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Impacts of Road Salt on Water Resources in the Chicago Region

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Introduction

Over 270,000 tons of road salt, primarily as halite (NaCl), is applied to roads in the Chicago region during an average winter (Friederici 2004; Keseley 2006). The "bare pavement" policy that exists for major roads significantly decreases accidents and allows traffic to flow at close to normal volumes during snow events (Salt Institute 2009). The clearing of roads of snow and ice has positive economic value, and court cases have suggested that such activities are not "discretionary activities" and that responsible government agencies can be held liable for inadequate deicing of roads (Anderson 1990).

However, road salting can have negative impacts, primarily through the release of chloride (Cl^-) ions to the environment. Chloride salts are very soluble, and most of the applied Cl^- is eventually transported to water bodies. Direct road salt runoff often has Cl^- concentrations in excess of 1000 mg/L (Panno et al. in press). There is a secondary drinking water standard for Cl^- of 250 mg/L, and negative ecological effects have been observed at concentrations less than 250 mg/L (Wilcox 1986; Hart et al. 1991; Environment Canada 2001; Kaushal et al. 2005). Effected biota include trees, grasses, fish, amphibians, and aquatic invertebrates. In surface water bodies, high Cl^- levels may augment concentrations of toxic metals in pond sediments and prevent spring turnover, preventing oxygen from reaching benthic sediments. Salt-tolerant plant species, such as cattails and phragmites, can outcompete native species in salt-affected wetlands and decrease biodiversity.

In addition to its environmental effects, Cl^- is highly corrosive of steel, and is the major cause of corrosion of steel reinforcement in concrete. In 1991, the Transportation Research Board (1991) estimated annual road repair and maintenance costs due to Cl^- corrosion to be between $200 and $450 million, primarily for bridge decks. Chloride can also accelerate corrosion of metallic pipes and structures, such as in water and wastewater treatment plants.

Urbanization and Road Salt in the Chicago Region

The population of the greater Chicago metropolitan region is greater than 8 million, having increased approximately 3 million in the last 50 years. It is projected to increase by an additional 2 million people by 2030, mostly in the collar counties to the west and south of Chicago (NIPC 2003). With increasing population there will be an increase in water demand. The two primary sources of drinking water in the region, Lake Michigan and deep bedrock aquifers, are near their limits legally and sustainably, respectively. Other sources will need to be exploited to meet the increased demand. These include shallow aquifers and surface water, such as the Fox River. These water bodies, however, are vulnerable to surface contamination, including road salt runoff.

There are more than 55,000 lane miles of roads in the six-county Chicago region (Cook, Lake, DuPage, Kane, McHenry, and Will Counties), and more than 270,000 tons of road salt are applied in an average winter (Friederici 2004; Keseley 2006). Shallow groundwater adjacent to

major highways can have Cl^- concentrations well above 1000 mg/L (Roadcap and Kelly 1994). Recent research has indicated that Cl^- concentrations have been increasing in shallow groundwater and surface waters in the Chicago region since the 1960's, when road salt began to be applied in earnest (Kelly 2008). More than half of shallow public supply wells in the region have increasing trends in chloride concentrations, especially in counties west of Chicago (Figure 1). Chloride concentrations are clearly linked to land use in parts of the region. For example, concentrations remain relatively low (< 15 mg/L) in rural areas of Kane County, but are much higher in the urban corridor in the eastern part of the county (Kelly 2005) (Figure 2).

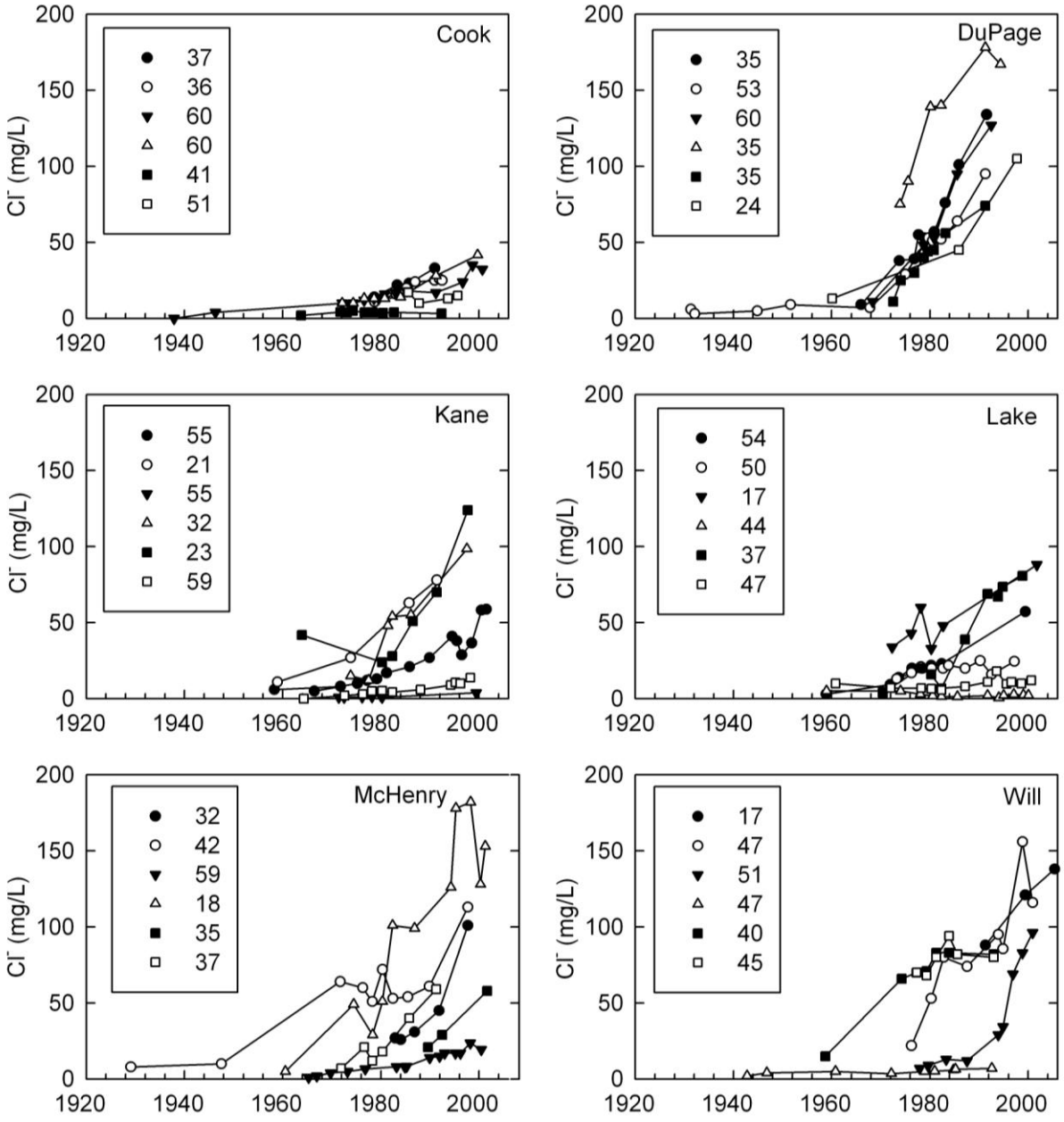

Figure 1. Chloride concentrations as a function of time in selected public supply wells in the Chicago region. Well depths in m.

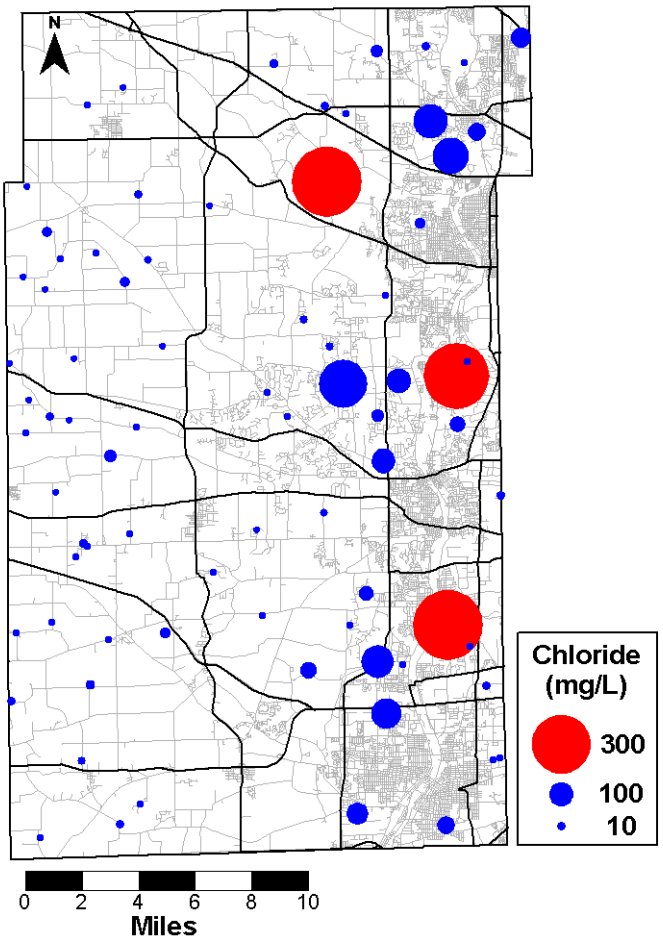

Figure 2. Chloride concentrations in shallow wells (< 250 ft) sampled in Kane County in 2003. Red symbols indicate concentrations above the secondary drinking water standard (250 mg/L).

High Cl^- concentrations have also been observed in surface waters of the Chicago region, including inland lakes, rivers, streams, and canals. Concentrations are seasonally controlled, with large spikes seen during the winter and early spring due to road salt runoff. Chloride concentrations in excess of 700 mg/L have been measured in the Chicago Sanitary & Ship Canal (Kelly et al. in prep.). Elevated Cl^- concentrations can be observed in the Illinois River well downstream of Chicago (Figure 3). Many of the surface water bodies have increasing trends in Cl^- concentrations, and it is likely that base flow Cl^- concentrations are increasing in many of these water bodies due to increasing Cl^- concentrations in the shallow groundwater.

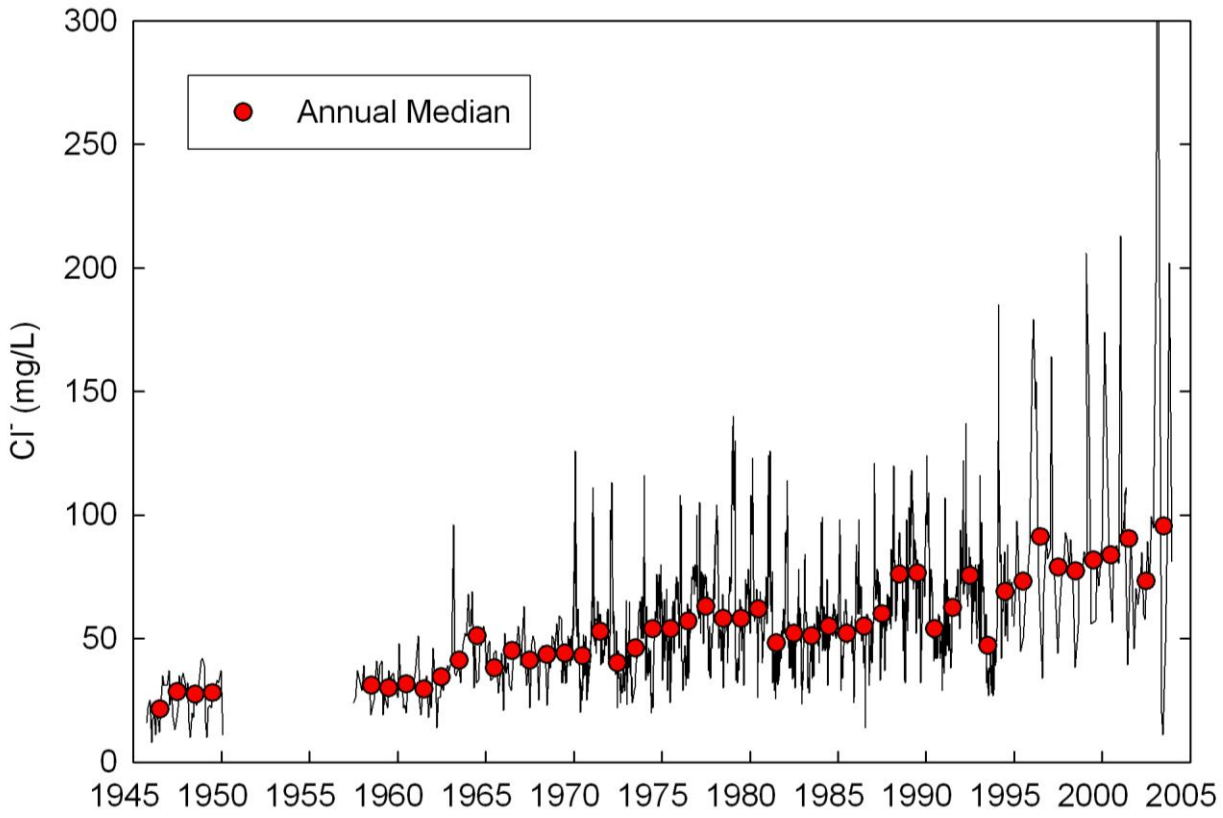

Figure 3. Chloride concentrations in Illinois River at Peoria as a function of time.

Road Salt: Future Considerations with Respect to Chicago's Water Resources

Record amounts of road salt were applied in the U.S. in three of the past four winters (Figure 4). State Departments of Transportation (DOT) in the Midwestern U.S. ordered significantly greater amounts of road salt for this past winter (2008-09) than the previous winter; the amount ordered by the Illinois DOT (IDOT) increased by 421,000 tons, a 34% increase (Salt Institute 2009). The increased demand has led to increased costs and occasional shortages, and agencies responsible for road deicing are reexamining their policies. For example, IDOT modified its policies for the previous winter in an attempt to reduce salt applications. Only roads having traffic greater than 10,000 vehicles per day continued to have a bare pavement policy. Less traveled roads and road shoulders were salted less, with a focus on keeping slippery spots dry.

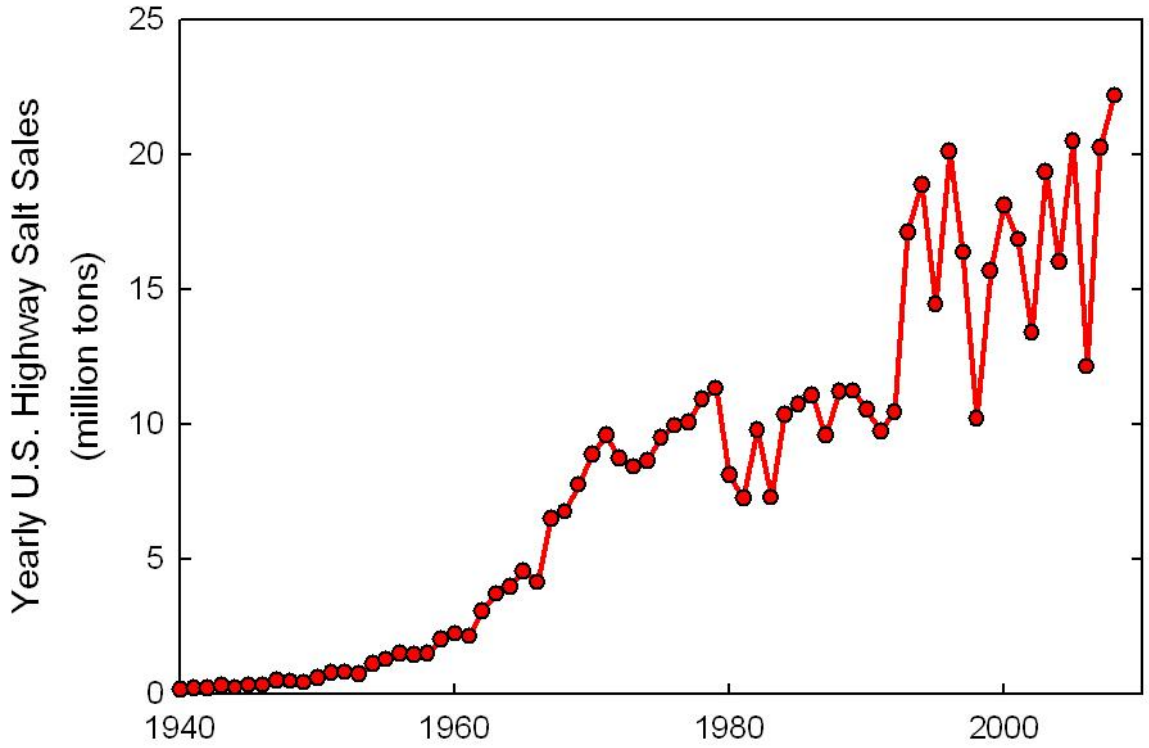

Figure 4. Yearly highway salt sales in U.S. (Salt Institute 2009).

Currently, alternative deicing agents are significantly more expensive than halite and thus are not economical for widespread use. Even as agencies attempt to apply less road salt, projected increases in population and roads in the Chicago region will almost certainly lead to increased Cl^- contamination of water resources. Planners will have some difficult decisions with respect to deicing policies in the next few decades. They must be aware of the interconnectedness of water resources; the Cl^- is going to go somewhere. Policies aimed at directing storm water runoff away from discharge to surface water bodies and into groundwater recharge have been promoted recently, but while this may protect surface water bodies from further degradation, it will increase Cl^- concentrations in shallow aquifers. There is anecdotal evidence that increased Cl^- concentrations in ponds used for irrigation have forced golf courses and nurseries to drill irrigation wells into deep bedrock aquifers, potentially putting more stress on these water resources (M. Adam, Lake County Health Dept., pers. comm.).

It is likely that there will be increased costs associated with continued road salt applications. Treatment costs of shallow groundwater will increase if chloride has to be removed. Increased Cl^- concentrations in drinking water supplies may also increase corrosion in both water and wastewater treatment plants. There is already evidence of negative effects on ecosystems due to increased salinity, and total maximum daily loads (TMDLs) have been promulgated for some surface water bodies. For example, the Illinois Environmental Protection Agency (IEPA) has determined that a 21% decrease in Cl^- application is needed to restore the East Branch of the DuPage River (IEPA 2002). It is clear that economic analyses are needed to help determine how to address these challenges.

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