State Water Resources Control Board

Division of Water Rights

1001 I Street, 14th Floor ♦ Sacramento, California 95814 ♦ 916.341.5300
P.O. Box 2000 ♦ Sacramento, California 95812-2000
Fax: 916.341.5400 ♦ www.waterrights.ca.gov

Linda S. Adams
Secretary for
Environmental Protection

Arnold Schwarzenegger
Governor

OBJECTIVE:

Division Staff has prepared the following sample calculation to illustrate how the Board's Instream Flow Policy would be applied to an example water rights application.

PROJECT DESCRIPTION:

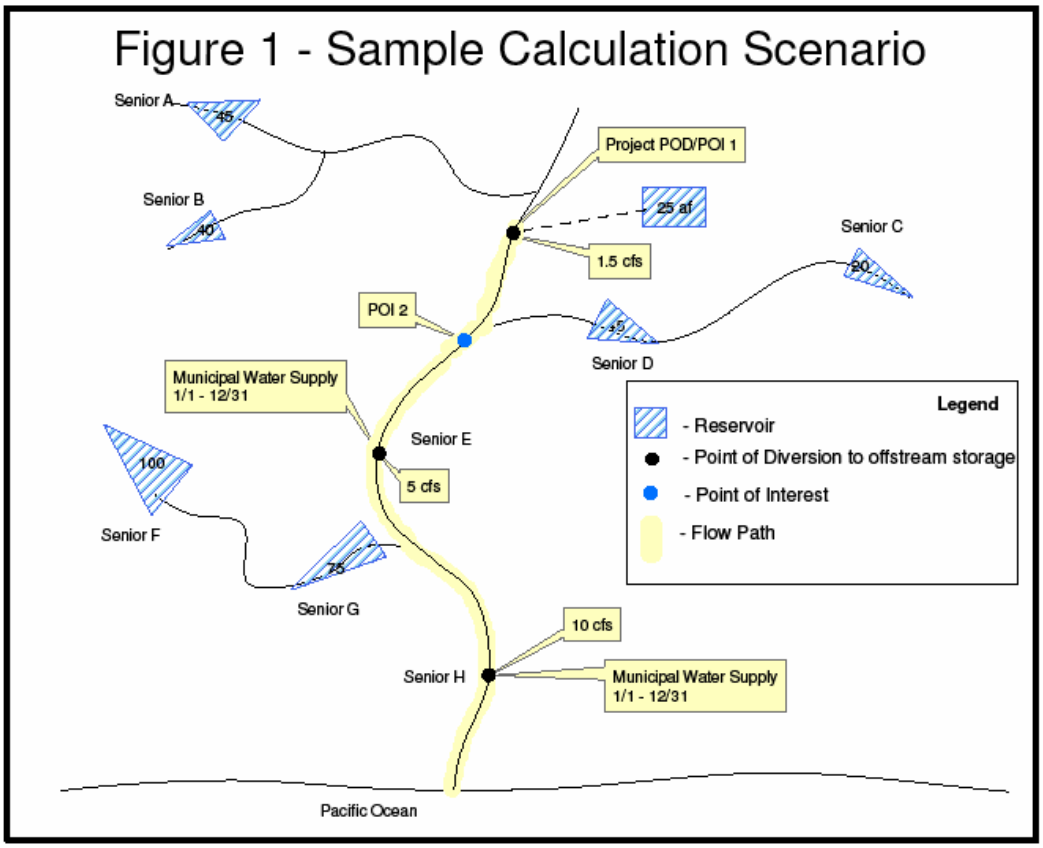
In this example, the applicant has applied for direct diversion to offstream storage. The applicant proposes to divert 1.5 cfs from an example stream to a 25 acre-foot offstream reservoir. The proposed uses are irrigation and frost protection on 50 acres of vineyard. Anadromous fish are present in the example stream making it a Class I stream tributary to the Pacific Ocean.

METHODOLOGY:

The Policy water availability analysis consists of (1) a Water Supply Report (WSR), which quantifies the amount of unappropriated water remaining instream after senior rights are accounted for; and (2) a Cumulative Diversion Analysis, which utilizes the instream flow criteria to evaluate the effects of the proposed project, in combination with existing diverters, on instream flows needed for protection of fishery resources.

Water Supply Report

This section describes the information and calculations that will be made and reported in the WSR. The first step is to identify (1) where the project is positioned within the watershed of interest and (2) the location and maximum demand at the points of diversion (PODs) associated with all the senior water rights that are located on the flow path of the project as well as any tributaries to the streams on that flow path. The flow path is defined as the stream reach extending from the project POD to that reach's confluence with the Pacific Ocean. For a sample flow path, see Figure 1; the flow path is highlighted in yellow. The location of the diversion points and maximum demand (D) of each of the senior water rights that must be included in the analysis can be determined using the Division's e-WRIMS data base, located online at http://www.waterboards.ca.gov/water_issues/programs/ewrims/. For this sample calculation, the senior water rights are identified as "Senior A," "Senior B", etc. This example includes senior water right holders who directly divert as well as senior water right holders who divert to storage facilities.



After the maximum potential demands of the senior water right holders and the proposed project have been determined, the applicant must estimate the available supply above the point of diversion of each water right. The available supply is calculated based on the watershed area (A) and annual precipitation (I) above each identified point of diversion on the flow path, including the project POD(s). For this example, this information is contained in Table 1. Watershed areas are most commonly determined using computer aided drafting software, computer aided graphic information systems, or a planimeter. Estimates of annual precipitation are most commonly made using precipitation isohyetal maps produced for the subject area. Those maps are often provided by counties, or one can use isohyetal data from the NOAA atlas. The last piece of information needed to calculate the unimpaired flow at each demand point is streamflow data. The applicant should locate the nearest USGS stream gage that is located on a non-regulated stream system and for which data is available for a continuous period of record of not less than 10 years. Stream gage information is available from the USGS's website as follows: http://waterdata.usgs.gov/nwis. The streamflow information for this sample calculation is included with this document as Attachment 1.

The seasonal unimpaired flow under the Policy represents the average flow volume from December 15 through March 31 at each diversion point. The seasonal unimpaired flow can be estimated using the USGS websites data for average daily flow. Unimpaired flow volume (Q) at each demand point can then be estimated using the following proration equation:

$$Q_{\text{Point of Demand}} = Q_{\text{Gage}} \times (I_{\text{Point of Demand}}/I_{\text{Gage}}) \times (A_{\text{Point of Demand}}/A_{\text{Gage}})$$

The product of the factored annual precipitation and watershed area are referred to in Table 1 as the "Ratio". The upstream senior demand (D_S) must be estimated at each point of demand along the flow path. Using the map created (Figure 1 here) the applicant can identify the point of demand along the flow path and summate D_S. In this example the points of demand are the project POD, Senior E, and Senior H, Figure 1. Once the senior demand is known the applicant calculates the remaining unappropriated water (Q_I) by subtracting D_s from Q at each point of demand.

There are three computational steps required to complete the WSR. For a complete discussion of the steps, refer to Appendix B of the Instream Flow Policy, Item B.2.2. Once Q_I has been computed the applicant is ready to estimate values for Step 1 – Remaining Unappropriated Water. Remaining unappropriated water is expressed as a percentage of the reduction in unimpaired flow by upstream senior demand. The value is computed by dividing Q_I for the diversion location by Q for that same diversion location and expressing the result as a percentage. See Table 1.

Step 2 requires that the applicant calculate the ratio of the project's demand to the remaining unappropriated water calculated in Step 1. The remaining unappropriated water (Q_I) is determined by subtracting the senior demand (D_S) from the unimpaired seasonal flow volume (Q) at a particular demand point. The ratio is then computed by dividing the project demand (D_P) by the remaining unappropriated water, D_P/Q_I.

Step 3 requires that the applicant perform a flow frequency analysis of the seasonal unimpaired flow volume at the project POD, the senior POD at which the percentage calculated in Step 1 is the lowest, and any other senior PODs at which the ratio is less than 50%, if any. Frequency occurrence is estimated using the Weibull formula as follows:

$$F = 1 - (m/(N+1)),$$

Where: F = the frequency of occurrence
m = the rank of the average seasonal unimpaired flow volume, with the largest value receiving m=1, and
N = the length of the gage data record, in years.

Frequency (F) is plotted verses the average seasonal unimpaired flow volume for each year of record. The seasonal unimpaired flow volume must be calculated for each water year of record. The seasonal unimpaired flow volume values are then ranked in descending order and F is computed for each year, Table 2. The computed values of F are then plotted verses the seasonal unimpaired flow volumes, Chart 1.

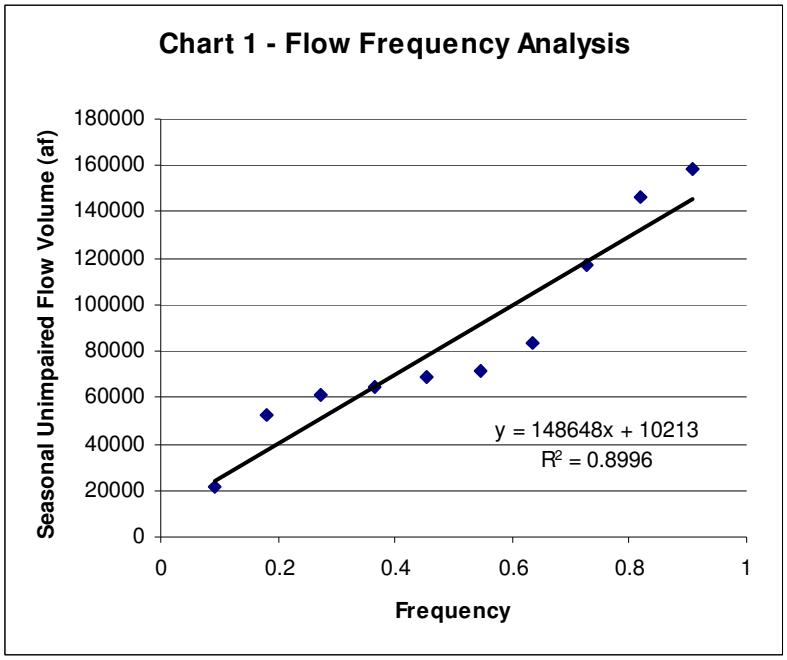
Table 1 - Water Supply Report

Points of Analysis	Watershed Area above Point (ac)	Annual Precip. of Watershed above Point (in)	Ratio	Seasonal Unimpaired Flow Volume at Point (Q) (af)	Demand Volume (D_S, $\mathbf{D_P}$) (af) [1]	Senior Demand Volume along Path (D_S) (af)	Senior Seasonal Impaired Fow at Point (Q_I) (af)	Step 1 - Remaining Unappropriated Water (%)	Step 2 - Ratio (%)
Gage	54000	45		84537		NA			
Senior A	200	45	0.0037	313	45	NA			
Senior B	200	45	0.0037	313	40	NA			
POD	700	45	0.0130	1096	**25**	85	1011	92.2%	2.5%
Senior C	250	45	0.0046	391	20	NA			
Senior D	500	45	0.0093	783	45	NA			
Senior E	8000	45	0.1481	12524	361	511	12013	95.9%	0.2%
Senior F	200	45	0.0037	313	100				
Senior G	400	45	0.0074	626	75				
Senior H	50000	45	0.9259	78275	3610	4296	73979	94.5%	0.0%

Notes:
[1] D_P refers to the demand at the POD only. D_S refers to the senior demand at any point.

Table 2 - Flow Frequency Analysis

WY	Seasonal Unimpaired Vol. (af)	Rank	F	N
1970	158532	1	0.909091	10
1969	146211	2	0.818182	
1965	117499	3	0.727273	
1967	83448	4	0.636364	
1966	71248	5	0.545455	
1972	68523	6	0.454545	
1963	64595	7	0.363636	
1968	61263	8	0.272727	
1971	52726	9	0.181818	
1964	21326	10	0.090909	
Average	84537			



Once Steps 1 through 3 are completed the applicant may submit the WSR to the Division for review. If there is unappropriated water to supply the proposed project the applicant must first establish the Upper Limit of Anadromy (ULA) before proceeding with the Cumulative Diversion Analysis. The ULA is determined by a qualified fisheries biologist whose qualifications must first be approved by the Division.

Assuming there is unappropriated water to supply the proposed project and the ULA has been defined the Division will select points of interest (POIs) and issue them to the applicant so that the applicant may begin the Cumulative Diversion Analysis. In this example the upper limit of anadromy is above the POD for this proposed project, therefore the POD is within the range of anadromy. In step 2 of the WSR the ratio of the project's demand compared to the remaining unappropriated water at Senior E was less than 1 percent. Therefore the Division would not need to select POIs beyond the POD for Senior E. For this example two POIs were selected, at the proposed projects POD and the point immediately downstream of the confluence of the example stream and the tributary stream containing senior rights C and D.

Cumulative Diversion Analysis (CDA)

The CDA assesses whether a proposed project may cause impacts to the minimum stream flows and the natural flow variability needed for protection of fishery resources. For this example the regional criteria was applied to complete the CDA, refer to Appendix B of the Instream Flow Policy at Section B.5.1.

As discussed above, for this example POIs were selected at the proposed project POD and at the point immediately downstream of the confluence of the example stream and the tributary

stream in which senior water rights C and D are located; See Figure 1 for the location of Point of Interest 2.

The applicant is required to calculate the following parameters at each POI:

DA = drainage area (sm)
I = Average annual precipitation (in)
Q_m = Mean annual daily unimpaired flow (cfs)
Q_{MBF} = Minimum bypass flow (cfs)
MCD = Maximum Cumulative Rate of Diversion (cfs)

Methods to Quantify DA and I have already been discussed with reference to the WSR. Q_m is the mean annual flow at the POI. It is computed by prorating the mean annual flow at the gage ($Q_{m(gage)}$) to the POI based on watershed area. $Q_{m(gage)}$ is calculated from the average of the daily flows reported by USGS for the gage during the period of record. For this example $Q_{m(gage)}$ was assumed to be 92.3 cfs. There are three equations that can be used to calculate the Q_{MBF}; the applicable equation depends on the size of the watershed area above the POIs. See Appendix B of the Instream Flow Policy, Section B.5.2.2 for more information. This example assumes that the watershed area above both POIs 1 and 2 is between 1.0 and 321 square miles. The following equation is used to calculate Q_{MBF}:

$$Q_{MBF} = 8.8\ Q_m\ (DA)^{-0.47}$$

In our example at POI 1:

$DA = 700 \text{ acres} / 640 \text{ acres/ mi}^2$

$DA = 1.1 \text{ mi}^2$

$Q_m = Q_{m(gage)} \times \text{Ratio for POI 1}$

or $92.3 \text{ cfs} \times 0.013 = 1.2 \text{ cfs}$

$Q_{MBF} = 8.8 \times 1.2 \text{ cfs} \times (1.1)^{-0.47}$

$Q_{MBF} = 10.1 \text{ cfs}$

In our example at POI 2:

$DA = 5.5 \text{ mi}^2$

$Q_m = Q_{m(gage)} \times \text{Ratio at POI 2}$

or $= 92.3 \text{ cfs} \times 0.065 = 6 \text{ cfs}$

$Q_{MBF} = 8.8 \times 6 \text{ cfs} \times (5.5)^{-0.47}$

Q_{MBF} = 23.7 cfs

At this point the applicant completes a daily flow analysis to estimate impaired flows at the POIs, project POD, and Senior PODs. The daily flows are estimated using the proration equation given above, taking into account the Q_{MBF}. Estimated impaired flows are used to evaluate impacts to the Q_{MBF} at the POIs and changes to the 1.5-year channel maintenance flows. The Daily Flow Analysis for this example is included in Attachment 1 and a sample calculation of the 1.5 year channel maintenance flows is included as Attachment 2. Results are summarized in Table 3.

Table 3 - CDA Results

	No. of Days Flow is above the MBF at the POIs				
	Unimpaired	Impaired w/o Project	Impaired with Project		
POI 1	93	77	77		
POI 2	208	204	204		
	1.5 Year Flood Flow (cfs)				
	Unimpaired	Impaired w/o Project	Impaired with Project	Percent Change w/o Project	Percent Change with Project
POI 1	34.8	33.9	32.9	3%	5%
POI 2	174.2	171.9	170.9	1%	2%

The results of the CDA are evaluated based on the requirements of sections B.5.3.4 and B.5.3.5 of Appendix B. With respect to the MBF, the results show that the number of days the MBF is exceeded at the POIs does not change with inclusion of the project. Therefore the sample project meets the requirements of section B.5.3.4. The percent change in the reduction of the 1.5 year peak flow at the POIs was found not to exceed 5% in either case. The project meets the requirement of item 3(b) of section B.5.3.5 and does not cause a reduction in instream flows needed to maintain natural flow variability.

By meeting the requirements of B.5.3.4 and B.5.3.5 the applicant has demonstrated the project does not impact instream flows needed for fishery resources and does not exceed the maximum cumulative diversion rate (MCD) at either POI. The applicant has demonstrated water is available for diversion. The project may be permitted as applied for and will have a bypass requirement of 10.1 cfs.