PAJARO VALLEY WATER MANAGEMENT AGENCY

Technical Memoranda for Subtasks 6.1 and 6.2

- Technical Memorandum 1.1
- Technical Memorandum 1.2
- Technical Memorandum 2.2
- Technical Memorandum 2.3
- Technical Memorandum 3
- Technical Memorandum 4

Doug,

I think this is the document you are looking for. Please call if you have questions or need further info.

Thank you

Mary Bannister

September 15, 2000

RMC

Raines, Melton & Carella, Inc.

PAJARO VALLEY WATER MANAGEMENT AGENCY
HYDROLOGIC ANALYSIS AND MODELING

TASK:	Technical Memorandum 4 for Subtask 6.1
SUBJECT:	Baseline Conditions and Basin Sustainable Yield Analysis
SUBMITTED BY:	David Lindow / Montgomery Watson
PREPARED BY:	S. Ali Taghavi / AT Associates Chris Smith / Montgomery Watson
REVIEWED BY:	Lyndel Melton / RMC
DATE:	May 31, 2000

N.B. – see last page # 9 herein

Introduction

The Pajaro Valley Water Management Agency (PVWMA) is in the process of refining and analyzing the potential alternative water supply scenarios to alleviate the long-standing groundwater overdraft and seawater intrusion problems in the Pajaro Valley. As part of this process, it is critical to have a clear understanding and knowledge of what the magnitude of the overdraft and seawater intrusion rates are for the present state of the groundwater basin. Additionally, it is important to understand and define the sustainable yield of the Basin, as the future water supply alternatives will depend on the sustainable yield from the local groundwater basin.

As documented in numerous groundwater studies conducted over the past several years, the Pajaro Valley groundwater basin is in an overdraft condition. In addition, the rate of seawater intrusion to the groundwater basin has been increasing over the same period. In general, a combination of both overdraft condition and seawater intrusion has limited the source of local fresh water supply to sustain the long-term agricultural and urban economy of the Valley.

The Pajaro Valley Integrated Ground and Surface water Model (PVIGSM) has been developed to assist in:

- Gaining knowledge on the historical conditions of the groundwater basin,
- Evaluate the present state of the groundwater basin,
- Estimate the sustainable yield of the basin, and

- Evaluate the impact of potential alternative water supply scenarios on the integrated surface water and groundwater system.

In order to estimate the sustainable yield of the basin, the present conditions of the groundwater basin must be evaluated and quantified. This present condition is called the "Baseline Condition".

The purpose of this memorandum is to present:

1. The assumptions and results from the Baseline Condition analysis; and

2. The definition of the basin sustainable yield, and document the sustainable yield analysis procedure, assumptions, and results for the groundwater basin.

Baseline Conditions

The Baseline Condition is different than the historic condition. The historic condition, as utilized in the model calibration process and summarized in Technical Memorandum No. 3, PVIGSM Recalibration Process and Results, is a summary of actual conditions that have resulted from changes in land and crop use and historic hydrologic conditions. The Baseline Condition defines the state of the groundwater basin based on the current level of land and water use during a set of hydrologic conditions that include normal, above normal, and below normal rainfall conditions.

This section describes the assumptions and results for the state of the basin under the Baseline Conditions.

Hydrologic Conditions

In order to define the present state of the basin, a long-term hydrologic period that contains a sequence of various rainfall conditions is required. This will provide a good basis to evaluate the state of the basin during most critical drought conditions, when water supplies are stressed to the limit, as well as wet conditions, when water supplies are more available and may operate under less stressful conditions.

The hydrologic period used during model calibration was 1964-97. This hydrologic period contains a reasonable distribution of normal, above normal, and below normal conditions. In order to allow enough time for the simulation model to adjust to changes in the water supply scenarios, the 1964-97 monthly hydrologic cycle is repeated to develop a sequence of 68 year hydrology for baseline and alternative scenarios. Figure 1 shows the annual rainfall patterns during the 68-year hydrologic sequence. A less preferable alternative to this 68-year hydrologic sequence is to develop a synthetic hydrologic sequence, which would be statistically representative of the climatic condition of the area. However, since there are sufficient historical records available to develop a long-term hydrologic sequence, historical data are used in the model.

Although there are no official year type classifications for the Central Coast hydrologic basins, the following year types have been defined for the purposes of this study:

The long-term average annual rate of seawater intrusion is estimated as 10 TAF/yr.

Groundwater Levels and Seawater Intrusion

The baseline condition simulations show that during the 68 years of hydrologic simulation, the average groundwater levels in the basin remain fairly steady. Figure 9 shows the average and minimum groundwater levels in the PVWMA area. Figure 9 shows that an initial adjustment in regional average groundwater levels occurs during the first year of simulation. The remaining period has reasonably steady groundwater levels, fluctuating due to the hydrologic conditions. Figure 9 also shows that the minimum groundwater levels in the PVWMA area occur at approximately 5 to 10 feet below mean sea level. This condition causes a constant intrusion of seawater into the groundwater basin.

Figures 10(a-d) show contour maps of groundwater levels after 68 years of simulation, for each aquifer layer. The contour maps show that the groundwater levels under the Baseline Conditions, in layers 1, 2, and 3 in the Valley floor area are generally at or below sea level. In addition, a cone of depression would persist in the Pajaro River mouth and Beach Road area. The Corralitos and foothill area would also experience a cone of depression, especially in the Lower Aromas formation.

The long-term average annual subsurface flows between the subregions are shown in Figure 11. Although the magnitude of flows is somewhat different from the historical calibration, the figure indicates no major change in the direction of subsurface flows between the subregions in the Valley.

As indicated earlier, the long-term average rate of seawater intrusion is estimated to be 10 TAF/yr under the Baseline Conditions. This rate is, of course, not constant over time. The annual fluctuations during the historical period and Baseline Conditions are shown in Figure 12a. Note that the rate of seawater intrusion has been increasing over the historical period. It is noteworthy that the rate of seawater intrusion is not the same in the different geologic units. Figures 12(a and b), also show the annual fluctuation of seawater intrusion by each layer. Based on Figure 12b, if the current conditions, as assumed under the Baseline Conditions, continue for the next 68 years, approximately an additional 680,000 AF of fresh groundwater will be lost due to seawater intrusion. This is in addition to the 220,000 AF already lost over the past 34 years (1964-97).

Figure 13 shows the long-term average annual rate of seawater intrusion in each of the model coastal subareas. Note that the subsurface flux to the Monterey Bay still occurs in the Purisima formation in the San Andreas subarea. However, the rate is fairly insignificant.

Basin Sustainable Yield Analysis

This section presents results of the analysis of the basin sustainable yield. Basin sustainable yield is defined as the long-term amount of groundwater extraction from the aquifer system, without causing an adverse impact on the quantity and/or quality of the groundwater basin.

In an integrated groundwater and surface water system, the sustainable yield of the basin is the amount of withdrawal from the system without causing adverse impact on the groundwater and/or surface water system. In this case, the following points should be considered:

- The groundwater and surface water systems act as an integrated system, such that excessive pumping and/or surface water diversion would impact the entire hydrologic system in the basin.
- Groundwater generally pumped from wells adjacent to the river system may withdraw water recharged from the stream system. As such, the lowering of groundwater levels adjacent to the stream system would induce additional recharge from the stream, causing smaller surface water supplies available for downstream beneficial uses.
- Excessive surface water diversions that take place upstream would the reduce rate of stream recharge to the groundwater system, causing a lowering of the groundwater levels adjacent to the river system.
- In alluvial valleys, such as the Pajaro River basin, seawater intrusion generally does not have a sharp interface with the fresh water. As such, the coastward movement of seawater is generally very slow. However, once intruded, the aquifer is considered unusable, and recovery of seawater intruded areas is considered a nearly impossible task.

The sustainable yield of the basin is the yield that can be obtained while eliminating seawater intrusion. In this regard, raising the groundwater levels in the coastal area is possibly the most effective means of stopping and/or reversing the coastward movement of seawater.

Basin Yield Analysis Methodology and Results

In order to determine the sustainable yield of the integrated groundwater and surface water system, the groundwater pumping in the basin was reduced at various increments. Appropriate PVIGSM simulations were performed, and the state of the hydrologic system was monitored for each level of pumping.

The monitoring indicators are: seawater intrusion, change in groundwater storage, and groundwater recharge from the stream system. The first and second indicators are to monitor the state of seawater intrusion and the groundwater system, and the last indicator is intended to monitor the state of the surface water and stream system.

In order to properly evaluate the impact of pumping reduction on the hydrologic system in the basin, two pumping reduction scenarios were considered. The first scenario considers a basin-wide pumping reduction. In this scenario, pumping is reduced uniformly throughout the basin. It is noteworthy that the long-term average annual groundwater pumping in the entire PVWMA area is estimated to be 69 TAF/yr under the Baseline Conditions. The second scenario considers a pumping reduction along the coastal area only.

A) Basin-wide Pumping Reduction- This scenario assumes that the basin-wide pumping is reduced uniformly. No changes to land use and or water use patterns or their magnitudes are made. It is assumed that, when pumping is reduced, the water needs are not reduced, and water needs are met by a source of water from outside the basin.

Figures 14 (a-c) show the effect of groundwater pumping reduction in both scenarios, for basin-wide and coastal pumping reduction. As shown on Figure 14(a), a 65 percent reduction in basin-wide groundwater pumping would nearly stop the rate of seawater intrusion. This reduction is approximately 45 TAF/yr. That is, to stop the seawater intrusion, the basin-wide groundwater pumping should be reduced to approximately 24 TAF/yr. Figure 14(b) shows that a 65 percent reduction in basin-wide groundwater pumping would have a positive effect on the rate of change in groundwater storage as well.

As shown on Figure 14(c), the 65 percent reduction in groundwater pumping would reverse the rate of stream recharge to the groundwater basin. Under the new groundwater pumping levels, the groundwater levels will be high enough to cause the streams to become gaining in most reaches, causing increased streamflows.

The 65 percent reduction in groundwater pumping in general has positive impacts on the hydrologic conditions in the Valley, however, this reduction may not be viable from economic stand point. The 1993 Pajaro Valley Basin Management Plan (BMP) had suggested that for economic viability of any alternative water supply scenario, a 1000 AF/yr threshold for seawater intrusion be maintained. Figure 14(a) shows that a 45 percent reduction in groundwater pumping would result in approximately 1000 AF/yr seawater intrusion. That is, the groundwater pumping should be maintained at approximately 38 TAF/yr to meet the 1,000 AF/yr seawater intrusion threshold. Based on Figures 14(b) and 14(c), this level of groundwater pumping would still have positive impacts on the rate of change in groundwater storage and streamflows.

Figure 15 shows the impact of pumping reductions on regional average groundwater levels, over time. Figure 16 shows the impact of groundwater pumping reduction on the rate of seawater intrusion, over time.

B) Coastal Pumping Reduction- In this case, the groundwater pumping in the production wells located to the west of highway 1 are reduced incrementally. However, as in Scenario A, the agricultural and urban water needs in the coastal area are not reduced, but met with an outside source of water, such as import water or desalinized water.

Figure 14(a) also shows that an 83 percent reduction in coastal groundwater pumping would nearly stop the seawater intrusion. This is approximately 17 TAF/yr reduction in coastal groundwater pumping. Although seawater intrusion can be limited with a minimum reduction in coastal groundwater pumping of 17 TAF/yr, a groundwater pumping reduction of 20 TAF/yr was considered. The basin-wide groundwater pumping will, therefore, be 49 TAF/yr.

As shown on Figure 14(b), the 83 percent reduction in coastal pumping would have a positive impact on the rate of change in groundwater storage, as well. The new rate of change in groundwater storage is 2.5 TAF/yr, which indicates a recovery in groundwater levels, although not as fast as in Scenario A. Figure 14(c) shows that the reduction in coastal groundwater pumping would not impact the stream recharge conditions significantly. In Scenario B, the groundwater system would still benefit from approximately the same recharge rate as in the Baseline Conditions.

Based on the suggestion in the 1993 Pajaro Valley Basin Management Plan (BMP) for the economic viability of any alternative water supply scenario, the 1000 AF/yr threshold for seawater intrusion is also analyzed under this coastal pumping reduction case. Figure 14(a) shows that a 70 percent reduction in groundwater pumping would result in approximately 1000 AF/yr seawater intrusion. That is, the groundwater pumping should be maintained at approximately 55 TAF/yr to meet the 1,000 AF/yr seawater intrusion threshold. Based on Figure 14(b), this reduction in groundwater pumping would still have positive impact on the rate of change in groundwater storage. Figure 14(c) shows that the stream recharge conditions would not be impacted significantly.

Figure 17 shows the impact of coastal pumping reductions on regional average groundwater levels, over time. Figure 18 shows the impact of coastal groundwater pumping reduction on the rate of seawater intrusion, over time.

Summary and Conclusions

The PVIGSM was used to analyze the present conditions of the integrated groundwater and surface water system in the Pajaro Valley, and to develop estimates of the scale and magnitude of the overdraft and seawater intrusion. In addition, two scenarios were developed to evaluate the level of pumping reduction that would be required to stop seawater intrusion. The resulting sustainable yield of the groundwater basin for the two scenarios was developed.

The present conditions of the basin are analyzed under the "Baseline Condition". The Baseline Conditions assume current levels of land and water use and irrigation practices continue for next several decades. The impact of this level of water use and groundwater pumping is evaluated during a 68-year hydrologic cycle.

Results of the Baseline Condition analysis shows that in the long-term, a total of 59 TAF/yr enters the groundwater basin in the PVWMA area. During the same period, groundwater pumping from the basin in the PVWMA area is estimated to be 69 TAF/yr. Since the long-term groundwater pumping exceeds total recharge into the basin, the groundwater basin is would be in overdraft condition by approximately 10 TAF/yr. The long-term average annual rate of seawater intrusion is estimated as 10 TAF/yr. This rate will fluctuate during the wet and dry hydrologic cycles, ranging between 8 to 14 TAF/yr.

In order to alleviate the basin from overdraft conditions and stop seawater intrusion, two pumping reduction scenarios were considered. Scenario A considered a basin-wide pumping reduction and Scenario B assumed that the pumping reduction would take place in the coastal areas west of Highway 1.

Under the basin-wide pumping reduction scenario, it is concluded that a 45 percent reduction in pumping would reduce the rate of seawater intrusion to about 1,000 AF/yr, and a 65 percent reduction would nearly stop the seawater intrusion. That is the sustained groundwater pumping in the basin should be 38 TAF/yr and 24 TAF/yr for the 1,000 AF/yr and 0 AF/yr thresholds for seawater intrusion, respectively. Under the basin-wide groundwater pumping reduction scenarios, the change in groundwater storage will become positive and the stream recharge to groundwater will be reduced, resulting in increasing streamflows and stream outflows to the Bay.

PRESENT SUSTAINABLE yield = 24K AF/yr w/ 0. intrusion

Under the coastal pumping reduction scenario, it is concluded that a 65 percent reduction in the coastal groundwater pumping would reduce the rate of seawater intrusion to about 1,000 AF/yr, and an 83 percent reduction in coastal groundwater pumping would nearly stop the seawater intrusion. That is the sustained groundwater pumping in the basin should be approximately 55 TAF/yr and 49 TAF/yr for the 1,000 AF/yr and 0 AF/yr seawater intrusion thresholds, respectively. Under the coastal groundwater pumping reduction scenarios, the change in groundwater storage will become positive, however, the stream recharge to groundwater will not be impacted significantly.

w/ no coastal pumping, yield gte; to 49K AF/yr w/ 0. intrusion