Dennis Jackson - Hydrologist

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October 12, 2009

Tom Lippe
329 Bryant Street, Suite 3D
San Francisco, CA 94107

Re: Mitigated Negative Declaration for Dunphy P07-00790-ECPA

Dear Mr. Lippe:

You have asked me to comment on the potential impacts of the proposed Dunphy Vineyard conversion from oak woodland and grassland to vineyard. A Mitigated Negative Declaration (MND) was prepared, dated September 11, 2009. The MND gives the following overview of the project.

> The proposed project is grading and earthmoving activities associated with the installation of approximately 1.55 acres of existing[1] vineyard and the conversion of ±2.79 additional acres of oak woodland and non-native grassland to vineyard, as shown in proposed vineyard Blocks 2,4 and 5 (2.14 net vine acres). The area directly affected by this project would include 2 existing vineyard blocks and 3 proposed vineyard blocks totaling 3.52 net acres (See Figure 2}. Approximately 0.61 acres of the proposed project, predominately located within proposed Block 4 are on slopes exceeding 30%. However, in accordance with County Conservation Code Section 1 B.108.055(H), the area directly east of the house within proposed Block 4 was cleared under the direction of the California Department of Forest and Fire Protection (Calflre)[2]. Proposed Block 4 will be head trained and hand farmed with a no-till cover crop and spot spray only, and will function as landscaping which will not require grading or earthmoving activities. Proposed Blocks 2 and 5 will require grading and the removal of non-native grassland and oak woodland in a 1.85 acre area.
>
> Approximately 40 trees will be removed from within or adjacent to the project area, including Coast Live Oak, Black Oak, California Bay and Pacific madrone. Deer exclusion fencing has been installed at the perimeter of existing Blocks 1 and 3, and proposed Block 2. The project proposes the installation of additional deer exclusion fencing around the perimeter of proposed Blocks 4 and 5. Wildlife movement would continue throughout the remainder of the property. Temporary rock storage and stockpiling areas will be located within the proposed blocks, to be used for landscaping and reincorporated back into the blocks, vineyard avenues, and the proposed erosion control features. There is one existing water supply well located on-site, approximately 320 feet north of proposed Block 4 (see Figure 2). The well will supply 100% of the proposed irrigation to the vineyard, which will be approximately 2.86 acre feet per year (ary) for the vineyard development and an additional 2.0 afy for the residence and landscaping irrigation. Refer to Section VIII, Hydrology and Water Quality for existing and proposed water usage on-site.

> The erosion control plan (P07·00790-ECPA) has been prepared with detailed temporary and permanent erosion control measures, including but not limited to, sill fencing, straw mulch, water bars, rock lined ditches, and a permanent no-till cover crop with a minimum 80% coverage or great. There are no future projects anticipated for this parcel.
>
> Footnotes:
> 1) The 1.55 acres of existing vineyard was planted by the previous property owner in 2001 This area is shown as blocks I and 3 (I 28 net vineyard acres) in the project erosion control plan application (see Figure 2). This subject proposal includes an assessment of likely impacts based on pre-violation conditions
> 2) August 20 2005, Gerri Finn of CalFire confirmed vegetation clearing was in accordance with fire wise program, Telephone Call.

The MND describes the environmental setting as follows:

> The project site is located on the west side of Dry Creek Road, with an existing driveway accessing the holding, including the single residence located directly west of proposed vineyard development (APN 035-010-057). The parcel is located in an Agricultural Watershed (AW) zoning district, with a Napa County General Plan designation of Agriculture. Watershed and Open Space (AWOS). Approximately 1.55 acres of vineyard exists onsite, located south of the residence. The project proposes to expand the existing vineyard by 2.79 acres for a total of 4.34 acres (3.52 vine acres) within a 20 acre parcel. The project site is located adjacent to existing vineyard. rural residential, oak woodland and coniferous forest. The project site is located between 195 and 365 feet above mean sea level. The project site is characterized by rolling hills. paved driveway accessing the existing residence, barn and 1.55 acres of vineyard. In May of 2001, under previous ownership approximately 1.55 acres (1.28 vine acres) of vineyard was developed without an erosion control plan. The existing vineyard has been included within this analysis and erosion control plan #P07-00790-ECPA. According to the US Department of Agriculture soil survey of Napa County, the dominate soil series identified on-site are Felton gravelly loam (Series 136) and Fagan clay loam (Series 131 and 133). These series are typically associated with slopes between 5% and 50%. However, according to the project engineer, actual slopes range from 5% to 40%. with an average slope of 20.5% within the development area. The Great Valley Complex characterizes the holding, which includes the Cretaceous to Jurassic pre-quaternary deposits and bedrock. Vegetative cover within the project area consists primarily of grassland, oak woodland, and coniferous forest. There is one intermittent streams on-site approximately 300 feet outside of the proposed development (refer to Figure 2 and Section VIII, Hydrology and Water Quality). The nearest residences to the proposed vineyard blocks are located approximately 90 feet to the southeast and over 340 feet to the south. The parcel is approximately 1.50 miles northwest of the City of Napa, located within the Dry Creek Drainage. Additional information regarding the environmental setting is provided in the environmental checklist form.

Incomplete Project Environmental Analysis

The *Hydrology and Water Quality* discussion in the MND (Section VIII of the Environmental Checklist) does not mention that the Napa River has been declared impaired by the San Francisco Bay Regional Water Quality Control Board (SFBRWQCB) due to a high sediment load. The SFBRWQCB has been working to prepare a Total Daily Maximum Load plan (TMDL) to reduce the volume of sediment carried by the Napa River.

The *Napa River Basin Limiting Factors Analysis* (Stillwater Sciences and Dietrich, 2002) report, prepared as part of the TMDL process, found that two adverse impacts of erosion and sedimentation on salmon and steelhead habitat:

- Low permeability values indicating a high concentration of fine sediment in the streambed
- Channel incision in mainstem Napa River

The environmental analysis in the MND does not discuss how the Dunphy Vineyard Conversion project has the potential to change the composition of the sediment delivered to the Napa River system. Shifting the mean diameter of the sediment produced on the Dunphy parcel to a finer caliber would potentially decrease the permeability of streambed gravel beds which would adversely impact salmon and steelhead habitat. This is especially important since salmon and steelhead are listed species. Typically, sediment control measures are good at capturing coarse sediment but often do not capture all of the finer sediment.

The environmental analysis presented in the MND also does not examine the Dunphy Vineyard Conversion projects potential to contribute to channel incision in the Napa River. The discussion of parts (c) and (d) of the *Hydrology and Water Quality* (Section VIII Environmental Checklist) states that:

> *As described in Section VI(b), the project is anticipated to have a* ***less than significant*** *impact with respect to alterations of the existing drainage pattern of the site or area that would result in* ***considerable erosion or flooding on or off-site****. WinTR-55 watershed runoff model calculations developed by the Napa County Resource Conservation District (2009) examined the change in storm runoff between pre- and post project conditions for the project area, which calculates the storm runoff volume and peak rate discharge. According to the results, post project conditions would result in a 2.4% increase in the 100-year peak flow discharged for the holding. Peak flow increases over existing conditions due to the project would be approximately 0.14 to 0.20 cubic feet per second (cts) Table 1 and 2 below show the results of the peak discharge calculations (TR-S5), and the percentage of change between pre- and post project discharge. The results indicate that the project has the potential to contribute to peak flow increases to existing watercourses located offsite.* (Emphasis Added)

The fact that the MND does not mention that the Napa River is impaired for sediment brings into question the appropriateness of the test for significance applied by the MDN. Given that the Napa River is impaired for sediment and supports listed fish it is inappropriate for the MND to require that the project cause “considerable erosion or flooding on or off-site” before the impacts from the project are considered significant.

I do not have the details of how the TR-55 model was applied to the Dunphy Vineyard Conversion so I can not ascertain if the model output is reasonable. However, the TR-55 model does not account for subsurface storm-flow. In my opinion, the Dunphy Vineyard conversion project will increase not only surface storm-flow but also subsurface storm-flow. The combined increase in both surface and subsurface storm-flow from the Dunphy Vineyard Conversion will result in a cumulative impact that sustains high flows in the Napa River. Sustained high flows in the Napa River erode the bed and banks of the river and result in channel incision (the progressive lowering of the stream channel).

To assess the impact of the change in storm-flow discharge from the Dunphy Vineyard Conversion requires that all development projects that affect the storm discharge in the Napa River be considered. I present evidence of a statistically significant change in storm discharge in the Napa River to demonstrate that the cumulative impact of development projects on the discharge in the Napa River is already occuring. The change in storm-flow that I present is linked to the channel incision process which Stillwater and Dietrich (2002) demonstrate has a significant adverse impact on salmon and steelhead habitat.

Statistical Evidence Change in Napa River Discharge

The following is a summary of a statistical analysis of the discharge of the Napa River. Details of the statistical analysis are attached as an appendix to this letter.

The U.S. Geological Survey (USGS) maintains two stream gaging stations on the Napa River. One station is located near Zinfandel Lane and is called the Napa River near St Helena. The drainage area above this station is 88.1 square-miles. The other station is at Oak Knoll Avenue and is called the Napa River near Napa. Its drainage area is 218 square-miles and includes the watershed above Lake Hennessey.

Changes in land use have been occurring in the Napa River watershed over the last two hundred years approximately. I assumed that the latest changes began in the mid 1970’s with the expansion of vineyards. Therefore, I divided the discharge record into the pre-expansion period of 1930-1975 and to the expansion period of 1976-2006. However, the discharge record at both stations has record for only 1930-1932. Data collection was resumed in 1940 at the St Helena station and in 1960 at the Napa River near Napa gage.

There is a weather station at Angwin. The 3-day total rainfall at Angwin on the day of the annual maximum discharge at the Napa River near Napa showed no statistical difference in either the variance or the mean for the periods 1960-1975 and 1976-2007. Rainfall data at Angwin was not available in the early 1930’s. These tests show that the changes in the storm discharge between 1960-1975 and 1976-2006 were not the result of changes in rainfall.

Changes in land use can cause a change in either the mean or variance of stream discharge data (McCuen, 2003). An increase in discharge variance indicates an increase in variability of the discharge data. An increase in the discharge variance means that either the low flows are getting lower or the high flows are getting higher or that both are becoming more extreme.

Table 1 summarizes the changes in the distribution of storm discharges. Table 2 summarizes the statistical tests on the Angwin 3-day rainfall. All statistical tests were done using alpha set at 0.05 which means there is only a 5% chance that the changes deemed significant are the result of chance.

No significant difference was found in either the mean or the variance of the annual maximum discharge for the Napa River near St Helena. This analysis found a significant increase in the variance of the associated daily discharge of the Napa River near St Helena. No significant difference was found in the mean of the associated daily discharge at the Napa River near St Helena.

A significant increase was found in the variance of both the annual maximum discharge and the associated daily discharge for the Napa River near Napa. But no difference was found in the mean of either the annual maximum or the associated daily discharge.

No difference in the variance of either the ratio (upstream discharge divided by downstream discharge) of the annual maximum or ratio of the associated daily discharge was found. A statistically significant increase in the mean of the ratio of the annual-maximum-discharge at the Napa-River-near-Napa to the Napa-River-near-St-Helena was found (alpha = 0.05). And a statistically significant increase in the mean of the ratio of the associated-daily-discharge at the Napa-River-near-Napa to the Napa-River-near-St-Helena was found (alpha = 0.05).

The statistically significant increase in the two ratios indicate that the watershed between the two gaging stations is contributing significantly more discharge during the 1976-2006 period than was contributed during the 1930-1975 period. This increase in discharge in the downstream direction between the two time periods indicates that the Napa River has more power to erode the bed and banks of the river which has been found to adversely impact salmon and steelhead habitat.

Since there was no change in rainfall during the two time periods it is reasonable to conclude that the changes in land use during the 1976-2006 time period are generating more surface and subsurface storm water runoff. The predominate change of land use in the 1976-2006 time period has been the increase in vineyard acreage, especially hillside vineyards.

Table 1. Summary of Changes in Discharge. The variance and the mean for the annual maximum discharge and the associated daily average discharge were compared for the periods 1930-1975 and 1976-2006 for two USGS gaging stations on the Napa River. The mean and variance for the ratio between the downstream-station and the upstream-station were also compared for the periods 1930-1975 and 1976-2006. All the tests used an alpha of 0.05.

Streamflow	Parameter	Napa near St Helena	Napa near Napa	Ratio Napa to St Helena
Annual Maximum Discharge	variance	equal	**Significant Increase**	equal
	mean	no difference	no difference	**Significant Increase**
Associated Daily Discharge	variance	**Significant Increase**	**Significant Increase**	equal
	mean	no difference	no difference	**Significant Increase**

Table 2. Summary of Rainfall. No statistical difference in Angwin 3-Day rainfall on the day of the annual maximum discharge at the Napa River near Napa.

Angwin 3-Day Rainfall	*1976-2007*	*1960-1975*	*Test Results*
variance	4.71	5.32	no difference
mean	6.47	4.86	no difference
Observations	32	16	

The above statistical analysis demonstrates that the storm discharge regime of the Napa River is changing in a way to increase the erosive power of the river. The change in the discharge regime of the Napa River must be considered when judging the cumulative impacts of storm runoff from the Dunphy Vineyard Conversion project.

The changes in the storm discharge regime of the Napa River are consistent with an increase in the subsurface storm-flow discharge associated with the expansion of vineyard acreage since the mid-1970's.

Groundwater Impacts

The Dunphy parcel is to the west of Dry Creek Road, on a hill adjacent to the Napa Valley. The alluvial fill of the Napa Valley begins just to the east of Dry Creek Road. According to the MDN the Dunphy parcel is underlain by the Great Valley Sequence.

No information about the Dunphy well is given in the MND except its approximate location on a drawing (see Figure 1) and that it is supposed to yield 25 gpm. The well yield was probably a rough estimate determined by the well driller and not the result from a sustained pump test. Well yields reported on well logs tend to be high. The location of the well is in the northeastern portion of the property adjacent to the intermittent stream.

The MND does not mention the type of the material encountered when the well was drilled. It is likely that the well penetrates a thin layer of surface alluvium but is mostly completed in the Great Valley

Sequence. The Great Valley Sequence is metamorphosed sandstone and supplies water to wells through fractures.

The depth of the well was not mentioned in the MND. The elevation of the ground surface at the well appears to be about 220 feet above sea level. Dry Creek, on the floor of the Napa Valley, is about 600 feet to the northeast of the Dunphy well. The bed of Dry Creek is about 140 feet above sea level. So, the bed of Dry Creek is approximately 80 feet below the ground surface at the well. If the depth of the well is more than about 80 feet then, there is a real possibility that the Dunphy well could induce flow from the alluvium of the Napa Valley into the fissures in the Great Valley Sequence that supplies the well.

If the Dunphy well obtains any of its water from the alluvium of the Napa Valley a cumulative impact would occur. In my comments on the Napa River Sediment TMDL dated July 2, 2009, I document that the summer and fall groundwater surface in the Napa Valley declines below the bed of the Napa River. The amount of the decline of the summer and fall groundwater surface below the Napa River is progressively increasing. The decline of the summer and fall groundwater surface is the result of the cumulative groundwater extraction from the Napa Valley aquifer. The decline of the summer and fall groundwater surface causes the Napa River to loose streamflow which adversely impacts juvenile salmon and steelhead.

The MND has not provide enough information about the Dunphy well to assess the impact of project pumping on the Napa Valley aquifer and the summer and fall streamflow in the Napa River.

Summary

The Dunphy Vineyard Conversion will cause an increase in surface and subsurface storm flow. The increase in surface and subsurface stream flow from the Dunphy project will contribute to a statistically significant increase in the storm-flow between the Napa River near St Helena stream gage and the Napa River near Napa stream gage. The cumulative increase in storm-flow between the two stream gages results in increased erosion of the bed and banks of the Napa River.

The Dunphy Vineyard Conversion project has the potential to decrease the caliber of the sediment discharged from the project in stormwater runoff.

The MND has not provided enough information about the Dunphy well to assess the impact of project pumping on the Napa Valley aquifer and the summer and fall streamflow in the Napa River.

Sincerely,

Dennis Jackson

Dennis Jackson
Hydrologist

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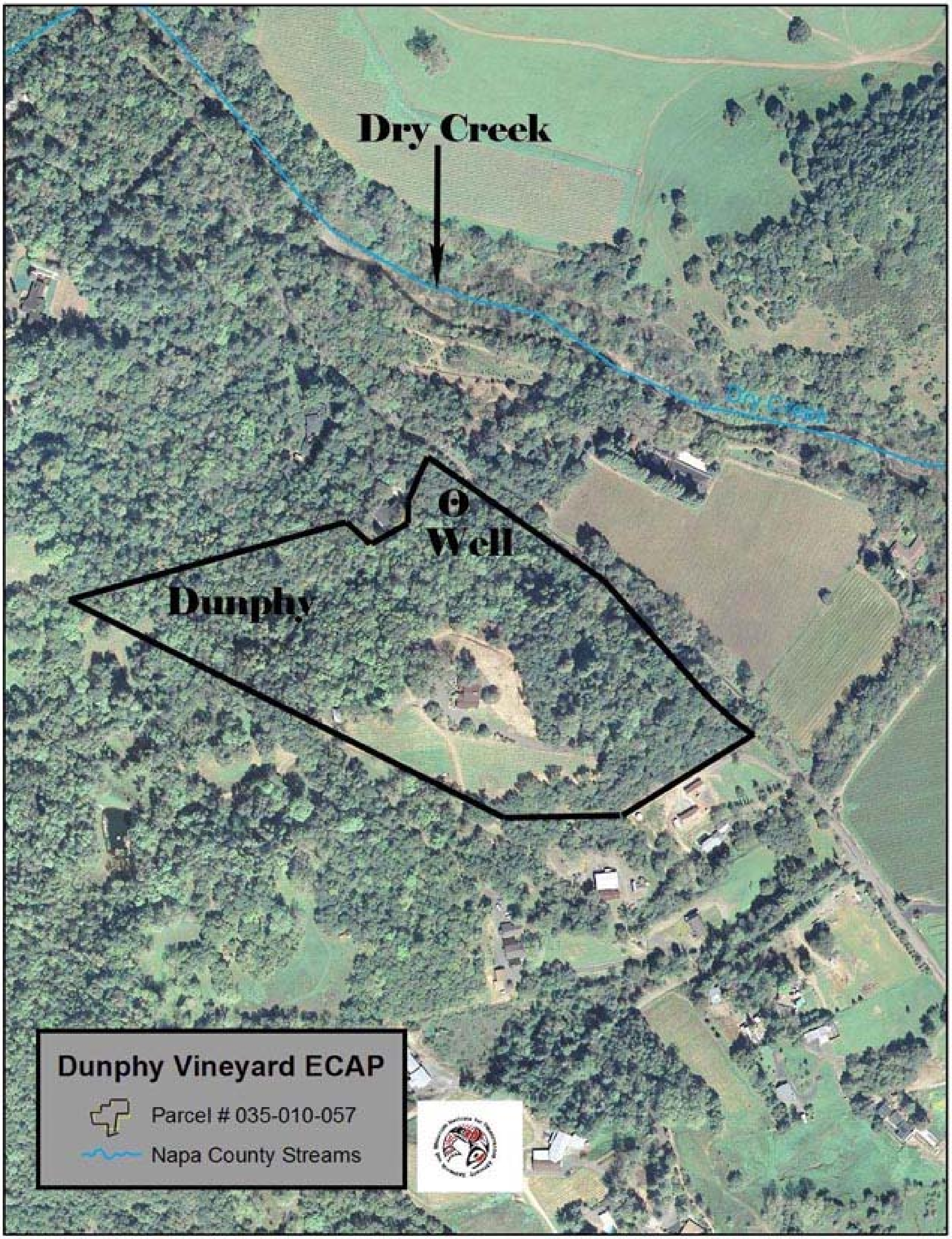

Figure 1. Dunphy Vineyard Conversion showing the approximate location of the well.

Comparison of Storm Discharges at the Napa River near Napa to the Storm Discharge at the Napa River near St Helena.

Prepared by Dennis Jackson, October 2009

Summary:

Statistical tests were applied to the maximum annual discharge and the associated daily discharge recorded at two USGS stream gaging stations to determine if any statistically significant change occurred between 1930-1975 and 1976-2006. The two stream gage stations are the Napa River near St Helena (upstream) and the Napa River near Napa (downstream).

The ratio of the annual maximum discharge at the downstream station was divided by the annual maximum discharge at the upstream station. This ratio is a measure of the downstream increase in streamflow. The ratio of the associated daily discharge was also calculated. Statistical tests were applied to these ratios to determine if a change in the relation between the gaging stations changed during the two time periods.

The Summary Table shows that the neither the mean nor the variance of the annual maximum discharge at the Napa River near St Helena did not change between the two time periods. The variance of the associated daily discharge is statistically different for the two time periods (alpha = 0.05) but there was no significant difference in the mean of the associated daily discharge at the St Helena station. The change in variance of the associated daily discharge demonstrates that changes in land use upstream of the St Helena gage are causing a change in the distribution of the daily discharge associated with the annual maximum discharge.

There was no statistical difference in the mean for either the annual maximum discharge or the associated daily discharge at the Napa near Napa gage (alpha = 0.05). However, there was a statistically significant difference in the variance (alpha = 0.05) for both the annual maximum discharge and the associated daily discharge at the Napa near Napa gage. The change in variance of both the annual maximum discharge and the associated daily discharge demonstrates that changes in land use upstream of the Napa near Napa gage are causing a change in the distribution of the annual maximum discharge and a change in the associated daily discharge.

There was no statistical difference in the variance of the ratio of the annual maximum discharge of the upstream station to the downstream station. There was no statistical difference in the variance of the ratio of the associated daily discharge of the upstream station to the downstream station. However, there was a statistically significant increase in the mean for both ratios (Table 4 and Table 6). This indicates that the downstream increase in annual maximum discharge was greater during the 1976-2006 period than it was during the 1930-1975 period. This increase in downstream discharge indicates that land use changes between the stream gages have increased storm runoff in the Napa River.

No statistical difference was found in either the mean or variance of the Angwin 3-day rainfall on the day of the annual maximum discharge at the Napa River near Napa. This demonstrates that changes in rainfall can not account for the changes in the discharge between 1930-1975 and 1976-2006.

Summary Table. The variance and the mean for the annual maximum discharge and the associated daily average discharge were compared for the periods 1930-1975 and 1976-2006 for two USGS gaging stations on the Napa River. The mean and variance for the ratio between the downstream-station and the upstream-station were also compared for the periods 1930-1975 and 1976-2006. All the tests used an alpha of 0.05.

Streamflow	Parameter	Napa near St Helena	Napa near Napa	Ratio Napa to St Helena
Annual Maximum Discharge	variance	equal	unequal	equal
	mean	no difference	no difference	Significant Difference
Associated Daily Discharge	variance	unequal	unequal	equal
	mean	no difference	no difference	Significant Difference

Summary of Tables 17 and 18. No statistical difference in Angwin 3-Day rainfall on the day of the annual maximum discharge at the Napa River near Napa.

Angwin 3-Day Rainfall	*1976-2007*	*1960-1975*	*Test Results*
variance	4.71	5.32	no difference
mean	6.47	4.86	no difference
Observations	32	16	

Station Descriptions

The U.S. Geological Survey (USGS) maintains two stream gaging stations on the Napa River. One station is located near Zinfandel Lane and is called the Napa River near St Helena. The drainage area above this station is 88.1 square-miles. The other station is at Oak Knoll Road and is called the Napa River near Napa. Its drainage area is 218 square-miles and includes the watershed above Lake Hennessey.

Procedure

The date of the annual maximum discharge at the Napa River near Napa (downstream) was compared the annual maximum discharge at the Napa River near St Helena (upstream). If the downstream peak discharge occurred more than one day after the upstream peak discharge than then it was assumed that different hydrologic processes were acting at the two stations and the events were excluded from this analysis. A total of 39 years were found to have the annual maximum discharge occur with in one day of each other at the two stations. Table 1 lists the 39 events used in this analysis.

Changes in land use have been occurring in the Napa River watershed over the last two hundred years. I assumed that the latest changes began in the mid 1970’s with the expansion of commercial vineyards. Therefore, I divided the discharge record into the pre-expansion period of 1930-1975 and to the expansion period of 1976-2006.

There are only three years of data from the early 1930's for both stations. The Napa River near St Helena discharge record resumes in 1940. The Napa River near Napa discharge record resumes in 1960. So, the 1930-1975 period is actually 1930-1932 and 1960-1975.

Dividing the annual maximum discharge at the Napa River near Napa (downstream) by the annual maximum discharge at the Napa River near St Helena (upstream) is a measure of the downstream increase in discharge. The larger the downstream-to-upstream ratio is the greater the downstream increase in annual maximum discharge. The ratios are shown in Table 1.

The maximum annual discharge is an instantaneous measurement. The discharge may be at its maximum value for only a few minutes. The daily average discharge associated with the maximum annual discharge occurs either on the day of the maximum discharge or on the next day if the maximum discharge occurred near the end of the day. I call the daily average discharge associated with the maximum annual discharge the "associated discharge".

The associated discharge is a measure of the sustained erosive power of the river. The downstream-to-upstream ratio using the associated daily discharge is another way of comparing the discharge downstream to the upstream discharge. Table 1 also contains the downstream-to-upstream ratio for the associated discharge.

The mean and variance of the downstream-to-upstream ratios were calculated for the pre-expansion period 1930-1975 and for the expansion period 1976-2006, see Table 2.

Table 3 shows that the variance of the Ratio of the Annual Maximum Discharge at the Napa River near Napa to the Annual Maximum Discharge at the Napa River near St Helena was compared for the 1930-1975 period to the 1976-2006 period. The computed F-statistic was less than the critical F-statistic at alpha = 0.05 so the variance are not statistically different.

Table 4 shows that the mean of the Ratio of the Annual Maximum Discharge at the Napa River near Napa to the Annual Maximum Discharge at the Napa River near St Helena was compared for the 1930-1975 period to the 1976-2006 period. The computed t-statistic was greater than the critical F-statistic so the variance are statistically different at the alpha = 0.05 level.

Table 5 shows that the variance of the Ratio of the Associated Daily Discharge at the Napa River near Napa to the Associated Daily Discharge at the Napa River near St Helena was compared for the 1930-1975 period to the 1976-2006 period. The computed F-statistic was less than the critical F-statistic so the variance are not statistically different at the alpha = 0.05 level

Table 6 shows that the mean of the Ratio of the Associated Daily Discharge at the Napa River near Napa to the Associated Daily Discharge at the Napa River near St Helena was compared for the 1930-1975 period to the 1976-2006 period. The computed t-statistic was greater than the critical F-statistic so the variance are statistically different at the alpha = 0.05 level.

Table 7 shows that the F-test found no statistically significant difference in the variance of the annual maximum discharge for the Napa River near St Helena between the period 1930-1975 and 1976-2006 at the alpha = 0.05 level.

Table 8 shows that no significant difference was found between the mean annual maximum discharge for the 1930-1975 period and the 1976-2006 period at the Napa River near St Helena stream gage, at the alpha =0.05 level.

Table 9 shows that the F-test found a statistically significant difference in the variance of the associated daily discharge for the Napa River near St Helena between the period 1930-1975 and 1976-2006 at the alpha = 0.05 level.

Table 10 shows that no significant difference was found between the mean associated daily discharge for the 1930-1975 period and the 1976-2006 period at the Napa River near St Helena stream gage, at the alpha =0.05 level.

Table 11 shows that the F-test found a statistically significant difference in the variance of the annual maximum discharge for the Napa River near Napa between the period 1930-1975 and 1976-2006 at the alpha = 0.05 level.

Table 12 shows that no significant difference was found between the mean annual maximum discharge for the 1930-1975 period and the 1976-2006 period at the Napa River near Napa stream gage, at the alpha =0.05 level.

Table 13 shows that the F-test found a statistically significant difference in the variance of the associated daily discharge for the Napa River near Napa between the period 1930-1975 and 1976-2006 at the alpha = 0.05 level.

Table 14 shows that no significant difference was found between the mean associated daily discharge for the 1930-1975 period and the 1976-2006 period at the Napa River near Napa stream gage, at the alpha =0.05 level.

Table 1. Annual maximum discharge at the Napa River near St Helena and the Napa River near Napa that occur within one day of each are assumed to represent a single hydrologic process. Other years were excluded from this analysis because the difference in timing of the peak events suggest that different hydrologic processes were acting at the two gages.

Water Year	Date of Peak	**Napa near St Helena** Annual Maximum Discharge	**Napa near St Helena** Associated Daily	Annual Max Napa/St Helena	Assoc Daily Napa/St Helena	Date of Peak	**Napa near Napa** Annual Maximum Discharge	**Napa near Napa** Associated Daily
1930	12/15/1929	4480	3610	1.49	1.05	12/15/1929	6660	3780
1931	1/23/1931	920	443	1.63	1.60	1/23/1931	1500	709
1932	12/27/1931	5980	4240	1.94	2.21	12/27/1931	11600	9370
1960	2/8/1960	11600	5820	1.06	1.43	2/8/1960	12300	8300
1961	1/31/1961	2160	1020	1.55	1.57	1/31/1961	3350	1600
1963	1/31/1963	12300	7160	2.03	1.55	1/31/1963	25000	11100
1964	1/20/1964	5020	1360	1.05	1.72	1/20/1964	5260	2340
1965	1/5/1965	11800	5540	1.53	1.47	1/5/1965	18100	8170
1966	1/5/1966	9190	5390	1.21	1.62	1/5/1966	11100	8730
1967	1/21/1967	11100	8380	1.93	1.44	1/21/1967	21400	12100
1968	1/29/1968	4970	2010	1.73	2.11	1/29/1968	8620	4250
1969	1/13/1969	6600	4640	1.33	1.45	1/13/1969	8760	6720
1970	1/24/1970	9450	4390	1.56	2.28	1/24/1970	14700	9990
1971	12/3/1970	9700	4920	1.26	1.66	12/4/1970	12200	8150
1972	12/27/1971	1120	482	1.28	1.57	12/27/1971	1430	757
1973	1/16/1973	11300	3400	1.23	2.49	1/16/1973	13900	8450
1974	3/30/1974	6680	3160	1.46	2.01	3/30/1974	9730	6350
1975	3/21/1975	8540	2410	1.26	2.02	3/22/1975	10800	4880
1976	2/29/1976	203	67	1.58	2.37	3/1/1976	321	159
1978	1/16/1978	10000	4900	1.53	2.08	1/16/1978	15300	10200
1979	1/11/1979	2480	1190	2.54	2.62	1/11/1979	6310	3120
1980	2/17/1980	7200	3100	1.74	2.47	2/18/1980	12500	7650
1981	1/27/1981	3660	2320	1.31	1.20	1/27/1981	4780	2790
1984	12/25/1983	9060	4590	1.35	1.93	12/25/1983	12200	8860
1985	2/8/1985	7390	3230	1.27	1.74	2/8/1985	9360	5610
1986	2/17/1986	16900	13700	2.20	1.58	2/18/1986	37100	21600
1987	2/13/1987	2730	1300	1.78	2.11	2/13/1987	4870	2740
1988	1/4/1988	1390	1170	1.65	1.58	1/4/1988	2290	1850
1989	3/11/1989	3730	1690	1.31	1.56	3/11/1989	4890	2640
1990	2/16/1990	1370	608	1.37	1.40	2/16/1990	1880	853
1991	3/4/1991	6940	3600	1.30	1.61	3/4/1991	8990	5790
1992	2/20/1992	2890	1300	1.61	2.28	2/20/1992	4660	2970
1993	1/20/1993	7930	4610	1.64	1.69	1/20/1993	13000	7780
1994	2/20/1994	900	577	1.80	2.24	2/20/1994	1620	1290
1995	3/9/1995	11100	7330	2.94	2.61	3/9/1995	32600	19100
2001	3/4/2001	3280	1170	1.32	2.03	3/5/2001	4320	2370
2003	12/16/2002	10200	4670	1.87	2.61	12/16/2002	19100	12200
2005	3/22/2005	3890	2090	1.57	1.97	3/22/2005	6090	4110
2006	12/31/2005	18300	10600	1.62	2.27	12/31/2005	29600	24100

Table 2. Summary statistics for the 1930-1975 period and the 1976-2006 period.

1930-1975	**Napa near St Helena** Annual Maximum Discharge	**Napa near St Helena** Associated Daily	Annual Max Napa/St Helena	Assoc Daily Napa/St Helena	**Napa near Napa** Annual Maximum Discharge	**Napa near Napa** Associated Daily
count	18	18	18	18	18	18
average	7,383.89	3,798.61	1.47	1.74	10,911.67	6430.33
variance	13,885,790	5,065,073	0.087	0.136	40,265,003	12,550,939
Std dev	3,726.36	2,250.57	0.29	0.37	6,345.47	3,542.73

1976-2006	**Napa near St Helena** Annual Maximum Discharge	**Napa near St Helena** Associated Daily	Annual Max Napa/St Helena	Assoc Daily Napa/St Helena	**Napa near Napa** Annual Maximum Discharge	**Napa near Napa** Associated Daily
Count	21	21	21	21	21	21
average	6,263.95	3,514.86	1.68	2.00	11,037.19	7,037.24
variance	25,158,486	11,816,492	0.182	0.179	109,890,210	47,839,733
Std dev	5,015.82	3,437.51	0.43	0.42	10,482.85	6,916.63

Table 3. The variance of the Ratio of the Annual Maximum Discharge at the Napa River near Napa to the Annual Maximum Discharge at the Napa River near St Helena was compared for the 1930-1975 period to the 1976-2006 period. The computed F-statistic was less than the critical F-statistic at alpha = 0.05 so the variance are not statistically different.

F-Test Two-Sample for Variances

Ratio of Annual Maximum Discharges	*1976-2006*	*1930-1975*
Mean	1.680	1.473
Variance	0.182	0.087
Observations	21	18
df	20	17
F	2.097	
P(F<=f) one-tail	0.064	
F Critical one-tail	2.230	

Table 4. The mean of the Ratio of the Annual Maximum Discharge at the Napa River near Napa to the Annual Maximum Discharge at the Napa River near St Helena was compared for the 1930-1975 period to the 1976-2006 period. The computed t-statistic was greater than the critical t-statistic so the means are statistically different at the alpha = 0.05 level. The mean of the second time period is greater than for the 1930-1975 period.

t-Test: Two-Sample Assuming Equal Variances

Ratio of Annual Maximum Discharges	*1976-2006*	*1930-1975*
Mean	1.680	1.473
Variance	0.182	0.087
Observations	21	18
Pooled Variance	0.1385	
Hypothesized Mean Difference	0	
df	37	
t Stat	1.727	
P(T<=t) one-tail	0.046	
t Critical one-tail	1.687	
P(T<=t) two-tail	0.092	
t Critical two-tail	2.026	

Table 5. The variance of the Ratio of the Associated Daily Discharge at the Napa River near Napa to the Associated Daily Discharge at the Napa River near St Helena was compared for the 1930-1975 period to the 1976-2006 period. The computed F-statistic was less than the critical F-statistic so the variance are not statistically different at the alpha = 0.05 level.

F-Test Two-Sample for Variances

Ratio of Associated Daily Discharges	***1976-2006***	***1930-1975***
Mean	1.997	1.736
Variance	0.179	0.136
Observations	21	18
df	20	17
F	1.316	
P(F<=f) one-	0.286	
F Critical one-	2.230	

Table 6. The mean of the Ratio of the Associated Daily Discharge at the Napa River near Napa to the Associated Daily Discharge at the Napa River near St Helena was compared for the 1930-1975 period to the 1976-2006 period. The computed t-statistic was greater than the critical t-statistic so the means are statistically different at the alpha = 0.05 level.

t-Test: Two-Sample Assuming Equal Variances

Ratio of Associated Daily Discharges	*1976-2006*	*1930-1975*
Mean	1.997	1.736
Variance	0.179	0.136
Observations	21	18
Pooled Variance	0.159	
Hypothesized Mean Difference	0	
df	37	
t Stat	2.039	
P(T<=t) one-tail	0.024	
t Critical one-tail	1.687	
P(T<=t) two-tail	0.049	
t Critical two-tail	2.026	

Table 7. The F-test found no statistically significant difference in the variance of the annual maximum discharge for the Napa River near St Helena between the period 1930-1975 and 1976-2006 at the alpha = 0.05 level.

F-Test Two-Sample for Variances

Annual Maximum Discharge	*1976-2006*	*1930-1975*
Mean	6,263.95	7,383.89
Variance	25,158,486	13,885,790
Observations	21	18
df	20	17
F	1.812	
P(F<=f) one-tail	0.110	
F Critical one-tail	2.230	

Table 8. No significant difference was found between the mean annual maximum discharge for the 1930-1975 period and the 1976-2006 period at the Napa River near St Helena stream gage, at the alpha =0.05 level.

t-Test: Two-Sample Assuming Equal Variances

Annual Maximum Discharge	*1976-2006*	*1930-1975*
Mean	6,263.95	7,383.89
Variance	25,158,486	13,885,790
Observations	21	18
Pooled Variance	19,979,139	
Hypothesized Mean Difference	0	
df	37	
t Stat	-0.780	
P(T<=t) one-tail	0.220	
t Critical one-tail	1.687	
P(T<=t) two-tail	0.440	
t Critical two-tail	2.026	

Table 9. The F-test found a statistically significant difference in the variance of the associated daily discharge for the Napa River near St Helena between the period 1930-1975 and 1976-2006 at the alpha = 0.05 level.

F-Test Two-Sample for Variances

Napa near St Helena

Associated Daily Discharge	*1976-2006*	*1930-1975*
Mean	3,514.86	3,798.61
Variance	11,816,492	5,065,073
Observations	21	18
Df	20	17
F	2.333	
P(F<=f) one-tail	0.041	
F Critical one-tail	2.230	

Table 10. No significant difference was found between the mean associated daily discharge for the 1930-1975 period and the 1976-2006 period at the Napa River near St Helena stream gage, at the alpha =0.05 level.

t-Test: Two-Sample Assuming Unequal Variances

Napa near St Helena

Associated Daily Discharge	*1976-2006*	*1930-1975*
Mean	3,514.86	3,798.61
Variance	11,816,492	5,065,073
Observations	21	18
Hypothesized Mean Difference	0	
df	35	
t Stat	-0.309	
P(T<=t) one-tail	0.380	
t Critical one-tail	1.690	
P(T<=t) two-tail	0.759	
t Critical two-tail	2.030	

Table 11. The F-test found a statistically significant difference in the variance of the annual maximum discharge for the Napa River near Napa between the period 1930-1975 and 1976-2006 at the alpha = 0.05 level.

F-Test Two-Sample for Variances

Napa near Napa

Annual Maximum Discharge	*1976-2006*	*1930-1975*
Mean	11,037.19	10,911.67
Variance	109,890,210	40,265,003
Observations	21	18
Df	20	17
F	2.729	
P(F<=f) one-tail	0.021	
F Critical one-tail	2.230	

Table 12. No significant difference was found between the mean annual maximum discharge for the 1930-1975 period and the 1976-2006 period at the Napa River near Napa stream gage, at the alpha =0.05 level.

t-Test: Two-Sample Assuming Unequal Variances

Napa near Napa

Annual Maximum Discharge	*1976-2006*	*1930-1975*
Mean	11,037.19	10,911.67
Variance	109,890,210	40,265,003
Observations	21	18
Hypothesized Mean Difference	0	
Df	34	
t Stat	0.046	
P(T<=t) one-tail	0.482	
t Critical one-tail	1.691	
P(T<=t) two-tail	0.964	
t Critical two-tail	2.032	

Table 13. The F-test found a statistically significant difference in the variance of the associated daily discharge for the Napa River near Napa between the period 1930-1975 and 1976-2006 at the alpha = 0.05 level.

F-Test Two-Sample for Variances

Napa near Napa

Associated Daily Discharge	*1976-2006*	*1930-1975*
Mean	7,037.24	6,430.33
Variance	47,839,733	12,550,939
Observations	21	18
Df	20	17
F	3.812	
P(F<=f) one-tail	0.004	
F Critical one-tail	2.230	

Table 14. No significant difference was found between the mean associated daily discharge for the 1930-1975 period and the 1976-2006 period at the Napa River near Napa stream gage, at the alpha =0.05 level.

t-Test: Two-Sample Assuming Unequal Variances

Napa near Napa

Associated Daily Discharge	*1976-2006*	*1930-1975*
Mean	7,037.24	6,430.33
Variance	47,839,733	12,550,939
Observations	21	18
Hypothesized Mean Difference	0	
Df	31	
t Stat	0.352	
P(T<=t) one-tail	0.364	
t Critical one-tail	1.696	
P(T<=t) two-tail	0.727	
t Critical two-tail	2.040	

Table 15. Three day rainfall totals at Angwin on the day of the annual maximum discharge at the Napa River near Napa station.

Date of Peak Discharge at Napa near Napa	Angwin 3-Day Rainfall on Day of Peak
2/8/1960	6.78
1/31/1961	3.20
2/15/1962	6.16
1/31/1963	10.78
1/20/1964	4.48
1/5/1965	4.37
1/5/1966	6.88
1/21/1967	7.42
1/29/1968	2.21
1/13/1969	6.60
1/24/1970	6.11
12/4/1970	6.06
12/27/1971	2.77
1/16/1973	4.15
3/30/1974	4.39
3/22/1975	2.83
3/1/1976	1.70
3/16/1977	2.36
1/16/1978	6.12
1/11/1979	4.79
2/18/1980	7.39
1/27/1981	3.14
1/4/1982	3.32
3/1/1983	6.27
12/25/1983	6.47
2/8/1985	4.75
2/18/1986	11.60
2/13/1987	4.36
1/4/1988	0.03
3/11/1989	2.71
2/16/1990	1.57
3/4/1991	6.79
2/20/1992	2.56
1/20/1993	4.66
2/20/1994	1.74
3/9/1995	7.88
2/4/1996	4.44
1/1/1997	8.29
2/3/1998	5.72
2/9/1999	3.71
2/14/2000	2.78
3/5/2001	2.47
1/2/2002	3.98
12/16/2002	8.70
2/18/2004	5.32
3/22/2005	3.09
12/31/2005	8.18
2/11/2007	3.85

Table 16. Angwin 3-day total rainfall on day of annual maximum at Napa River near Napa.

	1960-1975	**1976-2007**
count	16	32
Average	5.32	4.71
Variance	4.86	6.47

Table 17. There is no statistical difference in the variance for the Angwin 3-Day rainfall on the day of the annual maximum discharge at the Napa River near Napa at the alpha = 0.05 level..

F-Test Two-Sample for Variances

Angwin 3-Day Rainfall	*1976-2007*	*1960-1975*
Mean	4.71	5.32
Variance	6.47	4.86
Observations	32	16
df	31	15
F	1.3314	
P(F<=f) one-tail	0.2833	
F Critical one-tail	2.2414	

Table 18. There is no statistical difference in the mean for the Angwin 3-Day rainfall on the day of the annual maximum discharge at the Napa River near Napa at the alpha = 0.05 level.

t-Test: Two-Sample Assuming Equal Variances

Angwin 3-Day Rainfall	*1976-2007*	*1960-1975*
Mean	4.71	5.32
Variance	6.47	4.86
Observations	32	16
Pooled Variance	5.9491	
Hypothesized Mean Difference	0	
df	46	
t Stat	-0.8219	
P(T<=t) one-tail	0.2077	
t Critical one-tail	1.6787	
P(T<=t) two-tail	0.4154	
t Critical two-tail	2.0129	