BEFORE THE STATE WATER
RESOURCES CONTROL BOARD

In the Matter of the State Water Resources Control Board (State Water Board) Hearing to Determine whether to Adopt a Draft Cease & Desist Order against California American Water Regarding its Diversion of Water from the Carmel River in Monterey County under Order WR 95-10	)	Hearing Date: July 23 - 25, 2008 Carmel River in Monterey County

EXHIBIT MPWMD-TC7

MONTEREY PENINSULA WATER MANAGEMENT DISTRICT

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TECHNICAL MEMORANDUM 2003-02

USING GIS TO QUANTIFY RIPARIAN AREA OVERLYING THE CARMEL VALLEY ALLUVIAL AQUIFER

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INTRODUCTION

The Monterey Peninsula Water Management District (District) uses the Carmel Valley Simulation Model (CVSIM) to simulate the occurrence, distribution, and movement of surface and groundwater resources within the District. Specifically, CVSIM simulates the response of the surface and groundwater resources in the Monterey Peninsula Water Resources System (MPWRS) to varying physical, structural, and management conditions. The MPWRS, which includes surface water in the Carmel River and its tributaries and groundwater in the Carmel Valley alluvial aquifer and coastal subareas of the Seaside Ground Water Basin, is depicted in **Figure 1**. As shown, the Carmel Valley alluvial aquifer is divided into four subunits:

1. Aquifer subunit 1 (AQ1) which underlies the river reach between San Clemente Dam and the United States Geological Survey (USGS) Carmel River gaging station at Robles del Rio,

2. Aquifer subunit 2 (AQ2) which underlies the river reach between the USGS Carmel River gaging station at Robles del Rio and the Narrows,

3. Aquifer subunit 3 (AQ3) which underlies the river reach between the Narrows and the USGS Carmel River gaging station near Carmel, and

4. Aquifer subunit 4 (AQ4) which underlies the river reach between the USGS Carmel River gaging station near Carmel and the Carmel River Lagoon.

These divisions were made for model accounting and calibration purposes (Fuerst and Litwin, 1987). In reality, the subunits form a continuous, single layer, unconfined coastal aquifer. The CVSIM model is designed to assess the water supply performance of various alternatives for impact analyses and environmental documents. CVSIM is a dynamic accounting model based on the continuity equation ($I - O = \Delta S$). This equation represents the simple relationship that inflow minus outflow equals the change in storage.

Specifically CVSIM accounts for losses due to evapotranspiration associated with the estimated area of riparian vegetation within the four Carmel Valley alluvial aquifer subunits. These subunits and associated river miles are summarized below.

AQ1 (River mile 18.62 – 14.35)

AQ2 (River Mile 14.35 – 9.36)

AQ3 (River Mile 9.36 – 3.49)

AQ4 (River Mile 3.49 – 0.00).

OBJECTIVE

Currently, CVSIM estimates evapotranspiration based on riparian areas provided in the report, *An Inventory of the Riparian Resources of the Carmel Valley* (McNiesh, 1989). The

District is in the process of updating the CVSIM model for future simulations for a Long-Term Water Supply Project EIR. Because McNiesh's riparian (i.e., wooded) area and non-wooded area calculations were based on 1986 aerial photographs, the District decided to update the riparian area calculations using 2001 orthoimagery and Geographic Information Systems (GIS) technology to calculate current riparian and non-wooded acreage along the Carmel River. These values will be used to update the daily evapotranspiration values used in CVSIM.

METHODS

District staff (Christensen and Wheeler) reviewed McNiesh's 1989 report to determine where McNiesh had set the boundaries for his riparian and non-wooded area calculations. A large photocopy set of 1986 aerial photos was found that was part of McNiesh's original area calculations. This set included overlaying sheets that had riparian and non-wooded area polygons traced on them from San Clemente Dam to the Carmel River lagoon. These polygons showed that McNiesh included riparian vegetation and non-wooded areas that were relatively close to the active channel, taking care to avoid upland areas. After the polygons were established, McNiesh used a polar planimeter to calculate the areas. In his report McNiesh used an evapotranspiration coefficient of 3.70 acre-feet/acre/year for wooded areas and 1.85 acre-feet/acre/year for non-wooded areas.

After reviewing the boundaries to McNiesh's area calculations, staff digitized new polygons associated with the current extent of the riparian corridor and non-wooded areas near the active channel. This was done by creating a GIS project (riparianareacalc092503.mxd disc enclosed) that used 2001 orthoimagery from San Clemente Dam to the Carmel River lagoon. Following this step, staff opened Arc Catalog, and created shape files that included wooded and non-wooded areas for the respective aquifer subunits, in the State Plane Zone IV coordinate system. Staff then digitized polygons of existing riparian vegetation and non-wooded areas keeping similar boundaries to McNiesh. Staff deviated from some of McNiesh's boundaries to include riparian vegetation upstream of the confluences of the major tributaries within the boundaries of the Carmel Valley alluvial aquifer. In order to calculate area, staff selected the polygon shape files and selected the tab for the area and perimeter calculations. This last selection adds the area and perimeter information to the corresponding attribute tables. Staff opened the attribute tables for each aquifer subunit and exported the information as a .dbf file to MS Excel so the area of all the existing polygons for the project could be totaled (tables on CD under tables folder).

In addition to the riparian and non-wooded area calculations, staff decided to calculate the area of the individual aquifer subunits (AQ1 – AQ4). This was done by digitizing around the existing alluvial aquifer and creating four layers that corresponded to the individual units.

RESULTS

Wooded areas overlying the Carmel Valley alluvial aquifer totaled 298.69 acres in 1986 and 437.56 acres in 2001. Non-wooded areas overlying the aquifer totaled 110.61 acres in 1986 and 105.17 in 2001. These changes correspond to a 46.5 percent increase in wooded areas (i.e., riparian vegetation) and a 4.9 decrease in non-wooded areas for all the aquifer subunits within the Carmel Valley alluvial aquifer. These values are summarized in **Table 1**.

Total calculated water use from wooded and non-wooded areas from the 1986 aerial photographs used in the CVSIM model is 1,309.78 acre-feet/year. Based on the updated 2001 area calculations, total water use from wooded and non-wooded areas is 1,813.54 acre-feet/year (a 38.5 percent increase). **Table 2** shows 2001 water use by aquifer subunit and daily water use used in the CVSIM model. It also includes the aerial distribution of annual riparian water use by subunit (i.e., 16%, 30%, 30%, and 24% respectively) and the temporal distribution by month. In CVSIM, evapotranspiration demand is increased by 10 percent during "dry" or "critically dry" months.

The area of the Carmel Valley alluvial aquifer totaled 4,356.9 acres, with 461.8 acres in AQ1, 966.3 acres in AQ2, and 1,741.2 acres in AQ3, and 1,187.6 acres in AQ4. Percent of individual units of the total aquifer area is shown in **Table 3**.

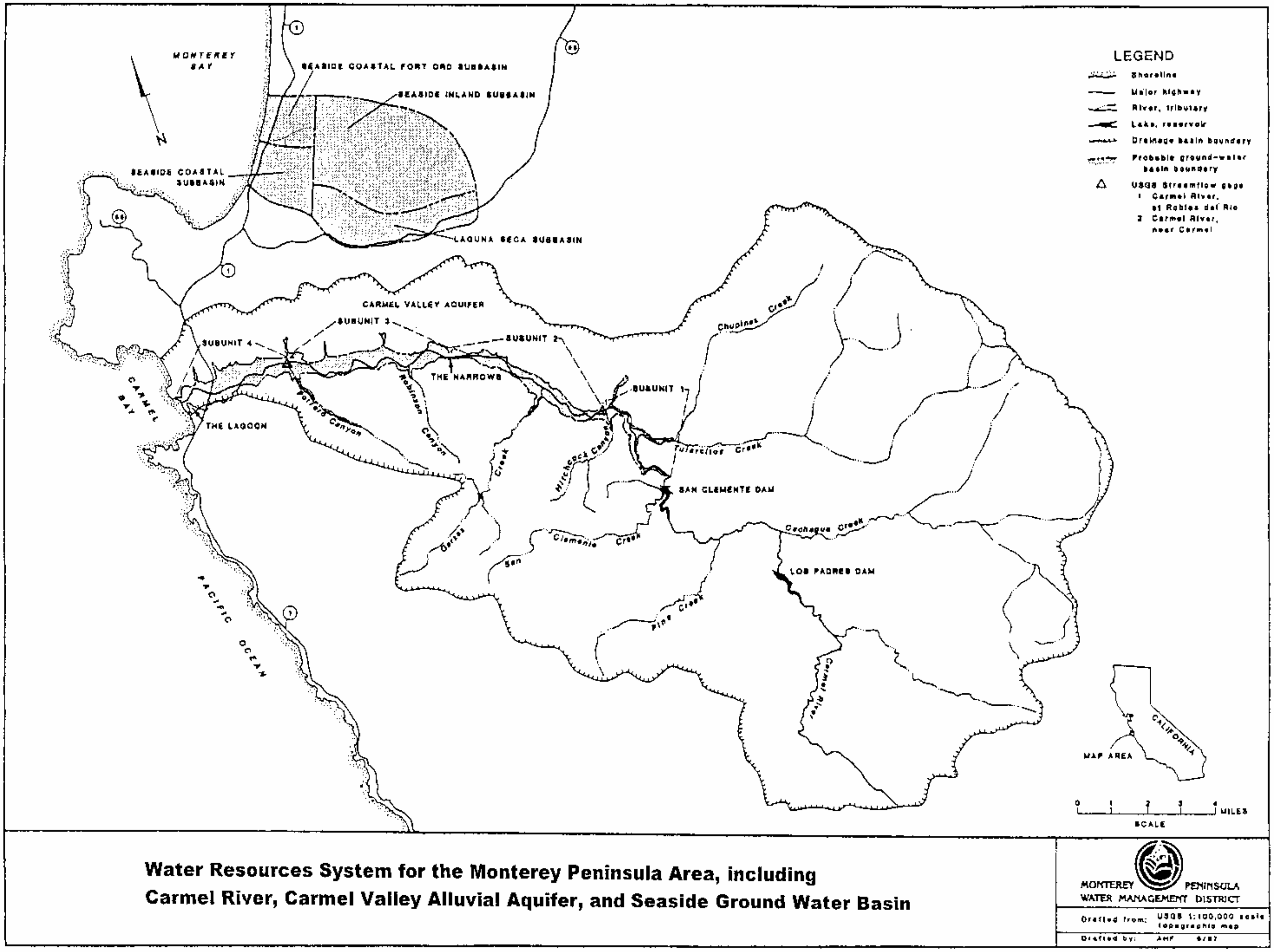
DISCUSSSION

The 3.70 acre-feet/acre/year "water duty" for wooded areas and the 1.85 acre-feet/acre/year for non-wooded areas was taken from McNiesh's June 1985 report *Pajaro Valley Irrigation Project*, prepared for the Association of Monterey Bay Area Governments. These values were not changed because they are still representative of current evapotranspiration rates.

McNiesh acknowledged some subjectivity when drawing polygons around wooded and non-wooded areas. Staff also acknowledges that there are areas where cases could be made either way for addition or subtraction of certain areas. For this analysis riparian areas that staff are familiar with through field experience that were omitted in McNiesh's original work were included. However, for the majority of the project, staff kept very similar boundaries to the areas McNiesh included in the calculations. The majority of the increase in riparian area is due to channel encroachment, revegetation efforts by the District, changes in Cal-Am's well pumping regime, reducing stress on riparian vegetation, and a period of relatively wet years.

CONCLUSION

There has been an increase in riparian area overlying the Carmel Valley alluvial aquifer of 46.5 percent and a slight decrease of 4.9 percent in non-wooded area from San Clemente Dam to the Carmel River lagoon from 1986 to 2001. This translates into an overall 38.5 percent increase (504 acre-feet/year) in annual water loss due to evapotranspiration by riparian vegetation along the Carmel River between San Clemente Dam and the Carmel River Lagoon. Total water use by vegetation and non-wooded areas along the Carmel River is now estimated to be 1,814 acre-feet/year. These values show that the current information **(Table 2)** should be incorporated into the future runs of the CVSIM model and that area calculations should be repeated every ten years.



Water Resources System for the Monterey Peninsula Area, including Carmel River, Carmel Valley Alluvial Aquifer, and Seaside Ground Water Basin

Figure 1.

Table 1.

Percent change in acres from 1986 to 2001 for riparian (wooded) and non-wooded areas
Carmel River (San Clemente Dam to Carmel River Lagoon)

Aquifer Subunit	wooded 1986	non-wooded 1986	wooded 2001	non-wooded 2001	% change wooded 01-86	% change non-wooded 01-86
AQ1	69.83	38.00	67.85	19.15	-2.84	-49.61
AQ2	65.16	35.77	128.57	36.09	97.31	0.89
AQ3	80.98	33.50	131.81	32.30	62.77	-3.58
AQ4	82.72	3.34	109.33	17.63	32.17	427.84
Total	298.69	110.61	437.56	105.17	46.49	-4.92

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Table 2.

Annual evapotranspiration by riparian vegetation and non-wooded river areas between SCD and CRL
Based on 2001 orthoimagery

Subunits	wooded area (acres)	nonwooded area (acres)	wooded water use (afy)	nonwooded water use (afy)	Total water use (afy)	Percent
AQ1	67.85	19.15	251.05	35.43	286.47	0.16
AQ2	128.57	36.09	475.71	66.77	542.48	0.30
AQ3	131.81	32.30	487.70	59.76	547.45	0.30
AQ4	109.33	17.63	404.52	32.62	437.14	0.24
Total	**437.56**	**105.17**	**1618.97**	**194.56**	**1813.54**	

"NORMAL"					
Water use by month	Month	AQ1 (daily use af)	AQ2 (daily use af)	AQ3 (daily use af)	AQ4 (daily use af)
0.07	Oct	0.65	1.22	1.24	0.99
0.04	Nov	0.38	0.72	0.73	0.58
0.03	Dec	0.28	0.52	0.53	0.42
0.04	Jan	0.37	0.70	0.71	0.56
0.05	Feb	0.51	0.97	0.98	0.78
0.07	Mar	0.65	1.22	1.24	0.99
0.10	Apr	0.95	1.81	1.82	1.46
0.14	May	1.29	2.45	2.47	1.97
0.12	Jun	1.15	2.17	2.19	1.75
0.13	Jul	1.20	2.27	2.30	1.83
0.11	Aug	1.02	1.92	1.94	1.55
0.10	Sep	0.95	1.81	1.82	1.46

"DRY"					
Water use by month	Month	AQ1 (daily use af)	AQ2 (daily use af)	AQ3 (daily use af)	AQ4 (daily use af)
0.077	Oct	0.71	1.35	1.36	1.09
0.044	Nov	0.42	0.80	0.80	0.64
0.033	Dec	0.30	0.58	0.58	0.47
0.044	Jan	0.41	0.77	0.78	0.62
0.055	Feb	0.56	1.07	1.08	0.86
0.077	Mar	0.71	1.35	1.36	1.09
0.110	Apr	1.05	1.99	2.01	1.60
0.154	May	1.42	2.69	2.72	2.17
0.132	Jun	1.26	2.39	2.41	1.92
0.143	Jul	1.32	2.50	2.53	2.02
0.121	Aug	1.12	2.12	2.14	1.71
0.110	Sep	1.05	1.99	2.01	1.60

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Table 3.

Area of Carmel Valley Alluvial Aquifer

Aquifer Subunit	sq. ft.	acres	%
AQ1	20114928.9	461.8	10.60
AQ2	42090313.7	966.3	22.18
AQ3	75845557.3	1741.2	39.96
AQ4	51733650.8	1187.6	27.26
Total	**189784450.7**	**4356.9**	**100.0**

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REFERENCES

Fuerst, Darby, and Yoram Litwin, 1987. *Overview of Carmel Valley Simulation Model.* Appendix A of New San Clemente Project Draft EIR/EIS.

McNiesh, Charles, 1985. *Pajaro Valley Irrigation Project*. Prepared for AMBAG.

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Thomas Christensen, 10 pages, 3/10/04