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For

The Residences at Quail Ridge
ACTON, MA

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Applicant: Quail Ridge Country Club, LLC
354B Great Road, Skyline Drive
Acton, MA 01720

Owner: Quail Ridge Country Club, LLC
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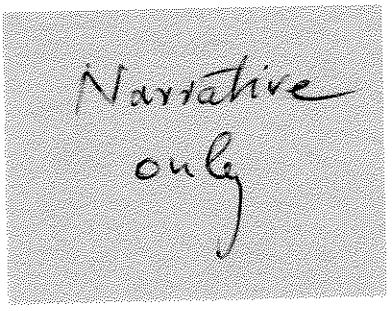
3.12 Drainage Calculations



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NARRATIVE

STORMWATER MANAGEMENT

The site is located off of Skyline Drive in Acton, Massachusetts, and is approximately 155 acres in size. The site presently contains an 18 hole golf course, family center, tennis courts, pool, parking lot and appurtenances and is known as Quail Ridge Country Club (QRCC). QRCC was not completed, since a proposed clubhouse was not built. This proposal will convert QRCC to a Senior Residence Development and will preserve 9 of the 18 holes along with the, family center, tennis courts, pool, parking lot and appurtenances. A restaurant will be added and there will be 177 residential units dispersed into 12 unit, 2 unit, and single unit buildings.

The stormwater analysis and design was performed by comparing the site prior to development to the proposed project, i.e., prior to the construction of QRCC.

The Natural Resources Conservation Service (N.R.C.S.) soil survey report for Middlesex County and associated soil maps for Acton and Boxborough indicate that soils on site consist of Scarboro mucky fine sandy loam, Wareham loamy fine sand, Whitman fine sandy loam, Charlton- Hollis-Rock outcrop complex, Hollis-Rock outcrop-Charlton complex, Hinckley loamy sand and Scituate fine sandy loam. These soils have been assigned to Hydrologic Groups D,C,D,B,C,A and C respectively.

Pre-Development

The Pre-Development Drainage Map shows conditions prior to the construction of QRCC. The surface coverage consisted of a dog kennel, wetlands, some open grass areas and primarily woods. Skyline Drive was essentially a driveway and there were three single family dwellings off of the present site. All areas have been taken into consideration in order to completely analyze the Post-Development Site.

Nagog Brook, which was found to be intermittent during the permitting of QRCC, flows through the site. Will's Hole Brook, which was found to be perennial during the permitting of QRCC, flows through the site and joins Nagog Brook prior to flowing into Nashoba Brook. All of the site runoff drains to the same point and has been analyzed accordingly.

Post-Development

The fully developed site will consist of 177 units of senior housing dispersed into 12-unit, 2-unit and single unit buildings with an associated roadway system. A small proposed parking area and mail station will serve the dwellings. The site will also contain a new restaurant building in a location that was previously slated for a large clubhouse. The existing Family Center, Maintenance Building, tennis courts, pool and parking lot will be preserved. Nine of the 18 holes will remain on the site for golf. Several detention basins and ponds will remain in place as well. Skyline Drive was improved for the QRCC project and is served by a Stormceptor unit and retention basin that will remain in place.

Compliance with Massachusetts Stream Crossing Standards

The project includes the crossing of Nagog Brook on the proposed Quail Ridge Drive at station 11+0. This crossing must comply with the Massachusetts Stream Crossing Standards. The crossing will consist of a precast Omega bridge which will span the entire stream. The bank full conditions width at the crossing was determined to be 12' as determined by field observation high water marks. The actual top of bank at the crossing is approximately 20 feet wide at it widest location. The bridge span selected is 30' in order to allow the placement of a haybale siltation barrier at the top of the bank and avoid the filling of flood plain. The bridge sections are 6' wide so seven sections are required to accommodate the required roadway cross section of 42'. The height of the box selected was 10' to allow for a 4' embedment into the existing ground. The opening must comply with the openness ratio requirement of .25 as specified in the Standards.

Openess ratio = (Height of box x Width of box)/Length of box > .25
(all calculations in meters)

Height of Box = 6'/3.28' per meter = 1.83 m
Width of Box = 30'/3.28' per meter = 9.15 m
Length of Box = 42'/3.28' per meter = 12.80 m
Openness Ratio = (1.83 x 9.15)/12.8 = 1.31 > .25 ok

The requirement for the opening of the bridge significantly exceeds sizing requirements from a hydrologic perspective. The proposed bridge will span the entire floodplain, therefore further hydraulic analysis is not needed.

Compliance with the MA DEP Stormwater Management Policy

The following describes the drainage system and the projects compliance with the Stormwater Management Policy's Performance Standards.

Standard #1 Untreated Direct Discharge of Stormwater:
No new direct discharges of untreated stormwater are proposed. Runoff from the point source will be treated with Best Management Practices (BMP) prior to discharge.

Runoff will be treated with a combination of BMP's. These include catch basins, Stormceptor units, infiltration basins, infiltration trenches, roof drain infiltration structures, water quality swales, detention basins and street sweeping. There is also and irrigation pond, Pond 3, that will receive and contain runoff from up to the 100 year storm event. This pond is lined with clay with the exception of several feet of the highest stages where runoff can infiltrate during peak water levels.

Standard #2 Post-Development Peak Discharge:
The Stormwater Management Policy requires that peak discharge rates for the 2-year and 10-year storm events not be increased from pre-development conditions. Furthermore,

the 100-year storm event will not increase flooding impacts offsite. Attenuation of peak discharge rates will be accomplished by using infiltration and detention.

The following table summarizes the peak runoff rates.

Discharge Summary Table

	2 year storm		10 year storm		100 year storm	
	Pre (cfs)	Post (cfs)	Pre (cfs)	Post (cfs)	Pre (cfs)	Post (cfs)
	33.88	33.76	126.52	112.01	302.33	257.40

Detailed calculations are attached.

Standard #3 Recharge to Groundwater:
This standard prescribes the stormwater volume that must be recharged to groundwater based on the existing site soil conditions. The Natural Resources Conservation Service (NRCS, formerly SCS) Middlesex Soils map indicated that the site contains soils in hydrologic group A,B,C and D. The Stormwater Management Policy requires 0.4, 0.25, 0.1 and 0 inches of runoff over the total impervious area to be recharged in areas with soils of respective hydrologic groups. Furthermore, the town's regulations require that the annual water budget is balanced to preserve groundwater supply. Detailed "Water Balance Calculations" showing compliance with this standard are attached.

Standard #4 80% TSS Removal:
According to the guidelines provided in the Stormwater Management Performance Standards, 80% Total Suspended Solids (TSS) removal is required for the total increase in impervious area associated with the project. This standard requires 0.5 inches of runoff from impervious surfaces to be treated when not in a critical area. All of the proposed point source discharges that will treat runoff from impervious surfaces are outside of critical areas. The following table indicates the TSS removal rates for the respective point source discharges:

Subcatchment 9,10,11,15,17,18:
Street sweeping (10%), deep sump hooded catch basins (25%), water quality swale (70%): 80% overall

Subcatchment 12,16,22:
Street sweeping (10%), deep sump hooded catch basins (25%), infiltration basin (80%): 86% overall

Subcatchment 13:
Street sweeping (10%), deep sump hooded catch basins (25%), Stormceptor (83%), detention basin (25%): 91% overall

Subcatchment 26:
Street sweeping (10%), deep sump hooded catch basins (25%), Stormceptor (80%), sediment forebay (25%): 90% overall

Subcatchment 27,29:
Street sweeping (10%), deep sump hooded catch basins (25%), infiltration basin (80%), detention basin (25%), Stormceptor (80%), sediment forebay (25%): 98% overall

Subcatchment 28:
detention basin (25%), Stormceptor (80%), sediment forebay (25%): 89% overall

Subcatchment 30:
Street sweeping (10%), deep sump hooded catch basins (25%), infiltration trench (80%): 86% overall

Subcatchment 31:
infiltration basin 80%

Subcatchment 25,32,33,34,35,36:
infiltration trench 80%

Additional treatment of runoff from impervious areas will be provided with infiltration of roof runoff from a number of the proposed buildings which will have a TSS removal rate of 80%.

Standard #5 Higher Potential Pollutant Loads:
The site is not considered to have a "Higher Potential Pollutant Load" as defined in the Stormwater Management Policy.

Standard #6 Protection of Critical Areas:
All of the proposed point source discharges that will treat runoff from impervious surfaces are outside of "Critical Area". Construction of an existing stormwater basin that is within a Zone II of a public water supply (Basin 20, which collects runoff from Subcatchment 20) will be completed since it has yet to be fitted with an acceptable outlet structure, but this subcatchment area only contains paved cart paths. This basin was part of the QRCC permit plans.

Standard #7 Redevelopment Projects:
This is not a redevelopment project.

Standard #8 Erosion/Sediment Control:
Erosion and sediment controls are incorporated into the project design to prevent erosion, control sediment movement, and stabilize exposed and disturbed soils during construction.

Temporary erosion and sedimentation controls include minimizing areas of exposed soil, directing and controlling runoff, and rapidly stabilizing exposed areas. Prior to the commencement of construction, trenched siltation fences and haybales will be placed down gradient of work areas. Stockpiled soils will be contained within siltation fence or staked haybales. Soils left exposed for extended period of time will be mulched and seeded for temporary vegetative cover. Following construction, exposed areas will be permanently vegetated with appropriate ground cover.

Erosion and sedimentation control measures will be maintained throughout all phases of construction. Inspections will be made regularly and after rainfalls exceeding 0.5 inches in a 24 hour period during construction. The contractor will be required to inspect erosion and sedimentation control measures at the end of each workday, when precipitation is forecast, and after each rainfall. All measures will be inspected prior to each weekend. The contractor will replace and repair any malfunctioning or damaged controls measures including vegetative stabilization.

Long term erosion and sedimentation control will be realized through the use of the Best Management Practices described previously. Areas where soils have been disturbed will be loamed and vegetated with lawn, trees, and shrubs.

Standard #9 Operation and Maintenance Plan:
The owner of the stormwater system will be the owner of the property. The owner will be responsible for operation and maintenance. See attached Site Plan.

Design Basis

1. The rational method (Q=CIA) was used as a basis for sizing pipes. Runoff Coefficients: C=0.15 for woods, 0.20 for grass/landscaped areas, 0.76 for gravel, and 0.9 for impervious surfaces.

2. The 100-year storm was used for sizing pipes. Rainfall intensity values were taken from the U.S. Weather Bureau Technical Paper 40.

3. The United States Department of Agriculture Natural Resource Conservation Service (N.R.C.S.) TR55 methodology was used to determine off-site rates of runoff.

4. The twenty-four hour rainfall, taken from N.R.C.S. publications, is 6.4 inches for the 100-year storm, 4.5 inches for the 10 year storm, and 3.1 inches for the 2-year storm event.

5. The hydrologic calculations were performed using the computer program: "Hydraflow Hydrographs 2007", by Intelisolve.

6. The soil types of the site were taken from the N.C.R.S. Soil Survey Map for Acton.

TABLE 2-1 HYDROLOGIC SOIL PROPERTIES CLASSIFIED BY SOIL TEXTURE*

Texture Class	Effective Water Capacity (C_w)	Minimum Infiltration Rate (f)	Hydrologic Soil Grouping
Sand	0.35	8.27	A
Loamy Sand	0.31	2.41	A
Sandy Loam	0.25	1.02	B
Loam	0.19	.52	B
Silt Loam	0.17	.27	C
Sandy Clay Loam	0.14	.17	C
Clay Loam	0.14	.09	D
Silty Clay Loam	0.11	.06	D
Sandy Clay	0.09	.05	D
Silty Clay	0.09	.04	D
Clay	0.08	.02	D

* Source: Rawls, Brakensiek and Saxton, 1982

ESTIMATING SOIL WATER CHARACTERISTICS TRANS. ASAE 1982