description of the many stakeholder activities which contributed to the development of the Stage 2 DBPR.

The Agency held two meetings to discuss consecutive system issues relevant to the proposal (February 22–23, 2001 in Denver, CO and March 28, 2001 in Washington, DC). Representatives from States, EPA Regions, and public water systems participated in the discussions. EPA also briefed the National Drinking Water Advisory Committee at their November 2001 meeting on consecutive system issues associated with the rule to receive input on the implementation strategy selected. This Advisory Committee generally supported EPA's approach. Section V describes EPA's analysis of consecutive system issues, comments and input received during these sessions, and how the proposed requirements will apply to consecutive systems. EPA also consulted with the Science Advisory Board in December 2001 on the requirements of the Stage 2 DBPR.

Finally, EPA posted a pre-proposal draft of the Stage 2 DBPR preamble and regulatory language on an EPA Internet site *(http://www.epa.gov/safewater/mdbp/st2dis.html)* on October 17, 2001. This public review period allowed readers to comment on the Stage 2 DBPR's consistency with the Agreement in Principle of the Stage 2 M–DBP Advisory Committee. EPA received important suggestions on this pre-proposal draft from 14 commenters which included public water systems, State governments, laboratories, and other stakeholders. While EPA will not formally respond to these comments, EPA has carefully considered them in developing today's proposal.

III. Public Health Risk

Chlorine has been widely used as a chemical disinfectant, serving as a principal barrier to microbial contaminants in drinking water. However, the microbial risk reduction attributes of chlorination have been increasingly scrutinized due to concerns about potential increased health risks from exposure to disinfection byproducts, which are formed when certain disinfectants interact with organic and inorganic material in source waters. Since the discovery of chlorination byproducts in drinking water in 1974, numerous toxicological studies have shown several DBPs (*e.g.*, bromodichloromethane, bromoform, chloroform, dichloroacetic acid, trichloroacetic acid and bromate) to be carcinogenic in laboratory animals. These findings of carcinogenicity influenced EPA to promulgate the TTHM Rule in 1979 and the Stage 1 DBPR in 1998. The Stage 1 DBPR primarily addressed possible carcinogenic effects (*e.g.*, bladder, colon and rectal cancers) reported in both human epidemiology and laboratory animal studies. Since the Stage 1 DBPR, new health studies continue to support an association between bladder, colon and rectal cancers from long-term exposure to chlorinated surface water. In addition to cancer effects, recent studies have reported associations between use of chlorinated drinking water and a number of reproductive and developmental endpoints including spontaneous abortion, still birth, neural tube defect, pre-term delivery, low birth weight and intrauterine growth retardation (small for gestational age). Short-term, high-dose animal screening studies on individual byproducts (*e.g.*, bromodichloromethane (BDCM), and certain haloacetic acids) have also reported adverse reproductive and developmental effects (*e.g.*, whole litter resorption, reduced fetal body weight) that are similar to those reported in the human epidemiology studies. This section discusses the new studies that have become available since promulgation of the Stage 1 DBPR and how they contribute to the weight of evidence for an association between health effects and exposure to chlorinated surface water.

While the Stage 1 DBPR was targeted primarily at reducing long-term exposures to elevated levels of DBPs to address chronic health risks from cancer, the Stage 2 DBPR targets reducing short-term exposures to address potential reproductive and developmental health risks and cancer risks.

Based on the weight of evidence from both the human epidemiology and animal toxicology data on cancer and reproductive and developmental health effects and consideration of the large number of people exposed to chlorinated byproducts in drinking water (approximately 254 million), EPA concludes that: (1) Current reproductive and developmental health effects data support a hazard concern, (2) new cancer data strengthens the evidence of an association of chlorinated water with bladder cancer and suggests an association for colon and rectal cancers, and (3) the combined health data warrant regulatory action beyond the Stage 1 DBPR.

A. Reproductive and Developmental Epidemiology

The following section briefly discusses reproductive and developmental epidemiology information EPA analyzed, some conclusions of these studies and reports, and implications for the Stage 2 DBPR. Further discussion of the implications and EPA's conclusions can be found in the Stage 2 Economic Analysis (USEPA 2003i).

EPA has evaluated recently published epidemiological studies examining the relationship between exposure to contaminants in chlorinated surface water and adverse reproductive and developmental outcomes. EPA also considered critical reviews of the epidemiological literature by Reif *et al.* (2000), Bove *et al.* (2002), and Nieuwenhuijsen *et al.* (2000). Based on these evaluations, EPA believes that the reproductive and developmental epidemiology data contribute to the weight of evidence on the potential health risks from exposure to chlorinated drinking water. Although the data are not suitable for a quantitative risk assessment at this time, due in part to inconsistencies in the findings, they do suggest that exposure to DBPs is a potential reproductive and developmental health hazard.

1. Reif *et al.* 2000

Reif *et al.* (2000) completed a critical review of the epidemiology literature pertaining to reproductive and developmental effects of exposure to disinfection byproducts in drinking water as a report to Health Canada. The review focused on 16 peer-reviewed scientific manuscripts and published reports and evaluated associations between DBP exposure and outcomes grouped as effects on: (1) Fetal growth—low birth weight (<2500g); very low birth weight (<1500g); preterm delivery (<37 weeks of gestation) and intrauterine growth retardation (or small for gestational age); (2) fetal viability (spontaneous abortion and stillbirth) and (3) fetal malformations (all malformations, oral cleft defects, major cardiac defects, neural tube defects, and chromosomal abnormalities).

a. *Fetal growth.* Reif *et al.* (2000) found inconsistent epidemiological evidence for an association between DBPs and fetal growth. Some studies found weak but statistically significant associations (Gallagher *et al.* 1998; Bove *et al.* 1992 and 1995), while two studies found no association (Dodds *et al.* 1999; and Savitz *et al.* 1995) with fetal growth.

b. *Fetal viability.* Reif *et al.* 2000's review of the literature found inconsistencies in the epidemiological evidence for the association between DBP exposure and fetal viability. For instance, the study by Waller *et al.* 1998 found an apparent dose-dependent increase in rates of spontaneous