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October 8, 2009

AE09-006
modelletter

Boyd Snowden
Snowden Consulting Engineers, Inc.
34 Libby Hill Professional Building, Suite 2
Oakland, Maine 04963

Subject: Report of Groundwater Model Results
Bay Park Drainage Improvements Study
Topsham, Maine

Dear Boyd:

This letter report includes a summary of the groundwater modeling effort and results for the above referenced project. As presented at the October 1, 2009 Town of Topsham Selectmen's meeting, model simulations indicated that lowering the Transfer Stations ponds by 4 feet and installing new underdrain piping on Hunter Lane and Loon Drive will help to lower groundwater elevations in a portion of the Bay Park development and likely alleviate some of the basement flooding issues.

INTRODUCTION

The original objective of the modeling effort was to use model simulations to provide an assessment of the potential effectiveness of proposed storm water system modifications. In order to accomplish this, Abbott Engineering (AE) developed a computerized groundwater flow model that encompasses the Bay Park development and vicinity. The model was calibrated using data from a recent test boring program and previous studies (Gerber, 1981). Predictive model simulations were used to evaluate the potential lowering of the groundwater table that may result from improvements to the storm drain, as well as other changes including a proposed lowering of two pond levels on the nearby Town-owned Transfer Station property.

MODEL CODE SELECTION AND MODEL CONSTRUCTION

The focus of the modeling effort was on the groundwater system within the surficial (shallow) sand deposit, described in earlier studies as a low yielding sand aquifer (Gerber, 1981). In order to represent flow conditions in the sand, AE chose to use a three-dimensional model capable of simulating drains and other imposed hydraulic changes.

The selected software used for the hydraulic model was Visual Modflow (Version 4.0 by Waterloo Hydrogeologic, Inc. 2003 – original authors Guiguer and Franz), which uses the MODFLOW flow code. MODFLOW, (McDonald and Harbaugh, USGS, 1988) is a three

dimensional, finite difference, saturated flow model. The MODFLOW code is widely used and accepted for representative modeling purposes.

Discretization and Layering. This model has one layer only, representing the sand unit. The flow model was set up on a 100 x 100 grid and encompassed Bay Park and the surrounding area (see Figure 1, attached), inclusive of the areas modeled in the Gerber, 1981 study. The area included in the model is approximately 8,700 feet by 9,000 feet, or a total of approximately 2.9 square miles. Note that the Gerber model was developed to assess the potential water quality impacts of leachfields within the subdivision and was not used to study basement flooding issues.

Model Boundaries. Based on interpretation of the regional hydrology, the main controlling hydrologic boundaries near Bay Park are the numerous ponds and streams, which all discharge to the Androscoggin River. The River acts as a regional groundwater discharge feature and was represented in the model using constant head values coinciding with USGS topographic elevations. Other streams and surface water bodies were also input as discharge features with localized influence. Water enters the model as precipitation recharge in an area defined by the watershed boundaries.

Hydrogeologic Properties. Initial model parameter values were selected based on Site observations and data from previous studies (Gerber, 1981). Some of these values were modified during the calibration process. However, in order to maintain a representative model of the geologic setting, parameter values were kept within ranges as deemed appropriate according to the natural heterogeneity of the sand unit. The ranges of values for individual parameters used in the model are listed below:

Table 1
Flow Model Hydrogeologic Properties

	Hydraulic Conductivity (ft/day)	Effective Porosity	Specific Storage (1/ft)	Recharge (inches/year)
Value	2 to 20	0.25 to 0.3	.0001 to .0002	14 to 18

FLOW MODEL CALIBRATION

The flow model was calibrated to match the interpreted phreatic (unconfined shallow groundwater) water table surfaces as determined using water level elevations from the Gerber study in 1981 as well as information gathered during the current (2009) project. New data included water level measurements in several shallow test borings performed in Bay Park on August 5, 2009 and survey measurements of the Pelletier and Town Pond elevations in September 2009. Model calibration was accomplished by comparing simulated hydraulic head values with measured values at specified locations. Parameter values were adjusted as necessary throughout the model in order to obtain a simulated water table that closely matched the interpreted water table based on field data.

For each flow model simulation, a plot was generated to compare field water levels and those simulated by the model run. Calibration of the flow model was considered complete when a reasonable match was obtained between simulated and field measured values, as indicated by a correlation coefficient (Cc) of greater than 90 %. Figure 2 shows a plot of the simulated water table configuration in the Bay Park area.

It should be noted in Figure 2 that Town ponds are several feet higher in elevation than many of the other nearby drainage features (e.g., the Pelletier Pond). The Town Ponds are manmade ponds resulting from past mining of the sand and clay at those locations. In Figure 2, flow direction lines superimposed on the groundwater table contours indicate that water in the sand does not discharge into the ponds, due to their elevation. Based on this observation, it was determined that the ponds may provide an opportunity to move some of the water away from the residences at Bay Park, assuming the water levels could be lowered and the water made to outflow to a nearby stream located to the northeast of the project. On September 21, 2009, several high capacity pumps were installed in the larger of the two Town Ponds by the Topsham Public Works Department (PWD) and pumped for approximately 48 hours at rates ranging from 1000 gpm to 3000 gpm. This resulted in lowering the water level in that pond by about 1.75 feet. Measurement of groundwater levels in shallow piezometers installed on Lover's Land and Eider Lane during this test indicated that lowering of the ponds resulted in drawing down the groundwater table in that portion of Bay Park approximately 1 inch. This is a strong indication that the Town Ponds are in direct hydraulic connection with the shallow water beneath Bay Park and that long term lowering the Town Ponds will result in substantial lowering of the groundwater beneath some of the residences. To further calibrate the model, simulations of the test described above were performed and several minor adjustments were made until the model accurately represented the response of the groundwater system to this short term test.

PREDICTIVE MODELING

Predictive simulations included the following:

Long term lowering of the Town Ponds by 4 feet. This scenario assumes that water from the ponds will be controlled by an outflow structure and discharge to surface water streams draining into the Muddy River and eventually to the Androscoggin. As shown in Figure 3, the main result of lowering these ponds is that they become significant discharge features (as indicated by the flow arrows) and remove much of the groundwater from the Eider Lane side of Bay Park. This results in a lowering of the groundwater table in the order of 1 to 1.9 feet.

New underdrains. In this simulation, the Town Ponds are left at their original elevations. Underdrain improvements on Loon Drive and Hunter Lane are simulated. The discharge for these underdrains would be to the stream located southwest of the development, which acts as a discharge location for the existing system. For specifications of underdrain placement and elevations, refer to the design by Snowden Consulting Engineers, Inc. Figure 4 shows the

simulated water table and flow directions. Under this scenario, the model indicates that the water table may be lowered up to 1 foot in areas close to the proposed underdrain improvements.

Combined pond lowering and new underdrains. In this scenario, the Town Ponds would be lowered 4 feet and the underdrain improvements on Loon Drive and Hunter Land would be implemented. Based on model simulations, the water table in Bay Park would be lowered up to 3 feet. The greatest magnitude of water table drawdown would occur near the intersection of Eider Lane and Hunter Lane. The amount of drawdown would decrease towards the northwest. For example, maximum drawdown in the vicinity of Teal Rd. would be 2 feet or less (Figure 5).

It should be noted also that model simulations indicate that it may take up to 2 years to reach maximum drawdown. This will depend on the amount of rainfall and other factors that cannot be predicted in detail using the model.

MODEL LIMITATIONS

The groundwater flow model presented herein is only a mathematical representation of the groundwater system and geologic setting. Due to the natural complexity of these entities, a model can only achieve a simplified representation of the actual system and therefore must be considered as generalized screening tools for use in studying this site. Furthermore, the calibration and validation of any model is limited by the availability and accuracy of field data and historical records of site activities.

SUMMARY AND CONCLUSIONS

Based on the predictive simulations described above, lowing of the Town Ponds and installation of the proposed underdrain improvements should result in significant lowering of the groundwater table in portions of Bay Park. This will hopefully reduce some of the problems that residents have been experiencing with water in their basements by creating a new baseline water elevation and increasing the capacity of the groundwater system and underdrains to handle storm events.

Please feel free to call with any questions or comments.

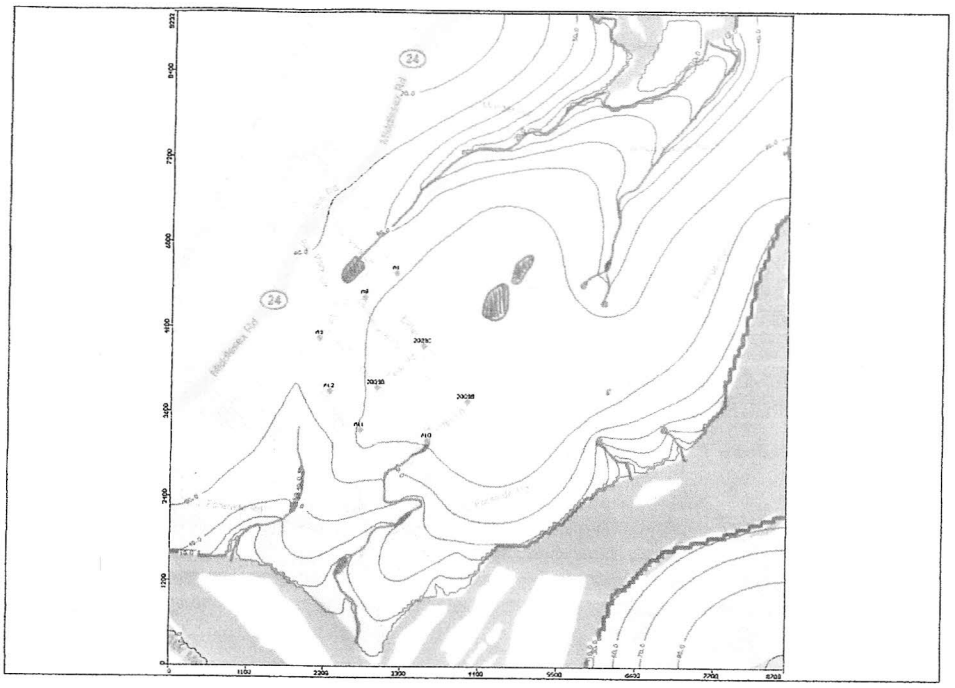
Sincerely,

ABBOTT ENGINEERING

Michael D. Abbott, P.E., C.G.

Attachments

ATTACHMENT 1 – MODEL FIGURES



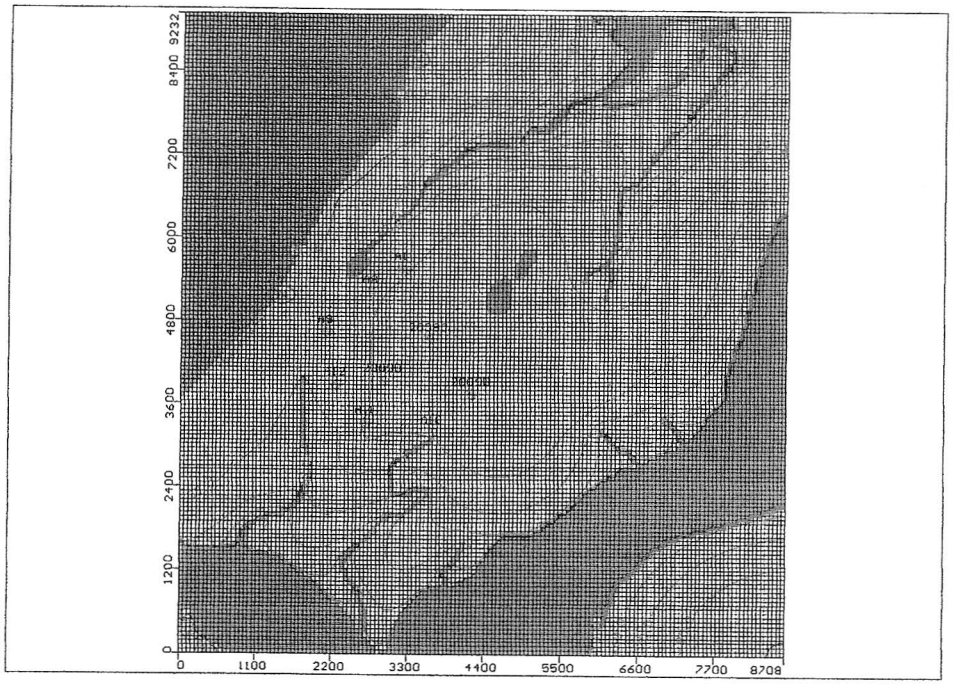


Figure 1

Model Region and Grid Configuration

ATTACHMENT 1 – MODEL FIGURES

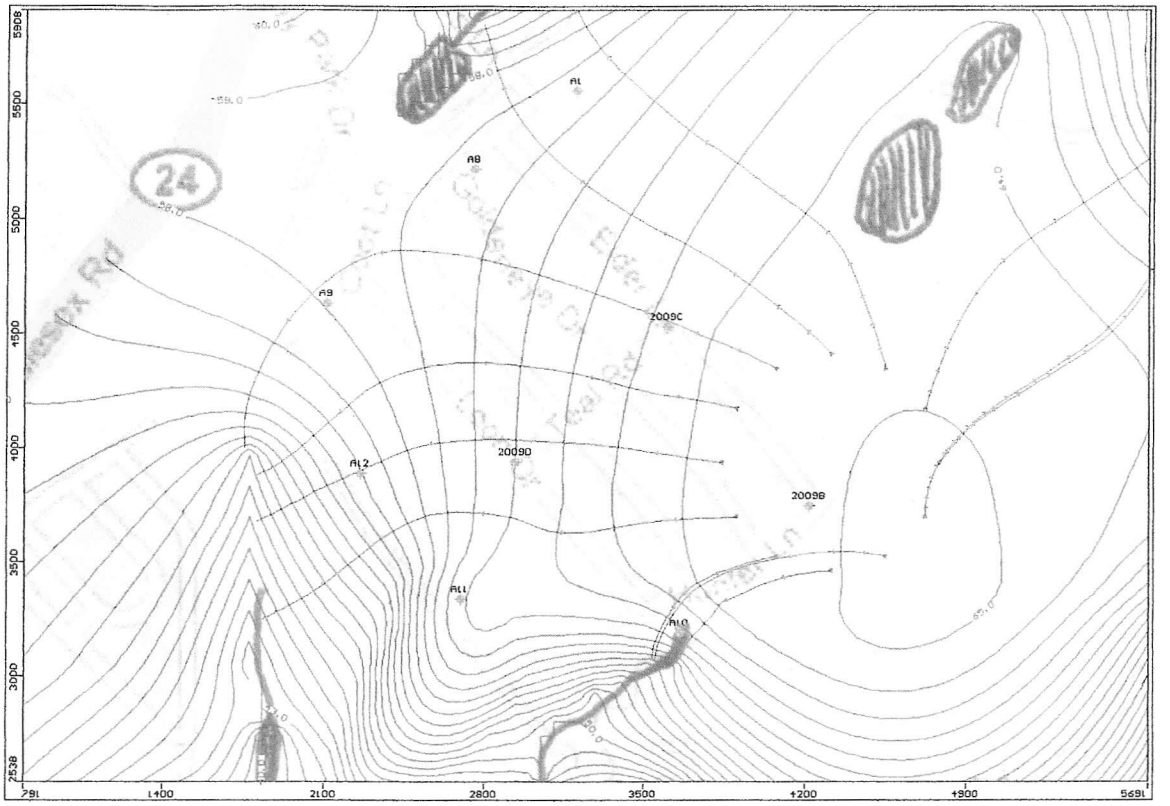


Figure 2

Calibrated Water Table
1 Foot Contours

ATTACHMENT 1 – MODEL FIGURES

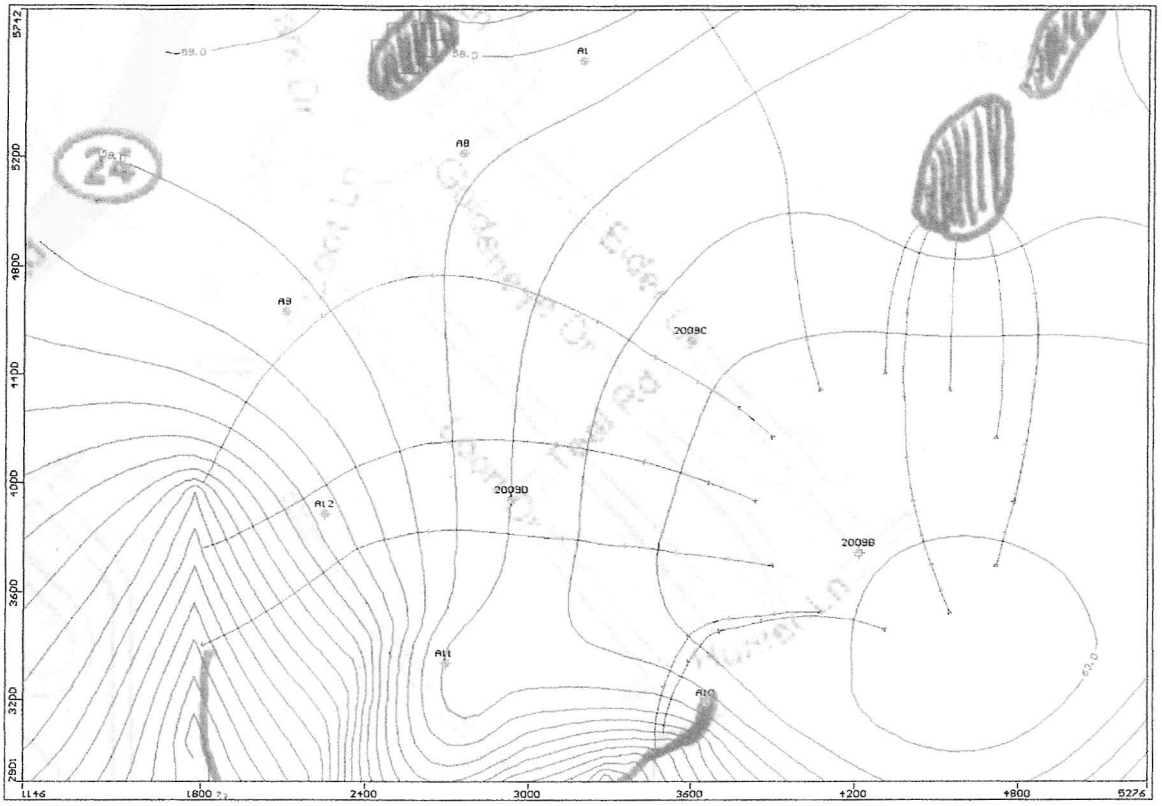


Figure 3

Simulated Water Table with Town Ponds lowered 4 feet.
1 Foot Contours

ATTACHMENT 1 – MODEL FIGURES

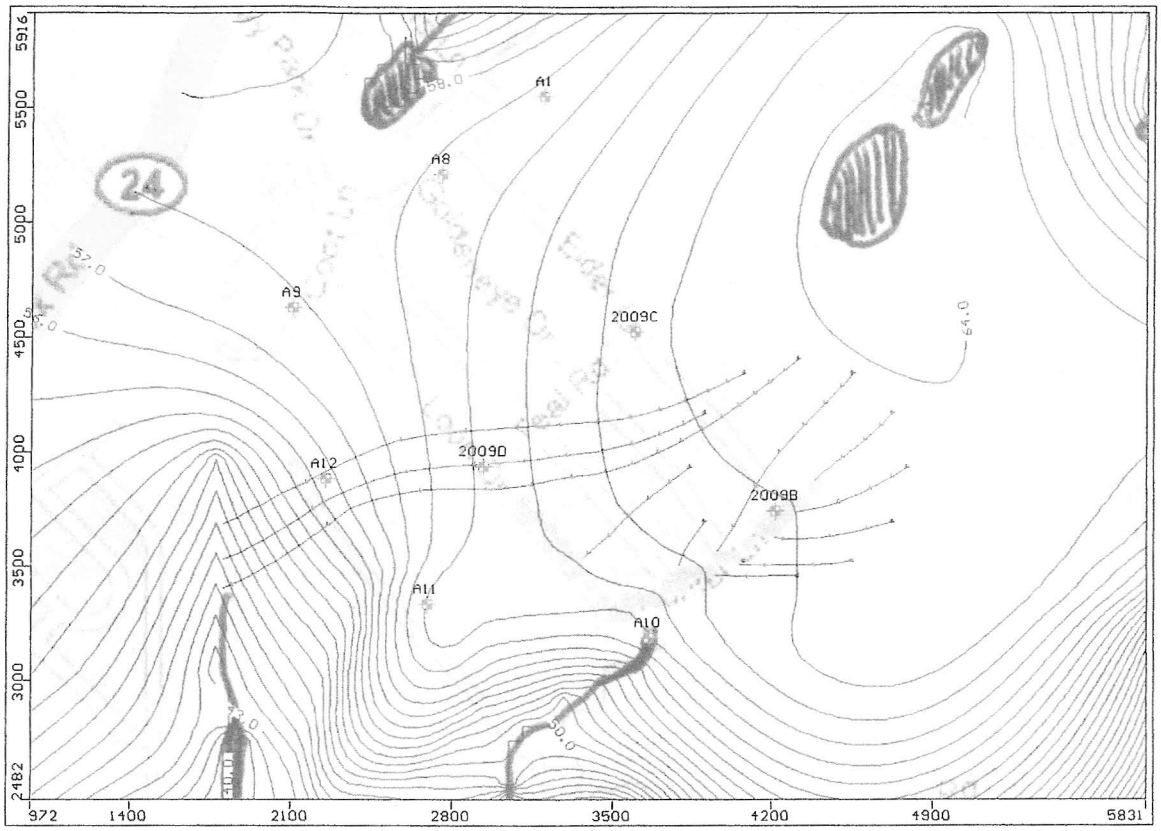


Figure 4

Simulated Water Table with Underdrain Improvements on Loon Dr. and Hunter Lane
1 Foot Contours

ATTACHMENT 1 – MODEL FIGURES

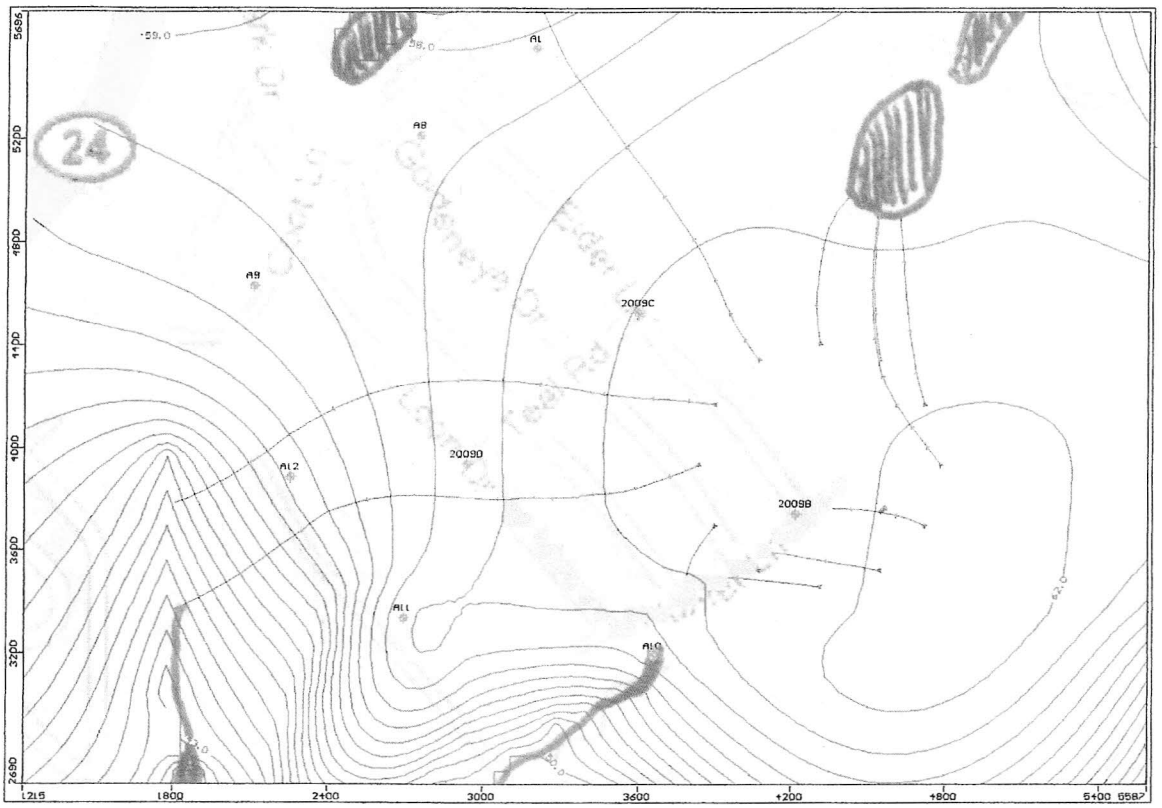


Figure 5

Simulated Water Table with Town Ponds Lowered (4 feet) and new Underdrains Installed (Loon Dr. and Hunter Ln.)