8.0 CONCLUSIONS AND RECOMMENDATIONS

This chapter highlights significant findings and water resource management issues, along with recommendations. The water availability findings are useful as a basis for decision making by regulatory agencies, for planning by local communities for sustainable growth, and as a guide for water resource consultants. The recommendations are intended to address critical needs for improvement or protection. In some cases, the recommended actions are not covered under existing SRBC, state, and federal programs. If they are to be implemented, the stakeholders in Morrison Cove, including municipalities, major industries, and conservation and sporting groups, must do so. With the exception of local zoning and development codes, the implementation of most of the recommendations will require some funding. Specific recommendations regarding funding sources are beyond the scope of this study. However, state and federal grants and matching funds will likely be required. Up-to-date information is available from the state and federal regulatory agencies.

8.1 Water Availability Conclusions and Recommendations

Currently permitted, registered, and approved water use from the Roaring Spring exceeds SRBC's 10-year base flow sustainability limit. This indicates that on an infrequent basis, once every 10 years on average, water use will approach and possibly exceed the amount of natural aquifer recharge received. If the preceding few years have been wetter than normal, adverse impacts will be minimal. However, if the preceding few years have been dryer than normal, then noticeable impacts and water shortages are likely. Additional water resource development would likely result in more frequent and more severe periods of potential water shortage.

Current permitted, registered, and approved water use in the Halter Creek Watershed is approximately 87 percent of SRBC's 10-year base flow sustainability limit. Once the remaining 13 percent are utilized, additional water will have to be sourced from outside the Halter Creek Watershed.

Water resources are largely undeveloped in the Yellow Creek, Clover Creek, and Piney Creek Watersheds, and in the Northern Gatesburg Terrain. Current permitted, registered, and approved water use in these basins is a small fraction of SRBC's 10-year base flow sustainability limit. In order to ensure development in a sustainable manner and with minimal environmental impact, the following recommendations are suggested:

1) Groundwater withdrawals should be located such that the strike of potential water-bearing-zones does not intercept a perennial stream located within one mile of the well. This will help prevent the direct dewatering of streams and help to ensure that the water quality is not compromised by the surface water contribution.

2) Groundwater withdrawals should be located in the downstream reaches of the watersheds. This helps ensure that there is adequate contributing area, minimizes flow-depleted stream reaches, and minimizes alteration of the natural flow regime.

3) Flows should be routinely measured and recorded at the downstream ends of the Halter Creek, Plum Creek, Clover Creek, and Piney Creek Watersheds, and at the outlets of the Roaring Spring and Williamsburg Spring. This information will allow refinement of the streamflow statistics developed in this report, and will provide a basis for evaluating the impact of future withdrawals and land use changes.

8.2 Recommendations for the Management of the Gatesburg Terrain CARAs

The Gatesburg Terrain CARAs (Critical Aquifer Recharge Areas) contain the greatest quantity and quality of groundwater available for development in the Morrison Cove. They should be managed in a manner that safeguards the quantity and quality of water available from these remarkable resource repositories. The following recommendations will help to ensure the fulfillment of these goals.

1) The quantity of water available from the Gatesburg Terrains is directly related to the amount of recharge they receive. Water resource availability in the Gatesburg Terrains should be protected through the use of development BMPs, which minimize impervious cover, and stormwater management BMPs, which address the recharge of stormwater.

2) Land use and water use in the Southern Gatesburg Terrain needs to be carefully managed in order to minimize impacts to water quality. The land in these areas is not generally suitable for agricultural activities so nitrate contamination is not a likely issue. The soil and residuum readily absorb precipitation, maximizing groundwater recharge, but provide minimal protection from surface spills.

3) Water quality in the Gatesburg Terrains should be protected by discouraging additional/new land use and activities requiring the routine use of potential chemical contaminants, and by carefully managing the existing use of potential contaminants to avoid over-application or unintended release.

4) The amount of water available for development from the Southern Gatesburg Terrain is limited by potential habitat impacts to tributaries of Yellow Creek. These are fed by 'overflow' from the Southern Gatesburg Terrain and have a designated use of HQ. When the total of all of the SRBC-approved withdrawals equals or exceeds 10 percent of 7Q10 (for each draining tributary), a passby will be required. Such water sources are then, by definition, interruptible. Passbys are used by SRBC to protect the aquatic habitat and downstream users.

8.3 Recommendations for the Management of the Roaring Spring

Current permitted, registered, and approved water use from the Roaring Spring exceeds SRBC's 10-year base flow sustainability limit. This indicates that on an infrequent basis, once in 10 years on average, water use will approach and possibly exceed the amount of natural aquifer

replenishment received. If the preceding few years have been wetter than normal, adverse impacts will be minimal. However, if the preceding few years have been dryer than normal, then noticeable impacts and water shortages are likely. Additional water resource development would likely result in more frequent and more severe periods of potential water shortage. Future water demands will need to be met from additional sources because the Roaring Spring is fully subscribed with respect to SRBC's sustainable withdrawal limit (10-year base flow).

The Roaring Spring is hydrologically connected to the Southern Gatesburg Terrain and the Yellow Creek Watershed. It represents a "natural" withdrawal (a groundwater discharge) from the Yellow Creek Watershed. Following recommendations made for protection of the Gatesburg Terrain CARAs (Section 8.2, above) will help to ensure sustainable water supplies and high quality aquatic habitat.

Care should be taken to avoid high volume withdrawals in the Gatesburg Formation outcrop area nearest the Roaring Spring in order to minimize the potential for impacting spring flow.

8.4 Recommendations for Mitigation of Nitrate Contamination

Nitrate contamination of groundwater is a major issue in the 55 percent of Morrison Cove that is dominated by agricultural land use. This longstanding problem has not been resolved through existing agricultural BMPs and manure management planning. Reduction of nitrate concentrations in the groundwater will require reduced application of manure on the land surface, either through reduced fertilization, by exporting it outside Morrison Cove, or by processing in a manure digester. Although it includes significant capital costs, the manure digester project is a long-term viable solution with many beneficial end results expected, including a reduction in nutrient loading of nitrogen and phosphorus to groundwater and streams, reduction of ammonia gas emissions, an outlet for local manure disposal, and two practical products for re-sale: soil amendment material and power.

Instream nitrate concentrations in Morrison Cove are generally below the safe drinking water standard (10 mg/l). However, all sampled streams had nitrate concentrations greater than the 75th percentile (2.3 mg/l) for all nitrate samples taken within the Susquehanna River Basin in the last five years, and a majority of nitrate concentrations are greater than the 95th percentile value (6.2 mg/l). For both groundwater and surface water, reduced nitrate concentrations and improved water quality in general not only benefit aquatic life and improve stream aesthetics through limiting excessive plant growth, but also lower water treatment costs for water suppliers. There is an effective, low cost approach to reduction of nitrate concentrations in surface waters that is neither widely used nor widely appreciated in the Morrison Cove area. The widespread use of riparian buffers would improve both stream water quality (through nitrate uptake) and benefit aquatic habitat.

Halter Creek and Plum Creek are the only two streams that have other water quality concerns in addition to the ubiquitous nitrate problem. Plum Creek and Halter Creek both have elevated concentrations of chloride, which likely result from the wastewater treatment plants

within each catchment. The lower reaches of Plum Creek also have elevated sulfate concentrations believed to be related to the large quarry that is adjacent to and along the lower mile of the stream. Additional water withdrawals would only exacerbate the concentrations of these two pollutants and as such, to protect water quality, caution should be taken when considering new withdrawal requests.

In November 2010, PADEP amended its Chapter 102 regulations in regards to stormwater management, agricultural planning, erosion and sedimentation control requirements, and riparian buffer provisions. Strengthening planning and implementation of nutrient management plans and farm conservation plans in light of these new regulations would also be beneficial in addressing the major sources of nitrate with Morrison Cove.

8.5 Recommendations for the Protection and Restoration of Stream Quality and Aquatic Habitat

In order to protect and improve the quality of the streams in Morrison Cove, the upgradient forested riparian areas surrounding headwaters should be prioritized for minimal disturbance and preservation, or targeted for protection with a set-back ordinance. A setback distance of 100-300 feet (from the streamway) is recommended (PADEP, 2010; USEPA, 2005) for optimum nitrate uptake and protection/restoration of aquatic habitat. While all of the subwatersheds in Morrison Cove have multiple reaches where the lack of riparian buffer is a detriment, the Clover Creek and Yellow Creek subwatersheds seem to have more continuous reaches of stream that flow directly through agricultural lands with little or no buffer. In these watersheds, the implementation of riparian buffer vegetation in any combination of trees, shrubs, or unmowed grasses will improve bank stability, increase flood plain connectivity and habitat, decrease scouring and erosion, and improve stream cover for biota.

Riparian areas in downstream reaches are also critical to providing form and function to stream channels, banks, flood attenuation, and the aquatic ecosystem. Riparian buffers not only act as filters along streambanks for nutrient uptake, but they also provide many other additional benefits. They help stabilize streambanks, which reduces erosion and leads to a decline in downstream sedimentation. Excessive sedimentation is detrimental to both macroinvertebrate and fish communities. All Morrison Cove streams support some level of a trout fishery, including some HQ-CWF and some reaches of Class A Trout Waters. To maintain the high quality and/or cold water fishery designations of several streams in the watershed, intact streamside riparian areas must be maintained and inadequate riparian areas should be improved. Trout communities and other cold water fish species would greatly benefit from riparian buffers as they facilitate cooler stream temperatures through shading and often provide increased instream cover via woody debris, leaf packs, and root wads. Yellow Creek in particular is well known regionally as one of the best recreational trout fishing streams in central Pennsylvania. This status could only be improved through the addition of riparian buffers along stream channels. A set-back ordinance prohibiting development within 100-300 feet of an intact riparian area should be considered for the areas where intact riparian areas remain (PADEP, 2010; USEPA, 2005). Further removal of existing riparian areas should be discouraged or prohibited.

Many valley bottom areas within Morrison Cove include lands under agricultural development. For those lands where riparian areas remain intact, streambank fencing to keep livestock out of the stream would result in protection of these areas and the functions they provide. However, site visits have noted that many riparian areas in this setting have been cleared or thinned throughout these lands. As riparian areas are lost, the functions and benefits they provide are lost. In agricultural lands, the most significant results of riparian area loss are increased streambank instability, flooding, dissolved nutrients, turbidity, and siltation.

Several Morrison Cove subwatersheds are listed on PADEP's 303(d) list as impaired by agriculture in terms of siltation, primarily in the Yellow Creek subwatershed. This has resulted in a non-attaining status for supporting aquatic life for the majority of streams in the subwatershed. To remediate excess siltation events that have contributed to the subwatershed's impaired waters, riparian areas need to be restored or reestablished where missing. Land owners could pursue coordination with the county conservation district or a local Farm Service Agency representative regarding the state's CREP for installing conservation practices on their land. Such conservation measures could include the creation of forested riparian buffers, wetland restoration, planting of native trees, shrubs, and grasses along streams, and installation of streambank fencing to prevent grazing and trampling by livestock.

8.6 Recommendations for Development of Municipal Grade, Potable Water Supplies from Groundwater in the Carbonate Aquifers of Morrison Cove

Groundwater exploration efforts should focus on the aquifers having both high quality water and sufficient permeability to allow high production rates. The aquifers in the Interior Carbonates Terrain, with the exception of the Bellefonte Formation and the toeslope carbonates of the Mountainside/Toeslope Carbonates Terrain, are capable of relatively high yields from properly sited wells. These areas are extensively developed for agricultural use, and nitrate levels have historically been high, often exceeding the federal safe drinking water standard (10 mg/l). This water will most likely require treatment for nitrates and other agricultural chemicals. Sinkholes may be activated by the drilling, developing, and testing phases, or by the drawdown during well use months or years after drilling. These may cause subsidence damage to buildings and infrastructure (roads, water mains, etc.), or capture and divert local streamflow. The success of a program to develop a high capacity well in the karst-prone carbonates in the Interior Carbonates Terrain and in the Mountainside/Toeslope Carbonates Terrain is highly dependent on the services of a hydrogeologist and a driller with extensive experience in the development of high capacity wells in karst.

8.7 Recommendations for Development of Municipal Grade, Potable Water Supplies from Groundwater in the Gatesburg Formation

In the Morrison Cove study area, the Gatesburg Formation has both high quality water and sufficient permeability to allow the development of high capacity production wells. Gatesburg wells are best located in the interior of the Gatesburg Terrains to avoid drawing agricultural contaminants from the neighboring Interior Carbonates Terrain into the Gatesburg

aquifer. Gatesburg wells will typically require a relatively long length of casing (100–300 feet) due to the deep weathering of the formation. Flowing sand and weak rock, often encountered in the Gatesburg, can increase drilling time and expense. Gatesburg wells frequently require screening to keep sand out of the well. Specialized drilling methods are generally employed due to the subsurface conditions encountered in the Gatesburg. These include cable tool drilling and various modified air rotary methods. The success of a program to develop a high capacity well in the Gatesburg Formation is highly dependent on the services of a hydrogeologist and a driller with extensive experience in the development of high capacity wells in unstable formations.

8.8 Optimum Well Locations

High rate withdrawals from aquifers within a given watershed will require an area of contribution of sufficient size to support the withdrawal on a sustainable basis. Large groundwater withdrawals are best located downgradient of major recharge areas, where the area of contribution is large and more water is available. Headwater watersheds generally do not have sufficient area to support high rate withdrawals. High rate withdrawals will reduce the base flow in a watershed. This will be especially evident during low base flow periods, when the flow is almost entirely from groundwater discharge. A downgradient location provides a relatively large area of contribution, and minimizes the stream miles with reduced base flow and modified flow regime. Well locations too close to a stream may result in streambed sinkholes and/or in a determination of 'surface water influence' due to poor filtration of stream water being drawn into the aquifer.