Summary of the Effects of Land Use on Water Quality, Aquatic Habitat and Biota
DRAFT

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Studies over the last three decades have clearly demonstrated that land use has direct and indirect impacts on water quality, stream characteristics, aquatic habitat, macroinvertebrates, and fish (e.g., references in Brown et al., 2005 and Hughes et al., 2006). Although the exact mechanisms for these impacts at specific sites is not always immediately obvious, the impacts have been demonstrated to be due to altered hydrology and its attendant water quality and aquatic habitat, both at the individual site and at the watershed scale. The two books cited in this paragraph contain more than 1,000 pages of peer-reviewed manuscripts reporting the results of dozens of studies recently conducted throughout the United States. There are hundreds of other recent manuscripts on this topic, some of which are cited here. It is the intent of this short paper to provide a summary of the effects of land use on the aquatic environment, and in doing so, a relatively small number of books and manuscripts have been cited. Some additional resources are contained in the Other References section. Inherent to land use is the fact that humans alter the hydrology watersheds.

Degradations in the channel morphology (e.g., Konrad et al., 2005), water quality, macroinvertebrates and fish (e.g., Deacon et al., 2005; Kennen et al., 2005; Walters et al., 2005; Stranko, et al., 2008) are common with increasing impervious area within a watershed. Overall, channel morphology and aquatic habitat become less diverse, nutrient and pollutant levels in streams increase, and macroinvertebrate and fish communities shift from those species that require high quality water to those that can survive in degraded water quality and habitat conditions.

Most studies have identified impervious surfaces as a quantifiable attribute of land use that is clearly linked to (i.e., actually causes) degradation of water quality, aquatic habitat and biota (e.g., Stranko et al, 2008; references in Brown et al., 2005 and Hughes et al., 2006). As more studies have been conducted throughout the United States and also in New Hampshire (see Deacon et al., 2005), the threshold at which impervious surfaces have been shown to cause impacts to stream channels, water quality and biota is about 4-5% (Stranko et al, 2008, who showed that wild brook trout were completely eliminated from watersheds in which the percent impervious surfaces were only 4% of the total watershed area), although 10% has also been reported as a general threshold by an earlier summary report (CWP, 2003). Additionally, the impacts occur quite rapidly, on the order of a decade or perhaps even more quickly. An important factor associated with impervious surfaces in New Hampshire is winter maintenance and the use of salt. The USEPA has criteria for chloride concentrations in receiving waters, and routinely these standards are violated by stormwater runoff (Houle, 2008). A striking example of current conditions in New Hampshire is the level of impervious surfaces in forty-two coastal towns. Of the fifty HUC-12 watersheds (typically about 10,000 acres each) within those towns, 30 (60%) already exceed the threshold of 4% impervious surfaces, and 13 (26%) exceed the threshold of 10% impervious surfaces (Justice and Rubin, 2006). Additionally, Deacon et al., 2005, who studied ten streams in coastal New Hampshire, found that the percent urban land (similar to the definition of impervious surfaces) within 25 meters of study streams was negatively correlated with water quality, aquatic habitat and macroinvertebrates, thereby demonstrating the value of riparian buffers to protect these attributes. The value of riparian buffers to water quality and aquatic habitat has been demonstrated in many other studies.

Recent and current stormwater regulations may not be protective of water quality, aquatic habitat, and biota (Stranko et al, 2008; references in Brown et al., 2005 and Hughes et al., 2006) because individual lots are often not regulated relative to stormwater. Because of this, land use activities cumulatively can and do lead to higher peak flood flows and increased flooding (Coles et. al., 2004; NRC, 2009), which can ultimately impact the public and infrastructure, and also aquatic habitat and organisms. The increased peak flows as well as the increased duration of peak flows often lead to stream channel enlargement and/or incision, which is manifested by streambank and streambed erosion due to the altered hydrology (Konrad et al, 2005). Eroding streambanks are a loss of land to private landowners and can threaten private and public infrastructure (e.g., roads, culverts, bridges, sewers, pipelines, and buildings). Armoring an eroding bank may provide stabilization at the specific site, but may simply transfer the stream's energy upstream or downstream to abutting properties and streambanks (Biedenharn, et. al, 1997). From biological and water quality perspectives, the intentional hardening of streambanks themselves is a poor substitute for natural, vegetated riparian buffers as the riparian vegetation provides shading, organic matter and food (e.g., insects) to fish and other animals in a stream and it serves to reduce nutrient inputs to the stream channel. When channels incise, the finer sediments are removed and larger sediment is left behind, effectively armoring the channel bed. The armored bed is poor aquatic habitat. The geomorphic result of channel widening and incising, in response to poor stormwater management practices, is that streams lose their characteristic pools and riffles (Booth, 1991, Sovern, et. al., 1997). Incised streams may be unable to fill floodplain wetlands in normal wet years. An unnoticed, yet important aspect of incising streams is that this affects groundwater. Streams in New Hampshire generally control groundwater levels nearby. Therefore the lower the streambed, the lower the water level in the stream and thus the lower the groundwater levels nearby. This results in dewatered wetlands as well as reduced soil moisture available for floodplain plants. Groundwater serves as the domestic water supply for at least 60% of the New Hampshire population (NHDES Drinking Water and Groundwater Bureau data) and therefore dropping the groundwater can have consequences on the very urban populations that created the problem.

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