10-year HEC-1 Models for Martin Acre Detention Basin Design

Jonathon Chill, E.I.T., CFM Hydrologist Intern
Bing Zhao, PhD, PE, Branch Manager
Engineering Application Development and River Mechanics Branch
Engineering Division
Flood Control District of Maricopa County
2801 W. Durango Street
Phoenix, Arizona 85009

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Purpose

The purpose of this project was to convert the existing 100-year HEC-1 models developed by Goodwin and Marshall to 10 year models for the proposed detention basin for Martin Acres. To do this, DDMSW 4.6.0 was used to compute time of concentration (Tc) and storage coefficient (R) for each sub-basin that contributes to the detention basin proposed in Martin Acres Design Conceptual Report (DCR) by Goodwin and Marshall (2011) for both the 10-year 6-hour and the 10-year 24-hour HEC-1 models. The rainfall and inflows for the 10-year events were also found using DDMSW. The detention basin location map can be found in Figure 1 (the red dot is the proposed detention basin location). The Tc and R values are Clark unit hydrograph parameters. The 10-year Tc and R values were used to replace the 100-year Tc and R values for each sub-basin that contributes to the detention basin in the current 100-year HEC-1 models developed by Goodwin and Marshall (2011) for Martin Acres DCR. It may be noted that Tc and R values in some sub-basins are still 100-year values since these sub-basins do not contribute to the detention basin location.

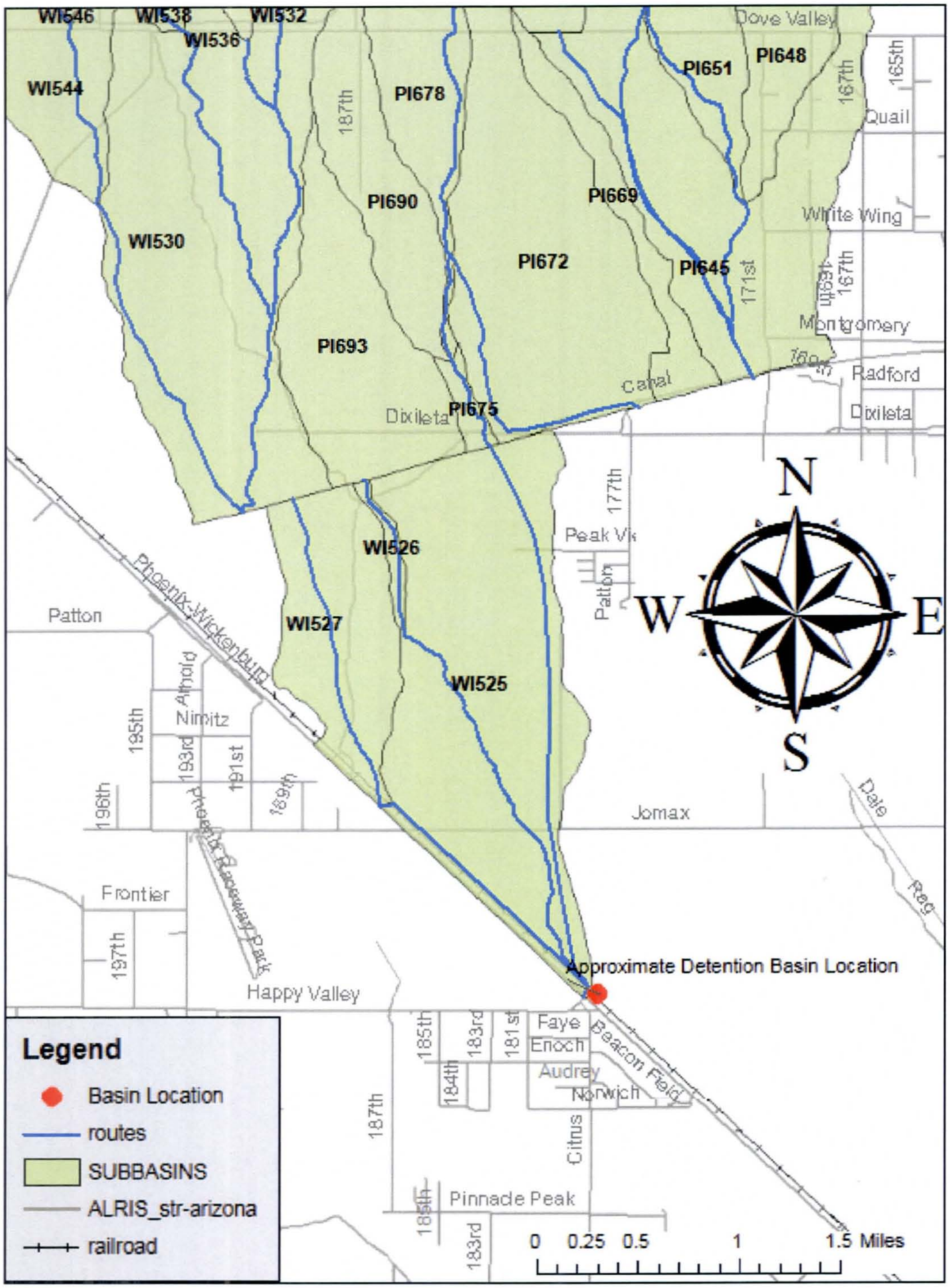


Figure 1 Vicinity Map

Assumptions

The discharge-elevation rating curve at CAP was developed for the 100-year storm event in Wittmann ADMSU (Entellus, 2005). The rating curves were based on the assumption that many ponding areas upstream of CAP crossing are connected and function as one big ponding area. Since this study is for 10-year storm event, this assumption may not be valid. Further analysis is needed to verify if the pond areas can be treated as one big pond area for the 10-year storm event.

Data Collection

The Martin Acres DCR 100-year 6-hour and 24-hour models, "EC 6-hr.dat" and "EC 24-hr.dat" respectively, are located under the folder "Original_HEC-1_file_by_Goodwin_and_ Marshall" on the attached CD and were obtained from FCDMC Project Planning and Management Division's project share drive (\\fcdsprojects\projects\344-Martin Acres\17.0 Team Working Files\17.1 Design Concept Report\17.1.2 Existing Conditions Memos\17.1.2.2 Final Submittal\Hydrology\HEC-1 Files). A drainage area exhibit (

Figure 2) by Goodwin and Marshalls (2011) is located under the "Reference_Material" folder on the attached CD and was obtained from the same share drive ((\\fcdsprojects\projects\344-Martin Acres\17.0 Team Working Files\17.1 Design Concept Report\17.1.2 Existing Conditions Memos\17.1.2.2 Final Submittal\Hydrology). The drainage area to Martin Acres is enclosed by a red line on the west side and a green line on the east side. The blue triangle is the Martin Acres area. Figure 3 shows a detailed location of the proposed detention basin alternatives.

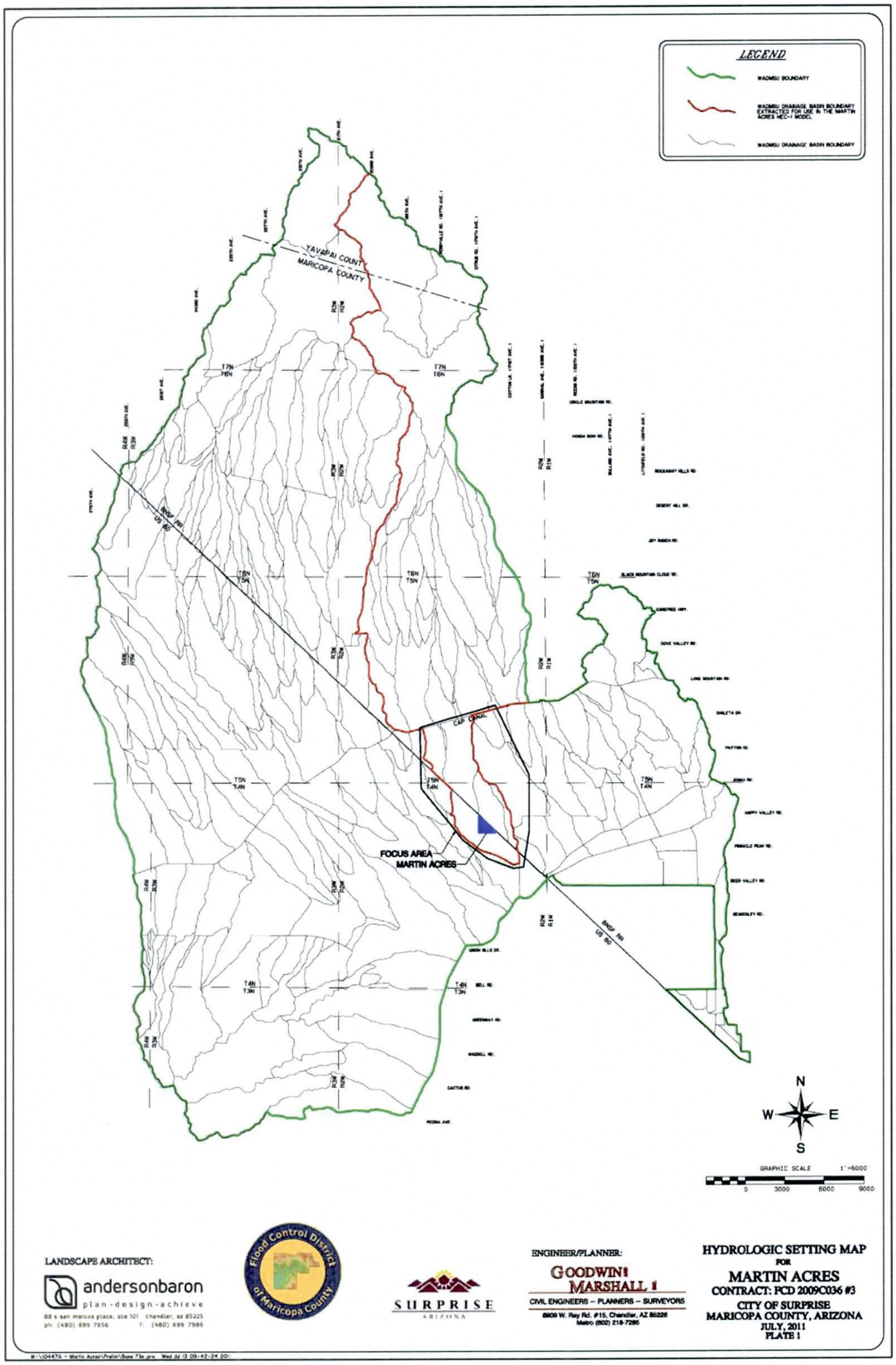


Figure 2 Project Focus Area by Goodwin and Marshall

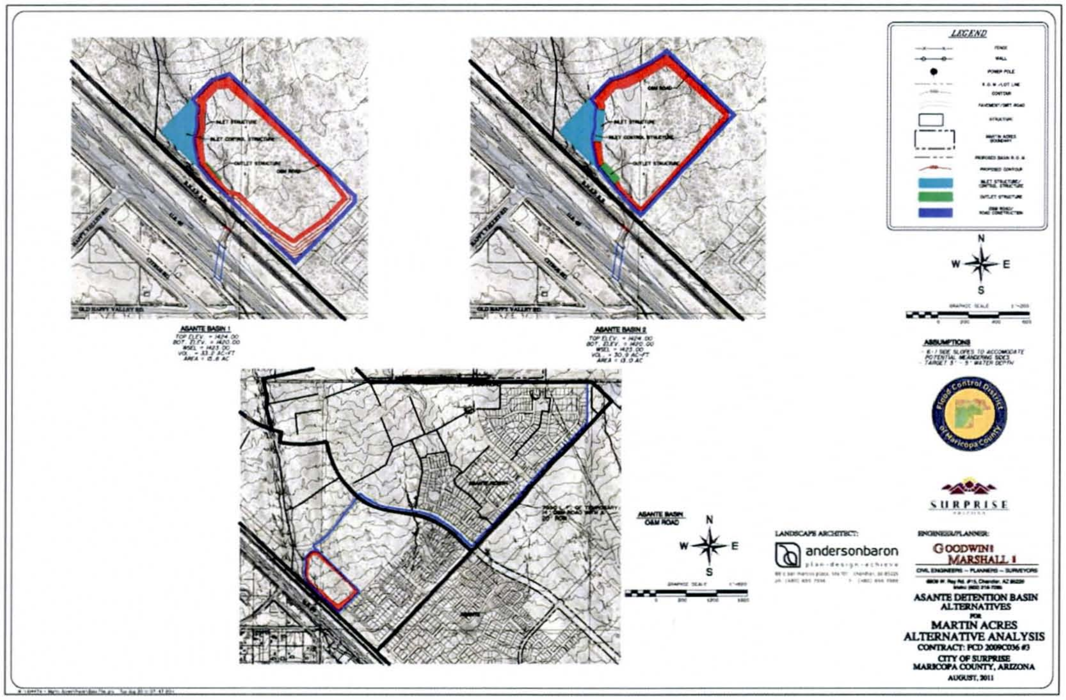


Figure 3 Detention Basin Location and Alternatives by Goodwin and Marshall

GIS shape files from Wittmann ADMSU (Entellus, 2005) are located under the folder "Original_Shape_Files" on the attached CD and were obtained from the engineering division share drive (\\fcdseng01\Hydrology-Hydraulics\jwh\Wittmann ADMSU Files\Hydrology Shape Files). These files were needed in order to compute Tc and R values. The shape files used for modeling were the Sub-Basin and Time of Concentration ESRI Shape files. The Routing Shape file was used to identify the sub-basins that contribute to the detention basin. It should be noted that the Land Use and Soils Shape files are also available, but these were not used to generate Green-Ampt parameters within DDMSW because the original default land use parameters could not be found. To be consistent with the original model, the same Green-Ampt parameters from the original models developed by Goodwin and Marshall were manually input into DDMSW.

Data Preparation

Drainage Area Boundaries

Based on the Martin Acres DCR, a detention basin was proposed near Grand Avenue (Figure 1 and Figure 3). A polygon shape file for contributing sub-basins is required by DDMSW to compute Tc and R. Since only a CAD file and PDF file were available for Martin Acres DCR project, a polygon shape file was created based on sub-basin polygon shape file from Wittmann ADMSU. To do this, first a polygon was drawn around the approximate study area and the sub-basins were clipped into a new shape file. Because this new shape file contained sub-basins that do not contribute to the detention basin location, the contributing sub-basins were identified by using the Routing shape file. If a sub-basin was found to not contribute to the detention basin, then it was deleted from the file. Shown below is the identified contributing area (Figure 4), it should be noted that after the initial modeling was completed it was determined that two sub-basins, WI542 and PI642, contribute to the ponding at the CAP but were not included in the original model. These two basins were added manually in DDMSW, thus the shape files do not contain data for them but they are included in the DDMSW model. As can be seen from Figure 4, it is identical to Figure 2, only Figure 4 does not have sub-basins WI542 (on the west side at the CAP) and PI642 (east side at the CAP).

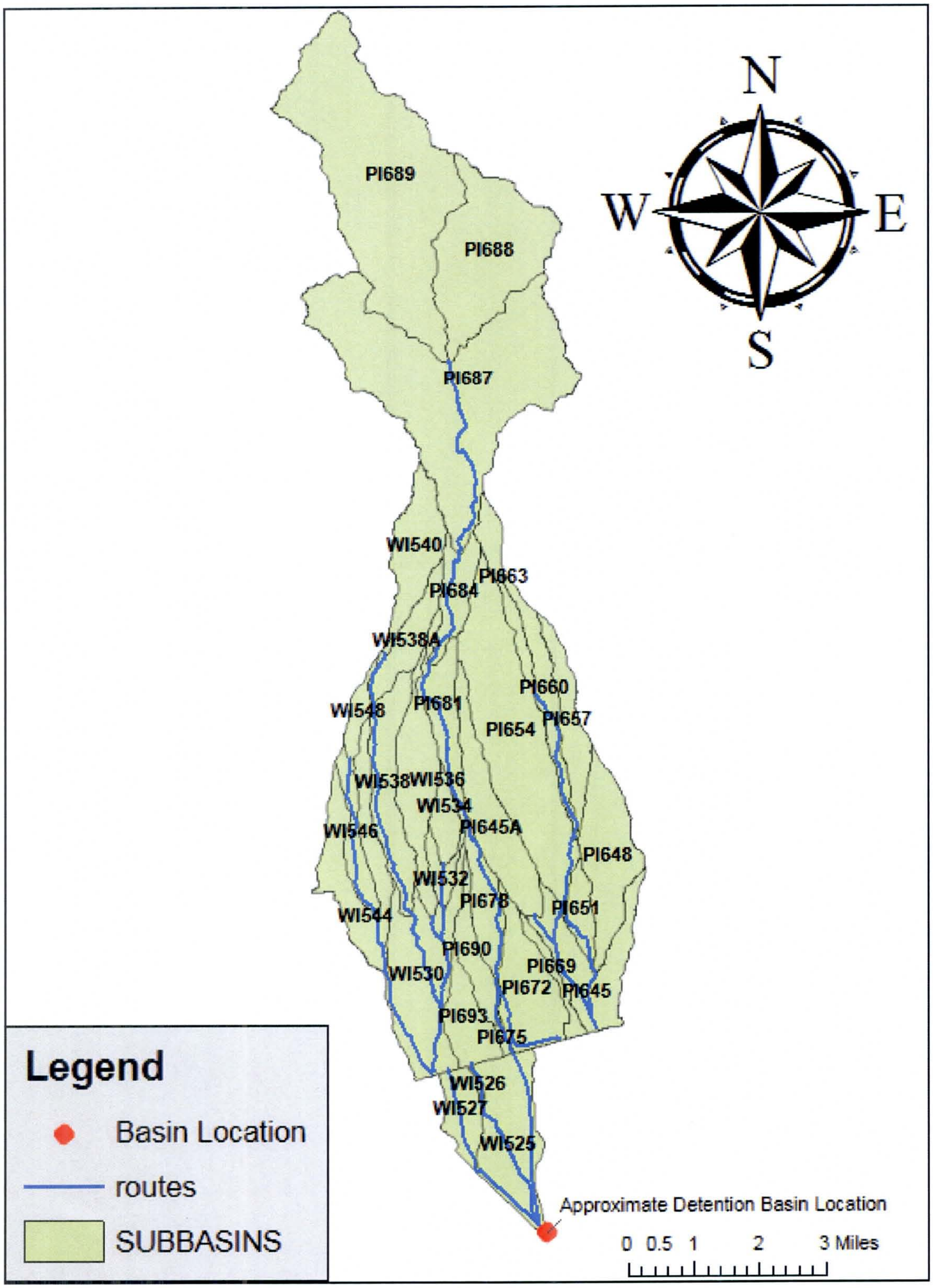


Figure 4 Shape File of Contributing Drainage Areas

Modifications were made to the shape file data based on the input requirements of DDMSW. The Sub-Basin shape file had all of the required data already in it; it just had to be reformatted to match the required format that can be found in *Preparing ESRI GIS Shape Files for DDMSW* (FCDMC, 2010). Each sub-basin area was recomputed in ArcMap based on the polygons. The BASINID field was created and the default major basin of 01 was entered into this field for each polygon. The AREAID was already in the file under the name of BASINNAME, so these were just copied into the BASINID field. Also added to the Sub-Basin shape file was a RAINID field to be used in DDMSW for the rainfall data, DEFAULT was entered into this field. The Time of Concentration shape file used to input data into DDMSW, was extracted from the Time of Concentration shape file for the entire Wittmann ADMSU by intersecting it with the Sub-Basin shape file that contains only the sub-basins in the study area that contribute to the detention basin location. The reason for doing this instead of clipping the file is because the Sub-Basin file contains data that is needed for the Time of Concentration file that was not included in the original Time of Concentration file. It should also be noted that the original Time of Concentration file needs to be modified slightly, before it is intersected, because a few of the time of concentration lines cross into adjacent sub basins. This causes the time of concentration line to be split up into multiple segments. The lines need to be modified so that they remain in the correct sub-basin. Since the Time of Concentration was intersected it already contains the BASINID and AREAID, it also has the USGE and DSGE but the fields that contain these parameters were not named correctly. So the USGE and DSGE fields were added, formatted and then the data was copied into them. Also added was the LENGTH field, which was calculated by using the built in geometry calculator. All of the shape files that were input into DDMSW are located on the attached CD under the folder "Shape_Files_Input_Into_DDMSW".

Physical Parameters

Since the Land Use and Soils shape files could not be used to reproduce the Green-Ampt parameters, the Green-Ampt parameters in the original HEC-1 model were manually input into DDMSW. However, a few steps were employed to more efficiently input the Green-Ampt parameters into DDMSW. The first step was to update the sub-basin data after the sub-basin and time of concentration shape files that were imported into DDMSW. The second step was to export the sub-basin data to an Excel file. The third step was to copy and paste the LG cards (Green-Ampt parameters) from the original HEC-1 model by Goodwin and Marshall into the sub-basin data file in Excel. The forth step was to import the Excel file into DDMSW and to set all of the Green-Ampt parameters to custom so that they would not be updated or erased. The model then contained all of the needed data. The Excel file containing the sub-basin data with the LG cards from Goodwin and Marshall is located on the CD under the "Sub_Basin_Data-DDMSW_input" folder.

Because the Land Use and Soil shape files were not used the Kb values must also be entered into DDMSW. These Kb values were obtained from the Wittman ADMSU (Entellus, 2005). Since this study only gives the type (A, B, C or D) for each sub-basin the actual Kb value then had to be calculated using the equation and methodology in Drainage Design Manual for Maricopa County. These calculations were done in the attached Excel spreadsheet. After these values were computed, they were entered into DDMSW using the same method as was used for the Green-Ampt parameters. The final sub-basin input files for the 10-year 24-hour and 10-year 6-hour models are also included under the "Sub_Basin_Data-DDMSW_input" folder.

Special Problems and Solutions

When the sub-basins were updated, it was found that the time of concentration for the sub basins PI687 and WI530 were over 1.5 hours for the 10-year 6-hour duration event. This indicates that the sub-basin should be subdivided. To determine if this variance in the time of concentration had any significant effects on the detention basin location, a sensitivity analysis was performed. This included estimating the time of concentration based on similar surrounding basins with similar water course slopes. Sub-basin PI688 was used to estimate the time of concentration for PI687. The flow wave speed was estimated by dividing the water course length by the time of concentration and then adjusted based on the ratio of the slopes. Therefore, the estimated time of concentration for PI687 = 6.167/(3.861*180/215)*1.149 = 2.19 hrs. The estimated time of concentration for WI530 can be estimated in the similar way as 1.67 hrs. Shown in the table below are the estimated times of concentrations and the data used to obtain them.

Basin	Basins used to estimate	Length (mi)	Slope (ft/mi)	Time of Concentration (hrs)	Estimated Time of Concentration (hrs)
PI687	PI687	6.167	180	1.5	2.19
	PI688	3.861	215	1.149	
WI530	WI530	3.689	56.4	1.5	1.67
	PI672	2.839	57.1	1.288	

Table 1 Estimated Time of Concentration

Separate runs of HEC-1 were setup for the 10-year 6-hour event, one with the time of concentration set at 1.5 hours which is what DDMSW gives and the other with the estimated times of concentration shown above. The results were compared at three points in the model, PI687, WI530 and CWI525. The concentration point CWI525 is considered because it is at the detention basin location.

			value	units
WI530	Tc=1.5	Peak	347	cfs
		Volume(6hr)	50	ac-ft
		Time to Peak	5.17	hrs
	Tc=1.67	Peak	315	cfs
		Volume(6hr)	49	ac-ft
		Time to Peak	5.33	hrs
PI687	Tc=1.5	Peak	1659	cfs
		Volume(6hr)	262	ac-ft
		Time to Peak	5.17	hrs
	Tc=2.19	Peak	1239	cfs
		Volume(6hr)	253	ac-ft
		Time to Peak	5.75	hrs
CWI525	Tc=1.5	Peak	669	cfs
		Volume(6hr)	312	ac-ft
		Time to Peak	9.33	hrs
	Mod Tc	Peak	662	cfs
		Volume(6hr)	310	ac-ft
		Time to Peak	9.42	hrs

Table 2 HEC-1 Model Results Comparison based on Estimated Time of Concentration

WI530	Peak Discharge Relative Difference	9.22%
	Volume Relative Difference	2.00%
	Time to Peak Relative Difference	-3.09%
PI687	Peak Discharge Relative Difference	25.32%
	Volume Relative Difference	3.44%
	Time to Peak Relative Difference	-11.22%
CWI525	Peak Discharge Relative Difference	1.05%
	Volume Relative Difference	0.64%
	Time to Peak Relative Difference	-0.96%

Table 3 Relative Differences for Peak Discharge, Volume, and Time to Peak

As can be seen, there appears to be only minimal differences at the actual detention basin, thus the variance in the time of concentration appears to be minor. Therefore, there is no need to sub-divide the sub-basins into smaller sub-basins. It can be noted that the time of concentration of 1.5 hours gives more conservative results, thus this value will be used in the final model. The HEC-1 input files and output files are included on the CD under the "Time_of_Concentration_Sensitivity" folder. It should be noted that these results were obtained before the west Padelford Wash Direct Inflow Hydrograph was updated to the 10-year flows. It was found that this made only minimal changes to the overall model so the sensitivity analysis was not redone.

10-year Tc and R by DDMSW

After the sub-basin and time of concentration shape files were properly setup, they were input into DDMSW 4.6.0 using methods outlined in *Preparing ESRI GIS Shape Files for DDMSW*. It is important to make sure that the February 16th, 2011 version of MCUHP1 should be downloaded from fcd.maricopa.gov to replace the old MCUHP1 in the original DDMSW 4.6.0 package. After the data has been input into DDMSW, it is important to make sure that the Rainfall and Sub Basin data have been updated. For this project, the 10-year 6-hour and 10-year 24-hour events are considered. The duration of rainfall must be set in the Select Project window and the return period is set when updating the HEC-1 input file or running the model.

Since only the Tc and R values for each sub-basin are of interest in this project a dummy network was created, that is the basins were all placed in the network without any combines or routing. Using this method the HEC-1 input file was created and exported that only contained the basin information. The DDMSW files for both storm events are included on the attached CD under the folder "DDMSW-Project_files" which contains folders for both 6-hour and 24-hour storms. It may be noted that the exported HEC-1 models do not actually represent the system but they have correct Tc and R values. The Tc and R values from the exported HEC-1 models will be used to replace the Tc and R values in the sub-basins that contribute to the detention basin in the original 100-year HEC-1 models developed by Goodwin and Marshall. These HEC-1 files with the dummy network are available on the CD under the folder "Intermediate_HEC-1_Files", this folder contains the files for both 24-hour and 6-hour events.

Columns (2) and (4) in Table 4 contain the time of concentration (Tc) values for the 10-year 6-hour and 10-year 24-hour storms obtained by using DDMSW 4.6.0 (this study). Table 4 also compares the Tc values between DDMSW 4.6.0 (this study) and Goodwin and Marshall (G&M) for the 100-year storms as a reference. Columns (3) and (5) contain the Tc values for the 100-year storms of 6 hour and 24 hour duration respectively by using DDMSW 4.6.0 (this study). Columns (6) and (7) contain the Tc values from the Goodwin and Marshall study for Martin Acres (Goodwin and Marshall

Inc, 2011), which are the same as the Tc values from Wittmann ADMSU (Entellus, 2005). As can be seen, the 100-year Tc values obtained from DDMSW 4.6.0 (columns (3) and (5)) are not the same as those from Goodwin and Marshall (columns (6) and (7)). It should be mentioned that the same Green-Ampt parameters are used for this study, Goodwin and Marshall's study, and Entellus' Wittmann ADMSU. The reasons for the difference in Tc are due to changes in methodology for computing Tc and the use of NOAA 14. The Entellus' study used WMS 7.1 to compute the Tc values, which was based on MCUHP1 released in 1994. Since 1994 MCUHP1 has gone through various revisions and changes in methodology. The latest MCUHP1 (February 16th, 2011) in DDMSW 4.6.0 was used to obtain the 10-year and 100-year Tc values. NOAA14 rainfall data was used in this study. The studies by Goodwin and Marshall (Goodwin and Marshall Inc, 2011) and Entellus (Entellus, 2005) were based on NOAA 2.

Basin ID	6 hr Tc values FCDMC		24 hr Tc values FCDMC		6 hr Tc G&M	24 hr Tc G&M
	10 yr	100 yr	10 yr	100 yr	100 yr	100 yr
(1)	(2)	(3)	(4)	(5)	(6)	(7)
PI645	1.378	0.906	1.073	0.839	0.858	0.863
PI645A	1.479	1.188	1.372	1.153	1.288	1.367
PI648	1.491	1.201	1.377	1.162	1.317	1.388
PI651	1.167	0.908	1.114	0.916	0.892	0.983
PI654	1.5	1.35	1.497	1.266	1.5	1.5
PI657	1.357	1.105	1.298	1.103	1.2	1.279
PI660	1.497	1.209	1.424	1.206	1.358	1.45
PI663	1.22	0.987	1.176	0.997	1.008	1.108
PI669	1.075	0.805	1.018	0.798	0.725	0.8
PI672	1.288	0.876	1.048	0.823	0.825	0.838
PI675	0.635	0.477	0.603	0.475	0.342	0.375
PI678	1.29	0.949	1.164	0.925	0.933	0.983
PI681	1.312	1.053	1.236	1.041	1.1	1.175
PI684	1.046	0.831	0.992	0.83	0.788	0.842
PI687	1.5	1.417	1.5	1.268	1.5	1.5
PI688	1.422	1.067	1.216	0.99	1.117	1.121
PI689	1.5	1.252	1.389	1.136	1.392	1.383
PI690	1.222	0.901	1.126	0.885	0.871	0.913
PI693	1.032	0.743	0.915	0.721	0.654	0.688
WI525	1.318	0.916	1.079	0.856	0.896	0.9
WI526	0.794	0.597	0.757	0.595	0.463	0.5
WI527	1.049	0.777	0.958	0.765	0.688	0.733
WI530	1.5	1.001	1.164	0.914	1.013	0.971
WI532	0.8	0.602	0.756	0.6	0.475	0.475
WI534	0.955	0.777	0.934	0.792	0.717	0.767
WI536	1.5	1.246	1.441	1.221	1.396	1.467
WI538	1.5	1.238	1.436	1.206	1.388	1.438
WI538A	1.158	0.924	1.099	0.921	0.913	0.979
WI540	1.254	0.985	1.163	0.962	1.008	1.063
WI544	1.189	0.905	1.053	0.865	0.875	0.863
WI546	0.935	0.754	0.917	0.763	0.688	0.725
WI548	0.737	0.577	0.706	0.583	0.471	0.504

Table 4 Comparison of Tc between FCDMC and Goodwin and Marshall

Replacing 100-year Tc and R

The Tc and R values in the original HEC-1 models were replaced with the 10-year Tc and R value by using a Perl based tool developed by Bing Zhao, FCDMC. These files are located under "UCreplace" folder on the attached CD, the files in this folder pertinent to this project are dated after 11/22/2011. The resulting HEC-1 files that have the Tc and R values for each sub-basin are located under the "Intermediate_HEC-1_Files" folder and the HEC-1 files that have been modified using these Tc and R values are located under the "Updated_HEC-1_files" folder on the attached CD. It should also be noted that these HEC-1 files have had the Rainfall and Inflow data modified to 10-year storm events for both durations in the models, how this was accomplished is detailed in the next section.

The original files and the final HEC-1 files were compared to ensure that the sub-basin names matched correctly. The sub-basins were also checked by comparing the sub-basin area's to ensure that it was the correct basin. This ensured that all of the sub-basins in the DDMSW model existed in the original HEC-1 file and that the data was transferred properly between HEC-1 files.

Precipitation

The rainfall data was copied out of the HEC-1 files generated by DDMSW and pasted into the modified HEC-1 files instead of the 100-year rainfall values. This is valid since the ESRI GIS Shape files for the sub-basins were used to obtain the NOAA14 rainfall data for the study area. This took care of all of the areas that used rainfall data to get the runoff. There was one area in the model, the west Padelford Wash area on the east side of the CAP that used a Direct Inflow Hydrograph to add the flow from this area to the model. To update these values the Padelford Wash study was obtained from the FCDMC Engineering library, call number: A287.014.003, FCD contract number: 99-12. From this study the DDMSW model used for the study was obtained. This study used version 1.5 of DDMSW, this version of DDMSW is still available for download on the FCDMC website, fcd.maricopa.gov. From the original HEC-1 input file from Goodwin and Marshall it was found that they used concentration point CO400 from the Padelford Wash study to obtain the Direct Inflow Hydrograph for their model. Because of various problems encountered with the Padelford Wash model in DDMSW 1.5, just the HEC-1 file of the 100 year models was exported. This HEC-1 model was then modified to the 10 year storms. To obtain the 10 year models all that needed to be changed was the rainfall data. To obtain the 10 year 6 hour and 24 hour NOAA14 rainfall data DDMSW 4.6.0 is used with a shape file of the Padelford Study area. The shape file of the contributing sub-basins for the Padelford Wash study was obtained from FCDMC Contract Records. This shape file had to be handled in the same manner as the previously mentioned shape files. Since only the rainfall data is of interest here only those fields need to be added to the shape file. The shape file was then input into DDMSW and the rainfall data updated. With this rainfall data and the areal reduction factors given in chapter 2 of the Drainage Design Manual for Maricopa County are used to obtain the index storms for the model. It should be noted that since the purpose of this model is to obtain the direct runoff hydrograph at concentration point CO400 an index storm was added for 23 square miles since this is the contributing area at CO400. All of the models used to obtain the direct inflow hydrograph are available on the attached CD under the "Padelford_Wash_Inflow" folder.

10-year HEC-1 Models

The final 10-year 6-hour and 10-year 24-hour HEC-1 models were developed. These models can be found in the attached CD under sub-folder "Updated_HEC-1_Files". The input file names are "Updated_10yr_6hr.dat" and "Updated_10yr_24hr.dat" for 6-hr and 24-hr storm events, respective.

Results

HEC-1 Model Results

Shown below are the discharges obtained at all of the concentration points in the HEC-1 model before the proposed detention basin location.

Concentration Point	Drainage Area (sq. mi.)	Peak Discharge for 10-yr, 24-hr Storm (cfs)	Time-to-Peak for 10-yr, 24-hr Storm (hr)	Peak Discharge for 10-yr, 6-hr Storm (cfs)	Time-to-Peak for 10-yr, 6-hr Storm (hr)	Peak Discharge to be used for FIS (cfs)
WI548	0.31	150	12.5	163	4.58	163
RWI548	0.31	96	13.67	107	5.67	107
WI546	0.61	225	12.5	264	4.5	264
CWI546	0.91	225	12.5	247	4.5	247
RWI546	0.91	210	13	231	5	231
WI544	1.79	638	12.5	553	4.67	638
CWI544	2.71	796	12.67	681	4.83	796
DO544	2.71	534	12.67	456	4.83	534
D544	2.71	263	12.67	225	4.83	263
RWI544	2.71	215	13.67	189	5.92	215
WI542	1.17	305	12.83	238	5	305
CWI542	2.07	384	13.25	323	5.5	384
WI540	1.25	454	12.83	432	5	454
SSR940	1.25	453	12.92	NA	NA	453
RWI540	1.25	418	13.08	403	5.25	418
WI538A	0.78	297	12.83	305	4.92	305
C538A	2.02	687	13	626	5.17	687
R538A	2.02	590	13.92	555	6.08	590
WI538	1.43	428	13.08	416	5.25	428
CWI538	3.45	877	13.83	788	6	877
RWI538	3.45	826	14.67	747	6.75	826
WI536	1.37	416	13.17	413	5.25	416
WI534	0.43	218	12.67	245	4.75	245
RWI534	0.43	197	13	223	5	223
WI532	0.32	123	12.58	137	4.58	137

Concentration Point	Drainage Area (sq. mi.)	Peak Discharge for 10-yr, 24-hr Storm (cfs)	Time-to-Peak for 10-yr, 24-hr Storm (hr)	Peak Discharge for 10-yr, 6-hr Storm (cfs)	Time-to-Peak for 10-yr, 6-hr Storm (hr)	Peak Discharge to be used for FIS (cfs)
CWI532	0.76	278	12.83	300	4.92	300
C530*	2.13	670	13	626	5.17	670
R530*	2.13	598	13.92	569	6.08	598
WI530	2.38	671	12.83	347	5.17	671
D544	2.71	534	12.67	456	4.83	534
RD544	2.71	483	13.42	420	5.5	483
CWI530	9.77	1733	14.33	1356	6.5	1733
CAP1*	11.84	1965	14.25	1484	6.5	1965
PI663	0.6	185	12.92	198	5	198
RPI663	0.6	166	13.92	176	5.92	176
PI657	0.87	271	13.08	275	5.08	275
PI660	0.84	204	13.17	207	5.25	207
CPI660	2.31	534	13.67	512	5.75	534
RPI660	2.31	514	13.92	491	6	514
PI654	4.03	1470	13.17	1318	5.25	1470
CPI654	6.34	1847	13.25	1579	5.33	1847
DO654	6.34	369	13.25	316	5.33	369
D654	6.34	1477	13.25	1263	5.33	1477
RPI654	6.34	1446	13.5	1242	5.67	1446
PI648	1.73	617	13.08	562	5.25	617
PI651	0.46	157	12.83	170	4.92	170
CPI651	7.26	2049	13.42	1728	5.58	2049
RPI651	7.26	1985	13.67	1691	5.83	1985
PI645A	1.63	544	13.08	510	5.25	544
R645A	1.63	518	13.5	492	5.58	518
PI645	1.56	459	12.75	274	5	459
D654	6.34	369	13.25	316	5.33	369
RD654	6.34	345	13.92	299	6	345
CPI645	11.72	2907	13.67	2299	5.83	2907
CAP1*	23.56	4483	13.75	3201	6.08	4483
PI689	6.78	2709	13	1946	5.17	2709
PI688	3.2	1325	12.83	960	5.08	1325
CPI689	9.98	3954	13	2605	5.17	3954
RPI689	9.98	3523	13.42	2425	5.67	3523

Concentration Point	Drainage Area (sq. mi.)	Peak Discharge for 10-yr, 24-hr Storm (cfs)	Time-to-Peak for 10-yr, 24-hr Storm (hr)	Peak Discharge for 10-yr, 6-hr Storm (cfs)	Time-to-Peak for 10-yr, 6-hr Storm (hr)	Peak Discharge to be used for FIS (cfs)
PI687	7.01	2379	13.08	1659	5.17	2379
CPI687	16.99	5342	13.33	3283	5.58	5342
RPI687	16.99	5191	13.58	3186	5.83	5191
PI684	0.74	329	12.75	337	4.83	337
CPI684	17.73	5316	13.58	3260	5.83	5316
SSR103	17.73	5311	13.58	3260	5.83	5311
RPI684	17.73	4968	14	3132	6.25	4968
PI681	0.99	340	12.92	338	5.08	340
CPI681	18.72	5114	14	3224	6.25	5114
RPI681	18.72	4651	14.75	2968	7.08	4651
PI678	0.83	175	12.92	169	5	175
CPI678	19.55	4685	14.75	2948	7.08	4685
DO678	19.55	1312	14.75	826	7.08	1312
D678	19.55	3373	14.75	2123	7.08	3373
PI690	0.63	124	12.83	130	5	130
CPI690	14.71	3491	14.75	2314	7	3491
RPI690	14.71	3340	14.92	2230	7.25	3340
PI675	0.06	25	12.42	28	4.5	28
CPI675	14.77	3339	14.92	2229	7.25	3339
CAP1*	38.33	6037	14.75	3802	6.92	6037
PI672	1.51	471	12.75	319	5	471
D678	19.55	1312	14.75	826	7.08	1312
RD678	19.55	1040	15.33	756	7.5	1040
CPI672	6.98	1132	15.25	902	7.42	1132
CAP1*	45.31	6913	14.83	4109	7	6913
PI693	0.84	300	12.67	277	4.75	300
CAP1*	46.15	6916	14.83	4092	7	6916
PI669	0.29	55	12.83	62	4.83	62
CAP1*	46.43	6925	14.83	4087	6.92	6925
PI642	0.24	51	12.42	59	4.42	59
CAP1*	46.67	6926	14.83	4084	6.92	6926
PDWEST	7.08	2751	13.42	1536	5.5	2751
CAP1*	53.75	7706	13.67	4525	6	7706
STOR1	53.75	2999	16.75	2350	8.92	2999

Concentration Point	Drainage Area (sq. mi.)	Peak Discharge for 10-yr, 24-hr Storm (cfs)	Time-to-Peak for 10-yr, 24-hr Storm (hr)	Peak Discharge for 10-yr, 6-hr Storm (cfs)	Time-to-Peak for 10-yr, 6-hr Storm (hr)	Peak Discharge to be used for FIS (cfs)
DOCAP*	53.75	0	0	0	0	0
DCAP*	53.75	2999	16.75	2350	8.92	2999
DOCP14	53.75	275	16.75	188	8.92	275
DCAP14	53.75	2724	16.75	2161	8.92	2724
DOCP13	53.75	346	16.75	282	8.92	346
DCAP13	53.75	2378	16.75	1879	8.92	2378
DOCP12	53.75	344	16.75	274	8.92	344
DCAP12	53.75	2034	16.75	1605	8.92	2034
DOCP11	53.75	356	16.75	284	8.92	356
DCAP11	53.75	1678	16.75	1321	8.92	1678
DOCP10	53.75	354	16.75	284	8.92	354
DCAP10	53.75	1324	16.75	1037	8.92	1324
DOCP09	53.75	344	16.75	274	8.92	344
DCAP09	53.75	980	16.75	763	8.92	980
DOCP08	53.75	331	16.75	259	8.92	331
DCAP08	53.75	649	16.75	504	8.92	649
DOCP07	53.75	331	16.75	253	8.92	331
DCAP07	53.75	318	16.75	251	8.92	318
DOCPOT	53.75	0	0	0	0	0
DCAPOT	53.75	318	16.75	251	8.92	318
DCAPOT	53.75	0	0	0	0	0
RDCPOT	53.75	0	0	0	0	0
WI527	0.71	269	12.67	266	4.75	269
CWI527	0.71	269	12.67	266	4.75	269
DO527	0.71	0	0	0	0	0
D527	0.71	269	12.67	266	4.75	269
DCAP08	53.75	331	16.75	259	8.92	331
RDCP08	53.75	331	17	259	9.17	331
WI526	0.05	10	12.58	12	4.67	12
CWI526	3.49	347	17.08	317	9.08	347
RWI526	3.49	347	17.92	316	10	347
WI525	1.94	682	12.75	449	5	682
DCAP09	53.75	344	16.75	274	8.92	344
RDCP09	53.75	344	17.75	273	9.83	344

Concentration Point	Drainage Area (sq. mi.)	Peak Discharge for 10-yr, 24-hr Storm (cfs)	Time-to-Peak for 10-yr, 24-hr Storm (hr)	Peak Discharge for 10-yr, 6-hr Storm (cfs)	Time-to-Peak for 10-yr, 6-hr Storm (hr)	Peak Discharge to be used for FIS (cfs)
D527	0.71	0	0	0	0	0
RD527	0.71	0	0	0	0	0
CWI525	8.92	737	12.75	611	9.92	737

Table 5 Discharges and Time to Peak for each Concentration Point

10-year Peak Discharges and Runoff Volumes at Detention Basin Location

The output files were generated by running HEC-1.exe which is attached on the CD under sub-folder of "Updated_HEC-1_Files." "Updated_10yr_6hr.out" and "Updated_10yr_24hr.out" correspond to the HEC-1 output files for the 10-year 6-hour and 10-year 24-hour storm events, respectively. Table 6 displays the 10-year peak flows and runoff volumes as well as 100-year values for location of the proposed detention basin (CWI525 in HEC-1). The 100-year values are from Goodwin and Marshall's DCR. Table 6 indicates that the 24-hour values are larger than the 6-hour values. Therefore, the detention basin design should be based on the 10-year 24-hour storm.

As can be seen, the 10-year peak discharges and runoff volumes are reduced. Table 7 displays the ratio of peak discharge in percent between the 10-year and 100-year events. The runoff volume ratio values are also displayed in Table 7.

	10-year (FCDMC, this study)		100-year (Goodwin and Marshall)	
	Peak (cfs)	Runoff Volume (ac-ft)	Peak (cfs)	Runoff Volume (ac-ft)
6-hour	611	498	1695	1087
24-hour	737	769	1614	1130

Table 6 Peak Discharges and Runoff Volumes at Detention Basin Location

	Peak Ratio	Runoff Volume Ratio
6-hour	36.05%	45.81%
24-hour	45.66%	68.05%

Table 7 Ratio in Percent between 10-year and 100-year Storms

The discharge hydrographs for both 10-year 6-hr and 10-year 24-hr can be found in Figure 5 and Figure 6. As a comparison, the 100-year discharge hydrographs can be found in Figure 7 and Figure 8.

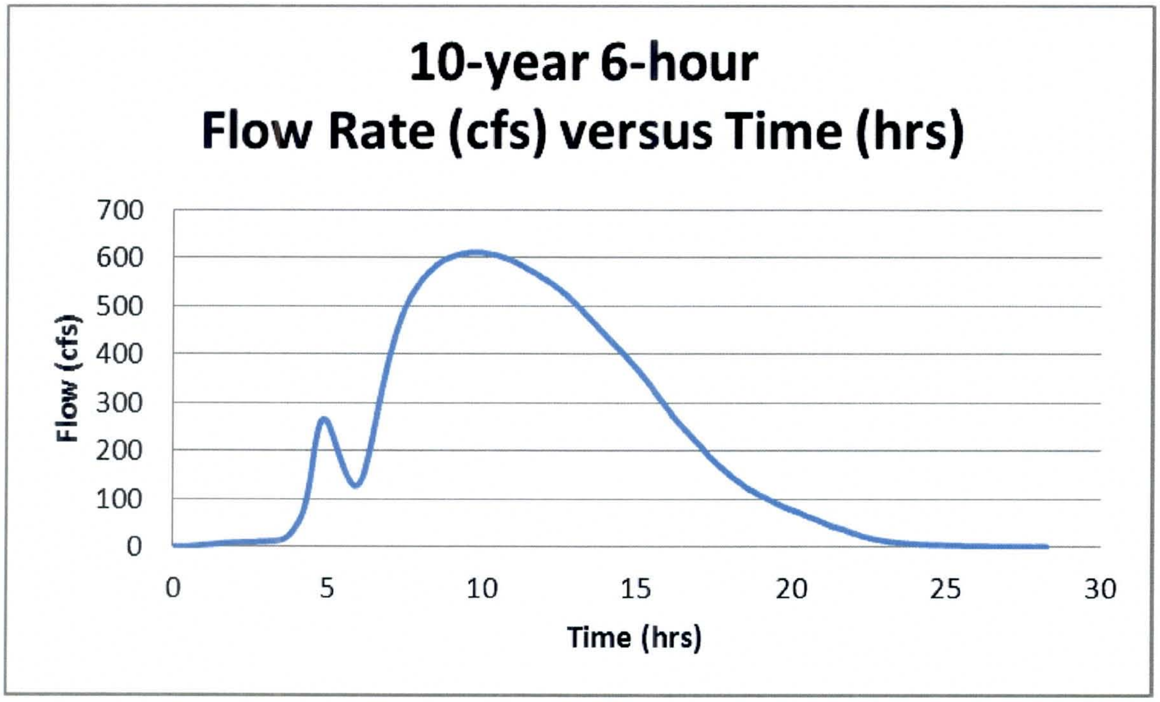


Figure 5 Discharge Hydrograph for 10-year 6-hour at Detention Basin Location

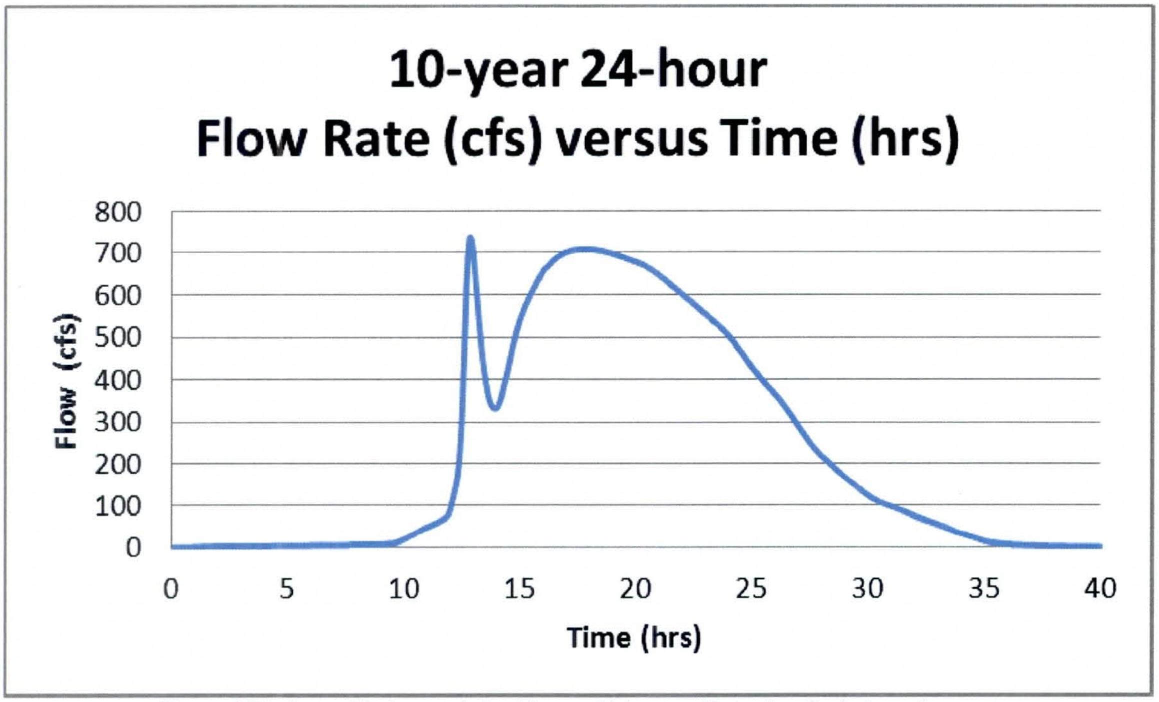


Figure 6 Discharge Hydrograph for 10-year 24-hour at Detention Basin Location

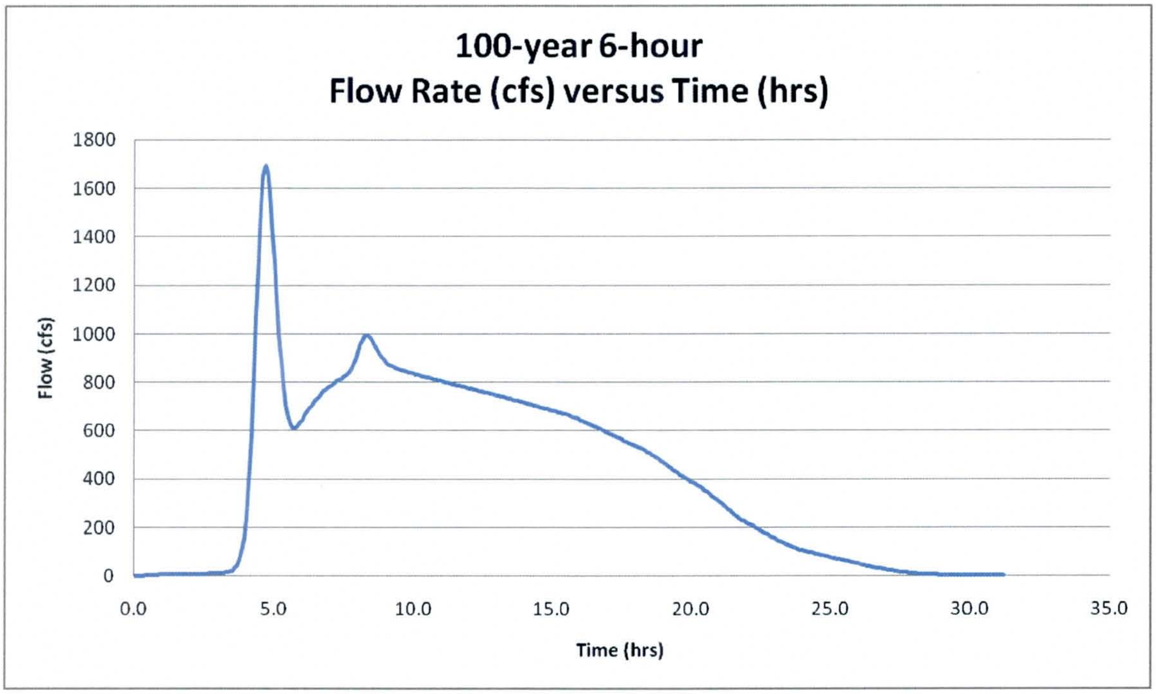


Figure 7 Discharge Hydrograph for 100-year 6-hour at Detention Basin Location

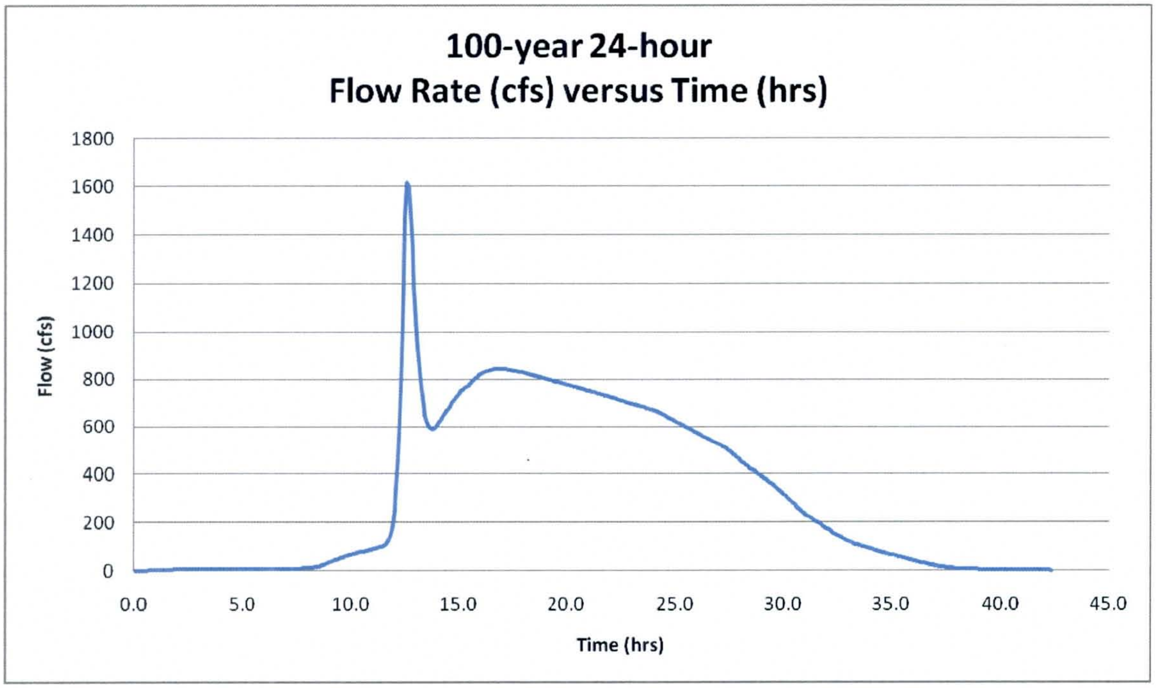


Figure 8 Discharge Hydrograph for 100-year 24-hour at Detention Basin Location

Discharge from Proposed Detention Basin

Using the hydrograph for the 10-year 24-hour event, the discharge rate associated with a detention basin of 30 ac-ft was computed. This was computed by taking the inflow hydrograph and determining the flow rate that corresponds to 30 ac-ft of storage above this flow rate. This was done using Microsoft Excel, a spreadsheet was setup to calculate the volume and then Solver was used to determine the flow rate that corresponds with the storage of 30 ac-ft. This Excel spreadsheet, and the ones used to create the figures and tables in this report is attached on the CD and is called "EXCEL_for_MartinAcres". It was found that the flow rate would be 625 cfs. Shown below is a plot that has this flow rate and inflow hydrograph.

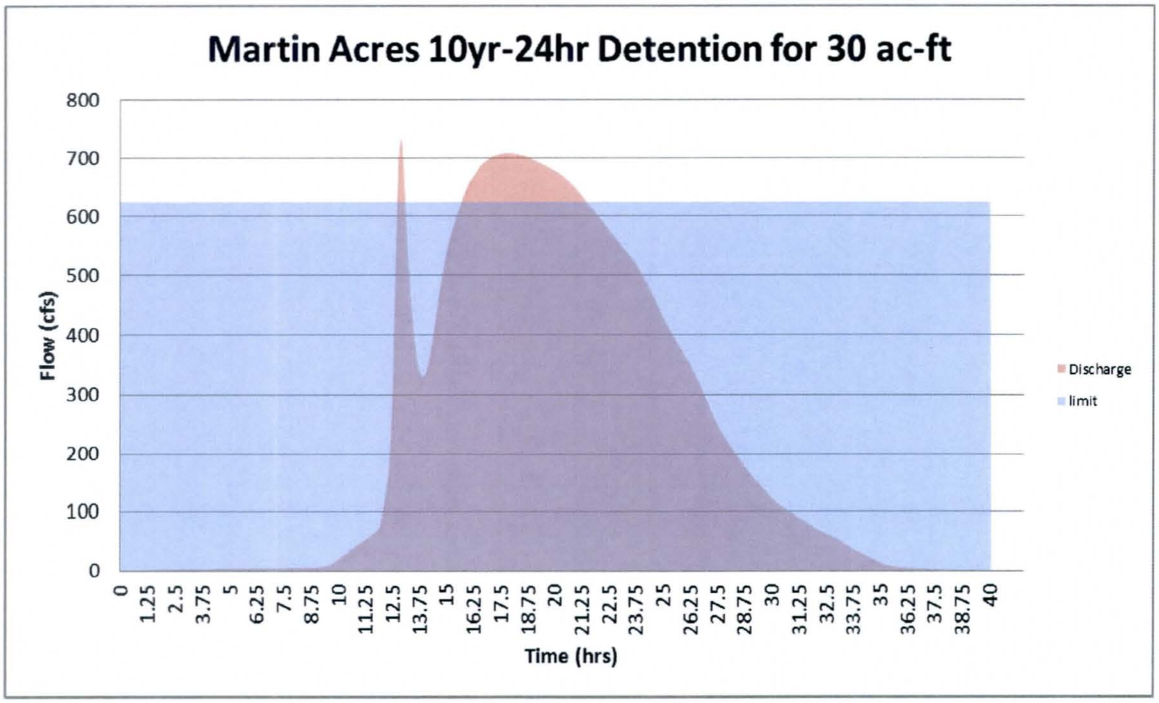


Figure 9 Martin Acres 10-year 24-hour Discharge for a 30 ac-ft Detention Basin

The red area above the blue area represents the volume stored in the 30 ac-ft detention basin. Shown below is the plot of the cumulative volume accumulation over time for this limit of 625 cfs.

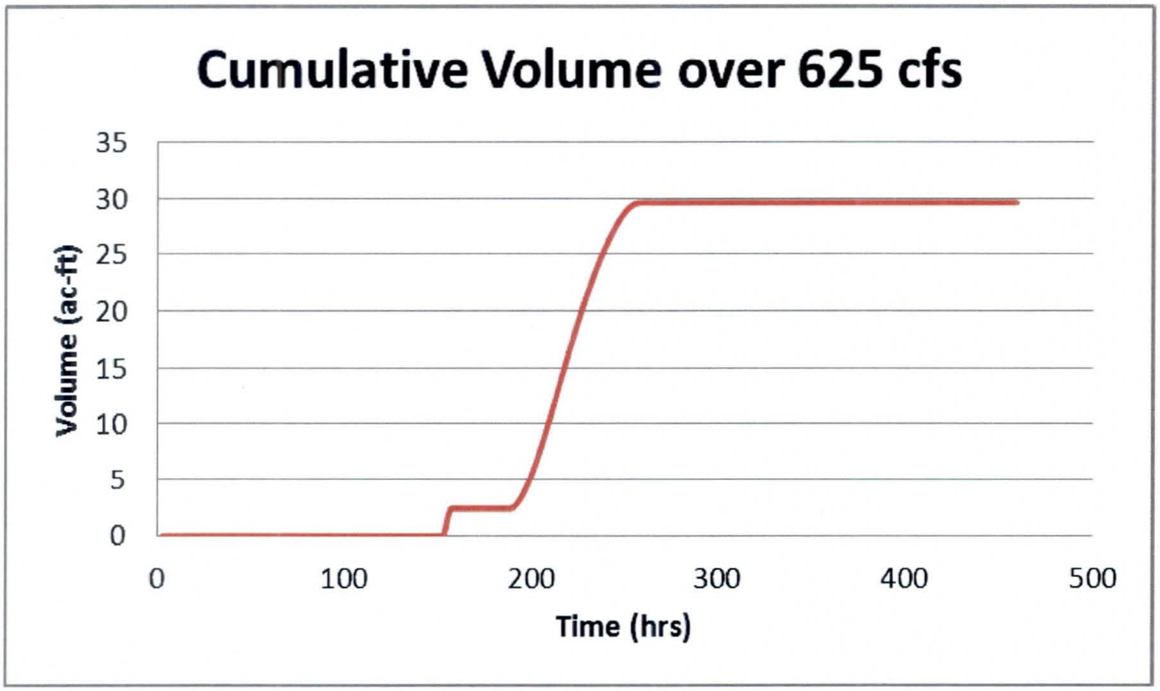


Figure 10 Cumulative Volume Accumulation for 30 ac-ft Detention Basin

In the 10-year 24-hour hydrograph the peak discharge is 780 cfs, this would reduce it to 625 cfs a reduction of 155 cfs.

After calculating the corresponding flow for a basin of 30 ac-ft other alternatives were also calculated using the same methodology for the 10-year 24-hour event.

Basin Volume (ac-ft)	Discharge form System (cfs)	Flow Reduction (cfs)
20	645	135
30	625	155
50	589	191
75	552	228
100	520	260
200	414	366

Table 8 Comparison of Detention Basin size and Discharge

If the 100-year 24-hour hydrograph is considered for a 30 ac-ft detention basin, then the corresponding out flow by this methodology would be 841 cfs, which would be a reduction of 773 cfs.

Future Analysis

Since the discharge-elevation for storage routing upstream of CAP was for 100-year storm event and was based on the assumption that many ponding areas were assumed to be connected and function as one big storage area, further analysis should be performed to evaluate if this assumption is still valid for a 10-year storm event. If such an analysis shows that the 10-year storm event will "flood" the upstream individual ponding areas, then this assumption is still valid and the results obtained from this study are valid. If such an analysis shows that the individual ponding areas function independently and the ponding areas are not connected, then individual storage routing rating curves should be used and HEC-1 models should be modified and re-run.

Shown below is a comparison between the 100-year and 10-year 24-hour events. As can be seen, there is a significant decrease in the initial peak between the two return periods. But the second peak does not decrease as much. This second peak comes from the outflow from the ponding at the CAP. One of the main inflows into the CAP comes from Padelford Wash (PDWEST in HEC-1). This inflow did not decrease much between the 100-year and 10-year return periods. Part of this could be because S-Graph unit hydrograph was used for the Padelford Wash study. This inflow and methodology should be reviewed to ensure that these inflows are reasonable for the 10-year event.

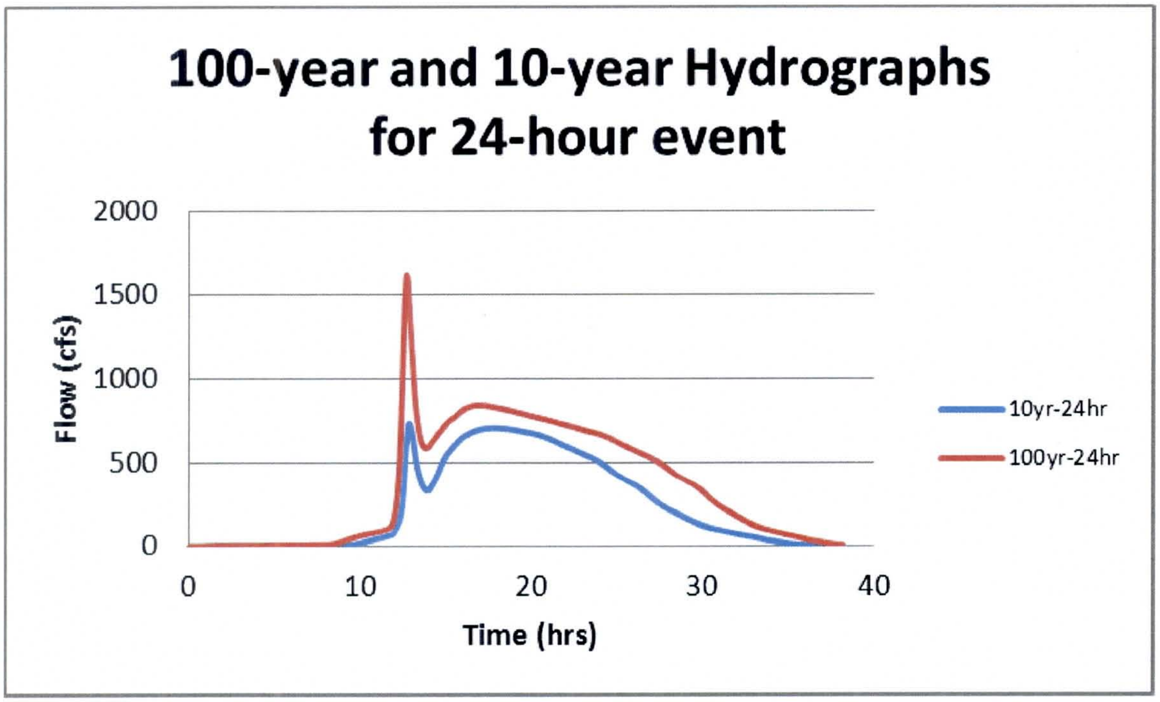


Figure 11 Comparison of 100-year and 10-year 24-hour Hydrographs

References

Entellus. (2005). *Wittmann Area Diranage Master Study Update.* FCDMC.

FCDMC. (2010). *Preaparing ESRI GIS Shape Files for DDMSW.* FCDMC.

Goodwin and Marshall Inc. (2011, August). Martin Acres DCR Recommended Alternative.

Goodwin and Marshall Inc. (2011, August). Asante Basin Display.

Appendix A – Physical Parameters

Sub Basin	Area	Type for Kb	Kb	IA	Dθ	PSIF	XKSAT
PI645	1.562	B	0.038752	0.34	0.28	4.17	0.45
PI645A	1.631	C	0.074534	0.32	0.15	8.04	0.09
PI648	1.728	C	0.073907	0.35	0.16	8.69	0.06
PI651	0.459	C	0.0883	0.35	0.17	6.77	0.14
PI654	4.028	C	0.064718	0.35	0.15	9.53	0.05
PI657	0.87	C	0.081358	0.35	0.14	9.92	0.04
PI660	0.839	C	0.081751	0.35	0.15	9.5	0.05
PI663	0.604	C	0.08532	0.35	0.15	9.37	0.05
PI669	0.286	B	0.04889	0.38	0.25	4.65	0.36
PI672	1.51	B	0.038954	0.35	0.25	4.4	0.39
PI675	0.063	B	0.057924	0.35	0.25	4.59	0.35
PI678	0.832	B	0.042513	0.32	0.25	4.34	0.42
PI681	0.991	C	0.079944	0.34	0.16	8.4	0.07
PI684	0.736	C	0.083174	0.35	0.15	7.86	0.09
PI687	7.009	D	0.090445	0.35	0.36	5.39	0.23
PI688	3.197	D	0.100672	0.35	0.39	5.75	0.2
PI689	6.785	D	0.090868	0.35	0.38	6.47	0.15
PI690	0.629	B	0.044184	0.35	0.25	4.35	0.4
PI693	0.836	B	0.042485	0.35	0.25	4.55	0.35
WI525	1.941	B	0.037455	0.33	0.25	4.55	0.36
WI526	0.049	B	0.059425	0.35	0.25	4.35	0.4
WI527	0.709	B	0.043469	0.33	0.24	4.86	0.3
WI530	2.376	B	0.036247	0.35	0.25	4.29	0.42
WI532	0.323	B	0.048163	0.35	0.25	5.05	0.28
WI534	0.434	C	0.088908	0.32	0.17	9.6	0.05
WI536	1.37	C	0.076427	0.33	0.16	9.68	0.05
WI538	1.43	C	0.075962	0.34	0.16	8.1	0.08
WI538A	0.776	C	0.082599	0.35	0.15	7.8	0.09
WI540	1.246	C	0.077458	0.35	0.2	6.5	0.15
WI544	1.794	B	0.037925	0.26	0.3	4.3	0.41
WI546	0.605	B	0.044416	0.23	0.31	4.48	0.36
WI548	0.308	B	0.048447	0.35	0.16	6.88	0.13
WI542	1.174	B	0.04	0.345	0.252	4.299	0.415
PI642	0.2367	B	0.05	0.332	0.334	4.103	0.501

Table 9 Physical Parameters of Sub-Basins

Appendix B – Final Technical Memorandum

Flood Control District
of Maricopa County

INTEROFFICE MEMORANDUM

Date: June 25, 2012

To: Anthony Beuché, PE, Project Manager, Project Management Branch, PPM Division

From: John Holmes, Hydrologist, Hydrology and Hydraulics Branch, Engineering Division

Via: Amir Motamedi, PE, Hydrology and Hydraulics Branch Manager, Engineering Division

Bing Zhao, PE, PhD, Engineering Application Development/River Mechanics Branch Manager, Engineering Division

CC: Jonathon Chill, PE, Hydrologist, Engineering Application Development/River Mechanics Branch, Engineering Division

Subject: Final Technical Memorandum: Analysis of the Stage-Discharge Rating Table of flows collected in Storage Area #1 (STOR1), upstream of the Central Arizona Project (CAP Canal), from the 100-year base model of the Wittmann ADMSU; to determine its effectiveness for use in the 10-year HEC-1 models of the Martin Acres DCR detention basin design concept

Purpose

The purpose of this memorandum is to report the results of an analysis to determine if the stage-discharge rating curve that Entellus developed for the 100-year event HEC-1 models, Wittmann ADMS Update (2005), would be effective in the 10-year HEC-1 design model for Martin Acres DCR. The rating table was developed specifically for the distribution of flows from the ponding area, STOR1 (HEC-1 ID), to the 19 over-chutes across the CAP Canal from US60 to Padelford Wash, based on a level pool scenario.

Results

The findings from the analysis showed that the 100-year event rating table was also effective in the 10-year design HEC-1 model. Resulting peak flows from the 10-year model were matched with comparable water surface elevations in the Wittmann ADMS Update, culvert discharge tables. When the 10-year water surface elevations were matched to the 2' and 10' index contour mapping of the CAP STOR1 area, it was evident that the 10-year runoff would also create a level pool effect, making the 100-year rating table similarly effective for the 10-year stage-discharge relationship. See Figures 4-6, below.

Background

A 10-year flood mitigation solution was proposed in the first phase of the Martin Acres DCR project after the 100-year solution proved to be cost-prohibitive. A proposed detention basin was to be located along the left overbank of Wash 3-East, upstream and adjacent to the BNSF railroad tracks and US60, at the southwest corner of the Asante development.

Discharges through two of the CAP Canal over-chutes, DOCP08 and DOCP09 (HEC-1 ID), see Figure 1, below, directly impacted the hydrology at the proposed basin site, downstream. So, it was necessary to verify whether or not the stage-discharge curve developed for the ponding area, STOR1, for the 100-year models was applicable for use in the 10-year model, in so far as, would the reduced runoff which would initially pond upstream of the CAP, create separate pools, due to the lower discharges and stages, vis-à-vis ground elevations/grade breaks, or a level pool scenario as in the 100-year models. If separate pools were created by the 10-year runoff, then the original rating curve used in the 100-year model would not produce the correct results.

Procedure

The following research tools and references were used to evaluate the rating curve to determine its efficacy in the 10-year design model:

- ArcGIS version 9.0
- District's 2 ft. aerial contour mapping of the Wittmann area watershed, digital files
- Discharge Calculations for Culvert System Table, Appendix D.4, Vol. 1, Wittmann ADMS Update, July 2004
- Peak Discharge Summary Report from the 10-year HEC-1 design models, 6-hour and 24-hour
- HEC-1 Schematic Map, Plate HY-1C, Wittmann ADMS Update, FCD 2002C029

First, ArcGIS was used to create a digital map of the CAP Canal, including the over chutes east of US60 to Padelford Wash. Then, a map layer was added with the 2 ft. index contours, based on the 2002 Wittmann aerial topography. Using the HEC-1 schematic map, the HEC-1 IDs of the two CAP over chutes were located.

The peak discharges of the two over chutes, DOCP09 and DOCP08, which were taken from the output summaries of the10-year 6-hour and 10-year 24-hour models, are as follows:

Figure 1 - FLOW COMPARISON - 10-year Storm Events

	CAP Over-chutes

Frequency	DOCP09	DOCP08
	Peak Flow (cfs)	
10-yr 6-hr	304	298
10-yr 24-hr	359	349

Next, the lowest flow for each of the two over chutes (culverts) was taken from the above table to interpolate the corresponding stage from the following discharge calculations tables, Appendix D.4, Wittmann ADMS Update, Hydrology Report:

Figure 2 – Discharge Calculation Tables – Wittmann Area Drainage Master Study Update, Appendix D.4

Discharge Calculations for Culvert System

Impoundment Area East of US60 CAP60-140

Water Surface Elevation: 1550

Culvert ID	Station	Description	Invert Elevation (feet)	D (inches)	HW (ft)	HW/D [ft/ft]	Q* (cfs)
CAP060	36+12	72" RCP	1543.29	72	6.71	1.12	238
CAP070	52+80	72" RCP	1543.1	72	6.9	1.15	238
CAP080	85+70	72" RCP	1542.93	72	7.07	1.18	**245**
CAP090	119+70	72" RCP	1542.55	72	7.45	1.24	**260**
CAP100	159+50	72" RCP	1542.3	72	7.7	1.28	270
CAP110	180+50	72" RCP	1542.2	72	7.8	1.3	270
CAP120	190+60	72" RCP	1542.61	72	7.39	1.23	260
CAP130	216+80	72" RCP	1542.4	72	7.6	1.27	270
CAP140	240+00	72" RCP	1544.65	72	5.35	0.89	172
					Q Total (CFS): 2223		

* Flows were calculated using nomograph for inlet control culverts

Discharge Calculations for Culvert System

Impoundment Area East of US60 CAP60-140

Water Surface Elevation: 1552

Culvert ID	Station	Description	Invert Elevation (feet)	D (inches)	HW (ft)	HW/D [ft/ft]	Q* (cfs)
CAP060	36+12	72" RCP	1543.29	72	8.71	1.45	305
CAP070	52+80	72" RCP	1543.1	72	8.9	1.48	320
CAP080	85+70	72" RCP	1542.93	72	9.07	1.51	**320**
CAP090	119+70	72" RCP	1542.55	72	9.45	1.58	**335**

CAP100	159+50	72" RCP	1542.3	72	9.7	1.62	345
CAP110	180+50	72" RCP	1542.2	72	9.8	1.63	345
CAP120	190+60	72" RCP	1542.61	72	9.39	1.57	335
CAP130	216+80	72" RCP	1542.4	72	9.6	1.6	335
CAP140	240+00	72" RCP	1544.65	72	7.35	1.22	260
					Q Total (CFS): 2900		

* Flows were calculated using nomograph for inlet control culverts

NOTE: CAP080 and CAP090 in the tables, above, refer to the same diversions coded in the HEC-1 models as DOCP08 and DOCP09, respectively.

Finally, linear interpolation of the stage-discharge relationships from the tables above produced the following results in Figure 3, below:

Figure 3 – Stage-Discharge Table

	CAP Over-chutes	
10-yr 6-hr Storm	CAP090	CAP080
	Stage / Discharge	
Stage (ft.)	1551.2	1551.4
Peak Flow (cfs)	304	298

When the stage (water surface elevation) contours are approximated in relation to the 10 ft. contour interval map segments at 1550', below, within a portion of the STOR1 ponding area, where CAP080 and CAP090 are located, the estimated stage-discharge will produce a level pool effect. See Figures 4 – 6, below.

Figure 4 –STOR1 ponding area on the upstream side of the CAP Canal with 1550' contour overlay

Figure 4, above, shows a segment of STOR1 which includes the two CAP Canal over-chutes, CAP080 and CAP090, within the area of interest.

Figure 5 - CAP090 over-chute and a close-up at contour 1550 ft.

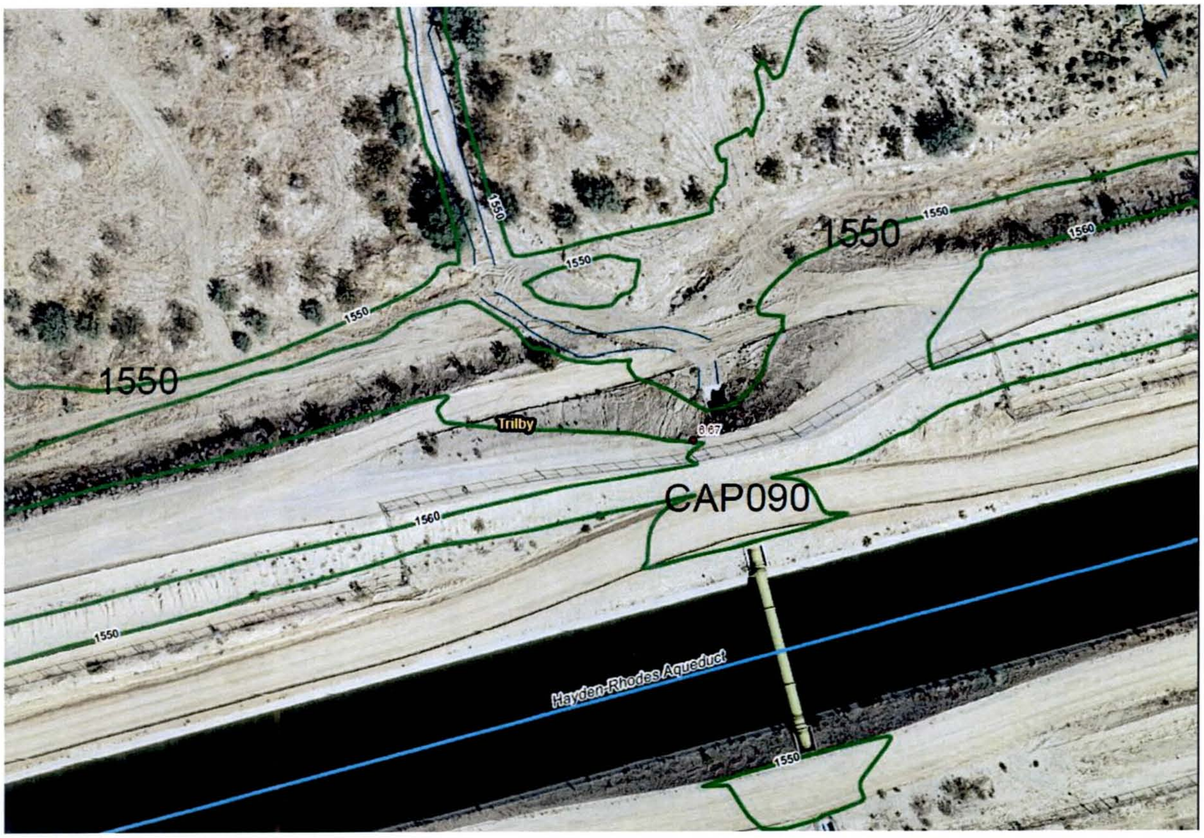


Figure 6 - CAP080 over-chute and a close-up at contour 1550 ft.

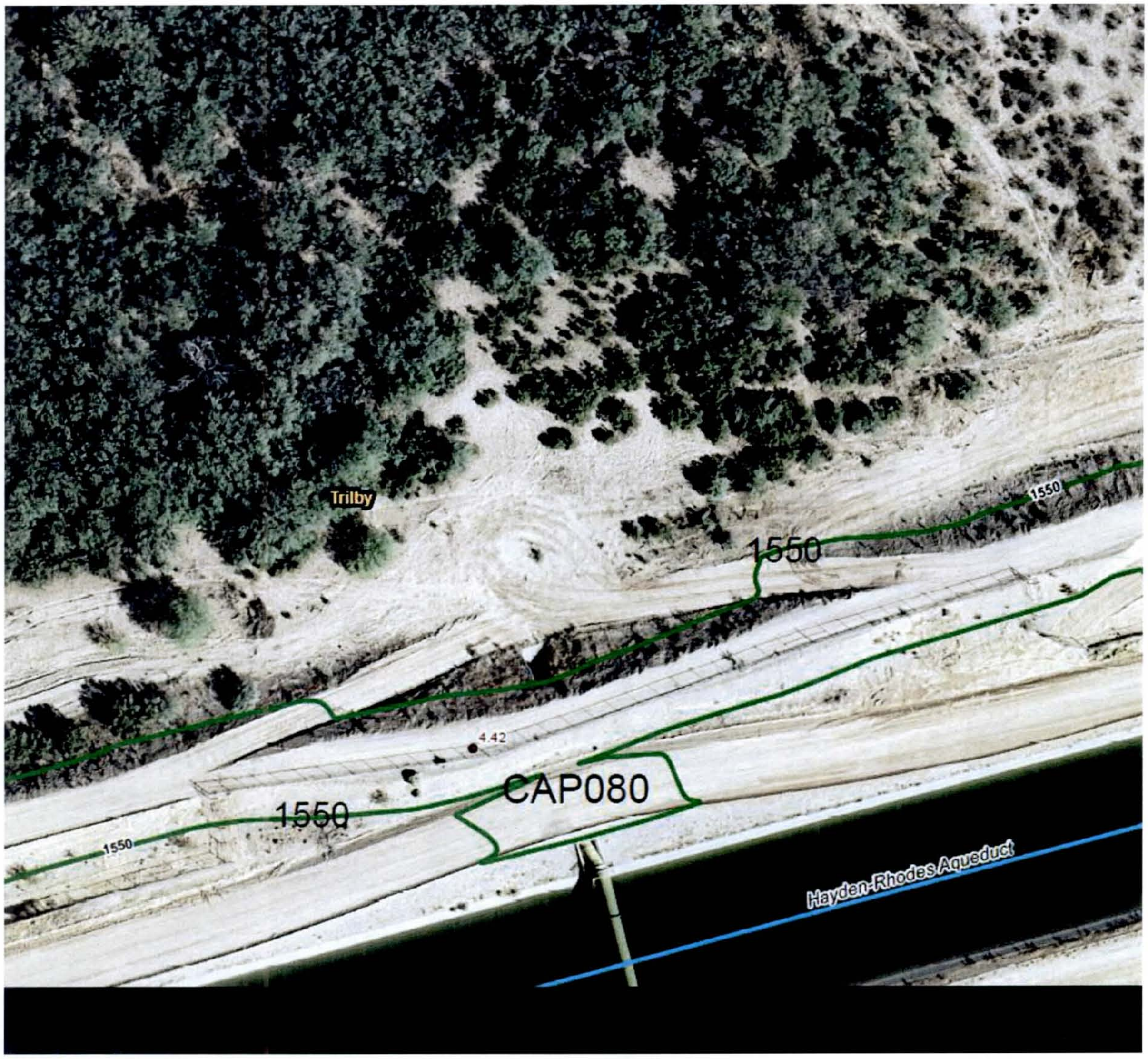


Figure 5 and Figure 6, above, show the over-chutes within the area of interest. These close-up photos clearly show that the ponding areas, vis-à-vis contour overlays, remain uninterrupted through the over-chute reaches, providing a level pool effect.

End of Memorandum
jwh/6-25-2012

Appendix C – Goodwin & Marshall Comments

GOODWIN & MARSHALL
CIVIL ENGINEERS – PLANNERS – SURVEYORS

TECHNICAL MEMORANDUM

Martin Acres Design Concept Report
10-yr Hydrologic Analysis Revisions

PURPOSE

The purpose of this memorandum is to provide an overview of the revisions made to the 10-yr hydrologic model provided to Goodwin & Marshall, Inc. (G&M) by the Maricopa County Flood Control District (FCD) on December 14, 2011. The FCD created a file in the Drainage Design Management System for Windows (DDMSW) for the sub-basins whose discharges contribute to the proposed detention basin located upstream of highway U.S. 60 in the City of Surprise. The DDMSW file was used to calculate new Time of Concentration (Tc) and Storage Coefficient (R) values for the 10-yr, 24-hr storm event. FCD created a 10-yr, 24-hr hydrology model utilizing the 100-yr, 24-hr model and substituting the Tc and R values for each respective sub-basin and also revising the precipitation depth to reflect a 10-yr, 24-hr storm. Upon review of the updated 10-yr hydrology model, G&M determined that there were a few modifications that could be made to the model in order to possibly better represent the 10-yr flows while maintaining consistency with the original Wittman Area Drainage Master Study Update (ADMSU) modeling methods.

REVISIONS TO THE MODEL

1. **10-yr, 24-hr Precipitation Depth**

   The DDMSW file provided by FCD utilized the GIS function to determine the rainfall depths for the project area. As seen in the information displayed below, the DDMSW file has determined a rainfall depth using the NOAA14 rainfall data. In the FCD model, a 10-yr, 24-hr precipitation depth of 2.805 inches was used.

NOAA 14 Rainfall ID: DEFAULT

Rainfall Map

W:\ENGAPPDEVRIVERMECHJONATHONCHILL\PROJECTS\MARTINACRES\JON\SUBBASINS.SHP

Required Map Fields

Rainfall Depth (in)

	2 yr	5 yr	10 yr	25 yr	50 yr	100 yr
5 Min	0.303	0.410	0.491	0.600	0.682	0.766
10 Min	0.461	0.624	0.747	0.913	1.038	1.166
15 Min	0.572	0.774	0.927	1.131	1.287	1.445
30 Min	0.770	1.042	1.248	1.523	1.733	1.946
1 Hour	0.953	1.290	1.544	1.886	2.144	2.409
2 Hour	1.104	1.474	1.758	2.142	2.436	2.743
3 Hour	1.159	1.523	1.813	2.214	2.532	2.869
6 Hour	1.355	1.735	2.038	2.459	2.788	3.131
12 Hour	1.583	2.005	2.340	2.794	3.143	3.505
24 Hour	1.864	2.389	2.805	3.382	3.837	4.313

Log | Info | Print... | Update | Rainfall ID | OK

DDMSW output of NOAA14 Rainfall Depths utilized by FCD.

The original 100-yr hydrologic model created for the ADMSU utilized a NOAA Atlas 2 rainfall depth. G&M used the original 100-yr, 6- and 24-hr rainfall depths of 3.4 inches and 4.18 inches, as well as the 2-yr, 6- and 24-hr rainfall depths of 1.18 inches and 1.40 inches, to allow DDMSW to generate NOAA 2 Rainfall Data as seen in the image below.

NOAA 2 Rainfall Data

List | Details

Duration	2-Year	5-Year	10-Year	25-Year	50-Year	100-Year	Rainfall	Rainfall ID
5 MIN	0.310	0.430	0.500	0.610	0.690	0.770	NOAA2	DEFAULT
10 MIN	0.470	0.650	0.770	0.930	1.060	1.190	NOAA2	DEFAULT
15 MIN	0.570	0.810	0.970	1.190	1.360	1.520	NOAA2	DEFAULT
30 MIN	0.760	1.090	1.300	1.600	1.840	2.070	NOAA2	DEFAULT
1 HOUR	0.930	1.340	1.620	2.000	2.290	2.580	NOAA2	DEFAULT
2 HOUR	1.010	1.480	1.790	2.210	2.540	2.860	NOAA2	DEFAULT
3 HOUR	1.070	1.570	1.900	2.350	2.700	3.050	NOAA2	DEFAULT
6 HOUR	1.180	1.740	2.110	2.620	3.010	3.400	NOAA2	DEFAULT
12 HOUR	1.290	1.920	2.340	2.910	3.350	3.790	NOAA2	DEFAULT
24 HOUR	1.400	2.110	2.570	3.210	3.690	4.180	NOAA2	DEFAULT

Rain ID | Info | Print... | Graph | Update | OK

DDMSW output of NOAA 2 Rainfall Data utilized by G&M.

Therefore, a rainfall depth of 2.57 inches was used in the updated 10-yr, 24-hr hydrology model presented herein. We feel that it certainly is acceptable to use the NOAA14 rainfall values; however, it is appropriate to utilize the original rainfall values to maintain consistency with the overall Wittman ADMSU.

2. Land Use

Upon inspection of the updated Tc and R values in the models received from FCD, G&M discovered that most of the updated 10-yr Tc and R values were lower than the original 100-yr model values. These results do not provide consistency with the ADMSU, as the 10-yr Tc and R values should always be higher than the 100-yr values based on Equation 5.5 of the FCD Hydrology Design Manual. It was determined that the difference in these values was caused by the watershed resistance coefficient (Kb) values being too low. The Kb value is determined based on the land use within each sub-basin. A majority of the sub-basins within the DDMSW file were composed mainly of the "General Open Space" land use. It was determined that the "Passive Open Space" originally used in the

ADMSU more accurately represented existing conditions for the area being modeled. G&M modified the default Passive Open Space land use in DDMSW to match the values used in the ADMSU. The following changes were made:

- Initial Loss (IA) was modified from 0.10 to 0.35
- Vegetation Cover was modified from 90 to 30
- Moisture Deficit (DTHETA) was modified from NORMAL to DRY

After these modifications to the land use defaults were completed, DDMSW was utilized to compute new Tc and R values for all sub-basins. These new values were then substituted into the 10-yr, 24-hr hydrology models provided by FCD. During this exercise, G&M realized that there were two sub-basins that had not been included in the DDMSW file prepared by the FCD. These sub-basins were WI542 and PI 642. G&M does not possess soil and land use data for the areas that these sub-basins are located in and hence could not recreate these sub-basins in DDMSW. Due to the fact that these sub-basins are upstream of the CAP and PI642 is less than 0.25 sq. mi. in size, the effects of leaving the 100-yr, 24-hr Tc and R values on these sub-basins for evaluation purposes is assumed to be negligible. However, G&M recommends that before completion of a final 10-yr, 24-hr hydrology model, these sub-basins should be input into the DDMSW and 10-yr Tc and R values be calculated.

3. Padelford Wash Floodplain Delineation Hydrograph

According to the ADMSU, a significant flow split occurs north of the CAP and was modeled in the *Padelford Wash Floodplain Delineation Study* (Padelford). This portion of the Padelford study was incorporated into the ADMSU models using a single hydrograph on QI cards. 10-yr hydrology models were not created as part of the Padelford study so it is not possible to recreate this hydrograph and incorporate it into the Martin Acres 10-yr hydrology models. In order to simulate a 10-yr event, a ratio was applied to this 100-yr Padelford hydrograph. This ratio was determined by the following steps:

- The G&M 10-yr, 24-hr hydrology model for Martin Acres was computed in HEC-1
- The combined 10-yr, 24-hr discharge at the CAP immediately upstream of where the Padelford discharge is introduced into the model was compared to the same location in the 100-yr model. The flows from the models can be seen in the images below. As seen in the images, the 100-yr, 24-hr discharge is 13,603 cfs and the 10-yr, 24-hr discharge is 6,490 cfs. This results in a ratio of 0.477.

+	HYDROGRAPH AT	PI642	162.	12.25	27.	7.	2.	.24
+	[illegible]	CAP1*	13603.	14.58	7261.	2120.	713.	46.67
+	HYDROGRAPH AT	PDWEST	4394.	13.25	1157.	353.	118.	7.08
+	2 COMBINED AT	CAP1*	14390.	14.50	8329.	2451.	824.	53.75

100-yr, 24-hr discharge upstream of PDWEST introduction.

	HYDROGRAPH AT							
+		PI642	61.	12.25	10.	3.	1.	.24
	2 COMBINED AT							
+		CAP1*	6490.	14.75	3475.	1044.	352.	46.67
	HYDROGRAPH AT							
+		PDWEST	4394.	13.25	1157.	353.	118.	7.08
	2 COMBINED AT							
+		CAP1*	8461.	13.42	4563.	1385.	467.	53.75

10-yr, 24-hr discharge upstream of PDWEST introduction.

- The Padelford 100-yr, 24-hr hydrograph was extracted from the model. The 0.477 ratio was applied to each ordinate of the hydrograph, which was then inserted into the 10-yr, 24-hr Martin Acres hydrology model in place of the 100-yr hydrograph.

The results of this exercise show that the discharge from the Padelford hydrograph decreases from 4,394 cfs during the 100-yr, 24-hr storm to 2,096 cfs during the 10-yr, 24-hr storm. After all revisions discussed in this memorandum were completed, a sensitivity analysis was performed to determine the effects of the Padelford hydrograph on the peak discharge at combination point CWI525. The hydrograph representing the Padelford area was removed from the model and the model was computed again. The resulting 10-yr, 24-yr peak discharge at CWI525 was 577 cfs, which is a reduction of 13 cfs from the 590 cfs in the updated model and is less than a 3% reduction. Therefore, it is assumed that because of the minimal effects of the Padelford hydrograph on peak discharges downstream, the methodology used to modify this hydrograph to represent a 10-yr, 24-hr event is sufficient.

4. Storage Routing Upstream of CAP

In the ADMSU, two storage routing functions are utilized to model the ponding upstream of the CAP and the discharge through the 14 culverts associated with this ponding area in the model. There is a berm that separates these 14 culverts into two storage areas, which are represented in the model by STOR1 and STOR2. STOR1 is the only storage routing that effects Martin Acres, and hence is the only one found in the revised existing conditions models prepared by G&M. After reviewing the model inputs for STOR1 and the ADMSU report, G&M agrees with the rating curves utilized for the culvert discharges. However, G&M determined that the storage values associated with STOR1 could be modified to be more accurate. The STOR1 storage routing in the original model was based on storage surface areas relative to elevations, which HEC-1 used to calculate volumes. The table below was taken from the ADMSU report and represents the input data in the model for STOR1.

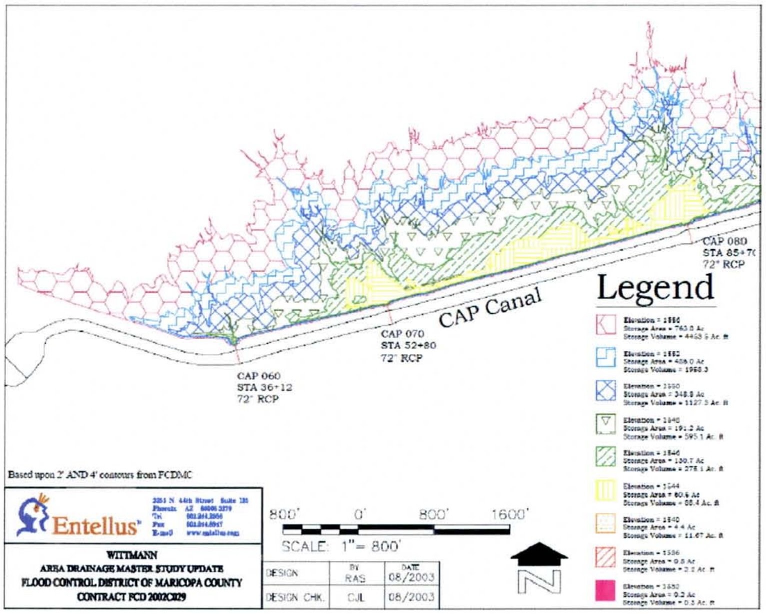
CAP Culvert Discharge vs Water Surface Elevation/ Storage Area
Location/ Description: Impoundment Area East of US60 CAP60-140

Water Surface Elevation [ft]	h [ft]	Storage Area [acre]	Storage Volume** [acre ft]	Discharge* [cfs]
1528	0	0.00	0.0	0
1532	4	0.00	0.0	0
1536	4	0.00	0.0	0
1540	4	0.00	0.0	0
1544	4	23.20	30.9	206
1546	2	63.00	113.8	638
1548	2	98.11	273.4	1430
1550	2	222.56	585.4	2223
1552	2	331.20	1135.0	2900
1554	2	442.50	1905.3	3395
1556	2	553.04	2897.8	3835
1557	1	553.04	2897.8	66348
1558	1	553.04	2897.8	180489

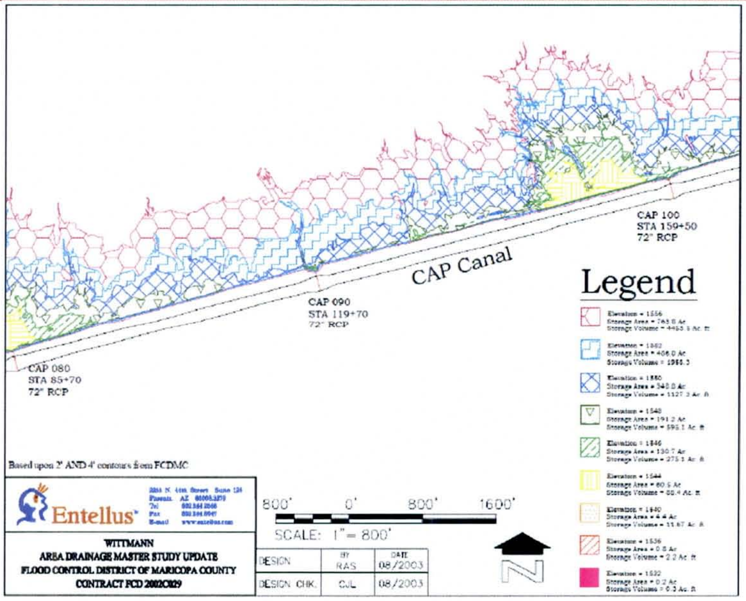
*Discharge calculated using nomograph and weir flow
**Storage volume calculated using conic method, $V_{12}=.333h*(A_1+A_2+(A_1*A_2)^{.5})$

Storage Area table from Appendix D.4 in the ADMSU Report

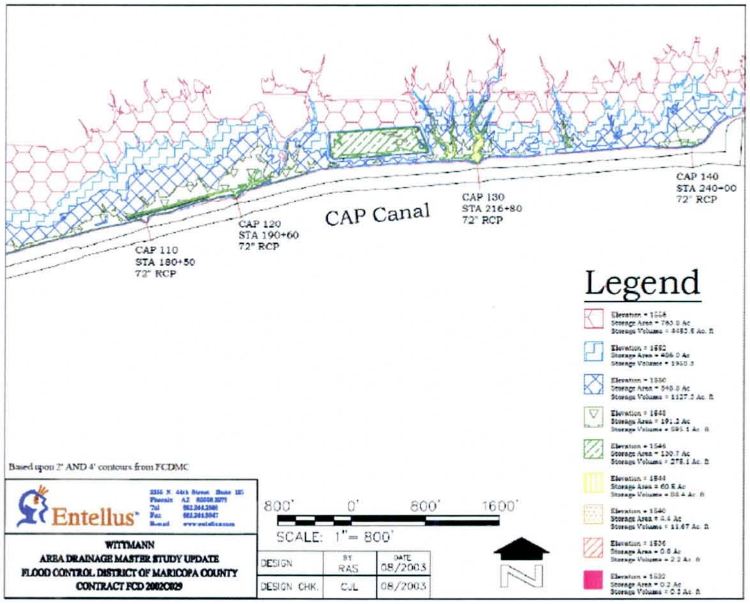
According to page 4b of 42 in Appendix D.1 of the ADMSU report, these areas were calculated based on existing contours upstream of the CAP and then adjusted as appropriate because the natural landscape has "many depressions and rises along the impoundment area." Appendix D.4 also contained the following exhibits showing the actual storage along the impoundment area upstream the CAP based on the contours provided by FCD.



Storage Volume exhibits from Appendix D.4 in the ADMSU Report



Storage Volume exhibits from Appendix D.4 in the ADMSU Report



Storage Volume exhibits from Appendix D.4 in the ADMSU Report

As seen in the images above, the actual calculated storage areas are larger than those that were input into the STOR1 storage routing in the original hydrology model. G&M has modified the STOR1 routing function as follows:

- The QA card associated with STOR1 was modified to a QV card. This changes the input data from a storage surface area (acres) to a storage volume (ac-ft).
- The storage volumes and elevations shown on the exhibits from Appendix D.4 of the ADMSU were input into the model. The images below show the original STOR1 function from the ADMSU and the modified STOR1 from the updated G&M model.

```
* *** STORAGE IN THE CAP IMPOUNDMENT AREA
KK STOR1
KO      0       0     0.0       0      22
RS      1    STOR       0
*
*
* This SQ card represents not only the flow through the culverts, but also the
* flow over the connecting berm between the two ponding areas STOR1 and STOR2.
* Only the values in the table following the DCAP* card were calculated, except
* for DCAP*.  Values were calculated using BOSS-RMS for all elevations of DCAP*.
* The rest of the structure capacities were interpolated assuming linear
* interpolation.
*
SQ      0     206     638    2223    2900    3271    3545    3961    4255    5071
SQ   5615    6148    6681    7725    8791    9885   79348  204489
SE   1541    1544    1546    1550    1552  1553.5    1554  1554.3  1554.5  1554.8
SE   1555 1555.15  1555.3  1555.5  1555.8    1556    1557    1558
*
SA      0   23.20   63.00   98.11  222.56  331.20   442.5  553.04   553.1   553.2
SE   1540    1544    1546    1548    1550    1552    1554    1556    1557    1558
*
```

STOR1 storage routing function from original ADMSU models

```
* *** STORAGE IN THE CAP IMPOUNDMENT AREA
KK STOR1
KO      1       0     0.0       0      22
RS      1    STOR       0
*
*
* This SQ card represents not only the flow through the culverts, but also the
* flow over the connecting berm between the two ponding areas STOR1 and STOR2.
* Only the values in the table following the DCAP* card were calculated, except
* for DCAP*.  Values were calculated using BOSS-RMS for all elevations of DCAP*.
* The rest of the structure capacities were interpolated assuming linear
* interpolation.
*
SQ      0     206     638    2223    2900    3271    3545    3961    4255    5071
SQ   5615    6148    6681    7725    8791    9885   79348  204489
SE   1541    1544    1546    1550    1552  1553.5    1554  1554.3  1554.5  1554.8
SE   1555 1555.15  1555.3  1555.5  1555.8    1556    1557    1558
*
SV      0    88.4   275.1   595.1  1127.3  1958.3  4453.5  4453.5  4453.5
SE   1540    1544    1546    1548    1550    1552    1556    1557    1558
*
```

STOR1 storage routing function from updated G&M model

- A storage volume for the 1554 elevation was not available from the exhibits in the ADMSU report, so that elevation was removed, allowing HEC-1 to interpolate between the provided values.

The table below shows a comparison of the surface areas and storage volumes calculated in the ADMSU model versus those utilized in the G&M updated 10-yr, 24-hr model for the impoundment area upstream of the CAP.

Elevation	ADMSU Storage Volume As Calculated by HEC-1		G&M Updated Storage Volume As Calculated Using Contours (ADMSU Appendix D.4)	
	Surface Area (ac)	Storage Volume (ac-ft)	Surface Area (ac)	Storage Volume (ac-ft)
1528	0	0	0	0
1532	0	0	0.2	0.3
1536	0	0	0.8	2.2
1540	0	0	4.4	11.67
1544	23.20	30.9	60.5	88.4
1546	63.00	113.8	130.7	275.1
1548	98.11	273.4	191.2	595.1
1550	222.56	585.4	348.8	1127.3
1552	331.20	1135.0	486.0	1958.5
1554	442.50	1905.3	-	-
1556	553.04	2897.8	763.8	4453.5
1557	553.04	2897.8	763.8	4453.5
1558	553.04	2897.8	763.8	4453.5

Comparison of ADMSU and G&M Update storage volumes upstream of CAP

As previously stated, a storage volume for elevation 1554 was not available based on the contour calculations so it was omitted from the model. Also, as elevation 1556 is the top of the CAP, the storage volumes for elevations 1557 and 1558 did not increase.

RESULTS

The results of the updated 10-yr, 24-hr hydrology model for Martin Acres show a discharge of 590 cfs at combination point CWI525 upstream of US 60. This discharge is 187 cfs lower than the 777 cfs discharge calculated at this point in the FCD 10-yr, 24-hr model.

Appendix D – FCDMC Review Comments

Flood Control District
of Maricopa County

INTEROFFICE MEMORANDUM

Date: January 26, 2012

To: Anthony Beuché, PE, Project Manager, Project Management Branch, PPM Division

From: Jonathon Chill, E.I.T., CFM Hydrologist Intern, Engineering Application Development and River Mechanics Branch, Engineering Division, Flood Control District of Maricopa County

CC: Bing Zhao, PhD, PE, Engineering Application Development and River Mechanics Branch Manager, Engineering Division

John Holmes, CFM, Hydrologist, Hydrology and Hydraulics Branch, Engineering Division

Subject: Martin Acres Design Concept Report 10-yr Hydrology Analysis Review Comments

Background

The Martin Acres Design Concept Report (DCR) prepared by Goodwin & Marshall (G&M) developed a 100 year detention basin solution. The DCR included 100-year 6-hour and 24-hour HEC-1 models. Because of the high cost of the 100 year solution it was recommended to also develop a 10 year solution. G&M had not developed the hydrology for the contributing area using DDMSW but rather had based their model on the findings of the Wittmann ADMSU by Entellus. To develop the 10 year hydrology then would require the Time of Concentration (Tc) and Storage Coefficient (R) for each contributing sub-basins to be updated to the 10 year values. The Flood Control District of Maricopa County (FCDMC) developed the 10 year hydrology models in house using DDMSW to calculate the Tc and R values and then used a Perl script to replace the values of Tc and R in the 100 year G&M HEC-1 models. FCDMC also updated the rainfall and inflows into the model to 10 year values.

1. **Precipitation**

(G&M 01/24/2012) NOAA14 was used by FCDMC to obtain precipitation data for the Martin Acres Models. G&M recommend using NOAA2 for consistency because that is what was used in the Wittmann ASMSU. Also G&M obtained lower precipitation values using NOAA2.

(FCDMCD 01/25/2012) The values used to calculate the NOAA2 precipitation input into DDMSW appear to be off, that is the values for the 100yr-6hr and 24hr events and the 2yr-6hr and 24hr events. The values for 100yr-24hr and 100yr-6hr used were 4.18 and 3.4 respectively. These were the values used for the entire Wittmann ADMSU study area and should be revised for the contributing area for Martin Acres. It was estimated that these values might be closer to 4.3 for the 100yr-24hr event and 3.33 for the 100yr-6hr event. The values of 1.18 and 1.40 were used for the 2yr-6hr and 24hr events respectively. These are the DDMSW default values and should be revised to the NOAA2 data for the contributing area to Martin Acres. The estimated values for these should be closer to 1.45 and 1.7 for the 2yr-6hr and 24hr events respectively. Using this data the following precipitation data is obtained.

NOAA 2 Rainfall Data

List | Details

Duration	2-Year	5-Year	10-Year	25-Year	50-Year	100-Year	Rainfall	Rainfall ID
5 MIN	0.390	0.470	0.520	0.600	0.670	0.730	NOAA2	DEFAULT
10 MIN	0.590	0.710	0.800	0.920	1.020	1.120	NOAA2	DEFAULT
15 MIN	0.720	0.880	1.000	1.170	1.310	1.440	NOAA2	DEFAULT
30 MIN	0.950	1.180	1.350	1.580	1.770	1.950	NOAA2	DEFAULT
1 HOUR	1.150	1.460	1.670	1.970	2.210	2.440	NOAA2	DEFAULT
2 HOUR	1.250	1.610	1.860	2.200	2.470	2.740	NOAA2	DEFAULT
3 HOUR	1.320	1.710	1.980	2.360	2.650	2.950	NOAA2	DEFAULT
6 HOUR	1.450	1.900	2.220	2.650	2.990	3.330	NOAA2	DEFAULT
12 HOUR	1.580	2.120	2.500	3.010	3.420	3.820	NOAA2	DEFAULT
24 HOUR	1.700	2.340	2.780	3.370	3.840	4.300	NOAA2	DEFAULT

Rain ID | Info | Print... | Graph | Update | OK

As can be seen the values obtained are very close to those obtained using NOAA14 in DDMSW. The rainfall depths for the 10yr-24hr event estimated from NOAA2 is 2.78 and NOAA14 gave 2.805, for the 10yr-6hr event NOAA2 gave 2.22 and NOAA14 gave 2.038. It should be noted that the NOAA14 data obtained from DDMSW using GIS Shape Files to calculate the rainfall is more accurate than estimating the parameters used to calculate the NOAA2 rainfall. Since this project is separate from the Wittmann study consistency with the Wittmann study is not our primary concern, accuracy is. Also as it has been shown, there is very little difference in the rainfall depths. The section on Precipitation in the report sent to G&M on 01/23/2012 addresses the modeling techniques used by FCDMC.

2. **Land Use**

(G&M 01/24/2012) The Tc and R values for the 10 year events are less than the 100 year events, the 10 year values should always be higher than the 100 year values. This does not provide consistency with the Wittmann ADMSU. It was found that the watershed resistance coefficient (Kb) in the model developed by FCDMC on 01/10/2012 were too low. Also the Initial Loss (IA), Vegetation Cover, and Moisture Deficit (DTHETA) were not consistent with the values used in neither G&M's original model nor the Wittmann ADMSU.

(FCDMC 01/25/2012) In the updated report sent to G&M on 01/23/2012 these values were corrected. The old values were replaced with calculated Kb values based on the Wittmann ADMSU by Entellus and the original HEC-1 models by G&M. Documentation on how these values were obtained and input into DDMSW is in the Physical Parameters section of the report sent on 01/23/2012. It should be noted that the Green-Ampt parameters were updated in the original report, to see the correct values used in DDMSW look in the subbasin data, the landuse and soil data may not reflect the values actually being used by the model.

3. **Basins not updated in Model**

(G&M 01/24/2012) The sub-basins WI542 and PI642 were not updated to the 10 year values of Tc and R in the FCDMC model. Their overall effect on discharge at the detention basin location will be minimal since they are small and contribute to the ponding at the CAP. It is recommended to update the values for these basins for consistency.

(FCDMC 01/25/2012) This comment has not yet been addressed. We will look into updating the model to model these basins correctly for the 10 year event.

4. **Padelford Wash Inflow**

(G&M 01/24/2012) Since there was no hydrology model for Padelford Wash the inflow from Padelford Wash was added as QI cards in the model. Use a reduction ratio based on the reduction in flow right before the flow from Padelford Wash is added to the CAP. This gave a ratio of 0.477, the reduction gives a peak discharge of 2,096 cfs instead of the 100yr-24hr value of 4,394 cfs.

(FCDMC 01/25/2012) The section on Precipitation in the report sent to G&M on 01/23/2012 addresses the modeling techniques used by FCDMC. The Padelford Wash study was obtained along with the DDMSW model for the study. This model was updated for the 10 year events. It should be noted that the rainfall used in this DDMSW for Padelford Wash is NOAA2 since it was done in DDMSW1.5 before NOAA14. The peak inflow from Padelford Wash into the CAP was found to be 3,050 cfs for the 10yr-24hr event.

5. **CAP Storage**

(G&M 01/24/2012) G&M agrees with the rating curves for the culverts but determined that the storage values in the model for STOR1 (the only one that contributes to the Martin Acres detention basin location) could be more accurate. Using data from the Wittmann ADMSU they developed a more accurate storage-elevation relationship, using storage volume instead of storage surface area. This increases the storage volume at the CAP. This helped G&M reduce the peak flow at the detention basin location.

(FCDMC 01/25/2012) The data used to obtain this increase in storage at the CAP comes from the Wittmann ADMSU study done by Entellus. It appears to be correct but the reason for the large difference in storage volumes obtained by changing from storage area to storage volume needs to be looked into. The values used by G&M were input into FCDMC's current model on 01/25/2012 and the peak was reduced to 715 cfs instead of the original 745 cfs before the storage was increased. It should be noted that the main effect that the change in storage has is to reduce the second peak, which is the outflow from the CAP. A comparison of these hydrographs is shown below.