6.0 Benefits of Plan Implementation

There are numerous watershed restoration strategies that may have a significant impact on the overall health and quality of the Sugarland Run and Horsepen Creek watersheds. In order to quantify the costs and benefits of implementing the watershed restoration strategies discussed in previous sections, additional analyses were required. This section discusses and summarizes the results of the pollutant load, hydrologic and hydraulic modeling used in the development of the watershed management plans to quantify any reductions in pollutant loading, total stormwater runoff volumes, peak rate of runoff and the extent of flooding. A summary of cost estimates and an analysis of the costs and benefits of the project plan are also discussed.

6.1 Stormwater Models

As discussed in Section 2, modeling is a way to mathematically predict and spatially represent what will occur during a given rainfall event. Hydrologic and hydraulic models are the two types of models that are used to achieve this. *Hydrologic models* take into account the particular rainfall event of interest, the physical nature of the land area where the rainfall occurs, and how quickly the resulting stormwater runoff drains a given land area. Hydrologic models can describe both the quantity of stormwater runoff and resulting pollution, such as nutrients (nitrogen and phosphorus) and sediment that are transported by the runoff. *Hydraulic models* are used to evaluate the effect the stormwater runoff from a particular rainfall event has on both man-made and natural systems. These models can predict both the ability man-made culverts/channels have in conveying stormwater runoff and the spatial extent of potential flooding.

Hydrologic and hydraulic models were created for three distinct scenarios as listed below:

- Existing conditions
- Future conditions without projects
- Future conditions with projects

For *Existing Conditions*, the models simulated the condition of the watersheds at the time the models were created by incorporating information on land use, soils, existing stormwater management and best management practice facilities, previous stream and watershed assessments, and actual field reconnaissance and site visits. The *Future Conditions without Projects* scenario simulated future conditions based on countywide future land use and development, derived from the county's comprehensive plan and build-out predictions. As the name implies, the *Future Conditions without Projects* models do not contain any of the watershed restoration strategies or projects identified in this plan. The *Future Conditions with Projects* scenario simulates the implementation of the projects discussed in the previous sections. The *Future Conditions with Projects* scenario uses the *Future Conditions without Projects* models as a base on which proposed restoration strategies are added and evaluated. Comparison of modeling results from these three scenarios yielded pollutant loading and stormwater runoff reductions discussed below. Detailed information on the setup and calibration of the STEPL pollution models, SWMM hydrologic models and HEC-RAS hydraulic models can be found in Technical Memo 3.6 in Appendix B.

6.2 Analysis of Stormwater Modeling Results

Results of the modeling efforts were compiled and analyzed to determine pollutant load and flow reductions. The reduction in values shown and discussed below indicates the overall benefits of implementing the restoration strategies described within the plan.

6.2.1 Sugarland Run

Tables 6.1 and 6.2 below summarize the results of the pollutant and hydrologic models in terms of pollutant loading and stormwater flow reductions for the Sugarland Run Watershed. All values were normalized to the drainage area to allow for direct and accurate comparisons. Runoff volume and peak flow values were obtained from SWMM hydrologic models and were calculated cumulatively. In other words, flows were summed from upstream to downstream and were divided by the total contributing drainage area. Total suspended solids (TSS), total nitrogen (TN) and total phosphorus (TP) values were obtained from the results of the STEPL pollutant models. These values were calculated based on the individual land area contributions and may not increase from upstream to downstream.

Table 6.1
Sugarland Run Pollutant Loading and Flow Reductions by WMA

WMA	Area (ac)	Scenario[3]	Runoff Volume (in/yr)[1]		Peak Flow (cfs/ac)[1]		TSS (lb/ac/yr)[2]	TN (lb/ac/yr)[2]	TP (lb/ac/yr)[2]
			2 Year	10 Year	2 Year	10 Year			
Folly Lick WMA	1,813.70	Existing Condition	2,086.37	4,742.46	0.24	0.55	1.11	53.59	8.15
		Future Without Projects	3,707.16	7,567.42	0.43	0.87	1.13	54.66	8.28
		Future With Projects	3,674.52	7,510.86	0.42	0.86	1.09	52.92	8.03
		Reduction (10-year Plan)	-1%	-1%	-1%	-1%	-4%	-3%	-3%
Headwaters WMA	1,390.97	Existing Condition	3,772.97	7,239.01	0.43	0.83	0.71	37.32	5.11
		Future Without Projects	3,756.78	7,209.14	0.43	0.83	0.71	37.39	5.12
		Future With Projects	3,550.03	6,825.42	0.41	0.79	0.69	36.32	4.97
		Reduction (10-year Plan)	-6%	-5%	-5%	-5%	-3%	-3%	-3%
Lower Sugarland WMA	3,742.65	Existing Condition	543.58	1,297.11	0.06	0.15	0.91	43.65	6.42
		Future Without Projects	581.80	1,402.64	0.07	0.16	0.91	44.24	6.5
		Future With Projects	555.87	1,367.30	0.06	0.16	0.88	43.04	6.3
		Reduction (10-year Plan)	-4%	-3%	-4%	-2%	-3%	-3%	-3%

Table 6.1
Sugarland Run Pollutant Loading and Flow Reductions by WMA

WMA	Area (ac)	Scenario[3]	Runoff Volume (in/yr)[1]		Peak Flow (cfs/ac)[1]		TSS (lb/ac/yr)[2]	TN (lb/ac/yr)[2]	TP (lb/ac/yr)[2]
			2 Year	10 Year	2 Year	10 Year			
Lower Middle Sugarland WMA	3,503.14	Existing Condition	296.59	627.33	0.03	0.07	2.44	112.33	16.89
		Future Without Projects	356.95	800.81	0.04	0.09	2.46	113.95	17.09
		Future With Projects	351.46	792.84	0.04	0.09	2.43	113.09	16.94
		Reduction (10-year Plan)	-2%	-1%	-2%	-1%	-1%	-1%	-1%
Potomac WMA[4]	1,053.05	Existing Condition	1,649.94	3,824.07	0.19	0.44	0.18	6.51	1.02
		Future Without Projects	1,649.94	3,824.07	0.19	0.44	0.18	6.51	1.02
		Future With Projects	1,649.94	3,824.17	0.19	0.44	0.18	6.51	1.02
		Reduction (10-year Plan)	0%	0%	0%	0%	0%	0%	0%
Upper Sugarland WMA	928.44	Existing Condition	3,398.88	6,772.61	0.39	0.78	1.33	62.17	8.54
		Future Without Projects	3,584.49	7,039.15	0.41	0.81	1.38	64.9	8.82
		Future With Projects	3,363.16	6,688.95	0.39	0.77	1.28	62.74	8.45
		Reduction (10-year Plan)	-6%	-5%	-6%	-5%	-7%	-3%	-4%
Upper Middle Sugarland WMA	1,975.12	Existing Condition	2,121.30	4,394.20	0.24	0.51	1.41	72.68	10.52
		Future Without Projects	2,413.53	5,142.53	0.28	0.59	1.41	73.13	10.56
		Future With Projects	2,285.29	4,854.73	0.26	0.56	1.27	69.53	9.94
		Reduction (10-year Plan)	-5%	-6%	-5%	-6%	-10%	-5%	-6%

[1] Flow is cumulative.
[2] Loads are representative of individual land area contributions.
[3] 25-year projects were not evalutaed in the hydrologic model.
[4] No projects were proposed in this WMA.

Table 6.2 Sugarland Run Overall Pollutant Loading and Flow Reductions									
Watershed	**Area (ac)**	**Scenario[3]**	**Runoff Volume (in/yr)[1]**		**Peak Flow (cfs/ac)[1]**		**TSS (lb/ac/yr)[2]**	**TN (lb/ac/yr)[2]**	**TP (lb/ac/yr)[2]**
			2 Year	**10 Year**	**2 Year**	**10 Year**			
Sugarland Run	14,407.07	Existing Condition	613.11	1,447.72	0.07	0.17	8.07	388.25	56.65
		Future Without Projects	649.40	1,550.05	0.07	0.18	8.19	394.78	57.39
		Future With Projects	624.97	1,516.01	0.07	0.17	7.82	384.15	55.65
		Reduction (10-year Plan)	-4%	-2%	-4%	-2%	-5%	-3%	-3%

[1] Flow is cumulative.
[2] Loads are representative of individual land area contributions.
[3] 25-year projects were not evaluated in the hydrologic model.

Based on modeling results, implementation of the restoration strategies and projects described in the 10-year plan will result in reductions in stormwater runoff flows and pollutant loads. The values shown in these tables have all been normalized to the drainage area and the reductions shown here indicate reductions per unit area. The model results show the greatest reductions in WMAs further upstream such as the Headwaters and Upper Sugarland WMAs where stormwater management generally has the greatest effect and where projects have been prioritized. WMAs where no projects or restoration strategies are proposed such as Potomac WMA, which is located completely within Loudoun County, are shown in Table 6.1 above without any reductions or increases in pollutant loadings or stormwater flow.

6.2.2 Horsepen Creek

Tables 6.3 and 6.4 below summarize the results of the pollutant and hydrologic models in terms of pollutant loading and stormwater flow reductions for the Horsepen Creek Watershed. All values were normalized to the drainage area to allow for direct and accurate comparisons. Runoff volume and peak flow values were obtained from SWMM hydrologic models and were calculated cumulatively. In other words, flows were summed from upstream to downstream and were divided by the total contributing drainage area. Total suspended solids (TSS), total nitrogen (TN) and total phosphorus (TP) values were obtained from the results of the STEPL pollutant models. These values were calculated based on the individual land area contributions and may not increase from upstream to downstream.

Table 6.3
Horsepen Creek Pollutant Loading and Flow Reductions by WMA

WMA	Area (ac)	Scenario[3]	Runoff Volume (in/yr)[1]		Peak Flow (cfs/ac)[1]		TSS (lb/ac/yr)[2]	TN (lb/ac/yr)[2]	TP (lb/ac/yr)[2]
			2 Year	10 Year	2 Year	10 Year			
Cedar Run WMA	782.41	Existing Condition	2,470.81	5,342.51	0.28	0.61	0.67	31.03	4.69
		Future Without Projects	2,497.59	5,393.07	0.29	0.62	0.67	31.18	4.70
		Future With Projects	2,306.92	5,062.73	0.27	0.58	0.59	29.93	4.41
		Reduction (10-year Plan)	-8%	-6%	-8%	-6%	-12%	-4%	-6%
Frying Pan WMA	1,130.42	Existing Condition	1,893.41	4,060.69	0.22	0.47	0.64	39.67	5.55
		Future Without Projects	2,523.19	5,297.10	0.29	0.61	0.66	40.93	5.71
		Future With Projects	2,165.20	4,592.11	0.25	0.53	0.62	39.74	5.50
		Reduction (10-year Plan)	-14%	-13%	-14%	-13%	-6%	-3%	-4%
Indian Creek WMA[4]	2,065.86	Existing Condition	1,883.67	4,184.63	0.22	0.48	0.76	36.63	5.25
		Future Without Projects	1,883.51	4,184.26	0.22	0.48	0.76	36.63	5.25
		Future With Projects	1,883.51	4,184.26	0.22	0.48	0.76	36.63	5.25
		Reduction (10-year Plan)	0%	0%	0%	0%	0%	0%	0%
Lower Horsepen WMA[4]	3,190.21	Existing Condition	1,176.07	2,625.44	0.14	0.30	1.70	59.76	7.45
		Future Without Projects	1,342.96	2,972.98	0.15	0.34	1.70	59.76	7.45
		Future With Projects	1,327.69	2,924.03	0.15	0.34	1.70	59.76	7.45
		Reduction (10-year Plan)	-1%	-2%	-1%	-2%	0%	0%	0%
Lower Middle Horsepen WMA	1,186.39	Existing Condition	1,174.06	2,715.91	0.14	0.31	1.53	69.33	10.53
		Future Without Projects	1,533.81	3,301.16	0.18	0.38	1.56	70.75	10.72
		Future With Projects	1,506.56	3,161.75	0.17	0.37	1.48	67.98	10.30
		Reduction (10-year Plan)	-2%	-4%	-2%	-4%	-5%	-4%	-4%
Merrybrook WMA	966.61	Existing Condition	3,518.40	6,938.40	0.40	0.80	0.24	19.29	2.88
		Future Without Projects	4,655.22	8,571.15	0.54	0.99	0.26	21.68	3.15
		Future With Projects	4,542.89	8,404.40	0.52	0.97	0.26	21.68	3.12
		Reduction (10-year Plan)	-2%	-2%	-2%	-2%	0%	0%	-1%

Table 6.3 Horsepen Creek Pollutant Loading and Flow Reductions by WMA									
WMA	**Area (ac)**	**Scenario[3]**	**Runoff Volume (in/yr)[1]**		**Peak Flow (cfs/ac)[1]**		**TSS (lb/ac/yr)[2]**	**TN (lb/ac/yr)[2]**	**TP (lb/ac/yr)[2]**
			2 Year	**10 Year**	**2 Year**	**10 Year**			
Middle Horsepen WMA	952.58	Existing Condition	1,040.98	2,784.46	0.12	0.32	0.98	41.30	5.03
		Future Without Projects	1,155.55	2,905.34	0.13	0.33	1.21	52.31	6.10
		Future With Projects	1,099.37	2,880.35	0.13	0.33	1.21	51.56	6.06
		Reduction (10-year Plan)	-5%	-1%	-5%	-1%	0%	-1%	-1%
Stallion WMA[4]	2,393.50	Existing Condition	1,150.72	2,571.28	0.13	0.30	0.74	24.92	3.13
		Future Without Projects	1,150.72	2,571.28	0.13	0.30	0.74	24.92	3.13
		Future With Projects	1,150.72	2,571.28	0.13	0.30	0.74	24.91	3.13
		Reduction (10-year Plan)	0%	0%	0%	0%	0%	0%	0%
Upper Horsepen WMA	1,929.06	Existing Condition	1,089.50	3,050.78	0.13	0.35	0.86	56.04	8.06
		Future Without Projects	1,110.70	3,092.65	0.13	0.36	0.88	56.95	8.16
		Future With Projects	1,050.29	3,048.50	0.12	0.35	0.80	54.58	7.73
		Reduction (10-year Plan)	-5%	-1%	-5%	-1%	-9%	-4%	-5%

[1] Flow is cumulative.
[2] Loads are representative of individual land area contributions.
[3] 25-year projects were not evaluated in the hydrologic model.
[4] No projects were proposed in this WMA.

Table 6.4 Horsepen Creek Overall Pollutant Loading and Flow Reductions									
Watershed	**Area (ac)**	**Scenario[3]**	**Runoff Volume (in/yr)[1]**		**Peak Flow (cfs/ac)[1]**		**TSS (lb/ac/yr)[2]**	**TN (lb/ac/yr)[2]**	**TP (lb/ac/yr)[2]**
			2 Year	**10 Year**	**2 Year**	**10 Year**			
Horsepen Creek	14,597.04	Existing Condition	1,176.07	2,625.44	0.14	0.30	8.12	377.98	52.57
		Future Without Projects	1,342.96	2,972.98	0.15	0.34	8.45	395.11	54.37
		Future With Projects	1,327.69	2,924.03	0.15	0.34	8.14	386.66	52.95
		Reduction (10-year Plan)	-1%	-2%	-1%	-2%	-4%	-2%	-3%

[1] Flow is cumulative.
[2] Loads are representative of individual land area contributions.
[3] 25-year projects were not evaluated in the hydrologic model.

Based on modeling results, implementation of the restoration strategies and projects described in the 10-year plan will result in reductions in stormwater runoff flows and pollutant loads. The values shown in these tables have all been normalized to the drainage area and the reductions shown here indicate reductions per unit area.

The model results show the greatest reductions in WMAs further upstream such as the Cedar Run, Frying Pan and Upper Horsepen WMAs where stormwater management generally has the greatest effect and where projects have been prioritized. WMAs where no projects or restoration strategies are implemented such as the Indian Creek and Stallion WMAs, which are both located completely within Loudoun County, are shown in Table 6.3 above without any reductions or increases in pollutant loadings or stormwater flow. Lower Horsepen WMA is also located completely within Loudoun County and no projects are proposed within its boundaries. STEPL results for pollutant loadings show no reductions or increases; however the flow values do indicate a reduction. Stormwater flow values were calculated cumulatively as described previously. Since Lower Horsepen WMA is the downstream most WMA in the Horsepen Run watershed and located on the main stem of Horsepen Run, the flow values shown in Table 6.3 for this WMA reflect flow reductions for the entire Horsepen Run watershed.

6.3 Project Costs and Benefits Analysis

An integral element to evaluating the benefits of restoration strategies and projects is associated costs. Cost estimates were calculated for all structural projects detailed in previous sections. Detailed cost estimates, as shown on the project fact sheets, were determined for structural projects in the 0-10 year implementation phase. The total costs of implementing projects in this phase were calculated to be approximately $18 million and $13 million for the Sugarland Run and Horsepen Creek watersheds, respectively. Associated costs for structural projects in the 11-25 year phase were roughly approximated based on the overall costs associated with similar projects in the 10 year implementation plan. Cost estimates were not calculated for non-structural projects, because non-structural projects do not require traditional construction measures to be implemented and may be programmatic in nature.

In addition to the calculation of cost estimates for projects listed in the implementation plan, a cost benefit analysis was also performed. The project cost distribution for all projects listed in the 10-year implementation plan was evaluated. The evaluation of the project cost distribution allowed for a determination of outliers within the lists of projects. These outliers could be projects that were significantly more or less expensive than other projects in the lists. These projects were further scrutinized and evaluated to determine if they should remain in the 10-year list. Outliers determined to be kept in the list were evaluated separately from the other projects in the 10-year list. A cost to benefit ratio was calculated based on the subwatershed ranking composite score and the projects' associated costs. Using the cost to benefit ratio, all structural projects in the 10-year implementation plan were reordered based on this analysis.

6.4 Overall Costs and Benefits of Plan Implementation

The stormwater modeling and costs and benefits analysis described in this section demonstrates the value of the projects and restoration strategies discussed within the plan. The overall cost of implementing all the projects on the 10-year list is $31 million. Implementation of all projects

and restoration strategies in the 10-year priority list will result in significant overall reductions in stormwater flows and pollutant loads. Stormwater runoff volume from the 2-year and 10-year storm events would decrease by 2% or 40 inches per year and 83 inches per year, respectively. The peak flow rate would also decrease by 2%, resulting in a reduction of 0.005 CFS per acre for the 2-year storm event and 0.010 CFS per acre for the 10-year storm event. Total suspended solids would be reduced by 4% overall or 68 pounds per acre per year. Total nitrogen would be reduced by 2% or 19 pounds per acre per year, and total phosphorus would be reduced by 3% or 3 pounds per acre per year.