Summary of Key Elements & Recommendations

Morgan Creek LWP
Targeting of Management Report

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Table 1. Key Characteristics of Potential Stream Restoration Sites in the Morgan Creek LWP Study Area

Site	Stream Name/Location	Estimated Stream Length	Potential Restoration Length	Observed Constraints	Recommended Restoration Priority	Estimated Restoration Cost/Linear Foot[1]	BMP Potential	Recommended for Restoration
1	UT* to Morgan Creek - Located on Maple View Farms and south of Dairyland Road	2,000	2,500	Mature bottomland forest.	Priority I and II	$160	Wetland creation at head of restored stream.	Yes
1a	Morgan Creek - Located on Maple View Farms and south of Dairyland Road	5,000	6,000	Mature bottomland forest, small existing flood plain.	Priority I and II	$180	Vernal Pools	Yes
2	Morgan Creek - Located on Lemola (Cheek Brothers) Dairy Farm and east of Dairyland Road	3,500	4,200	Upstream portion of segment is currently in use for cattle grazing; downstream portion occupied by mature bottomland hardwood forest.	Priority I and II	$130	Yes, Ag BMPs - cattle fencing and crossings to prevent access and upland watering structures.	Yes
3	Booker Creek - Located below Eastwood Lake and northwest and west of 15/501	4,000	4,500	Sanitary sewer, greenway trails and bridges, multiple property owners, mature bottomland hardwood forest, stormwater outfalls, other unknown infrastructure. Also will more than likely require Flood Study and LOMR.	Priority I, II and III	$300-350	Yes, flood plain detention ponds and retrofit existing BMP located behind strip mall off of East Franklin Street and west of 15/501.	Need additional information.
4	UT* to Bolin Creek - East to Airport Road, south to Bolin Creek, west of Hillsborough Street	500	600	Sewer line, downstream end has very steep side slope and mature hardwood forest.	Priority I and II	$160	Yes, area dominated by kudzu could be used to treat stormwater from surrounding apartment complexes.	Yes

Site	Stream Name/Location	Estimated Stream Length	Potential Restoration Length	Observed Constraints	Recommended Restoration Priority	Estimated Restoration Cost/Linear Foot[1]	BMP Potential	Recommended for Restoration
							complexes.	
5	UT* to Bolin Creek - East of Hillsborough Road, south of Bolin Creek, near East Franklin Street	1,000	1,200	Apartment complex infrastructure, greenway, sewer line, mature bottomland and wetland areas located to east of concrete lined ditch.	Priority I	$125	Yes	Need additional information.
6	Little Creek - Located east of Pinehurst Drive	800	900 - 1000	Existing golf course and support infrastructure, may require flood study and LOMR.	Priority I	$180	Yes, retrofit existing irrigation ponds located to south of stream.	Yes
7	Bolin Creek - Located within Hogan Farms Subdivision 1,000 feet below Hogan Lake	3,300	4,000	Bottomland hardwood forest, gas line, sanitary sewer line, stormwater outfalls, may require flood study and LOMR. Control by neighborhood association and subdivision development continues.	Priority II possibly I	$160	Yes, treat stormwater discharges from subdivision.	Yes

Site	Stream Name/Location	Estimated Stream Length	Potential Restoration Length	Observed Constraints	Recommended Restoration Priority	Estimated Restoration Cost/Linear Foot[1]	BMP Potential	Recommended for Restoration
8	UT* to Morgan Creek - Located south of East Main Street and east of Greensboro Street and is partially piped	800	1,000	Channel is partially piped through site; overburden located above and adjacent to pipe.	Priority II	$160	Yes, retrofit existing sedimented pond located at outlet of piped creek and create BMP at bottom end of creek before it is once again piped under a parking lot and Greensboro Street.	Yes, off-set construction cost by locating contractor, municipality that needs excess dirt located above pipe.
9	UT* to Morgan Creek - Located east of NC 54 (Bypass) and south of Main Street	1,700	2,000	Channel is located parallel to sanitary sewer and apartment buildings located along west bank, Bottomland hardwood along east bank.	Priority II	$160	Yes, create BMP to treat stormwater generated by apartment complex and parking lots.	Yes, move creek to east away from apartment complex.
10	Chapel Creek - Located east of Fordham Blvd. and north of Mason Farm Rd.	1,100	1,300	Channel is located in abandoned Finley Golf Course fairway. Riparian vegetation was previously mowed, so no trees are present. Little or no infrastructure constraints in riparian corridor.	Priority 1	$110	Opportunity may exist to develop stormwater BMPs in headwater areas west of Fordham to treat runoff from UNC Campus.	Yes

*Unnamed Tributary

[1] While it is not possible to estimate exact cost without a detailed engineering analysis of restoration plans for a given reach, to the extent possible, the project team utilized *conceptual design* level costs to generate cost estimates for the recommended restoration approach at each site. It should be noted that the cost estimates are based on limited field reconnaissance; additional constraints and obstacles may be identified following a detailed survey of each site that could potentially increase the actual restoration cost. The cost estimates presented herein are not based on detailed engineering/design studies, but rather, are based on the professional judgment of stream restoration professionals with extensive experience in budgeting, designing and implementing restoration projects for a wide array of stream types and physical settings.

Table 2. Key Characteristics of Recommended Stormwater BMPs

Site Num	Location	LWP Sub	Site (acres)	Contributing Watershed (acres)	Watershed Landuse	Watershed Impervious	Recommended Practice	Estimated BMP Size (acres)	Estimated Const. Cost	Estimated Maint. Cost (20 yr-PV*)	Total Annualized Cost**
1	Chapel Hill Library	BL4	1.590	81.628	Residential	Moderate	Stormwater Wetland	1.63	$32,435	$3,758	$1,810
2	Eastgate Shopping Center	BL10	1.130	28.766	Parking/Roofs	Very High	Stormwater Wetland	0.86	$19,579	$3,204	$1,139
4	Cedar Falls Park	BL8	0.353	12.447	Ball Fields	Low	Pocket Wetland	0.25	$13,053	$2,819	$794
5	Weaver Dairy Retrofit	BL8	0.699	21.333	Residential	Moderate	Retrofit Existing Pond	NA	NA	NA	NA
6	Chapel Hill Comm. Center	BL5	0.095	0.569	Rooftop	Very High	Bioretention	0.040	$5,502	$1,343	$342
7	Rainbow Soccer Field	BL5	6.151	129.047	Res/Ball Fields	Low	Retrofit Existing Pond	NA	NA	NA	NA
8	Meadowmont Pool	BL12	0.981	31.534	Residential	High	Stormwater Wetland	0.79	$20,469	$3,249	$1,186
9	Chapel Ck. Bioretention	LM5	0.305	1.996	Parking	Very High	Bioretention	0.140	$21,555	$1,625	$1,159
10	UNC CH Tennis Courts	LM5	2.015	72.219	Residential	Low	Stormwater Wetland	1.44	$30,568	$3,689	$1,713
11	Carrboro Tracks	LM1	0.795	20.106	Urban	Very High	Wet Detention	0.40	$104,503	$8,781	$5,664
12	Carrboro Elementary Sch.	BL4	0.756	30.890	Institutional	Moderate	Stormwater Wetland	0.62	$20,266	$3,239	$1,175
13	Carrboro Park	BL4	0.526	24.365	Courts/Fields	Moderate	Stormwater Wetland	0.49	$18,067	$3,124	$1,060
14	Toms Creek @ Main St.	LM1	1.776	29.023	Residential	Moderate	Stormwater Wetland	0.58	$19,663	$3,208	$1,144
15	Carrboro USPS	LM1	0.263	2.800	Parking/Roofs	High	Bioretention	0.084	$31,152	$1,711	$1,643
16	Adjacent Carrboro USPS	LM1	0.859	16.629	Road/Res	Low	Stormwater Wetland	0.33	$15,017	$2,946	$898
17	Tarheel Manor Apts	LM1	0.601	12.471	Parking/Apts	High	Stormwater Wetland	0.37	$13,065	$2,819	$794
18	Food Lion Parking Lot	LM1	0.389	16.763	Parking/Roofs	Very High	Wet Detention	0.34	$92,483	$8,362	$5,042
19	Airport Road Retrofit #1	BL6	0.429	9.890	Road/Res	Moderate	Pocket Wetland	0.20	$11,678	$2,721	$720
20	Airport Road Retrofit #2	BL6	0.138	5.136	Road/Res	Moderate	Pocket Wetland	0.10	$8,504	$2,462	$548
21	Airport Road Retrofit #3	BL6	0.264	10.403	Road/Res	Moderate	Pocket Wetland	0.21	$11,967	$2,742	$735
22	Airport Road Retrofit #4	BL6	0.359	16.775	Road/Res	Moderate	Stormwater Wetland	0.34	$15,081	$2,950	$902
23	Hogan Farms D/S Lake	BL1	0.202	9.191	Residential	Moderate	Pocket Wetland	0.18	$11,271	$2,691	$698
24	Hogan Farms Power Lines	BL2	0.641	17.560	Residential	Moderate	Stormwater Wetland	0.35	$15,418	$2,971	$919
25	Hogan Farms Old Silo	BL1	0.168	3.212	Residential	Moderate	Bioretention	0.10	$36,170	$1,747	$1,896
26	Hogan Farms Main Road	BL1	0.424	10.746	Residential	Moderate	Pocket Wetland	0.21	$12,157	$2,756	$746

*Maintenance costs are presented as 20-year estimates at present values based on a 10% annual discount rate.

** Total Annualized Costs reflect the sum of initial construction costs and 20-year present value maintenance costs divided by 20.

Source of information to derive cost estimates: Wossink and Hunt, 2003.

Table 3. Feasibility Scores for Potential Stream Restoration Projects

Site Num	Stream Name/Location	Est. Stream Length	Est. Rest. Length	Owners	Pts	Infrastructure	Pts	Site Cover	Pts	Earthwork Req	Pts	FEASIBILITY SCORE
10	Chapel Creek at Finley Golf Course	1,100	1,300	Public-Few	3	None	3	Open	3	Low	3	**12**
2	Morgan Creek at Lemola Dairy Farm	3,500	4,200	Private-Few	2	None	3	Open	3	Low	3	**11**
1& 1a	Morgan Creek at Maple View Farms	7,000	8,500	Private-Few	2	None	3	Wooded	1	Low	3	**9**
6	Little Creek at Chapel Hill Country Club	800	900 - 1000	Private-Few	2	Minimal	2	Open	3	Med	2	**9**
8	UT to Morgan Creek near S. Greensboro St.	800	1,000	Private-Few	2	Few	1.5	Open	3	Med	2	**8.5**
5	UT to Bolin Creek near E. Franklin St.	1,000	1,200	Mixed-Few	2	Numerous	1	Mixed	2	Low	3	**8**
4	UT to Bolin Creek at Airport Rd.	500	600	Private-Few	2	Numerous	1	Mixed	2	Med	2	**7**
7	Bolin Creek at Hogan Farms	3,300	4,000	Private-Numerous	1	Minimal	2	Wooded	1	Med	2	**6**
9	Toms Creek at Main St.	1,700	2,000	Private-Numerous	1	Numerous	1	Mixed	2	Med/High	1.5	**5.5**
3	Lower Booker Creek	4,000	4,500	Mixed-Numerous	1	Numerous	1	Wooded	1	High	1	**4**

Table 4. Feasibility Scores for Potential BMP Projects

Site Num	Stream Name/Location	Site (ac)	Wshed (ac)	Owners	Pts	Infrastructure	Pts	Site Cover	Pts	Earthwork Req	Pts	FEASIBILITY SCORE
9	Chapel Ck. Bioretention	0.31	2.00	1 Public (UNC)	3	None	3	Grass	3	Low	3	**12**
19	Airport Road Retrofit #1	0.43	9.89	1 Public (NCDOT)	3	None	3	Grass	3	Low	3	**12**
20	Airport Road Retrofit #2	0.14	5.14	1 Public (NCDOT)	3	None	3	Grass	3	Low	3	**12**
21	Airport Road Retrofit #3	0.26	10.40	1 Public (NCDOT)	3	None	3	Grass	3	Low	3	**12**
22	Airport Road Retrofit #4	0.36	16.78	1 Public (NCDOT)	3	None	3	Grass	3	Low	3	**12**
10	UNC CH Tennis Courts	2.02	72.22	1 Public (UNC)	3	None	3	Grass	3	Medium	2	**11**
13	Carrboro Park	0.53	24.37	1 Public (Carrboro)	3	Sewer <20'	2	Grass	3	High	3	**11**
5	Weaver Dairy Retrofit	0.70	21.33	1 Public (TOCH)	3	None	3	Wooded	1	Low	3	**10**
6	Chapel Hill Comm. Center	0.10	0.57	1 Public (TOCH)	3	None	3	Grass	3	High	1	**10**
7	Rainbow Soccer Field	6.15	129.05	1 Public (UNC)	3	None	3	Pond	3	High	1	**10**
16	Adjacent Carrboro USPS	0.86	16.63	1 Private	2	None	3	Grass	3	Medium	2	**10**
18	Food Lion Parking Lot	0.39	16.76	1 Private	2	None	3	Grass	3	Medium	2	**10**
23	Hogan Farms D/S Lake	0.20	9.19	1 Private (Hogan Farms)	2	None	3	Grass	3	Medium	2	**10**
25	Hogan Farms Old Silo	0.17	3.21	1 Private (Hogan Farms)	2	None	3	Grass	3	Medium	2	**10**
11	Carrboro Tracks	0.80	20.11	1 Public (Carrboro)	3	Water <25'	2	Wooded	1	Low	3	**9**
15	Carrboro USPS	0.26	2.80	2 Mixed (USPS & Private)	1	None	3	Grass	3	Medium	2	**9**
17	Tarheel Manor Apts	0.60	12.47	1 Private	2	None	3	Mixed	2	Medium	2	**9**
2	Eastgate Shopping Center	1.13	28.77	2 Private	1	Sewer <20'	2	Mixed	2	Low	3	**8**
4	Cedar Falls Park	0.35	12.45	1 Public (TOCH)	3	None	3	Wooded	1	High	1	**8**
8	Meadowmont Pool	0.98	31.53	1 Private (Meadowmont)	2	None	3	Wooded	1	Medium	2	**8**
12	Carrboro Elementary Sch.	0.76	30.89	1 Public (CH/Carr. PSS)	3	W&S <20'	1	Wooded	1	High	3	**8**
24	Hogan Farms Power Lines	0.64	17.56	2 Mixed (Hogan & UNC)	1	None	3	Wooded	1	Low	3	**8**
26	Hogan Farms Main Road	0.42	10.75	1 Private (Hogan Farms)	2	None	3	Wooded	1	Medium	2	**8**
1	Chapel Hill Library	1.59	81.63	1 Public (TOCH)	3	Water <20'	2	Wooded	2	High	1	**8**
14	Toms Creek @ Main St.	1.78	29.02	1 Private	2	Sewer <20'	2	Wooded	1	Medium	2	**7**

Table 5. Sediment Load Reduction Cost-effectiveness for Potential Stream Restoration Sites

Site Num	Stream Name/Location	Stream Length	Rest. Length	Cost/ Foot	Total Cost	Sediment Reduction (tons/yr)	Cost/Ton (initial)	Cost/Ton per Year (20 yrs)
4	UT to Bolin Cr. at Airport Rd.	500	600	$160	$96,000	135.0	$711	$36
1&1a	Morgan Cr. at Maple View Farms	7,000	8,500	$170	$1,445,000	1461.7	$989	$49
2	Morgan Cr. at Lemola Dairy Farm	3,500	4,200	$130	$546,000	374.5	$1,458	$73
10	Chapel Cr. at Finley Golf Course	1,100	1,300	$110	$143,000	83.2	$1,719	$86
3	Lower Booker Cr.	4,000	4,500	$325	$1,462,500	759.6	$1,925	$96
9	Toms Cr. at Main St.	1,700	2,000	$160	$320,000	127.0	$2,520	$126
7	Bolin Cr. at Hogan Farms	3,300	4,000	$160	$640,000	250.9	$2,551	$128
6	Little Cr. at Chapel Hill Country Club	800	950	$180	$171,000	64.4	$2,655	$133
5	UT to Bolin Creek near E. Franklin St.	1,000	1,200	$125	$150,000	—	—	—
8	UT to Morgan Cr. near S. Greensboro St.	800	1,000	$160	$160,000	—	—	—

Table 6. Results of BMP Nutrient Load Reduction and Cost-effectiveness Analysis

Site Num	Location	Recommended Practice	Treated Area (acres)	Total Annualized Cost (20 yr)	TN Load (lbs/yr)	TP Load (lbs/yr)	TN Reduction (percent)	TP Reduction (percent)	TN Reduction (lbs/yr)	TP Reduction (lbs/yr)	TN cost/lb (20 yr)	TP cost/lb (20 yr)
2	Eastgate Shopping Center	Stormwater Wetland	28.77	$1,139	711.5	108.4	22.0%	32.5%	156.5	35.2	$7	$32
8	Meadowmont Pool	Stormwater Wetland	31.53	$1,186	541.7	85.0	22.0%	32.5%	119.2	27.6	$10	$43
10	UNC CH Tennis Courts	Stormwater Wetland	72.22	$1,713	697.0	115.4	22.0%	32.5%	153.3	37.5	$11	$46
17	Tarhell Manor Apts	Stormwater Wetland	12.47	$794	310.6	47.4	22.0%	32.5%	68.3	15.4	$12	$52
1	Chapel Hill Library	Stormwater Wetland	81.63	$1,810	672.0	117.4	22.0%	32.5%	147.8	38.1	$12	$47
12	Carrboro Elementary Sch.	Stormwater Wetland	30.89	$1,175	422.4	67.6	22.0%	32.5%	92.9	22.0	$13	$54
14	Toms Creek @ Main St.	Stormwater Wetland	29.02	$1,144	329.1	54.2	22.0%	32.5%	72.4	17.6	$16	$65
13	Carrboro Park	Stormwater Wetland	24.37	$1,060	304.0	48.8	22.0%	32.5%	66.9	15.9	$16	$67
24	Hogan Farms Power Lines	Stormwater Wetland	17.56	$919	160.7	27.2	22.0%	32.5%	35.3	8.9	$26	$104
22	Airport Road Retrofit #4	Stormwater Wetland	16.78	$902	148.6	25.8	22.0%	32.5%	32.7	8.4	$28	$108
23	Hogan Farms D/S Lake	Pocket Wetland	9.19	$698	96.0	15.9	22.0%	32.5%	21.1	5.2	$33	$135
4	Cedar Falls Park	Pocket Wetland	12.45	$794	99.7	17.1	22.0%	32.5%	21.9	5.6	$36	$143
26	Hogan Farms Main Drag	Pocket Wetland	10.75	$746	93.0	15.7	22.0%	32.5%	20.5	5.1	$36	$147
19	Airport Road Retrofit #1	Pocket Wetland	9.89	$720	86.3	14.2	22.0%	32.5%	19.0	4.6	$38	$156
21	Airport Road Retrofit #3	Pocket Wetland	10.40	$735	80.9	13.8	22.0%	32.5%	17.8	4.5	$41	$164
11	Carrboro Tracks	Wet Detention	20.11	$5,664	432.1	66.6	28.0%	46.0%	121.0	30.6	$47	$185
16	Adjacent Carrboro USPS	Stormwater Wetland	16.63	$898	79.7	16.4	22.0%	32.5%	17.5	5.3	$51	$168
6	Chapel Hill Comm. Center	Bioretention	0.57	$342	14.1	2.1	45.0%	71.0%	6.3	1.5	$54	$225
18	Food Lion Parking Lot	Wet Detention	16.76	$5,042	417.4	63.7	22.0%	32.5%	91.8	20.7	$55	$244
20	Airport Road Retrofit #2	Pocket Wetland	5.14	$548	34.1	6.3	22.0%	32.5%	7.5	2.0	$73	$268
9	Chapel Ck. Bioretention	Bioretention	2.00	$1,159	34.5	5.5	45.0%	71.0%	15.5	3.9	$75	$299
25	Hogan Farms Old Silo	Bioretention	3.21	$1,896	49.9	7.9	45.0%	71.0%	22.5	5.6	$84	$338
15	Carrboro USPS	Bioretention	2.80	$1,643	42.2	6.7	45.0%	71.0%	19.0	4.7	$86	$346
5	Weaver Dairy Retrofit	Retrofit Existing Pond	21.33	NA	248.3	41.1	28.0%	46.0%	69.5	18.9	NA	NA
7	Rainbow Soccer Field	Retrofit Existing Pond	129.05	NA	1485.9	244.3	28.0%	46.0%	416.1	112.4	NA	NA

Table 7. Watershed Functional Benefit Scores for Identified Stream Restoration Projects

Site Num	Stream Name/Location	Cost Per Foot	Total Cost	Sed Reduction (cost/ton/yr)	Pts	LWP Subwatershed SVAP	Pts	Nutrient	Pts	Conjunction	Pts	BENEFIT SCORE	BENEFIT SCORE*
8	UT to Morgan Cr. near S. Greensboro St.	$160	$160,000	NA	2	LM1	2	LM1	3.5	BMP	2	**9.5**	**6**
3	Lower Booker Cr.	$325	$1,462,500	$96	3	BL10	2.5	BL10	2.5	BMP	1	**9**	**6.5**
4	UT to Bolin Cr. at Airport Rd.	$160	$96,000	$84	3	BL4	2	BL4	4	No	0	**9**	**5**
10	Chapel Cr. at Finley Golf Course	$110	$143,000	$101	3	LM5	2.5	LM5	1	BMP	2	**8.5**	**7.5**
6	Little Cr. at Chapel Hill Country Club	$180	$171,000	$99	3	BL12/13	3	BL12/13	2.5	No	0	**8.5**	**6**
9	Toms Cr. at Main St.	$160	$320,000	$250	1	LM1	2	LM1	3.5	BMP	2	**8.5**	**5**
5	UT to Bolin Cr. near E. Franklin St.	$125	$150,000	NA	2	BL4	2	BL4	4	No	0	**8**	**4**
1	Morgan Cr. at Maple View Farms	$170	$1,445,000	$103	3	UM1	2	UM1	0	Pres	2	**7**	**7**
2	Morgan Cr. at Lemola Dairy Farm	$130	$546,000	$89	3	UM1	2	UM1	0	Pres	2	**7**	**7**
7	Bolin Cr. at Hogan Farms	$160	$640,000	$169	1	BL1/2	2.5	BL1/2	1.5	BMP	2	**7**	**5.5**

*Score without LWP Subwatershed Parameter reflecting nutrient delivery to Jordan Lake

Table 8. Watershed Functional Benefit Scores for Identified BMP Retrofit Opportunities

Site Num	Location	Stream/Catchment	Recommended Practice	Annualized Cost	TN Reduction (cost/lb/yr)	Pts	LWP Subwatershed Nutrient	Pts	Morph	Pts	Conjunction	Pts	BENEFIT SCORE
14	Toms Creek @ Main St.	Toms Creek	Stormwater Wetland	$1,144	$16	3	LM1	3.5	LM1	3	Yes	2	**11.5**
17	Tarheel Manor Apts	Toms Creek	Stormwater Wetland	$794	$12	3	LM1	3.5	LM1	3	Yes	2	**11.5**
2	Eastgate Shopping Center	Booker Creek	Stormwater Wetland	$1,139	$7	3	BL10	4	BL10	3	Yes	1	**11**
11	Carrboro Tracks	UT to Morgan Creek	Wet Detention	$5,664	$47	2	LM1	3.5	LM1	3	Yes	2	**10.5**
15	Carrboro USPS	Toms Creek	Bioretention	$1,643	$86	1	LM1	3.5	LM1	3	Yes	2	**9.5**
16	Adjacent Carrboro USPS	Toms Creek	Stormwater Wetland	$898	$51	1	LM1	3.5	LM1	3	Yes	2	**9.5**
18	Food Lion Parking Lot	Toms Creek	Wet Detention	$5,042	$55	1	LM1	3.5	LM1	3	Yes	2	**9.5**
1	Chapel Hill Library	UT to Bolin Creek	Stormwater Wetland	$1,810	$12	3	BL4	4	BL4	2	No	0	**9**
12	Carrboro Elementary Sch.	UT to Bolin Creek	Stormwater Wetland	$1,175	$13	3	BL4	4	BL4	2	No	0	**9**
13	Carrboro Park	UT to Bolin Creek	Stormwater Wetland	$1,060	$16	3	BL4	4	BL4	2	No	0	**9**
8	Meadowmont Pool	UT to Little Creek	Stormwater Wetland	$1,186	$10	3	BL12	3	BL12	3	Near	0	**9**
10	UNC CH Tennis Courts	Chapel Creek	Stormwater Wetland	$1,713	$11	3	LM5	1	LM5	2.5	Yes	2	**8.5**
24	Hogan Farms Power Lines	Upper Bolin Creek	Stormwater Wetland	$919	$26	2	BL2	1.5	BL2	3	Yes	2	**8.5**
7	Rainbow Soccer Field	Little Creek	Retrofit Existing Pond	NA	NA	2	BL5	4	BL5	2	No	0	**8**
23	Hogan Farms D/S Lake	Upper Bolin Creek	Pocket Wetland	$698	$33	2	BL1	1	BL1	3	Yes	2	**8**
26	Hogan Farms Main Road	Upper Bolin Creek	Pocket Wetland	$746	$36	2	BL1	1	BL1	3	Yes	2	**8**
6	Chapel Hill Comm. Center	Lower Bolin Creek	Bioretention	$342	$54	1	BL5	4	BL5	2	No	0	**7**
25	Hogan Farms Old Silo	Upper Bolin Creek	Bioretention	$1,896	$84	1	BL1	1	BL1	3	Yes	2	**7**
9	Chapel Ck. Bioretention	Chapel Creek	Bioretention	$1,159	$75	1	LM5	1	LM5	2.5	Yes	2	**6.5**
4	Cedar Falls Park	Cedar Fork	Pocket Wetland	$794	$36	2	BL8	3	BL8	0.5	No	0	**5.5**
5	Weaver Dairy Retrofit	UT to Booker Creek	Retrofit Existing Pond	NA	NA	2	BL8	3	BL8	0.5	No	0	**5.5**
19	Airport Road Retrofit #1	Upper Booker Creek	Pocket Wetland	$720	$38	2	BL6	2	BL6	1	No	0	**5**
21	Airport Road Retrofit #3	Upper Booker Creek	Pocket Wetland	$735	$41	2	BL6	2	BL6	1	No	0	**5**
22	Airport Road Retrofit #4	Upper Booker Creek	Stormwater Wetland	$902	$28	2	BL6	2	BL6	1	No	0	**5**
20	Airport Road Retrofit #2	Upper Booker Creek	Pocket Wetland	$548	$73	1	BL6	2	BL6	1	No	0	**4**

Projects Recommended for High Priority Implementation

It is recommended that the following projects be given high priority for implementation. The order in which they are presented here is not intended to reflect priorities within this list. Rather, this list is offered as a group that should be given higher priority within the context of priorities determined between NCEEP and local jurisdictions.

- **Stream Restoration and BMPs in the Toms Creek Watershed (Subwatershed UM1)**

  The BMP opportunities within the watershed (Toms Creek at Main Street, Tarheel Manor Apts., two at the Carrboro USPS, and the Food Lion parking lot) all rated among the highest in terms of Benefit Scores, and while not necessarily among the easiest in terms of feasibility, they do not suffer excessive constraints as projects in an urban setting go. The Benefit Score for Toms Creek stream restoration falls among the middle third and in terms of feasibility it ranks as one of the most difficult, but if implemented in conjunction with one or more of the BMP opportunities identified in this small watershed it offers the opportunity to make a substantial improvement in the functions of this small urban watershed.

- **Restoration of Stream Segments in Upper Morgan Creek (Subwatershed UM1)**

  The stream restoration projects identified at the Maple View and Lemola Dairy Farms offer two opportunities that are among the easiest to implement, provided landowner participation can be successfully negotiated, and they both offer large and highly cost-effective benefits in terms of sediment load reduction and aquatic habitat improvement. They do not provide significant tangible benefit regarding reduction of nutrient loads to Jordan Lake, but these sites are of great value to University Lake in that respect, and their location provides watershed scale opportunity to realize mutual benefits between stream restoration and preservation of high quality riparian and terrestrial habitats (refer to Section 4).

- **Stream Restoration and BMPs in the Chapel Creek Watershed (Subwatershed LM5)**

  The restoration of Chapel Creek is rated as the most feasible to implement and the project is among the top tier in terms of projected benefits. It is also highly cost-effective in terms of sediment load reduction. The appropriate agreements are in place between UNC and NCEEP to bring about stream restoration at this site. If the BMP opportunities identified in the headwaters of this watershed can be implemented in conjunction with this restoration, it offers another small watershed where substantial improvement in watershed functions could be realized. The potential stormwater wetland BMP at the UNC Tennis Courts (Site 10) is not rated particularly high in terms of Benefit Score, but it does offer the opportunity for one of the most cost-effective sites in terms of nutrient load reduction (refer to Table 5). This BMP would also provide critical peak flow reduction to protect the integrity of the restoration site.

- **Restoration of Lower Booker Creek and Stormwater BMP at Eastgate Mall**

  As previously noted, while restoration of Booker Creek below Eastwood Lake may prove to be a large and challenging undertaking, it would provide one of the greatest overall benefits to watershed functions. The stormwater BMP site just downstream behind Eastgate Mall has a very similar low feasibility/high benefit profile. However, implementation of these projects together could make significant progress toward alleviating the impairment of lower Booker Creek.

- **Restoration of UT to Morgan Creek Near South Greensboro Street and Stormwater BMP at Carrboro Tracks**

  Sediment load cost-effectiveness could not be approximated for this stream restoration project because the stream segment is currently buried in an underground conveyance. Day-lighting the stream would provide obvious benefits to a full range of watershed functions, and the wet detention BMP site at the Carrboro Tracks (Site 11) offers an opportunity to capture and treat runoff from a substantial portion of the urbanized downtown section of Carrboro.

- **Restoration of Floodplain Functions along Morgan Creek at Mason Farm**

  While this project may not be directly comparable to the other stream restoration projects considered in this study, it is likely to provide significant functional benefit for a relatively low cost. Since the project involves removal of a berm disconnecting Morgan Creek from a historical floodplain area, it will not require construction of a new channel, and the excavation requirements, and hence cost, for the project should be lower than those associated with conventional stream restoration projects. The nutrient reduction potential of the restored floodplain area is of high functional value in this area immediately upstream of Jordan Lake. A field study is planned for implementation in conjunction with this project to evaluate the level of nutrient removal resulting from the restored floodplain.

- **Stand-Alone Stormwater BMP Projects**

  Several of the potential BMPs identified in this report, while not necessarily associated with a particular stream restoration project, are projected to offer significant watershed benefits based on their strategic locations and are highly cost-effective in terms of reducing nutrient loads. They are the sites at Chapel Hill Library (Site 1), Meadowmont Pool (Site 8) and Carrboro Elementary School (Site 12). In addition, while cost estimates could not be developed for the retrofits of existing ponds at Weaver Dairy and Rainbow Soccer Fields, given that they would have only minimal excavation requirements, it is likely that they will prove to be highly cost-effective sources of nutrient load reduction, and they are both located in watersheds with high to very high potential to deliver nutrients to Jordan Lake.

Projects Recommended as Low Priority for Implementation

It is recommended that the following projects be given low priority for implementation due to limited watershed benefits, logistical concerns, or other reasons as discussed.

- **BMP Retrofits at Airport Road**

  Retrofitting the existing sediment basins along North Airport Road should be given low priority because the resulting stormwater wetlands would provide only limited nutrient load reduction benefit due to their location in the Bolin/Little Creek watershed. However, if detailed source identification investigations in the future show that nonpoint source pollutant loads from the vicinity of the upper Booker Creek watershed are contributing to the impairment of Booker Creek, the local jurisdictions may wish to consider implementing them at a later date. As the level of development increases in this portion of the Booker Creek watershed, the localized benefit of these facilities will also increase.

- **Stream Restoration and BMPs in the Hogan Farms Vicinity (Subwatersheds BL1 and BL2)**

  The stream restoration of Bolin Creek in this area and the potential BMP projects identified all fell in the lower half or at the bottom of the list in terms of the Benefit Scores, and they tend toward the lower half of the Feasibility Scores as well. In addition, implementing a stream restoration project in the Hogan Farms subdivision may be premature at this juncture, due to the fact that significant amounts of additional development are projected in the next phases of the community (currently

under construction). Stream restoration and BMP implementation may be more prudent after the whole development is complete and its full imperviousness realized.

While it is recommended that stream restoration and BMP implementation in the Hogan Farms area be given lower priority among the project opportunities identified in this report, the future phases of Hogan Farms and other subdivision developments planned for this upper Bolin Creek portion of the LWP study area, such as Winmore, offer ideal opportunities for implementation of low impact design measures in conjunction with restoration projects. Appropriate low impact design features and the means to facilitate their implementation are discussed in the following section.

Evaluation of Three LWP Stormwater Ordinances

Tetra Tech reviewed portions of Carrboro's, Chapel Hill's, and Orange County's stormwater management ordinances, or development ordinance sections devoted to stormwater management. Where available, Tetra Tech also reviewed their Phase II stormwater permit applications outlining the intent to revise or upgrade ordinances to meet new Phase II requirements. Tetra Tech then compared the existing ordinances to elements of a strong/progressive stormwater program (clear goals and objectives, strong performance standards, and buffer requirements) and to Phase II requirements. Each local program's strengths, gaps and opportunities are described in the following sections. These three local governments represent the main jurisdictions in the Morgan LWP study area.

Carrboro

The Town of Carrboro staff forwarded relevant portions of the Carrboro Land Use Ordinance as well as the town's NPDES Phase II permit application to Tetra Tech for evaluation. Section 15-263 (Stormwater Management) provides a general policy and standard related to property damage stipulating that all developments shall be constructed and maintained so that they do not cause storm-related damage to upstream or downstream properties. The ordinance further states:

> *Compliance with this standard shall be determined in reference to storm events up to the 100-year storm for upstream properties and up to the 25-year storm for the downstream properties. To achieve this objective, the potential impact on surface water quantity and quality from all proposed developments requiring special use or conditional use permits shall be identified and evaluated.*

The storm events referenced above are traditionally associated with evaluations to mitigate flooding and property damage associated with flooding. Missing from the ordinance are clear goals, objectives, and performance standards related to stream channel and stream bank stability and water quality. On an administrative level, the town staff and contract engineer evaluate the adequacy of the developer's stormwater impact statement using a treatment performance standard of 85 percent removal of TSS and peak discharge matching for pre- and post-development conditions for the 2-, 5-, 10-, and 25-year storm events. The town, using the impact statement, also checks on potential impacts from the 100-yr storm. The town believes that having a general goal and putting the burden on the developer to show the impact, allows for working and negotiating with developers on a project-by-project basis (per conversation with Mr. Henry Wells, Town of Carrboro Contract Engineer). The impact statement is required only for developments needing a special use or conditional use permit; all individual single family and two family residences are exempted (regardless of impervious level or land disturbance).

At this time, the town does not have a total volume control/treatment requirement (e.g., control and treat increased stormwater volume (post-development) from 1-yr, 24-hr storm or the 2-yr, 24-hr storm event),

which can be a more stringent standard than controlling for the peak discharge. Most progressive ordinances and the Phase II requirements have total volume control performance standards.

The Town of Carrboro has strong stream buffer requirements (Sections 15-264 through 15-269), and open space requirements (Section 15-198). Creek and tributary buffers are 50 ft from the edge of the floodplain plus a distance of 4 x slope x 100. Intermittent stream buffers are 50 ft from steam centerline (unless in University Lake watershed, which is 100 ft from centerline). In the Bolin Creek watershed, buffer requirements are even stronger: 100 ft from centerline for creeks; 60 ft for intermittent streams; 30 ft for minor intermittent streams. The town has a 40 percent open space requirement for new development (the stream buffers can help meet this open space requirement).

The peak discharge and TSS performance standards, along with the buffer and open space requirements, form the core of the town's post-construction stormwater management program; these are also the standards/requirements that the town intends to use to meet Phase II requirements. As noted in the Town of Huntersville example, Huntersville explored using a strong open space requirement (30 to 40 percent) and buffer rules along with the state's minimum water supply protection rules (treatment of runoff from the first inch of rainfall for development greater than 24 percent impervious). When the Town of Huntersville tested how adequate this approach was in mitigating development impacts, it found that significant degradation could still occur. Based on that analysis, Huntersville strengthened its stormwater ordinance performance standards.

Note: In the University Lake drinking water supply watershed, the town has strong impervious surface limits for residential development (4 percent impervious cap). Commercial development is allowed up to 24 percent imperviousness, but must retain the first inch of rainfall.

In comparing the town's existing regulations to the Phase II Interim Rule, it appears that the existing rules at least partially meet the interim regulations (control and treat the difference in volume between the pre- and post-development conditions for the 1-yr, 24-hr storm event). Additional analysis is needed to determine the adequacy of the town's stormwater management and open space regulations in meeting the Phase II Interim Rule. Also, to meet the state's minimum Phase II NPDES stormwater requirements, the town will need to add provisions to its stormwater ordinances and program for inspecting and monitoring BMPs to ensure they are performing as intended.

Opportunities for Strengthening the Town's Stormwater Ordinance

When the Town adopts its Phase II stormwater ordinance, it has the opportunity to clarify, formalize, and strengthen its stormwater management regulations. Key areas to focus on include:

- Develop and adopt a clear goal statement for the town's stormwater management program, and include it in the stormwater ordinance.
- Develop and adopt clear objectives related to natural resource protection, and include these in the stormwater ordinance.
- Based on goals and objectives, evaluate the effectiveness of existing regulations, Phase II requirements, or stronger standards in meeting the town's goals.
- Enhance performance standards, particularly for stormwater volume control. If adopting Phase II minimum requirements, use stronger "thresholds" of applicability: instead of 24 percent imperviousness, use at minimum 10 percent imperviousness as the threshold for treatment and volume control. Consider adopting even stronger performance standards than minimum Phase II requirements, using the progressive community examples as models. Apply the standards to all new developments and redevelopment, not only to special use and conditional use permits.
- Add provisions for inspecting and monitoring the BMPs to ensure they are working properly.

Chapel Hill

In 2003, the Town of Chapel Hill adopted a new stormwater ordinance. The ordinance has very clear goals, objectives, and performance standards. The threshold of applicability is strong, allowing few development exemptions. The town's ordinance is a model for other communities. It clearly meets the Phase II Interim Rules.

Chapel Hill has strong stream buffer requirements through its Resource Conservation District Ordinance. New development is required to preserve a 150-ft stream buffer (each side of the stream).

Redevelopment or development in the Downtown or Community Commercial Districts may find it difficult at times to meet these performance standards onsite. The town may wish to develop a mechanism for partial offsite mitigation.

Opportunities for Strengthening the Town's Stormwater Ordinance:

- For the Downtown or Community Commercial Districts, some projects may find it very difficult to meet the performance standard on-site. In order to not penalize the developer or create an incentive for a variance to the stormwater performance standard, the town could create a mechanism for partial offsite mitigation (i.e., the developer would have to provide for some onsite stormwater management, but provide the rest offsite). High priority watersheds could be targeted for preservation or restoration efforts. At minimum, the state's phase II requirements must be met in these areas.

Orange County

Most of Orange County's jurisdiction in the Morgan Creek LWP is in the University Lake Watershed. The county's University Lake (drinking) water supply protection overlay zone requires a maximum density of 1 unit per 5 acres and 6 percent impervious cap on development. Modeling during the Detailed Assessment showed that these drinking water supply protection standards also met other habitat and water quality objectives. The county also has strong buffer requirements: 50-ft minimum measured from the 100-year floodplain.

Opportunities for Strengthening the County's Stormwater Ordinance:

- As noted above, for the University Lake Watershed (Upper Morgan Creek), the county's existing performance standards are sufficiently strong to meet multiple objectives including but not limited to drinking water supply protection. In a Phase II Stormwater Ordinance or other amendments to the existing development ordinance, the county should broaden the scope of its stormwater management authority, and formally adopt other habitat and water quality goals and objectives.
- Although not a high priority area, the Lower Morgan Creek 6 area near Jordan Lake faces continued development pressure. The rural buffer regulations (1 unit per 2 acres) should, at minimum, be coupled with the state's Phase II stormwater management requirements, or stormwater management performance standards that provide additional protection in this area. Protection of this are could also be improved if similar measures were adopted for the Chatham County portion of this subwatershed.

As noted previously, DENR is currently developing a phosphorus and nitrogen TMDL for the Upper New Hope Creek arm of Jordan Lake, including the LWP study area. While the exact TMDL is still undecided, all parties have agreed that, at minimum, the total nonpoint source loading should be capped at existing levels. Whether this load target or a more stringent load target is adopted, the TMDL will clearly require additional controls on new development and redevelopment. The final TMDL will determine the extent to which local governments must go beyond their existing regulations and Phase II requirements in reducing phosphorus and nitrogen loads from new development.

Table 9 summarizes opportunities for strengthening the local stormwater ordinances.

Table 9. Opportunities for Strengthening Stormwater Ordinances

Jurisdiction	Meeting Elements of Progressive Stormwater Management Programs				Meeting Pending State Requirements	
	Clear Goals and Objectives	Strong Performance Standards	Applicability and Exemptions	Stream Buffers	Phase II Stormwater Rules	Nutrient TMDL
Carrboro	○	◐	◐	●	◐	*
Chapel Hill	●	●	●	●	●	*
Orange Co.	○	●	●	●	●	*

○ BigGap/Opportunity
◐ Moderate Gap/Opportunity
● Meets Element/Requirement
* TMDL requirements still pending at the time of report production.

Summary of Local Governments LID Design Survey

As a part of this project, the Cape Fear River Assembly worked with the staff from Carrboro, Chapel Hill, and Orange County to administer the *Better Site Design Handbook*'s Code and Ordinance Worksheet. The worksheet has a scoring/point system which helps evaluate how well local practices meet better site design principles. The scoring ranges include:

Score	Evaluation
90-100:	Community has above average provisions that promote the protection of streams and lakes.
80-89:	Local development rules are good, but could use minor adjustments or revisions in some areas.
70-79:	Opportunities exist to improve development rules. Consider creating a site planning roundtable.
60-69:	Development rules are likely inadequate to protect aquatic resources. A site planning roundtable would be very useful.
Less than 60:	Development rules are definitely not environmentally friendly. Serious reform is needed.

Staff from each community's planning department reviewed their respective ordinances and completed the worksheet, including the assigned scoring. Cape Fear River Assembly staff noted that the Morgan Creek LWP jurisdictions scored higher than any other jurisdictions surveyed in the Cape Fear Basin. The Town of Carrboro scored 81, indicating good rules, minor adjustments needed. The Town of Chapel Hill scored 71, indicating that opportunities still exist to improve development rules. Since many of the points related to urban issues, the overall point system was not applicable to Orange County's ordinance. The county had an average score on design issues related to rural development in the Cape Fear Basin, indicating opportunities for improvement.

The worksheet exercise helped staff identify areas of the development ordinance that could be strengthened. In addition, Tetra Tech talked with staff to discern what the ordinances allow versus what the town encourages and discourages "on the ground." Based on the survey and follow-up conversations, below is a summary of key opportunities that offer the most potential for strengthening habitat and water quality protection.

All Jurisdictions (Carrboro, Chapel Hill, Orange County):

- Encourage pervious pavement material for residential applications for ultra-urban infill or redevelopment (e.g., downtown Carrboro or Chapel Hill) and for nonresidential developments that have a minimum of 50 parking stalls. Recently, Tetra Tech has worked with Bill Hunt of NCSU and Bradley Bennett of DWQ's stormwater program to develop more detailed guidance on the use of pervious pavement materials in piedmont North Carolina. Develop and adopt a maximum parking requirement.
- Require at least 30 percent of parking spaces at large commercial lots to have smaller dimensions for compact cars.
- Encourage use of 4-ft wide sidewalks, where sidewalks are built.
- Reduce residential setback and frontage requirements (front setbacks for ½ acre lot –20 ft or less; rear setbacks for ½ acre lot –25 ft or less; side setbacks for ½ acre lot –8 ft or less). (For the county, this would be appropriate for "cluster design" residential development.)

Carrboro Only:

- Encourage water quality swales in place of curb and gutter (where there is low to moderate slope). (Note: The town does allow swales, but according to staff, does not encourage them. In some areas where swales have been used, two problems have occurred: swales were used in steeply sloped areas and now are eroding and were built so deep as to pose a safety problem for children. Also, citizens do not want to maintain (or mow) the swales. The first two problems can be handled with proper design; the latter could be addressed through town maintenance).
- Provide incentives for parking garages rather than parking lots (especially in town center).

Chapel Hill Only:

- Encourage water quality swales in place of curb and gutter (where there is low to moderate slope).
- Reduce the minimum right-of-way width for a residential street to less than 45 ft.
- Develop and adopt street standards that promote efficient street layout and reduce overall street length.
- Reduce minimum radius allowed for a cul-de-sac to 35 ft or less and allow alternative turnarounds such as hammerheads.
- Slope sidewalks to yards.
- Reduce minimum driveway width (9 ft or less for single lane and 18 ft or less for double lane).
- If forest or specimen trees are present at a residential development, require that some of the stand be preserved.

Orange County:

- Reduce the minimum right-of-way width for a residential street to less than 45 ft.
- Develop and adopt street standards that promote efficient street layout and reduce overall street length.
- Allow sidewalks on one side of residential streets instead of requiring them on both sides.
- Slope sidewalks to yards.
- Require that at least some part of the stream buffer be maintained in native vegetation. (Note: the county's regulations for the Cape Fear Basin require that existing vegetation be maintained or replaced with new vegetation that will provide similar drainage characteristics. This wording does not require that property owners plant or maintain the buffers with native vegetation.)
- Develop and adopt ordinance provisions that limit clearing and grading and encourage the preservation of natural vegetation at residential development sites.
- If forest or specimen trees are present in a residential development, require that some of the stand be preserved.
- Provide flexibility to meet stormwater management or conservation restrictions (density compensation, transfer of development rights, offsite mitigation). Target high priority watersheds for offsite mitigation.
- Do not allow stormwater to be directly discharged into a jurisdictional wetland without pretreatment. (At this time, Orange County does not allow such discharges in the Neuse Basin, but does allow them in the Cape Fear Basin.)

Tetra Tech recommends making the ordinance revisions highlighted above, either through a holistic "roundtable process" described in the *Better Site Design Handbook*, or incrementally through text amendments. However, as noted in conversations with staff, many LID elements are currently allowed in the local ordinances, but are not encouraged and in some cases discouraged. Therefore, Tetra Tech recommends that each jurisdiction work interdepartmentally—with the Planning, Engineering and Public Works Departments—to resolve issues and remove barriers which are currently blocking use of the above LID practices. Once these internal issues have been resolved, and ordinances revised as needed, Tetra Tech recommends that local jurisdictions meet with development applicants early in the process to educate them about LID techniques and to discuss their potential use in the project. Use of a "checklist" in this process can proactively encourage LID.