4.0 WATER BUDGET ANALYSIS

Within the project site, there are two existing arroyo habitat areas: the Northern Arroyo and the Southern Arroyo, located downstream of the 18th Street and downstream of the 16th Street, respectively (Figure 7). Unlike the Salt Marsh habitats, the habitats of these two arroyos rely on fresh water (storm water) inputs. Thus, the objective in this water budget analysis is to understand the hydrologic impact on these arroyos due to the potential change in drainage as a result of the project. The water budget analysis estimates the water demand and supply for habitats and further determines the ecological condition of the habitat from the water balance perspective. The water budget analysis was performed in this study following the drainage concept established in the hydrology analysis with respect to the existing and proposed condition watersheds.

4.1 SETTING

4.1.1 ARROYO DRAINAGE CHARACTERISTICS

In general, both of the existing arroyos are found in the Upland Mesa area of the project site, in association with significant off-site drainage areas. Specifically, the Northern Arroyo is located around the northeast corner of the project site, receiving the off-site runoff primarily from a 42-inch storm drain pipe and a "V"-ditch along the project boundary. In addition, its drainage includes the natural land within the project boundary. The Arroyo starts at the discharge location of the above 42-inch pipe, runs about 930 feet to east and discharges to the Lowland basin. Under the existing condition, there are no engineering improvements to the Northern Arroyo. The habitat's footprint is approximately 6 acres with mostly good vegetation cover. Under the proposed condition, the arroyo will continue to receive storm water runoff from the existing 42-inch pipe. Only a small portion of the natural land in its drainage area will be converted to the residential development. See Figure 13 for the Northern Arroyo drainage.

The Southern Arroyo, located in the south portion of the project site, begins at an existing 48-inch storm drain pipe discharge point. The Arroyo runs approximately 2,340 feet through the project site from east to west, and terminates at a dirt road approximately 500 feet upstream of the Oxbow Loop. The Southern Arroyo is surrounded by approximately 30 acres of natural habitat area with a heavy vegetation cover. Evidence of undercutting and erosion of the side tributaries of the Arroyo exist on-site, and these areas will be stabilized under the proposed condition. Under the existing condition, the Southern Arroyo receives the runoff from existing off-site developments though a 48-inch pipe, as well as receives sheet flow from the surrounding natural area within the project site. Under the proposed Project, a portion of the Upland area will be converted to residential and mixed land uses, and will drain towards the Arroyo under proposed conditions. See Figure 14 for the Southern Arroyo drainage.

Table 4.1 summarizes the drainage areas of the arroyos with respect to the existing and proposed conditions. For the water budget analysis, the on-site area used in the table refers

to the area of riparian habitat associated with the Arroyo. The off-site area refers to the surface inflow contribution area to the Arroyo habitat areas from both Project and upstream drainage areas. Refer to Figures 13 and 14 for locations of the drainage areas associated with the water budget analysis.

ARROYO DRAINAGE AREA SUMMARY				
Location	Off-Site Drainage Area (acres)		On-Site Drainage Area (acres)	
	Existing	Proposed	Existing	Proposed
Northern Arroyo	129	122 (–7)	6	6 (–0)
Southern Arroyo	115	57 (–58)	26	24 (–2)

1. Refer to Figures 13 and 14 for locations of the on-site and off-site drainage boundaries for the Northern and Southern Arroyos, respectively.
2. Numbers in parentheses represent change as compared to existing condition.

Table 4.1 Drainage Area Summary of the Northern and Southern Arroyos

As shown in the table below, the Northern Arroyo will have similar off-site and on-site drainage acreages between the existing and proposed conditions. However, the Southern Arroyo will have its off-site tributary drainage areas reduced by approximately 58 acres and on-site areas by 2 acres under the proposed condition.

SEE FIGURE 13 FOR CHAPTER 04

PDF 66

SEE FIGURE 14 FOR CHAPTER 04

PDF 67

4.1.2 CLIMATE

In water budget analysis, climate an important factor affecting the water demand and supply for the habitat studied. In general, the project area exhibits a mild Mediterranean-type climate with warm/dry summers and cold/wet winters. Tables 4.2 and 4.3 below summarize the monthly temperature range and the average precipitation for the project area, respectively.

AVERAGE TEMPERATURE (°F)												
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Maximum	64	64	63	65	66	69	72	73	73	72	67	64
Minimum	47	48	50	52	56	59	62	64	62	58	52	47
Source: Newport Beach Harbor Station (33.36N 117.53W 10 Feet, 11/1/1934 – 7/31/1998).												

Table 4.2 Average monthly temperatures for the project area.

AVERAGE PRECIPITATION (inches)													
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Year
Rainfall Depth	2.08	2.05	1.84	0.90	0.17	0.05	0.01	0.09	0.36	0.18	1.55	1.57	10.85
Source: Newport Beach Harbor Station (33.36N 117.53W 10 Feet, 11/1/1934 – 7/31/1998).													

Table 4.3 Average monthly precipitation for the project area.

4.2 METHODOLOGY

4.2.1 WATER BUDGET MODEL

The water budget model is a water balance calculation, which accounts for the inflow and outflow of water to and from the habitat area over a certain period, while at the same, considering the habitat's water demand. The inflow water usually comes directly from precipitation or surface water run-on. The outflow water usually results from evaporation, sub-surface infiltration or surface outflow, thus referring to the amount of the inflow water that can not be utilized by the vegetation. Alternatively, the habitat's water demand can be referred to the plant's evapotranspiration rate.

However, due to the complexity of the process, the water budget model is usually set up on a monthly basis to calculate monthly separate results rather than month-to-month continuous water balance. In addition, for the purposes of this study, all of the water losses are combined into a single loss term and calculated by using a yearly mean loss ratio in order to simplify the loss calculation. Therefore, the water budget model is expressed in the following water balance equation (Equation 4.1):

$$\text{Water Balance} = P + S_i - G_o - ET \quad (4.1)$$

Where: P = precipitation (in inches)
S_i = surface inflow (in inches)
G_o = loss (in inches)
ET = evapotranspiration (in inches)

The monthly precipitation (P) can be directly obtained from Table 4.3. The calculations for the remaining variables are described in the following sub-sections.

4.2.2 SURFACE INFLOW

The amount of the surface inflow (S_i) is determined by the drainage area, land use and precipitation. The inflow is calculated as total runoff volume first and then converted into the depth by dividing by the habitat's footprint area. In this water budget model, the runoff volume (R) is calculated by multiplying a runoff coefficient (RV, defined as the overall average ratio of runoff to rainfall) to the precipitation (P) and drainage area (A). The runoff coefficient (RV) is computed by the following equation (Equation 4.2):

$$RV = 0.007 \times IMP + 0.1 \quad (4.2)$$

Where: RV = runoff coefficient (unitless)
IMP = percent impervious of the drainage area (%)

The runoff volume (R) is then determined by the following equation:

$$R = P \times A \times RV/12$$

Where: R = runoff volume (in acre-feet)
P = precipitation (in inches)
A = drainage area (in acres)
RV = runoff coefficient (unitless)

Table 4.4 summarizes the result of the surface runoff inflow factors for the Northern and Southern arroyos in terms of drainage area, imperviousness and runoff coefficient. Refer to Appendix D for detailed calculations.

SURFACE RUNOFF INFLOW FACTORS						
Location	Drainage Area (A, acres)		Average % Impervious		Runoff Coefficient (RV)	
	Existing	Proposed	Existing	Proposed	Existing	Proposed
Northern Arroyo	129	122 (–7)	68 %	70 % (+2)	0.58	0.60 (+0.01)
Southern Arroyo	115	57 (–58)	39 %	73 % (+34)	0.38	0.61 (+.23)

Table 4.4 Summary of surface runoff inflow factors.

4.2.3 EVAPOTRANSPIRATION

Evapotranspiration (ET) is a process involving the uptake of water by the plant system in which excess water is transpired to the atmosphere causing evaporation and transpiration. It thus can be referred as the water demand factor in the water budget model. The ET amount can be acquired from monitoring data or estimated from empirical equations. The table below shows the monthly potential evapotranspiration amount calculated by the Thornthwaite Method:

$$ET_u = 0.63 \times (10t_c / I)^a \quad (4.3)$$

Where: ET_u = unadjusted potential evapotranspiration (in inches)
t_c = temperature (°F)
I = temperature efficiency index (see Appendix D)
a = $0.000000675(I)^3 - 0.0000771(I)^2 + 0.01792(I) + 0.49239$

Results are summarized in Table 4.5 below. Refer to Appendix D for detailed calculations regarding the Thornthwaite Method.

POTENTIAL EVAPOTRANSPIRATION (INCHES)													
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Year
ET	1.44	1.60	1.78	2.16	2.66	3.21	3.68	3.77	3.35	2.77	1.91	1.41	**29.74**
Source: Thornthwaite Method with Correction Factors for Monthly Sunshine Duration (Dunn & Leopold 1978)													

Table 4.5 Summary of potential evapotranspiration.

4.2.4 LOSS

For this water budget model, the water losses within the Arroyo habitat areas can be considered primarily from the infiltration and surface outflow processes. The Arroyo valleys do not have significant flat-bottom pond areas, and thus the evaporation loss from open water is considered to be negligible. Since the soils have a slow rate of water transmission (Hydrologic Soil Group D) and the habitats have a good vegetation cover, the average loss ratio is estimated to be 30%.

In the original water balance equation discussed at the beginning of this section, the loss term (G_o) is calculated by multiplying 30% to the sum of the precipitation term (P) and the surface inflow term (S_i).

$$G_o = 0.3 \times (P + S_i) \quad (4.4)$$

Where: G_o = water loss (in inches)
P = precipitation (in inches)
S_i = surface inflow (in inches)

4.3 RESULTS & DISCUSSION

4.3.1 NORTHERN ARROYO

Tables 4.6 and 4.7 summarize the monthly water budget results for the Northern Arroyo habitat area, with respect to the existing and proposed conditions. The red number in parentheses in the balance row of the tables means a negative balance and this indicates a drought month for the habitat. As shown in the tables, in general, the existing and proposed conditions exhibit very similar water balance results. Therefore, there will be no significant change in the habitat-related drainage under the proposed condition.

NORTHERN ARROYO MONTHLY WATER BUDGET FOR EXISTING CONDITION													
Factor	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Year
P	2.1	2.1	1.8	0.9	0.2	0.1	0.0	0.1	0.4	0.2	1.6	1.6	10.9
S_i	26.6	26.2	23.5	11.5	2.2	0.6	0.1	1.1	4.6	2.3	19.8	20.0	138.5
G_o	8.6	8.5	7.6	3.7	0.7	0.2	0.0	0.4	1.5	0.7	6.4	6.5	44.8
ET	1.4	1.6	1.8	2.2	2.7	3.2	3.7	3.8	3.4	2.8	1.9	1.4	29.7
Water Balance[1]	18.6	18.2	16.0	6.5	(1.0)	(2.7)	(3.6)	(2.9)	0.1	(1.0)	13.0	13.7	74.8

1 Water balance calculated under Equation 4.1. Red number in parentheses denotes a negative balance.
P Precipitation (inches)
S_i Surface Inflow (inches)
G_o Loss (inches)
ET Evapotranspiration (inches).

Table 4.6 Water Balance under existing conditions of the Northern Arroyo.

NORTHERN ARROYO MONTHLY WATER BUDGET FOR PROPOSED CONDITION													
Factor	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Year
P	2.1	2.1	1.8	0.9	0.2	0.1	0.0	0.1	0.4	0.2	1.6	1.6	10.9
S_i	25.6	25.3	22.7	11.1	2.1	0.6	0.1	1.1	4.4	2.2	19.1	19.3	133.7
G_o	8.3	8.2	7.4	3.6	0.7	0.2	0.0	0.4	1.4	0.7	6.2	6.3	43.4
ET	1.4	1.6	1.8	2.2	2.7	3.2	3.7	3.8	3.4	2.8	1.9	1.4	29.7
Water Balance[1]	18.0	17.5	15.4	6.2	(1.1)	(2.7)	(3.6)	(2.9)	0	(1.1)	12.5	13.2	71.4

1 Water balance calculated under Equation 4.1. Red number in parentheses denotes a negative balance.
P Precipitation (inches)
S_i Surface Inflow (inches)
G_o Loss (inches)
ET Evapotranspiration (inches).

Table 4.7 Water Balance under proposed conditions of the Northern Arroyo.

Specifically for the Northern Arroyo habitat area, the drought season is from May to August and October. July is the driest month through the year since the precipitation is only 0.01 inch. The remaining 7 months of the year are considered to have sufficient water supply for the habitat. The net annual total of water is around 75 inches. Therefore, there will be no anticipated water budget impact at all on this Arroyo habitat from the proposed development.

4.3.2 SOUTHERN ARROYO

The tables below show the monthly water budget results for the Southern Arroyo habitat area, with respect to the existing and proposed conditions.

SOUTHERN ARROYO MONTHLY WATER BUDGET FOR EXISTING CONDITION													
Factor	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Year
P	2.1	2.1	1.8	0.9	0.2	0.1	0.0	0.1	0.4	0.2	1.6	1.6	10.9
S_i	3.5	3.4	3.1	1.5	0.3	0.1	0.0	0.2	0.6	0.3	2.6	2.6	18.2
G_o	1.7	1.6	1.5	0.7	0.1	0.0	0.0	0.1	0.3	0.1	1.2	1.3	8.7
ET	1.4	1.6	1.8	2.2	2.7	3.2	3.7	3.8	3.4	2.8	1.9	1.4	29.7
Water Balance[1]	2.5	2.2	1.7	(0.5)	(2.3)	(3.1)	(3.7)	(3.6)	(2.7)	(2.4)	1.0	1.5	(9.4)

2 Water balance calculated under Equation 4.1. Red number in parentheses denotes a negative balance.
P Precipitation (inches)
S_i Surface Inflow (inches)
G_o Loss (inches)
ET Evapotranspiration (inches).

Table 4.8 Water Balance under existing conditions of the Southern Arroyo.

SOUTHERN ARROYO MONTHLY WATER BUDGET FOR PROPOSED CONDITION													
Factor	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Year
P	2.1	2.1	1.8	0.9	0.2	0.1	0.0	0.1	0.4	0.2	1.6	1.6	10.9
S_i	3.1	3.0	2.7	1.3	0.3	0.1	0.0	0.1	0.5	0.3	2.3	3.3	16.1
G_o	1.6	1.5	1.4	0.7	0.1	0.0	0.0	0.1	0.3	0.1	1.2	1.2	8.1
ET	1.4	1.6	1.8	2.2	2.7	3.2	3.7	3.8	3.4	2.8	1.9	1.4	29.7
Water Balance[1]	2.2	2.0	1.4	(0.6)	(2.4)	(3.1)	(3.7)	(3.6)	(2.7)	(2.5)	0.8	1.3	(10.9)

2 Water balance calculated under Equation 4.1. Red number in parentheses denotes a negative balance.
P Precipitation (inches)
S_i Surface Inflow (inches)
G_o Loss (inches)
ET Evapotranspiration (inches).

Table 4.9 Water Balance under proposed conditions of the Southern Arroyo.

In general, under the existing condition, this Southern Arroyo habitat area has a longer drought period than the Northern Arroyo. The results show a deficit in water balance from April to October. The remaining five months exhibit positive balances. However, the net water amount is significantly smaller in comparison to the Northern Arroyo habitat area, putting the net annual total of water into a deficit. The reason the Southern Arroyo receives less flow nourishment than the Northern Arroyo is that the Southern Arroyo has a greater habitat footprint area (about 5 times larger than the Northern Arroyo). The size of the habitat footprint attenuates the surface inflow nourishment. Therefore, based on the field reconnaissance, the existing habitat survives well through the year under the existing water budget condition.

For the proposed condition, although the upland area will be converted to the residential area and be therefore removed from its drainage, the water budget results for the Southern Arroyo do not vary significantly as compared to existing conditions. The drought period will remain as 7 months, and the annual balance will decrease only by approximately one inch. The approximately 60 acres of natural land conversion to developed area leads to only a 10% reduction in surface inflow during the wet season. The reason for the insignificant influence by the proposed upland area conversion is that the primary supply of the inflow water for this arroyo is from the off-site development area, and not the development areas.

It is a commonly accepted observation that urban development, especially residential, has the potential to create sources of urban runoff during the dry season based on over irrigation, car washing, cleaning, etc and this can create changes in downstream habitats. Based on the implementation of the project LID features and drainage systems designed to deliver initial flows to landscaped areas and other LID features, dry season runoff is not expected to be a significant impact and will be controlled by the on-site water quality features. Refer to Section 5 for further discussion of the proposed water quality and LID features.

In conclusion, there is no significant water budget impact on this Arroyo habitat due to the proposed development. However, enhancement opportunities exist by diverting treated dry weather flows and storm event low-flows to the Arroyo from the proposed storm drain system and LID features. This creates additional hydrologic inputs to the system for maximum habitat diversity. The low-flow diversion alternative will be considered during the resource agency permitting process.

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