Engineering Report
SCHH Phase 5 Stormwater System

By: Timothy J. Doyle, P.E.
January 16, 2009

Background

Sun City Hilton Head Phase 5 construction began in 2005. As portions of the community were completed and residents moved in, many became concerned about the design and construction of the stormwater management system after observing apparent problems. Since I have had several years experience with the design and construction of similar stormwater management systems, I volunteered to review and analyze certain documents which were obtained from regulatory agencies. My analysis is based on the following items:

1. Construction Plans for Argent 3, Blocks 61-66 (released for construction on 5/11/2005) and Construction Plans for Argent 3, Blocks 68, 69, 71 & 72 (released for construction on 8/22/2005) (official permit exhibits on file with DHEC); and
2. As-built Record Drawings dated 7/8/2008.

These plans and drawings were prepared by Thomas & Hutton Engineering Company. Item No. 1 documents the design of the stormwater system as approved by the South Carolina Department of Health and Environment Control (DHEC). Item No. 2 documents what was actually constructed. A comparison of the two items, supplemented by field inspections, revealed a number of construction deficiencies that are discussed in this report.

This report includes the issues of pond depth deficiency, rip-rap overflow failure, erosion and wetland impacts, which I believe are the most important considerations with respect to design and construction standards of care.

For clarity, the water bodies mentioned herein are stormwater detention ponds; they are not “lagoons” in the classical sense. Therefore, I call them ponds in this report.

Pond Depth Deficiencies

The approved Construction Plans indicate the bottom of each pond is to be a minimum of 5 feet below the pond’s normal water level (NWL); some ponds were designed to be deeper, up to 5.7 feet (Table 1). The developer should be required to provide these pond depths for the following reasons:

1. The pond depths are documented on the approved Construction Plans.

2. The design is consistent with DHEC guidelines that call for average pond depths between 4 and 6 feet. Considering the shallower areas near the shorelines, the design average depths for the Phase 5 ponds should have been between 4 and 5 feet, depending on pond size.

3. Pond depth is an important design parameter in order to achieve water quality function. Research has shown that stormwater treatment in wet-detention ponds is achieved by various physical, chemical and biological processes in the water column; and sufficient depth is required to keep sediments from re-suspending during storm inflows. The approved design, having pond bottoms 5.0 to 5.7 feet below control levels, is consistent with this requirement.

4. During a recent survey conducted on Pond L-178, littoral vegetation planted along the shoreline was found to have propagated across the entire pond in water depths up to 4 feet. This proliferation of vegetation is unsightly and objectionable. It is unlikely that this would have happened in water five or more feet deep.

As indicated in Table 1, there are 32 stormwater ponds in Phase 5. The As-built Record Drawings indicate that 19 ponds have as-built NWLs below their design levels; elevation deficiencies range from 0.2 feet to 2.0 feet. These deficiencies were the result of improper construction. Many control weirs were built too low, and several wetland overflows have eroded. In one case, a weir that was supposed to have been installed was not constructed at all. This weir was to be provided at the pipe connection between Ponds L-159 and L-162. Because of pond interconnectivity, this omission has resulted in the NWLs of nine ponds being 1.3 feet below design level.

After careful examination of the as-built bottom contours, I conclude that 27 of the 32 ponds in Phase 5 do not meet the 5.0 to 5.7 foot depths indicated on the approved Construction Plans (Table 1). The reasons are two-fold: One, low or missing control weirs. Two, many pond bottoms are higher than design; either they were not excavated deep enough during earthwork operations or excessive sedimentation has occurred during subsequent construction.

To illustrate the problem, I examined a sampling of ten ponds in detail by computing their mean depths using conventional computational methods (volume ÷ surface area). I computed the volumes of the ten ponds using the average-end-area method, pond bottom contours shown on the As-built Record Drawings, and a polar planimeter to measure areas at each contour. As indicated in Table 1, five of the ten ponds have mean depths less than three feet; one pond (L-164) has a mean depth of less than two feet. These depths are clearly unacceptable.

I recommend two remedies. First, all NWLs should be restored to the levels shown on the approved Construction Plans by installing the missing weir and by repairing or replacing other control structures. With these levels restored, any remaining non-compliant ponds should be modified by dredging to achieve the depths shown on the approved Construction Plans.

Rip-Rap Overflow Problems

Table 1 lists seven ponds that have discharge structures known as "rip-rap overflows." The structures are supposedly designed to hold water at specified levels (NWLs) and to allow excess stormwater to flow into adjacent wetlands. As indicated, six of the seven overflows have failed to retain water at their respective design normal water levels (NWLs). The as-built NWL deficits range from 0.2 to 2.0 feet. One pond (L-161) has held its design NWL, but its overflow is much different from the other six.

Design details for these overflows have not been disclosed (they are not shown on the Construction Plans), but observation of two of the overflows indicate design and/or construction deficiencies. Soil berms adjacent to the overflows are insufficient in width and height and are not protected from erosion. During periods of high water (after rainfall events), water has seeped through the berms resulting in eroded channels that allow the water to drain down to levels below the design NWLs. In each case, the rip-rap overflow structure protects only a relatively short section of the pond bank. Typically, hundreds of feet of pond bank outside of the riprap are exposed to overflow without erosion protection.

I recommend the pond banks exposed to erosion damage must be protected. Possible remedial measures include: 1) Raise exposed banks using engineered embankments or sheetpile walls to provide at least 0.5

feet of freeboard above 100-year water level as required by DHEC; 2) extend erosion protection (such as rip-rap or other measures) over all exposed banks where water would overflow up the 100-year level, or 3) provide hardened outfall structures such as discharge pipes and bubbler boxes along with raised embankments.

Erosion

Three erosion problems were observed during field inspections:

1. South Bank of Pond L-153. The slope of the road embankment adjacent to the pond appears to be too steep, and sheet erosion has caused considerable sediment flow into the pond.

2. North Bank of Pond L-181. Large volumes of runoff from the adjacent wetland have caused severe gully erosion in several locations resulting in sediment accumulation in the pond.

3. Northeast Bank of Pond L-183. Similar to the condition at Pond L-181, runoff from the adjacent wetland has caused gully erosion. In this case, the gully was lined with rip-rap some months ago. However, over time erosion has taken place under the rip-rap causing the stone to subside and eroded subsoil to enter the pond.

Wetland Impacts

The SCHH community was developed upon forested upland areas adjacent to forested wetlands. As required by regulations, the wetlands were not developed. The hydrology of the uplands was drastically altered during development, changing the vegetative cover from woods to urban. Instead of forests, we now have pavements, rooftops and lawns which greatly increase stormwater runoff volumes from those areas.

In the older sections of SCHH developed prior to 2003, stormwater runoff from about half of the development was directed to stormwater ponds that are interconnected to a single outfall to the New River, thereby bypassing the wetlands. Runoff from the other half is directed to wetlands. Overall, the volume of runoff to the wetlands is about the same as that which existed before development. These wetlands remain healthy and vibrant.

The stormwater system design concept for the areas of SCHH developed after 2003 is much different. All of the stormwater runoff for the newer areas is directed to wetlands; none of it is bypassed to the river as was done in the older areas. Thus, the wetlands in Phase 5 and other recent phases are being seriously impacted because the volume of runoff has drastically increased. The result is permanent flooding of forested wetlands and dying off of hardwoods and other vegetation. This is clearly evident in the wetland area immediately east of the Hidden Cypress Recreation Center. The die off is beginning to show in the wetlands downstream and can be seen from Col T Heyward Blvd and Bishop Street; another section of die off is evident south of Red Dam Road east of the sports activity area. The problem is exacerbated by road crossing embankments that tend to prevent proper drainage from upstream areas. The developer has added cross drains at Hidden Cypress Lane and Col T Hayward, but the die off continues. At Red Dam Road, the cross drain pipe has been found to have been set too high and should be lowered to relieve upstream drainage.

To prevent further die off in the wetlands south of Red Dam, some stormwater runoff needs to be diverted from the wetlands. Since the stormwater system is already designed and constructed with agency approval, it is unlikely any changes will be made in SCHH. For future developments in South Carolina, DHEC should adopt regulations to require developers to include in their permit applications wetland assessments that estimate pre-development runoff volume estimates. The stormwater systems would then be designed to maintain wetland hydration to match the pre-development estimates. This can be done by diverting excess runoff volumes away from wetland areas (as was done in the older sections of SCHH). This is the approach that other states have taken which has resulted in preserving, rather than destroying, existing wetlands that coexist with developments.

Recommendations

1. Normal water levels (NWLs) for all ponds should be restored to the levels shown on the DHEC-approved Construction Plans.
2. When these NWLs are restored, any remaining non-compliant ponds should be modified to achieve the depths shown on the DHEC-approved Construction Plans.
3. For the six ponds with failed rip-rap overflows, the banks exposed to erosion damage must be protected with adequate embankments (with freeboard) or other erosion protection.
4. The three listed erosion problem areas need to be addressed.
5. DHEC should adopt regulations to control post-development runoff volumes to wetlands to match pre-development hydration rates. Its not too late to save the wetlands in the Jasper County portion of SCHH.

Table 1 – Analysis of Existing Stormwater Pond Conditions

Pond Number	Design NWL (1)	Design Pond Bottom Elevation	Bottom Depth below NWL	As-built NWL	NWL Deficiency	Mean Depth (Ft)	Deficient in Depth (2)	Rip-rap Overflow Failure	Comment
L-149	12.70	7.70	5.00	12.70			?		As-built info missing
L-150	12.20	7.20	5.00	11.78	0.42		X		Sides slopes too flat
L-151	14.00	9.00	5.00	13.56	0.44		X		
L-152	14.80	9.80	5.00	14.90					
L-153	15.90	10.90	5.00	16.19		2.22	X		
L-154	17.00	12.00	5.00	17.04			X		
L-155	14.00	9.00	5.00	12.70	1.30		X		
L-156	11.40	6.40	5.00	11.31	0.09	4.10	X		N end shallow
L-157	12.00	7.00	5.00	10.40	1.60	3.96	X	X	
L-158	14.00	9.00	5.00	14.01			X		
L-159	14.00	8.50	5.50	12.70	1.30		X		E & W portions shallow; weir missing
L-160	12.00	6.30	5.70	10.92	1.08		X		
L-161	12.70	7.50	5.20	12.70					W portion shallow
L-162	12.70	7.70	5.00	12.70		4.10			NW portion shallow
L-163	14.00	9.00	5.00	14.01		2.89	X		
L-164	14.00	9.00	5.00	12.00	2.00	1.97	X	X	
L-165	8.50	3.50	5.00	8.00	0.50			X	
L-166	14.00	9.00	5.00	12.70	1.30		X		Sides slopes too flat
L-167	14.00	9.00	5.00	12.70	1.30		X		
L-168	14.00	9.00	5.00	12.70	1.30		X		Back-door Bubbler
L-169	14.00	8.50	5.50	12.70	1.30		X		
L-171	14.00	8.50	5.50	12.70	1.30		X		
L-172	15.00	10.00	5.00	15.12		2.56	X		
L-173	14.00	9.00	5.00	13.80	0.20	3.33	X	X	Sides slopes too flat
L-174	14.00	8.50	5.50	12.70	1.30	2.28	X	X	
L-175	15.00	10.00	5.00	14.40	0.60		X	X	
L-176	16.00	11.00	5.00	16.09			X		
L-178	17.00	12.00	5.00	15.54	1.46		X		Discrepancies: NWL, As-builts
L-179	12.70	7.70	5.00	12.70		3.45	X		
L-181	14.00	9.00	5.00	12.70	1.30		X		N bank slope too flat
L-182	15.00	10.00	5.00	15.12			X		Bottom contour flags missing
L-183	15.00	10.00	5.00	14.40	0.60		X		

Notes: 1 – Normal Water Level as shown on DHEC approved Construction Plans; also known as Top of Conservation Pool.
2 – Deficiency determined by comparing Construction Plans with As-built Record Drawings.

Evaluation of Del Web Phase 5 Lagoon Maintenance Items dated December 18, 2008

The developer presented the referenced document in a meeting with residents on December 19, 2008. The document includes repair of eleven control structures to maintain design normal water levels (NWLs), the installation of the missing control weir at Pond L-159, and dredging of seven ponds. The proposed actions are summarized in Table A-1. These steps will go a long way toward correcting observed construction deficiencies. However, in my opinion, several issues remain which should be addressed as discussed below.

Pond Depth Deficiencies

In the December 19 meeting, Thomas & Hutton explained that the seven ponds would be dredged to achieve four feet of depth rather than a minimum of five feet as shown on the approved Construction Plans. When asked why four feet instead of five, they provided the following answer:

> *While the construction drawings show ponds will be a minimum of 5 feet deep, there is an allowance for one foot of sediment accumulation during construction. Therefore, T&H considers four feet average depth as being adequate as it meets DHEC's regulatory guidelines (average depth between 4 and 6 feet). For this purpose, average depth is defined for the areas of each pond over the bottom, while shallower sections at side slopes are not included in the definition.*

In a subsequent meeting, I was told that the one-foot-of-sediment assumption is not specifically documented on the construction plans or in the DHEC permit application, nor is the method for computing average depth which ignores shallow portions at side slopes. Thomas & Hutton engineers said that it is normal to expect sediment runoff during construction from disturbed areas up to a rate of 67 cubic yards per acre. They admitted that the construction plans specifically require silt barrier or sod around all ponds during construction, but that no sediment control method is 100% effective. The net result, they said, would be an average of about one foot of sediment accumulation in each pond.

Based on my 40 plus years experience with civil engineering construction including stormwater systems, I have two issues with the forgoing interpretation of the construction plans.

- First, facility configurations shown on construction documents should represent conditions at the *end of construction*, unless the plans state otherwise. Since pond sediment accumulation was anticipated during construction, the developer should have excavated the ponds deeper to accommodate the sediment so that the ponds would end up at the depths shown on the plans at the conclusion of construction.

- Second, I disagree with T&H's unusual method for computing average depth. Ignoring shallow portions of a pond does not represent a true average. While DHEC does not specify how to compute this parameter, a conventional method should be used. When there are uneven bottom contours, the normal method for computing average or mean depth is to divide total pond volume by surface area.

Table A-1 includes the results of computing average or mean depth of several ponds using conventional methods. I believe DHEC guidelines should be the basis upon which to judge whether the ponds will have adequate depth. Assuming a pond is 5 feet deep over its bottom, its average depth will be less than 5 feet based on conventional calculations. Depending on the pond size, most should meet the 4-foot depth requirement. Therefore, DHEC guidelines should be followed and a minimum of 4-foot average depth should be enforced which requires a 5-foot depth over the bottom.

Using that criterion, Table A-1 indicates there will be 16 ponds that will not meet the 4-foot-average-depth guideline *after* the "maintenance items" are implemented. (There is one pond for which no as-built bottom contours have been provided.) Even if the seven ponds to be dredged were excavated to the 5-foot depth over the bottom as shown on the construction plans, there will still remain 9 ponds that will not comply with the DHEC depth guideline.

Rip-Rap Overflow Problems

Table A-1 lists five overflows to be repaired.

Erosion

Three erosion problems listed in the main report have not been addressed in the current "maintenance" list. These problems need to be addressed.

Wetland Impacts

As expected, the problem of wetland vegetation die off is not addressed in the current plan. Adjustment to the cross drain pipe at Red Dam Road, an obvious fix, is not included either.

Recommendations

1. DHEC should apply its pond-depth guidelines to the ponds selected for dredging. Instead of dredging to a four-foot bottom (which results in an average depth of less than four feet), dredging should proceed to a five-foot bottom as shown on the approved construction plans.
2. Further, DHEC should add to the dredge list the other nine ponds that do not meet the depth guidelines.
3. The rip-rap overflow at Pond L-165 should be added to the repair list.
4. The three erosion problems should be added to the repair list.
5. The Red Dam Road cross drain should be adjusted to relieve flooding upstream.

Table A-1 – Analysis of 12/18/2008 Del Web Phase 5 “Lagoon Maintenance Items”

Pond Number	NWL Deficiency (1)	Modifications Proposed by 12/18/08 Plan				After Proposed Modifications		
		Concrete Control Structure	Rip-rap Overflow	Restored NWL	Dredge Pond	Mean Depth (Ft)	Deficient in Depth (2)	Comment
L-149						?	?	As-built info missing
L-150	0.42	Repair		12.20		3.33	X	Sides slopes too flat
L-151	0.44	Repair		14.00				
L-152								
L-153					X		X	
L-154		Repair		17.00		3.84	X	
L-155	1.30	Repair		14.00				
L-156	0.09					4.10		
L-157	1.60		Repair	12.00		4.03		
L-158								
L-159	1.30	Install		14.00				E and W portions
L-160	1.08	Repair		12.00				
L-161								W portion shallow
L-162						4.10		NW portion shallow
L-163						2.89	X	
L-164	2.00		Repair	14.00		1.97	X	Requires embankment
L-165	0.50							Need to repair overflow
L-166	1.30			14.00		3.46	X	Sides slopes too flat
L-167	1.30			14.00		3.21	X	
L-168	1.30			14.00				
L-169	1.30			14.00				
L-171	1.30			14.00				
L-172					X		X	
L-173	0.20		Repair	14.00		3.92	X	Sides slopes too flat
L-174	1.30		Repair	14.00	X		X	
L-175	0.60		Repair	15.00	X		X	
L-176					X		X	
L-178	1.46	Repair		17.00				
L-179						3.45	X	
L-181	1.30			14.00		3.21	X	N bank slope too flat
L-182					X		X	
L-183	0.60			15.00	X		X	

Notes: 1. Distance in feet that normal water level is below design.
2. Average depth less than DHEC 4-foot guideline. For ponds to be dredged to a 5-foot depth over the bottom, average depth will be less than 4 feet.