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Technical Memorandum

To: Lockwood Folly Storm Water Management Committee	
From: Ron Geiger, PE	Project: Storm Water Master Plan
CC:	
Date: October 11, 2006	Job No: 42944-018

INTRODUCTION

Lockwood Folly is a 500-acre gated community comprised of approximately 550 home sites and an 18-hole golf course, Lockwood Folly Country Club. The residential community, located on the west bank of Lockwood Folly River, includes custom home lots, patio homes, common areas, roads, Clubhouse, and marina. Nearly 300 homes have been constructed over the 17 years that this community has existed. Heavy rains from tropical storms have shown that the storm water runoff drainage system is inadequate to allow many areas to drain. This inadequate capacity has resulted in flooding of private properties, roadway overtopping, and inundation of homes and structures.

Runoff flow patterns intertwine amongst residential lots and the community golf course. Inadequate flow routes have resulted in frequent nuisance flooding, occasional inundation of home sites and, overtopping of roadways during heavy rains. The community has requested a storm water master plan be developed, providing guidance for the community, to allow implementation of both short- and long-term correction of the noted storm water drainage deficiencies. Lockwood Folly Property Owners Association Inc. (POA) has contracted with HDR Engineering, Inc of the Carolinas (HDR) to develop a storm water master plan for the purpose of developing recommended improvements to alleviate the noted drainage deficiencies including the road overtopping, inundation of home sites and nuisance flooding.

PURPOSE

The master plan process includes an evaluation of the performance of the storm water drainage system, which can identify potential existing, and future inadequacies of the systems, and subsequent presentation of corrective action recommendations. The POA has requested that where possible any recommendations recognize how work efforts can be distributed to either, 'mini-project' categories to be performed by the POA maintenance staff, or to 'major-project' categories to be performed through general contracts. Performance of drainage improvement work will need to be planned over a multiple year schedule, as funding is secured. Improvements will be coordinated with implementation policies and procedures of Brunswick County and the North Carolina Department of Environment and Natural Resources (NCDENR) where necessary.

HDR has prepared to complete the Lockwood Folly Storm Water Master Plan (Plan) in the five following phases.

1. Data Collection/Research
2. Existing Conditions Analysis
3. Storm Water Master Plan
4. POA Coordination
5. Construction Implementation

Phases 1 and 2 are substantially complete. The results and information obtained thus far are summarized in this Technical Memorandum. HDR is prepared to initiate work on Phase 3, Storm Water Master Plan, upon direction from the POA's Storm Water Management Committee.

PHASE 1 – DATA COLLECTION AND RESEARCH

The purpose of the data collection and research phase is to obtain any existing construction drawings and plans or other available datasets that will assist in developing and documenting baseline system mapping. A summary of the findings of these tasks is presented below.

Field Data Collection

In June 2006, HDR spent two days in Lockwood Folly collecting data to support the assessment of the existing drainage system and the development of planning level recommendations. HDR provided a senior engineer and a project engineer to collect general locations of drainage pipes that will be key for modeling purposes, and information on ponds (i.e. outlet structures, overflow conditions, and observed structure deficiencies), and confirm the overall direction of storm water runoff. This information was collected using a handheld GIS/GPS data collector that recorded location to within a 3-foot horizontal accuracy, and recorded text information (attribution) on the pipes (such as pipe size, material, and condition). No vertical elevation was recorded at this time.

Following this effort, HDR assisted the POA with contracting a professional surveyor to place vertical benchmarks throughout the community, and to provide vertical elevations on the pond features necessary for hydraulic model development. It is the intention that the POA can use the benchmarks for future construction of drainage and other utility improvements. Figure 1 provides a Base Map of the Lockwood Folly community.

Observations of the drainage pipe systems and inlets indicated that the systems are functioning well in general. Some disrepair was noted and included culvert failures under pavements and pavement subsidence and cracking above the culvert, which can indicate loss of soil around the pipe.

- There are locations where the lower portion of a galvanized or corrugated pipe has corroded causing a source of "blow-outs". This distress mode occurs when storm water exiting these holes begins to wash away the surrounding soil leaving an area of unstable soil or causing a cavity. This soil loss can propagate upward to the surface and cause a sinkhole. This was evident at Clubhouse Drive and Lockwood Lane.
- Several ponds do not have a primary outlet control device or an emergency overflow spillway. This can lead to an excess accumulation of runoff in the pond causing flooding in the area. Additionally, uncontrolled flow over an unprotected embankment can cause, if not maintained, eroding of the embankment and possible breaching of the pond.
- The overall community from its highpoints to the outfalls near the inlet and River exhibits significant topographic relief for a coastal community. There appears to be at least 20 feet of elevation change within Lockwood Folly. HDR will consider the elevation relief when examining solutions for creating positive drainage for areas with no current outfall or primary spillway.

HDR understands that a pipe-cleaning program has not occurred since the main infrastructure was constructed 15 years ago. Several pipes were observed to have at least one-third of its depth filled with sediment, causing significant reduction in flow capacity. This in turn can cause upstream flooding until

the depth of water is sufficiently high to force the water under pressure through the system. Pipes in need of cleaning have been recorded on a previously submitted map to assist you in locating these areas.

Immediate Corrective Action Recommendations

During the data collection process, HDR observed conditions of the drainage system and evidence of past problems or potential flooding to aid in the development of recommendations for immediate action. On July 6, 2006, HDR transmitted a report to the POA with the following information.

™ Pipe/Culvert Cleaning – Pipes identified on the previous map are recommended to be hydraulically jet-cleaned to remove as much of the sediment as possible. This effort will allow the flow of storm water through the pipes more efficiently, possibly allowing for less flooding on the upstream side of the culvert/pipe. Desired capacities for the drainage pipes are presently being evaluated and future recommendations may include reconfiguration, replacement, or reconstruction of the existing pipes that are to be cleaned.

™ Clubhouse Drive/Lockwood Lane Blow-out – The inlet located in the median of the roadway and the pipe exiting the inlet towards the lake should be removed and replaced. This inlet has the potential to have pipes installed to it from another area upstream (as part of our final master plan recommendations). Therefore, if this area does not get any worse, this corrective action should be delayed to allow for implementation of other upstream master plan recommendations.

™ Temporary Pumping of Pond Areas – Several ponds that exhibit no positive drainage or outlet system will flood in moderate to severe storm events. These ponds have the potential to back storm water up and across streets or cause flooding of nearby structures (excluding yard or nuisance flooding) and should have means to discharge to a nearby pond or positive drainage system. The POA reports the community has used portable pumps in the past. Until a final recommendation is developed, the practice of temporary pumping should be continued. The ponds that, in our opinion based on limited visual observations, appear to provide the highest degree of risk include the following:

- Pond #12 – On Marina Drive near Genoe's Point Road (water appears to be trapped on the north side of the roadway and is not able to enter the pond).

  Pond #13 – At 17th Green (pond has no primary outlet, and the area east of Lockwood Lane and south of Bogie Court is trapped in the roadway and is not able to enter the pond). Pumping from this pond may be necessary depending on rainfall and remaining storage capacity.

  Pond #21 – The pond has a pipe outlet to a low area near the 4th Tee, which then overflows Marshview Drive potentially obstructing access for emergency and other vehicles to Marshview and Purple Finch. Temporary pumping to pond near Fairway 3 Court is a short-term solution; however, it compounds the problems occurring at the ponds on Fairway 3 Court.

  Ponds #16, #17, and #18 – The two upper ponds located at Fairway 3 Court are connected to the lower pond by a small outfall pipe. They have only a limited storage available and the capacity of the pipe is easily exceeded. As a result, Fairway 3 Court becomes frequently flooded. Although this area has not been modeled yet, it is recommended to install double 18 inch corrugated plastic pipes with control boxes on each end.

™ Future Home Construction Practices – Providing for positive drainage around each lot will aid in the reduction of nuisance flooding as well as help reduce long-term issues with pavement failures. During construction of new homes, it is recommended that the builder be required to have perimeter swales to allow off-site drainage to flow around the new house, maintaining its existing flow path downstream. Furthermore, the requirement of a roadside swale and properly sized drive culverts will

allow road runoff to collect away from the pavement and direct it eventually to an outfall point. Use of the Brunswick County standard details should be applicable to these areas.

- All existing swales should be inspected to identify and eliminate any observed blockages due to sedimentation or overgrowth of vegetation. These swales need to be on a scheduled maintenance to ensure flow efficiencies are kept. This maintenance may include mowing, cleaning of sediment deposits, clearing obstructions, and limiting regrading projects.

It is understood that some of this work could be performed by the POA maintenance staff or the Golf Course maintenance crew. HDR would recommend contracting for any jet cleaning of the pipes as this might require equipment rental and traffic control measures. These recommendations should be considered as maintenance staff and financial resources are available, as well as based on the anticipation of severe or prolonged rainfall periods.

NCDENR Coordination

On September 5, 2006, HDR met in the Wilmington Regional Office with NCDENR representative Linda Lewis. The purpose of this meeting was to understand NCDENR perspectives regarding the recommendations to ensue from this Project and receive guidance on any required permitting and approval process. Several of Ms. Lewis's comments are summarized below:

- Storm water drainage system improvements may use existing piped outfall structures.
- New outfalls, if constructed, must be non-structural (i.e. grassed swales) and maximize potential for sheet flow and infiltration.
- Storm water drainage system improvements would require only a Plan Revision since densities are not being reallocated nor are additional built upon areas being created.
- The Plan Revision process requires a cover letter and two copies of the plan and details for the improvements.
- Changes in roadway coverage or creation of new built upon areas would trigger the Permit Modification process.
- Operation and maintenance activities on outfalls may require CAMA or 404/401 wetland permitting requirements.

PHASE 2 – EXISTING CONDITIONS ANALYSIS

The purpose of the existing conditions analysis phase is to establish a baseline performance of the storm water drainage system under existing operating conditions. First, the data collected in the initial phase is incorporated into a representative network of the storm water drainage system and contributing drainage. Using a hydrologic-hydraulic model, problem areas, such as pond, road overtopping or yard and home flooding, can be simulated in the future development. The findings of these tasks are summarized in this section.

Hydrologic and Hydraulic Modeling

Lockwood Folly, being located within close proximity to the Atlantic Ocean coast, experiences many challenges regarding effective storm water management. Tidal influences along the Lockwood Folly Inlet and River may create tailwater conditions at low-lying outfalls resulting in backwater effects into interior drainage systems. Additionally, minor relief in coastal topography and the presence of depressed areas produce situations of significant flooding and reversed flow. To evaluate systems under these conditions, a hydrodynamic routing model, such as ICPR (Inter-Connected Pond and Routing model)

must be used to account for the rapidly changing conditions. ICPR incorporates traditional hydrologic processes with dynamic hydraulic functions. These functions include the use of downstream boundary conditions like tailwater effects at sea-level outfalls and bi-directional solution processes to account for reversal in flows. ICPR has been used in many coastal applications along the Carolinas and has received approval from FEMA for flood insurance related studies. Therefore, HDR chose this model to perform the hydrologic and hydraulic modeling.

Model Development

Individual ICPR models were developed to represent the ponds and storm water systems that drain to 14 outfall areas surrounding the Lockwood Folly community. An additional model was developed for a series of ponds on the west side of the community, which appeared to have no apparent outfall. For each watershed draining to an outfall, sub-basins were delineated for distinct storm water drainage systems and identified points of analysis (i.e. ponds, roadway crossings, inlets, etc). Sub-basin characteristics used in generating runoff, such as SCS curve numbers, drainage areas, and times of concentration, were estimated using GIS datasets for soil type, land use, and topography. Storm water drainage systems were modeled as a series of open channels, pipes, weirs, swales, and temporary and permanent (i.e. ponds) storage areas. Survey data on structure inverts, overflow elevations, and water surface elevations were incorporated into system characteristics where provided. Other operation data, such as storage volume, weir width, and channel lengths and slopes were estimated using topographic GIS dataset. The accuracy of the model results is heavily dependent on the accuracy of the data being used. This project is using existing mapping, and limited survey data along with engineering judgment. Figure 2 displays the modeled system and sub-basins. Several assumptions were made to streamline the model development process and progress beyond the shortcomings of the available data. Several assumptions for developing the model are listed on the next page.

- ™ Ponds where assumed to have vertical side slopes when field assessment data or photos did not indicate otherwise. This results in higher flood stages at ponds and likely more overflow than what may occur.
- ™ Open channels connecting piped sections of storm water drainage systems were given a simple geometry to establish connectivity with the system.
- ™ Most piped systems were modeled with an overflow weir to release excess storage downstream. This assists in evaluating overtopping of roadways, fairways, and cart paths, where problems have been documented.
- ™ Storage areas behind culverts and pipes and on top of drop inlets were given a consistent, small storage volume unless indicated otherwise by field assessment data or photos.
- ™ Depressed areas, which may not have positive drainage out of the community, were incorporated into other outfall models that presented a potential opportunity for connection.
- ™ The land use dataset represents a final platted community. Therefore, modeling under this land use constitutes a build-out scenario if development occurs as planned.
- ™ These assumptions allow the ICPR models to run sufficiently and approximate known and expected problems. The characteristics of these systems and assumptions may be refined further in the next Phase as additional or improved data is obtained.

Model Results and Validation

The existing conditions analysis serves to simulate the performance of the current storm water drainage network under various precipitation events that would provide flooding conditions suitable for potential improvement. The ICPR model was executed for the 25- and 50-year, 24-hour design storms, which

have rainfall depths of 8.62 and 10.12, respectively. An SCS-type III rainfall distribution was used which results in lower peaks but maintains the same volume as other distributions. SCS-type III distribution is typical for coastal environments. Model results, such as maximum stages at storage areas behind inlet structures and ponds, were recorded. The maximum stages were translated into approximate spatial limits of flooding or overtopping which results in golf, yard, roadway, and structure inundation. The locations of these overtopping occurrences, their approximate limit of effect, and parcels identified as being affected are graphically depicted in Figure 3. Tabular results are included on the Figure.

Models can be calibrated with noted historical field evidence when data are available. Calibration of this model was made to general reported occurrences of whether flooding, road overtopping, ponding was noted to have occurred at any past times. Model results of the existing conditions analysis can be compared with data collected from Lockwood Folly residents. Figure 3 displays the results of the neighborhood assessment for comparison.

RECOMMENDATIONS FOR MASTER PLANNING

The existing conditions analysis provided an indication of inadequate facilities and their resulting impact to flooding of road, structures, yards, and the golf course. Phase 3 of this Project, Storm Water Master Plan, will include the analysis of up to two alternatives for mitigating these impacts. Since many impacts exist, HDR has aggregated several correlated problems together for prioritization of the master plan efforts. Several criteria were established to assist in identifying the most significant impacts and reducing the list to a suitable set for alternative analysis. The following criteria were used to prioritize focus areas to meet this objective.

A. Potential flooding may cause disruption to passage of emergency vehicles on roadways.
B. Potential flooding may cause damage to homes, roads, and golf course facilities.
C. Potential for mass (i.e. flooding of driveways, patios, overland conveyance through yards).
D. Potential for nuisance flooding associated with ponding in yard and golf course.

The aforementioned criteria are important in the initial identification of the most significant problems; however, additional measures were considered in the prioritization. Among these measures include the potential for downstream flooding as a result of the improvement, the correction of several parallel problems, the overall cost of the improvement versus the benefit gained, and the ability to obtain easements for the improvements (i.e. public support) among other measures. The following focus areas have been prioritized for future alternative analysis and master planning.

Those areas that met the highest priority A:

- Clubhouse Road and Channel Side Drive Area involving systems upstream and downstream of Pond #14.
- Fairway #3 Court Area involving Ponds #16, #17, and #18.
- Clubhouse Drive Area involving Pond #23 and downstream systems.
- Clubhouse and Facilities Area at the end of Clubhouse Road
- River Road Area at 15th Fairway involving Pond #1 and upstream system.
- Channel Side Drive Area near 1st Hole.
- River Road Area at 18th Fairway involving upstream systems and Pond #13.

Those areas that met priority B:

™ South Fairway Circle at Lockwood Lane Area involving Ponds #3 and #14.
™ River Road Area at 16th and 17th Hole involving Ponds #9, #10, and #28.

Those areas that met priority C:

™ Oyster Shoals at River Road Area systems.

Those areas that met tpriority D:

™ Fairway #4 Court Area involving Ponds #19, #20, and #21.
™ Lockwood Lane at East Lakeview Drive Area systems.

Figure 4 depicts the focus areas and recommended prioritization. The POA and Storm Water Management Committee may decide to reallocate a prioritization given other knowledge or other extenuating circumstances. If the prioritization of focus areas meets the needs of the POA and Committee, HDR is prepared to initiate Phase 3 of the master planning effort.

Tabular Results from ICPR Modeling

PID	OUTFALL	LOCATION	STRUCTURE TYPE	CONTROL ELEVATION (FT)	25-YEAR ELEVATION (FT)	50-YEAR ELEVATION (FT)	25-YEAR OVERTOPS	50-YEAR OVERTOPS
P-1	A	Pond 25	POND	12.21	12.04	12.79		Y
P-2	B	Pond 16	POND	17.59	19.67	20.13	Y	Y
P-3	B	Pond 17	POND	18.95	19.58	20.00	Y	Y
P-4	B	Pond 18	POND	16.39	17.03	17.54	Y	Y
P-5	B	Cart path below Pond 18	P-IN	7.80	7.91	8.95	Y	Y
P-6	C	Pond 23	POND	16.04	16.83	17.21	Y	Y
P-7	C	Cart path below Pond 23	P-IN	9.50	11.12	11.97	Y	Y
P-8	None	Pond 6a	POND	24.57	24.45	25.04		Y
P-9	None	Pond 6b	POND	21.50	24.45	25.04	Y	Y
P-10	None	Pond 22	POND	24.00	24.69	25.04	Y	Y
P-11	D	Pond 24	POND	9.60	9.43	9.76		Y
P-12	D	East of Channel Side Drive	DI	11.50	12.72	13.04	Y	Y
P-13	D	Below Pond 14	P-IN	11.50	12.77	13.12	Y	Y
P-14	D	Pond 14	POND	13.95	14.86	15.29	Y	Y
P-15	D	North of Clubhouse Road and Lockwood Lane	LOW	19.50	19.58	20.05	Y	Y
P-16	D	Pond 15	POND	17.85	19.95	20.48	Y	Y
P-17	E	Culvert under driveway	C-IN	7.00	8.07	8.27	Y	Y
P-18	E	East of Channel Side Drive	C-IN	7.00	8.70	9.15	Y	Y
P-19	F	Pond 26	POND	6.08	7.49	7.76	Y	Y
P-20	G	Pond 8	POND	11.16	10.09	10.46		
P-21	G	Clubhouse Parking Lot	DI	10.50	11.54	11.94	Y	Y
P-22	H	Pond 13	POND	17.00	16.10	16.61		
P-23	H	Pond 12	POND	15.02	14.22	14.80		
P-24	H	South of 18th Tee	P-IN	14.00	13.78	14.16		Y
P-25	H	South of Pond 12	LOW	12.50	12.24	12.44		
P-26	H	West of Genoes Point Road	LOW	11.00	12.24	12.44	Y	Y
P-27	I	Pond 28	POND	10.05	10.34	10.60	Y	Y
P-28	I	To Pond 9	DI	9.50	9.29	9.58		Y
P-29	I	Pond 9	POND	7.80	8.61	9.04	Y	Y
P-30	I	Pond 10	POND	6.46	7.38	7.81	Y	Y
P-31	J	Interior side of Myrtle Court	DI	5.40	5.75	6.17	Y	Y
P-32	J	Pond 11	POND	7.06	6.58	7.16		Y
P-33	None	Pond 5	POND	24.57	23.07	23.67		

Tabular Results from ICPR Modeling Continued

PID	OUTFALL	LOCATION	STRUCTURE TYPE	CONTROL ELEVATION (FT)	25-YEAR ELEVATION (FT)	50-YEAR ELEVATION (FT)	25-YEAR OVERTOPS	50-YEAR OVERTOPS
P-34	K	Pond 4	POND	20.58	21.13	21.48	Y	Y
P-35	K	South corner of Lockwood Lane	LOW	20.67	21.85	22.05	Y	Y
P-36	K	West of Fairway Circle	DI	18.80	19.13	19.26	Y	Y
P-37	K	Pond 3	POND	16.34	16.82	17.12	Y	Y
P-38	K	Cart path below Pond 3	C-IN	15.00	15.25	15.81	Y	Y
P-39	K	West of River Road	LOW	7.50	8.67	8.99	Y	Y
P-40	K	Pond 2	POND	24.37	23.61	24.22		
P-41	K	West of Eagle Court	P-IN	13.30	13.53	13.83	Y	Y
P-42	K	West of Fairway Circle near Eagle Court	LOW	19.00	20.65	21.09	Y	Y
P-43	K	West of Birdie Court	LOW	24.00	24.63	24.91	Y	Y
P-44	K	Pond 1	POND	6.99	9.05	9.71	Y	Y
P-45	L	West of Oyster Circle near River Road	P-IN	8.00	8.84	9.08	Y	Y
P-46	L	West of River Road near Oyster Shoals	P-IN	8.00	9.58	9.85	Y	Y
P-47	M	South of River Road	C-IN	17.50	19.12	19.44	Y	Y
P-48	N	End of unnamed street near Pond 7b	P-IN	31.10	32.67	32.77	Y	Y
P-49	N	Across the 7th Fairway	P-IN	26.30	27.22	27.54	Y	Y
P-50	N	Pond 7a	POND	28.44	25.55	25.89		
P-51	N	Pond 7b	POND	25.69	26.08	26.42	Y	Y
P-52	None	Pond 19	POND	26.63	24.68	25.16		
P-53	None	Pond 20	POND	25.23	23.67	24.50		
P-54	None	Pond 21	POND	25.63	24.36	25.03		
P-55	None	Across the 4th Fairway	P-IN	24.19	24.79	25.70	Y	Y
P-56	None	Into Pond 21	P-IN	24.06	24.79	25.70	Y	Y