Potential Yield of Gravel Pits in the Sangamon River Valley:

Refinement of 2012 Estimates

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Executive Summary

The City of Springfield is evaluating alternatives for a 12 mgd supplemental water supply. Previous studies have estimated the anticipated yield of wells and gravel pits in the Sangamon River Valley (Anliker and Woller, 1998; CMT, 2008, 1998a,b), including three general groups of pits— A, B, and C (Figure 1). For these previous studies, the gravel pit volumes were estimated based on the average depths as reported at the time by the gravel pit owners.

In 2012, Layne updated the previous yield estimates based on a detailed field investigation at Clear Lake (Site A) and a detailed groundwater modeling analysis (Layne, 2012). Layne concluded that a 12 mgd, 18-month drought supply from gravel pits alone may be possible from all of the gravel pits, depending on actual site conditions at the B and C gravel pits. Layne also concluded that pumping water from the gravel pits would significantly lower water levels in the aquifer at neighboring well fields belonging to the Village of Riverton, the Village of Dawson, the South Sangamon Water Commission, and the Village of Mechanicsburg (Figure 1). Any additional drawdown at the municipal wells due to withdrawals at the gravel pits would increase pumping costs for the municipalities and depending on individual well construction details and performance characteristics, could lower the pumping water level in wells below the top of the screen, disabling these wells until aquifer water levels recover.

To reduce uncertainty in gravel pit yields and to better quantify the potential impacts of pumping on neighboring municipal wells, CWLP collected additional field data and hired Layne to update the 2012 estimates. The new field data included bathymetric surveys of all the B and C gravel pits. CWLP also compiled well data for the neighboring municipal wells, including pump capacity and elevation, and the elevation of the top of the well screens.

Model simulations were performed to estimate the 100-yr drought yield of the gravel pits if water is pumped directly from each pit at a constant rate for 18 months. The drought yield was determined for three cases, as described below and summarized in Table A:

1. The ***maximum drought yield*** for each pit group is defined as the yield that drains each gravel pit by the end of the 18-month period of pumping. The ***maximum drought yield*** is evaluated without considering the effects on the nearby municipal well fields. The purpose in evaluating the ***maximum drought yield*** is to update the yield from the previous study, while including more accurate representations of actual gravel pit volumes and depths in the model. This provides a point of comparison with the previous work. The ***maximum drought yield*** of all gravel pits combined is estimated to be approximately 9 mgd. Model simulations show that it is not possible to obtain a 12 mgd drought supply by pumping from all of the gravel pits. The maximum estimated yield is lower than the 2012 estimates because the actual gravel pit volumes of the pits determined with bathymetry were smaller than previous estimates.

2. The ***allowable drought yield*** of individual gravel pit groups is estimated based on impacts to the nearest adjacent municipal well fields. Acceptable impacts to municipal wells are based on well construction information collected and summarized by CWLP (Appendix A). The ***allowable drought yields*** for each individual gravel pit group are: 0.2 mgd for Clear Lake South pit (group A); 0 mgd for Hidden Valley Lake, Sangamon Valley S&G and Vulcan Materials (group B); 0.0 mgd for Buckhart S&G West and East pits (group C1), and 1.4 mgd for Sang Chris S&G (group C2). These yields are restricted due to predicted impacts to the nearby municipal well fields. This limits withdrawals from all gravel pits, but is most restrictive at the B-pits (B1, B2, B3) and C1 pits. Simulations show that a 100-year drought may cause pumping levels to fall near the top of the well screens for wells in the South Sangamon Water Commission well field, without withdrawals from the B-pits or C1-pits. Therefore, no drought withdrawals can safely be made from the these pits without significant impacts to the operation of the South Sangamon Water Commission well field.

3. Finally, the ***total allowable drought yield*** of simultaneous pumping withdrawals from all gravel pit groups is considered. The ***total allowable drought yield*** for simultaneous pumping of all gravel pits is estimated to be 1.6 mgd. This is equal to the sum of the ***allowable drought yields*** of individual gravel pit groups, as the pumping rates are very small and the pits being pumped simultaneously or individually are distant from each other with negligible interaction.

Table A: Summary of estimated yields for 18 months of continuous pumping during the 100-year drought: the ***maximum drought yield***, the ***allowable drought yield*** by pit group, and the ***total allowable drought yield***.

Gravel pit	Site ID	Pit group	Maximum drought yield (mgd)	Allowable drought yield by pit group (mgd)	Total allowable drought yield (mgd)
Clear Lake S&G	A South	A	3.0	0.2	0.2
Hidden Valley Lake	B1	B	1.6	0.0	0.0
Sangamon Valley S&G	B2	B	0.4	0.0	0.0
Vulcan Materials	B3	B	1.4	0.0	0.0
Buckhart S&G	C1 West	C1	1.0	0.0	0.0
Buckhart S&G	C1 East	C1	0.3	0.0	0.0
Sang Chris S&G	C2	C2	1.4	1.4	1.4
Total			**9.1**	**–**	**1.6**

Note. mgd=million gallons per day

1 Introduction

The City of Springfield is evaluating alternatives for a 12 million gallons per day (mgd) supplemental water supply. The yield of Lake Springfield, which provides both the drinking-water supply and the cooling water for the City's power plants, is inadequate to meet existing demand during a severe drought. As part of the Environmental Impact Statement for Hunter Lake, numerous alternatives for a supplemental water supply were evaluated. Some of the alternatives evaluated included the use of groundwater from the sand and gravel aquifer along the Sangamon River. For these alternatives, water pumped from wells screened in the aquifer or directly from gravel pits would be pumped either to Lake Springfield or directly into the water treatment plant.

Previous studies have estimated the anticipated yield of wells and gravel pits in the Sangamon River Valley (Anliker and Woller, 1998; CMT, 2008, 1998a,b), including three general groups of gravel pits— A, B, and C (Figure 1). For these previous studies, the gravel pit volumes were estimated based on the average depths as reported at the time by the gravel pit owners.

In 2012, Layne updated the previous yield estimates based on a detailed field investigation at Clear Lake (Site A) and a detailed groundwater modeling analysis (Layne, 2012). Layne concluded that a 12 mgd, 18-month drought supply from gravel pits alone may be possible from all of the gravel pits, depending on actual site conditions at the B and C gravel gravel pits. Layne also concluded that pumping water from the gravel pits would significantly lower water levels in the aquifer at neighboring well fields belonging to the Village of Riverton, the Village of Dawson, the South Sangamon Water Commission, and the Village of Mechanicsburg (Figure 1). Any additional drawdown at the municipal wells due to withdrawals at the gravel pits would increase pumping costs for the municipalities and depending on individual well construction details and performance characteristics, could lower the pumping water level in wells below the top of the screen, disabling these wells until aquifer water levels recover.

To reduce uncertainty in gravel pit yields and to better quantify the potential impacts of pumping on neighboring municipal wells, CWLP collected additional field data and hired Layne to update the 2012 estimates. The new field data included bathymetric surveys of all the B and C gravel pits. CWLP also compiled well data for the neighboring municipal wells, including pump capacity and elevation, and the elevation of the top of the well screens. The data compiled by CWLP–obtained from as-built drawings and maintenance records provided by the well field owners–is presented in a report that is included as Appendix A.

This document presents the results of an analysis to refine the previous yield estimates (Layne, 2012). The previous yield estimate was based on detailed information, including aquifer testing and lake bathymetry, only at the Clear Lake (A) gravel pits; bathymetry for all other gravel pits and aquifer properties south of Clear Lake were assumed based on estimates made in earlier studies. The

new information provided by CWLP is incorporated into the present analysis, including the stage-volume relationships for the B and C gravel pits and construction characteristics of neighboring municipal wells.

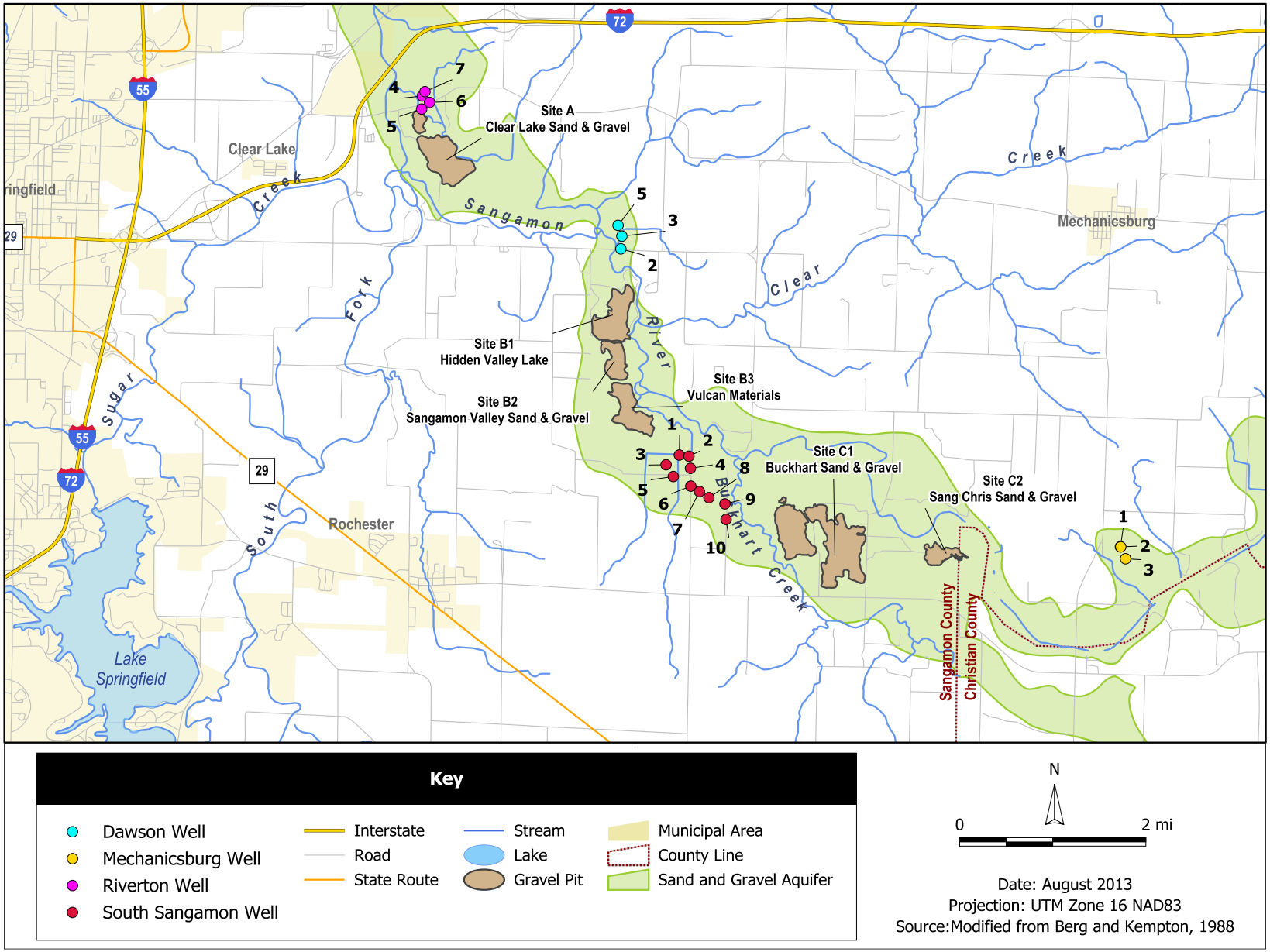

Figure 1: Location of gravel pits and municipal wells in the Sangamon River Valley considered in the study.

1.1 Objectives

The objective of this project was to refine the estimates of drought yield for the gravel pits in the Sangamon River Valley by incorporating newly obtained data into the previous analysis reported in Layne (2012). Specifically, the project objectives were to:

1. incorporate new bathymetric survey data into a revised groundwater flow model
2. incorporate well construction data into the yield analysis
3. estimate the ***maximum drought yield*** of all gravel pits in the region
4. estimate the ***allowable drought yield*** for each individual gravel pit group that will not significantly impact nearby municipal wells
5. estimate the ***total allowable drought yield*** of all gravel pits pumping simultaneously that will not significantly impact nearby municipal wells

1.2 Approach

The approach used to meet the project objectives included the following steps:

1. reviewed and analyzed new bathymetric information, and municipal well data
2. revised the groundwater flow models developed in 2012 (Layne, 2012) into a single model of the entire region, incorporating the new data
3. established a maximum allowable drawdown criteria for each neighboring well field
4. used the groundwater flow model to predict ***maximum, allowable,*** and ***total allowable drought yields*** from the gravel pits during the 100-year drought

2 Regional Groundwater Flow Model

Revisions were made to the groundwater flow models developed in 2012 (Layne, 2012) to reflect newly obtained field data. The new data include bathymetric surveys of gravel pits conducted by CWLP and a compilation of well construction details for the nearby municipal well fields. The two models from the previous study (Clear Lake model and South model) were combined into a single regional model. The model was developed using the Groundwater Vistas pre-processor (Rumbaugh and Rumbaugh, 2007) for MODFLOW 2000. MODFLOW 2000 is an industry standard.

The current groundwater flow model is configured to simulate conditions during the 100-year drought. Simulated conditions are based on the drought of record which occurred during the four year period from 1952 to 1956. The groundwater flow model is assigned 48 monthly stress periods to simulate transient conditions during the drought, including varying river stages, aquifer recharge, and direct precipitation and evaporation at the gravel pits. The regional hydrogeology, the hydrogeological conceptual model, the boundary conditions, and the basis for aquifer properties specified in the model are described in detail in the 2012 report (Layne, 2012). Here we discuss only the changes that were made to the original models.

2.1 Model domain

A single regional model domain was defined by joining the two domains from the previous study (Layne, 2012). A sloping, impermeable aquifer base was defined based on well construction details compiled by CWLP (Appendix A); the aquifer base varies from an elevation 470 ft at the north end of the model to 495 ft (NAVD 88) at the south end of the model. The aquifer is confined above by a thick layer of clay. The thickness of the model aquifer is constant throughout the domain and equal to 45 ft, based on well boring logs. The MODFLOW 2000 model allows for combined confined/unconfined flow to occur throughout the domain. The model domain is discretized into cells of 100 ft by 100 ft.

2.2 Aquifer properties

The aquifer parameters from the original study (Layne, 2012) are modified slightly, based on newly obtained data (Appendix A), to reflect an aquifer thickness of 45 ft: the transmissivity of the aquifer from the previous study is held constant and the hydraulic conductivity is calculated based on a 45 ft thick aquifer. Two zones of different hydraulic conductivity are included in the model, as described in Layne (2012): first, a low transmissivity zone at the north end of the model extending south to the Dawson well field, and second a higher transmissivity zone at the south, extending from the Dawson well field to the south end of the model. The aquifer properties in the north zone are based

on aquifer testing performed in 2012; properties of the south zone are based on estimates from earlier studies of the aquifer. The parameter values specified in the regional model are presented in Table 1. The gravel pit conductance (C_p), river bed conductance (C_r), specific storage, (S_s), and specific yield (S_y) remain unchanged from the previous study.

Table 1: Parameters in the regional groundwater flow model.

Parameter	Units	Value
Aquifer thickness, H	ft	45
Hydraulic conductivity (north), k	ft/day	68
Hydraulic conductivity (south), k	ft/day	168
Gravel pit bed conductance, C_p	1/day	2.25
River bed conductance, C_r	1/day	7.90×10^{-3}
Specific storage, S_s	1/ft	3.50×10^{-5}
Specific yield, S_y	(–)	0.1

2.3 Sangamon River

To correspond with the sloping aquifer base, the Sangamon River is also sloped in the present model. The river is divided in the model into three reaches of constant slope, estimated from digital elevation maps. The river stages representative of the 100-year drought were defined in the model to have the same slope as the river bed. The river was simulated in MODFLOW2000 using the RIV package.

2.4 Model description of gravel pits

As in the previous study, the gravel pits are simulated in the model as having vertical sides with a specified entry resistance to include the effects of flow through the sloping sides and bottom of the pits. The stage-storage curve for each gravel pit is approximated with a straight line; the y-intercept of the line is used to represent the minimum elevation of the bottom of the gravel pit in the groundwater flow model. The surface area of each simulated gravel pit was determined by matching the surveyed total volumes of the pits between the filled stage and the simulated pit bed. This approach preserves the gravel pit volume rather than the exact geometry; in all cases, the area of the simulated pits is smaller than the surface area measured in the field, but the simulated volume of water stored in the lakes is the same as the measured value. All of the gravel pits in the model

are simulated using the LAK3 package for MODFLOW 2000. Each gravel pit group and their representation in the model is described in more detail below.

2.4.1 Clear Lake S&G (A South)

The stage-storage relationships for Clear Lake S&G North and South pits were determined by field survey in October 2011. The stage-storage curve for the South pit is illustrated in Figure 2, along

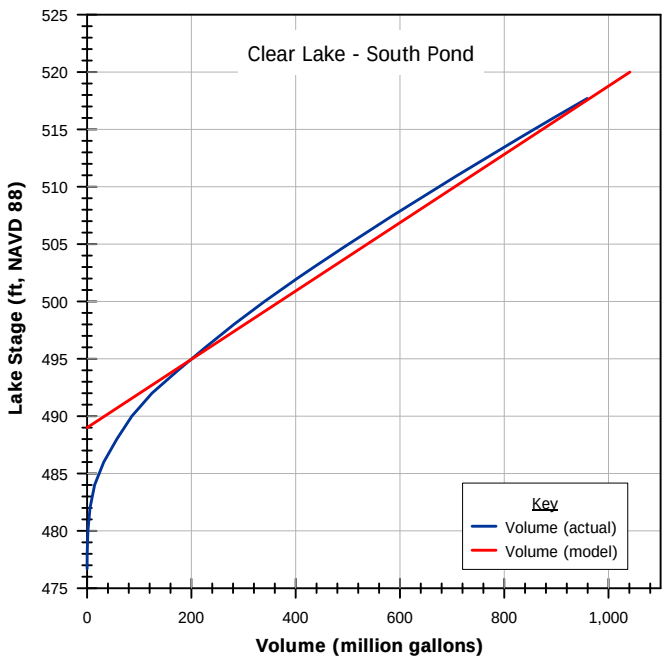

Figure 2: Surveyed (*blue*) and simulated (*red*) stage-storage relationships for Clear Lake (South Pond).

with its representation in the groundwater flow model. The North pit is also simulated in the model, but it is a passive feature. No drought withdrawals are made from the North pit, as it is much smaller in area and volume than the South Pit. However, the water levels in the North pit respond to pumping in the South pit because both pits are hydraulically connected to the aquifer. Pumping from the South pit causes aquifer water levels to decrease, which causes the water level in the North pit to decrease as well.

2.4.2 Hidden Valley Lake (B1), Sangamon Valley S&G (B2), and Vulcan Materials (B3)

The stage-storage relationships for Hidden Valley Lake, Sangamon Valley S&G, and Vulcan Materials are illustrated in Figure 3. Each gravel pit is simulated individually in the model.

2.4.3 Buckhart S&G (C1 West and C1 East)

Buckhart S&G consists of five gravel pits, as described by CWLP (Appendix A). In the model, we consider pumping from the two largest gravel pits, Buckhart West and Buckhart East. The remaining three lakes are significantly smaller than the West and East pits and are therefore simulated as passive model features with no direct withdrawals. The stage-storage relationships for the West and East gravel pits are illustrated in Figure 4.

2.4.4 Sang Chris S&G (C2)

The stage-storage relationship for the Sang Chris S&G gravel pit is illustrated in Figure 4.

2.5 Municipal wells

Municipal wells in the region include the well fields of Riverton, Dawson, the South Sangamon Water Commission (SSWC), and Mechanicsburg. Each well is simulated in the groundwater flow model as pumping continuously at an average constant rate based on the most recent information reported for each well field in the state water withdrawal database (ISWS, 2012). The average annual yield of each well field is summarized in Table 2. Pumping rates for individual wells in each well field correspond to the total well field rate divided by the number of wells in the well field. This provides background aquifer levels in the well fields simulating average pumping conditions. The cycling on and off of pumping wells at higher rates is not directly simulated with the model but is incorporated into the yield analysis for the gravel pits.

Table 2: Model pumping rate for each well field.

Well field	Average pumping rate (mgd)	Source
Riverton	0.34	(ISWS, 2012)
Dawson	0.18	(ISWS, 2012)
South Sangamon Water Commission	1.25[1]	(Vancil, 2012)
Mechanicsburg	0.08	(ISWS, 2012)

Note: mgd=million gallons per day, [1]Projected value

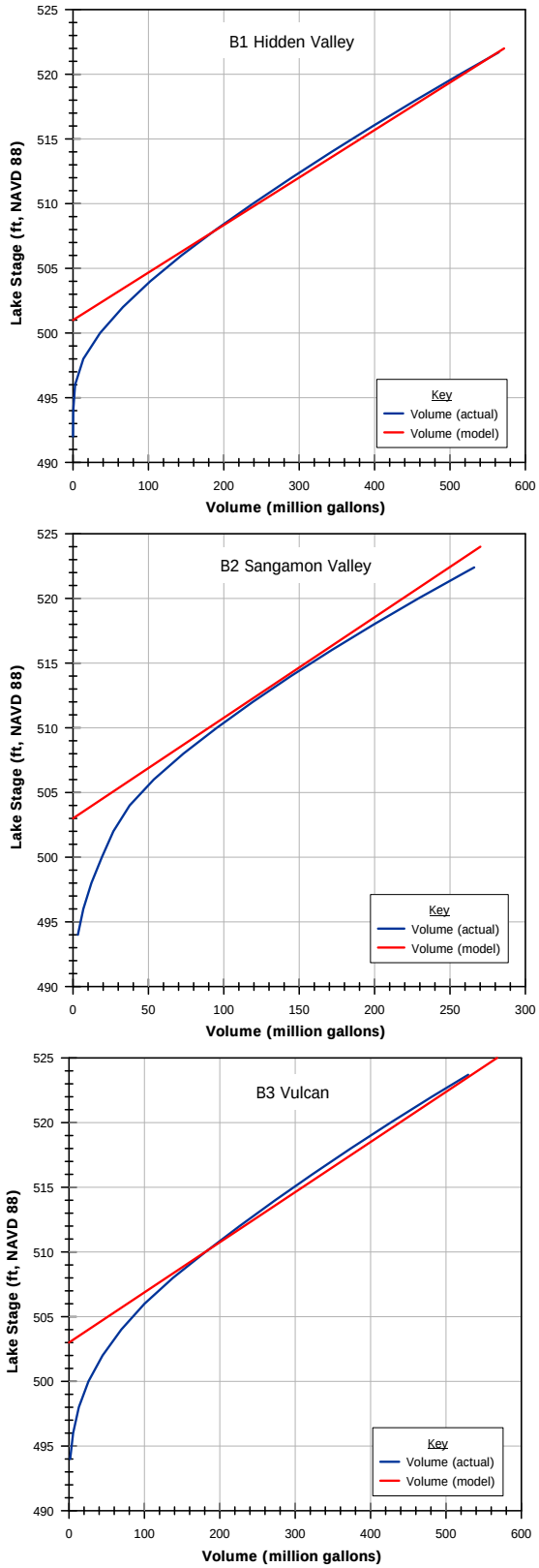

Figure 3: Surveyed (*blue*) and simulated (*red*) stage-storage relationships for the group B gravel pits: Hidden Valley Lake (B1, *top*), Sangamon Valley S&G (B2, *middle*), and Vulcan Materials (B3, *bottom*).

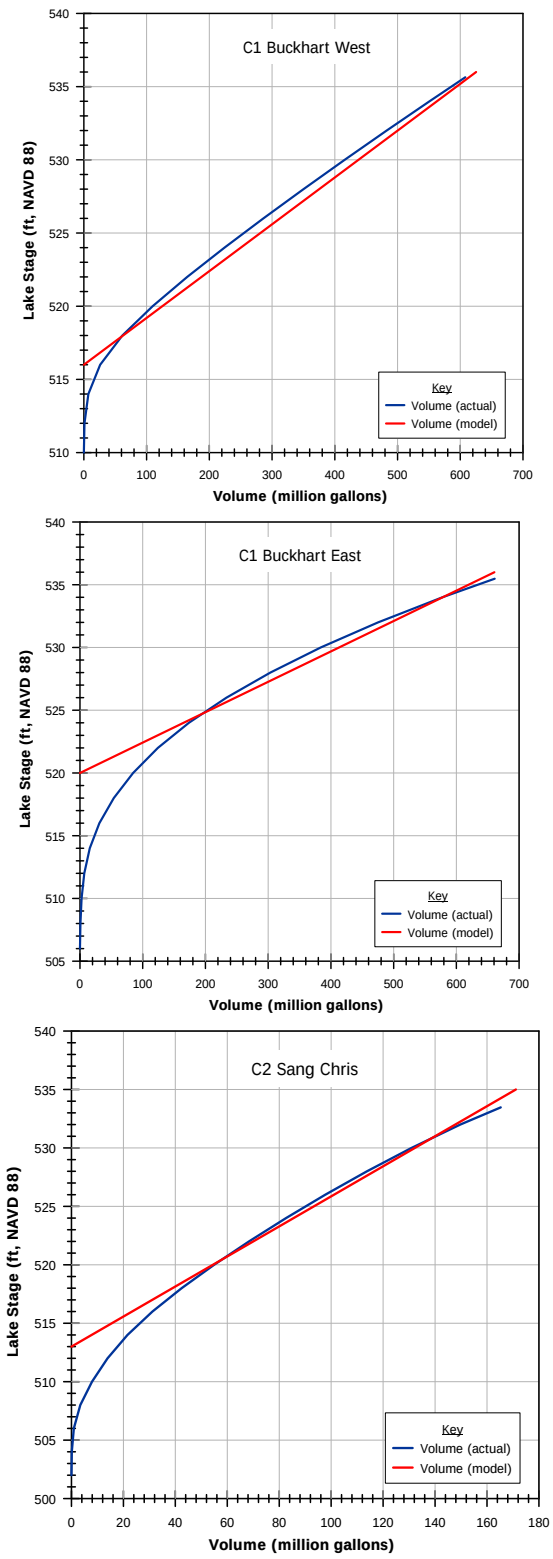

Figure 4: Surveyed (*blue*) and simulated (*red*) stage-storage relationships for C gravel pits: Buckhart S&G West (C1 West, *top*), Buckhart S&G East (C2 East, *middle*), and Sang Chris S&G (C2, *bottom*).

3 Yield Analysis

Model simulations were performed to estimate the drought yield of the gravel pits if water is pumped directly from each pit at a constant rate for 18 months. A four year period is simulated by the groundwater flow model. The period of drought is defined as the 18-month period beginning at the start of the third year of the simulation. The following steps were taken to estimate the drought yield of the gravel pits:

1. A simulation was performed, reflecting the 100-year drought, with no pumping from the gravel pits. This was done to assess the ambient or baseline conditions expected to occur in the aquifer during a drought. Changes to the groundwater flow system that occur when pumping from the gravel pits are assessed by comparison to the ambient conditions at the end of the 18-month period of drought.

2. Simultaneous pumping from all gravel pit groups was simulated. The ***maximum drought yield*** for each pit group is defined as the yield that drains each gravel pit by the end of the 18-month period of pumping. The ***maximum drought yield*** is evaluated without considering the effects on the nearby municipal well fields. The purpose in evaluating the ***maximum drought yield*** is to update the yield from the previous study, while including more accurate representations of actual gravel pit volume and depth in the model. This provides a point of comparison with the previous work.

3. The ***allowable drought yield*** of individual gravel pit groups is estimated based on impacts to the nearest adjacent municipal well fields. Acceptable impacts to municipal wells are based on well construction information collected and summarized by CWLP (Appendix A). The methodology for evaluating acceptable impacts is described below.

4. Finally, the ***total allowable drought yield*** of simultaneous pumping withdrawals from all gravel pit groups is considered.

Each step in the analysis along with results is described below in more detail.

3.1 Ambient drought simulation

Results from simulations of ambient drought conditions at each gravel pit are illustrated in Figure 5. Gravel pit stages at the beginning and end of the 18-month period of drought are summarized in Table 3.

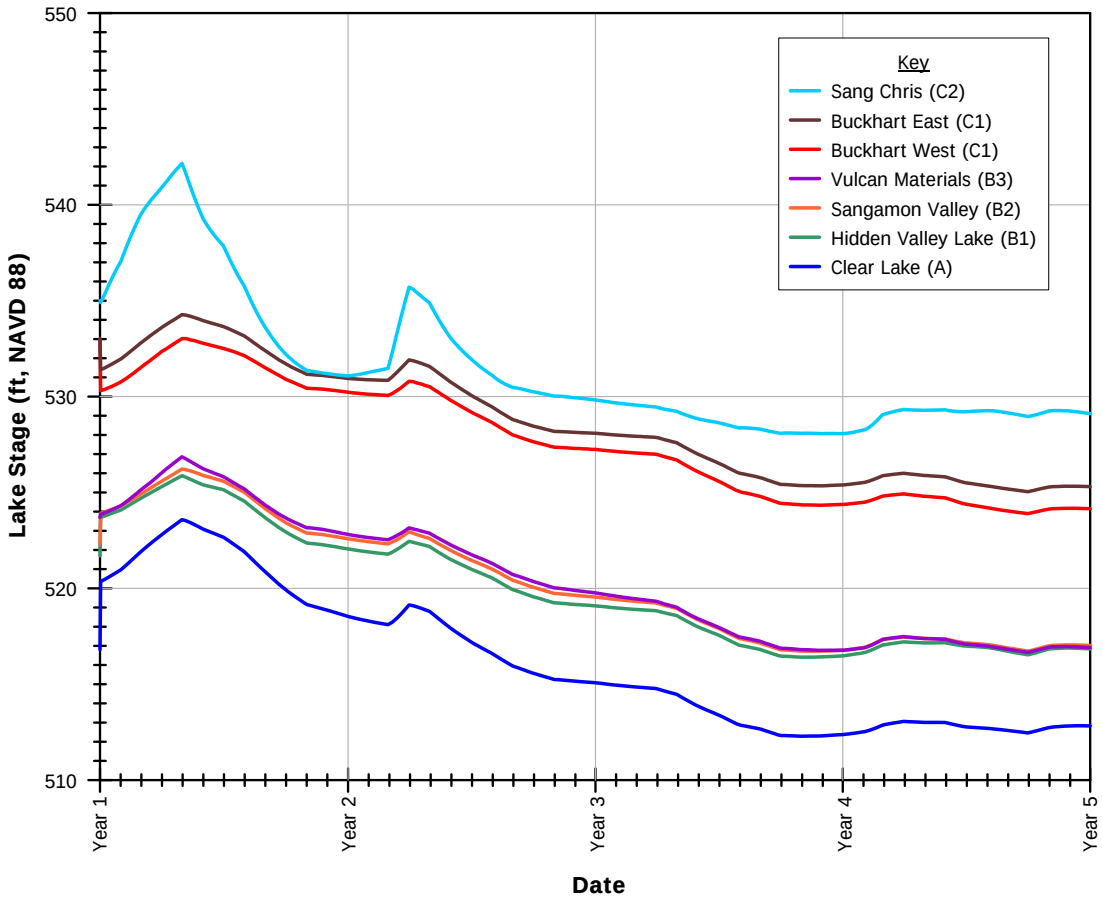

Figure 5: Simulated stage in gravel pits during the 100-year drought, without withdrawals.

3.2 Simulation of maximum drought yield

The ***maximum drought yield*** for simultaneous withdrawals from all gravel pits was evaluated by trial and error. Model simulations were performed by varying withdrawal rates at each gravel pit until the water elevation at the end of the 18-month period of drought corresponded to the modeled elevation of the gravel pit bottom. Results are summarized in Table 4. The total ***maximum drought yield*** of the gravel pits is estimated to be approximately 9 mgd. The yield is lower than the previous estimates because the gravel pit volumes measured by CWLP are smaller than previous estimates (CMT, 1998b, 2008).

Table 3: Ambient water levels in gravel pits at the start and end of the 18-month period of drought simulation. Surveyed stages representing non-drought conditions are also presented (Appendix A).

Gravel Pit	Site ID	Surveyed stage (non-drought) (ft, NAVD 88)	Ambient stage at start of drought (ft, NAVD 88)	Ambient stage at end of drought (ft, NAVD 88)
Clear Lake S&G	A South	516.4	515.1	512.8
Hidden Valley Lake	B1	521.7	519.1	517.0
Sangamon Valley S&G	B2	522.3	519.5	517.1
Vulcan Materials	B3	523.7	519.8	517.1
Buckhart S&G	C1 West	535.6	527.2	524.4
Buckhart S&G	C1 East	535.5	528.0	525.5
Sang Chris S&G	C2	533.7	529.8	529.2

3.3 Allowable drought yields for individual gravel pit groups

Withdrawals from individual gravel pit groups (A, B, C1, and C2) were simulated for multiple withdrawal rates, while considering the effects of the withdrawals on the municipal wells nearest to each group. Results are presented below.

3.3.1 Criteria for allowable impact to municipal wells

Our criteria defining an allowable impact to the municipal wells is that at the end of the 18-month period of drought, the pumping level in the wells must be at least four feet above the elevation of the top of the screen. It is standard industry practice to construct wells so that the pumping water level remains above the screen under all operating conditions (HRI, 2012). If a well is operated with the pumping level below the top of the screen, the well capacity is reduced and the rate of screen degradation is significantly increased.

We assume that four feet of freeboard above the top of the well screen is sufficient for operation of the neighboring municipal wells. If water levels fall below the pump elevation, but four feet of freeboard remains above the well screen, we assume that the pumps can be reset at a lower elevation, but above the top of the screen. Application of this criteria and results at individual wells are presented below for each gravel pit group. Well data, including pump capacity and elevation, and the elevation of the top of the screen for wells in the Village of Riverton, Village of Dawson, South Sangamon Water Commission, and Village of Mechanicsburg was provided by CWLP (Appendix A).

Table 4: Maximum drought yields for all pits pumping simultaneously.

Gravel Pit	Site ID	Maximum drought yield (mgd)
Clear Lake S&G	A South	3.0
Hidden Valley Lake	B1	1.6
Sangamon Valley S&G	B2	0.4
Vulcan Materials	B3	1.4
Buckhart S&G	C1 West	1.0
Buckhart S&G	C1 East	0.3
Sang Chris S&G	C2	1.4
Total		**9.1**

Note: mgd = million gallons per day.

3.3.2 Pumping level in municipal wells

As described in Section 3.1, the groundwater flow model was used to predict ambient drought elevations throughout the aquifer, representative of conditions during the 100-year drought without withdrawals at the gravel pits. Throughout this simulation, the municipal wells are pumping at steady-state average conditions. The average conditions simulated at the well fields must be adjusted to reflect individual wells pumping at capacity. Typical operation of the well fields includes cycling individual wells pumping at capacity on and off rather than pumping at a constant steady rate, as simulated in the model.

The drawdown in individual wells pumping at capacity was determined using the reported specific capacity for each well and the difference between the pump capacity and the average steady-state rate for the well used in the model simulations. The following equation is used to estimate the water levels in municipal wells pumping at capacity, at the end of the 18-month period of drought:

$$P = A - (Q_c - Q_s)/S_c$$

where

P estimated ambient water level in well while pumping at capacity, at the end of the drought (ft, NAVD 88)

A ambient water level in the well while pumping at the average steady rate, at the end of the drought (ft, NAVD 88), predicted with the groundwater flow model

Q_s average steady pumping rate of the well specified in the groundwater flow model (gpm)

Q_c pumping capacity of the well (gpm)

S_c Specific capacity of the well (gpm per foot of drawdown)

Details of these calculations for select municipal wells are provided in Table 5, along with well construction details.

To estimate the impacts of pit withdrawals on the municipal wells, individual simulations were made reflecting withdrawals at each of the gravel pit groups (A, B, C1, and C2) individually. The withdrawals were made at a constant rate for 18 months. Aquifer water levels at the end of the 18-month period of pumping the gravel pits were compared to the ambient aquifer levels to determine the average drawdown at each well field due to the withdrawals from the gravel pits. Water levels in wells estimated at the end of the 18-month pumping period show the largest impact on aquifer water levels caused by pit withdrawals. The results for each gravel pit group are described below and compiled in Table 6.

3.3.3 Clear Lake S&G (A South)

Figure 6 shows water levels in the Riverton Wells 5, 7, and 4 at the end of the drought, in relation to the withdrawal rate at the Clear Lake South pit. Riverton Well 5 is the nearest municipal well to the Clear Lake South pit. As shown on the figure, background aquifer levels for no withdrawals from the pit (0 mgd on the horizontal axis) correspond to the ambient level in the well of 508.6 ft, as reported in Table 5. Similarly, the pumping level at capacity shown on the figure for no withdrawals from the pit corresponds to the pumping level reported in Table 5 of 501.3 ft. Increasing the pumping rate from the gravel pit results in decreased background aquifer levels and pumping levels at the well. As illustrated on the figure, a pumping rate of 1.4 mgd from the pit results in the pumping level at the well to drop to the elevation of the pump. An increase to a rate of 1.6 mgd results in the pumping level at the well to drop within four feet of the top of the screen. As discussed above, we assume that the pump in the well may be lowered, and therefore the allowable drought yield from Clear Lake South Pit, based on impacts to Riverton Well 5, is 1.6 mgd.

Similar graphs are presented for conditions at Riverton Well 7 and Well 4 (Figure 6). Well 7 is the most distant of the Riverton wells from the pit, but has a low reported specific capacity, and Well 4 has the highest elevation of the top of screen in the well field. Following the same approach presented above for Well 5, and based on conditions at Well 7, the allowable drought yield from the Clear Lake South pit is 2.9 mgd (Figure 6). Based on conditions at Well 4, the allowable drought yield from the pit is 0.2 mgd (Figure 6). Riverton Well 4 is the critical well in the Riverton well field limiting the drought yield of the pit to 0.2 mgd. Impacts on the Dawson well field due to pumping

Table 5: Details of ambient pumping level calculations for select wells at the end of the 18-month drought.

Well	Ambient level at end of drought, A (ft, NAVD 88)	Model pumping rate, Q_s (gpm)	*Well capacity, Q_c (gpm)	*Specific capacity, S_c (gpm/ft)	Ambient pumping level at end of drought, P (ft, NAVD 88)	*Pump elevation (ft, NAVD 88)	*Top of screen (ft, NAVD 88)
Riverton 4	507.6	59	300	33.0	500.2	495.5	495.7
Riverton 5	508.6	59	300	33.0	501.3	495.5	490.7
Riverton 7	507.3	59	300	23.0	496.8	495.5	485.8
Dawson 3	514.5	42	125	17.7	509.8	503.0	504.0
Dawson 4	514.9	42	200	24.3	508.4	494.5	500.0
Dawson 5	514.0	42	200	33.2	509.2	493.0	491.0
SSWC 1	512.4	87	250	18.1	503.4	503.3	497.3
SSWC 3	512.4	87	250	16.1	502.3	508.4	502.4
SSWC 9	515.7	87	250	18.3	506.8	505.5	499.5
SSWC 10	515.7	87	250	11.2	501.1	501.5	495.5
Mechanicsburg 1	532.7	56	150	22.8	528.6	515.0	514.0

Note: gpm=gallons per minute

* indicates data obtained from the CWLP report (Appendix A)

from the Clear Lake South pit were also examined, but the critical well limiting yield from the pit was determined to be Riverton Well 4, due to its proximity to Clear Lake and the elevation of the top of the well screen. Impacts on the South Sangamon Water Commission well field due to pumping from Clear Lake are negligible due to distance from Clear Lake and the sheltering effect the B-pits have on the wells.

3.3.4 Hidden Valley (B1), Sangamon Valley (B2), and Vulcan Materials (B3)

Graphs showing the effects of pumping from the group B gravel pits on the Dawson Wells 3 and 4 are shown in Figure 7. Well 4 is the nearest Dawson well to the B pits, and Well 3 has the highest screen elevation in the well field. Based on the criteria of 4 ft of freeboard above the well screen at the end of the drought, Well 4 allows 2.6 mgd to be withdrawn from the B group of gravel pits, while Well 3 will only allow 1.2 mgd to be withdrawn.

Graphs representative of wells in the SSWC well field are shown in Figures 8 and 9; Wells 1 and 3 (Figure 8) are at the north end of the well field, near the Vulcan Materials gravel pit. Wells 9 and 10 (Figure 9) are at the south end farthest from the B pits. Allowable yields based on conditions at each of the wells are 0.8 mgd (Well 1), 0.0 mgd (Well 3), 3.4 mgd (Well 9), and 3.0 mgd (Well 10).

The critical well restricting the total pumping rate from the group B series of pits is the SSWC Well 3, due to its proximity to the B-lakes, the high top of screen elevation, and the low specific capacity in comparison to the other wells in the well field. As shown in Table 5 and Figure 8, the pumping level at SSWC Well 3 at the end of the drought is 502.3 ft, the elevation of the pump is 508.4 ft, and the elevation of the top of the screen is 502.4 ft. With no gravel pit withdrawals, the pumping level in the well has fallen below the top of the screen by the end of the drought. Based on our criteria for allowable impacts to wells, no pumping from the group B gravel pits is allowable.

3.3.5 Buckhart S&G (C1 West and C1 East)

Figure 10 shows the impacts of pumping from the C1 group of gravel pits on conditions at SSWC Wells 9 and 10, located at the south end of the well field, north of the Buckhart gravel pits. Of the two wells, the critical well limiting the drought yield from the Buckhart gravel pits is Well 10 of the South Sangamon Water Commission. This is due to the well's relatively low specific capacity. As illustrated in the Figure 10, 4 ft of freeboard above the top of the well screen is obtained at a gravel pit pumping rate of 0.6 mgd; for this combined rate, the west pit is pumped at a rate of 0.4 mgd, and the east pit at 0.2 mgd. Figure 10 also shows the impact of pumping the C1 group on SSWC Well 3, which lies at the north end of the well field, farthest from the C1-pits. While the impact on Well 3 of pumping 0.6 mgd from the C1 pits is small (0.5 ft), the drawdown does result in water levels

below the top of the well screen, as shown in the figure. Therefore, the critical well is Well 3, and no pumping is allowed from the C1 pits.

3.3.6 Sang Chris Sand and Gravel (C2)

The critical municipal well limiting the drought yield from Sang Chris S&G is Well 9 of the South Sangamon Water Commission. Results for SSWC Wells 9 and 10 are illustrated in Figure 11, which show that the allowable drought yield from the Sang Chris gravel pit is equal to the maximum drought yield of 1.4 mgd for both wells. At the pumping rate of 1.4 mgd, the pumping level in the well is greater than the required four feet above the top of the screens. Therefore, for this gravel pit, the allowable drought yield is limited by the dimensions of the gravel pit and not by impacts at the SSWC wells. Impacts at SSWC Well 3 are less than 0.1 ft of additional drawdown, which is negligible. Impacts at the Mechanicsburg well field due to pumping from the Sang and Chris gravel pit were also negligible.

Table 6: Allowable drought yield for individual gravel pit groups.

Gravel Pit	Site ID	Limiting Municipal Well	Allowable drought yield (mgd)
Clear Lake S&G	A South	Riverton Well 4	0.2
Hidden Valley Lake	B1	SSWC Well 3	0.0
Sangamon Valley S&G	B2	SSWC Well 3	0.0
Vulcan Materials	B3	SSWC Well 3	0.0
Buckhart S&G	C1 West	SSWC Well 3	0.0
Buckhart S&G	C1 East	SSWC Well 3	0.0
Sang Chris S&G	C2	SSWC Well 9	1.4

Note: mgd = million gallons per day.

3.4 Total allowable drought yield

The total allowable drought yield for all gravel pits pumping simultaneously was evaluated with the groundwater flow model by trial and error. Withdrawal rates were specified at the gravel pits based upon the allowable drought yield for each individual gravel pit group, and varied until the allowable impact criteria was met at the municipal wells. For this analysis, the combined drawdown effects of pumping multiple pit groups is accounted for. However, the resulting total allowable drought yield

for each gravel pit group is equal to allowable drought yield for each gravel pit group (Table 7). The total allowable drought yield for pumping all of the gravel pit groups simultaneously is 1.6 mgd.

Table 7: Total allowable drought yield for all pits pumping simultaneously.

Gravel Pit	Site ID	Total allowable drought yield (mgd)
Clear Lake S&G	A South	0.2
Hidden Valley Lake	B1	0.0
Sangamon Valley S&G	B2	0.0
Vulcan Materials	B3	0.0
Buckhart S&G	C1 West	0.0
Buckhart S&G	C1 East	0.0
Sang Chris S&G	C2	1.4
Total		**1.6**

Note: mgd = million gallons per day.

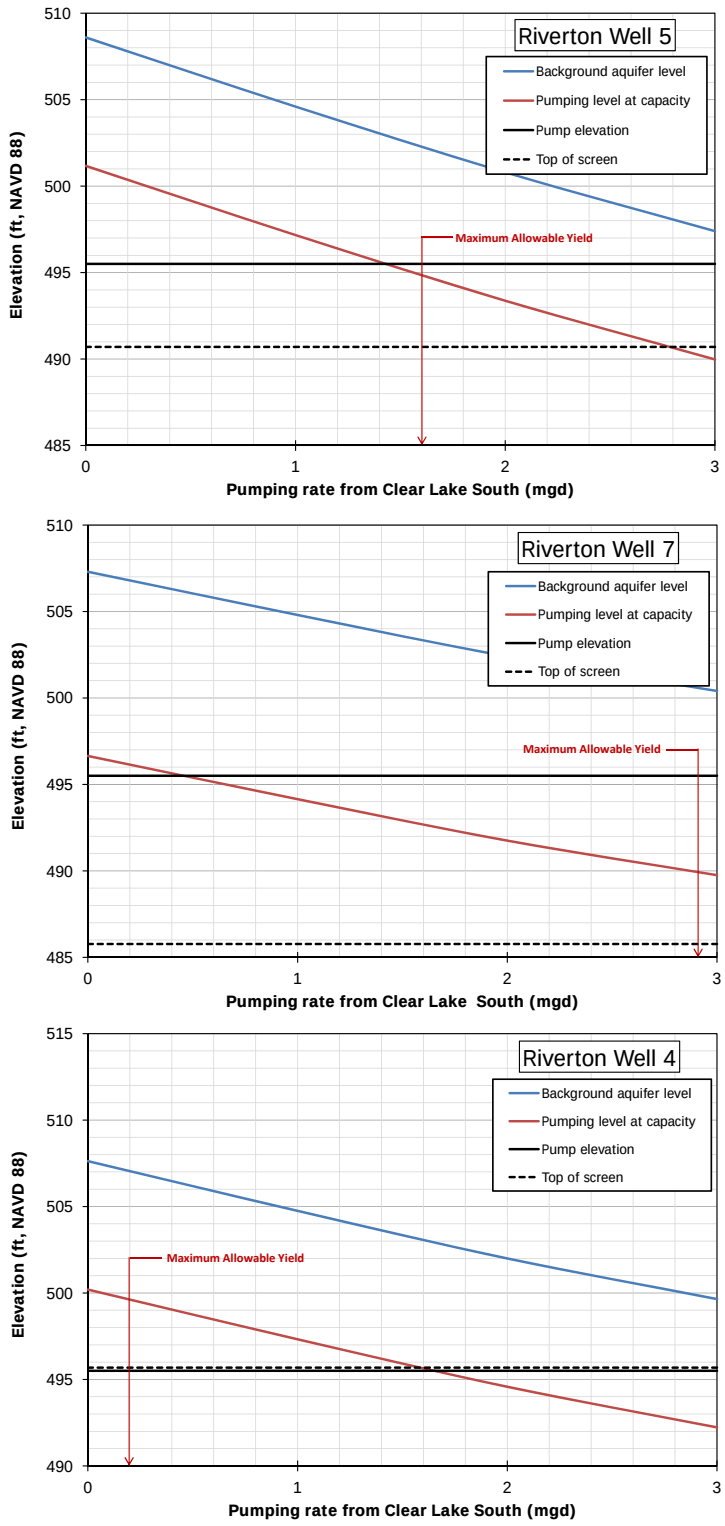

Figure 6: Pumping levels at Riverton Well 5 (*top*), Well 7 (*middle*), and Well 4 (*bottom*) versus pumping rates from Clear Lake. The background aquifer level represents water levels at the well under a steady average pumping rate. The pumping level reflects the additional drawdown when the well is pumping at capacity. The elevations of the well pump and top of the screen are shown in black on the figure.

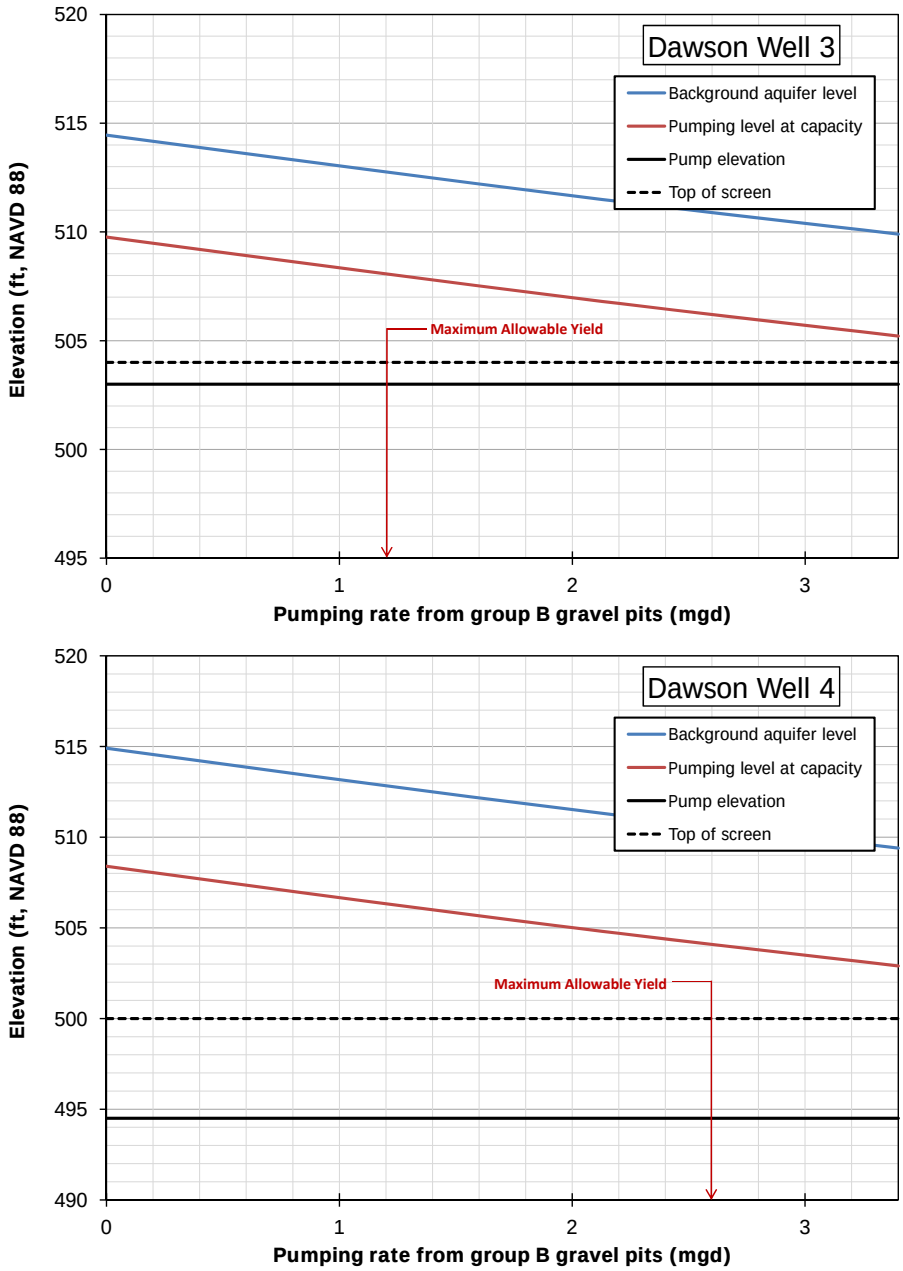

Figure 7: Pumping levels at Dawson Well 3 (*top*) and Well 4 (*bottom*) versus total pumping rates from the group B gravel pits. The background aquifer level represents water levels at the well under a steady average pumping rate. The pumping level reflects the additional drawdown when the well is pumping at capacity. The elevations of the well pump and the top of the screen are shown in black on the figure.

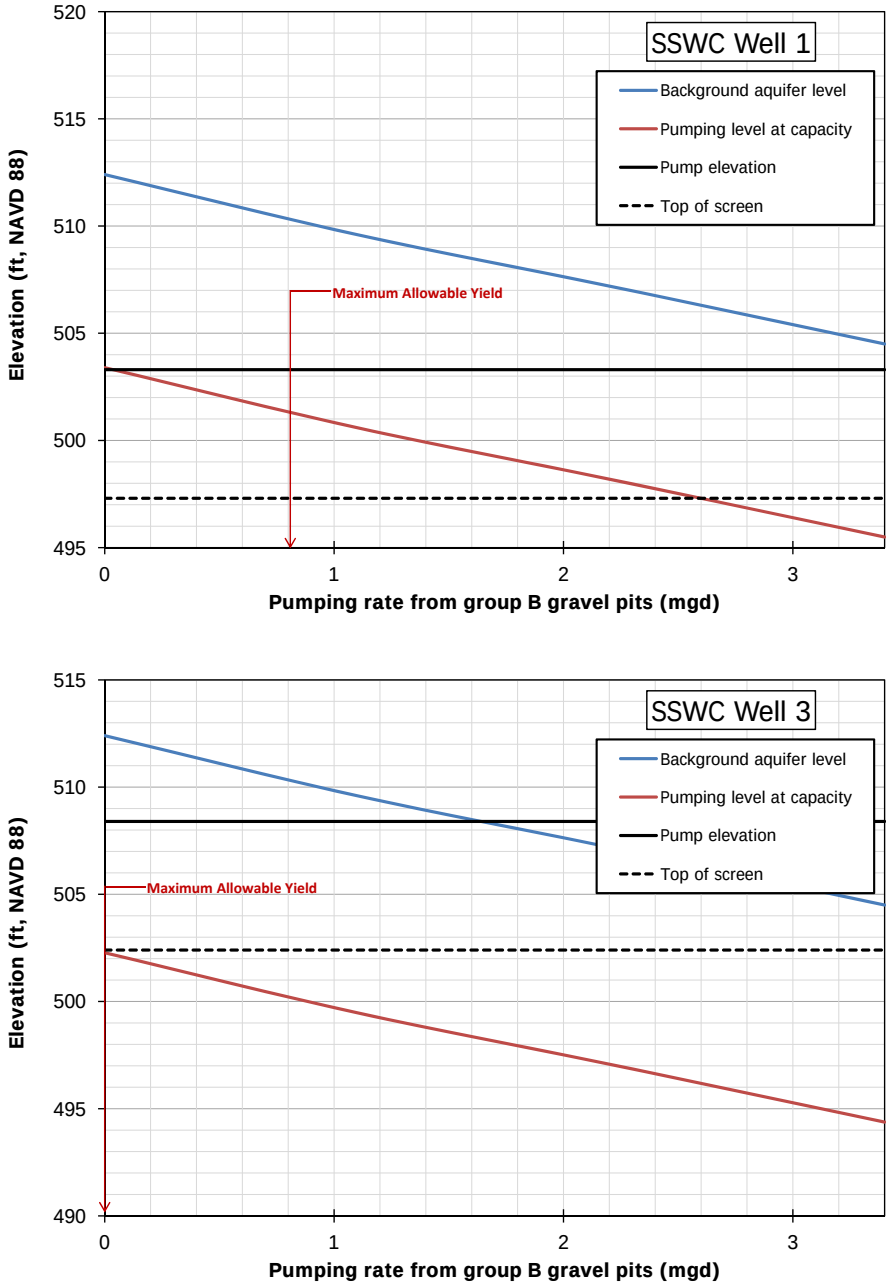

Figure 8: Pumping levels at SSWC Well 1 (*top*) and Well 3 (*bottom*) versus total pumping rates from the group B gravel pits. The background aquifer level represents water levels at the well under a steady average pumping rate. The pumping level reflects the additional drawdown when the well is pumping at capacity. The elevations of the well pump and top of the screen are shown in black on the figure.

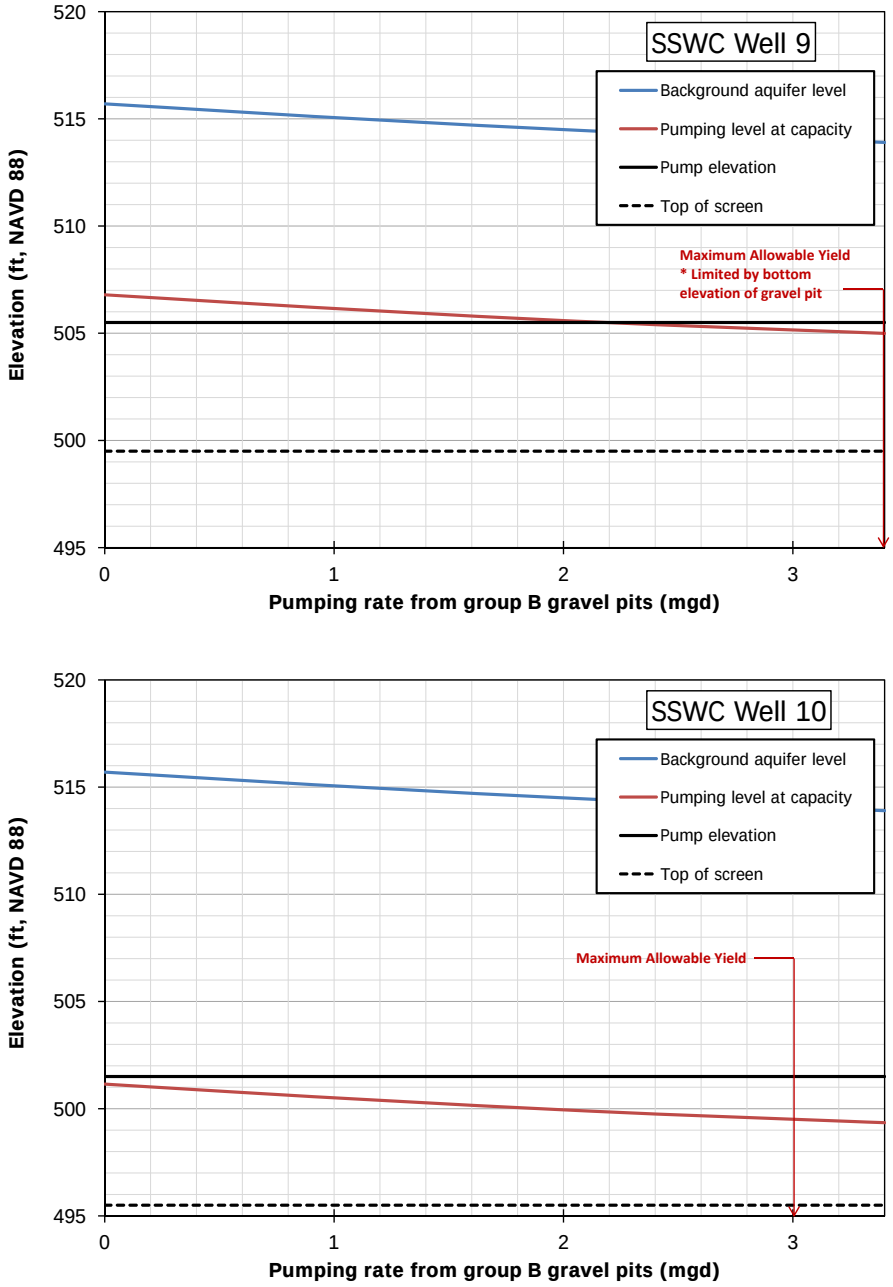

Figure 9: Pumping levels at SSWC Well 9 (*top*) and Well 10 (*bottom*) versus total pumping rates from the group B gravel pits. The background aquifer level represents water levels at the well under a steady average pumping rate. The pumping level reflects the additional drawdown when the well is pumping at capacity. The elevations of the well pump and top of the screen are shown in black on the figure.

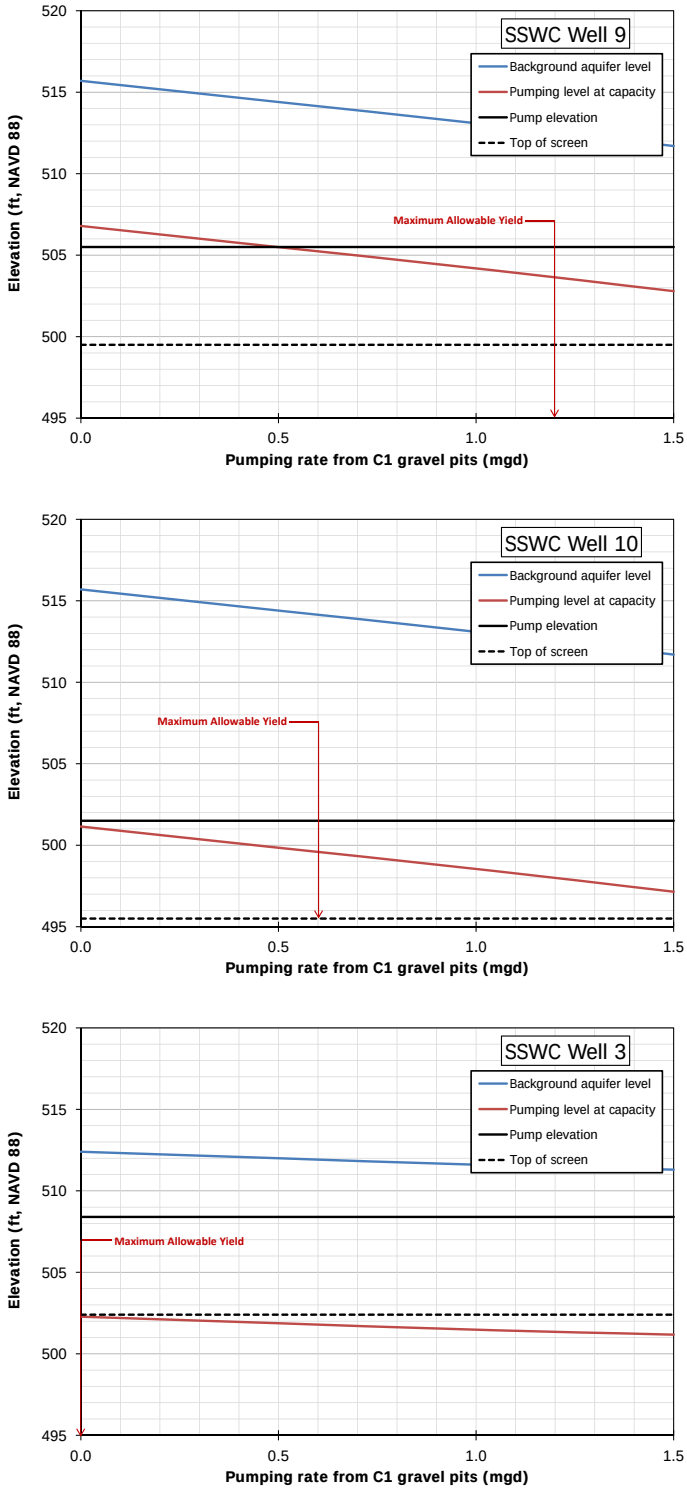

Figure 10: Pumping levels at SSWC Well 9 (*top*), Well 10 (*middle*), and Well 3 (*bottom*) versus total pumping rates from the Buckhart Lake West and East gravel pits (C1 West and East). The background aquifer level represents water levels at the well under a steady average pumping rate. The pumping level reflects the additional drawdown when the well is pumping at capacity. The elevations of the well pump and top of the screen are shown in black on the figure.

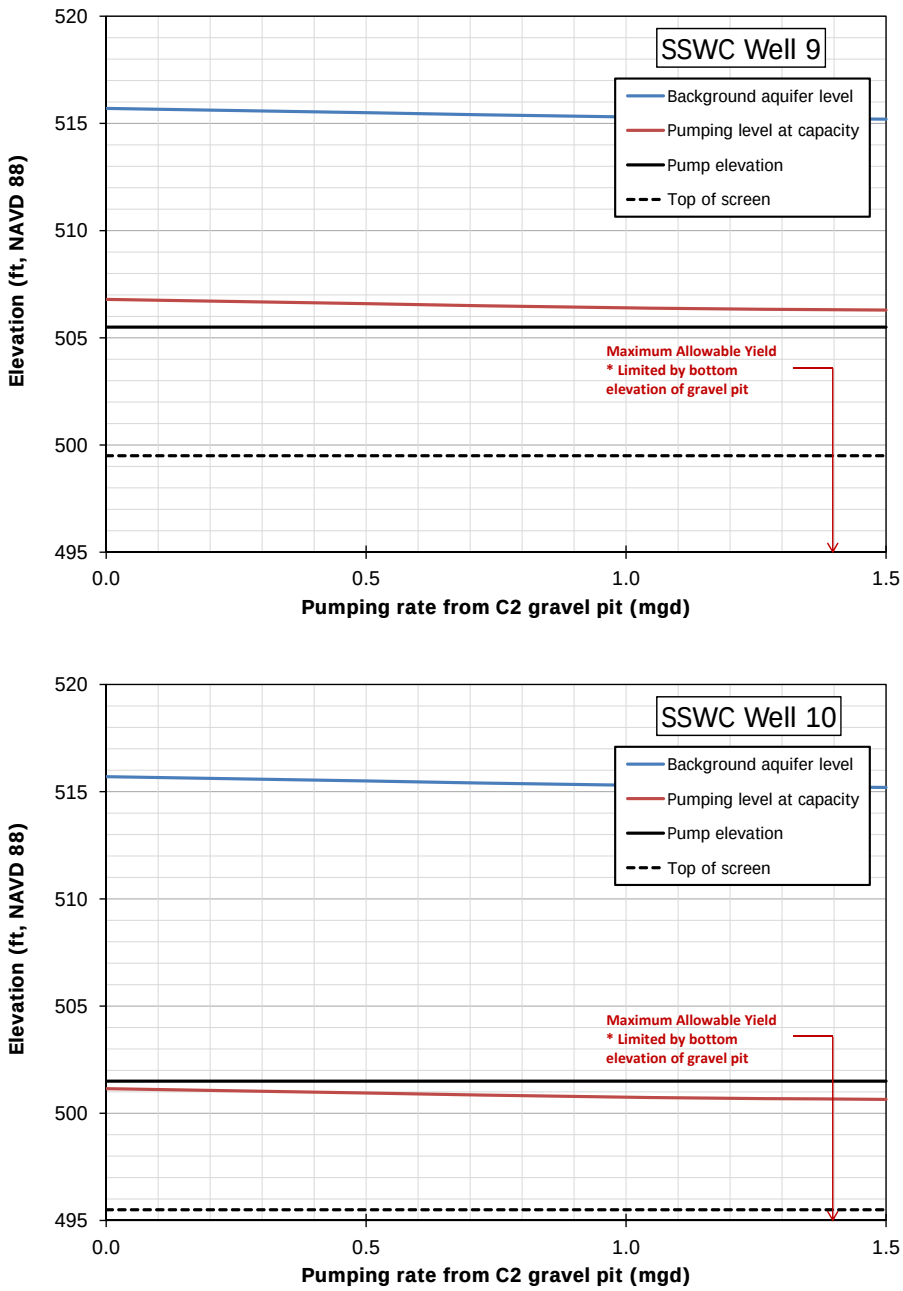

Figure 11: Pumping levels at SSWC Well 9 (*top*) and Well 10 (*bottom*) versus total pumping rates from the Sang Chris Sand and Gravel pit (C2). The background aquifer level represents water levels at the well under a steady average pumping rate. The pumping level reflects the additional drawdown when the well is pumping at capacity. The elevations of the well pump and top of the screen are shown in black on the figure.

4 Conclusions

We have incorporated field-surveyed bathymetry data into a revised groundwater flow model of the Sangamon River Valley, and have simulated conditions representative of the 100-year drought. Aquifer properties and hydrologic conditions specified in the model are based on the previous modeling study and are described in detail in that report Layne (2012). No new aquifer testing was performed for the current study. Using the groundwater flow model we have updated previous estimates of the maximum drought yield based on pumping from all of the gravel pits. In addition we have used well construction details for the surrounding municipal wells, collected by the CWLP, to estimate potential impacts to the wells caused by pumping of the gravel pits during a drought. Using those results, we have estimated drought yields from the gravel pits based on allowable impacts to the municipal wells. Our conclusions follow:

1. The ***maximum drought yield*** of all gravel pits combined is estimated to be approximately 9 mgd. This yield is revised from the previous study based on bathymetric surveys of all gravel pits conducted by CWLP, and without consideration of impacts to nearby municipal wells. Model simulations show that it is not possible to obtain a 12 mgd drought supply by pumping from all of the gravel pits. The maximum estimated yield is lower than the 2012 estimates because the actual gravel pit volumes determined with bathymetry were smaller than previous estimates.

2. The ***allowable drought yields*** for each individual gravel pit group are: 0.2 mgd for Clear Lake South pit (group A); 0.0 mgd for Hidden Valley Lake, Sangamon Valley S&G and Vulcan Materials (group B); 0.0 mgd for Burkhart S&G West and East pits (group C1), and 1.4 mgd for Sang Chris S&G (group C2). These yields are restricted due to predicted impacts to the nearby municipal well fields. This limits withdrawals from all gravel pits, but is most restrictive at the B-pits (B1, B2, B3) and C1-pits (C1 West and C1East). Simulations show that a 100-year drought may cause pumping levels to fall to the top of the well screens for wells in the South Sangamon Water Commission well field, without withdrawals from the B-pits and C1-pits. Therefore, no drought withdrawals can safely be made from these pits.

3. The ***total allowable drought*** yield for simultaneous pumping of all gravel pits is estimated to be 1.6 mgd.

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Appendix A - Study of Gravel Pits and Surrounding Wells

Study of Gravel Pits and Surrounding Wells

Table of Contents

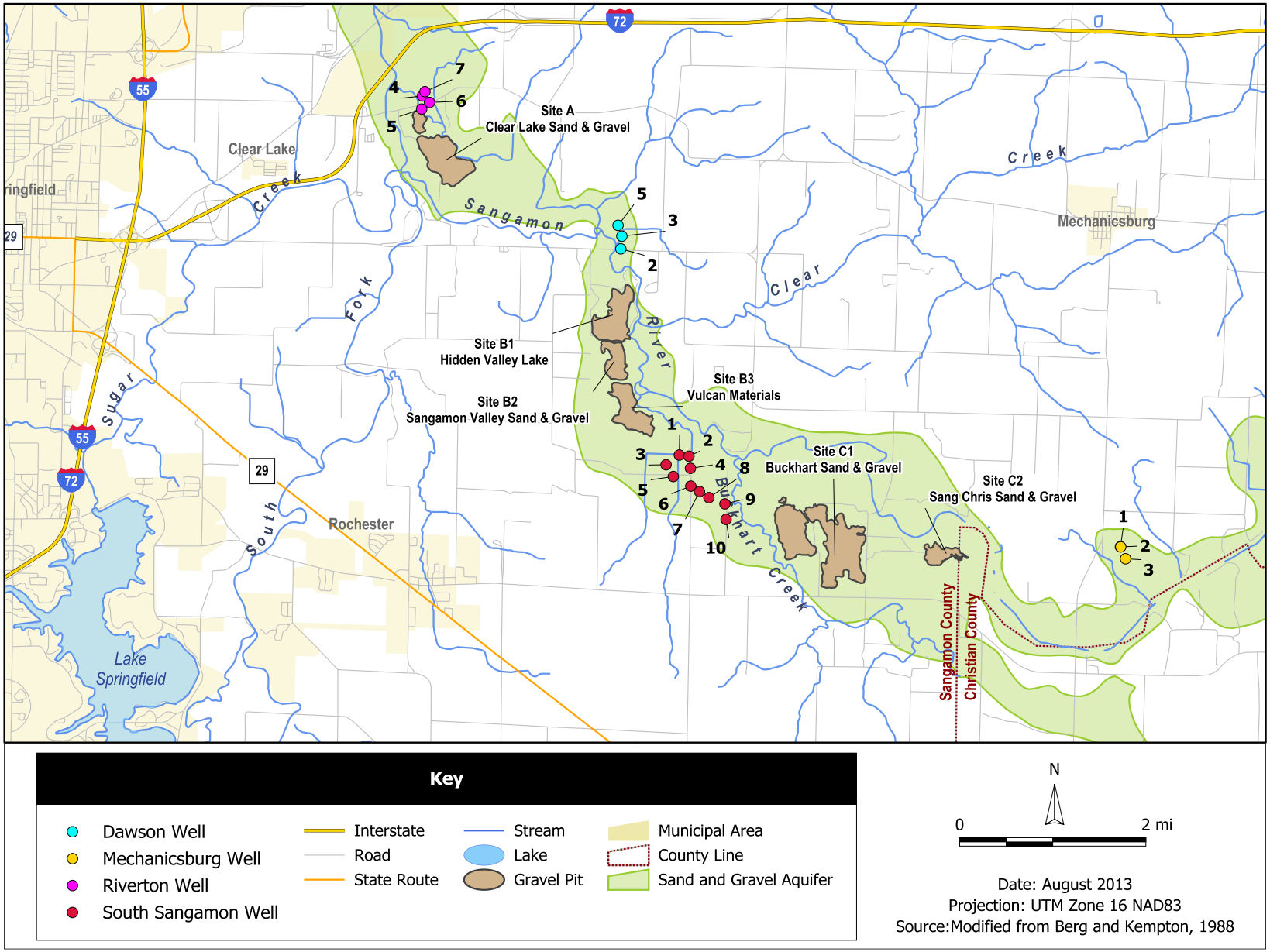


Figure 1: Location of gravel pits and municipal wells in the Sangamon River Valley considered in the study.

Riverton Well Field Data

Well No.	Ground Elevation CWLP Survey	Capacity gpm	Specific Capacity	Well Depth Ft	Screen Length	Top of Screen	Bottom of Well	Pump Elevation
4	532.68	300	33	52	15	37	480.68	495.5
5	532.68	300	33	57	15	42	475.68	495.5
6	532.44	300	22	55	15	40	477.44	495.5
7	526.77	300	23	56	15	41	470.77	495.5

Source- (Brotcke Well & Pump)

Pumps are approximately 37 feet below ground elevation

Mechanicsburg/Buffalo Well Data

Well No.	Ground Elevation	Capacity gpm	Specific Capacity	Well Depth Ft	Screen Length	Top of Screen	Bottom of Well	Pump Elevation
1	545.0	150	22.83	45	14	514	500	515
2	545.0	150	24.19	48	14	511	497	512
3	545.0	300	27.3	51	15	509	494	510.5
4	545.0	Just drilled not active						

Dawson Well Field Data

Well No.	Ground Elevation CWLP Survey	Capacity gpm	Specific Capacity	Well Depth Ft.	Screen Length	Top of Screen	Bottom of Well	Pump Elevation
3	530	125	17.71	41	15	504	489	503
4	530	200	24.3	45	15	500	485	494.5
5[3]	530	200	33.2	54	15	491	476	493

[3] From August 13, 2002 Illinois State Water Survey well production test-

[3] Raised well head when they raised the road- now 543.3

South Sangamon Water Commission (SSWC) Well Data

Well No	Ground Elevation	Capacity GPM/TDH	Specific Capacity	Screen length	Top of Screen	Bottom of Well	Pump Elevation
1	534.8	250/148’	18.1	15	497.3	482.3	503.3
2	534.7	250/148’	24.6	15	493.4	478.4	499.4
3	537.5	250/148’	16.1	15	502.4	487.4	508.4
4	534.5	250/148’	8.7	15	497.2	482.2	503.2
5	537.4	250/148’	10.8	15	502.3	487.3	508.3
6	536.5	250/148’	8.6	15	499.9	484.9	505.9
7	536.1	250/148’	17.6	15	499.1	484.1	505.1
8	536.9	250/148’	22.7	15	499.2	484.2	505.2
9	537.5	250/148’	18.3	15	499.5	484.5	505.5
10	537.8	250/148’	11.2	15	495.5	480.5	501.5

Pump Elevations assumed from attached drawing to be 21 feet above bottom of well.

Gravel Pit Volume Spreadsheet

No	Description	Volume (M gals)	Elevation (FSL)	Avg. Depth (ft.)	Max. Depth (ft.)
A	Clearlake Sand and Gravel Pit (north) 10/15/12	46.2	516.4	8.7	15.7
A	Clearlake Sand and Gravel Pit (south) 10/15/12	879.7	516.4	22.7	39.7
B-1	Hidden Valley Lake 9/19/12	566	521.68	18.3	30
B-2	Sangamon Valley Sand and Gravel 9/19/12	267	522.33	16.7	34
B-3	Vulcan Materials 9/27/12	527	523.72	18.2	33
C-1	Buckhart Sand and Gravel 5/29/13	1,438.2	534.38	13.4	31.9
C-2	Sang Chris Sand and Gravel 9/18/12	162	533.67	14.2	33

Gravel Pit Volume Estimations

		CMT 2006			LAYNE 2011		CWLP 2012/2013		
		Water Elev (Ft)	**Depth (Ft)**	**Vol. (MG)**	**Depth (Ft)**	**Vol. (MG)**	**Water Elev (Ft)**	**Avg. Depth (Ft)**	**Vol. (MG)**
Clear Lake	A	517	35	870	9.9-23.9	1,000	516.4	8.7-22.7	925.9
Hidden Valley	B1	525	25	428	25	665	521.7	18.3	566
Sangamon Valley S&G	B2	525	50	1,560	50	2,437	522.3	16.7	794
Vulcan Materials	B3	525	55		55		523.7	18.2	
Buckhart S&G	C1	538	30	1,220	30	2,884	534.4	13.4	1,438.2
Sang-Chris S&G	C2	538	30	80	30	362	533.7	14.2	162

Appendix

Bathymetric Survey of Gravel Pit A (Clear Lake Sand and Gravel)

Bathymetric Survey of Gravel Pit B

(B1-Hidden Valley Lake, B-2 Sangamon Valley Sand and Gravel, Vulcan Materials)

Bathymetric Survey of Gravel Pit C

(C1-Buckhart Sand and Gravel, C2- Sang Chris Sand and gravel)

Clearlake Sand and Gravel Pit (A)

Volume Analysis Report

Dan Brill and Mike Johnson

City Water Light and Power

October 15, 2012

The Clearlake Sand and Gravel Mining Pit is located at 6500 Oakcrest Road, south of the Village of Riverton, Illinois in the Sangamon River valley. The gravel pit site lies in the Sangamon River valley aquifer. The City of Springfield purchased the property in March of 2009 for the possible use as an alternative water supply to Lake Springfield in the case of a severe drought. The gravel pit has been used to mine sand and gravel since the early 1960's. The shape and size of the gravel pit has changed considerably throughout its time of use. Currently the gravel pit contains two bodies of water. One body of water is found on the north end of the property, north water body, and is much smaller than the second body of water. The second, larger body of water, south water body, is south of the smaller body of water, see Figure 1.

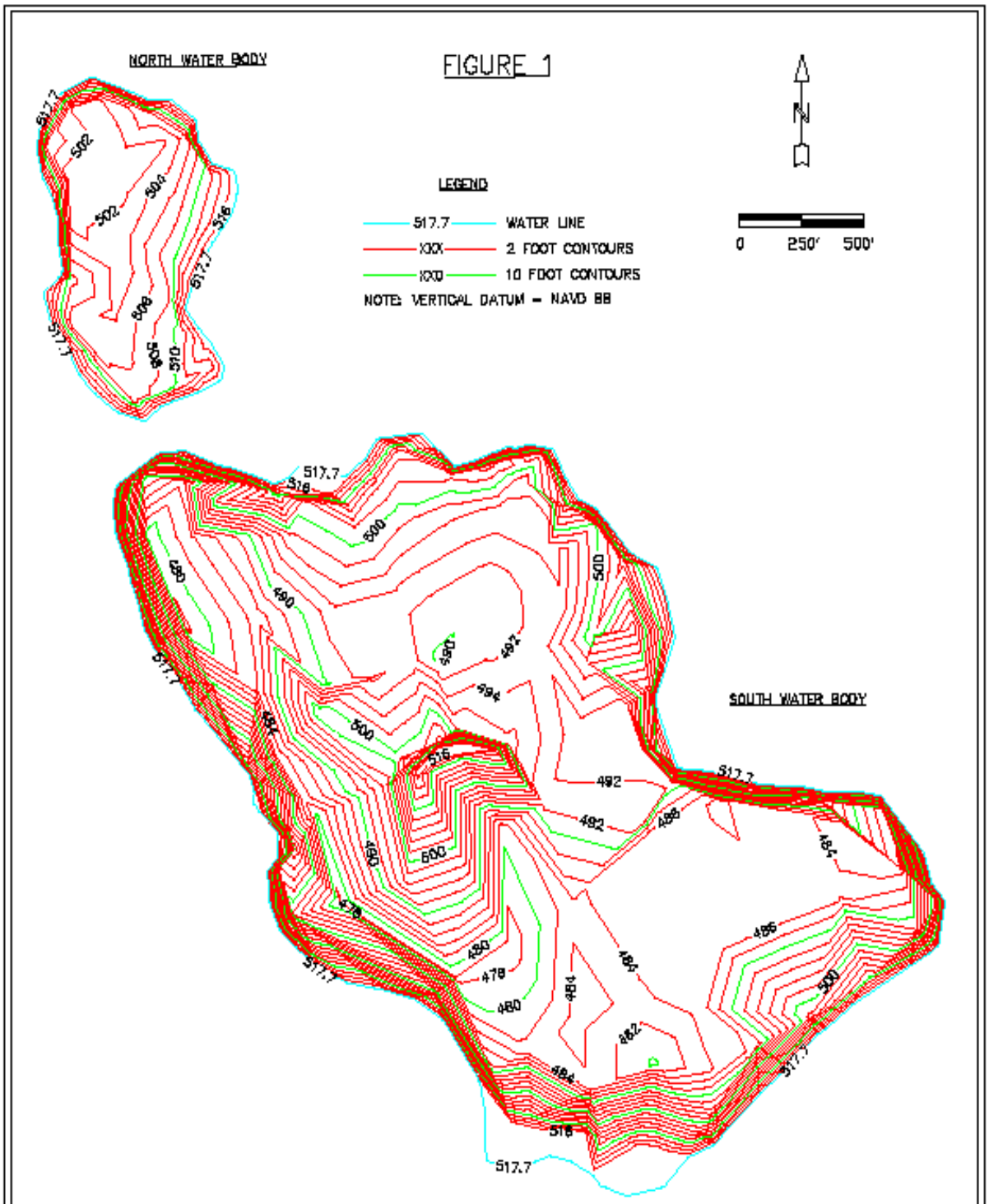
During the original bathymetric survey, each body of water was mapped and depth readings were recorded using GPS points taken at a maximum interval of 300 feet collecting horizontal coordinates and depth information. The perimeter of each water body was walked at the water's edge to determine the surface area, and depth readings were taken using multiple random cross sections to map the bottom of each pit to determine each volume. A Trimble hand held Geo XT unit was used to record GPS points. A Manta, Fish Ray, FR-100 hand held sonar unit was used to determine depth readings. Depth readings were compared to a weighted tape measure periodically for accuracy. A digital terrain model was created from these points utilizing CAD 3D software. From which contours were generated at 2' intervals. Volume was calculated by CAD 3D software utilizing the contour line/grid method with a grid size of 50 feet x 50 feet for each individual water body.

From February 2012 to October, 2012 the water surface elevation of the gravel pit dropped 1.3 feet from 517.7 to 516.4 feet above mean sea level. The existing data collected in February of 2012 was analyzed to determine an approximate water volume for the 516.4 elevation. This was done by measuring the surface area of the 516.4 contour in AutoCAD and using the average end area method to calculate the volume difference between the 517.7 and 516.4 elevations.

On October 15, 2012, a water elevation of 516.4 feet was measured on that day; the north water body had a surface area of 15.7 acres, and a total volume of 141.8 acre-feet or 46.2 MG. The average depth is 8.7 feet. The south water body had a surface area of 116.4 acres, and a total volume of 2699.7 acre-feet or 879.7 MG. The average depth is 22.7 feet. The total water surface acreage of the two water bodies was 132.1 acres, with a total volume 2841.5 acre-feet, or 925.9 million gallons (MG). This is a decrease of 58.6 MG from February 2012 water surface elevation of 517.7. On the days of data collection the two water bodies were not connected. There was a mud flat of spoil material from past dredging that separates the two water bodies at the 516.4 water elevation.

Photo of Clearlake Sand and Gravel (A), south water body, looking south from the boat ramp on north shoreline.

Photo of Clearlake Sand and Gravel (A), north water body, looking north from south shoreline.



CLEARLAKE SAND & GRAVEL PIT TOPOGRAPHIC SURVEY (FEB. 1, 2012)
[WATER BODY ONLY]

Hidden Valley Lake (B-1)

Bathymetric Survey and Volume Report

Dan Brill, CPESC and Mike Johnson, P.E.

City Water Light and Power

October 5, 2012

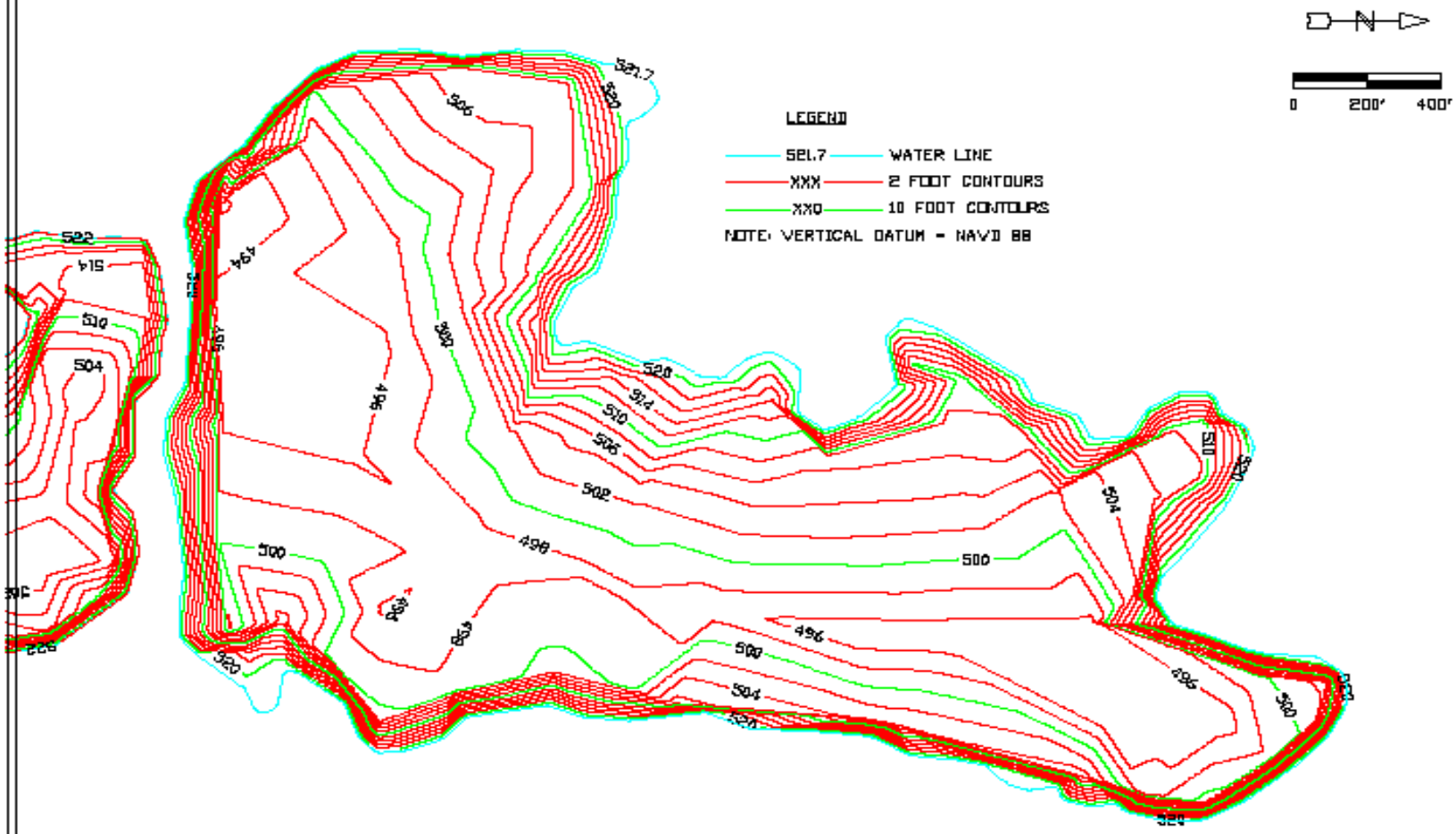
The Hidden Valley Lake is located at 460 Pakey Road, southeast of the Village of Riverton, Illinois and northeast of Rochester, Illinois in The Sangamon River valley. The gravel pit site lies in the Sangamon River valley aquifer. Hidden Valley Lake is privately owned by Hidden Valley Lake Inc. Currently there are 33 lots on the north and west sides of the lake. The gravel pit was used to mine sand and gravel in the 1940's and 50's. The shape and size of the gravel pit has changed considerably throughout its time of use. The gravel pit contains one body of water with a small box culvert at the north end used as a spillway. There was no active mining operation at this site at the time of this survey.

The body of water was mapped and depth readings were recorded using GPS points taken at a maximum interval of 400 feet collecting horizontal coordinates and depth information. The perimeter of the water body was walked at the water's edge to determine the surface area, and depth readings were taken using multiple random cross sections to map the bottom of the pit to determine a volume. A Trimble hand held Geo XT unit was used to record GPS points. A Speedtech Instruments, Hondex® Hand-Held Portable Depth Sounder, was used to determine depth readings. Depth readings were compared to a weighted tape measure periodically for accuracy. A digital terrain model was created from these points utilizing CAD 3D software. From which contours were generated at 2' intervals (Figure 1). Volume was calculated by CAD 3D software utilizing the composite method with a grid size of 50 feet x 50 feet the water body.

On September 19, 2012, a water elevation of 521.68 feet was measured on that day. The total water surface area of the water body was 95 acres, with a total volume of 1737.6 acre-feet or 566 million gallons (MG). The average depth is 18.3 feet. The deepest recorded depth was 30 feet, and the shallowest recorded depth was 1 foot.

Photo of Hidden Valley Gravel Pit (B-1,) looking north from road separating pits B-1 and B-2.

FIGURE 1



SITE B1 – HIDDEN VALLEY LAKE TOPOGRAPHIC SURVEY (SEPT. 20, 2012)

[WATER BODY ONLY]

Sangamon Valley Sand and Gravel Pit (B-2)

Bathymetric Survey and Volume Report

Dan Brill, CPESC and Mike Johnson, P.E

City Water Light and Power

October 5, 2012

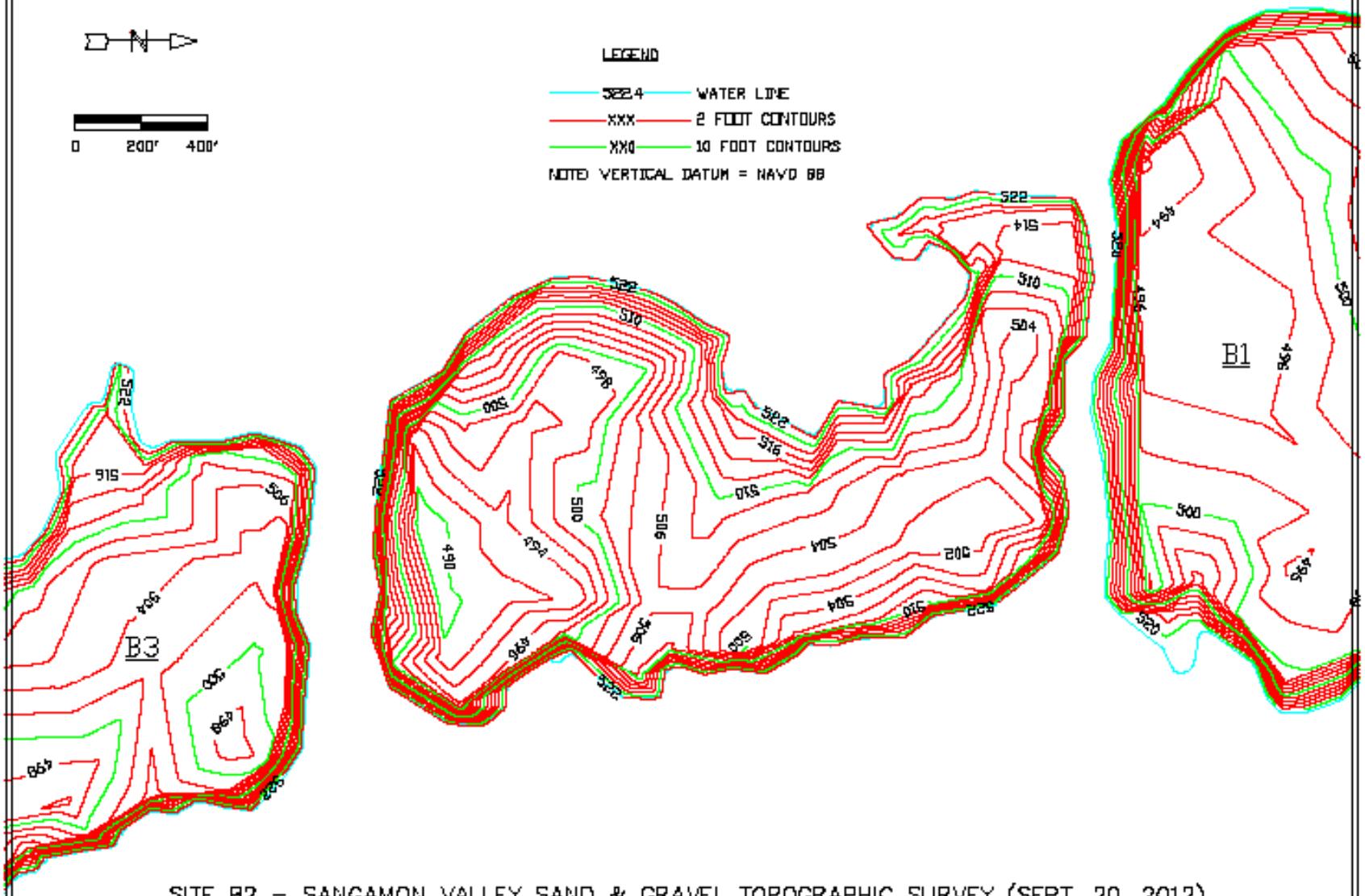
The Sangamon Valley Sand and Gravel Pit is located at 1050 Jostes Road, southeast of the Village of Riverton, Illinois and northeast of Rochester, Illinois in the Sangamon River valley. The gravel pit site lies in the Sangamon River valley aquifer. Sangamon Valley Sand and Gravel is owned by Judith C. Decroix, etal. The gravel pit was used to mine sand and gravel since 1968. The shape and size of the gravel pit has changed considerably throughout its time of use. The gravel pit contains one body of water. There was an active mining operation at this site at the time of this survey.

The body of water was mapped and depth readings were recorded using GPS points taken at a maximum interval of 300 feet collecting horizontal coordinates and depth information. The perimeter of the water body was walked at the water's edge to determine the surface area, and depth readings were taken using multiple random cross sections to map the bottom of the pit to determine a volume. A Trimble hand held Geo XT unit was used to record GPS points. A Speedtech Instruments, Hondex® Hand-Held Portable Depth Sounder, was used to determine depth readings. Depth readings were compared to a weighted tape measure periodically for accuracy. A digital terrain model was created from these points utilizing CAD 3D software. From which contours were generated at 2' intervals (Figure 1). Volume was calculated by CAD 3D software utilizing the composite method with a grid size of 50 feet x 50 feet the water body.

On September 19, 2012, a water elevation of 522.33 feet was measured on that day. The total water surface area of the water body was 49 acres, and a total volume of 819.3 acre-feet or 267 million gallons (MG). The average depth is 16.7 feet. The deepest recorded depth was 34 feet, and the shallowest recorded depth was 1 foot.

Photo of Sangamon Valley Sand and Gravel Pit (B-2), looking south from road separating pits B-1 and B-2.

FIGURE 1



SITE B2 – SANGAMON VALLEY SAND & GRAVEL TOPOGRAPHIC SURVEY (SEPT. 20, 2012)

[WATER BODY ONLY]

Vulcan Materials (B-3)

Bathymetric Survey and Volume Report

Dan Brill, CPESC and Mike Johnson, P.E.

City Water Light and Power

October 5, 2012

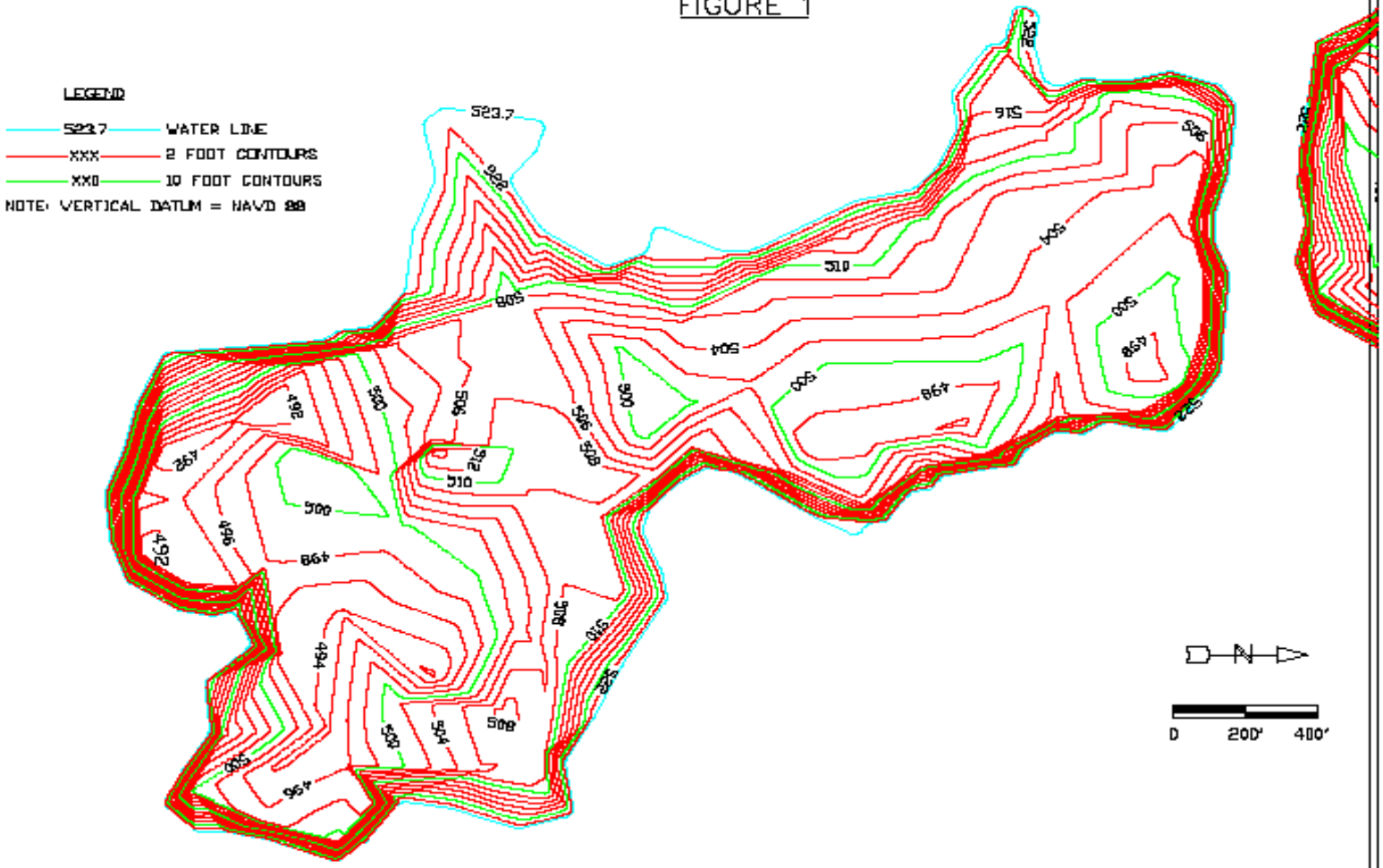
The Vulcan Materials Sand and Gravel Pit is located at 1200 Jostes Road, southeast of the Village of Riverton, Illinois and northeast of Rochester, Illinois in the Sangamon River valley. The gravel pit site lies in the Sangamon River valley aquifer. The sand and gravel pit is owned by Bonnie Wright. The gravel pit has been used to mine sand and gravel since the early 1980's. The shape and size of the gravel pit has changed considerably throughout its time of use. The gravel pit contains one body of water. There was an active mining operation at this site at the time of the survey.

The body of water was mapped and depth readings were recorded using GPS points taken at a maximum interval of 400 feet collecting horizontal coordinates and depth information. The perimeter of the water body was walked at the water's edge to determine the surface area, and depth readings were taken using multiple random cross sections to map the bottom of the pit to determine a volume. A Trimble hand held Geo XT unit was used to record GPS points. A Speedtech Instruments, Hondex® Hand-Held Portable Depth Sounder, was used to determine depth readings. Depth readings were compared to a weighted tape measure periodically for accuracy. A digital terrain model was created from these points utilizing CAD 3D software. From which contours were generated at 2' intervals (Figure 1). Volume was calculated by CAD 3D software utilizing the composite method with a grid size of 50 feet x 50 feet the water body.

On September 27, 2012, a water elevation of 523.72 feet was measured on that day. The total water surface acreage of the water body was 89 acres, with a total volume of 1618.1 acre-feet or 527 million gallons (MG). The average depth is 18.2 feet. The deepest recorded depth was 33 feet and the shallowest recorded depth was 1 foot.

Photo of Vulcan Materials Sand and Gravel Pit (B-3), looking south from north shoreline.

FIGURE 1



SITE B3 – VULCAN MATERIALS TOPOGRAPHIC SURVEY (SEPT. 27, 2012)

[WATER BODY ONLY]

Buckhart Sand and Gravel Pits (C-1)

Bathymetric Survey and Volume Report

Dan Brill, CPESC and Mike Johnson, P.E.

City Water Light and Power

May 29, 2013

The Buckhart Sand and Gravel Pits are located at RR #1, Mechanicsburg, Illinois, in The Sangamon River valley. The gravel pit site lies in the Sangamon River valley aquifer. The Buckhart Sand and Gravel Pits are owned by The Flatt family and Skip Homeier. The gravel pits have been used to mine sand and gravel since the mid 1940's. There are five pits at this site; east pit, west pit, south pit, northwest pit, and northeast pit (see attached aerial image). Shapes and sizes of these gravel pits have changed considerably throughout their time of use. There was an active mining operation at C-1 northeast pit at the time of this analysis. C-1 west pit is being filled as a permitted disposal area for clean construction or demolition debris (CCDD).

The body of water was mapped and depth readings were recorded using GPS points taken at a maximum interval of 500 feet collecting horizontal coordinates and depth information. The perimeter of the water body was walked at the water's edge to determine the surface area, and depth readings were taken using multiple random cross sections to map the bottom of the pit to determine a volume. A Trimble hand held Geo XT unit was used to record GPS points. A Speedtech Instruments, Hondex® Hand-Held Portable Depth Sounder, was used to determine depth readings. Depth readings were compared to a weighted tape measure periodically for accuracy. A digital terrain model was created from these points utilizing CAD 3D software. From which contours were generated at 2' intervals (Figure 1). Volume was calculated by CAD 3D software utilizing the composite method with a grid size of 50 feet x 50 feet the water body.

East Pit
On May 9th, 2013 a water elevation of 535.48 feet was measured on that day. The total water surface area of the water body was 179.8 acres, and a total volume of 2028.9 acre-feet or 661.1 million gallons (MG). The average depth is 11.3 feet. The deepest recorded depth was 31.1 feet, and the shallowest recorded depth was 1 foot, Table 1.

West Pit
On May 9th, 2013 a water elevation of 535.64 feet was measured on that day. The total water surface area of the water body was 107.7 acres, and a total volume of 1863.1 acre-feet or 607.1 million gallons (MG). The average depth is 16.8 feet. The deepest recorded depth was 26 feet, and the shallowest recorded depth was 1 foot, Table 1.

South Pit
On May 9th, 2013 a water elevation of 536.70 feet was measured on that day. The total water surface area of the water body was 21.2 acres, and a total volume of 226.7 acre-feet or 73.9 million gallons (MG). The average depth is 10.7 feet. The deepest recorded depth was 21.6 feet, and the shallowest recorded depth was 1 foot, Table 1.

Northwest Pit
On May 9th, 2013 a water elevation of 535.66 feet was measured on that day. The total water surface area of the water body was 2.1 acres, and a total volume of 15.0 acre-feet or 4.9 million gallons (MG). The average depth is 7.1 feet. The deepest recorded depth was 18.0 feet, and the shallowest recorded depth was 1 foot, Table 1.

Northeast Pit
On May 9th, 2013 a water elevation of 535.40 feet was measured on that day. The total water surface area of the water body was 19.7 acres, and a total volume of 279.8 acre-feet or 91.2 million gallons

(MG). The average depth is 14.2 feet. The deepest recorded depth was 31.9 feet, and the shallowest recorded depth was 1 foot, Table1.

Table1. Water Elevation, Surface Areas, Volumes, and Depths of the Five Buckhart Sand and Gravel Pits, May 9th, 2013.

Pit	Water Elevation	Surface Area (sf)	Volume (ac-ft)	Volume (cf)	Volume (MG)	Avg Depth ft	Deepest Point
east	535.48	7,832,584	2028.9	88,379,416	661.1	11.3	31.1
west	535.64	4,690,115	1863.1	81,158,486	607.1	16.8	26.0
south	536.70	923,615	226.7	9,876,872	73.9	10.7	21.6
north west	535.66	91,885	15.0	654,143	4.9	7.1	18
north east	535.40	856,875	279.8	12,188,167	91.2	14.2	31.9
Total		**14,395,074 sf**	**4413.5 ac-ft**	**192,257,084 cf**	**1438.2 MG**	**13.4 ft**	

On May 9th, 2013, the total surface area of the five water bodies was **331 acres**, and a total volume **of 4413.5 acre-feet** or **1438.2 MG**. The average depth of the five pits was 13.4 feet. The elevation of the water bodies varied from 536.70, the highest at the south pit, to 535.40, the lowest at the northeast pit, a difference of 1.3ft, Table 1.

Photo 1. Buckhart Sand and Gravel east pit, looking west.

Photo 2. Buckhart Sand and Gravel, west pit, looking north. The Clean Construction or Demolition Debris is left center of the photo.

Photo 3. Buckhart Sand and Gravel south pit, looking south.

Photo 4. Buckhart Sand and Gravel northwest pit, looking north.

Photo 5. Buckhart Sand and Gravel northeast pit, with active dredging, looking west.

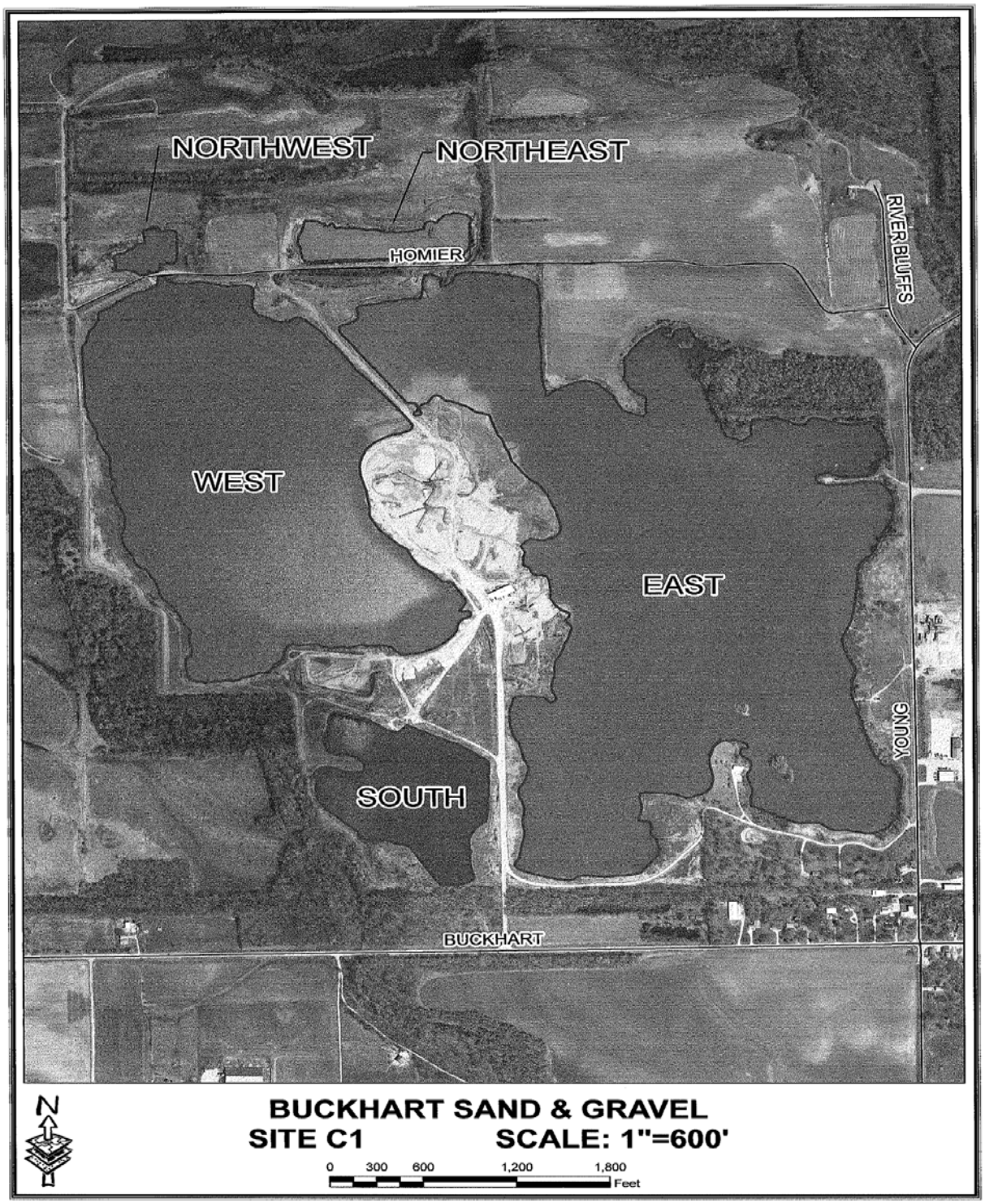
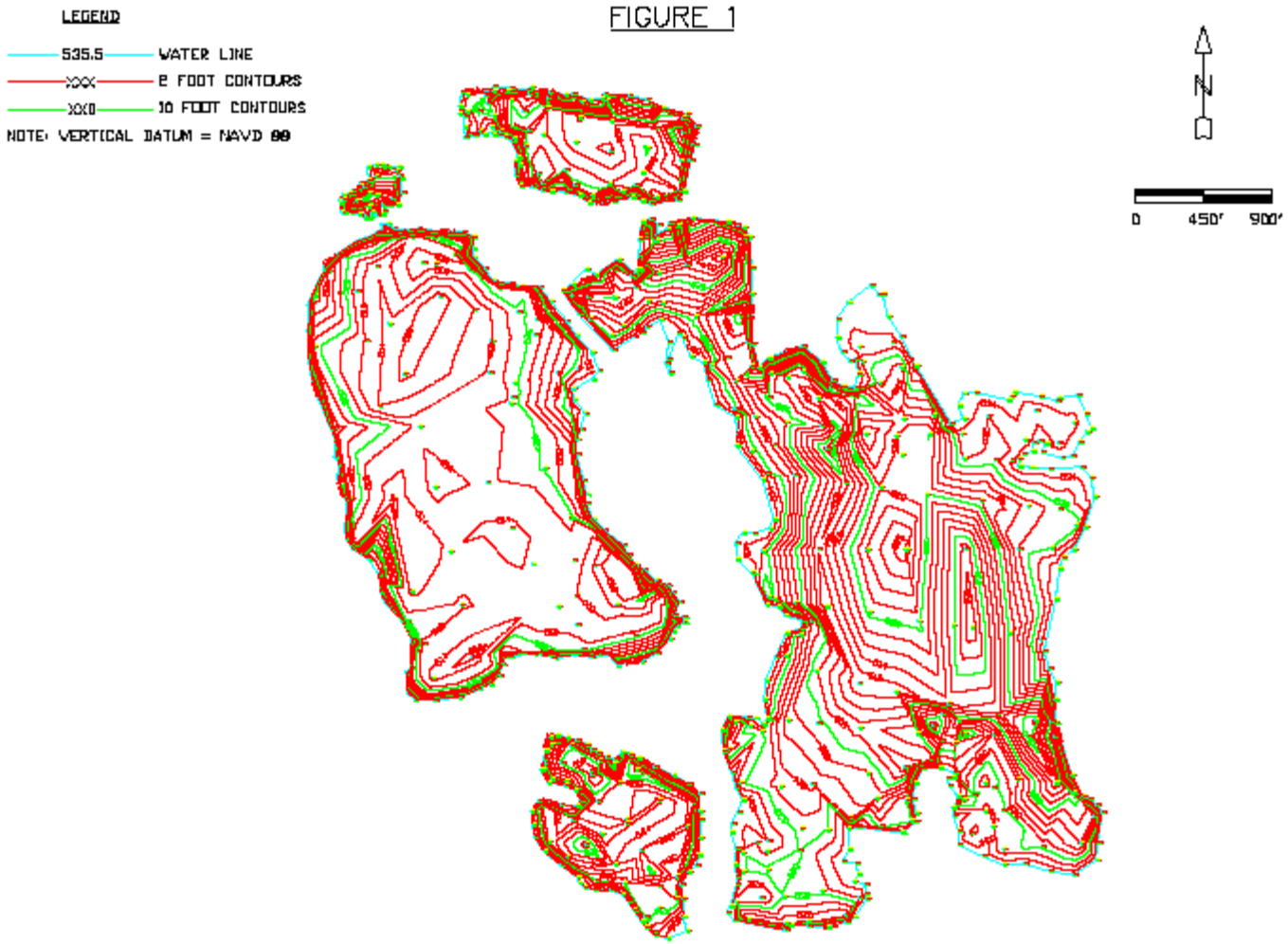


Figure 1. Aerial image of the Buckhart Sand and Gravel area.

FIGURE 1



SITE C1 – BUCKHART SAND & GRAVEL TOPOGRAPHIC SURVEY (MAY, 2013)

[WATER BODY ONLY]

Sang-Chris Sand and Gravel Pit (C-2)

Bathymetric Survey and Volume Report

Dan Brill, CPESC and Mike Johnson, P.E.

City Water Light and Power

October 5, 2012

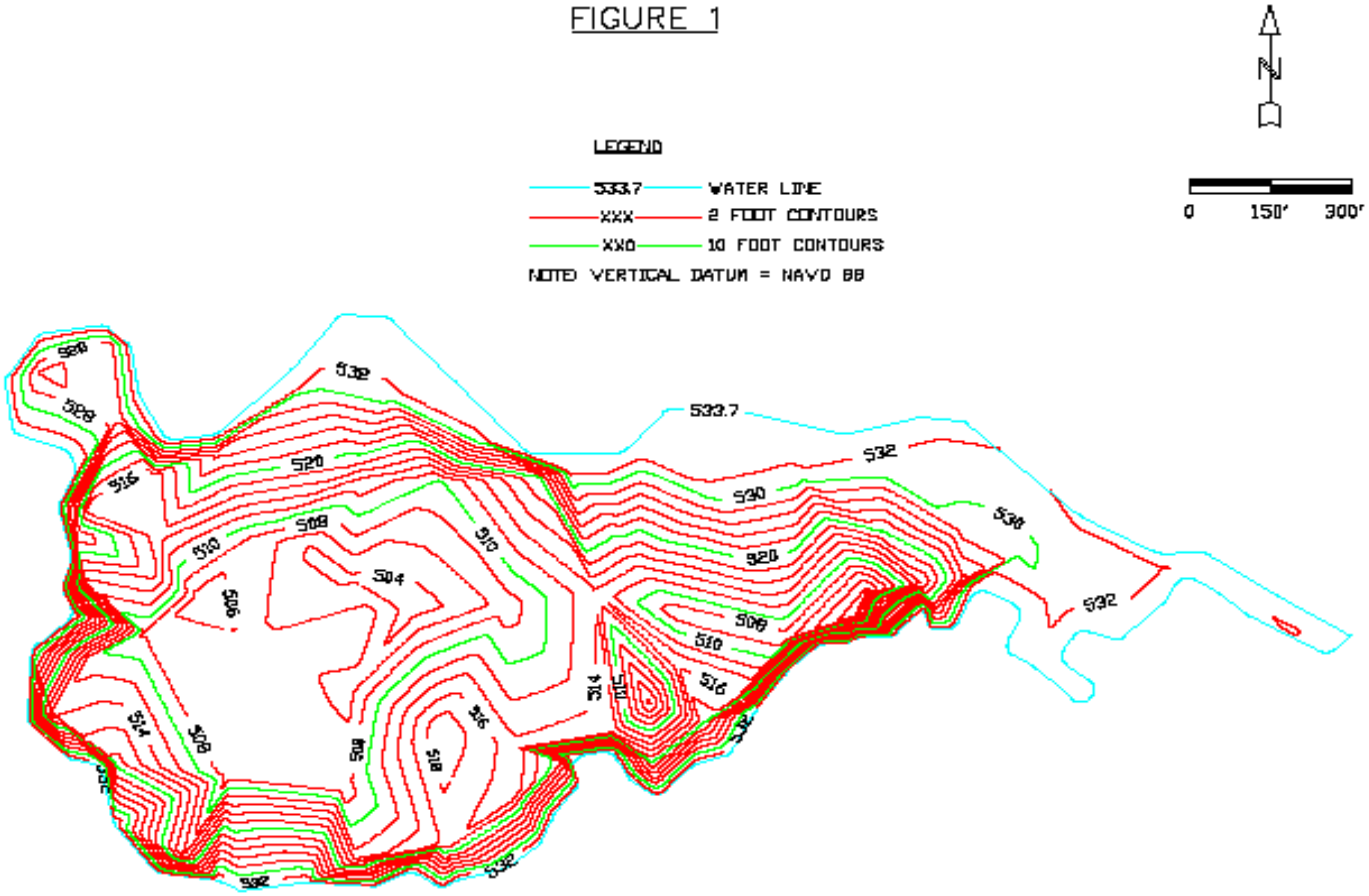
The Sang-Chris Sand and Gravel Pit is located at 2850 Young Road, Mechanicsburg, Illinois east of Rochester, Illinois in the Sangamon River valley. The gravel pit site lies in the Sangamon River valley aquifer. The Sang-Chris Sand and Gravel Pit is owned by Skip Homeier. The gravel pit has been used to mine sand and gravel since the fall of 2000. There is one pit at this site. The shape and size of this gravel pit has changed considerably throughout its time of use. There was an active mining operation at this site at the time of this survey.

The body of water was mapped and depth readings were recorded using GPS points taken at a maximum interval of 400 feet collecting horizontal coordinates and depth information. The perimeter of the water body was walked at the water's edge to determine the surface area, and depth readings were taken using multiple random cross sections to map the bottom of the pit to determine a volume. A Trimble hand held Geo XT unit was used to record GPS points. A Speedtech Instruments, Hondex® Hand-Held Portable Depth Sounder, was used to determine depth readings. Depth readings were compared to a weighted tape measure periodically for accuracy. A digital terrain model was created from these points utilizing CAD 3D software. From which contours were generated at 2' intervals (Figure 1). Volume was calculated by CAD 3D software utilizing the composite method.

On September 18, 2012, a water elevation of 533.67 feet was measured on that day. The total water surface area of the water body was 35 acres, with a total volume of 498.2 acre-feet or 162 million gallons (MG). The average depth is 14.2 feet. The deepest recorded depth was 33 feet, and the shallowest recorded depth was 1 foot.

Photo of Sang-Chris Sand and Gravel Pit (C-2), looking east from the west shoreline.

FIGURE 1



SITE C2 – SANG-CHRIS SAND & GRAVEL TOPOGRAPHIC SURVEY (SEPT. 18, 2012)

[WATER BODY ONLY]