Recommended Action Levels for Free Chlorine for Disinfectants Chlorine and Chloramines

A free chlorine concentration of 25 mg/L should be used as an emergency acute effects level for water treatment facilities employing chlorine or chloramines as disinfectants.

Facilities which treat with the oxidants chlorine or monochloramine monitor in real- or near real-time the amount of total and or free or residual chlorine in the water that they treat. Assuming that there is no continuous monitoring for the concentrations of the second or third added oxidants themselves, an acute exposure limit for chlorine only will be identified to be used with facilities that employ these different disinfectants.

The U.S. Environmental Protection Agency's Drinking Water Criteria Document for Chlorine (US EPA 1994) summarizes the health effects of exposure to chlorine which is a strong respiratory and dermal irritant.

There is a federal standard of 4 mg/L for chlorine in drinking water known as a Maximum Residual Disinfectant Level (MRDL). An MRDL is "a level of a disinfectant added for water treatment that may not be exceeded at the consumer's tap without an unacceptable possibility of adverse health effects. For chlorine and chloramines, a PWS is in compliance with the MRDL when the running annual average of monthly averages of samples taken in the distribution system, computed quarterly, is less than or equal to the MRDL. MRDLs are enforceable in the same manner as maximum contaminant levels under Section 1412 of the Safe Drinking Water Act. Notwithstanding the MRDLs, operators may increase residual disinfectant levels of chlorine or chloramines (but not chlorine dioxide) in the distribution system to a level and for a time necessary to protect public health to address specific microbiological contamination problems caused by circumstances such as distribution line breaks, storm runoff events, source water contamination, or cross-connections." (US EPA 2000). Since compliance is based on an annual average, the MRDL does not apply to individual samples that are allowed to be higher than the MRDL (US EPA 1994). Because of the manner of derivation of the MRDLs and the fact that they can be exceeded in drinking water treatment systems, they do not appear as appropriate values to use as a cutoff value requiring issuance of "Do Not Drink" or "Do Not Bathe" notices during upset conditions.

The MRDL was set using toxicological data from a chronic rat study. The value was derived to be protective of human health with chronic exposure and includes uncertainty factors. It therefore is not the sort of number that could serve as an emergency level from a toxicological point of view. During an upset emergency, exposures would be of short-term or acute duration. From an operational perspective it seems best to have a limit representing conditions where adverse effects would be expected if exposures took place.

The US EPA identifies Health Advisory values for short-term exposures to chemicals. They did not find suitable information for determining a One-day Health Advisory (HA) for chlorine. They did find suitable data to allow them to derive a 10-day HA value of 3 mg/L (US EPA 2006). EPA notes that in the absence of a unique 1-day value, the 10-day value is a conservative estimate for a 1-day exposure. The values do not appear to be appropriate for use as an acute shutdown or "Do Not Drink" level because they are based on an animal no adverse effects level

(NOAEL) which was numerically reduced by the application of a total of 100-fold of uncertainty factors applied for interspecies extrapolation and recognition of the variation in sensitivity across the population. Temporary exceedance of the 1-day value would not necessarily reflect a critical enough situation to warrant shutting down a water system or issuing use limitation notices. However, the information on which the HA is based can serve as a basis for identifying an acute exposure limit not to be exceeded. The current 10-day HA value is based upon a NOAEL (25 mg/kg/d or 200 mg/L) from a mouse study by (Blabaum and Nichols 1956). There was an absence of gross lesions, histological abnormalities and changes in weight or growth over the 50-day exposure period. Ideally, an acute limit for use at a treatment plant should be near an effect level for a chemical. In order to translate the NOAEL used for the 10-day HA value into an effect level, it can be multiplied by a factor of 10 to reflect the standard conversion factor used when extrapolating lowest adverse effect levels (LOAELs) to NOAELS (in those cases dividing by the factor of 10 to reduce the LOAEL dose to a NOAEL dose). The LOAEL values can then be numerically decreased by dividing by 10 and 10 for interspecies extrapolation and sensitivity in the population. The resulting drinking water concentration for a child (assumed 10 kg body weight ingesting 1L of water per day) would be **25 mg/L**. This value is graphically contrasted against other reported effects levels from the literature to put it in perspective.

This concentration should also be used to indicate the likely potential for dermal and ocular irritation through uses of the drinking water in the home for bathing or showering, although no dose-response information for these types of acute exposures has been located. Operational guidance for the treatment of swimming pools and whirlpool baths may provide some perspective. Recommended free chlorine concentrations in properly maintained swimming pools disinfected with chlorine (in several different forms) range from 1.5 – 2.0 mg/L. The Centers for Disease Control's recommended levels in spas and whirlpool baths are >3 - <10 mg/L. The degree of ocular irritation is also a function of the chlorine species present and the pH level, with the potential for irritation being more pronounced at lower pHs.

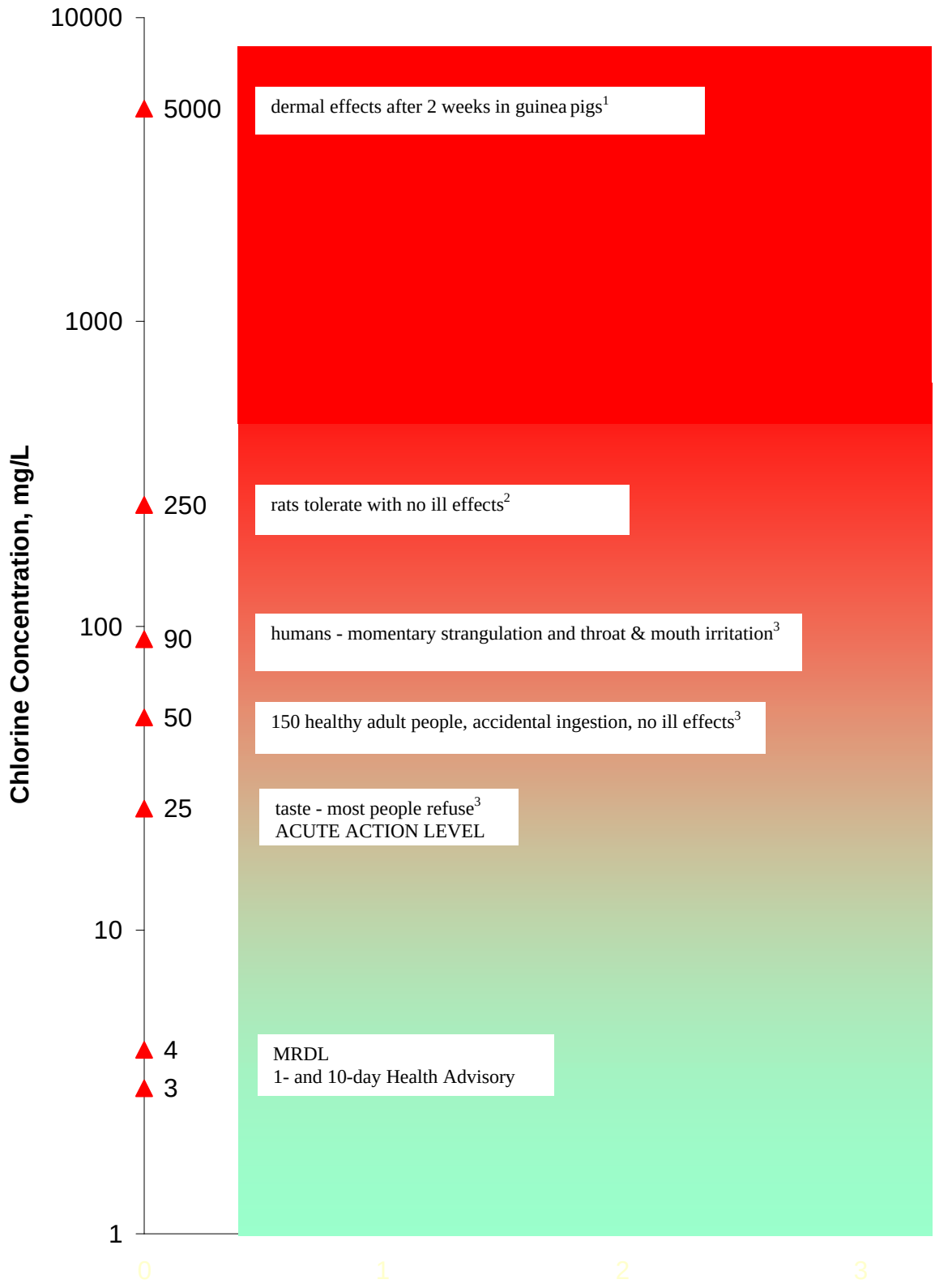

Figure 1. Chlorine Effects Levels, Exposure Limits and Recommended Acute Emergency Level for Drinking Water Treatment Plants. [1]- Cotter et al., 1985; [2]- Druckrey 1968, Furukawa et al 1980, Hasegawa et al 1986 and Kurokawa et al. 1986b cited in Bull 1992; [3] – Muegge et al. 1956 cited n US EPA 1995; [4] - FR. 1994. Drinking Water; National Primary Drinking Water Regulations: Disinfectants and Disinfection Byproducts. U.S. Environmental Protection Agency. 40 CFR Parts 141 and 142. Para IX. D.July 29, 1994. 38668-38829.

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