Sec. 25-32d-4. Calculation of safe yield

(a) **Surface water sources.** Safe yield shall be developed using a mathematical mass balance methodology and shall be based on a ninety-nine percent dry year or a critical dry period with a 1 in 100 occurrence frequency and shall be based on the usable storage capacity of a reservoir which can be used without additional equipment or treatment, except that the safe yield may be less due to requirements for the passing of minimum stream flows or other release requirements. The statistical frequency analysis shall be performed by developing a low flow duration curve using the adjusted stream gaging data for the critical drawdown duration. All surface water safe yield analyses shall be performed by an individual with a minimum of five years experience in surface water analysis and a bachelor's or advanced degree from an accredited college or university in hydrology or related engineering field, or a professional engineer licensed in accordance with Chapter 391 of the Connecticut General Statutes with a minimum of five years experience in surface water analysis. For cases where a mass balance analysis cannot be performed due to insufficient usable storage volume, such as run of the river type situations or diversions, the safe yield shall be determined based upon an analysis of the streamflow for a ninety nine percent dry year assuming a seven day average flow duration. Information developed for other sections of the water supply plan may be referenced, if appropriate. The methodology for determining the safe yield of surface water supplies shall include the following:

(1) Inflow into the reservoir shall be based on gaged streamflow data collected from within the watershed or calculated from measured historical reservoir levels. Where such data is not available, unregulated stream gaged data from another watershed (external) which closely approximates the watershed of interest shall be used as determined by a verification analysis of historic inflows or reservoir levels versus the selected gage. Factors to consider when selecting the external gaging station shall include amount of stratified drift, land uses, slope, stream length, length of record, vegetation and geomorphology. The selected stream gage flow record or historic inflow record shall be of sufficient length and period of record as necessary to perform the required frequency analysis in subdivision (10) of this subsection. In cases where historic reservoir data is insufficient or unavailable for a verification procedure, then the selected gage shall have similar watershed characteristics and worst case low flows.

(2) Operating rules. The operating rules for the movement of water, reservoir conditions, and operation of the reservoir or reservoir system shall be listed and described. Reservoir conditions shall include the total and usable reservoir storage capacity; top and bottom elevation of the reservoir dam; spillway elevation, length and type; elevations and diameters of water supply intakes; and use of flashboards. Operating rules shall address conjunctive use of multiple reservoirs or wells, diversions, alternate release patterns, and operation of reservoirs in series or parallel. Operating rules shall be utilized in performing safe yield calculations.

(3) Computational interval. The mass balance analysis shall utilize a computational interval of no more than one month. Daily flow analysis may be required to appropriately model flood skimming diversions or low flow diversions unless truncated flow hydrographs are developed.

(4) Diversions. The safe yield analysis model shall include any diversions of water into or out of the watershed. The operating characteristics, flow capacity of the diversions and the runoff to the point of diversion shall be provided. Both existing and proposed diversions shall be analyzed, provided such proposed diversions are identified as needed within the five year planning period.

(5) Withdrawal rates. The reservoir outflow due to water withdrawal shall be varied on a monthly basis, based upon historic withdrawals for the last five year period of record. All supportive data shall be provided.

(6) The safe yield analysis shall be extended to determine the time to refill after the critical dry period assuming normal system operation, annual withdrawal rates equal to the calculated safe yield and inflow from the period immediately following the critical dry period.

(7) The safe yield of surface water sources shall be analyzed as a combined multiple reservoir system based upon a flow routing analysis and specified operating rules, unless previously approved by the department.

(8) Safe yield model inflow.

(A) Developing inflow record. The flow record for the chosen streamflow gage shall be adjusted to the watershed being analyzed by a ratio of the watershed area being analyzed to the watershed area of the selected streamflow gage. Further adjustment may be necessary to calibrate the safe yield model based upon verification procedures.

(B) Verification of safe yield model. In cases where an external stream gage is utilized, the inflow data shall be verified by comparing the end of period storage levels predicted from the chosen streamflow gage record against the actual measured historical reservoir levels from a representative dry period. Operating rules indicated to be in use during the chosen dry period shall be used for the verification procedure.

(C) Period of record. The entire period of record using mass balance methodology shall be analyzed to determine the critical dry period.

(D) Usable storage. The reservoir yield shall be developed using usable storage capacity based on bathymetric or topographic surveys and shall factor in sediment deposition. The calculation of usable storage excludes storage based on flashboards and water that cannot be accessed without special use of pumps or other emergency techniques.

(E) Direct precipitation. Direct precipitation on the surface area of the reservoir shall be calculated using the closest representative precipitation gage for the historic critical dry period or the ninety nine percent exceedance. Published data shall be used where possible. If unpublished data is used the data shall be submitted in support of the analysis. Water companies may choose to use the net impact of the direct precipitation minus the evaporation. The precipitation data shall be based on an interval no greater than one month.

(9) Safe yield model outflow

(A) Evaporation rates. The safe yield analysis shall incorporate monthly evaporation rates computed over the surface area of the reservoir either as calculated at the end of each computational interval or, assuming a constant surface area based upon two-thirds of usable storage capacity. Monthly evaporation rates as listed in this sub-paragraph shall be used in the safe yield analysis:

Evaporation rates (inches per month)	
January	0.85
February	0.93
March	1.51
April	2.15
May	4.15
June	5.10
July	5.61
August	5.25
September	3.64
October	2.60
November	1.66
December	1.34

(B) Consumptive losses to the watershed shall be evaluated.

(C) Dam leakage. Leakage rates shall be based upon field measurements or data obtained from the Department of Environmental Protection. If data is not available, then use of an estimated value is acceptable.

(D) Minimum streamflow releases. The minimum streamflow release shall be determined in accordance with Sections 26-141a-1 through 26-141a-26, inclusive, of the Regulations of Connecticut State Agencies and, where applicable, Sections 22a-365 through 22a-378, inclusive, of the Connecticut General Statutes, and the regulations adopted pursuant to Section 22a-377 of the Connecticut General Statutes. This requirement may be met by dam leakage and required riparian releases which equal or exceed the required minimum releases.

(10) 1 in 100 occurrence frequency. A statistical frequency analysis shall be performed using a Log-Pearson Type III distribution analysis to confirm that the average inflows over the critical drawdown duration equal or exceed a 1 in 100 occurrence frequency. A minimum of thirty years of streamflow record is required, unless otherwise approved by the department. The computed 1 in 100 occurrence frequency flow for the specified critical drawdown duration shall then be compared to the average flows for the same historic period. If necessary to meet or exceed the 1 in 100 occurrence frequency requirement, the inflow record shall be modified by a ratio adjustment and the mass balance analysis shall be rerun accordingly.

(A) All low-flow data used in computing Log-Pearson Type III frequencies shall be non-zero values. If zero values have occurred, then the statistical parameters, such as mean, standard deviation, and skew, shall be adjusted as recommended by the United States Geological Survey in technical memorandum number 89.11, available from the United States Geological Survey.

(B) For critical drawdown durations exceeding three hundred and sixty five days, the data to be used in the frequency analysis shall be non-independent values based upon flow periods equal to the critical drawdown duration within consecutive overlapping years.

(C) If the inflow record utilized in the safe yield analysis exceeds the 1 in 100 occurrence frequency, then, at the water company's option, the inflow record may be modified by a ratio adjustment to exactly meet but not be under the 1 in 100 occurrence frequency requirement and the mass balance analysis rerun accordingly.

(11) Submittal requirements. The water companies required to submit plans shall submit information on the dam leakage quantities, precipitation, riparian releases, minimum streamflow releases or an indication of exemption to such releases, critical drawdown duration, drought duration, 1 in 100 year low flow value, frequency analysis, safe yield computations including input and output, schematic of the reservoir system and stage or storage tables and curves, and the stage or area tables and curves, for approval. All sources of data used in the safe yield analysis shall be referenced. A summary graph of reservoir storage versus time for the critical dry period and extended to refill shall be submitted.

(b) **Ground water sources.** Safe yield of all active wells shall be computed based upon simultaneous pumping tests of all wells in the wellfield and adjusted for the maximum drawdown available during a critical dry period. The pumping tests shall be performed in accordance with subdivision (3) of this subsection. Ground water safe yield analyses shall be performed by an individual with a minimum of five years experience in ground water analysis in a glaciated geomorphological setting and a bachelor's or advanced degree from an accredited college or university in a ground water related science or related engineering field, or by a professional engineer licensed in accordance with Chapter 391 of the Connecticut General Statutes with a minimum of five years experience in ground water analysis in a glaciated geomorphological setting.

(1) The standard method of adjusting pumping test data to account for the critical dry period shall be based on one of the following:

(A) For all ground water sources, a multiplier of seventy-five percent, equivalent to an eighteen hour pumping day, shall be applied to the pumping test rate. This adjustment factor shall be applied for calculating and making adjustments for the critical dry period. The resulting safe yield shall be reported in units of both gallons per minute, and gallons or million gallons per day. In addition to the critical dry period adjustment factor, an additional multiplier of ninety percent shall be applied to bedrock or consolidated aquifer ground water sources.

(B) Pumping test data shall be analyzed and adjusted for the critical dry period using methodologies appropriate to the hydrogeologic setting and published methodologies as approved by the department. Analytical methodologies shall include steps to:

(i) correct pumping test data for significant ambient water level variations. The corrections shall be based on precipitation and static water level influences observed prior to and during the pumping test;

(ii) analyze impacts from no-flow boundaries, surface waters, existing pumping wells and any other hydrogeologic influences as evidenced by pumping test data;

(iii) project a 180 day pumping event assuming no precipitation recharge;

(iv) use analytical methodologies or modeling techniques to determine safe yield and adjust for the critical dry period. At ungaged sites, regional equations or base-flow measurements, in conjunction with United States Geological Survey Open-File Report 91-244, available from the United States Geological Survey, or Connectcut Water Resources

Bulletin Number 34, available from the State of Connecticut Department of Environmental Protection, or other reference deemed comparable by the commissioner, shall be used to estimate the streamflow condition with a seven day duration and a one in ten year recurrence frequency; and

(v) demonstrate that the water levels at the end of the critical dry period shall be maintained above the intakes.

(2) An alternative method for analyzing pumping test data may be made at the water company's option in cases where stabilized water levels are above the pump intake or water levels did not stabilize and predicted water levels are above the pump intake after an extrapolation of drawdown over 180 days of pumping. The alternative method may be used in such cases to indicate the additional yield of the well above the installed pumping capacity at the time of the pumping test and, if stabilization did not occur, show that the aquifer has sufficient storage to sustain pumping at the higher rate during the critical dry period and is intended to indicate the maximum well yield attainable with pump replacement, modification, or increased capacity. The alternate method shall meet the following criteria:

(A) Analytical methodologies or modeling techniques appropriate to the hydrogeological setting and published methodologies as approved by the department shall be applied to predict water levels at the higher pumping rate.

(B) The analysis technique shall take into account mutual interference effects on all wells located in the same wellfield.

(C) Corrections for the critical dry period shall be performed in accordance with sub-paragraphs (A) or (B) of subdivision (1) of this subsection.

(3) Wellfield pumping tests used in determining safe yield shall satisfy the following criteria:

(A) A pumping test shall be conducted with all wells in the wellfield pumping simultaneously to determine time-drawdown characteristics of the pumped wells. The rate of pumping of all wells shall be constant throughout the pumping test. Each well shall be individually metered. For wellfields with more than one well, existing data from individual, non-simultaneous pumping tests of each well in the wellfield that meet the other pumping test requirements may be utilized, provided corrections are made for mutual interference.

(B) Pumping test duration. The pumping test shall be conducted for at least the minimum duration as required in Section 19-13-B51k of the Regulations of Connecticut State Agencies.

(C) Stabilization. Stabilization shall be achieved for the last twelve hours prior to completion of the pumping test. If, after the required pumping test duration, stabilization is not achieved then the pumping test shall be extended, or an analysis and extrapolation of pumping test drawdown versus time data shall be performed to show whether there is sufficient storage in the aquifer to sustain the pumping rate for 180 days of continual operation and maintain water levels above the pump intake. If the projection shows the pump intake would be reached, a reduced pumping rate shall be calculated based on specific capacity at the end of the pumping test such that the pumping level at the reduced rate remains above the pump intake.

(D) Interference effects. The drawdown tests shall run simultaneously for all wells located within the same wellfield unless interference effects can be shown to be minimal or

can be properly estimated using analytical methodologies or modeling techniques.

(E) Where contaminants can reasonably be expected to be drawn into the wellfield during the test, the maximum pumping rate may be further limited by the department.

(F) Antecedent conditions

(i) The pumping test shall be conducted following a period of five days during which precipitation does not exceed one-half inch during any twenty-four hour period, and one inch in any seventy-two hour period.

(ii) Precipitation at the site of the pumping test shall be monitored daily beginning one week prior to start-up of pumping through completion of the pumping test, where applicable, using equipment capable of measuring precipitation to within one hundredth (0.01) of one inch.

(iii) Water level measurements in the pumping well or nearby monitoring wells shall be collected at least daily for at least one week prior to the start of testing.

(iv) For currently developed wells, the wellfield shall be shut down for at least three days prior to the start of testing, unless such shut down is not feasible and the department approves pumping at the minimum possible rate for the background shut down period.

(G) Drawdown measurements. Drawdown in each pumping well shall be measured hourly, or at such frequency that accurately measures drawdown to properly document the trend leading up to stabilization, and as necessary for proper analysis of pumping test data.

(H) Ground water level measurement accuracy. Ground water level measurements shall be obtained with a measuring tape, electric line, or pressure transducer accurate to two one hundredths (0.02) of a foot; unless direct access is not feasible without performing major modifications to the well, then airline readings may be utilized.

(I) Discharge of pumped water. The water withdrawn from the well during a pumping test shall be discharged so as not to interfere with the test.

(J) Surface water levels shall be measured to the nearest two one hundredths (0.02) of a foot and recorded at least twice daily during the duration of the pumping test for all surface water bodies within 500 feet of the pumping well.

(K) The criteria in subparagraphs (A) through (J) of this subdivision shall be used in calculating safe yield, unless the water company demonstrates to the department that any variations from these criteria had no noticeable effect or that the effect can be negated through the use of analytical methods. Induced infiltration tests performed in accordance with subparagraph (B) of subdivision (4) of subsection (d) of Section 22a-354b-1 of the Regulations of Connecticut State Agencies regarding level A mapping are considered to fully meet the pumping test requirements.

(4) Submittal requirements. The following items shall be submitted in support of the calculated ground water safe yield:

(A) static water level before pumping;

(B) date, time and duration of pump test;

(C) pumping rate in gallons per minute;

(D) drawdown records of time and measured water;

(E) date, time and amounts of precipitation;

(F) location of discharge point;

(G) well driller's log;

(H) physical well data regarding well construction, screen lengths and intervals, well development and diameter;

(I) graphs of drawdown or depth to water versus time plotted arithmetically if stabilization was achieved, or plotted on semi-logarithmic paper and extrapolated to 180 days if stabilization was not achieved;

(J) static water levels without any pumping and stabilized water levels during continuous pumping;

(K) rated pump capacity and pump curves;

(L) limitations on pumping, if any;

(M) other pertinent ground water modeling or testing data if utilized; and

(N) justification, description and reference information for use of selected methodology.

(c) Where sufficient historical records are available, data on the safe yield of any sources available during a critical dry period may be used if approved by the department.

(1) For existing wells, production records spanning a dry period of low streamflow recharge and below normal precipitation recharge may be used if approved by the department, provided that a sufficient margin of safety is maintained as demonstrated in subdivision (8) of subsection (b) of section 25-32d-3 of the Regulations of Connecticut State Agencies, that a new or expanded source of supply or a new or revised diversion permit is not needed within the five year planning period, and that the well or wells can be shown to have consistently produced the average rate over a multi-year period of record on an annual basis and over the seasonal low water table period extending from July to November. In such cases where historic production records are proposed to be used for calculating groundwater safe yield, the critical period adjustment in subparagraphs (A) and (B) of subdivision (1) of subsection (b) of this section shall be applied.

(2) The average production rate shall be based upon metered production records at each individual source of supply and the approved yield shall not exceed the current installed pump or treatment capacity.

(3) The following data shall be provided to the department:

(A) historic long term production records encompassing a representative dry period, including average day, maximum month average day, and peak day withdrawal rates; and

(B) available information as listed in subdivision (11) of subsection (a) of this section and subdivision (4) of subsection (b) of this section.

(d) Safe yield analyses previously performed that substantially meet the requirements of this section may be submitted in lieu of the study required by this section and shall be reviewed by the department on a case by case basis.

(e) The reduction in safe yield imposed by any constraints such as hydraulic considerations, system losses, treatment limitations, or interference effects shall be considered in the calculation of available water for all active sources.

(f) Other methods may be used provided that they are approved by the Department of Public Health and the Department of Environmental Protection and ensure an adequate water supply.

(Adopted effective August 10, 2000)