Executive Summary of Hydrolysis Studies

3M has completed a series of studies of the hydrolytic reactions of various fluorochemicals. The materials included specific (monomeric) compounds potentially related to the manufacture and/or environmental persistence of more complex materials. The purpose of the studies was to provide information regarding the hydrolytic stability of these materials. These studies are based on United States EPA Fate, Transport and Transformation Test Guidelines OPPTS 835.2110, "Hydrolysis as a Function of pH". Table 1 lists the relevant compounds and their chemical abbreviations.

Table 1 also presents identification numbers for each of the reports and analytical methods developed by 3M for these studies. The studies are GLP-like; many GLP standards were used in the studies, and the quality assurance procedures followed were based on the practices described in the GLP documentation (40 CFR Part 792, TSCA).

Each study included the preparation of replicate aqueous samples at 50°C and several pH levels. After incubation over specific hydrolytic reaction periods, HPLC/MS techniques provided concentration trends in the samples for one or more compounds of interest. These results, subject to stringent data quality objectives, directly addressed the generation of potential hydrolytic products and the degradation of the "parent" material.

Within the limits of our ability to quantify, no loss of PFOS, PFOA, or FOSA was measured. Loss of the parent compounds N-EtFOSE and N-MeFOSE was observed, but because the loss was not pH-dependent, it is not likely due to hydrolysis. No formation of PFOS was observed from FOSA, N-EtFOSE, or N-MeFOSE.

First-order kinetic theory provides a suitable framework for interpretation of all the analytical results, and has been used to calculate estimated hydrolytic half-lives. Table 2 lists the results of these interpretations. In some cases the analytical results indicated slow loss of the "parent" materials, but in no case did they indicate a clear dependence of the loss rate on the sample pH level. Under these circumstances, it is appropriate to pool the results over the observed pH levels and to estimate possible half-life values supported by the data. Because hydrolysis products were not observed in these studies, the hydrolytic half-lives are estimated based on the analytical limits of quantitation (LOQ). These studies did not directly establish the limits of detection (LODs), so nearly all the estimates of the minimum hydrolytic half-lives presented here are based on the limits of quantification (LOQs); for one compound only, we have included supplemental results based on a conservative LOD estimate. The half-life estimates were extrapolated from the experimental temperature of (50°C) to 25°C, a more environmentally relevant temperature, using standard thermodynamic approximations. The calculated half-lives represent the fastest possible hydrolysis consistent with the levels of quantitation (LOQ) or below.

Table 1. Information Regarding Compounds Involved in Hydrolysis Studies			
Compound	**Abbreviation**	**3M Report Number and Date**	**Method Number**
Perfluorooctanesulfonate - potassium salt	PFOS	W1878 (March 27, 2001)	3M ETS - 8-13.0
2-(*N*-Methylperfluorooctanesulfonamido)-ethyl alcohol	*N*-MeFOSE alcohol	W1880 (March 30, 2001)	3M ETS - 8-178.0
2-(*N*-Ethylperfluorooctanesulfonamido)-ethyl alcohol	*N*-EtFOSE alcohol	W1872 (March 23, 2001)	3M ETS - 8-179.0
Perfluorooctanoic acid - ammonium salt	PFOA	E00-1851 (March 30, 2001)	3M ETS - 8-212.0
Perfluorooctanesulfonamide -ammonium salt	FOSA	EL-1132 (April 3, 2001)	3M ETS - 8-210.0

Table 2. Summary of Hydrolysis Study Results							
				Half-Life Results (Years)			
Compound Abbreviation	**pH Levels Studied**	**Max. Hydrolysis Period (days)**	**Number of Sample Replicates**	**pH**	**Parent Study (25°C)**	**PFOS LOQ (25°C)**	**PFOS LOD (25°C)**
PFOS	1.5, 5, 7, 9, 11	49	3	All	≥ 41**		
N-MeFOSE alcohol	1.5, 3, 5, 7, 9, 11	49	2	All	6.3*	≥ 27***	
N-EtFOSE alcohol	1.5, 3, 5, 7, 9, 11	49	2	All	7.3*	≥ 31***	
PFOA	1.5, 3, 5, 7, 9, 11	109	3	All	≥ 92**		
FOSA	1.5, 3, 5, 7, 9, 11	42	3	All	≥ 11**	≥ 8.3***	≥ 33***

*Loss of parent compound detected but not pH dependent. The ≥ result is based on measurement uncertainties. No PFOS formation detected.

**No loss of parent compound detected. The ≥ result is based on measurement uncertainties.

***No PFOS formation detected. The ≥ result is based on LOQ/LOD and measurement uncertainties.