street to serve Santa Cruz, Scotts Valley, and Soquel Creek Service Area 1 demands. So increasing that capacity does not enable transfer of additional water. Thus, the results of Scenario 3 are virtually identical to those of Scenario 2, with the possible exception of the surplus supplies which may be somewhat higher.

Thus, the remainder of this memo is devoted to reporting the results of Scenario 4. Scenario 4 modifies Scenario 2 by adding infrastructure to provide a second transmission line to the lake and to allow the Felton diversion to operate at any level up to its maximum capacity, thus eliminating the capacity steps assumed in the IWP and in our previous scenarios. In addition, the annual lake withdrawal limit is assumed to be removed.

The elimination of the Felton capacity steps will improve the ability to divert at Felton and might therefore be expected to somewhat increase transfers to Scotts Valley and Soquel Creek. On the other hand, the enhanced ability to divert from Felton to the lake might be expected to somewhat reduce transfers since the added water diverted from Felton to the lake makes less water available for transfers.

All three changes will tend to improve the reliability of service to Santa Cruz customers. This is in contrast to Scenarios 1 and 2 in which the Santa Cruz reliability is essentially unchanged. This memo therefore begins with a section that shows the extent of these reliability improvements. To maintain the numbering system for the other tables and charts for the sake of comparability to previous memos, the table and chart numbers in this new section begin with "R".

[1] The September diversion right is 7.8 cfs.

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The Scotts Valley and Soquel Creek Service Area 1 demands are once again as shown in Table 1.

Table 1. Assumed Monthly Demands (millions of gallons)

Month	Scotts Valley	Soquel Creek (SA1)
November	42.8	39.6
December	38.7	36.1
January	37.2	35.6
February	33.8	32.2
March	40.3	37.4
April	48.3	41.9
TOTAL	**241.1**	**222.7**

Impacts on City of Santa Cruz Reliability

Figure R-1 compares the 2030 peak-season shortage duration curves for Scenarios 2 and 4. Table R-1 compares key peak-season reliability indices for the two scenarios. As expected, there are clear improvements in reliability, although not in the driest years.

Figure R-1

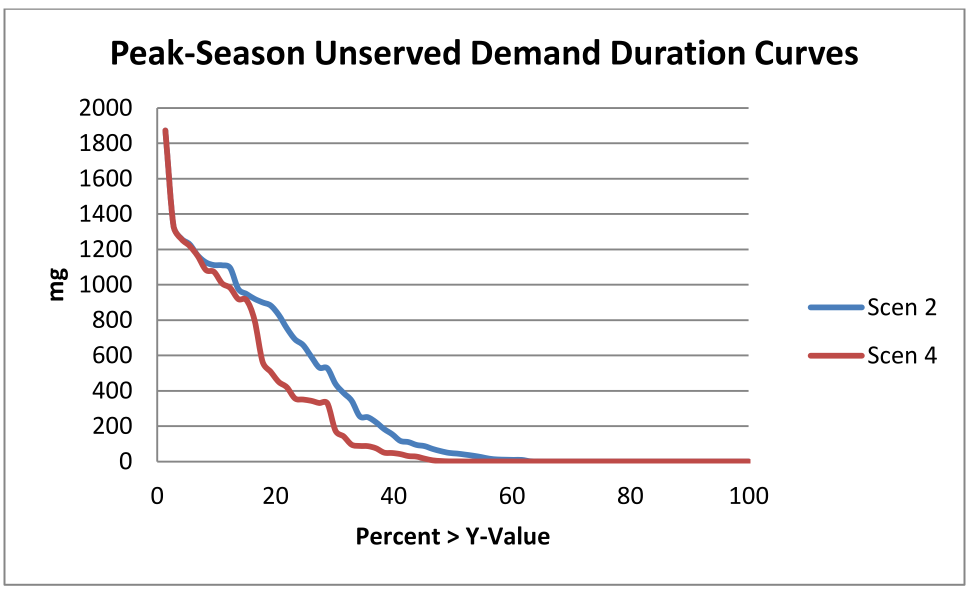


Table R-1. Comparison of Key Peak-Season 2030 Reliability Indicators

	Scenario 2	Scenario 4
Expected PS Shortage (mg)	349	266
Likelihood of PS Shortage:		
Likelihood of 5% PS Shortage	40%	32%
Likelihood of 15% PS Shortage	30%	22%
Likelihood of 25% PS Shortage	25%	16%

Averages and Distributions of Water Transfer Volumes

Table 2 compares the Scenario 4 2030 monthly average Scotts Valley and Soquel Creek transfers across all hydrologic years to the corresponding transfers under Scenario 2. Table 3 shows the average transfers for each hydrologic year type. There is very little difference between the two scenarios.

Figure 1 shows the duration curves across all hydrologic years for the Scenario 4 annual transfers, and Figures 2-5 show the transfer duration curves for each year type.

Table 2. 2030 Monthly Average Transfers Across All Hydrologic Years (millions of gallons)

Month	Scotts Valley Transfer Volume		Soquel Creek Transfer Volume		Total Transfer Volume	
	Scen 2	Scen 4	Scen 2	Scen 4	Scen 2	Scen 4
November	21.4	21.4	8.5	6.9	29.9	28.3
December	19.0	18.9	13.8	14.1	32.8	33.0
January	22.5	22.4	18.5	18.5	40.9	40.9
February	21.6	21.9	20.6	20.3	42.2	42.1
March	29.9	30.5	27.0	26.8	56.9	57.3
April	38.9	40.0	32.3	32.2	71.2	72.2
TOTAL	**153.3**	**155.1**	**120.7**	**118.8**	**274.0**	**273.9**

Table 3. 2030 Annual Average Transfers by Hydrologic Year Type (mg)

Year Type	Scotts Valley		Soquel Creek		Total	
	Scen 2	Scen 4	Scen 2	Scen 4	Scen 2	Scen 4
Critically Dry	109.3	102.9	67.1	66.7	176.5	169.7
Dry	150.3	153.7	112.0	114.4	262.3	268.1
Normal	169.9	173.7	139.2	138.7	309.1	312.3
Wet	156.1	154.4	133.3	131.5	289.3	285.9
Average	**153.3**	**152.9**	**120.7**	**121.0**	**274.0**	**273.9**

Figure 1

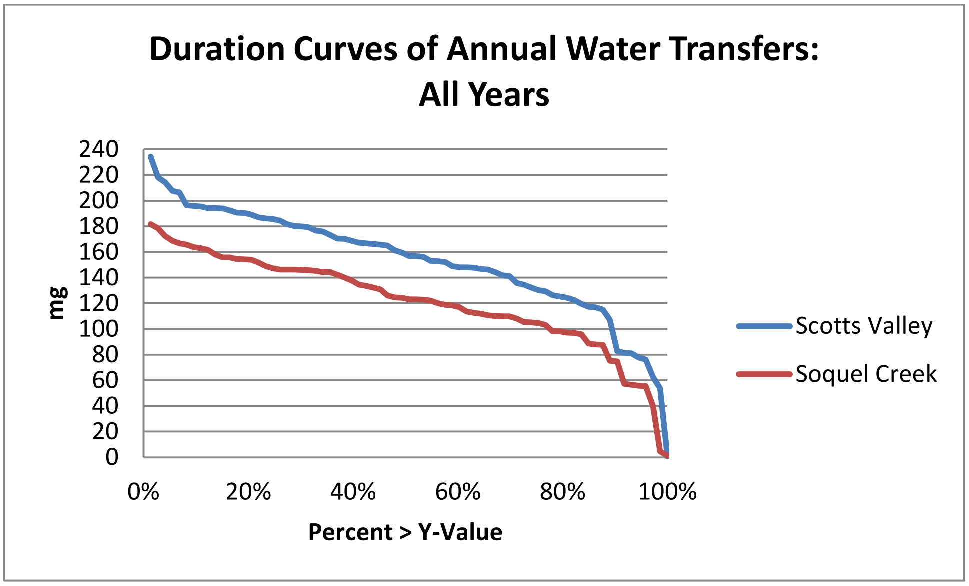


Figure 2

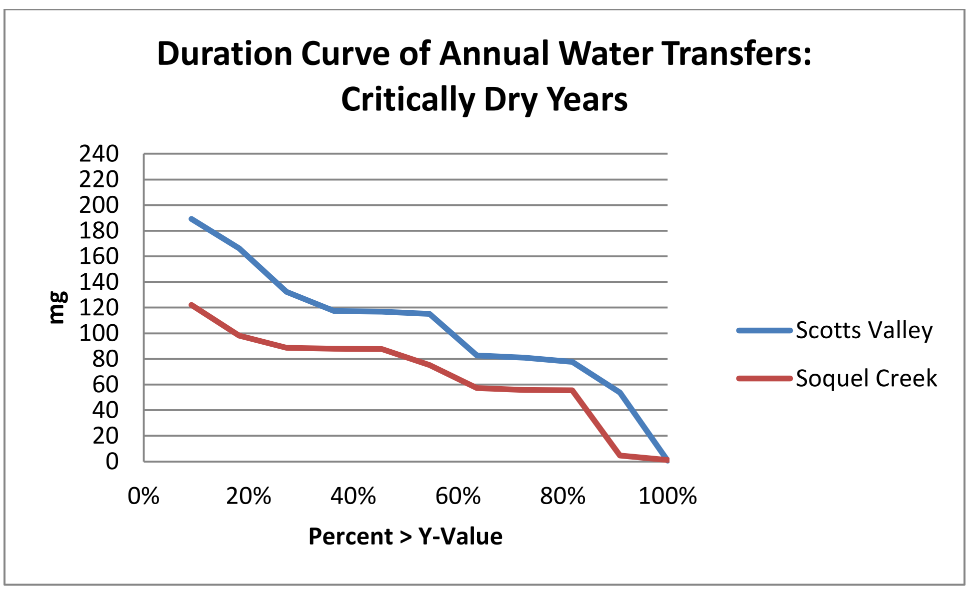


Figure 3

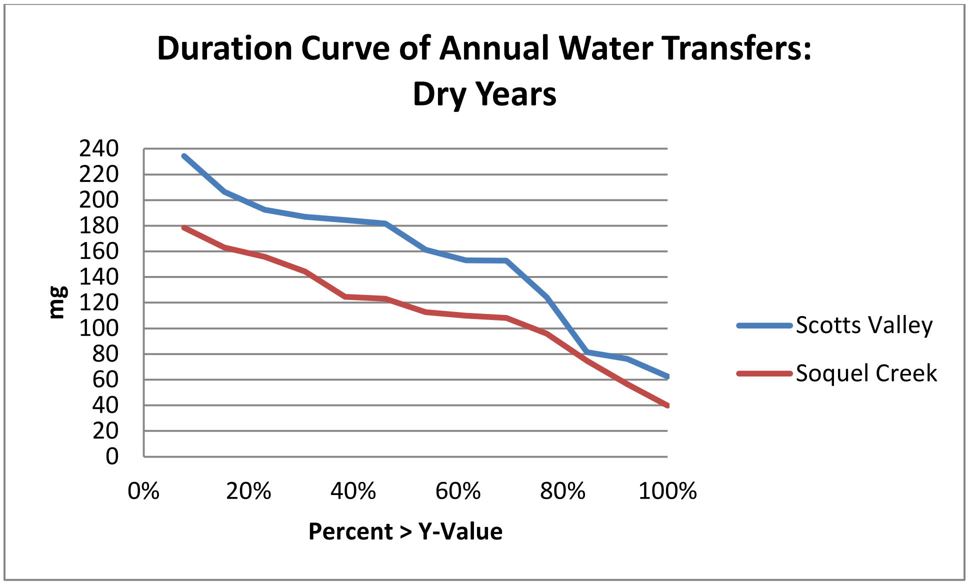


Figure 4

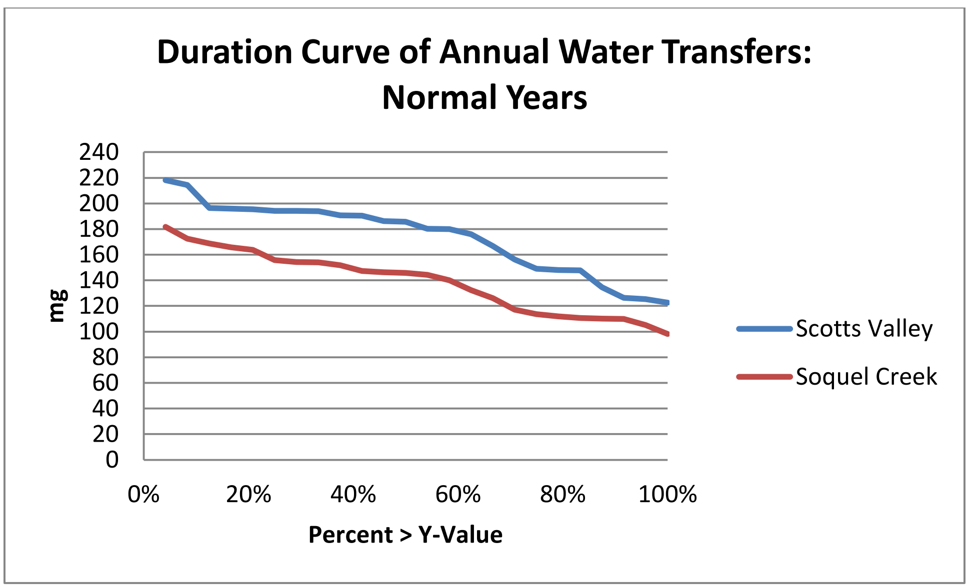
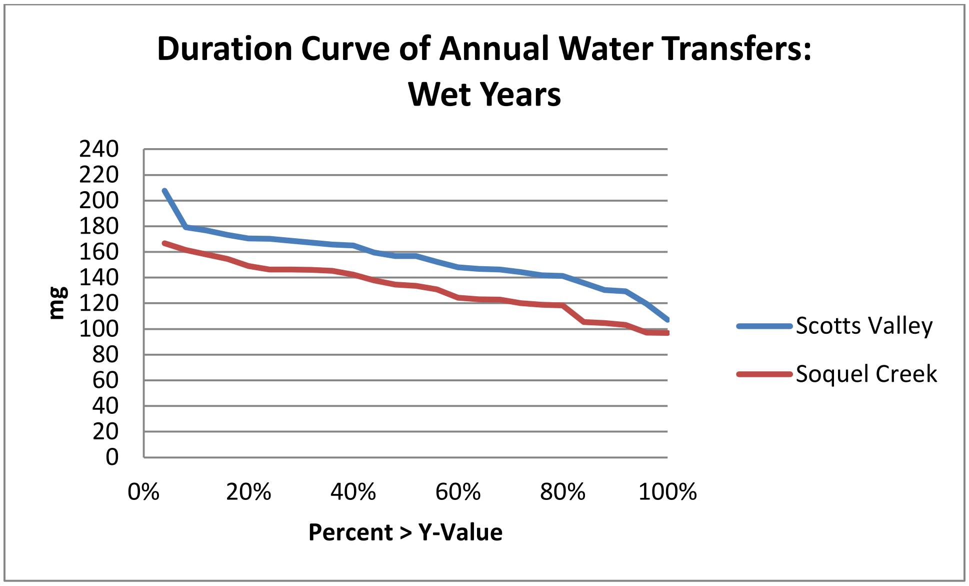


Figure 5



Surplus Supply

Using the same approach that was used to calculate surplus supply in my revised Scenario 2 memo, dated June 22, Table 4[2] shows the expected November-April surplus supply. Because of the added ability to divert from Felton to the lake as a result of the second pipeline, the Scenario 4 transfer, while still substantial, is less than in Scenario 2.

Table 4. Expected 2030 November-April Surplus Supply at Tait Street and Felton (millions of gallons)

Year Type	Surplus Supply	
	Scen 2	Scen 4
Critically Dry	270	77
Dry	555	222
Normal	838	676
Wet	890	755
Average	**720**	**532**

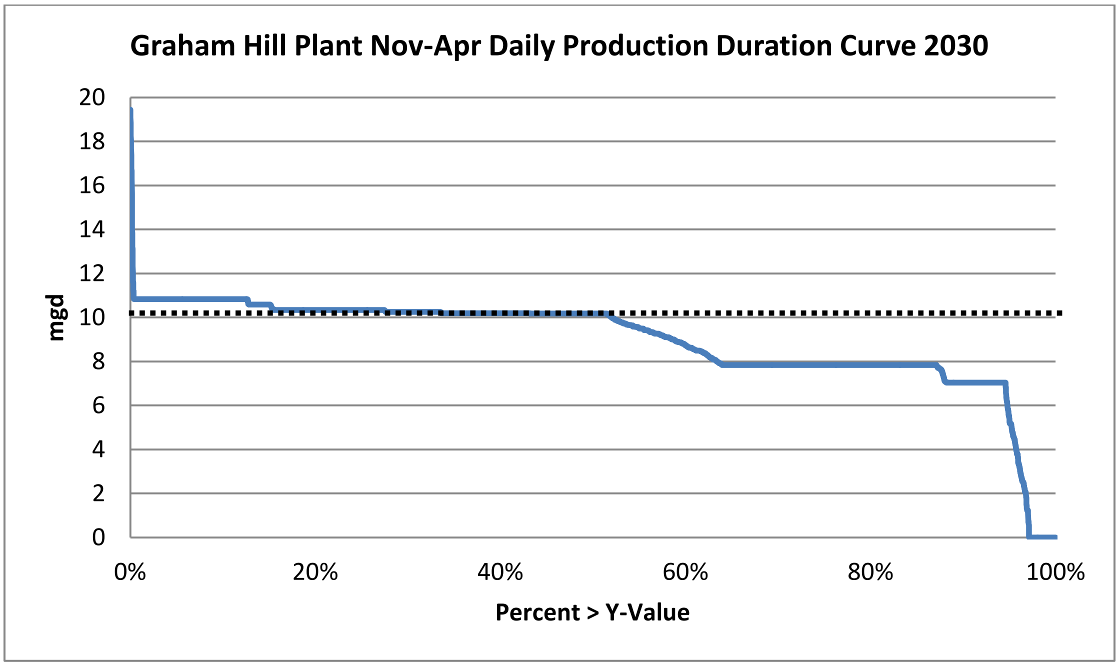
Treatment Plant Capacity Requirements

Figure 6 shows the Scenario 4 duration curve of Graham Hill treatment plant production required to accomplish the transfers depicted in the tables and charts above. The chart is virtually identical to the corresponding chart for Scenario 2. Once again, treatment plant usage exceeds the current 10 mgd

[2] Table 4, which in prior memos shows added Felton and Tait production, is intentionally omitted, since much of added Felton production in this scenario is due to additional diversion to the lake rather than to transfers to Scotts Valley and Soquel Creek.

capacity on more than 50% of days. Constraining the plant capacity to this level would reduce the total 274 mg average annual transfer shown in Table 2 by about 15% to 232 mg. Put another way, an investment in treatment plant expansion would, at most, result in additional average annual transfers of about 42 million gallons.

Figure 6



Transmission Capacity Requirements

Figure 7 shows the Scenario 4 duration curve for the required transmission capacity to move water from the treatment plant to yield the combined transfer volumes discussed above. Figure 8 shows the duration curve for the required transmission capacity to Scotts Valley, while Figure 9 shows the required capacity to Soquel Creek. Once again, these are almost indistinguishable from Scenario 2.

Figure 7

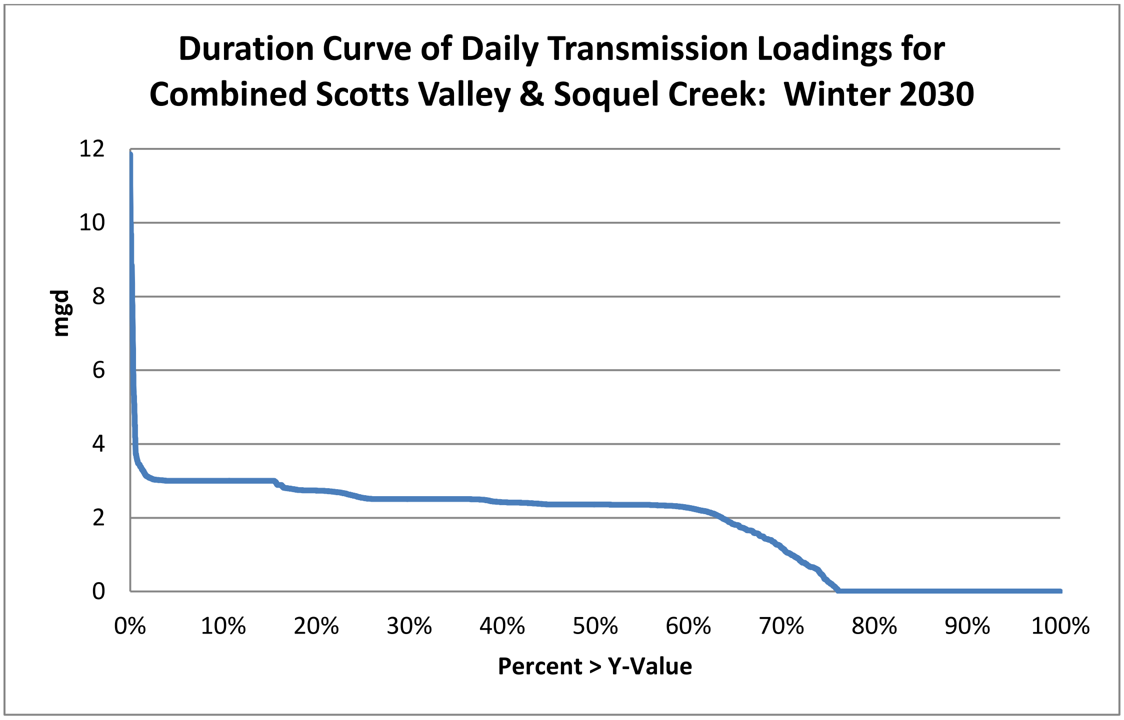


Figure 8

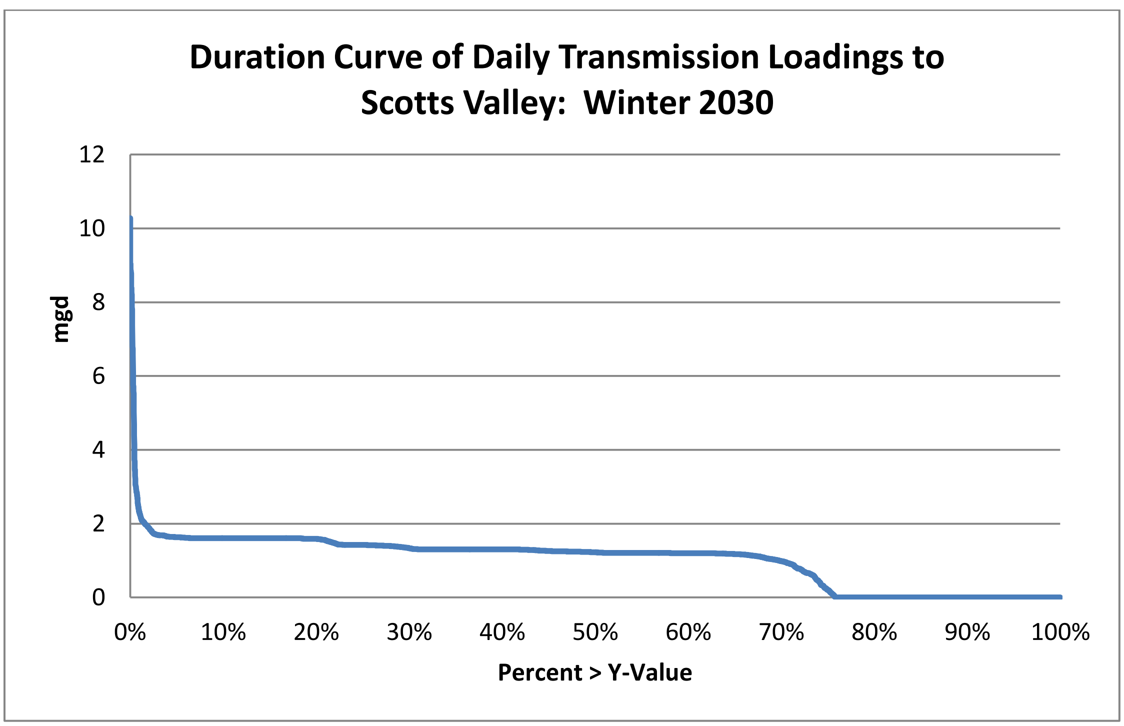
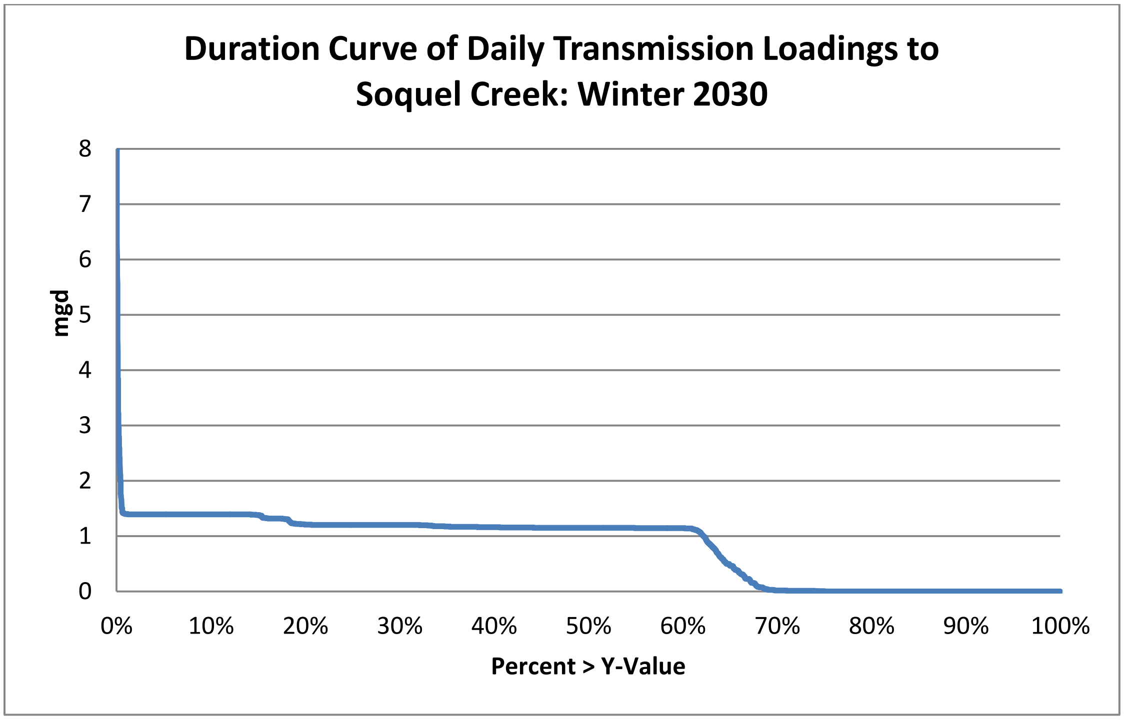


Figure 9


Duration Curve of Daily Transmission Loadings to Soquel Creek: Winter 2030
mgd
8
7
6
5
4
3
2
1
0
0%
10%
20%
30%
40%
50%
60%
70%
80%
90%
100%
Percent > Y-Value

Date: July 2, 2012
From: Gary Fiske
To: Linette Almond, John Ricker
Re: Water Transfer Project Long-Term Analysis Scenario 5: GHWTP Improvements

The final long-term scenario of the Water Transfer Project examines the impacts of improving the Graham Hill Water Treatment Plant (GHWTP) to allow it to treat more turbid water. This reduces the number of days on which the Tait Street diversion must be shut down, which in turn can improve the water supply reliability for Santa Cruz retail customers and also allow more water to be transferred to Scotts Valley and Soquel Creek. The purpose of the analysis reported on here is to estimate the magnitude of these impacts. (The improvements at GHWTP do not affect the North Coast; the turbidity constraints for those diversions remain unchanged due to the need to avoid frequent and disruptive flushes of the North Coast pipeline.)

Background

The Confluence model will shut down a diversion on days on which the water at that diversion is deemed to be too turbid. For modeling purposes, those days are defined as a function of rainfall. The current rule for Tait Street, as set forth in the IWP Update, is as follows:

> *On any day that the rainfall at the weather station exceeds 0.67 inches, the diversion is shut down on that day plus two additional days, or three days total.*

This rule is intended to not allow raw water with turbidity above 25 NTU, which is the limit of the current treatment process at GHWTP, to reach the plant. By changing treatment processes at Graham Hill Water Treatment Plant to membrane treatment, the plant could treat water with turbidity as high as several hundred NTU. This allows modification of the turbidity constraint at Tait Street to:

> *On any day that the rainfall at the weather station exceeds 1.25 inches, the diversion is shut down on that day plus 1 additional day, or two days total.*

This relaxation of the turbidity constraint reduces the average annual number of Tait shutdown days over the November-April period from 35 to 11.

To assess the degree to which this reduced number of shutdown days affects both Santa Cruz supply reliability and external water transfers, this Scenario 5 modifies the Tait Street turbidity constraint as above for our long-term Scenario 1, which includes no water right or infrastructure changes at Felton or Loch Lomond. We would expect the impact of the turbidity modification to be similar for the other long-term scenarios.

The Scotts Valley and Service Area 1 Soquel Creek demands are shown in **Error! Not a valid bookmark self-reference.**.

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Table 1. Assumed Monthly Demands (millions of gallons)

Month	Scotts Valley	Soquel Creek (SA1)
November	42.8	39.6
December	38.7	36.1
January	37.2	35.6
February	33.8	32.2
March	40.3	37.4
April	48.3	41.9
TOTAL	**241.1**	**222.7**

Impacts on City of Santa Cruz Reliability

Figure R-1 and Table R-1 show the small improvements in peak-season reliability to Santa Cruz customers due to the reduction in the number of turbidity turn-outs at Tait Street.

Figure R-1

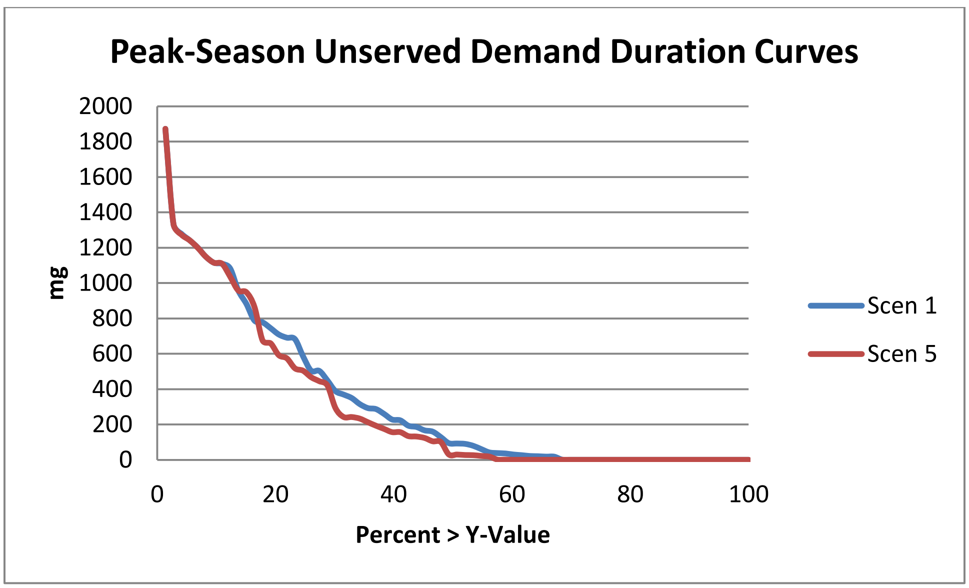


Table R-1. Comparison of Key Peak-Season 2030 Reliability Indicators

	Scen 1	Scen 5
Expected PS Shortage (mg)	327	296
Likelihood of PS Shortage:		
Likelihood of 5% PS Shortage	48%	45%
Likelihood of 15% PS Shortage	31%	29%
Likelihood of 25% PS Shortage	24%	20%

Averages and Distributions of Water Transfer Volumes

Table 2 compares the Scenario 5 2030 monthly and annual average Scotts Valley and Soquel Creek transfers across all hydrologic years to the corresponding transfers under Scenario 1. The Scenario 5 transfers are about 30 mg higher. Table 3 shows the average annual transfers for each hydrologic year type.

Figure 1 shows the duration curves across all hydrologic years for the Scenario 5 annual transfers, and Figures 2-5 show the transfer duration curves for each year type.

Table 2. 2030 Monthly Average Transfers Across All Hydrologic Years (millions of gallons)

Month	Scotts Valley Transfer Volume		Soquel Creek Transfer Volume		Total Transfer Volume	
	Scen 1	**Scen 5**	**Scen 1**	**Scen 5**	**Scen 1**	**Scen 5**
November	21.4	23.9	6.0	6.9	27.4	30.9
December	11.9	17.3	5.5	6.8	17.4	24.1
January	14.0	20.0	8.5	10.2	22.5	30.1
February	15.9	20.1	10.6	12.6	26.5	32.7
March	23.6	26.6	15.0	16.9	38.6	43.5
April	25.0	26.6	10.0	10.6	35.0	37.2
TOTAL	**111.8**	**134.6**	**55.6**	**64.0**	**167.4**	**198.6**

Table 3. 2030 Annual Average Transfers by Hydrologic Year Type (mg)

Year Type	Scotts Valley		Soquel Creek		Total	
	Scen 1	**Scen 5**	**Scen 1**	**Scen 5**	**Scen 1**	**Scen 5**
Critically Dry	74.5	82.6	30.7	34.2	105.2	116.8
Dry	87.7	102.7	31.4	36.9	119.1	139.6
Normal	127.9	151.5	58.2	65.9	186.1	217.4
Wet	125.3	157.8	76.7	89.3	202.0	247.1
Average	**111.8**	**134.6**	**55.6**	**64.0**	**167.4**	**198.6**

Figure 1

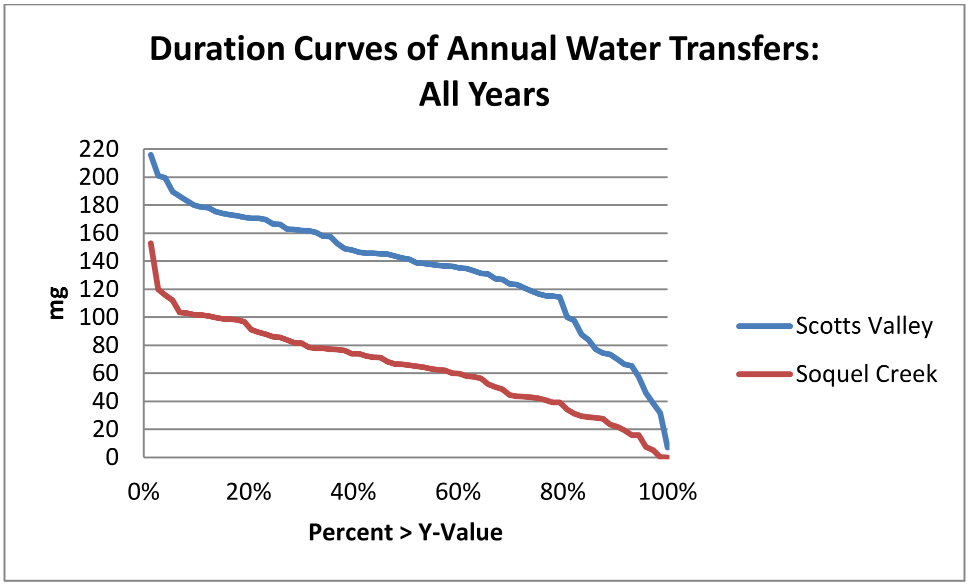


Figure 2

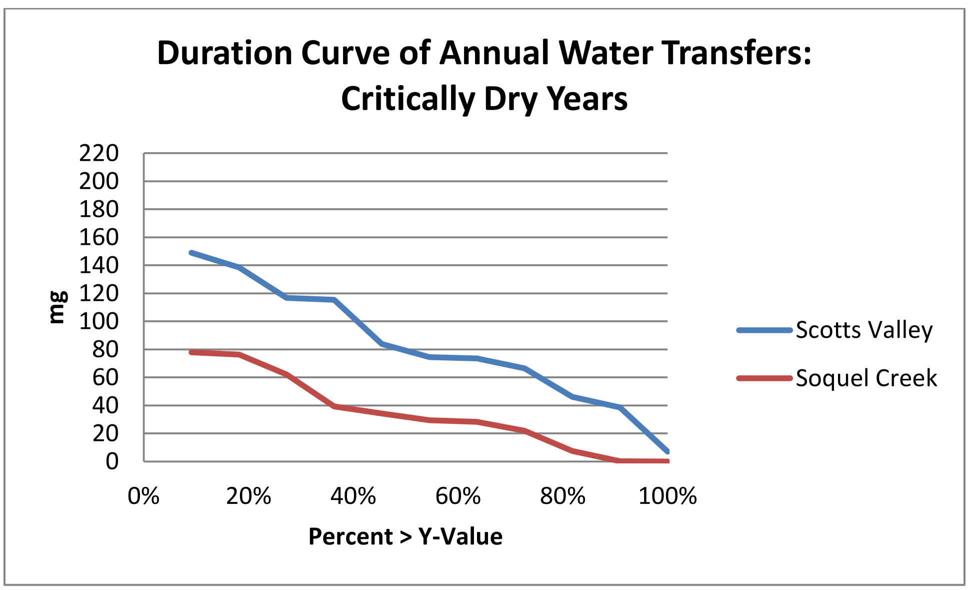


Figure 3

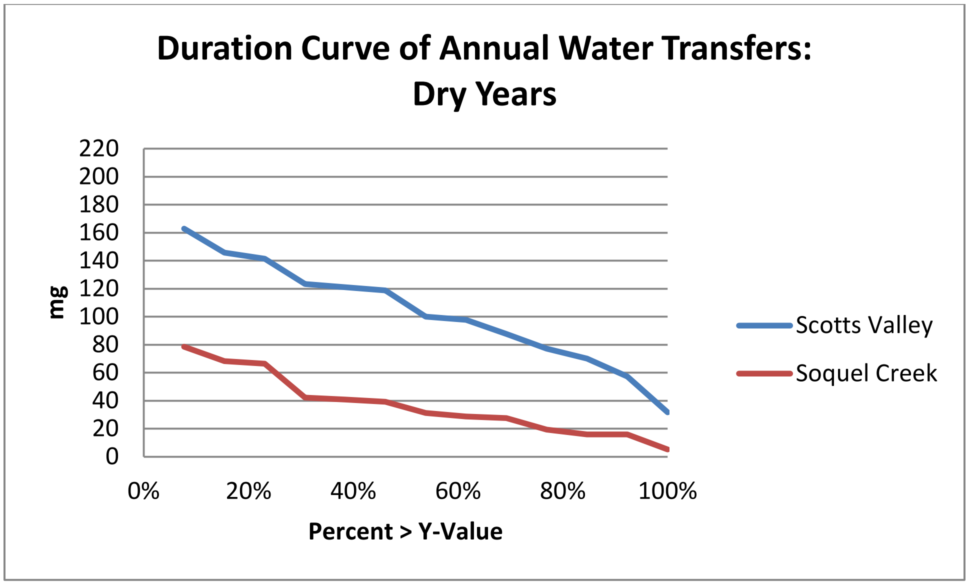


Figure 4

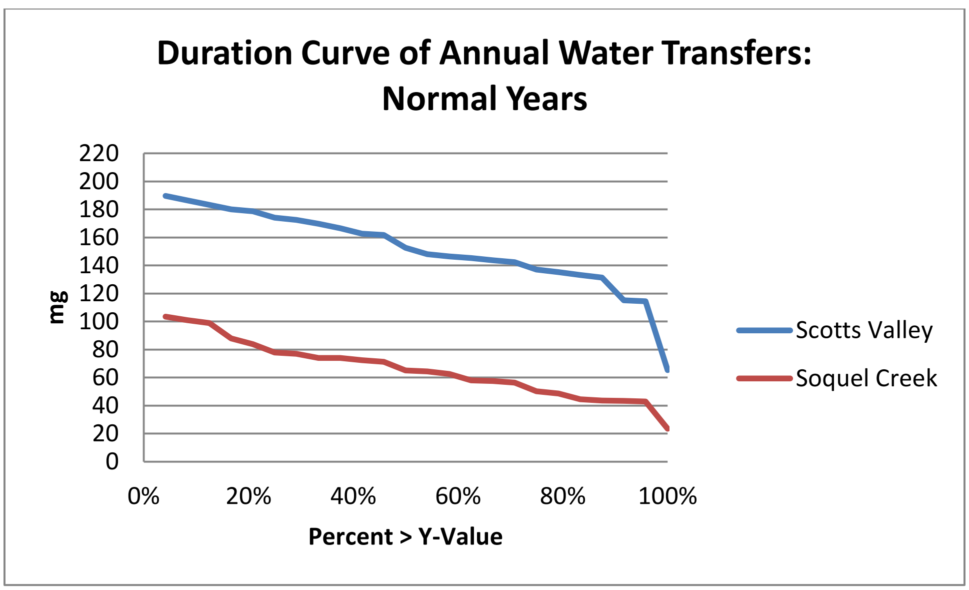
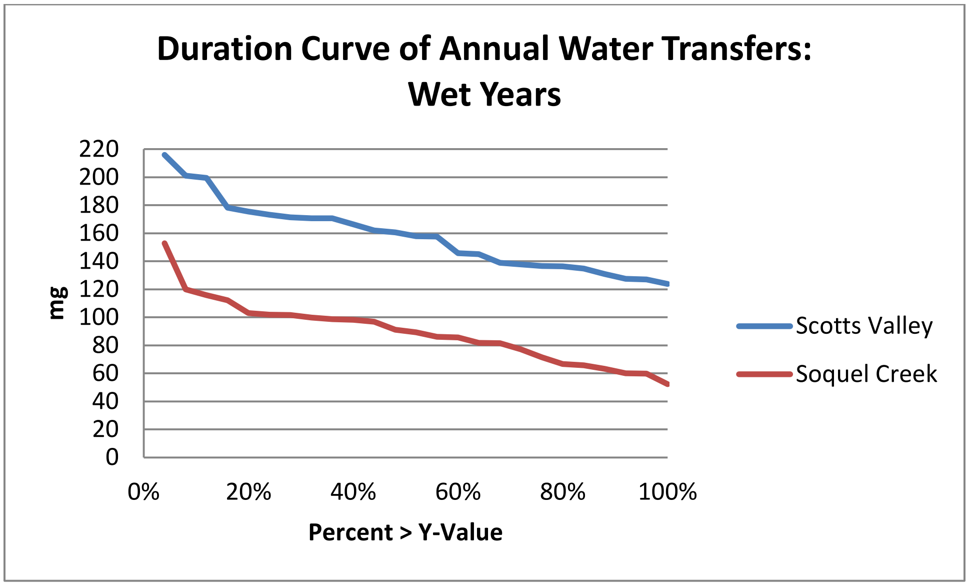


Figure 5



Source Production

Table 4 shows the monthly average added production at Tait Street required to serve Scotts Valley and Soquel Creek demands.

Table 4. 2030 Monthly Average Added Production at Tait Street to Serve Scotts Valley and Soquel Creek (millions of gallons)

Month	Base	With Transfers		Added Production	
		Scen 1	Scen 5	Scen 1	Scen 5
November	157.9	181.1	186.0	23.1	28.1
December	158.4	174.1	182.5	15.7	24.1
January	158.6	180.3	188.7	21.7	30.1
February	134.3	160.2	167.0	25.9	32.7
March	151.2	189.8	194.7	38.5	43.5
April	173.5	208.0	210.7	34.6	37.2
TOTAL	**933.9**	**1093.5**	**1129.7**	**159.6**	**195.8**

Surplus Supply

Given these production levels, how much surplus supply is there available at Tait Street to potentially meet other external demands? For our purposes, surplus supply on any day is defined as:

> *The excess of the maximum potential Tait Street diversion over the volume that has already been diverted to meet Santa Cruz, Scotts Valley, and Soquel Creek demands. The maximum potential diversion is the minimum of the available flow at Tait Street and the capacity of the Tait Street*

diversion (11.52 cfs). On days when there are no turbidity constraints at Tait St., the available flow at Tait Street is the Tier 3 Big Trees flow less the diversion at Felton plus the tributary inflows between Felton and Tait Street. On days when Tait St. is shut down due to turbidity, the Tait St. available flow is zero.

Based on this definition, Table 5 shows the expected November-April surplus supply. Because of the additional days of Tait Street operation, the Scenario 5 surplus is 25% larger than Scenario 1.

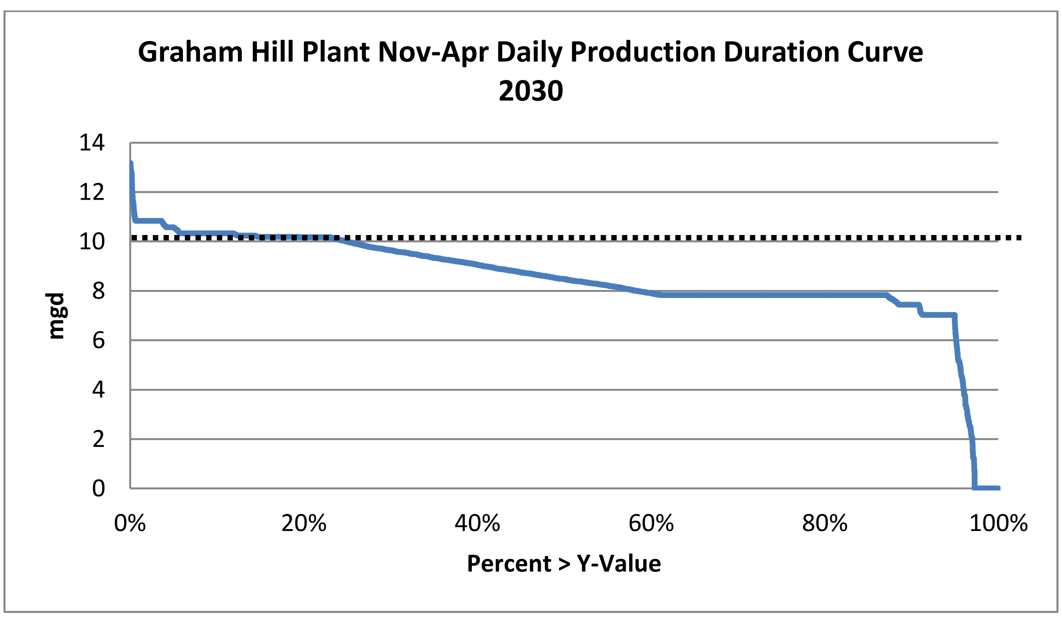
Table 5. Expected 2030 November-April Surplus Supply at Tait Street (millions of gallons)

Year Type	Surplus Supply	
	Scen 1	**Scen 5**
Critically Dry	14	16
Dry	18	22
Normal	44	55
Wet	83	103
Average	**48**	**60**

Treatment Plant Capacity Requirements

Figure 6 shows the Scenario 5 duration curve of Graham Hill treatment plant production required to accomplish the transfers depicted in the tables and charts above. The chart shows that treatment plant usage exceeds the current 10 mgd capacity on 25% of days. Constraining the plant capacity to this level would reduce the total 199 mg average annual transfer shown in Table 2 by about 9% to 182 mg. Put another way, an investment in treatment plant expansion would, at most, result in additional average annual transfers of about 17 million gallons.

Figure 6



Transmission Capacity Requirements

Figure 7 shows the Scenario 5 duration curve for the required transmission capacity to move water from the treatment plant to yield the combined transfer volumes discussed above. Figure 8 shows the duration curve for the required transmission capacity to Scotts Valley, while Figure 9 shows the required capacity to Soquel Creek.

Figure 7

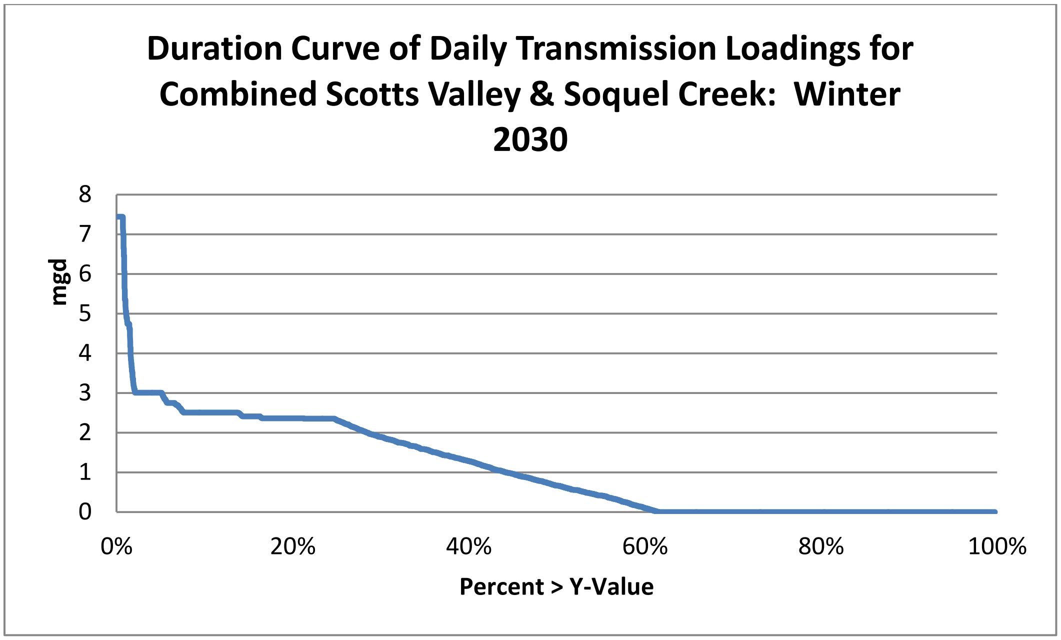


Figure 8

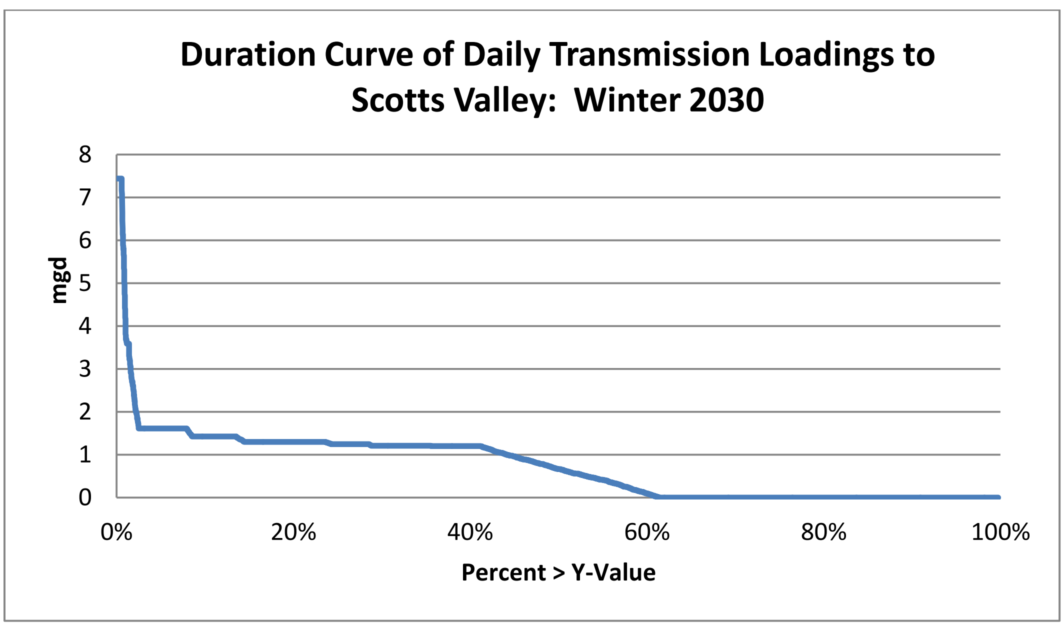
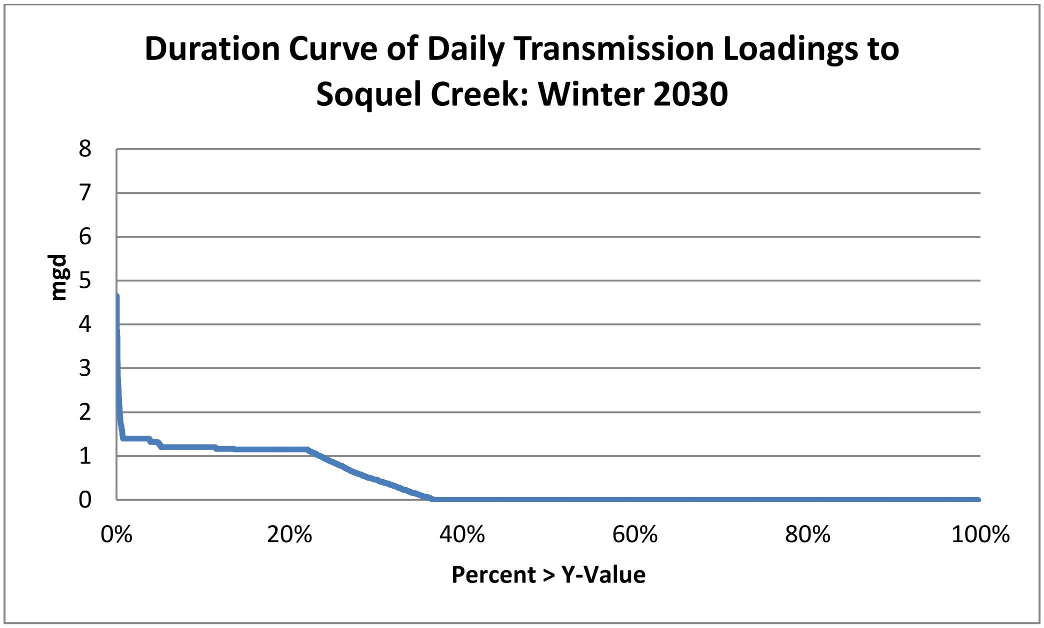


Figure 9



Additional Improvements at GHWTP

By adding two pretreatment processes to the membrane process in order to handle higher organic loads, GHWTP could possibly be upgraded to treat turbidity up to 1000 NTU. This would further relax the turbidity constraint at Tait Street to:

> *On any day that the rainfall at the weather station exceeds 2 inches, the diversion is shut down on that day only.*

While this rule further reduces the number of turbidity days at Tait Street, on all of those days, the North Coast streams would be shut down. All Tait capacity would therefore be needed to meet Santa Cruz demands, so no additional transfers to Scotts Valley or Soquel Creek could be made. The transfer volumes therefore remain unchanged, as do the surplus volumes.

G A R Y F I S K E A N D A S S O C I A T E S , I N C .
W a t e r R e s o u r c e s P l a n n i n g a n d M a n a g e m e n t

Date: June 27, 2013
From: Gary Fiske
To: Linette Almond, John Ricker
Re: Water Transfer Phase 2 Summary

This memorandum presents tables and charts that compare the volumes that can be transferred to Scotts Valley and Soquel Creek under each of the scenarios analyzed in Phase 2. Recall that Phase 2 assumes that the total Soquel Creek demand for all service areas could potentially be served by transferred water.

Specifically, the following infrastructure/water rights scenarios are compared:

- Current infrastructure and water rights
    - With current and unlimited GHWTP capacity
- GHWTP improvements to treat more turbid supplies (current water rights)
    - With current and unlimited GHWTP capacity
- Unconstrained Tait St. capacity and water rights, with unlimited transmission and GHWTP capacity

Table 1 compares the expected annual transfer volumes across scenarios.

Table 1. Comparison of Expected Annual Transfer Volumes (mg)

Scenario	GHWTP Capacity	Scotts Valley	Soquel Creek	Total
1a. Current Infrastructure/ Water Rights	**Current (10 mgd)**	106	39	**145**
	Unlimited	108	95	**204**
5a. GHWTP Improvements to Treat 200 ntu Water	**Current (10 mgd)**	123	55	**178**
	Unlimited	124	136	**260**
Unconstrained Tait St. Capacity	**Unlimited**	154	333	**488**

The table tells us that improving the treatment process at Graham Hill to treat more turbid water has the potential to increase transfers to Soquel Creek by about 40% (either with the current assumed 10 mgd plant capacity or with expanded capacity).

The table also shows that the current 10 mgd plant capacity limits transfers and that augmenting that capacity can increase the expected annual transfer to Soquel Creek by a factor of almost 2.5, with or without treatment process improvements. (Transfers to Scotts Valley are little affected by either treatment plant improvements or capacity expansion.)

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When the capacities of both the Tait Street diversion and the treatment plant are unconstrained, the expected transfer to Soquel Creek is even more substantially increased (by a factor of about 8.5).[1]

Figures 1 and 2 show the distributions of annual transfers to each district over the 73 hydrologic years, assuming unconstrained treatment plant capacity.

Figure 1

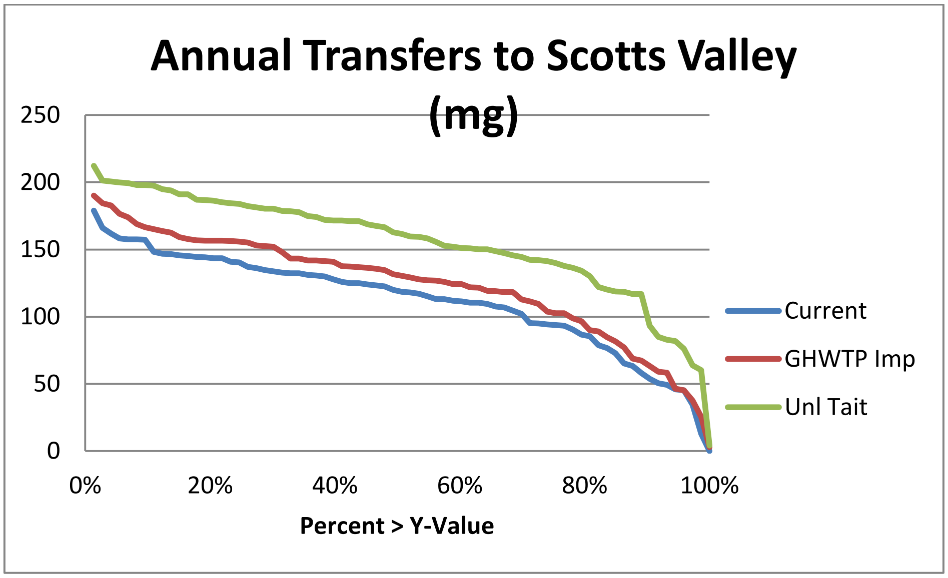
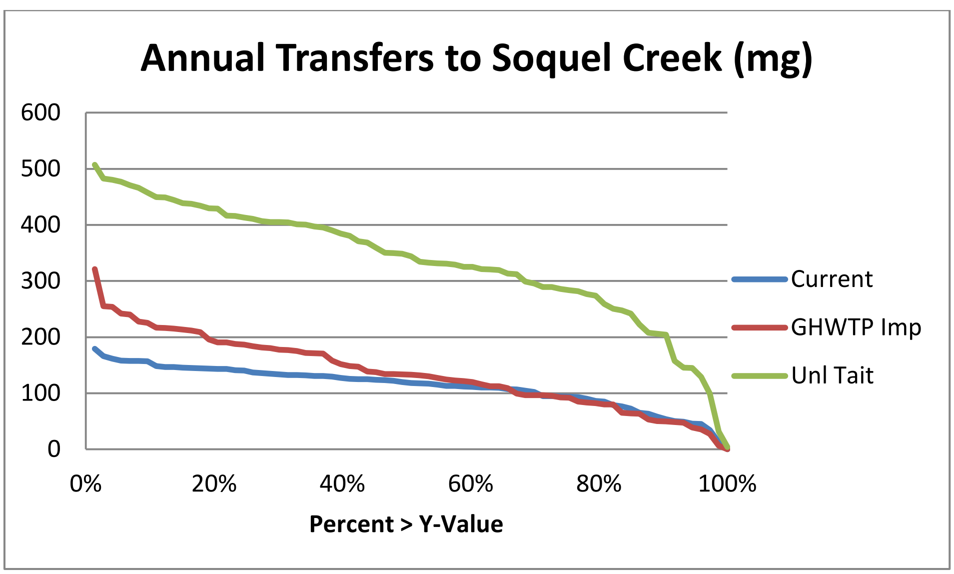


Figure 2



[1] We did not analyze the case in which Tait Street capacity was increased and GHWTP was simultaneously upgraded to treat more turbid water.

G A R Y F I S K E A N D A S S O C I A T E S , I N C .
W a t e r R e s o u r c e s P l a n n i n g a n d M a n a g e m e n t

Date: May 22, 2013
From: Gary Fiske
To: Linette Almond, John Ricker
Re: Phase 2 Water Transfer Analysis: Task 1 Results (Second Revision)

INTRODUCTION

Phase 2 of the analysis of potential water transfers from the Santa Cruz system to Scotts Valley and Soquel Creek assumes that, rather than limiting the Soquel Creek demand that could be served by such transfers to Service Area 1, we will assume that the total Soquel Creek demand for all service areas could potentially be served by transferred water. Task 1 calls for the analysis of two infrastructure/ water rights configurations, corresponding to two of the cases analyzed in Phase 1:

- 1a. Current infrastructure and water rights.
- 5a. GHWTP improvements to treat more turbid water.

Aside from the higher Soquel Creek demands, all other Phase 2 assumptions are the same as Phase 1, with the exception of the specification of the turbidity constraint at Tait Street in Scenario 5a. Based on analysis done by Santa Cruz Water Department staff since the Phase 1 report regarding reasonable turbidity constraints, the parameters at Tait Street are set to approximate a 200 ntu turnout threshold.

Discussion of the results and relevant comparisons to the Phase 1 results follow.

DEMANDS

Table 1 shows the assumed monthly demands for the two districts, and compares the Soquel Creek demands to those used in Phase 1. In this and all tables, figures are in millions of gallons.

Table 1. Assumed Monthly Demands (millions of gallons)

Month	Scotts Valley	Soquel Creek Phase 2	Soquel Creek Phase 1
November	42.8	99.2	39.6
December	38.7	93.4	36.1
January	37.2	92.2	35.6
February	33.8	81.5	32.2
March	40.3	98.6	37.4
April	48.3	116.9	41.9
TOTAL	**241.1**	**581.8**	**222.7**

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TRANSFER VOLUMES

Base Case

Tables 2 and 3 compare the monthly average transfers for the Base Case scenarios in Phases 1 and 2.

Table 2. 2030 Monthly Average Transfers Across All Hydrologic Years: Base Case (mg)

Month	Scotts Valley		Soquel Creek		Total	
	Phase 1	Phase 2	Phase 1	Phase 2	Phase 1	Phase 2
November	19.0	19.0	6.0	5.8	25.0	24.8
December	11.5	11.5	5.5	8.1	17.0	19.6
January	13.6	13.6	8.5	14.5	22.1	28.1
February	17.0	17.0	10.6	22.3	27.6	39.3
March	22.8	22.8	15.0	27.8	37.8	50.6
April	25.0	25.0	10.0	16.4	35.0	41.4
TOTAL	**108.9**	**108.9**	**55.6**	**94.9**	**164.5**	**203.7**

Table 3. 2030 Annual Average Transfers by Hydrologic Year Type: Base Case (mg)

Year Type	Scotts Valley		Soquel Creek		Total	
	Phase 1	Phase 2	Phase 1	Phase 2	Phase 1	Phase 2
Critically Dry	70.6	70.6	30.7	41.3	101.3	111.9
Dry	85.1	85.1	31.4	45.9	116.5	131.0
Normal	125.1	125.1	58.2	94.3	183.3	219.4
Wet	122.5	122.5	76.7	144.4	199.2	266.9
AVERAGE	**108.9**	**108.9**	**55.6**	**94.9**	**164.5**	**203.7**

Figures 1-5 show the duration curves by year type for the Base Case transfer volumes.

Figure 1

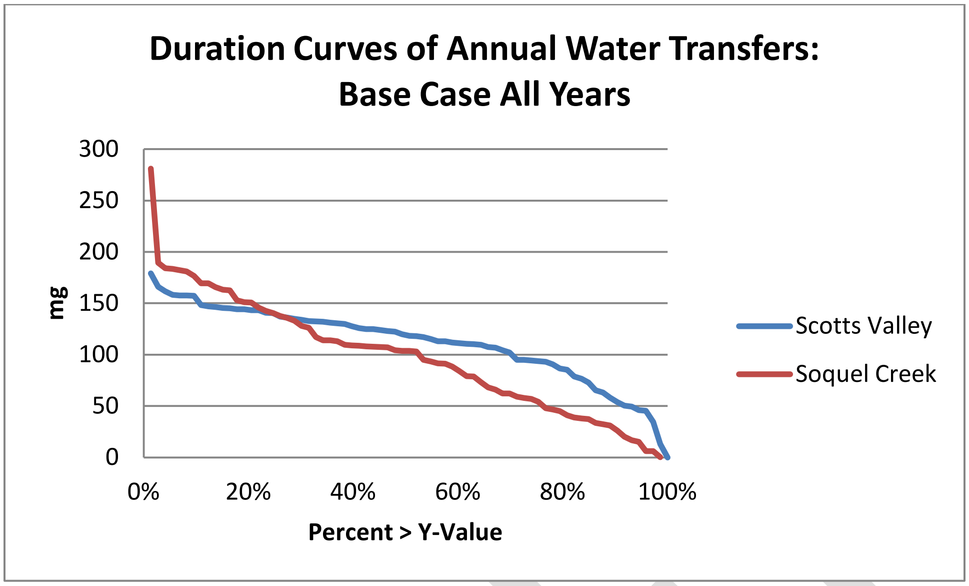


Figure 2

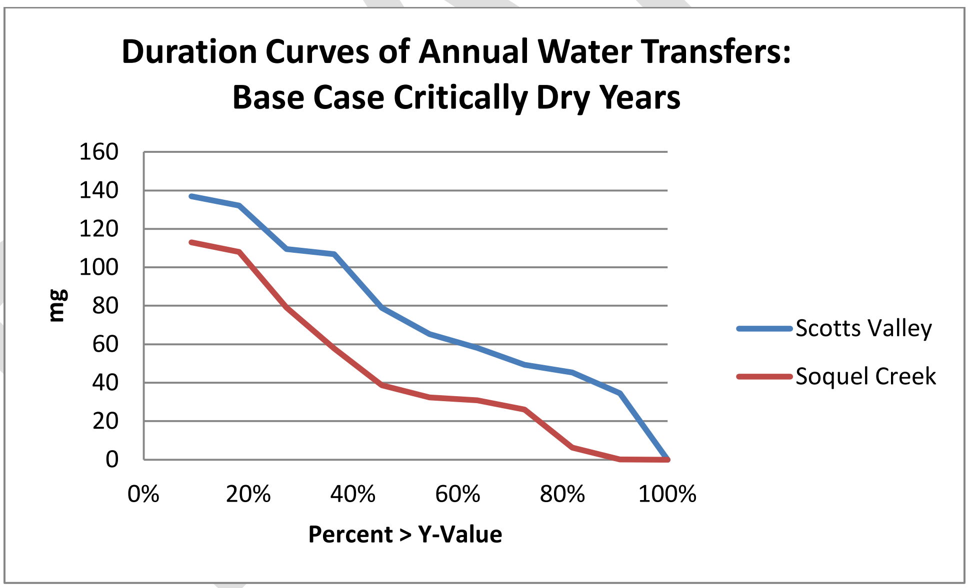


Figure 3

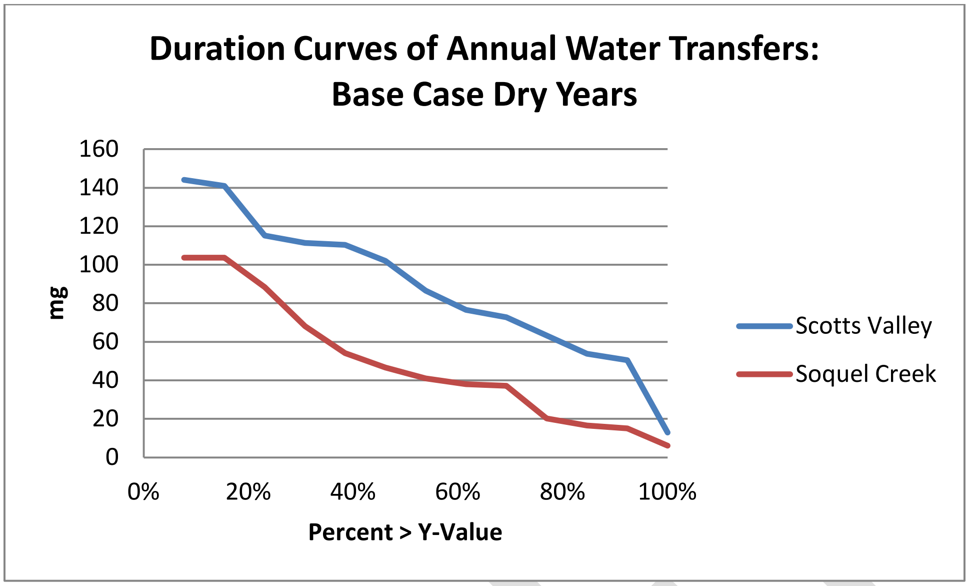


Figure 4

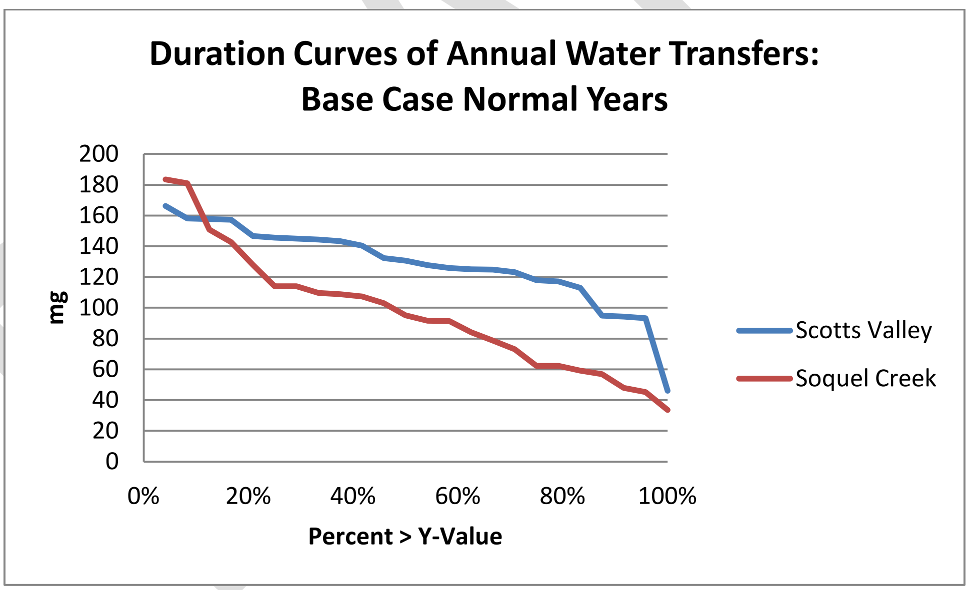
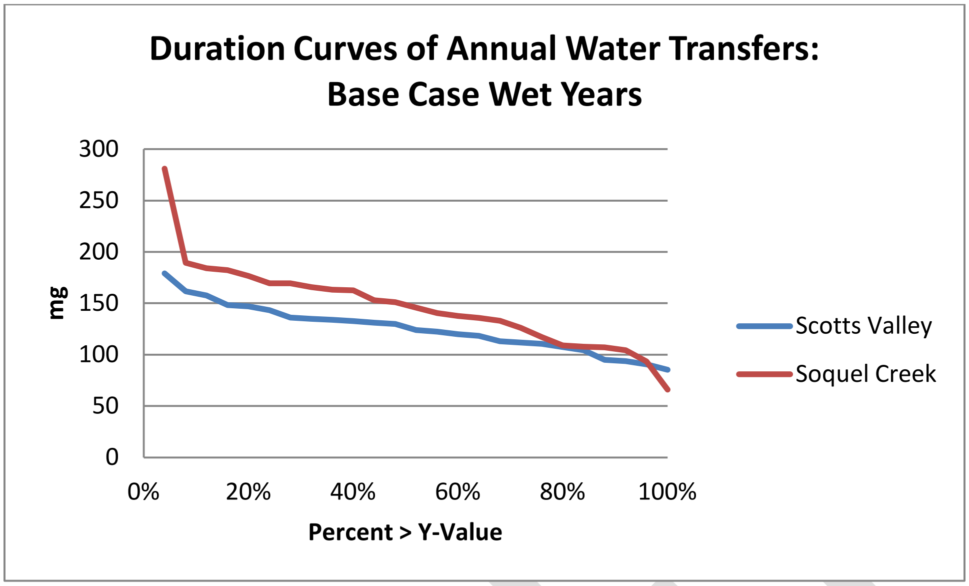


Figure 5



GHWTP Improvements

Tables 4 and 5 compare the monthly average transfers for the Graham Hill treatment plant improvement scenarios in Phases 1 and 2.

Table 4. 2030 Monthly Average Transfers Across All Hydrologic Years: GHWTP Improvements (mg)

Month	Scotts Valley Transfer Volume		Soquel Creek Transfer Volume		Total Transfer Volume	
	Phase 1 [1]	Phase 2	Phase 1	Phase 2	Phase 1	Phase 2
November	20.3	20.4	6.5	13.1	26.8	33.5
December	13.8	14.2	7.3	14.9	21.1	29.1
January	16.3	16.4	10.5	21.7	26.8	38.1
February	17.9	18.4	12.4	27.5	30.3	45.9
March	25.8	27.4	16.8	38.5	42.6	65.9
April	26.2	26.8	10.6	20.8	36.8	47.6
TOTAL	**120.3**	**123.6**	**64.2**	**136.5**	**184.4**	**260.1**

[1] The Phase 1 results have been revised to be consistent with methodological changes made in Phase 2.

Table 5. 2030 Annual Average Transfers by Hydrologic Year Type: GHWTP Improvements (mg)

Year Type	Scotts Valley		Soquel Creek		Total	
	Phase 1	Phase 2	Phase 1	Phase 2	Phase 1	Phase 2
Critically Dry	75.5	79.0	33.1	66.8	108.6	145.7
Dry	93.2	98.6	36.8	87.0	130.0	185.7
Normal	136.8	140.9	66.5	135.7	203.3	276.6
Wet	138.2	139.6	89.7	193.8	227.9	333.4
AVERAGE	**120.3**	**123.6**	**64.2**	**136.5**	**184.4**	**260.1**

Figures 6-10 show the duration curves by year type for the transfer volumes with the GHWTP improvements.

Figure 6

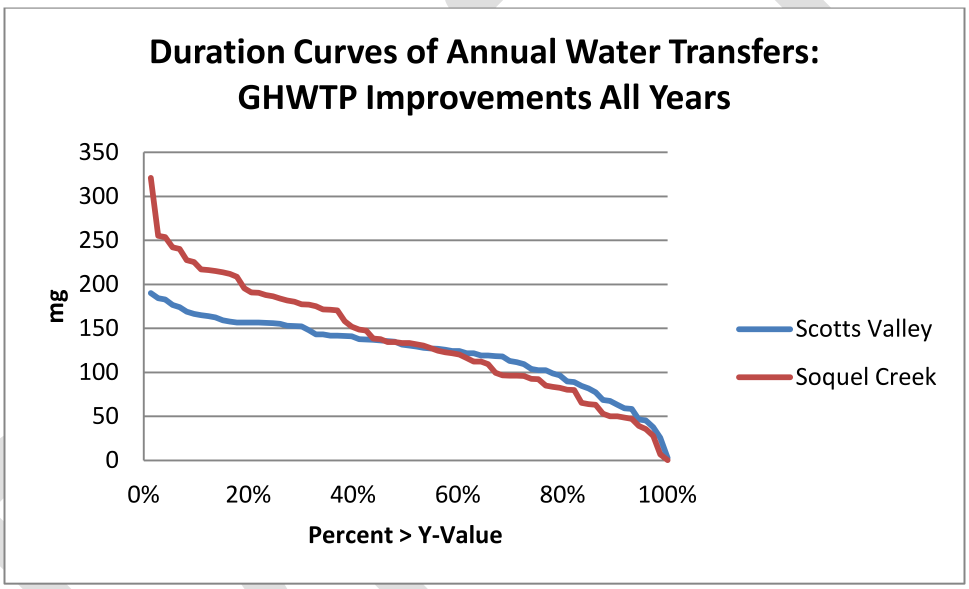


Figure 7

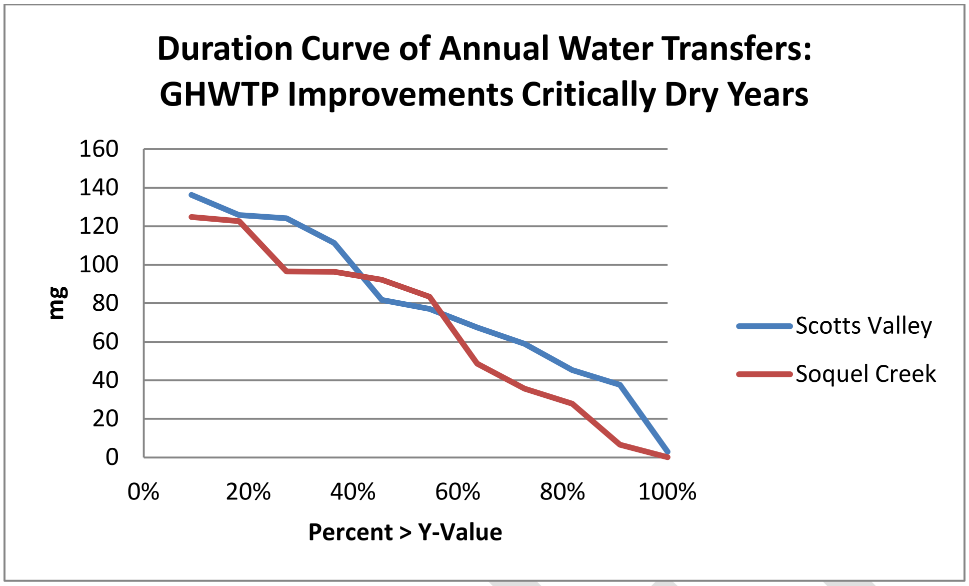


Figure 8

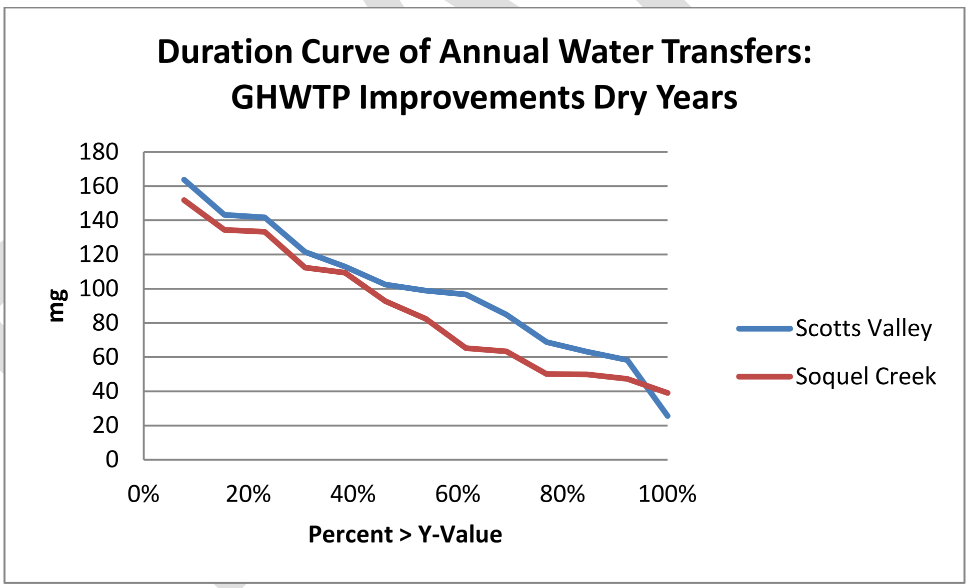


Figure 9

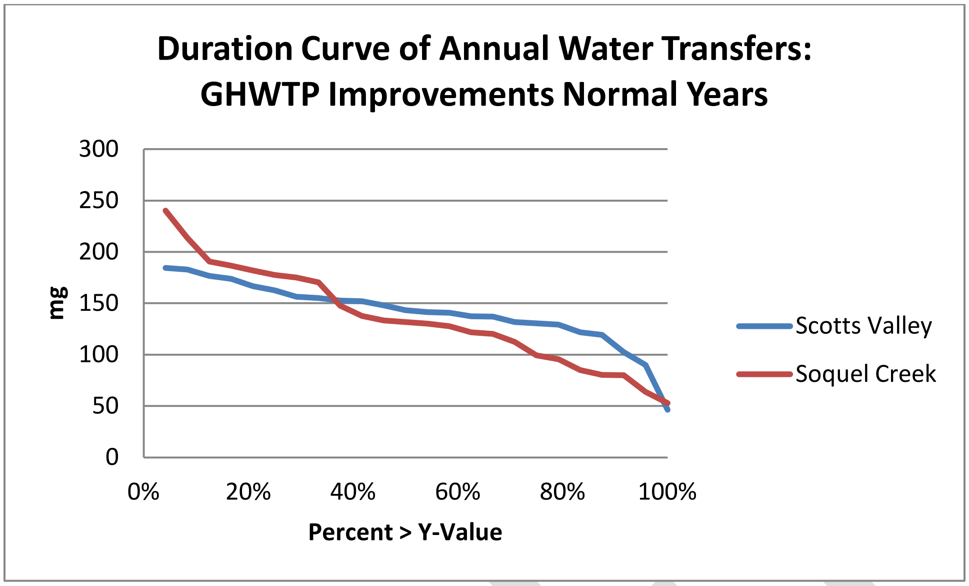
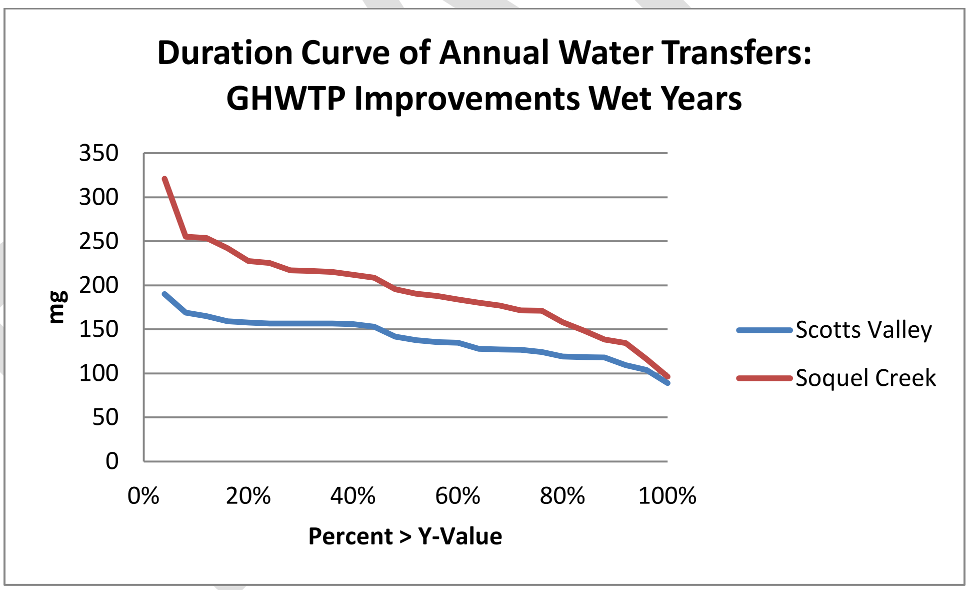


Figure 10



SOURCE PRODUCTION

Table 6 compares the combined expected Tait Street monthly production to the expected production without any transfers.

Table 6. Combined Expected Monthly Tait Street Production (mg)

Month	Without Transfers	With Transfers	
		Base Case (Scen 1a)	GHWTP Imp (Scen 5a)
November	141	166	174
December	127	148	156
January	126	155	165
February	107	143	153
March	121	173	187
April	152	194	200
TOTAL	**775**	**979**	**1035**
INCREMENT	**--**	**204**	**260**

TREATMENT PLANT CAPACITY REQUIREMENTS

Figures 11 and 12 show the duration curves of the Graham Hill treatment plant production required to serve Santa Cruz demand and accomplish the combined transfers to both districts depicted in the tables and charts above.

Figure 11

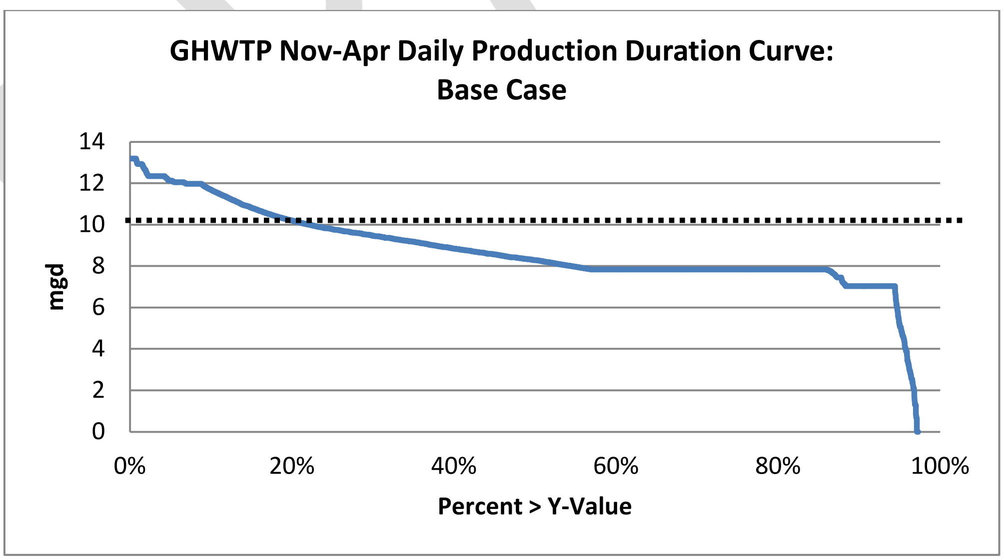


Figure 12

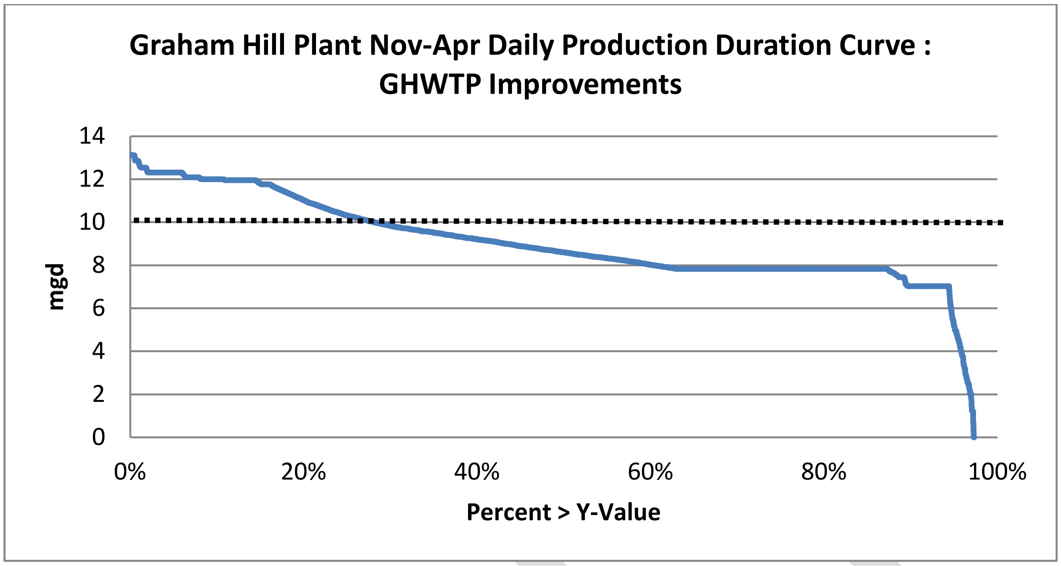


Table 7 shows the percentage of days that the current 10 mgd winter plant capacity limits transfers and the expected volume reduction in the annual combined transfer to the two districts due to this capacity limitation.

Table 7. Impacts of Current GHWTP Capacity on Potential Transfer Volumes

Scenario	Percentage of Days Exceeding 10 mgd	Expected Reduction in Expected Annual Transfer	
		Volume (mg)	Percentage of Potential Transfer
Base	22%	59	28%
GHWTP Improvements	28%	82	31%

The current assumed 10 mgd winter capacity of the treatment plant significantly limits the ability to transfer water to the districts.

TRANSMISSION CAPACITY REQUIREMENTS

Base Case

Figure 13 shows the duration curve for the transmission loadings to move water from the treatment plant to yield the combined transfer volumes discussed above for the Base Case. Figure 14 shows the duration curve for the transmission loadings to Scotts Valley, while Figure 15 shows the loadings to Soquel Creek.[2]

Figure 13

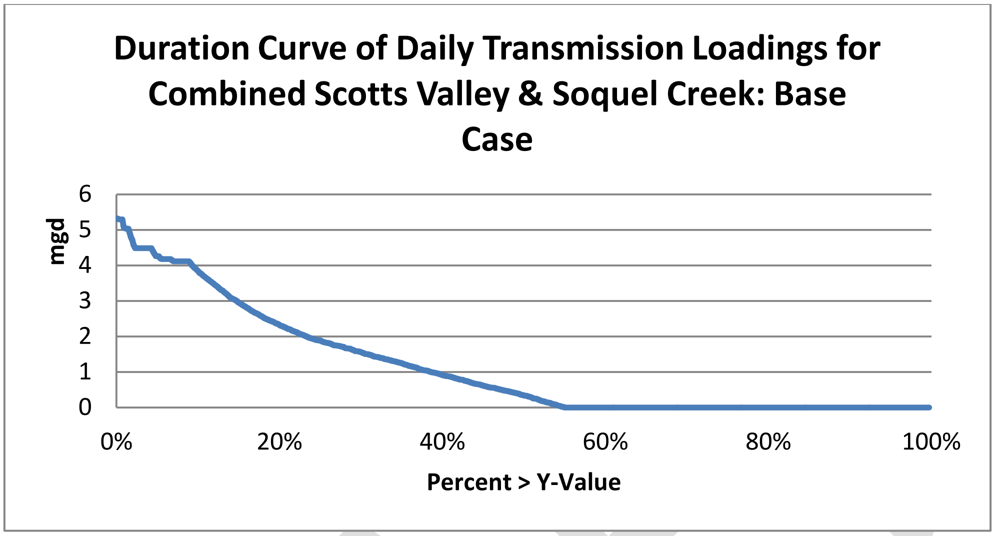
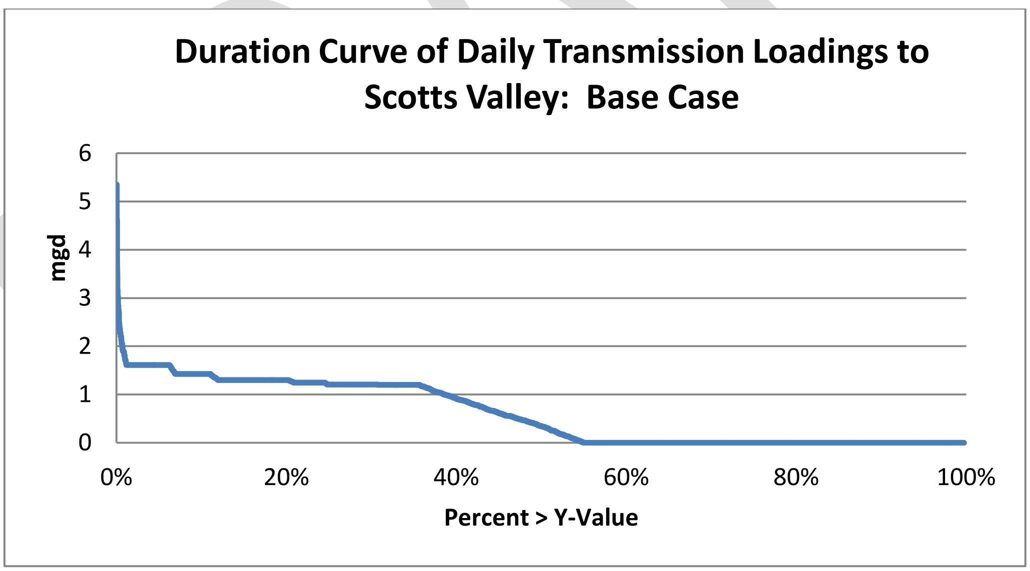


Figure 14



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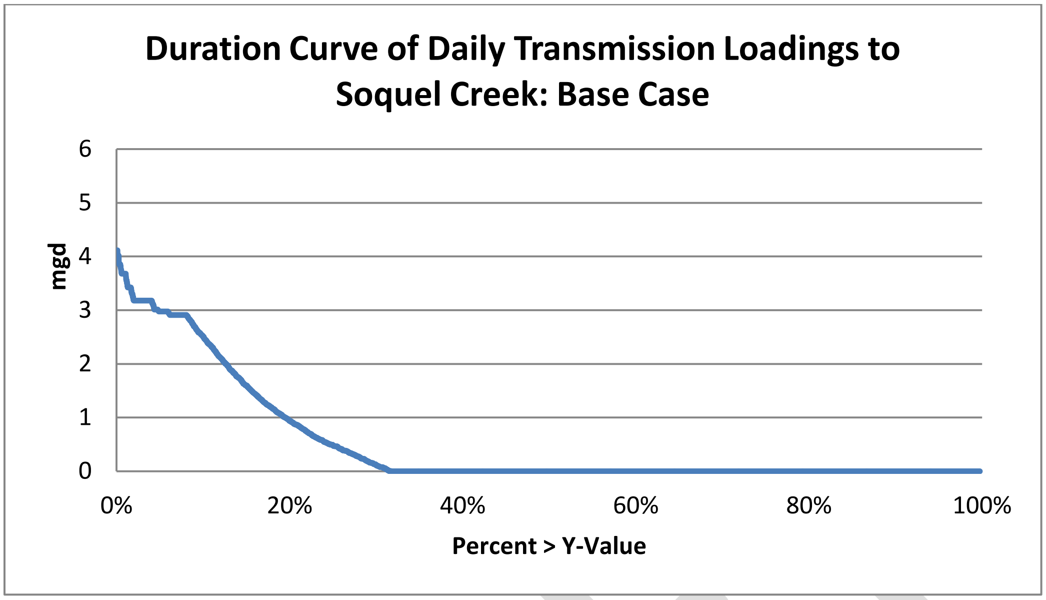
[2] The duration curve in Figure 13 is less than the sum of the two district-specific curves due to the non-coincidence of the daily demands.

Figure 15



GHWTP Improvements

Figure 16 shows the duration curve for the transmission loadings to move water from the treatment plant to yield the combined transfer volumes discussed above for the case of GHWTP improvements. Figure 17 shows the duration curve for the transmission loadings to Scotts Valley, while Figure 18 shows the loadings to Soquel Creek.

Figure 16

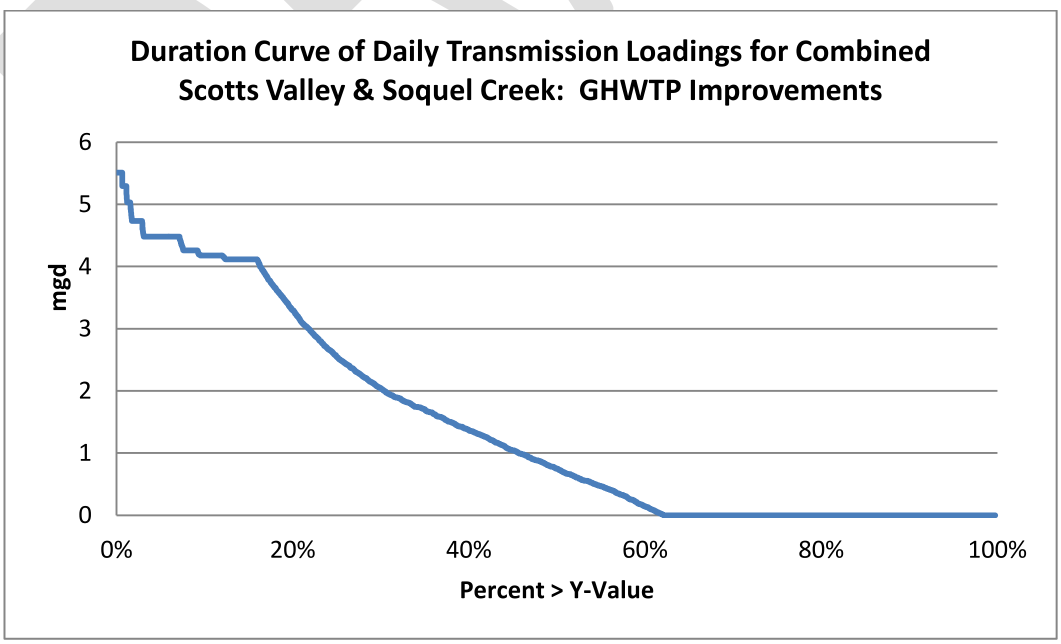


Figure 17

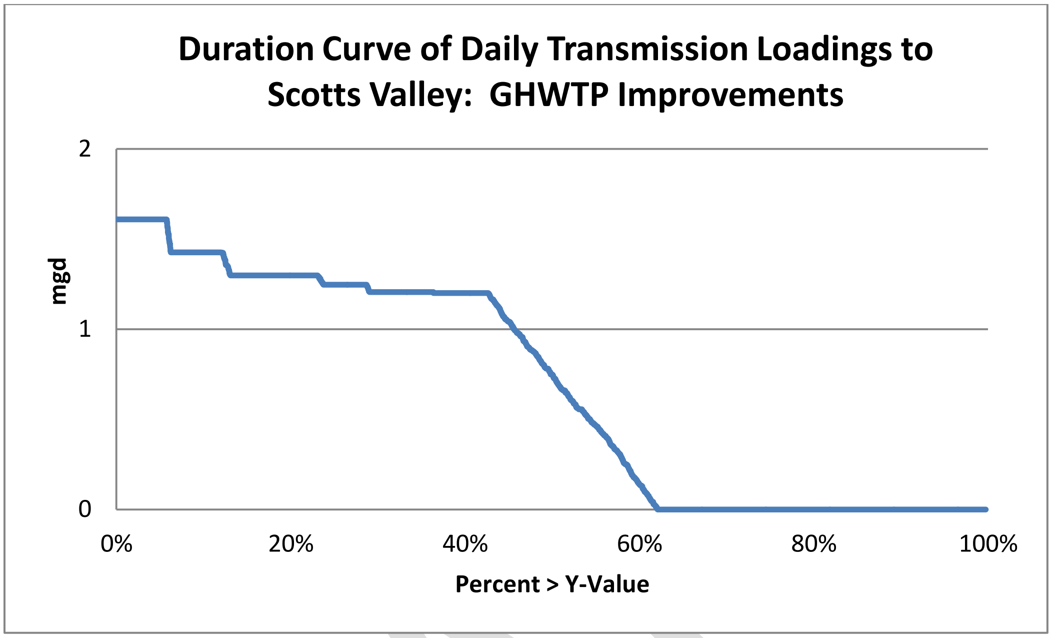
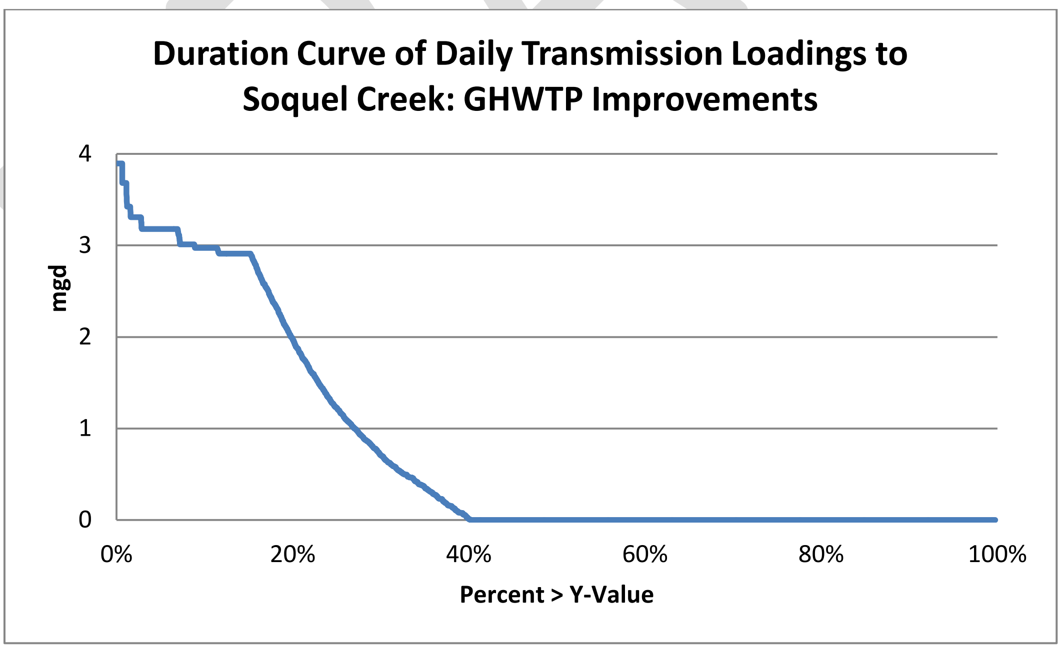


Figure 18



GARY FISKE AND ASSOCIATES, INC.
Water Resources Planning and Management

Date: February 12, 2014
From: Gary Fiske
To: Kevin Crossley
Cc: Heidi Luckenbach
Re: Volumetric Shortage Analysis for Water Transfer Project

As we discussed, this memorandum contains charts and tables that specify the distributions of total volumetric peak-season shortages. Consistent with the earlier short-term analysis, these distributions assume Tier 3 flows, current infrastructure, and 3500 MG annual demand.

Table 1 shows the peak-season shortage for the 25 hydrologic years for which there is any shortage. All of the other hydro years show a zero peak-season shortage.

Figure 1 shows the corresponding peak-season shortage duration curve over all years and Figure 2 depicts the shortages in these 25 years.

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Table 1. Volumetric Peak-Season Shortages

Hydro Year	Peak Season Shortage (MG)
1977	1,580
1976	1,100
1988	1,045
1961	1,009
1991	897
1972	878
1992	874
1990	807
1989	730
1939	680
1987	633
1994	431
2009	387
1981	373
2008	373
1947	294
1966	261
1962	249
1948	240
1960	193
1964	182
1993	72
1986	61
1971	57
1949	5
All other yrs	0
Mean over all years	**184**

Figure 1. Peak-Season Shortage Duration Curve Over All Hydrologic Years

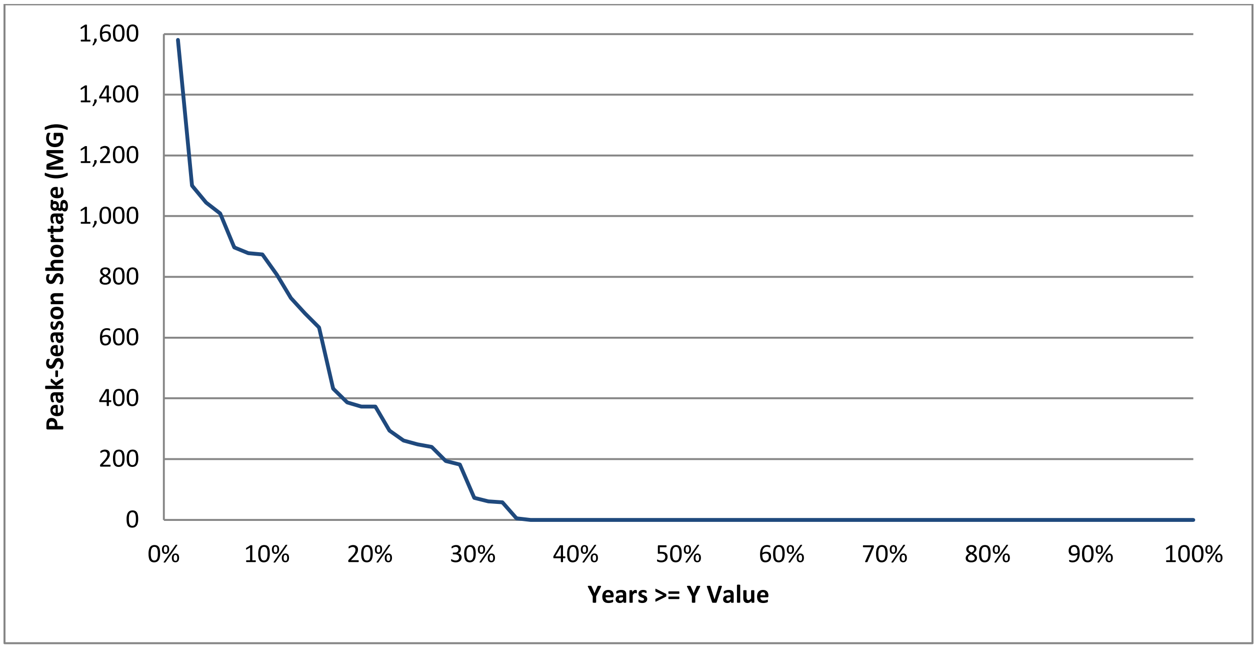
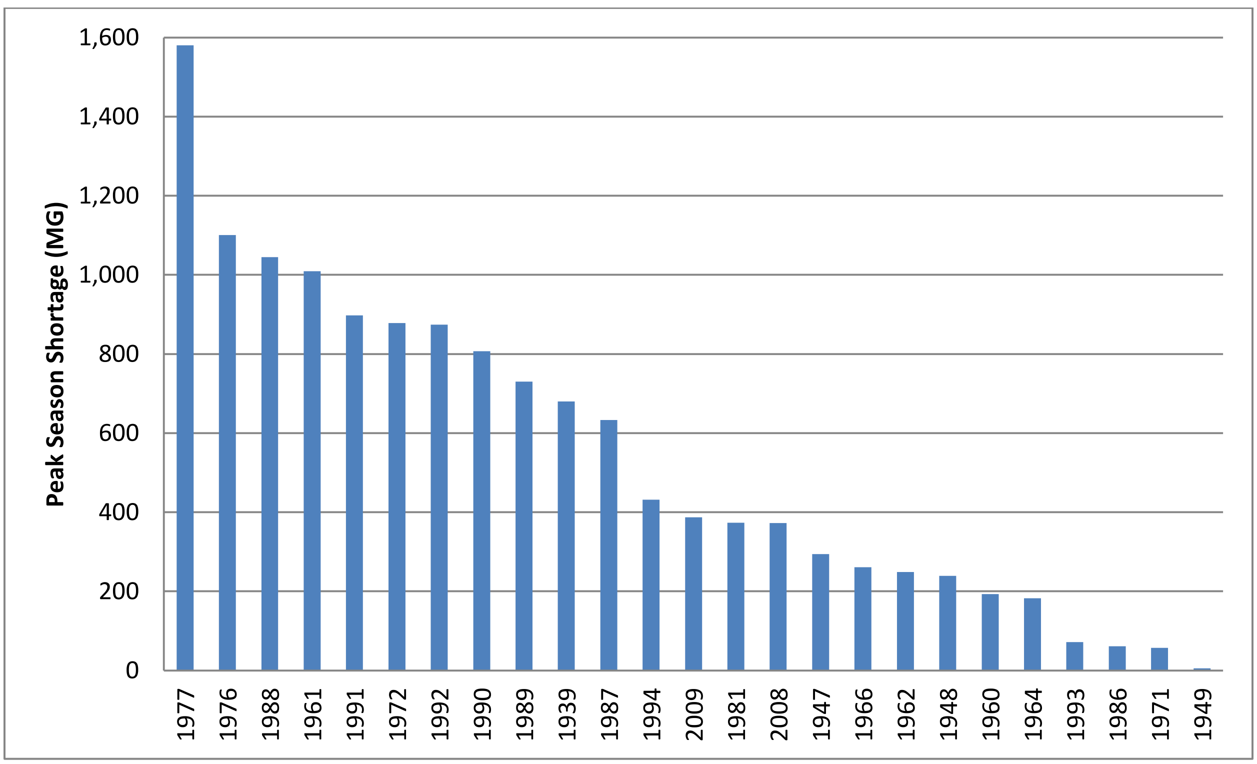


Figure 2. Hydrologic Years with Non-Zero Peak Season Shortages



City of Santa Cruz Water Department

and

Soquel Creek Water District

INTERTIE CAPACITY ANALYSIS

FINAL

February 19, 2014

AKEL ENGINEERING GROUP, INC.

Table 1 Intertie Analysis Results

Existing City / District Intertie Capacities

City of Santa Cruz Water Department / Soquel Creek Water District

Assumptions

Analysis Scenarios: Run No.	Run Description	Demand Condition	City: Existing Demands (MGD)	City Supply Sources: GHWTP (MGD)	Beltz Wells (MGD)	Transfer Pump from District	Total Available Supply (MGD)	District: Existing Demands (MGD)	Total Demand in SA1 and SA2	Active Wells - SA 1: New Cunnison Lane (Y/N)	Garnet (Y/N)	Main Street (Y/N)	New O'Neill Ranch (Y/N)	Rosedale (Y/N)	Tannery II (Y/N)	Active Wells - SA 2: Aptos Creek (Y/N)	New Austrian Way Tank Site (Y/N)	Estates (Y/N)	New Granite Way (Y/N)	Ledyard (Y/N)	Madeline (Y/N)	T. Hopkins (Y/N)	McGregor Pump Station Active (SA1 to SA2) (Y/N)
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24
Transfer from City to District																							
1-1		Min Month (Nov. - April)	6.8	6.8	0	0	6.8	3.2	1.48	-	Y	Y	Y	Y	N	N	-	N	-	Y	N	N	Y
1-2		Min Month (Nov. - April)	6.8	6.8	0	0	6.8	3.2	1.48	-	N	Y	Y	Y	N	N	-	N	-	Y	N	N	Y
1-3		Min Month (Nov. - April)	6.8	6.8	0	0	6.8	3.2	1.48	-	Y	Y	N	Y	N	N	-	N	-	Y	N	N	Y
1-4		Min Month (Nov. - April)	6.8	6.8	0	0	6.8	3.2	1.48	-	N	Y	N	Y	Y	N	-	N	-	Y	N	N	Y
1-5		Min Month (Nov. - April)	6.8	6.8	0	0	6.8	3.2	1.48	-	N	N	N	Y	Y	N	-	N	-	Y	N	N	Y
1-0	**Existing System Operation (Baseline)**	Min Month (Nov. - April)	6.8	6.8	0	0	6.8	3.2	1.48	-	Y	Y	Y	Y	N	N	-	N	-	Y	N	N	Y
1-6 and 1-7	**System Operation with Existing System Interties Active**	Min Month (Nov. - April)	6.8	6.8	0	0	8.28	3.2	1.48	-	N	N	N	N	N	N	-	N	-	N	N	N	Y
1-8	**System Operation with Upsized Existing Interties**	Min Month (Nov. - April)	6.8	6.8	0	0	8.28	3.2	1.48	-	N	N	N	N	N	N	-	N	-	N	N	N	Y
1-9	**System Operation with 8-inch Intertie at Soquel**	Min Month (Nov. - April)	6.8	6.8	0	0	8.28	3.2	1.48	-	N	N	N	N	N	N	-	N	-	N	N	N	Y
Transfer from District to City																							
2-1		Max Month	1.25	12.0	0.8	0	12.8	5.3	3.58	-	Y	Y	Y	Y	Y	N	-	Y	-	Y	N	N	Y
2-2		Max Month	1.25	12.0	0.8	0	12.8	5.3	3.58	-	Y	Y	Y	Y	Y	N	-	Y	-	Y	N	N	Y
2-3		Max Month	1.25	12.0	0.8	0	12.8	5.3	3.58	-	Y	Y	N	Y	Y	N	-	Y	-	Y	N	N	Y
2-0	**Existing System Operation (Baseline)**	Max Month	1.25	12.0	0.8	0	12.8	5.3	3.58	-	Y	Y	Y	Y	Y	N	-	N	-	Y	N	N	Y
2-4 and 2-5	**System Operation with Transfer Pump**	Max Month	12.5	10.2	0.8	1.5	12.5	5.3	3.58	-	Y	Y	N	Y	Y	Y	-	Y	-	Y	Y	Y	N

Analysis Results — Transfer from City to District

Run No.	41st Ave and Soquel Dr Intertie: Daily Average Flow (gpm)	Max Daily Flow (gpm)	Peak Hour Flow (gpm)	Average Headloss Through Valve (ft)	Average City Pressure (psi)	Average District Pressure (psi)	41st Ave and Jade St Intertie: Daily Average Flow (gpm)	Max Daily Flow (gpm)	Peak Hour Flow (gpm)	Average Headloss Through Valve (ft)	Average City Pressure (psi)	Average District Pressure (psi)	41st Ave and Bain Ave Intertie: Daily Average Flow (gpm)	Max Daily Flow (gpm)	Peak Hour Flow (gpm)	Average Headloss Through Valve (ft)	Average City Pressure (psi)	Average District Pressure (psi)	Total Daily Flow (gpm)	Max Daily Flow (gpm)
1	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41	42	43	44
1-1	64	-		8	65	55	32	-		8	85	75	2	-		11	90	80	98	-
1-2	95	-		8	65	55	39	-		10	85	75	8	-		11	90	80	142	-
1-3	106	-		7	65	55	24	-		8	85	75	7	-		12	90	81	137	-
1-4	89	-		8	65	55	24	-		11	85	74	5	-		11	90	79	118	-
1-5	209	-		8	65	55	60	-		9	84	75	10	-		11	90	80	279	-
1-0	-	-	-	-	66	55	-	-	-	-	86	75	-	-	-	-	91	80	-	-
(intertie size)	6 -inch						4 -inch						2 -inch							
1-6 and 1-7	669	902	1023	7	61	55	298	403	451	6	81	76	61	83	92	4	87	80	1,028	1,388
(intertie size)	8 -inch						6 -inch						6 -inch							
1-8	640	1,058	1,199	3	60	55	221	366	400	1	81	76	167	277	307	1	87	81	1,028	1,701
(intertie size)	8 -inch						4 -inch						2 -inch							
1-9	726	1,103	1,260	3	60	55	250	351	430	5	81	76	52	79	90	4	87	81	1,028	1,533

Analysis Results — Transfer from District to City

Run No.	Transfer Pump Flow (gpm)	Pressures (41st Ave and Soquel Dr): City (psi)	District (psi)
2-1	0	64	55
2-2	786 (O'Neill well)	64	-
2-3	1,000	66	53
2-0	-	64	55
2-4 and 2-5	1,000	69	53

Run No.	Figures (45)	Analysis Comments (46)
1-1	Figure 1	Analysis used the existing intertie sizes (6, 4, and 2 inches)
1-2	Figure 2	Analysis used the existing intertie sizes (6, 4, and 2 inches)
1-3	Figure 3	Analysis used the existing intertie sizes (6, 4, and 2 inches)
1-4	Figure 4	Analysis used the existing intertie sizes (6, 4, and 2 inches)
1-5	Figure 5	Analysis used the existing intertie sizes (6, 4, and 2 inches)
1-0	**Figure 9:** Existing MinMD City System Headlosses **Figure 10:** Existing MinMD District System Headlosses **Figure 11:** MinMD Tank, Pump, and Well operations	System headlosses and tank operation during Minimum Month Demands for comparison purposes.
1-6 and 1-7	**Figure 12:** City Headlosses with Interties Active **Figure 13:** District Headlosses with Interties Active **Figure 14:** Tank, Pump, and Well operations with Interties Active	Hydraulic analysis indicates the City system can provide the total zone demands for SA1 and SA2 (1.48 MGD or 1,028 gpm) through the existing interties, however headlosses in the City's and the District's system can increase up to 4 ft/1,000ft.
1-8	**Figure 15:** City Headlosses with 8-inch Intertie **Figure 16:** District Headlosses with 8-inch Intertie **Figure 17:** Tank, Pump, and Well operations with 8-inch Intertie	Hydraulic analysis indicates the City system can provide the total zone demands for SA1 and SA2 (1.48 MGD or 1,028 gpm) through the upsized interties, however headlosses in the City's and the District's system can increase up to 5 ft/1,000ft.
1-9		
2-1	Figure 6	City unable to receive water through interties due to head difference during MMD
2-2	Figure 7	Water transferred via O'Neill Well pumping directly to City
2-3	Figure 8	Water transferred via new transfer pump station at O'Neill Well site.
2-0	**Figure 18:** Existing MDD City System Headlosses **Figure 19:** Existing MDD District System Headlosses **Figure 20:** MDD Tank, Pump, and Well operations	System headlosses and tank operation during Maximum Month Demands for comparison purposes.
2-4 and 2-5	**Figure 21:** City Headlosses with Transfer Pump **Figure 22:** District Headlosses with Transfer Pump **Figure 23:** Tank, Pump, and Well operations with Transfer Pump	Hydraulic analysis indicates the District system can provide approximately 1,000 gpm through a transfer pump near 41st Ave and Soquel Dr, however headlosses in the City's and District's system can increase up to 4 ft/1,000ft. District well production and operation time in SA1 increases due to the transfer pump.

2/14/2014

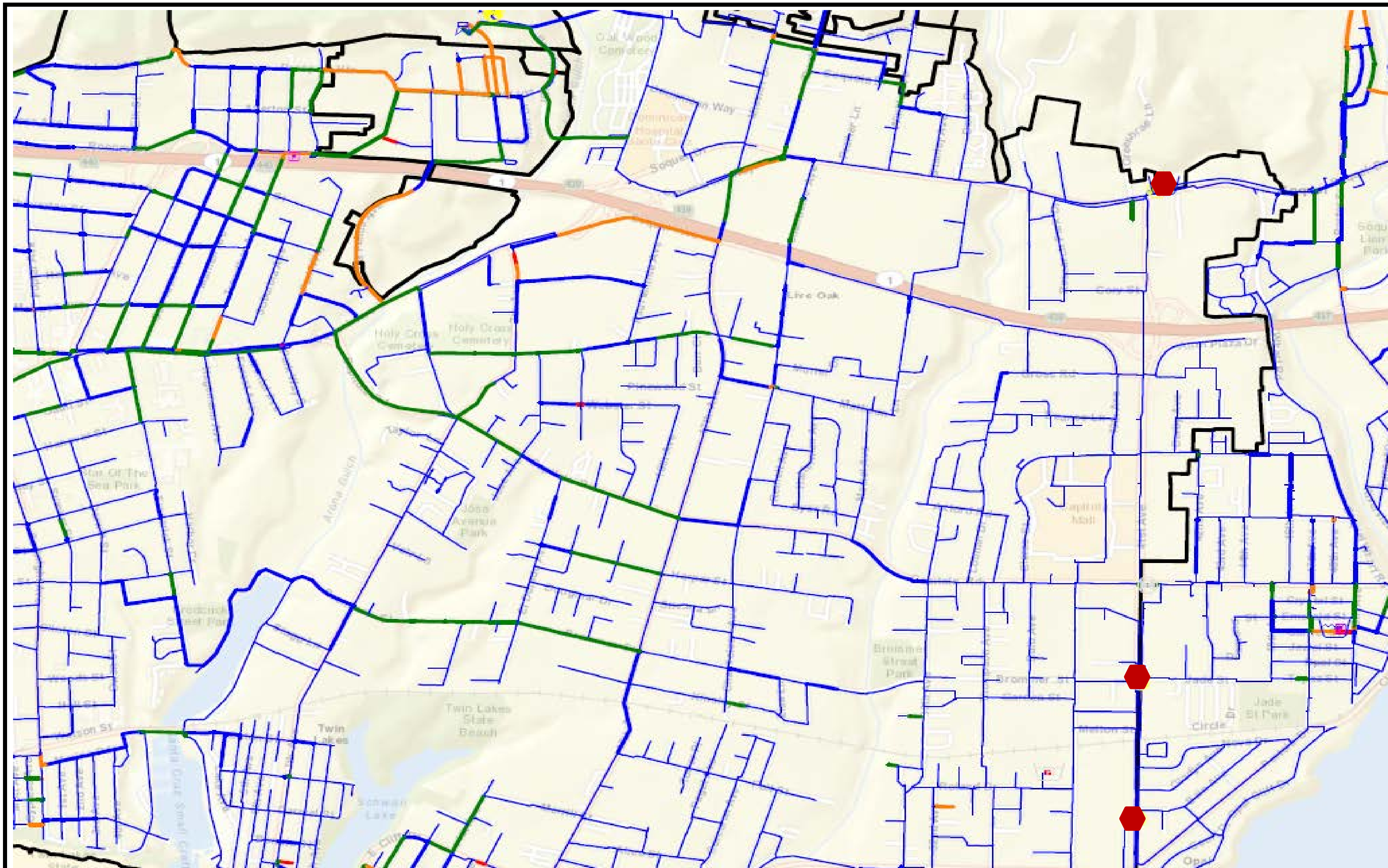
Table 2 District Well Run Times

Existing City / District Intertie Capacities
City of Santa Cruz Water Department / Soquel Creek Water District

	Existing Maximum Month Demands			Scenario 2-4 and 2-5 Maximum Month Demands plus 1,000 gpm Transfer to City		
	Run Time[1] (hr)	Max Flow (gpm)	Daily Average (gpm)	Run Time[2] (hr)	Max Flow (gpm)	Daily Average (gpm)
SA1 - 244						
Garnet	8	636	212	8	644	214
Rosedale	16	927	604	21	935	812
Main Street	16	876	569	21	883	767
Tannery II	16	1,020	662	21	1,024	895
O'Neill	-	-	-	-	-	-
SA2 - 244						
Madeline	4	203	37	9	203	78
Aptos/T-Hopkins	0	0	0	4	420	72
Estates	11	630	283	18	655	480
SA2 - 420						
Ledyard	8	194	61	8	194	61
SA3 - 359						
Aptos	11	377	173	11	377	173
Country Club	10	360	149	10	360	149
Bonita	11	927	427	11	927	427
San Andreas	11	956	440	11	956	440
Seascape	-	-	-	-	-	-
SA4 - 244						
Altivo	-	-	-	-	-	-
Sells	-	-	-	-	-	-

Notes: 2/19/2014

1. The well run times listed are with the McGregor pump station active (run time: 11 hrs)
   If the McGregor pump station is inactive the well run times in SA1 are reduced to 8, 13, 13, and 13 hours respectively, and SA2 well run times will increase to approximately 9, 4, and 18 respectively
2. The McGregor pump station is inactive during this scenario



LEGEND

- Intertie Locations

HEADLOSS (ft/kft)

- less than 0.5
- 0.5-1
- 1-2
- 2-5
- greater than 5

ASSUMPTIONS

- Minimum Month Demands
- No intertie flow
- Beltz Wells inactive

February 7, 2014

Figure 9

City of Santa Cruz

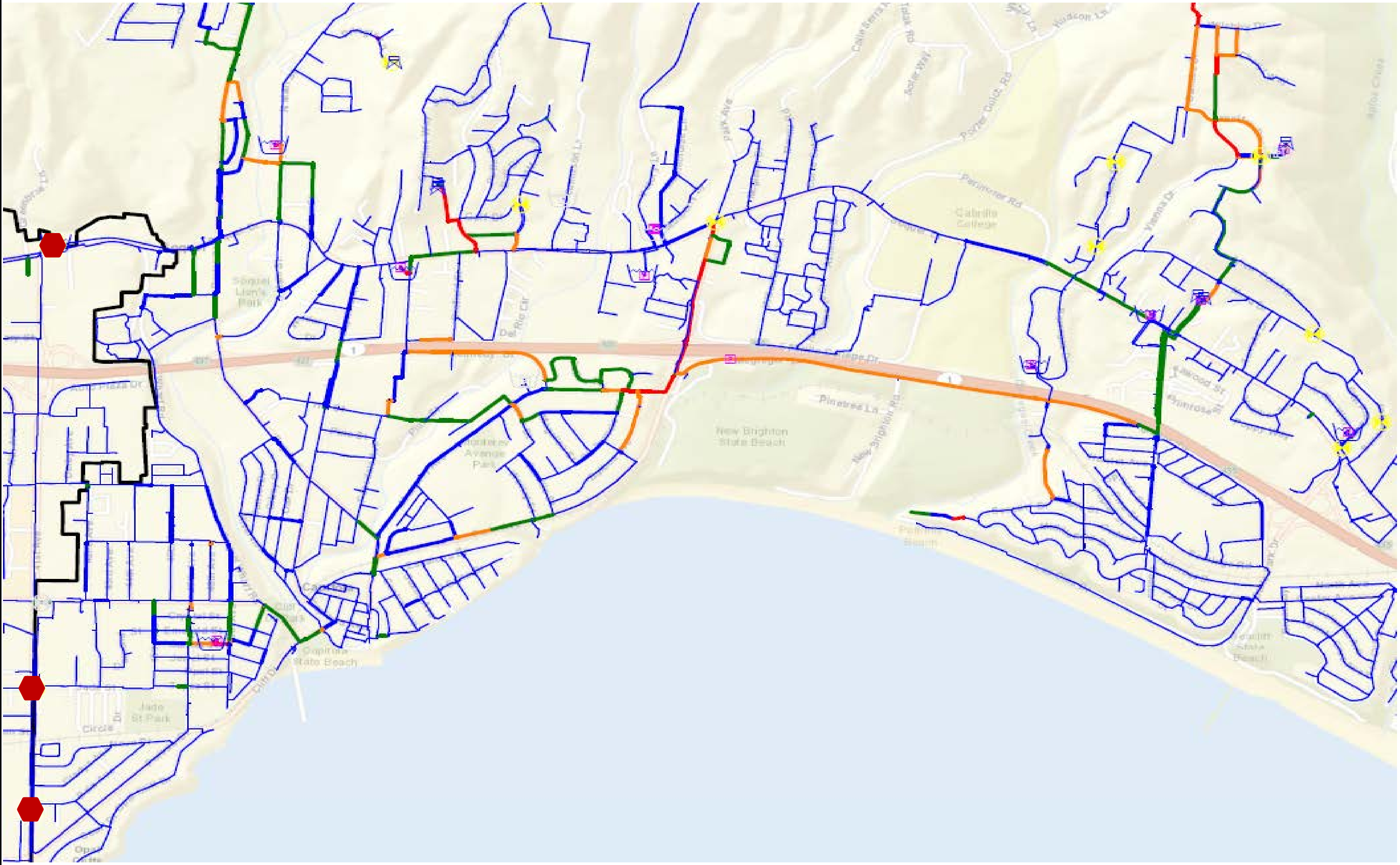
Existing MinMD Headlosses

Existing Intertie Capacities

City of Santa Cruz Water Department

Soquel Creek Water District

AKEL ENGINEERING GROUP, INC.



LEGEND

Intertie Locations

HEADLOSS (ft/kft)

- less than 0.5
- 0.5-1
- 1-2
- 2-5
- greater than 5

ASSUMPTIONS

- Minimum Month Demands
- No intertie flow

February 7, 2014

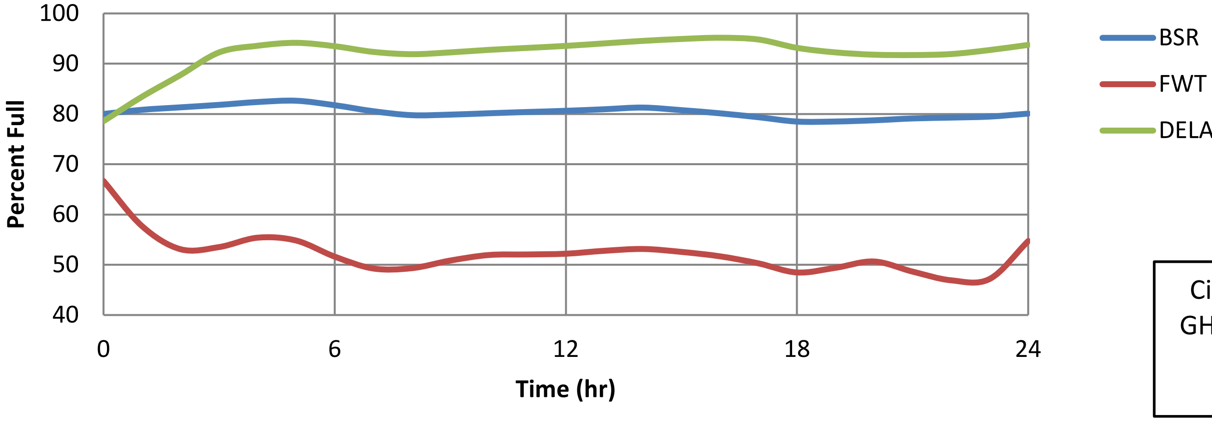
Figure 10

Soquel Creek Water District
Existing MinMD Headlosses

Existing Intertie Capacities
City of Santa Cruz Water Department
Soquel Creek Water District

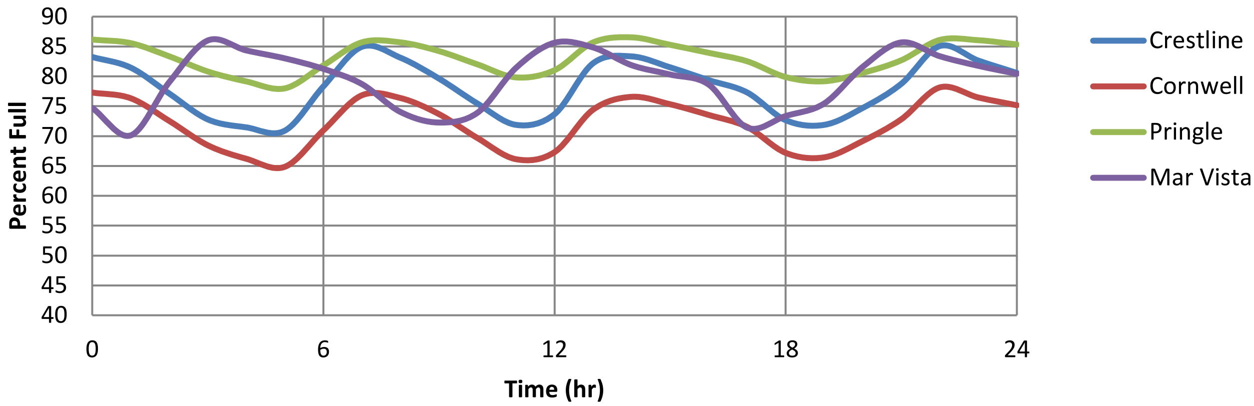
AKEL ENGINEERING GROUP, INC.

City of Santa Cruz - Tanks (Percent Full)

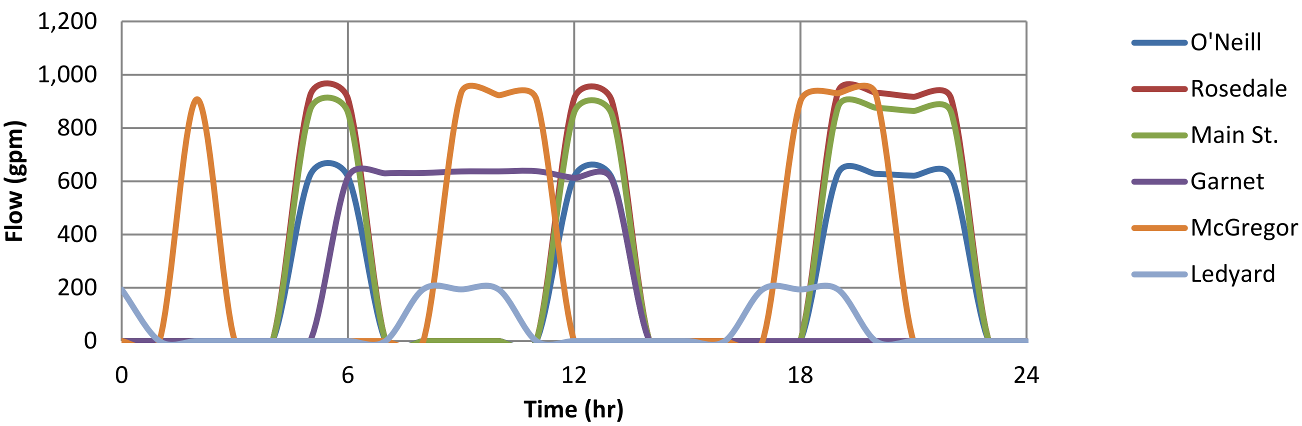


City Production:
GHWTP: 6.8 MGD
Beltz: 0

Soquel Creek Water District -Tanks (Percent Full)



District Pump Station and Well Production



NOTES:

February 11, 2014

Figure 11

MinMD Existing System Operation

Existing Intertie Capacities

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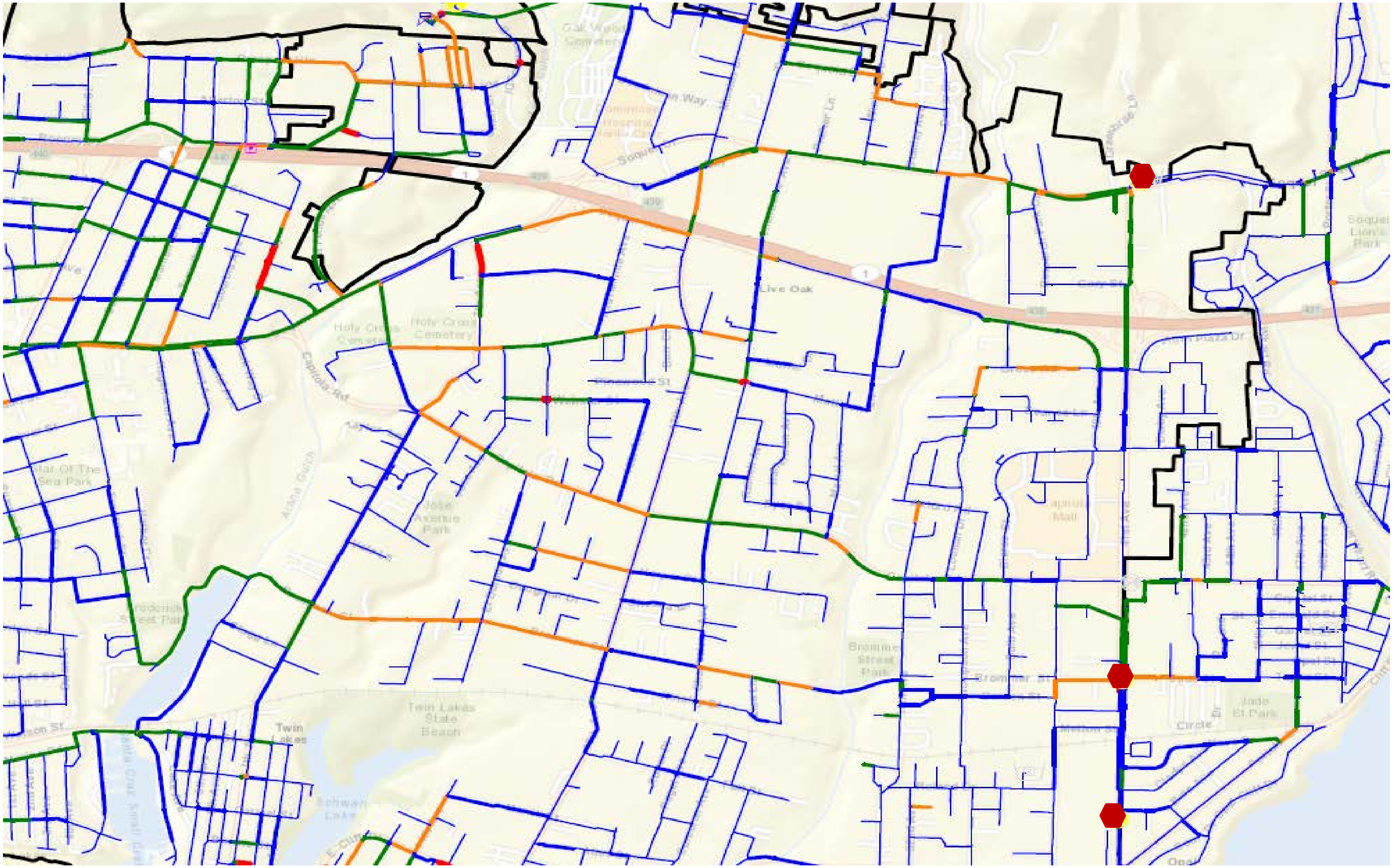


LEGEND

- Intertie Locations

HEADLOSS (ft/kft)

- less than 0.5
- 0.5-1
- 1-2
- 2-5
- greater than 5

ASSUMPTIONS

- Minimum Month Demands
- Interties supplying District SA1 and SA2 demands (1.48 MGD)
- Beltz Wells inactive

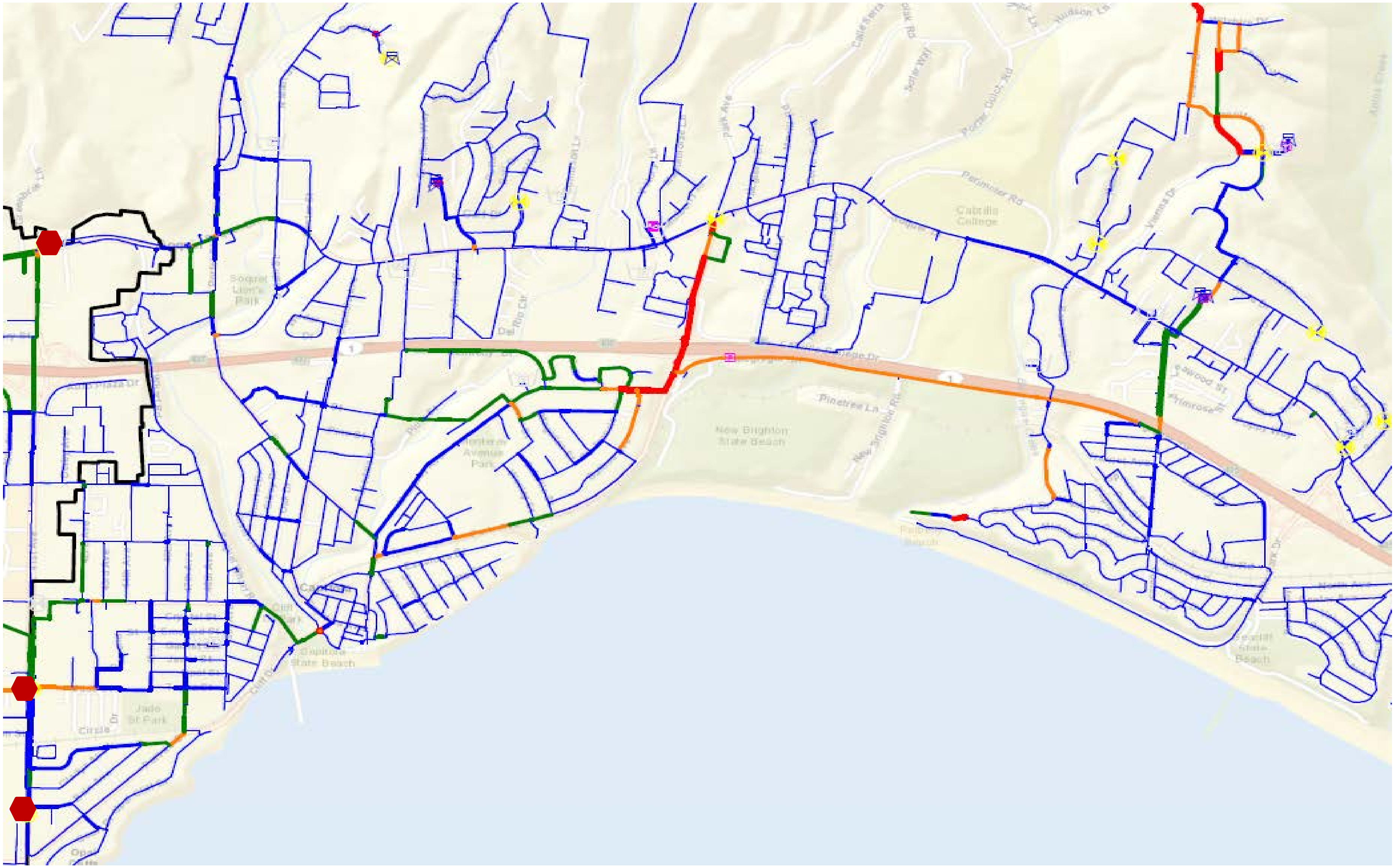
February 7, 2014

Figure 12

City of Santa Cruz
MinMD Headlosses with Interties Active
Scenario 1-6

Existing Intertie Capacities
City of Santa Cruz Water Department
Soquel Creek Water District

AKEL ENGINEERING GROUP, INC.



LEGEND

Intertie Locations

HEADLOSS (ft/kft)

- less than 0.5
- 0.5-1
- 1-2
- 2-5
- greater than 5

ASSUMPTIONS

- Minimum Month Demands
- SA1 or SA2 wells are inactive
- Interties supplying SA1 and SA2 zone demands (1.48 MGD)

February 7, 2014

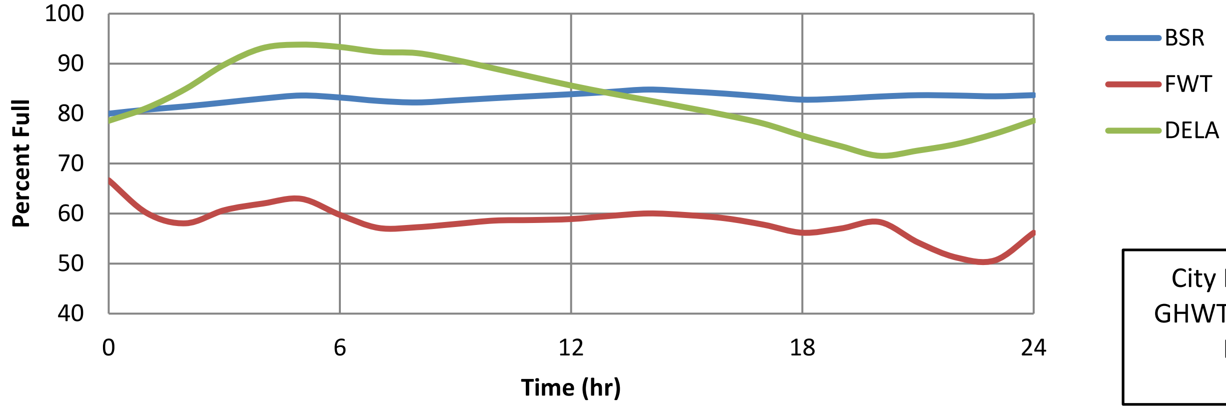
Figure 13

Soquel Creek Water District
MinMD Headlosses with Interties Active
Scenario 1-7

Existing Intertie Capacities
City of Santa Cruz Water Department
Soquel Creek Water District

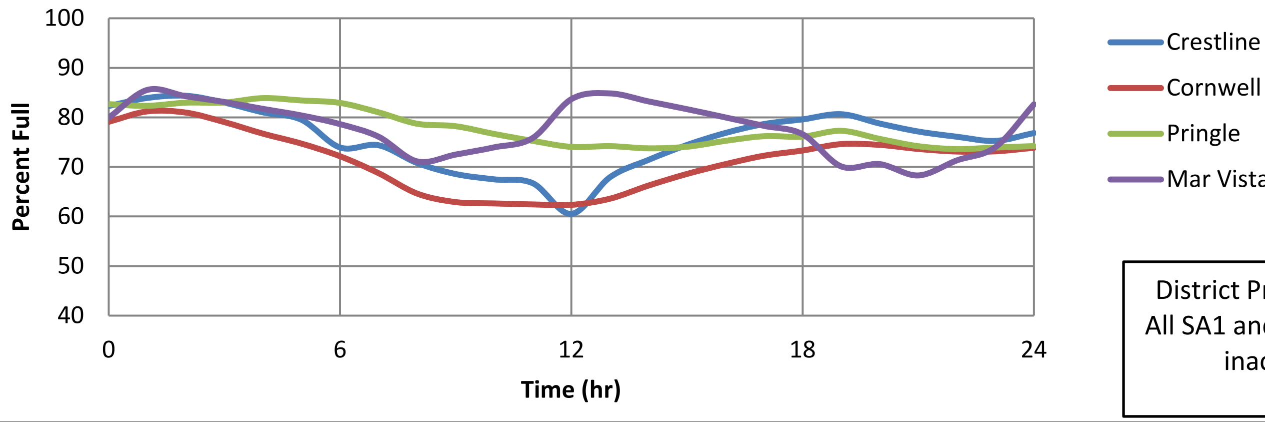
AKEL ENGINEERING GROUP, INC.

City of Santa Cruz -Tanks (Percent Full)



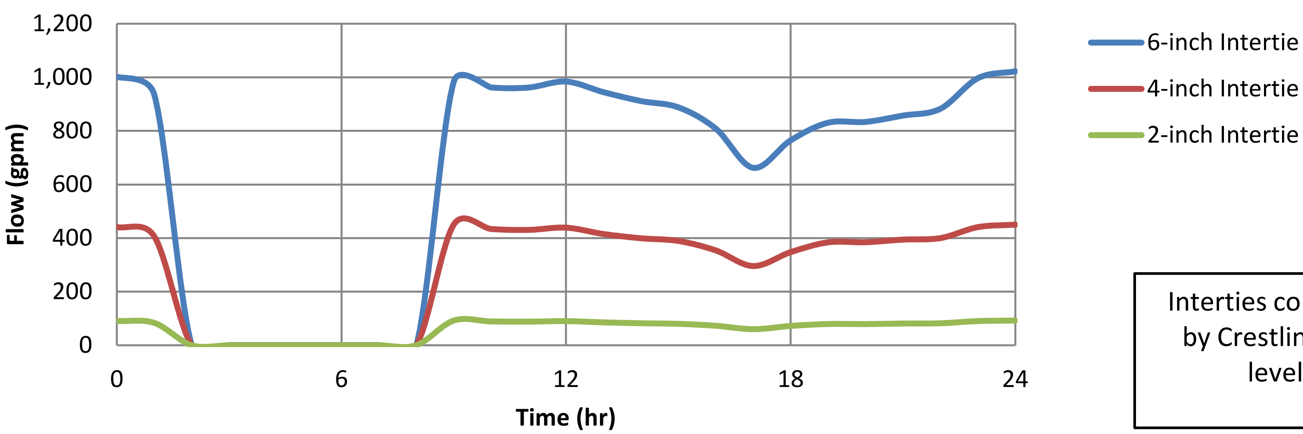
City Production:
GHWTP: 8.28 MGD
Beltz: 0

Soquel Creek Water District -Tanks (Percent Full)



District Production:
All SA1 and SA2 wells inactive

Intertie Flows



Interties controlled by Crestline tank levels

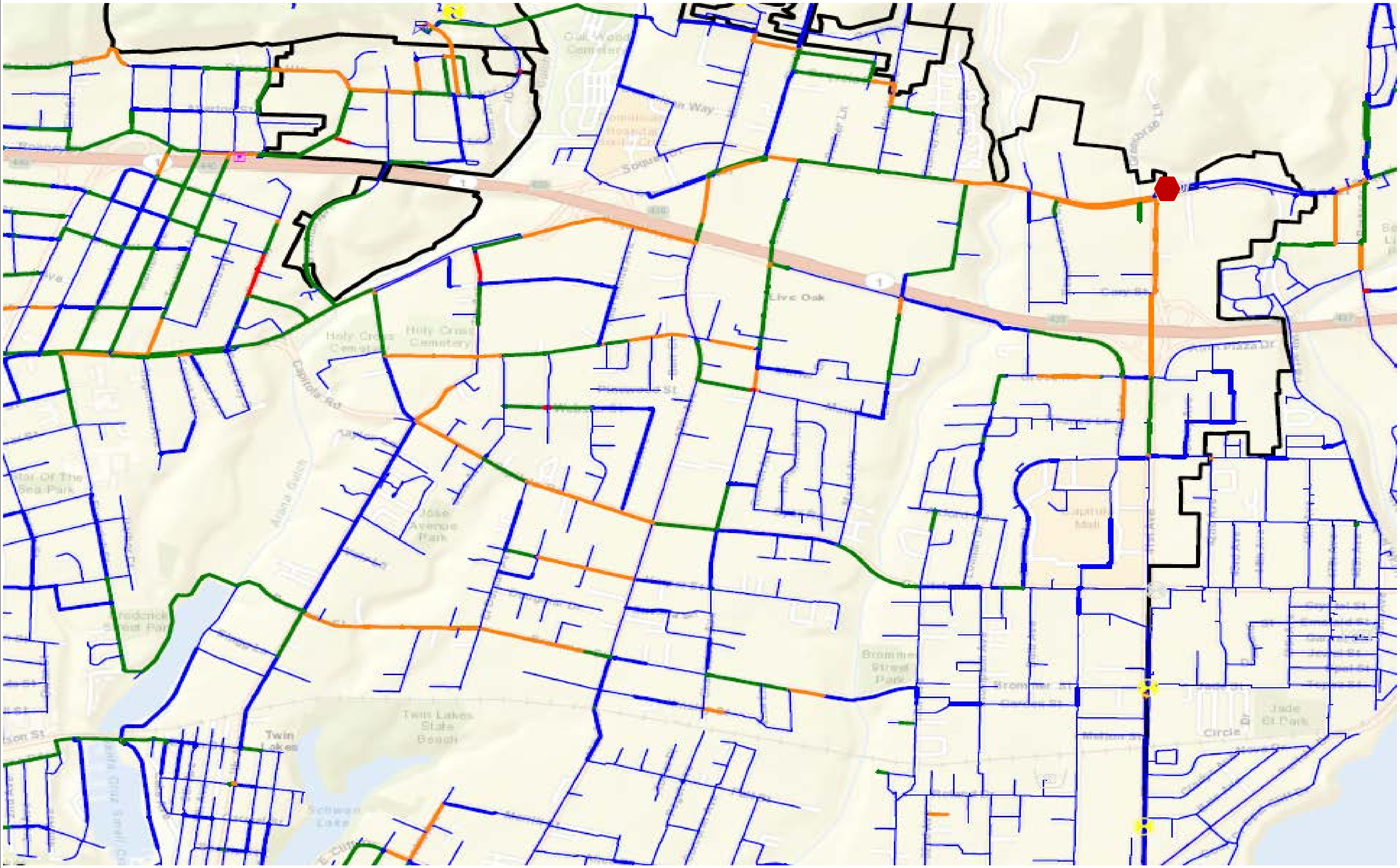
NOTES:
1. District zones SA1 and SA2 MinMD is 1.48 MGD.
2. SA1 and SA2 demands are supplied by the intertie flows

February 7, 2014

Figure 14
System Operation with Active Interties
Scenario 1-6, 1-7
Existing Intertie Capacities

SANTA CRUZ
SOQUEL CREEK WATER DISTRICT

AKEL ENGINEERING GROUP, INC.



LEGEND

Intertie Location

HEADLOSS (ft/kft)

- less than 0.5
- 0.5-1
- 1-2
- 2-5
- greater than 5

ASSUMPTIONS

- Minimum Month Demands
- Intertie supplying District SA1 and SA2 demands (1.48 MGD)
- Beltz Wells inactive
- Single 8-inch intertie located near 41st Ave and Soquel Dr

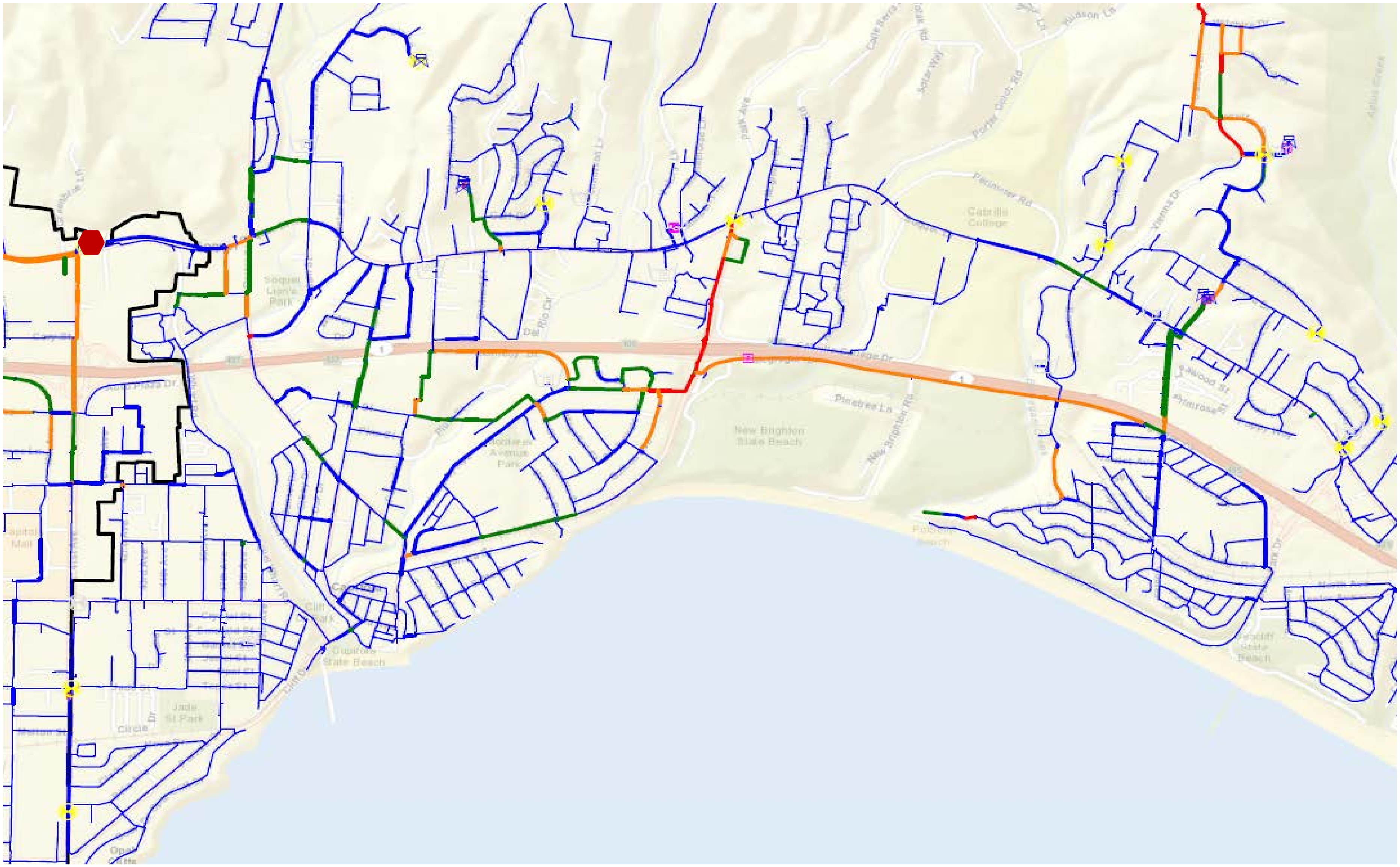
February 7, 2014

Figure 15

City of Santa Cruz
MinMD Headlosses with a Single 8" Intertie Active
Scenario 1-8

Existing Intertie Capacities
City of Santa Cruz Water Department
Soquel Creek Water District

AKEL ENGINEERING GROUP, INC.



LEGEND

Intertie Location

HEADLOSS (ft/kft)

- less than 0.5
- 0.5-1
- 1-2
- 2-5
- greater than 5

ASSUMPTIONS

- Minimum Month Demands
- SA1 or SA2 wells are inactive
- Intertie supplying District SA1 and SA2 demands (1.48 MGD)
- Single 8-inch intertie located near 41st Ave and Soquel Dr

February 7, 2014

Figure 16

Soquel Creek Water District MinMD Headlosses with a Single 8" Intertie Active

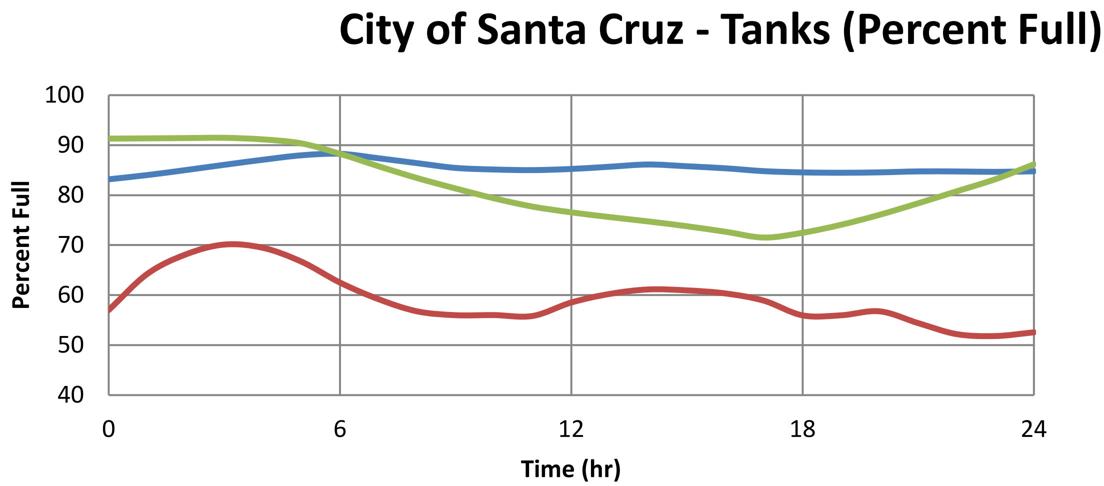
Scenario 1-8

Existing Intertie Capacities

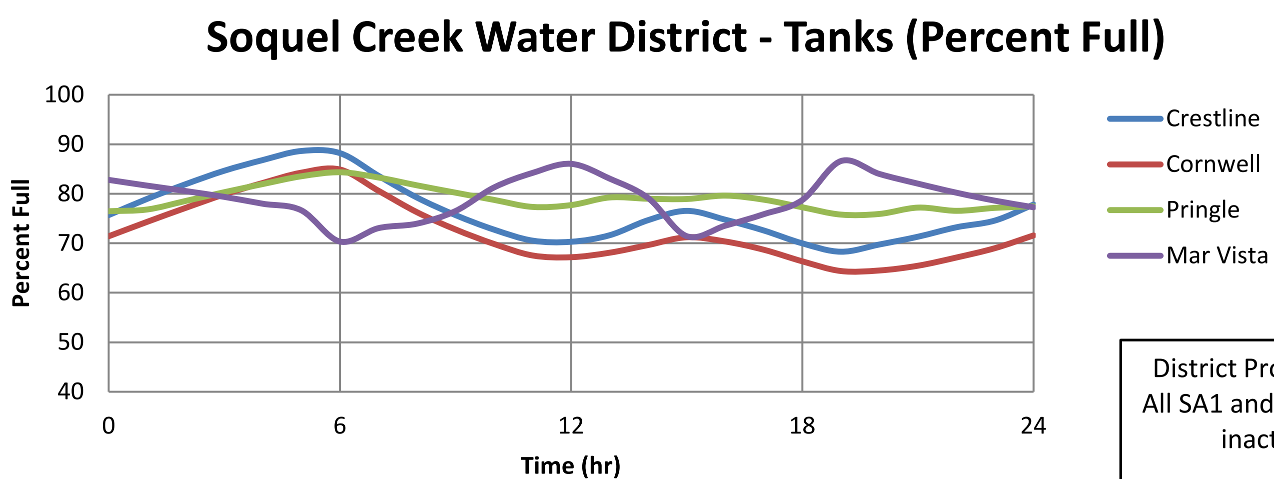
City of Santa Cruz Water Department

Soquel Creek Water District

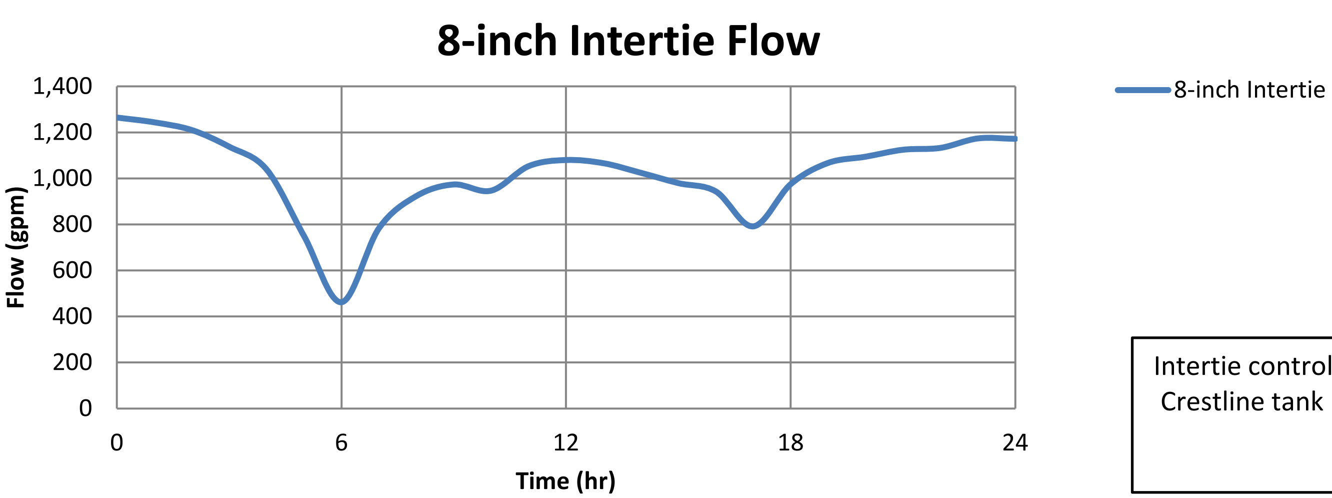
AKEL ENGINEERING GROUP, INC.



City Production:
GHWTP: 8.28 MGD
Beltz: 0



District Production:
All SA1 and SA2 wells inactive



Intertie controlled by Crestline tank levels

NOTES:

1. The 8-inch intertie can provide the required 1.48 MGD, however the HGL in zone SA1 is reduced by approximately 1-2ft.

February 7, 2014

Figure 17

System Operation with a 8-inch Intertie

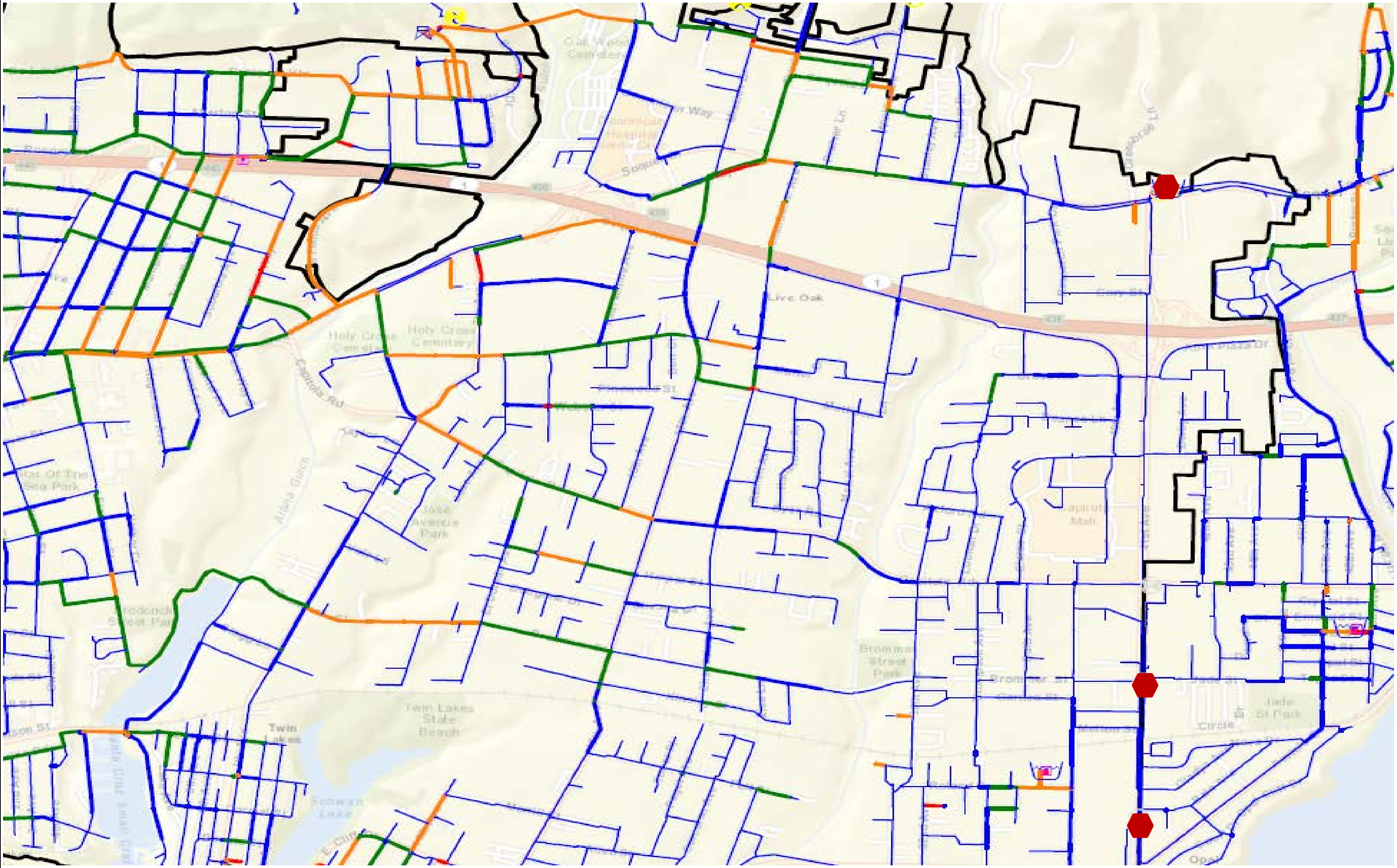
Scenario 1-8

Existing Intertie Capacities

CITY OF SANTA CRUZ

SOQUEL CREEK WATER DISTRICT

AKEL ENGINEERING GROUP, INC.



LEGEND

Intertie Locations

HEADLOSS (ft/kft)

- less than 0.5
- 0.5-1
- 1-2
- 2-5
- greater than 5

ASSUMPTIONS

- Maximum Month Demands
- Beltz Active (0.8 MGD)
- No Intertie Flow

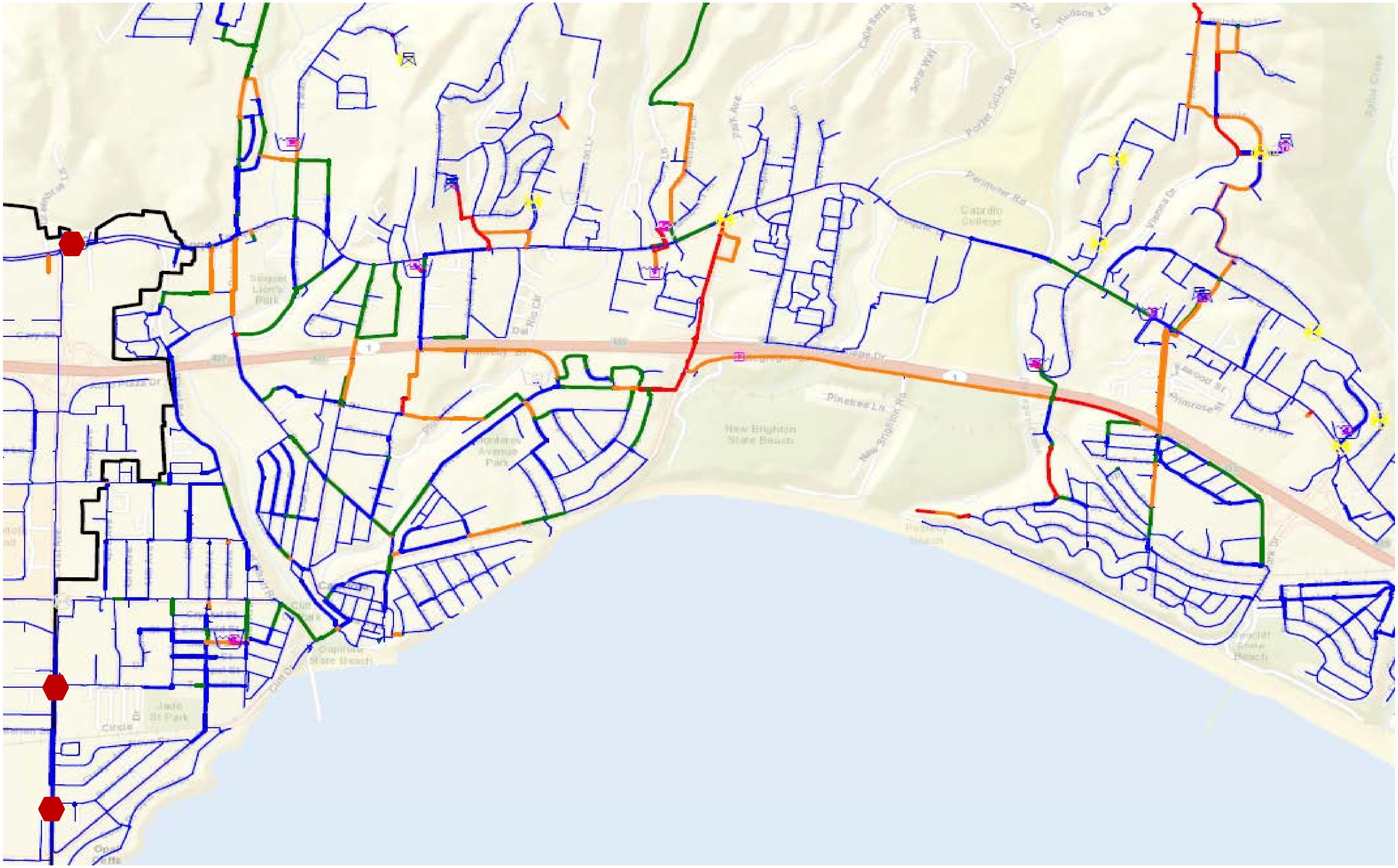
February 11, 2014

Figure 18

City of Santa Cruz
Existing MMD Headlosses

Existing Intertie Capacities
City of Santa Cruz Water Department
Soquel Creek Water District

AKEL ENGINEERING GROUP, INC.



LEGEND

Intertie Locations

HEADLOSS (ft/kft)

- less than 0.5
- 0.5-1
- 1-2
- 2-5
- greater than 5

ASSUMPTIONS

- Maximum Month Demands
- No Intertie Flow

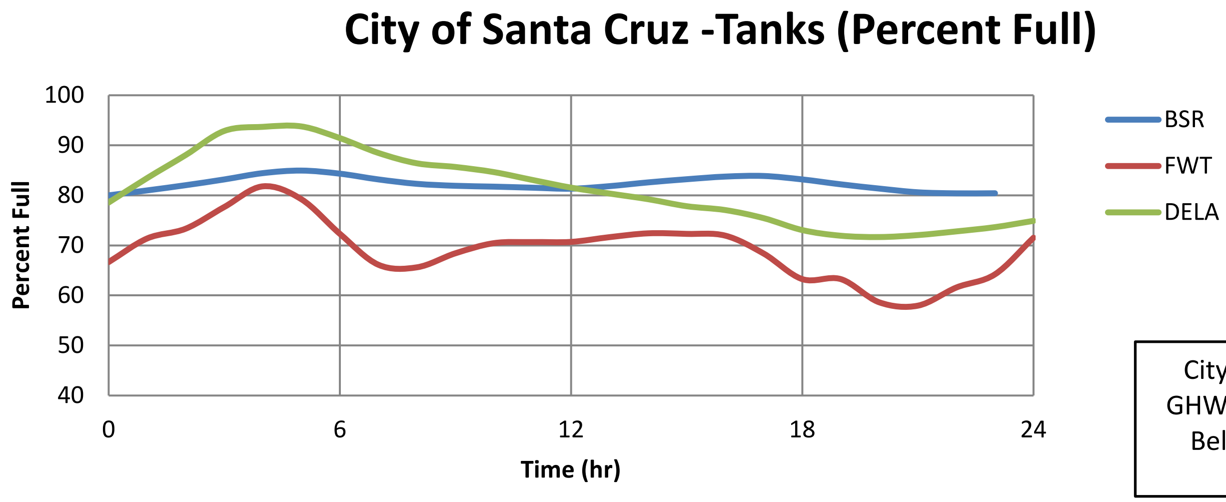
February 11, 2014

Figure 19

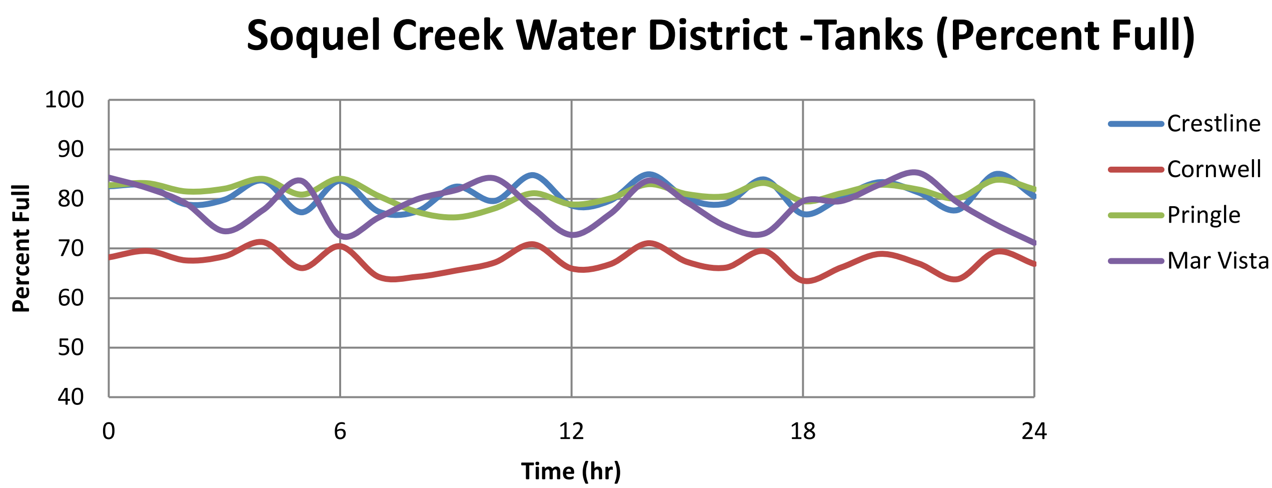
Soquel Creek Water District
Existing MMD Headlosses

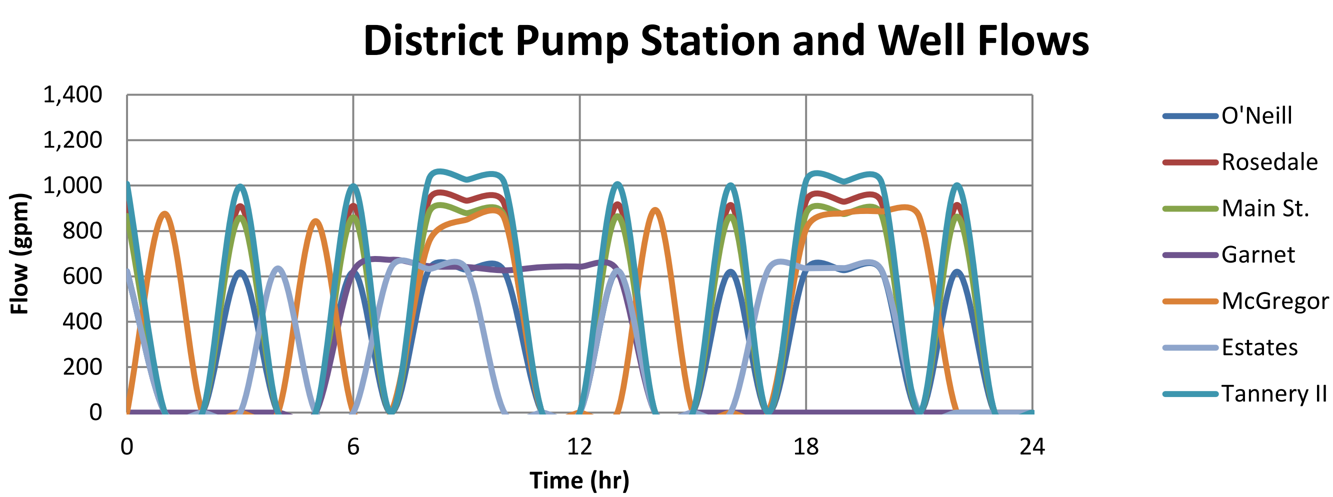
Existing Intertie Capacities
City of Santa Cruz Water Department
Soquel Creek Water District

AKEL ENGINEERING GROUP, INC.



City Production:
GHWTP: 12.0 MGD
Beltz: 0.8 MGD





NOTES:

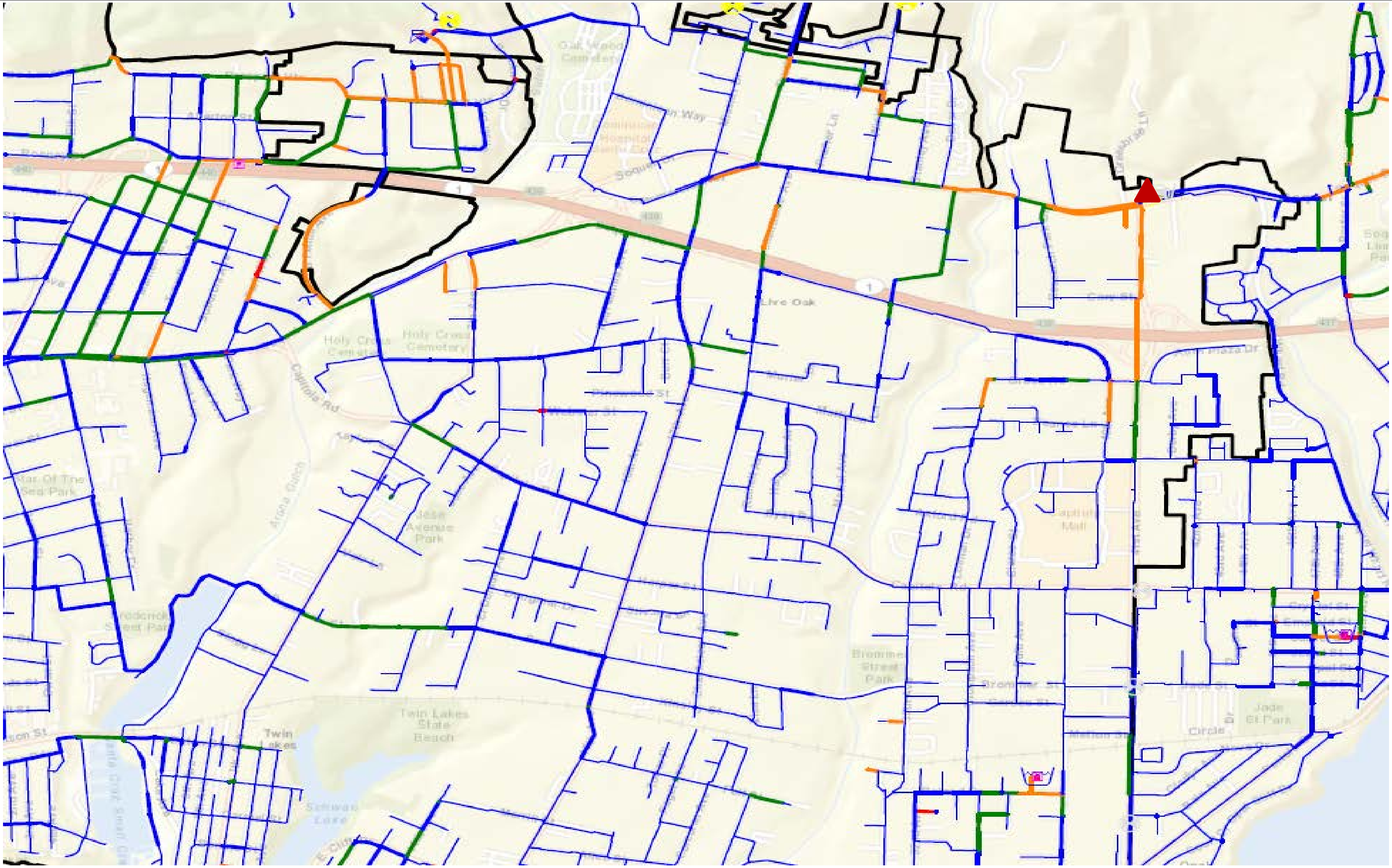
February 11, 2014

Figure 20

MMD Existing System Operation

Existing Intertie Capacities

AKEL ENGINEERING GROUP, INC.



LEGEND

Transfer Pump

HEADLOSS (ft/kft)

- less than 0.5
- 0.5-1
- 1-2
- 2-5
- greater than 5

ASSUMPTIONS

- Maximum Month Demands
- No Intertie Flow
- Beltz Wells active (0.8 MGD)
- 1,000 gpm transfer pump station located near 41st Ave and Soquel Dr

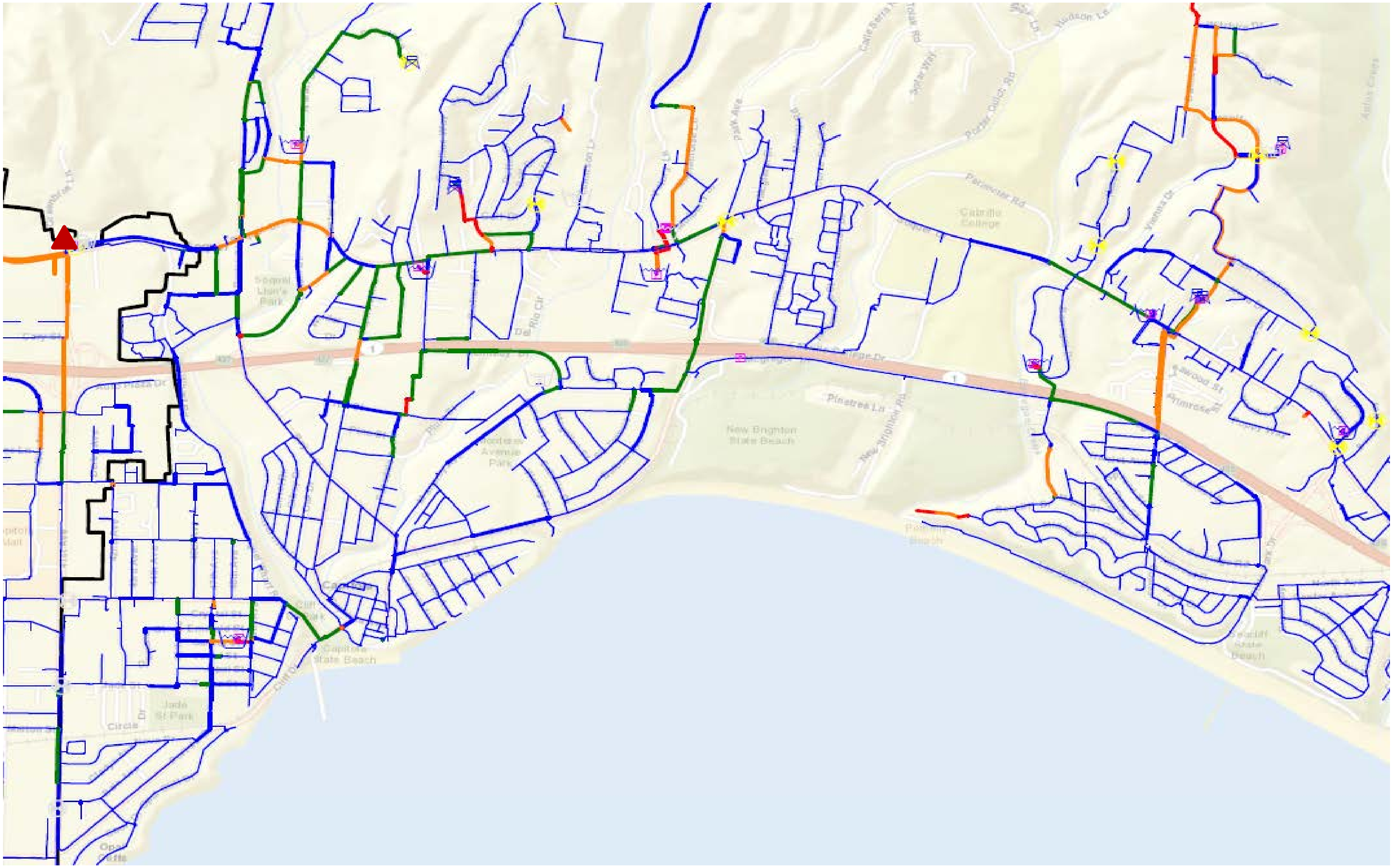
February 11, 2014

Figure 21

City of Santa Cruz
MMD Headlosses with 1,000gpm Transfer Pump
Scenario 2-4

Existing Intertie Capacities
City of Santa Cruz Water Department
Soquel Creek Water District

AKEL ENGINEERING GROUP, INC.



LEGEND

▲ Transfer Pump

HEADLOSS (ft/kft)

- less than 0.5
- 0.5-1
- 1-2
- 2-5
- greater than 5

ASSUMPTIONS

- Maximum Month Demands
- No Intertie Flow
- 1,000 gpm transfer pump station located near 41st Ave and Soquel Dr

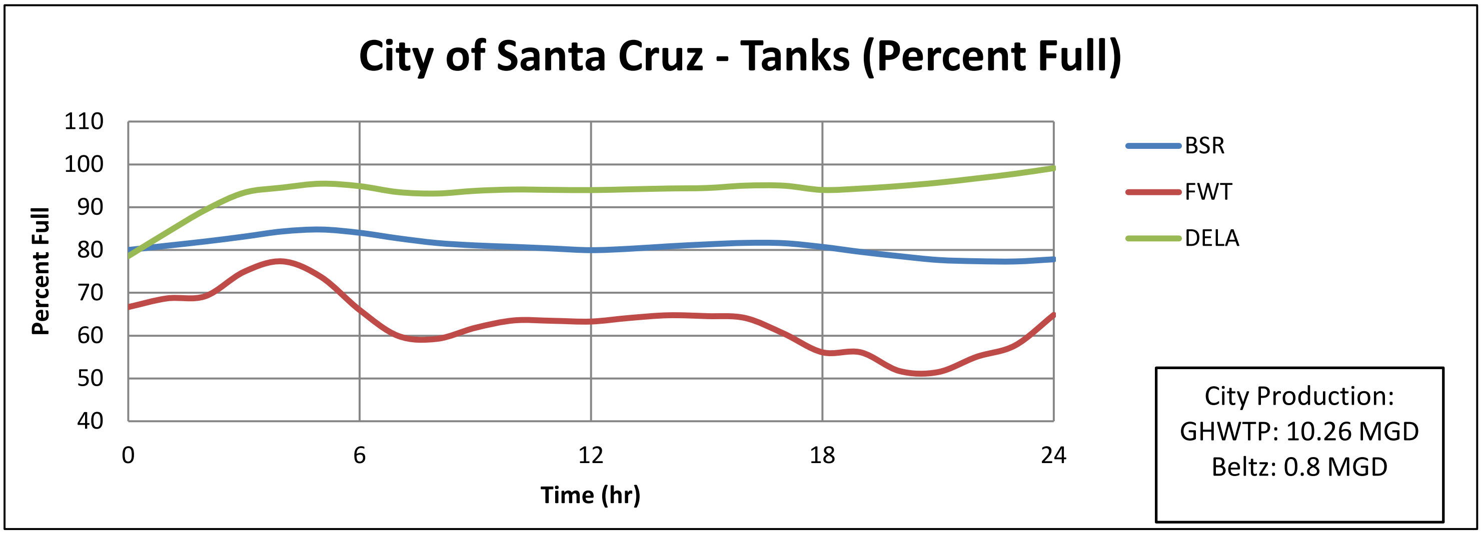
February 11, 2014

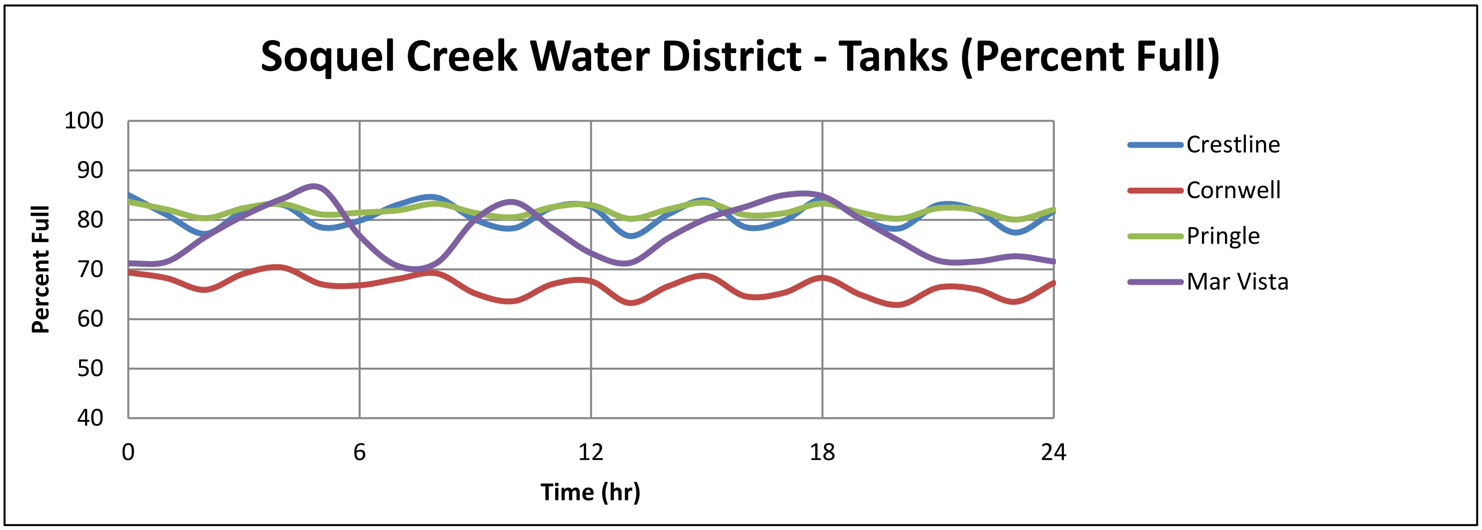
Figure 22

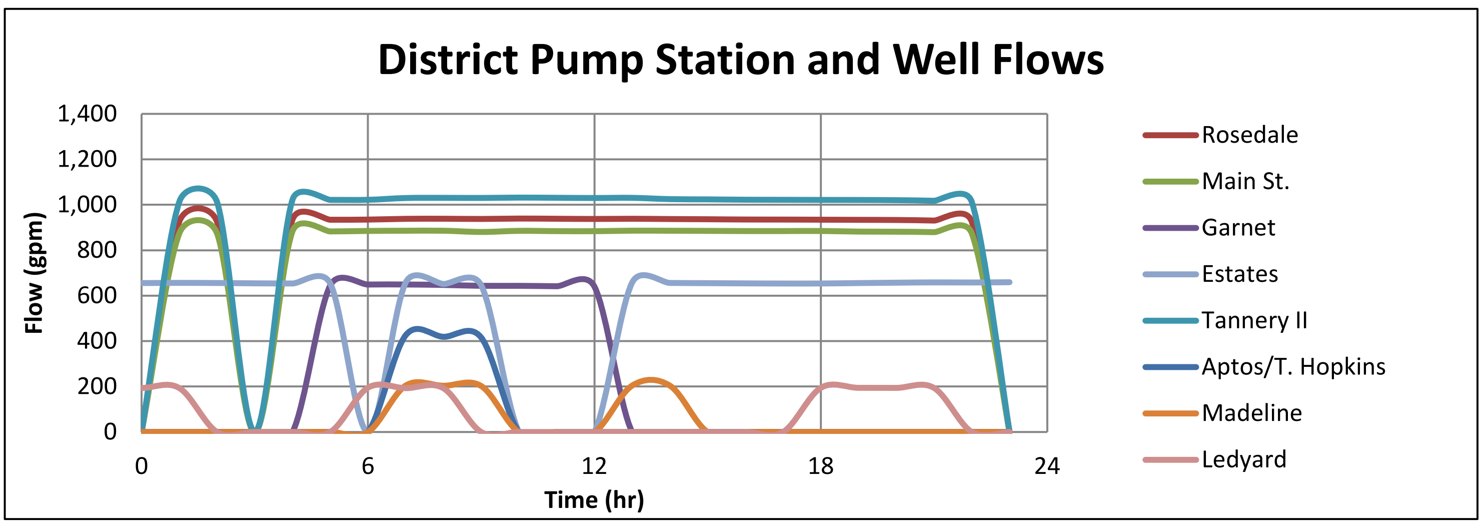
Soquel Creek Water District
MMD Headlosses with 1,000gpm Transfer Pump
Scenario 2-5

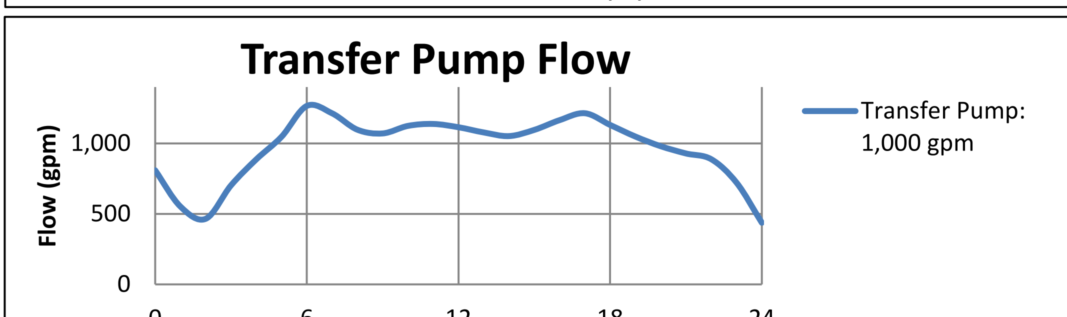
Existing Intertie Capacities
City of Santa Cruz Water Department
Soquel Creek Water District

AKEL ENGINEERING GROUP, INC.









February 11, 2014

Figure 23

MMD System Operation with a 1,000 gpm Transfer Pump Station

Scenarios 2-4, 2-5

Existing Intertie Capacities