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Level A Mapping

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Sec. 22a-354b-1. Regulations for mapping wells in stratified drift aquifers to level A standards

(a) **Definitions.**

(1) The definitions of the following terms used in this section shall be the same as the definitions in Section 22a-354h of the general statutes: aquifer; aquifer protection area; area of contribution; municipality; recharge area; stratified drift; well field.

(2) The definition of ''water company'' shall be the same as the definition in Section 25-32a of the general statutes.

(3) As used in this section:

''Aquifer test'' means a yield test conducted for the purposes of evaluating the capacity of a well or well field for withdrawing water from an aquifer, of analyzing the hydraulic properties of the aquifer, of evaluating the effects of induced infiltration on surface water bodies, and/or of identifying the effects of other boundaries on the pumping well(s).

''Area of influence'' means the land area that directly overlies and has the same horizontal extent as the part of the water table or other potentiometric surface that is perceptibly lowered by the withdrawal of water. The area of influence delineated by the use of modeling shall be that area of land in which the water table or potentiometric surface is lowered by at least 0.5 feet.

''ASCII'' means American Standard Code for Information Interchange.

''Calibration'' means the adjustment of model input data for the purpose of matching model-generated output with field-measured values.

''Commissioner'' means the Commissioner of Environmental Protection or his designated agent.

''Conceptual model'' means a qualitative description of the physical characteristics and operating processes of an aquifer system.

''Critical drought event for stream flow'' means the lowest average stream flow over a continuous period of seven days with a calculated return frequency or recurrence interval of once in every ten years.

''Hydraulic boundaries'' means boundaries as described in the U.S. Geological Survey publication entitled, Techniques of Water Resources Investigations of the United States Geological Survey, Book 3, Chapter B5, ''Definition of Boundary and Initial Conditions in the Analysis of Saturated Ground-Water Flow Systems — An Introduction,'' O. Lehn Franke, Thomas E. Reilly, and Gordon D. Bennett, 1987.

''In use,'' when referring to existing well fields in use, means well fields in which any constituent well is identified, in the water supply plan which is current as of the date that level A maps are required to be complete under section 22a-354c and 22a-354d of the general statutes, as an active source of supply and which is not identified as solely an emergency source of supply.

''Indirect recharge area'' means an area from which water by overland flow or ground-water discharge is contributed to a surface watercourse which flows into the area of contribution.

''Initial setback'' means a distance from a pumping center that would represent the radius of an area approximately equal to the area of influence, as determined from Level B mapping.

''Level B mapping'' means a methodology to map the locations of existing and potential well fields, as required pursuant to Section 22a-354b of the general statutes.

''Model'' means a representation of a natural system consisting of a mathematical representation of two- or three-dimensional flow in an aquifer based on differential equations known to govern ground-water flow.

''Sensitivity analysis'' means an analysis which determines the degree of influence that various input parameters have on model results by varying individual input parameter values during a series of simulations.

''Simulation'' means the use of an operating model of a system or process.

''Sink'' means a process whereby, or a feature from which, water is extracted from the ground-water flow system.

''Stratified drift aquifer'' means a predominantly sorted sediment laid down by or in meltwater from glaciers and includes sand, gravel, silt and clay arranged in layers.

''Source'' means a process whereby, or a feature from which, water is added to the ground-water flow system.

''Steady state flow'' means a condition in which the amount of water flowing into a defined volume of the aquifer is equal to the amount flowing out of that volume. Under steady state flow conditions the head distribution in an aquifer is constant over time.

''Transient flow'' means a condition in which the amount of water flowing into a defined volume of the aquifer is equal to the amount flowing out of that volume plus or minus some amount of water held in the volume as storage. Under transient flow conditions the head distribution in an aquifer varies as a function of time.

''Verification'' means demonstration of a calibrated model's ability to simulate an historic hydrologic event for which field data are available.

''Water budget mass balance'' means an accounting of volumes and rates of water gains and losses from ground water, produced by a computer model simulation.

''Water supply plan'' means a plan prepared by a water company serving more than 1000 persons and approved by the Department of Health Services pursuant to section 25-32d of the general statutes.

(b) **Plan for Data Collection and Analysis.**

Each water company required by Sections 22a-354c and 22a-354z of the general statutes, to perform Level A mapping for existing well fields in use and potential well fields shall submit to the Commissioner for his review and written approval two copies of a plan for data collection and analyses which meets the requirements of subsections (d) and (e) of this section, and includes the information specified in subdivisions (1) through (5) of this subsection. Maps and reports prepared to fulfill Level B mapping, diversion applications pursuant to section 22a-369 of the general statutes, and ground water safe yield calculations provided in a water supply plan may be included in the plan to provide data to satisfy some of the requirements of this subsection. The plan shall include the following:

(1) A summary of all existing hydrologic and geologic data and information pertaining to the aquifer system in which the well or well field is, or is planned to be located, including, but not limited to:

(A) the location of each of the following which are within the estimated area of contribution: commercial, industrial, and irrigation wells that have the capacity to withdraw more than 50,000 gpd of water; borings; observation wells; and water company supply wells. Such locations shall be plotted on a 1:24,000 U. S. Geological Survey topographic map. In areas where data points are of a density such that they may not be clearly shown at the scale of 1:24,000, an enlargement of that area showing the data shall be provided. The following additional data shall be provided:

(i) historic pumping rates of each well within the estimated area of contribution plotted over the last ten years, including, but not limited to, average daily rate for the most recent twelve months of operation, estimated maximum daily rate, and the average daily rate during critical drought events, if known;

(ii) all data, information, and calculations from conducted pump tests for each well; and

(iii) geologic logs of available borings and wells;

(B) locations of available geophysical surveys conducted in the estimated area of contribution;

(C) estimated stream flow characteristics, including, but not limited to, flow duration and low flow frequency of any surface water body that may be affected by the pumping well(s).

(D) a description of any known ground water contamination which can reasonably be expected to be drawn into the well field during the aquifer testing required by subsection (d) (4), including (if known), but not limited to, the contaminant and concentrations in the ground water, and location of the source and extent of the contaminant plume, plotted on a 1:24,000 U. S. Geological Survey topographic map.

(2) A conceptual model of the aquifer system, describing its physical characteristics, its operating processes, and the behavior of ground and surface water under pumping and non-pumping conditions. At a minimum, this conceptual model shall include Level B mapping of the well field and description of the boundary conditions. The model may also include preliminary mathematical modeling. The conceptual model discussion shall be based only on the information and data specified in subdivision (b) (1) of this section and as set forth in subparagraphs (A) to (G) of this subdivision and shall include, but not be limited to, the following:

(A) a geologic description of the aquifer system, with at least two cross sections perpendicular to each other that transect the well field and a map showing areal distribution of the water-bearing formation, if the information is available, or surficial geology, if information on the water-bearing formation is not available, and:

(i) textural descriptions of the geologic units, with specific identification and description of any known confining or semi-confining layers; and

(ii) a list of the sources of information for geologic interpretations;

(B) contour maps, with control points identified on the maps, of:

(i) the water table under non-pumping or specified pumping conditions; and

(ii) bedrock elevations;

(C) estimates of hydraulic conductivity and specific yield of various aquifer units for unconfined aquifers or transmissivity distribution for confined aquifers, with a description of methods and any references used to estimate these values;

(D) a description of the physical limits of the area to be modeled with a discussion of the hydraulic boundaries known or assumed to exist;

(E) a discussion of the sources and sinks found within the area of contribution and the aquifer;

(F) an estimate of the area of contribution; and

(G) a map or maps at a scale of 1:24,000 (1″ = 2000′) showing the estimated extent of the area of contribution.

(3) A proposed plan to conduct the data collection required by subsection (d) of this section. The plan shall include, but not be limited to, the following:

(A) Discussion of the number, locations, and specifications of proposed test borings, as required by subdivision (d) (1) of this section. Existing borings may be

used to define the aquifer stratigraphy only if the geologic logs of those borings are available and are suitable for interpretation of aquifer properties;

(B) Discussion of the number, locations, and specifications of proposed observation wells and piezometers as required by subdivision (d) (2) of this section. Existing observation wells and piezometers may be used to gather water level data only if a well's construction characteristics and its physical relationship to the aquifer are known and meet the requirements of subdivision (d) (2) of this subsection.

(C) Locations, instrumentation, and procedures proposed to measure stream flow and stage as required by subdivision (d) (3) of this section.

(D) Discussion of the aquifer tests to be conducted, as required by subdivision (d) (4) of this section. This proposal shall include, but not be limited to, the following:

(i) the types of aquifer tests with detailed descriptions of any potential constraints or problems related to conducting the aquifer test. If there is known ground-water contamination in the vicinity of the well field, also include an evaluation of the potential to induce contaminant migration into the well field during the aquifer test;

(ii) identification of the well(s) to be pumped and observation wells to be monitored;

(iii) the pumping rate to be used;

(iv) frequency and level of accuracy of discharge rate measurements from pumping well(s). If unavoidable fluctuations in the discharge rate are anticipated, a discussion of how this will be accounted for in the testing and/or analysis shall be provided;

(v) construction specifications of the pumping well(s) and pump(s)

(vi) location of the outfall discharge line;

(vii) frequency and level of accuracy of precipitation measurements:

(viii) an estimate, using existing data, of the duration of the aquifer test and a reference to the analytical methods used for this estimate;

(ix) frequency and level of accuracy of drawdown measurements in pumping well and observation wells;

(x) frequency and level of accuracy of water level recovery measurements in pumping well and observations wells;

(xi) frequency and accuracy of stream flow and stage measurements; and

(xii) frequency and level of accuracy of temperature measurements of the discharge water and surface water, if the test is to quantify induced infiltration.

(4) A proposed plan to conduct the ground-water modeling required by subsection (e) of this section. The plan shall include, but not be limited to, the following:

(A) An identification of the ground-water model to be used to simulate flow and delineate the area of contribution.

(i) Models shall have the following characteristics:

(aa) a water budget mass balance shall be part of the solution;

(bb) the model shall provide a two- or three-dimensional solution of ground-water flow;

(cc) an exact copy of the computer code shall be available in ASCII format; and

(dd) an explanation of the code theory shall be available;

(ii) In determining the acceptability of the model, the Commissioner shall also include, but not be limited to, consideration of the following:

(aa) the degree to which the computer code is readily available to the Department of Environmental Protection staff and to the public;

(bb) the degree to which the code is well-tested and widely accepted; and

(cc) the capability of the Department of Environmental Protection staff to use the model.

(iii) Examples of acceptable models are:

(aa) ''Finite-Difference Model for Simulation of Ground-Water Flow in Two Dimensions,'' Trescott, P.C., Pinder, G.F. and Larson, S.P., U. S. Geological Survey, 1975; and

(bb) ''Modular Three Dimensional Finite-Difference Ground-Water Flow Model,'' McDonald, M.G. and Harbaugh, A.W., U. S. Geological Survey, 1983.

(iv) Under the conditions listed below, the use of analytical models may be permitted in lieu of numerical (digital) techniques at the Commissioner's discretion. If the Commissioner allows analytical modeling to be used, the well field shall be mapped in accordance with subsection (h) of this section. If drawdown, as determined by the analytical model, exceeds ten percent of the saturated thickness for the stratified drift aquifer, numerical modeling shall be conducted. The Commissioner may allow analytical modeling if:

(aa) the existing or potential well field has a total allowable pumping rate of less than 100,000 gallons per day as determined from either the water supply plan submitted under section 25-32d of the general statutes or the diversion registration or permit issued pursuant to sections 22a-362 or 22a-373 of the general statutes, whichever is greatest;

(bb) pumping will cause water levels to be affected over the entire stratified drift aquifer;

(cc) the area of influence can be shown not to extend to any lateral boundary and it can be shown to the satisfaction of the Commissioner that anisotropic aquifer conditions will not significantly affect the shape of the area of influence or those effects can be corrected; or

(dd) existing land use and zoning in the estimated area of contribution and direct recharge areas for the existing or potential well field consists entirely of low density residential development, state park land, and/or municipal or other open space, and there are no existing, planned, or zoned commercial, industrial or institutional land uses within the estimated area of contribution or direct recharge areas.

(B) Written documentation that the model analyst has at least a bachelor of science degree in the earth sciences or engineering with an emphasis in earth sciences, and two years professional experience and/or training in numerical and analytical ground-water modeling.

(C) A discussion of the proposed model application strategy with particular attention given to how the unconfined, partially confined or fully confined aquifer system shall be modeled.

(D) A discussion of how the hydraulic boundaries identified in subsection (b)(2)(D) above shall be simulated in the model.

(E) A discussion of the data to be used as input to the model that identifies data sets that are to be derived from field collection, literature searches, and those sets that are based on assumptions.

(F) A discussion of model sensitivity analyses, identifying the parameters to be tested during the model sensitivity testing and potential ranges of variation for each parameter.

(G) A discussion of the discretization scheme that shall be utilized during final modeling simulations, identifying the use of either a regular or variable spaced grid and indicating an approximate range of cell dimensions and areas.

(H) A discussion of the approach and methods to be used for model calibration and verification as required by subdivision (e) (1) of this section. Proposed calibration and verification goals shall be described in detail. At a minimum these goals shall include the following:

(i) matching of simulated water levels with actual water levels measured in observation wells; and

(ii) a simulation mass balance difference (comparison of sources and discharges) of no greater than 0.5 percent.

(I) A discussion of the approach and methods to be used for predictive simulations to delineate the area of influence, as required by subdivision (e) (2) of this section.

(5) Any other information which the Commissioner deems necessary in order to assure that the proposal for data collection and analysis will result in the accurate delineation of the area of contribution and areas of recharge to the well field.

(6) A water company may propose in the plan for data collection and analysis that certain of the requirements of subsections (d) and (e) will not be met. Such a proposal shall include, but not be limited to, the following:

(A) a demonstration that such requirements are not necessary, that an alternative proposal would provide sufficient and appropriate data, or that existing data are sufficient, to accurately delineate the area of contribution and recharge areas of the particular well field, or that the constraints of the physical operation of the water system will not allow such requirements to be met; and

(B) a complete description of and justification for any proposed alternative data collection or analysis methods.

(c) **Compliance With Approved Plan.**

(1) Upon receipt of the Commissioner's written approval of the plan for data collection and analysis, the water company shall conduct the proposed data collection and analyses in accordance with the approved plan.

(2) If, at any time before written approval of the Level A map under section 22a-354d of the general statutes, the water company becomes aware that hydrogeologic conditions have changed such that the approved plan for data collection and analysis will no longer provide accurate data for the delineation of the area of contribution and the recharge areas for a well field, or that any information submitted was erroneous or any relevant information was omitted, the water company shall submit within thirty days an amendment to the plan for data collection and analysis for the Commissioner's review and written approval. The amendment shall fully describe the changes, error, or omission and propose modifications to the plan to ensure that accurate delineation of the area of contribution and recharge areas will be obtained.

(3) If field conditions during data collection necessitate modifications to the approved plan for data collection and analysis, the water company shall use best professional judgement and proceed with appropriate modifications. The alternative methods for data collection and analysis shall ensure that accurate delineation of the area of contribution and recharge areas can be obtained using the resulting data. The water company must subsequently submit to the Commissioner for review and written approval, documentation of the necessity of the modification, justification for the alternative methods used, and a discussion of the suitability of the data collected. The alternative methods used shall ensure that accurate delineation of the area of contribution and recharge areas can be obtained using the data collected as a result of the modification. The water company shall collect and submit additional data to the Commissioner, if the Commissioner determines that the modifications resulted in unsuitable data.

(d) **Data Collection**

All hydrogeologic data used in determining the area of contribution and the recharge area pursuant to this section shall be collected in accordance with the provisions of this subsection. Any data type not described in this subsection shall be collected, processed and interpreted in an accepted scientific manner, with references to methods used specified in the plan for data collection and analysis required by subsection (b) and final reports required by subsection (g).

(1) Test borings.

The number and locations of test borings shall be adequate to fully define the aquifer stratigraphy, given the approximate size of the area of contribution and the complexity of the aquifer material. The test borings shall be conducted as follows:

(A) Drilling methods and equipment shall assure the collection of samples that identify major textural changes.

(B) Borings shall penetrate the entire saturated thickness of the aquifer whenever possible.

(C) Samples of formation material shall be taken at depth intervals of five feet or less. Such samples shall be labeled with test boring well number and depth interval. In addition:

(i) samples shall be collected by use of split spoon samplers or other core barrel sampling devices capable of retaining samples of unconsolidated material; and

(ii) all samples shall be retained by the water company for inspection by the Commissioner until sixty days after a municipality delineates an aquifer protection area on a local map in accordance with section 22a-354n of the general statutes.

(D) Boring logs shall be kept for all borings. The boring logs shall describe the materials penetrated, and shall include, but not be limited to:

(i) the depth at which there is a layer of material that differs in texture or other appearance from the materials found above or below it;

(ii) the thickness of each such layer;

(iii) a visual description of the material which identifies the constituent grain sizes, using the Wentworth grade scale, and gross color;

(iv) a description of drill behavior in the comments section of the boring log;

(v) a description of sampling methods, including, but not limited to:

(aa) the type of sampling device being used, the method of driving the sampling device, and the weight and fall distance of the hammer;

(bb) intervals sampled;

(cc) percent recovery of samples;

(dd) blow count; and

(vi) a site sketch of boring locations with a bar scale, north arrow, and the exact distances of the borings from two specified permanent landmarks noted.

(2) Observation wells and piezometers.

Observation wells and piezometers shall be adequate in number, of proper construction, and in proper locations to allow determination of aquifer parameters, the response to the stress created by the aquifer tests, and the locations and effects of hydraulic boundaries. The number and location of observation wells and piezometers shall be determined by the approximate size of the area of contribution, the complexity of the aquifer system and the number and location of the well(s) to be pump tested.

(A) The number of observation wells and their locations may vary with hydrogeologic and boundary conditions as well as with the purpose of the wells:

(i) Observation wells screened for the purpose of model construction and calibration shall be sufficient in number and in appropriate locations to allow for water levels in various hydrogeologic and physiographic units to be determined.

(ii) At least two observation wells shall be installed between the water supply well(s) and each potential hydraulic boundary within the estimated area of contribution. At least one additional observation well shall also be installed beyond each surface water body that has been tentatively identified by the modeler as a hydraulic boundary.

(iii) At least one observation well is required to monitor background water levels outside the area of influence during the aquifer test.

(B) Nested observation wells screened at appropriate intervals shall be installed to evaluate:

(i) the presence and characteristics of confining or semi-confining layers;

(ii) the effects of partial penetration of pumping well(s) where such conditions are expected to occur during the aquifer test; and

(iii) vertical hydraulic conductivity.

(C) All observation wells and piezometers shall be tested for response by injecting or removing a known volume of water into the observation well and measuring the subsequent decline or recovery in water level.

(D) Piezometers installed for the purpose of measuring induced infiltration from a surface water body shall have a minimum inside diameter of one inch and shall be installed into the streambed or lakebed, with the top of the screen at least one foot below the bed materials. Static head changes shall be monitored throughout the pump test.

(E) Observation wells shall be constructed in accordance with the following:

(i) casing material shall have a minimum inside diameter of two inches;

(ii) screens shall be slotted or wire-wound, with a minimum diameter of two inches and a minimum length of eighteen inches;

(iii) where needed, appropriate gravel pack materials shall be installed;

(iv) screened intervals shall be open to the aquifer such that measured water levels represent the head in the aquifer at the interval screened;

(v) when confining layers are penetrated by observation, monitoring, or test wells, the integrity of those layers shall be maintained by emplacement of impermeable backfill in the annular space. Materials used for impermeable backfill shall be bentonite clay or an equally impermeable material;

(vi) locking protective devices shall be used to cap the observation wells; and

(vii) each observation well and piezometer shall be permanently and uniquely labelled.

(F) The depth, diameter, screened interval, distance from pumping well(s), and elevation above sea level shall be determined for each observation well and piezometer.

(G) Observation wells which shall or may be used for collection of water samples for chemical analysis shall be constructed of materials that shall not impact the quality of water to be sampled.

(3) Stream flow and stage measurements.

Stream flow or water stage measurements shall be made, where such measurements will provide accurate and meaningful data, to establish the volume of water flowing in streams or other surface watercourses before, during and after an aquifer test period to determine the effects of an aquifer test on the stage or flow of surface water.

(A) Measuring sections shall be established and stream flow or stage measurements shall be conducted at a minimum of two locations along each watercourse that will be affected by the pumping well(s).

(i) The location of measurement sections shall be based on the estimated limits of the area of influence and suitability of the section for making accurate measurements. The measurement sections shall be located immediately above and immediately below the limits of the estimated area of influence.

(ii) Establishment of measuring sections shall include improvement of channel sections where appropriate in order to facilitate more accurate measurements.

(B) Staff gages or weirs may be installed. Staff gages shall be calibrated using at least eight independent stream flow measurements which bracket discharge conditions expected at the time of aquifer testing. The measurements shall be capable of producing a rating curve with the ability to estimate stream flows within ten percent. A weir shall be calibrated using at least three independent stream flow measurements which bracket discharge conditions expected at the time of aquifer testing.

(C) The altitude of any measuring point from which stage or stream flow measurements are made shall be surveyed and established with respect to the nearest U.S. Geological Survey, National Geodetic Survey, Department of Transportation, or other local benchmark relative to mean sea level.

(D) Stream flow or water stage measurements shall conform to procedures described in the U.S. Geological Survey Techniques of Water Resources Investigations, Book 3, Chapter A8, Thomas J. Buchanan and William P. Somers, 1969.

(E) Flow duration shall be estimated for any stage or stream flow measurements made by reference to the nearest long term U.S. Geological Survey continuous gaging station.

(4) Aquifer tests.

Aquifer tests shall be performed to determine aquifer properties such as transmissivity and storage coefficient, to evaluate hydraulic boundary conditions, to provide data for model calibration and verification and to quantify induced infiltration from surface water bodies. The aquifer test to quantify induced infiltration may be combined with the aquifer test to quantify aquifer properties and evaluate boundary conditions if the conditions of subsections (d) (4) (A) and (d) (4) (B) can be met:

(A) Aquifer tests to determine aquifer properties, to evaluate hydraulic boundaries and to provide data for model calibration and verification shall be performed in accordance with the following:

(i) Stream flow during the test period shall be less than the stream flow that is equaled or exceeded five percent of the year (five percent duration flow);

(ii) for a well field consisting of multiple wells, aquifer tests shall be performed using one existing well pumping at the highest feasible constant rate. Where contaminants can reasonably be expected to be drawn into the well field during the test, the maximum pumping rate shall be determined with the concurrence of the Commissioner of Health Services;

(iii) All wells in the well field shall be shut down for a period of at least three consecutive days prior to the start of the test. All wells not to be tested shall remain shut down for the duration of the test;

(iv) the rate of pumping for a potential well field shall be the maximum sustainable yield from a test well that is at least six (6) inches in diameter;

(v) wells to be pumped shall be equipped with reliable power, pump, discharge control equipment and water level measuring equipment with an air line and gage, or access for electrical or manual tape or transducer;

(vi) Discharge rate measurements shall be obtained within the first minute of start-up, and checked for stability at no more than five minute intervals for the first thirty minutes. Thereafter, measurements shall be obtained at least once per hour

for the duration of the test. The method used to measure discharge rate shall be accurate to at least ten percent and discharge rate shall not vary by more than ten percent during the test period. All pump discharge variation shall be documented. Unavoidable fluctuations in the discharge rate must be accounted for in the testing and/or analysis procedures;

(vii) the aquifer test outfall discharge line shall be located so as not to affect stream flow and head measurements;

(viii) stream flow shall be measured in accordance with subdivision (d) (3) at a minimum of once per day for a minimum of five consecutive days prior to test start-up;

(ix) precipitation at the site of the aquifer test shall be monitored continuously for a period of from one week prior to start up of pumping through completion of recovery phase, where applicable, using equipment capable of measuring precipitation to within 0.01 of one inch;

(x) for a minimum of five consecutive days before start-up of pump test, water level measurements in each observation well shall be collected at least once per day;

(xi) the duration of an aquifer test for existing or potential well fields shall be estimated using analytical methods suitable for field conditions. Actual duration of the aquifer tests shall also be consistent with the following quality assurance controls:

(aa) the aquifer test shall be continued until such time as sufficient data are collected to allow for interpretation of aquifer properties and hydraulic boundary effects, but shall under no circumstances be less than three days.

(bb) aquifer tests shall be conducted following a period of five days during which rainfall does not exceed (1) one-half inch during any 24-hour period, and (2) one inch in any 72-hour period;

(cc) during the first three days of the aquifer test, rainfall shall not exceed (1) one-half inch during any 24-hour period and (2) one inch during any 72-hour period;

(dd) during the next seven days of the aquifer test, rainfall shall not exceed (1) one inch during any 24-hour period, and (2) two inches during any 72-hour period;

(ee) during testing, there shall be no pump shutdown in the first four hours of pumping, no more than one half hour of shutdown during the next twelve (12) hours of pumping, and no more than one hour of shutdown in any succeeding twenty-four (24) hours of pumping;

(ff) if the above conditions can not be met, the pump test shall be repeated, unless the modeler can demonstrate to the Commissioner that rainfall or pump shutdown had no noticeable effect or that the effect can be negated. In such a case, the modeler shall use best professional judgement to determine if the pump test must be repeated, and if the test is not repeated, the modeler shall, within fourteen days, submit written documentation of the suitability of the test to the Commissioner.

(xii) drawdown in pumping well and observation wells shall be measured with sufficient frequency that each log cycle in time, beginning with time equal to 1.0 minute, contains at least ten water level measurements evenly distributed throughout the cycle. At least two measurements shall be in the time range of 0.1 to 1.0 minutes.

(xiii) ground-water level recovery measurements shall be taken immediately after pumping ceases, with frequency comparable to that of the pumping cycle. Recovery measurements shall continue for a time equal to the pumping cycle.

(xiv) water level measurements shall be accurate to two one-hundredths of a foot.

(xv) barometric pressure shall be continuously monitored for confined and semi-confined conditions.

(B) Aquifer tests to quantify induced infiltration shall be performed in accordance with the following:

(i) stream flow shall be equal to or less than the stream flow that is equaled or exceeded 80 percent of the time (80 percent duration flow) during the test period;

(ii) stream flow shall be measured in accordance with subdivision (d) (3) at a minimum of once per day for a minimum of five consecutive days before test start-up. Stream flow for the three days immediately prior to the aquifer test shall approximate base-flow conditions;

(iii) the rate of simultaneous pumping of all water supply wells shall be constant and as close to the rate specified by the diversion registration or permit as possible. Where contaminants can reasonably be expected to be drawn into the well field during the test, the maximum pumping rate shall be determined with the concurrence of the Commissioner of Health Services;

(iv) the rate of pumping for a potential well field shall be the maximum sustainable yield from a test well at least six (6) inches in diameter in the potential well field area;

(v) the duration of the aquifer test to quantify induced infiltration shall be until such time as sufficient data are collected to allow for interpretation of the effects of pumping on stream flow, but shall, under no circumstances, be less than five days;

(vi) stream flow measurements, as required under subdivision (d) (3), shall be routinely taken throughout the test except during periods of rapidly changing stream flow conditions, as may occur due to a heavy rainfall event;

(vii) temperature of the discharge water and surface water shall be monitored throughout the test; and

(viii) water levels shall be measured in observation wells, at a minimum, on a daily basis for the duration of the test.

(e) **Ground-water flow modeling.**

Numerical modeling of ground-water flow shall consist of separate but related operations, as set forth in subparagraphs (1) to (3), inclusive, of this subsection. The model shall, at a minimum, cover the stratified drift areas.

(1) Initial set-up, calibration, and verification of the model shall be based upon data collected in accordance with the provisions of subsection (d) of this section, and shall be conducted as follows:

(A) A preliminary model shall be constructed by assembling an initial data set of appropriate hydrogeologic parameters.

(B) Sensitivity analyses shall be performed to assess the adequacy of existing data and as a guide for the collection of new data. The sensitivity analyses shall include, but not be limited to, both reductions and increases of at least fifty percent in specified values describing hydraulic conductivity or transmissivity, storage coefficient or specific yield, evapotranspiration and recharge through hydraulic boundaries.

(C) Model input parameters shall be refined using new hydrogeologic data collected in accordance with subsection (d) of this section after the sensitivity analyses have been completed.

(D) The ground-water flow model shall be calibrated for transient flow conditions in accordance with the following:

(i) simulated pumping rates for all wells in the well field shall be equal to actual pumping rates at the time of the calibration event. Wells within the approximated area of influence, but not included in the well field, that have pumping rates of 50,000 gallons per day or more, shall be included;

(ii) initial conditions of areal recharge, evapotranspiration and fluxes to and from the aquifer shall be representative of actual conditions at the time of the calibration event;

(iii) Calibration has been achieved when the following conditions have been met:

(a) The water budget mass balance difference between sources and discharges is less than 0.5 percent;

(b) the difference between simulated water levels and those measured in fifty percent or more of the observation wells is less than two feet;

(c) the difference between simulated water levels and those measured in seventy percent or more of the observation wells is less than five feet;

(d) the maximum difference between simulated water level and that measured in any observation well is less than ten feet; and

(e) simulated ground-water runoff is as close as possible to ground-water runoff estimated from streamflow records collected from the modeled area.

(E) The calibrated ground-water flow model shall be verified by simulating at least one other transient event for which there is hydrogeologic data. Verification has been achieved when all the conditions of (e)(1)(D)(iii) have been met.

(2) A steady-state predictive simulation shall be performed to delineate the area of contribution and determine the water budget mass balance. Such predictive simulation shall be performed in accordance with the following:

(A) Streamflow and associated stream stage shall be the flow equaled or exceeded fifty percent (50%) of the time (50% duration flow);

(B) Mean annual rates shall be specified for precipitation, evapotranspiration and flux across the boundaries; and

(C) The maximum pumping rate allowable for the well field shall be used, in accordance with the following:

(i) The maximum pumping rate as established by the diversion registration or permit, issued pursuant to sections 22a-368 or 22a-373 of the General Statutes; or

(ii) if the maximum diversion registration or permit issued pursuant to sections 22a-368 or 22a-373 of the General Statutes is not sustainable for the predictive simulation, an alternative pumping rate may be determined by the commissioner, in consultation with the Department of Public Health and the water company; or

(iii) in the case of potential wells that the commissioner may map pursuant to subsection (b) of section 22a-354c of the General Statutes, a pumping rate that does not exceed maximum sustainable yield.

(3) Particle tracking, or other vector analyses, shall be applied to the predictive simulation to delineate the area of contribution to the well field.

(f) **Aquifer Mapping.**

(1) The area of contribution shall be determined in accordance with the following:

(A) For well fields for which numerical ground-water flow modeling has been conducted, the area of contribution shall be delineated in accordance with subdivision (3) of subsection (e) of this section.

(B) For well fields for which analytical ground-water modeling has been conducted, the area of contribution shall be determined as follows:

(i) The area of influence shall be determined as specified in subdivision (3) of subsection (h) of this section.

(ii) The area of contribution shall be mapped using the analytical model-generated ground-water level contours as that part of the area of influence that drains directly to the pumping well.

(2) The recharge area for the well field shall be determined using the following methods:

(A) For areas of stratified drift adjacent to the area of contribution where model-generated ground-water level contours are available, the recharge area shall be delineated using those contours; and

(B) For areas of stratified drift and till where model-generated ground-water level contours are not available, the recharge area shall be determined by assuming ground water divides are coincident with surface water divides and that ground water flow directions are normal to the land surface contours, unless better data are available, provided:

(i) topographic maps used for the interpretation of drainage divides representing the boundaries of the recharge area shall have a contour interval no greater than ten feet; and

(ii) watersheds in till areas for perennial streams that discharge into the area of contribution shall be assumed not to contribute ground water to the area of contribution by ground-water flow.

(3) The indirect recharge area shall be determined within a five-mile radius of the area of contribution using topographic maps with a contour interval no greater than ten feet.

(g) **Submission of Final Maps and Reports.**

Each water company shall submit two copies of the maps, reports and computer data listed in subdivisions (g)(1) through (g)(6) of this subsection to the Commissioner for review and written approval.

(1) A map at a scale no less than 1:4,800 (1 inch = 400 feet), on which the following information shall be shown:

(A) all cultural, surface drainage, and transportation features;

(B) the area of influence, if delineated under subparagraph (B) of subdivision (1) of subsection (f) of this section;

(C) the area of contribution within stratified drift;

(D) location of all pumping wells; and

(E) locations of all observation wells, test borings, geophysical surveys, gaging stations, weirs, and streambed piezometer. Locations map be shown on a separate map at scale of 1 inch = 400 feet.

(2) A map at a scale of 1:24,000 (1 inch = 2,000 feet) of the area of contribution, on which the following are shown:

(A) all geologic contacts between unconsolidated materials;

(B) delineation of the area of contribution within stratified drift;

(C) all existing or proposed pumping wells for which the area of contribution is delineated;

(D) recharge areas; and hydraulic boundaries.

(3) All maps used for constructing the flow model including, but not limited to, the following:

(A) finite difference grid or finite element mesh;

(B) model boundary locations;

(C) contours of aquifer bottom; and

(D) horizontal hydraulic conductivity distribution.

(4) A hydrogeologic investigation report which includes, but is not limited to all of the following:

(A) A description of hydrogeologic setting;

(B) A discussion of geologic and hydraulic boundaries and their treatment in the model.

(C) A discussion of the data used in interpretation of hydraulic characteristics including, but not limited to, hydraulic conductivity and storage coefficient or specific yield.

(D) A discussion of recharge to and discharge from the aquifer system including, but not limited to:

(i) recharge from precipitation;

(ii) recharge from underflow;

(iii) recharge from streamflow losses;

(iv) discharge to evapotranspiration;

(v) discharge to underflow;

(vi) discharge to streamflow; and

(vii) discharge to pumpage.

(E) A discussion of and the data relating to ground water and surface water relationships which takes into consideration the following:

(i) streamflow measurements;

(ii) estimated flow duration of streams;

(iii) elevations of top of surface waterbodies; and

(iv) streambed parameters used in the model.

(F) A discussion of calibration and verification procedures and results. Failure to meet any of the proposed calibration or verification goals shall be explained.

(5) Computer storage media deemed acceptable by the commissioner containing the following data:

(A) All input and output generated under subsection (e) of this section including, but not limited to, data for the following:

(i) final calibration runs,

(ii) verification runs, and

(iii) final predictive runs; and

(B) Electronic submission of the area of contribution and recharge areas, formatted in a manner prescribed by the commissioner.

(6) Any other information which the Commissioner deems necessary in order to support the delineation of the area of contribution and the areas of recharge to the well field.

(h) **Analytical Modeling Methods.**

Existing or potential well fields for which the Commissioner has allowed analytical modeling under subparagraph (b) (4) (A) (iv) shall be mapped at Level A in accordance with subdivisions (1) through (5) of this subsection. Unless otherwise specified, below, data shall be collected in accordance with subsection (d) of this section.

(1) Existing data and a plan for data collection and analysis shall be submitted to the Commissioner for review and approval in accordance with the statutory deadlines and shall include:

(A) All information required by subdivisions (b) (1) and (b) (2) of this section;

(B) A detailed plan for conducting aquifer test(s) as required by subdivision (h) (2) of this section;

(C) An identification of the methodology to be utilized to delineate the area of influence. This delineation may be accomplished by the use of an analytical model, as described in subdivision (h) (3) of this section; and

(D) Any other information which the Commissioner deems necessary in order to assure that the proposal for data collection and analysis will result in the accurate delineation of the area of contribution and the areas of recharge to the well field.

(2) Aquifer tests shall be conducted to determine hydraulic properties of the aquifer in accordance with the following:

(A) Pump tests shall be a minimum of 72 hours in duration and meet all requirements of Sections 19-13-B51a through 19-13-B51m of the Regulations of Connecticut State Agencies;

(B) Stream flow characteristics, including, but not limited to, low flow, of any watercourse that can reasonably be expected to be affected by induced infiltration shall be estimated. Field measurements of stage and discharge are not required;

(C) Observation wells shall be installed in sufficient number to measure water table elevations for the construction of water table contour maps; and

(D) Effects of induced infiltration shall be calculated using analytical techniques.

(3) Modeling shall be performed to determine the area of influence. In lieu of use of a digital model, the area of influence may be approximated by the determination of an initial setback area as determined by an analytical model in accordance with the following:

(A) An analytical model used to determine the extent of water table lowering due to pumping shall be fully documented;

(B) The area of influence shall be determined by superimposing the cone of depression upon an estimated configuration of the water table under non-pumping conditions;

(C) The water table configuration for non-pumping conditions shall be estimated using appropriate static water-level data from wells and test borings as well as perennial water bodies that represent water table conditions;

(D) The outer limit of the area of influence shall be determined by the analytical model-predicted water-level drawdown of 0.5 feet within the stratified drift aquifer;

(E) Simulation of the effects of pumping on the water table configuration shall be based on the maximum pumping rates allowable for the well or well field as determined from either the water supply plan, diversion permit or registration, whichever is greatest.

(4) Upon receipt of the Commissioner's written approval of the plan for data collection and analysis, the water company shall conduct the proposed data collection and analyses in accordance with subsection (c) of this section.

(5) Aquifer mapping shall be conducted in accordance with subsection (f) of this section.

(6) Submission of final materials.

(A) Maps and reports shall be submitted in accordance with subdivisions (g) (1) and (g) (2), and subparagraphs (g) (4) (A) through (D) of this section.

(B) The hydrogeologic investigation report submitted pursuant to subparagraph (h) (6) (A) shall also include:

(i) A full description of the analytical technique employed to determine the area of contribution;

(ii) A listing of all data used in analytical models; and

(iii) A listing of all results obtained from analytical modeling.

(C) Floppy diskette(s) containing all programs, input and output generated in subdivision (h) (3) above shall be submitted. The diskette(s) shall be formatted for IBM or compatible microcomputers and the required files shall be in ASCII format.

(i) **Modifications of Level A Mapping.**

If, at any time after written approval of a Level A map under section 22a-354d of the general statutes, a water company becomes aware that hydrogeologic conditions have changed such that a change in the boundaries of an area of contribution or recharge areas on the Level A map can reasonably be expected, or that any information submitted to the Commissioner under this section was not compiled in accordance with this section, was erroneous or any relevant information was omitted, the water company shall, within thirty days of becoming so aware, submit notice of such change, error or omission to the Commissioner. The Commissioner may require a water company to submit a revised Level A map whenever hydrogeologic conditions have changed such that a change in the boundaries of an area of contribution or recharge areas on the Level A map can reasonably be expected, or whenever he finds that any information submitted under this section was not compiled in accordance with this section, was erroneous, was unreliable, any relevant information was omitted, or if, in a case where analytical modeling has been allowed in lieu of numerical modeling under subparagraph (b) (4) (A) (iv) (dd), land use or land use controls change and contamination threats increase. Such mapping shall be performed in accordance with this section, at a time and on a schedule determined by the Commissioner.

(j) **Petition To Amend an Approved Level A Map.**

(1) On or before sixty days after a municipality delineates an aquifer protection area on a local map in accordance with section 22a-354n of the general statutes, any person may petition the Commissioner requesting a change in the boundaries of the area of contribution and recharge areas which are delineated on the corresponding Level A map which was approved by the Commissioner under section 22a-354d of the general statutes.

(2) An owner of land which is located in whole or in part within the boundaries of an aquifer protection area delineated on a local map in accordance with section 22a-354n of the general statutes, may petition the Commissioner requesting a change in the boundaries delineated on the corresponding Level A map.

(3) In making a petition under subdivisions (1) or (2) of this subsection, the petitioner shall have the burden of demonstrating that the approved Level A map was not compiled in accordance with this section or that a material error or omission was made in compiling such map, or that hydrogeologic conditions have changed, and that such changed conditions or the correction of such noncompliance, error or omission can reasonably be expected to result in a specified change in the boundaries of the area of contribution or recharge areas which are delineated on such approved map.

(4) A petition under this subsection shall be submitted in writing on a form prescribed by the Commissioner. The petitioner shall send a copy of such petition by certified mail, return receipt requested, to the water company which submitted the Level A map in question and the chief executive officer and the aquifer protection agency of each municipality which is depicted on such Level A map. The petition shall include but not be limited to a detailed description of the facts and circumstances which give rise to the petition, including a detailed demonstration as required by subdivision (3) of this subsection; the source of all technical information relied upon in the petition; the name, address and signature of the petitioner and the name, address and signature of any representative of the petitioner who participated in compiling technical information relied upon in the petition or preparing the petition; and a certification that a copy of the petition was sent to the water company, chief executive officer(s) and aquifer protection agency(ies), as required by this subsection, on a specified date.

(5) The water company which submitted the Level A map in question, the chief executive officer and the aquifer protection agency of each municipality which is depicted on such Level A map may submit comments on the petition to the Commissioner on or before a date specified by the Commissioner, or if no date is specified by the Commissioner, on or before thirty days after the petition was received by them. The Commissioner may, in his discretion, hold a hearing on the petition, and shall give notice of his decision on the petition to the petitioner, the water company and the chief executive officer and aquifer protection agency of each municipality depicted on the Level A map, briefly stating the reasons for the decision.

(6) An approved Level A map shall not be amended except in accordance with the procedures specified in this section.

(Effective June 21, 1991; amended September 1, 2005)