SCHREUDER, INC. WATER-RESOURCES & ENVIRONMENTAL CONSULTANTS

Investigation and Conceptual Design of Options for the Lake Brooklyn Watershed, Clay County, Florida

Prepared for the:

St. Johns River Water Management District
Lake Region Council Association
Keystone Heights Lake Advisory Council
Clay County Commission
Camp Blanding (Fla.National Guard)
E.I.DuPont de Nemours & Co, Inc.
and
State Representative Joe Pickens

by:

Schreuder, Inc.
Water-Resources and Environmental Consultants

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DEDICATION

This report has been prepared in and is dedicated to the memory of:

Rodney Bamford,

who has worked tirelessly to restore the Alligator Creek system. His work and dedication has been and will in the future be an inspiration for all of us to continue our efforts to improve the management of the water resources in the Alligator Creek system so that our children can enjoy what we have known.

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SCHREUDER, INC.

SUBMITTAL STATEMENT

This report has been prepared by the undersigned professionals and has been prepared in accordance with the applicable standards of professional care in the State of Florida. We appreciate the considerable help of the stakeholders for the Lake Brooklyn Watershed Project.

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DEFINITIONS

Many of the readers may be unfamiliar with the units of water volumes and rates used in this report. Therefore, theyare summarized below

MG	million gallons, unit of volume
AF	acre foot, unit of volume, 1 foot deep over one acre
MGD	million gallons per day, rate of flow
CFS	cubic feet per second, rate of flow
GPM	gallons per minute, rate of flow
NGVD	elevation referenced to mean sea level

APPROXIMATE CONVERSION TABLE

1 AF	=	326,000 gallons				1 MG ~ 3 AF	
1 CFS	~	2 AF/day	=	724 AF/year			
1 CFS	=	0.646 MGD	=	449 GPM			
1 MGD	=	1.55 CFS	~	3 AF/day	=	1120 AF/year	
1000 GPM	=	1.44 MGD	=	4.4 AF/day	=	2.2 CFS	

EXECUTIVE SUMMARY

Schreuder, Inc. was retained by the St. John's River Water Management District (SJRWMD) to conduct a study entitled "Investigation and Conceptual Design of Restoration Options for the Upper Lake Brooklyn Watershed". Stakeholders in this investigation are the Lake Region Council Association (LRCA), Keystone Heights Lake Advisory Council (KHLAC), Clay County Commission, Camp Blanding (National Guard), E.I.DuPont de Nemours & Co. Inc, the Florida Department of Environmental Protection (FDEP) and State Representative Joe Pickens. In the Request for Proposal, the consultant was directed to work directly with the stakeholders to investigate the impacts of the current mine reclamation in the Upper Watershed on flows in Alligator Creek and to recommend any actions needed to restore the pre-mining streamflow. Schreuder, Inc. (SI) compiled a large data base and conducted several field investigations. However the most important part of the study were four one-day meetings held in the Keystone Heights City Hall. During these meetings, SI representatives presented their findings and solicited comments on the findings and took careful notes of the suggestions and instructions of the stakeholders group directing the research.

One of the initial components of the investigation was the evaluation of the old mined area on Trail Ridge and the status of mine reclamation at the upper end of the Lake Brooklyn Watershed. Included in the task were any recommendations to restore pre-mining stream flows. Based upon the pre-mining topography in 1949, it was determined that about 220 acres of the mined area had been tributary to Alligator Creek. The remainder of the area was tributary to Black Creek and the Santa Fe River. After mining was completed in 1962 and the berm around the mined area was breached in 1992, present topography indicates that more than 750 acres of the mined area are tributary to Alligator Creek. This increase in wateshed area was accomplished by ditches in the mined area which connect ponds and surface flows to the head of Alligator Creek. Since surface flows are proportional to watershed area, more flow is now available to Alligator Creek than was in 1949 and no action is needed to restore the flows to pre-mining condition.

All of the investigations in the past 40 years have concluded that changes in the rainfall volume on the watershed are the primary cause of lake level variation in the Keystone Heights area. While this study did conclude that mining in the upper watershed has not reduced flows to Lake Brooklyn, it also determined that there are options to better manage the available water in the watershed in order to augment water levels in the downstream lakes.

This investigation is the result of an iterative process which ultimately led to finding answers to the question of what could be done to increase water levels in Lake Brooklyn and at what stage could the surface water level in Lake Brooklyn be maintained. Preliminary calculations set the lake stage at 100 Ft. National Geodetic Vertical Datum (NGVD). At this stage, the lake is estimated to lose approximately 250,000 to 300,000 gallons per day. At the old mined area in the upper part of the Lake Brooklyn Watershed, computer modelling showed that an average yield of approximately 500,000 gallons per day could be obtained by harvest of evapo-transpiration losses. To assist in maintaining Lake Brooklyn water level at 100 Ft. NGVD, the SI project team developed several hydrologic and engineering options. These were all presented to the stakeholders and they selected several design options for further evaluation. These include cleaning of the ditches within the old mined area in combination with improving surface water outflow by the construction of controlled outfalls and possible pipeline conveyance, and the creation of additional water storage in Lake Lowry in combination with the construction of a controlled outfall and pipeline.

The conclusions of the conceptual design evaluation do indicate that it is possible to increase the time that surface water levels in Lake Brooklyn are at 100 Ft. NGVD, but it will require the construction of several engineering modifications. This action would increase water levels in Lake Brooklyn and increase aquifer reccharge from the lake, but would also increase the fluctuations in Lake Lowry. As a result, significant steps would need to be taken to modify the existing minimum levels set for Lake Lowry.

The SI project team recommends that the stakeholders consider the options and select one or more final options before the next step be implemented, which calls for detailed engineering designs and cost estimates. A pumping test is proposed in the old mined area to develop aquifer yield data that would be useful in the final design. A key part of the following step will be to evaluate and obtain the necessary permits to allow the construction, as proposed and designed, to proceed.

1.0 INTRODUCTION

1.1 Purpose and Scope

The low water level of Lake Brooklyn during the current drought period has renewed the interest of local residents in Southwest Clay County to determine if any solution could be found to increase the water levels of the lake. A coalition of local residents, industries and government with the help of Rep. Joe Pickens obtained funding for this study through the St. Johns River Water Management District (SJRWMD). Schreuder Inc was retained to work with the Lake Region Council Association (LRCA) and the Keystone Heights Lake Advisory Council (KHLAC) to investigate the Lake Brooklyn watershed and particularly the old mined area at the upper end of the watershed and to recommend if any remedies could be implemented. The study was aided by active support of personnel from Camp Blanding and the Dupont Company.

The scope of work was developed by the interested parties and the water management district staff to include a review of the previous studies, interviews with the stakeholders, field visits to the mined area and the downstream drainage, analyses of the data and reports, the organization and conduct of several meetings to discuss the progress in the study and to present preliminary results, and the preparation of a final report to contain the study's conclusions and recommendations. A final presentation to the stakeholders is included as the final task.

1.2 Location

Lake Brooklyn is located in southwest Clay County, just north of Keystone Heights (See Figure 1-1). The lake is the fourth in a chain of karstic lakes connected by Alligator Creek. The creek continues southward through four other lakes to become part of Etonia Creek. All of these lakes leak downward into the Floridan Aquifer and the area around Lake Brooklyn provides a major recharge source to the aquifer. Lake Brooklyn has the greatest rate of leakage of all of the lakes and, when Alligator Creek ceases to flow into the lake, the lake level falls rapidly. Lake Brooklyn is listed as the second most variable lake in Florida with a total range of more than 27 feet. The maximum recorded lake level was 118 feet National Geodetic Vertical Datum (NGVD) and the level is currently about 90 feet NGVD.

The headwaters of Alligator Creek are located at the southern end of Trail Ridge, a narrow sand ridge which extends northward along the west side of Clay County and on north into Georgia. The sand ridge consists of old beach deposits and sand dunes from ancient higher sea levels. The headwater elevation of the creek is about 220 feet NGVD and the creek flows southward for six miles to Lake Brooklyn. The intervening lakes in the chain along the creek are Blue Pond, Lake Lowry and Lake Magnolia. For the purpose of this report, the names of the major lakes in the watershed will be referred to with the word "Lake" first

1.3 Previous Investigations

Lake Brooklyn and the chain of lakes in Clay County have been the focus of numerous reports and studies since the mid-1950's. The reference section at the end of this report provides a list of most of the published reports. Two other studies have recently been completed by the U.S. Geological Survey (Merritt, 2001) and Golder and Associates (Powell and Oliveros, 2001). These two reports looked at different aspects of the area hydrology. The following summary of the previous investigations is based upon the work by Merritt.

After the decline in Lake Brooklyn levels between 1954 and 1958, the USGS performed a comprehensive investigation of the hydrology of the area. The results were reported by Clark and others (1963) and included the local hydrogeology and hydrology of Lake Brooklyn and other lakes, Lowry, Magnolia and Blue Pond. This study focused most on Lake Brooklyn and the movement of water between the surficial aquifer and the lake. Clark was the first hydrologist to state that multi-year periods of deficient rainfall were responsible for the lake level declines. Clark prepared a water budget of Lake Brooklyn and suggested some options for augmenting the lake. Following this report, Clark and others (1964) reported on the hydrology of a wider area including Alachua, Bradford, Clay and Union Counties.

Following a period of flooding in the lower part of the Etonia Creek Basin in 1973, the Army Corps of Engineers (1975) published the results of a flood-plain study for the area. This report was followed by an investigation of the surface water and groundwater resources of the Etonia Basin by the SJRWMD (Yobbi and Chappell, 1979).

Following a record low level in Lake Brooklyn in 1991, the SJRWMD conducted a study by Robison (1992) in which a rainfall-runoff model was used to simulate the surface flows of Alligator Creek and the levels of Blue Pond, Lake Lowry, Lake Magnolia, and Lake Brooklyn. The model also included gains and losses to the surficial aquifer and leakage to the Floridan Aquifer. The study also included surveys of the creek channel profile between the lakes and evaluated the possible effects of channel changes between the lakes.

In 1990, a study of the lakes and Alligator Creek and the Etonia Creek Basin was begun by the University of Florida (UF) for the SJRWMD. Motz and others (1991) prepared a report of the first phase of the study which described the lakes and creek and the relationship with the Surficial, Intermediate and Floridan Aquifers. The report also evaluated the long-term trends in rainfall, lake levels, and water levels in the aquifers. The report indicated that low rainfall periods were the primary cause of lake level declines. Following the release of this report, Stephen Boyes (1991 and 1992) prepared several reports for Clay County, which evaluated the conclusions of Motz and looked at other relations in Alligator Creek flows. Boyes concluded that the Surficial Aquifer had considerable influence on the surface water flows.

In Phase 2 of the UF study, Motz and others (1994) compiled and evaluated additional data and prepared a flow model to evaluate lake leakage to the Floridan Aquifer. Double-mass curves showed a steady relation between rainfall and lake levels and between lake levels and the Floridan Aquifer levels. Long-term water budgets were prepared for Lakes Lowry, Magnolia, Brooklyn, and Geneva. These budgets did not include the Surficial Aquifer due to a lack of data about the water table conditions. In a further study, Annable and others (1996) installed a network of surficial aquifer monitor wells in the area from Lake Lowry to Lake Geneva. Data from these wells were used to estimate groundwater flow to and from the surficial aquifer to refine the previous water budgets for the lakes.

In Phase 3 of the UF study, Motz and others (1995) used a groundwater flow model to further evaluate the relationship between the lakes and the Floridan Aquifer in the area around Lake Brooklyn. This report concluded that regional water use from the Floridan Aquifer would not cause significant decline in lake levels in the area.

In 1994, the SJRWMD prepared evaluations (Neubauer 1994) of Lakes Lowry, Magnolia, Brooklyn and Geneva and Blue Pond, so that minimum lake levels could be set for each lake.

In 1999, the USGS began a study of the relationship between the surface flows, the lakes and the Floridan Aquifer. This work was reported by Merritt (2001). He used a groundwater flow model to simulate the interaction between Alligator Creek, Surficial and Floridan Aquifers, and Lakes Magnolia and Brooklyn. The model calculated the leakage rates for the lakes. The study concluded that the lake level decline and subsequent reduced leakage volume could cause most of the level decline in the Floridan Aquifer. He also concluded that efforts to change the physical nature of the Alligator Creek channel would only have a temporary effect on the inflow to Lake Brooklyn.

In January 2001, SJRWMD (2001) prepared a summary of the hydrologic data for the Alligator Creek watershed and the chain of lakes for the benefit of the Keystone Heights Lake Advisory Council. This report provided water level data from 1994 up to January 2001.

In May 2001, the E.I.DuPont de Nemours & Co. Inc. (DuPont) retained Golder and Associates to perform an analysis of the hydrology of the mined area at the headwaters of Alligator Creek and to determine a comparison of the present post-mining condition of the area with the pre-mining conditions regarding flow to the downstream lakes in the watershed. This report by Powell and Oliveros (2001) presented a description of the hydrogeology and hydrology of the mined area and concluded that the drainage area to Alligator Creek has been increased by about 700 acres and that streamflow under normal rainfall conditions has been increased by about 1.5 cfs. Under drought conditions, the flow increase would be less, about 0.4 cfs.

1.4 Work Performed

During the course of this investigation, Peter Schreuder and John Dumeyer met four times with the involved stakeholders at the Keystone Heights City Hall on June 27, July 27, September 25, and December 19, 2001. A register of the stakeholders attending these meetings is included in the Appendix of this report. In addition, John Dumeyer met with Paul Catlett of Camp Blanding on July 5 and October 22 to tour the old mined area and the channel of Alligator Creek downstream to Lake Magnolia. On December 18, Paul catlett, Glen Lassiter, and Bobby Ludwig were able to travel upstream in the old mined area to view the drainage conditions and reported that water flowed from the Smokehouse Pond into Alligator Creek.

Copies of previous investigation reports and data were furnished by the stakeholders, SJRWMD, DuPont and the U.S. Geological Survey (USGS). In addition, hydrologic data records were obtained from DuPont, SJRWMD, and USGS and analyzed. Considerable additional information was exchanged with the stakeholders by e-mail.

While considerable amounts of historical and anecdotal information were provided about the prior conditions of Alligator Creek and the chain of lakes, the primary data which could be technically evaluated about Alligator Creek flows and spring flow into Lake Lowry are limited to the period after 1991. Water level records for the lakes and particularly Lake Brooklyn and the Floridan Aquifer levels do extend back to the 1950's, but the ability to evaluate the streamflow based on recorded data in conjunction with the lake levels is limited to this recent period.

The focus of the study kept evolving throughout the study period, greatly enhanced and directed by the participation of the stakeholders during the progress meetings. Finally, the initial issue of what could be done about the long term water level regime in Lake Brooklyn came into focus. The focus is on the question of what an acceptable low water level in Lake Brooklyn would be. Because the rate of leakance from the lake increases geometrically with the increases in the water levels, a larger sustained surface water flow from Alligator Creek will be needed to maintain higher water levels in Lake Brooklyn. The Schreuder, Inc. Project team therefore focused on the quantitative relationship between surface water levels in Lake Brooklyn and the potential average long term surface water flow from Alligator Creek. The average long term flow of surface water in the Alligator Creek watershed can be improved by creating surface water storage. The two areas where potential surface water storage can be created and managed are in Lake Lowry and the old mined area on Trail Ridge. Our work involved a quantitative analysis of the storage potential and preliminary engineering design and associated cost recommendations.

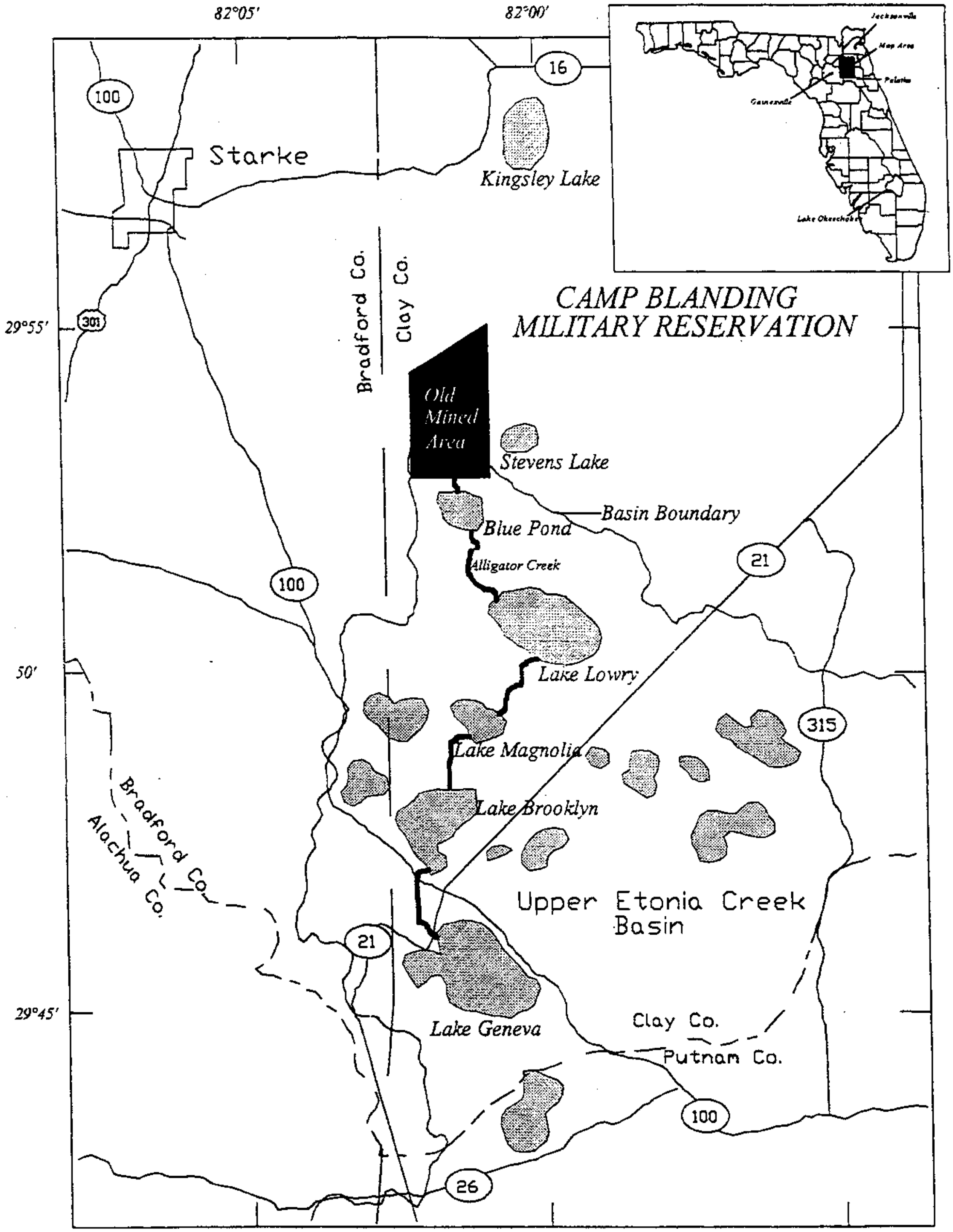


Figure 1-1: Location of Project Area

2.0 LAKE BROOKLYN WATERSHED HYDROLOGY

This section was prepared to describe the inter-relationship of the rainfall pattern in the area, the hydrogeology of the related geologic formations and aquifers, the surface water flow of Alligator Creek , and the consequent changes in the lake water levels and volumes. As stated by other investigators in the section on previous studies, rainfall is the water source within the Lake Brooklyn watershed. Since Trail Ridge and the Keystone Heights area occupy a topographic high area, there is no other water source flowing into the area.

2.1 Rainfall

The long-term rainfall in the Lake Brooklyn area is best recorded by the rainfall station in Gainesville. This station has the longest continuous record (since 1897) and comparison with other rainfall stations by Motz (1994) showed that the Gainesville record provided a good indicator of rainfall in the watershed. While there is considerable spatial variability in short-term rainfall in Florida on a weekly or monthly basis, over a long period of time, the variability tends to average out. The long-term average for the area is 51 inches and about 60 percent of rainfall occurs in the summer months of June, July, August, and September. Minimum annual rainfall at Gainesville was 32.8 inches and the maximum annual was 77 inches.

2.2 Hydrogeology

The hydrogeologic components in the watershed consist of three aquifers, the Surficial, the Intermediate, and the Floridan Aquifers. The Surficial Aquifer is the uppermost at the land surface and is comprised of surficial layers of sand, silt and clay. The aquifer contains sands of the Trail Ridge Formation on the top and flanks of the Trail Ridge and also recent sands and clay deposits at lower elevations around the ridge and the lakes. The sands, silts and clay of the Cypresshead Formation form a confining layer at the base of the Surficial Aquifer. The unconfined groundwater in the aquifer is derived from direct rainfall recharge on the land surface. The recharge water moves downward to the water table and then flows horizontally in relation to the surficial topography and discharges to wetlands, or lakes, or streams. Some groundwater in the aquifer also leaks downward into the Intermediate and Floridan Aquifers.

The Intermediate Aquifer consists of interbedded layers of sand, shell, limestone and clayey marls of the Hawthorn Formation. The groundwater in this aquifer in under confined conditions and provides a small but important supply of water for domestic wells in the area. The major function of the intermediate aquifer is as a confining unit between the surficial sands and the Floridan Aquifer.

The Floridan Aquifer is the major source of groundwater in Florida. The aquifer contains several limestone and dolomite formations, but the formation of primary interest in the Lake Brooklyn area is the uppermost one, the Ocala Limestone. The limestone layers have been highly altered by solution of the limestone with the resultant formation of solution channels and collapse features in the layers, which lead to the formation of sinkhole features in the overlying clays and sands. The solution of the limestone has produced the karst topography of the Keystone Heights area with its numerous lakes.

Motz (1995) reported that the transmissivity of the upper part of the Floridan Aquifer ranges from 50,000 to 500,000 ft^2 per day, which is in the very high range for aquifers. This high rate of transmission of groundwater is due to the solution channels within the limestone. The presence of the karst features and lakes in the Keystone Heights have produced a significant recharge source to the Floridan Aquifer. The potentiometric map shown in Figure 2-1 indicates a water level high centered in the Keystone Heights vicinity. This feature is indicative of the amount of recharge downward to the aquifer.

2.3 Alligator Creek and Streamflow

The surface drainage of Alligator Creek begins north of Blue Pond in the old mined area. The water source for the creek consists of surficial runoff from high-intensity rainfall and from seepage from the unmined and mined sand deposits. At the breach at the south side in the mine berm, most of the flow to the creek comes from the west perimeter ditch around the mined area and from the north ditch. The creek flows southward into the wetlands flanking the north side of Blue Pond. There is flow into and out of Blue Pond for more than 99 percent of the time. The creek flows from the south side of Blue Pond and is measured at a SJRWMD gaging station on Impact Road, prior to entering Lake Lowry. Lake Lowry is also supplied by three springs from the Surficial Aquifer which flow into a combined channel at the northeast side of the lake. Figure 2-2 shows the combined surface flow of the springs and the creek into Lake Lowry.

Alligator Creek flows out of the south side of Lake Lowry and is measured at a SJRWMD gaging station at Greble Road. Figure 2-3 shows the difference between the measured inflow and outflow from Lake Lowry. The values on the left axis of the graph range from -10 to + 30 cfs. When there is significant rainfall on the lake and/or Surficial Aquifer seepage into the lake, the outflow is greater than the inflow. The negative values occur when the outflow is less than the inflow to the lake and provide an indication of the rate of loss to evaporation and leakage from Lake Lowry. During non-rainfall periods in 1999 and 2000, the steady loss rate was about 2.5 to 3.5 cfs.

Alligator Creek flows south from Lake Lowry into Magnolia Lake and then on south to Lake Brooklyn. The outflow from Magnolia Lake is measured at a SJRWMD gaging station at Treat Road. Figure 2-4 shows a graph of the difference between the inflow and outflow at Magnolia Lake . This graph shows a greater fluctuation between negative and positive values than does Figure 2-3.

Another measure of water loss in Alligator Creek is a comparison of the annual flows out of Lake Lowry and into Lake Brooklyn, as measured by the gaging stations at Greble road and Immokalee Road.

Year	Annual Loss in AF
1995	964
1996	1833
1997	1827
1998	746
1999	334

When the Lake Brooklyn level is above the outlet elevation of 115 feet NGVD, Alligator Creek will flow on southward through Keystone Lake and into Lake Geneva. This condition has occurred infrequently in the last 25 years, but did occur during the high rainfall period in 1998.

2.4 Lakes

Figure 2-5 shows a profile of Alligator Creek from the headwaters at Smokehouse Pond in the old mined area downstream to Lake Geneva to give a perspective on the elevation changes along the creek system. The elevation drops from 220 feet NGVD down to 100 feet in a distance of about eight miles.

Blue Pond is the uppermost lake in the chain of lakes. It has a surface elevation of 171 feet, a surface area of about 200 acres and maximum depth of about 40 feet. Bottom contours of the lake indicate that it was formed by a single subsidence feature. Blue Pond has a very stable water level with a range of 1.9 feet from low to high. There is a well-developed wetland fringe around the lake, due its near constant level.

Lake Lowry (previously called Sand Hill Lake) is the second lake in the chain with an outlet elevation of 131 feet NGVD, a surface area of 1250 acres and a maximum depth of 30 feet. The bottom contours of the lake indicate that it was formed by the convergence of two subsidence features. Lake Lowry has a stable water level with a range of about 3.5 feet. The lake does occasionally fall below the outlet level, as it did in 2000 and 2001. The wetland fringe is confined primarily to the northern edge of the lake, possibly due to groundwater seepage to support the vegetation.

Lake Magnolia is the third in the chain with an outlet elevation of 121 feet NGVD, a surface area of about 210 acres, and a maximum depth of about 47 feet. The bottom contours indicate that the lake was formed by a single subsidence feature. Lake Magnolia has a water level range of 9 feet and the water level falls as soon as inflow ceases. The lake has an open sandy margin due to the range in water levels.

Lake Brooklyn is the fourth in the chain with an outlet elevation of 115 feet NGVD, a surface area of about 650 acres when full and a maximum depth of about 47 feet. The bottom contours indicate the lake has about ten distinct sinkhole features in the bottom area. SJRWMD has performed several surveys of the sinkhole areas around the lake. When the water level falls below 99 feet elevation, the lake separates into individual ponds. The water level range is more than 27 feet.

2.5 Trail Ridge Mine: Pre-mining and Post-mining Water Yield

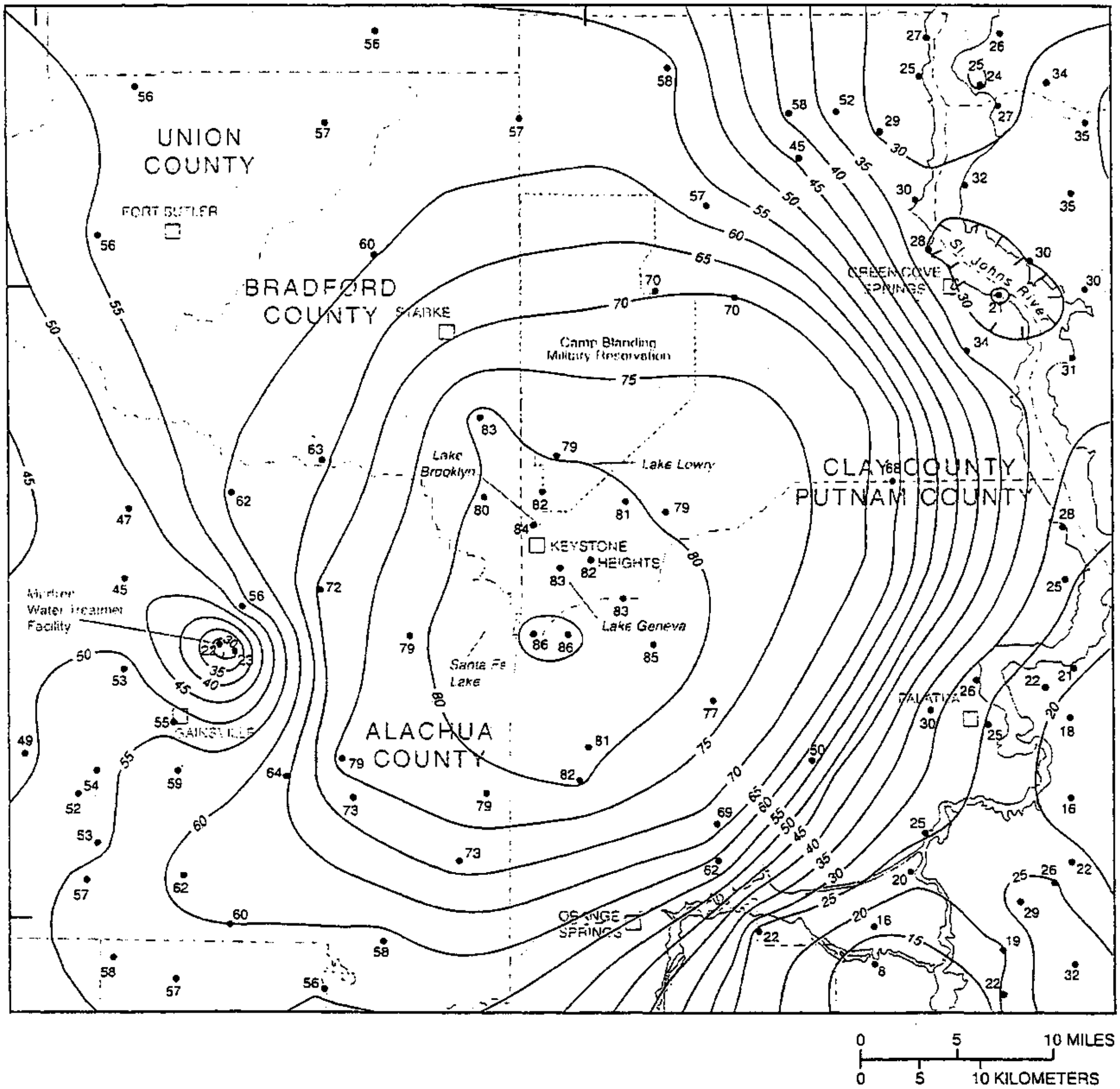
The area of Trail Ridge at the headwaters of Alligator Creek was mined in the early 1960's to extract heavy minerals from the sand deposits. The mining was performed by dredge and the sands remaining after mineral separation were returned into the dredge pond. The fine materials from the original sands were carried from the mined area by the flowing water and were collected north and west of Treat Road. The mining operation did not cut into the clay layers under the sands, so the resulting mined area and the remaining sands after mining are similar to a tub filled with clean sand. The walls of mined area are unchanged from the original layered materials and groundwater can still flow away from the mined area as it did prior to mining. Figure 2-6 is a map of mine bottom contours from DuPont mining data to show the depth and shape of the mine pit.

During the mining operation, a berm (also known as a levee or dike) was constructed around the mined area to prevent surface discharges of the sediment-laden water. The berm was constructed of native material and placed on un-mined land. Therefore, the berm did not alter the underlying sand deposits and the flow of groundwater through the sand deposits around the mined area. A perimeter ditch was constructed inside of the berm to convey the water to a treatment point during mining.

Figure 2-7 shows the pre-mining topography of the mined area with the outline of the mining berm and the heavy triangular shaped line delineates the portion of the pre-mining area which was tributary to Alligator Creek. The area of this triangle within the mined area was about 220 acres (0.35 sq. miles). The majority of the mined area was tributary to the Santa Fe River on the west and Black Creek on the east. It should noted that only about one-third of the Alligator Creek watershed within the mined area and the berm was actually mined.

After mining ended and breaching of the berm at the south end of the mined area, the perimeter ditches have increased the tributary area to Alligator Creek to about 750 acres. Figure 2-8 shows the approximate area which is now tributary to Alligator Creek. This increased area is capable of delivering additional water to Alligator Creek and the downstream lakes. As a result, there is no indication that the historic mining activity has reduced water flows to Lake Brooklyn, rather it has actually increased the watershed area and the resulting water flows. However, in the 40 year period since the perimeter ditches were constructed, vegetation and trees have grown within the ditches and should be removed to any unintended obstruction to water flow.

One of the concerns of the stakeholders in the original scope of work entailed an estimate of the volume of lakes and pond within the old mined area. During the investigation, DuPont staff were able to survey the bottom contours of the two largest lakes, the Northeast(Long Pond) and Southwest Lakes. Based upon the bottom contours, the volume of the Northeast Lake is 336 AF and the Southwest Lake contains 155 AF. The remaining ponds could not be accessed due to their location in the ordnance impact area. An estimated combined volume for the remaining ponds is about 100 AF. Copies of the depth contours of the Northeast and Southwest Lakes are in the appendix.



EXPLANATION

—20— POTENTIOMETRIC CONTOUR – Shows altitude at which water level would have stood in tightly cased wells. Hachures indicate depression. Contour interval 5 feet. Datum is sea level

Figure 2-1: Floridan Aquifer Levels, Sept. 1998 (from Merritt, 2001)

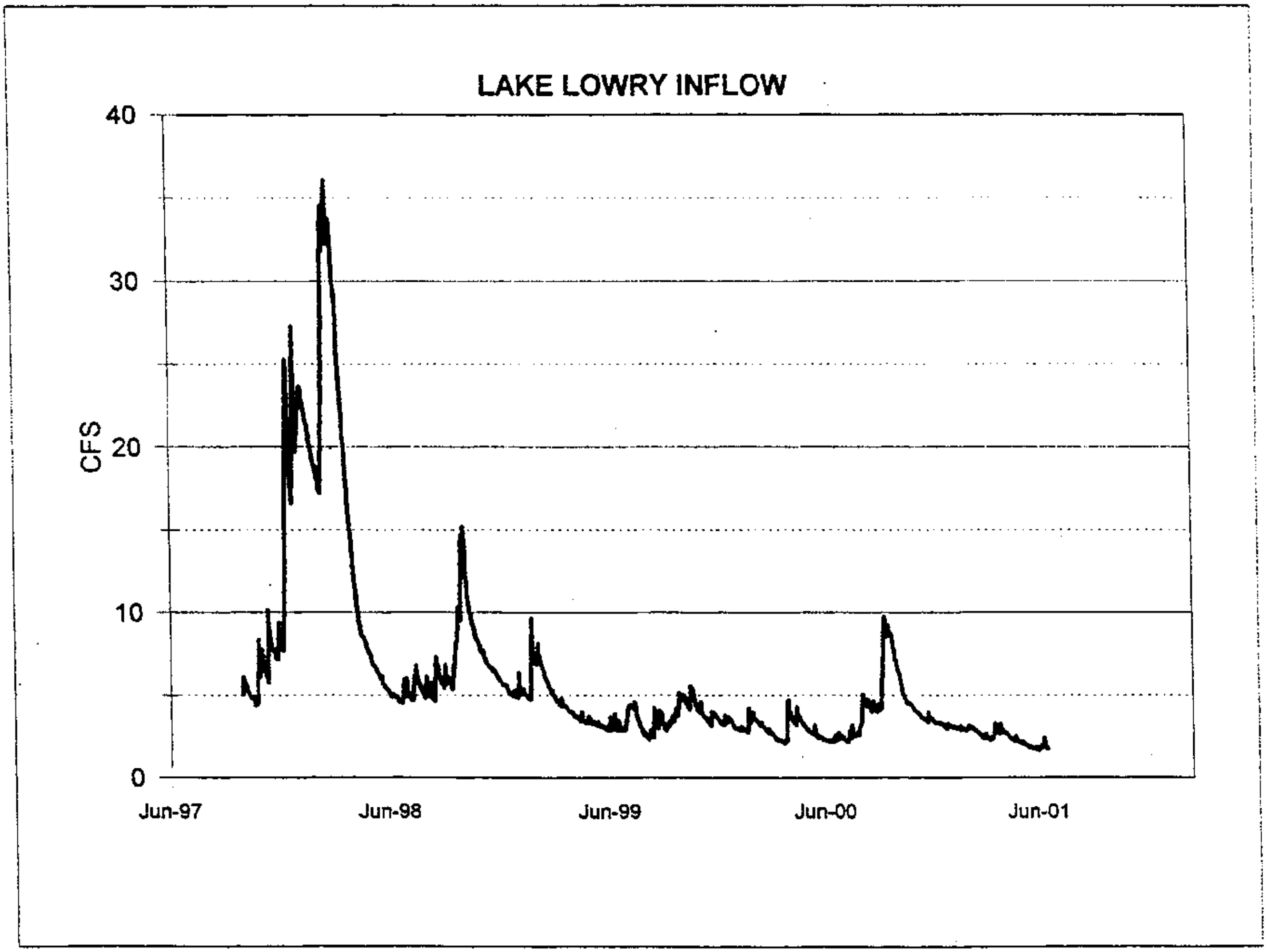


Figure 2-2: Inflow to Lake Lowry

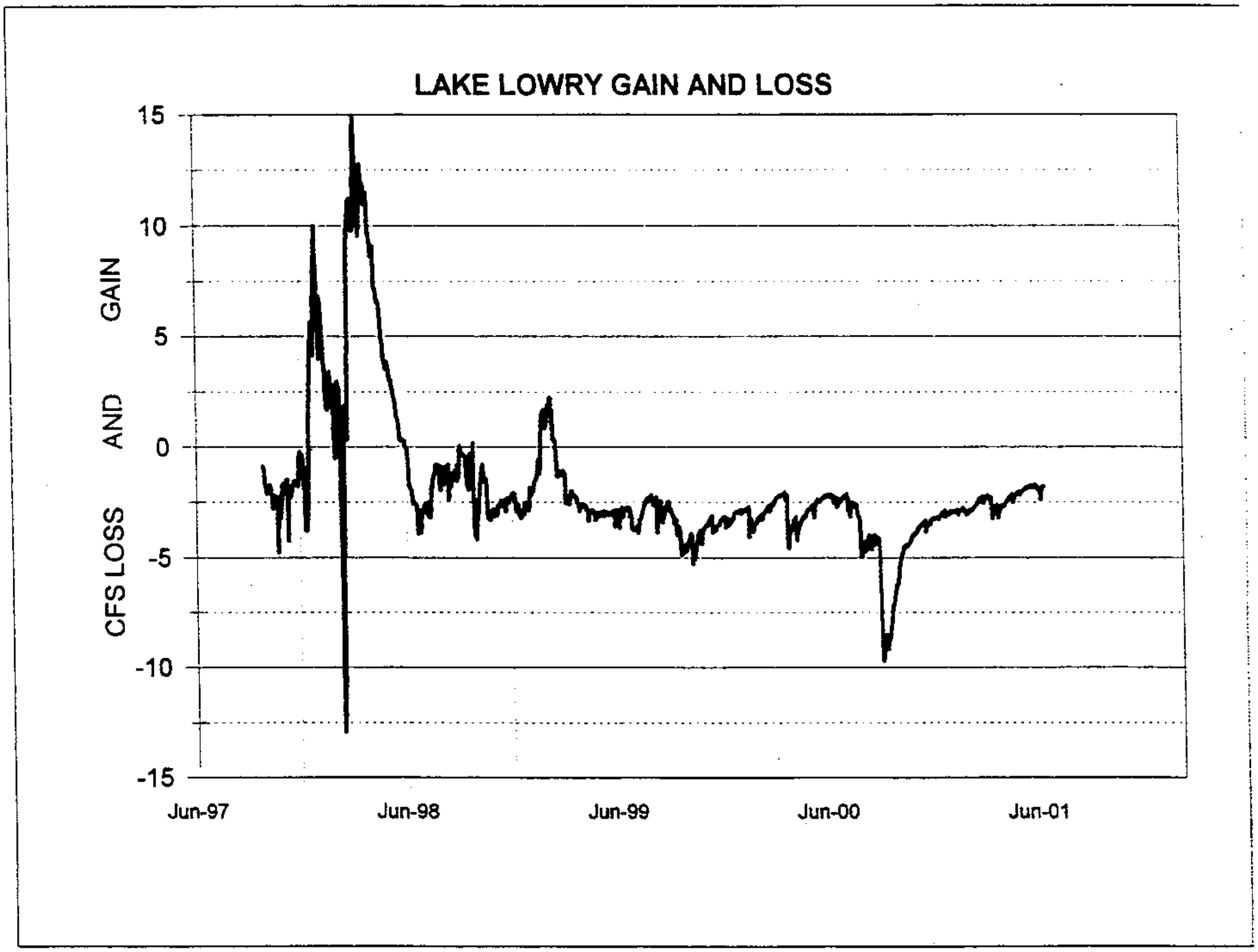


Figure 2-3: Lake Lowry Gain and Loss — (Outflow - Inflow)

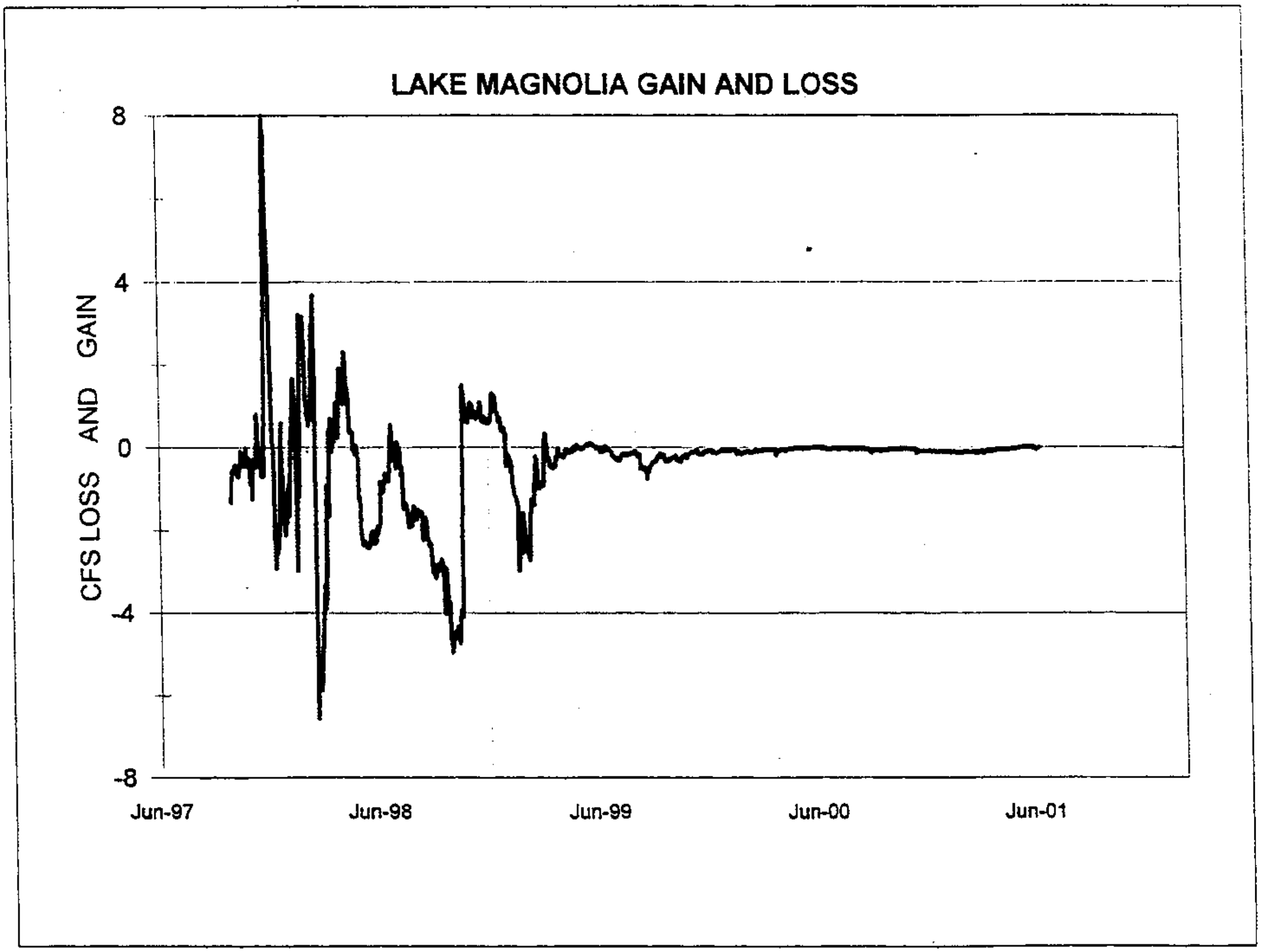


Figure 2-4: Lake Magnolia Gain and Loss

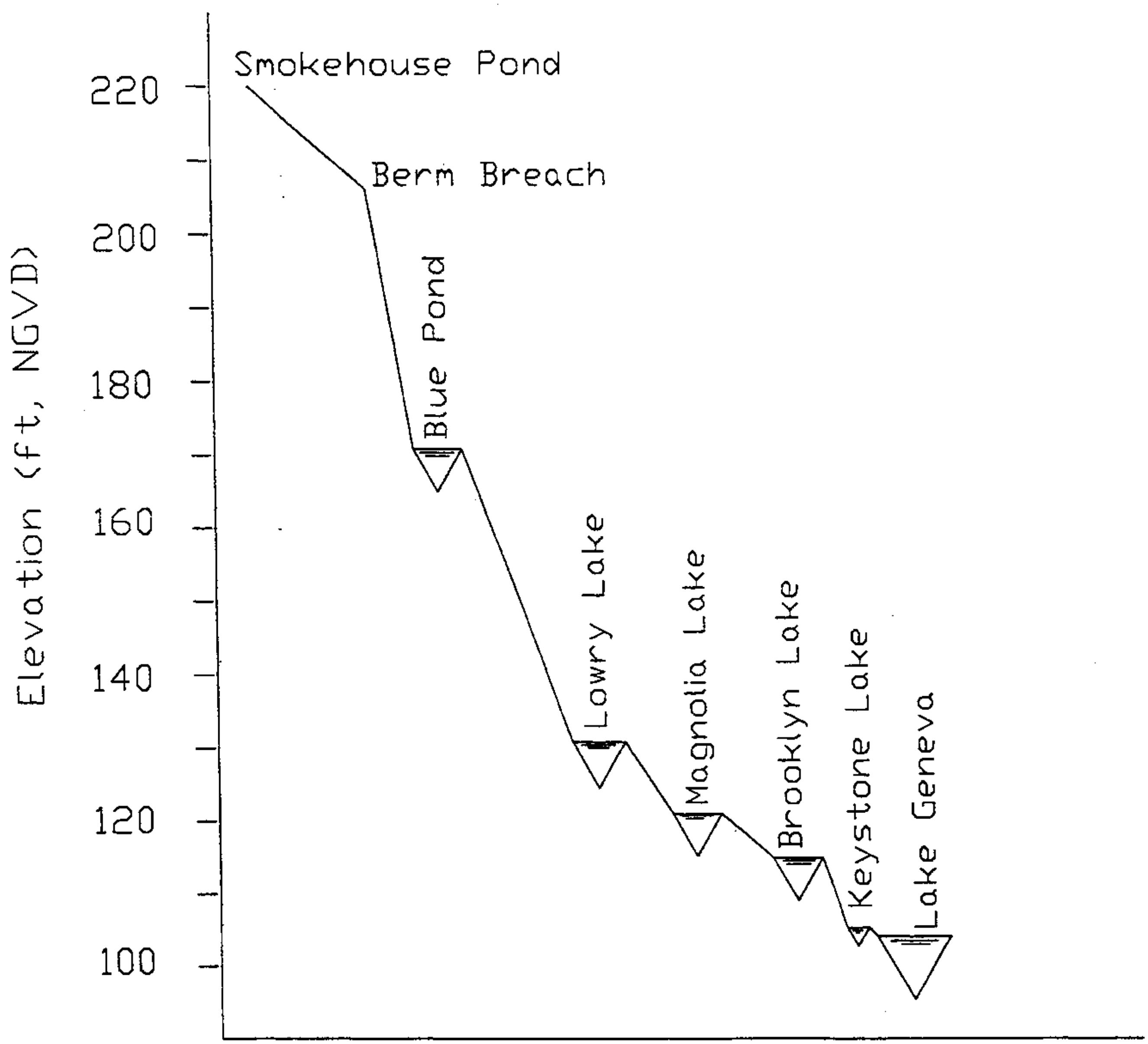


Figure 2-5 Alligator Creek Profile

Figure 2-6 Mine Pit Extent and Bottom Contours (from DuPont mining data)

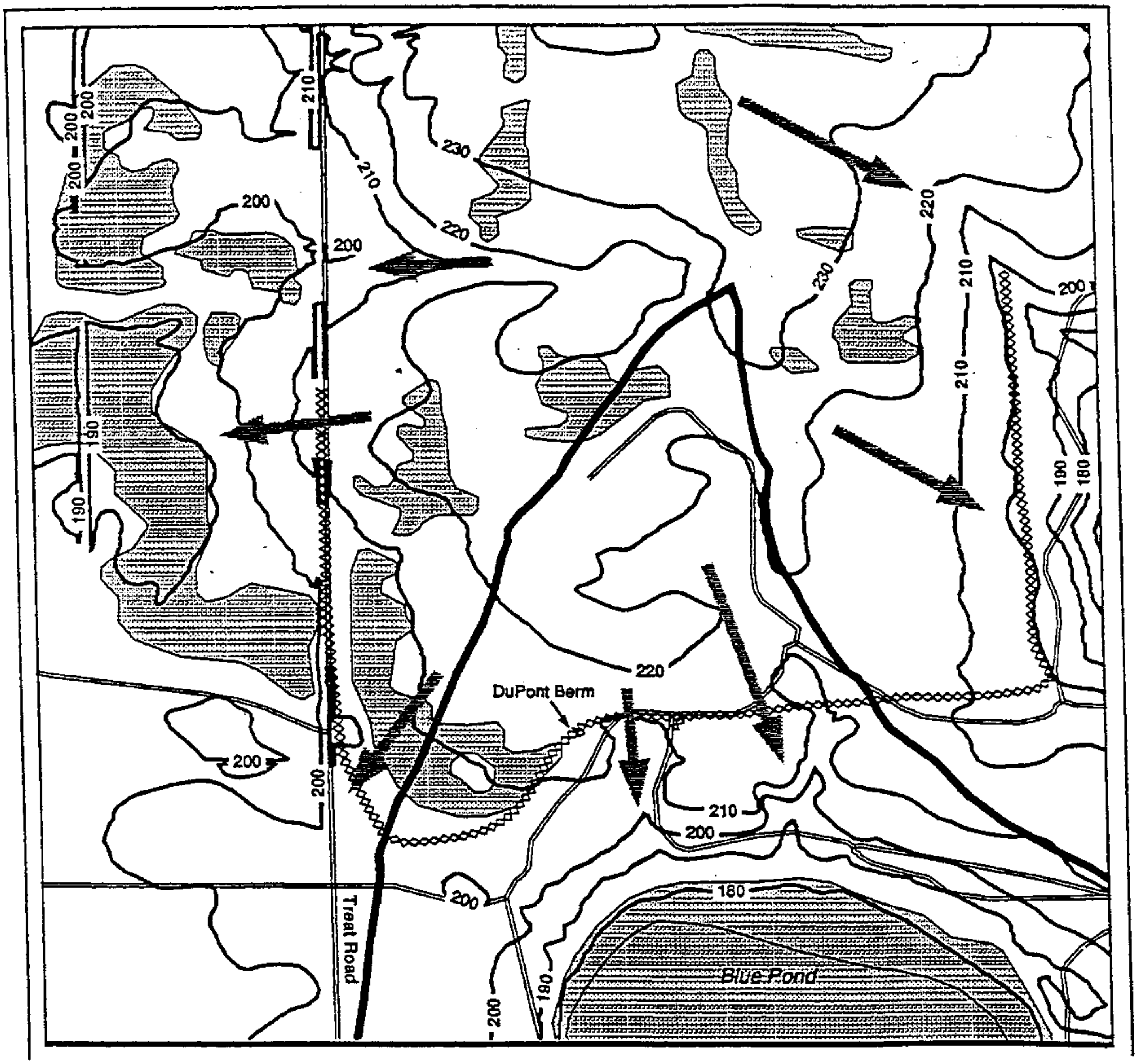


Figure 2-7: Pre-mining Topography and Watershed Boundary (from SJRWMD)

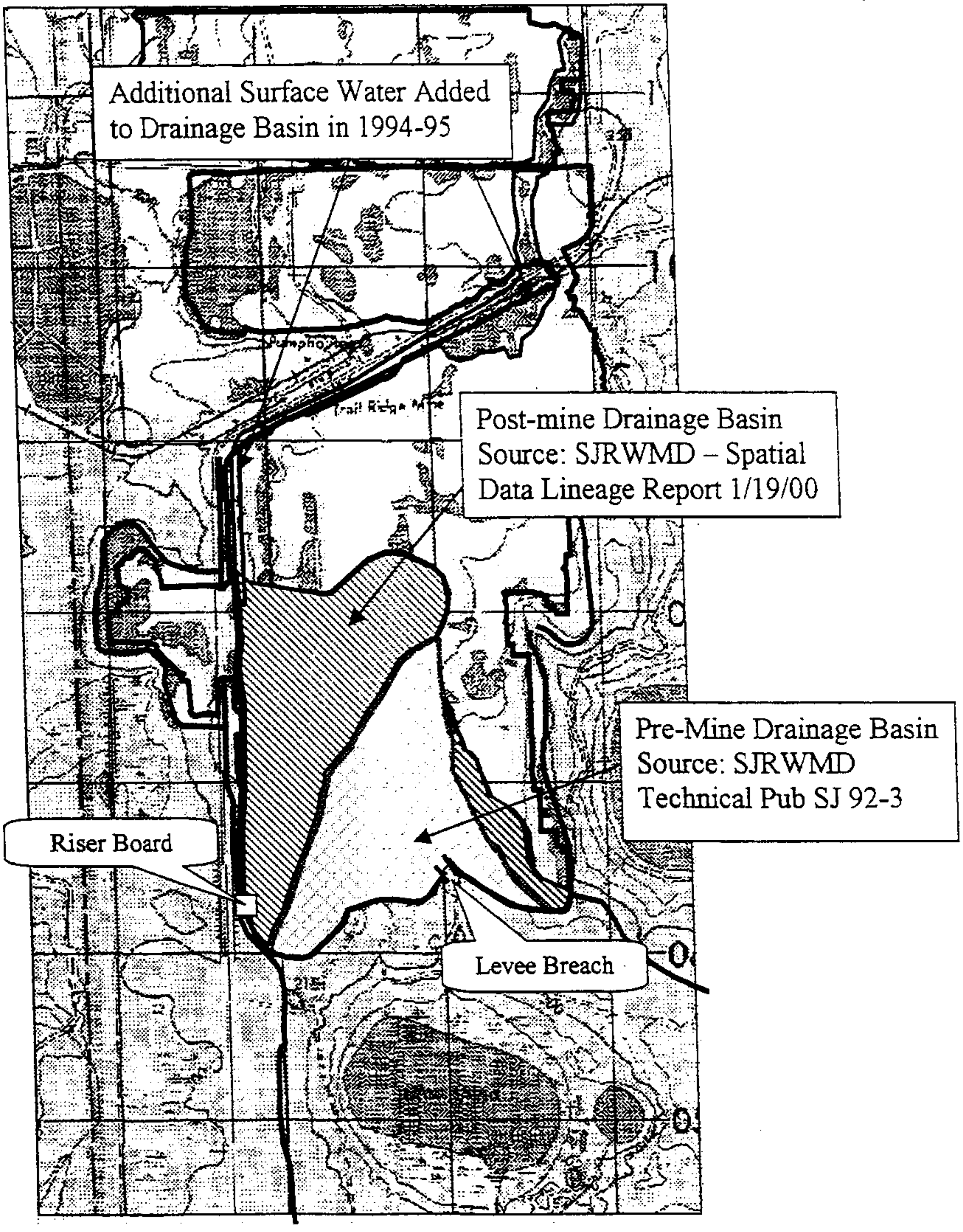


Figure 2-8: Post-mining Watershed Boundaries (from SJRWMD)

3.0 LAKE BROOKLYN HYDROLOGY

3.1 Water Level Variations and Trends

As mentioned above, Lake Brooklyn water levels have been measured and recorded since 1957 by the USGS and SJRWMD. Figure 3-1 shows a hydrograph from Merritt (2001) of the water level since 1957 The hydrograph shows that Lake Brooklyn levels have been low since 1975, with the only recent full period in response to the "El Nino" rainfall in 1997-1998. Since then, the lake levels have declined markedly and reached the lows levels not experienced since 1992. One interesting point demonstrated on Figure 3-1 is that water levels in Lake Brooklyn followed a normal cycle until 1975. This period occurred after mining in the headwaters of Alligator Creek ended in 1962 and prior to the breaching of the berm in 1992. This water level pattern is further indication that the mining activity did not change water flows in Allligator Creek.

3.2 Floridan Aquifer Levels and Trends

The Keystone Heights area is a major recharge source to the Floridan Aquifer. The water level pattern shown on Figure 2-1 depicts this condition. Water which leaks from Lake Brooklyn and the other lakes moves downward through sinkholes and solution channels to supply the Floridan Aquifer. The groundwater levels in the aquifer have been measured by the USGS and SJRWMD in Well C-120, located on the northwest side of Lake Brooklyn. Figure 3-2 shows a hydrograph of the levels in C-120 from 1960 to 1992 (from Motz, 1994). This graph shows a general decline in Floridan Aquifer levels over the period. Figure 3-3 shows a composite hydrograph of both Lake Brooklyn and Well C-120 since 1983 to show the relationship between the lake and aquifer levels.

3.3 Water Level Augmentation Goal for Lake Brooklyn

The determination of the water needs for Lake Brooklyn has been arrived at through an iterative process in which the volume of water lost through downward seepage through the lake bottom was balanced by the long term average surface water flow from Alligator Creek. Through this process, the SI project team arrived at a surface water level augmentation goal in Lake Brooklyn of 100 ft NGVD. According to the stage/seepage loss graph shown in Figure 3-4, based upon Clark's water budget, the seepage loss at a lake stage of 100 ft NGVD is about 0.45 cfs (0.3 MGD).

To provide a visual impression of the 100 ft NGVD lake stage, a elevation cross section across Lake Brooklyn from East to West is presented in Figure 3-5. The horizontal extent of the lake at the 100 ft. elevation was reconstructed using information provided by Clark and others (1963). The horizontal extent of Lake Brooklyn at the 100 ft. elevation is shown in Figure 3-6. For comparison purposes the elevation of Lake Brooklyn at the 97.2 elevation is shown in Figure 3-7. At the 100 ft NGVD level the center portion of the lake is continuous, however, there are still five outlying pools that are not connected by surface continuous, however, there are still five outlying pools that are not connected by surface water. It is important to emphasize that the selection of the 100 ft NGVD lake level stage is based on what the project team determined would be a sustainable surface water flow from Alligator Creek provided that additional releasable surface water can be permitted and created on Lake Lowry and the old mined area on Trail Ridge.

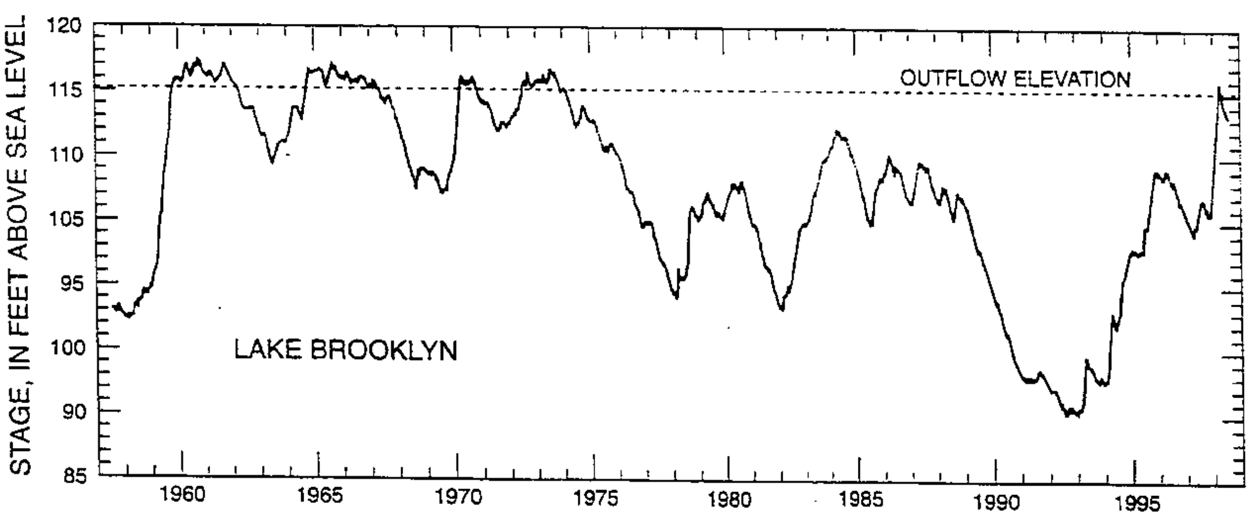


Figure 3-1: Lake Brooklyn Water Level (from Merritt 2001)

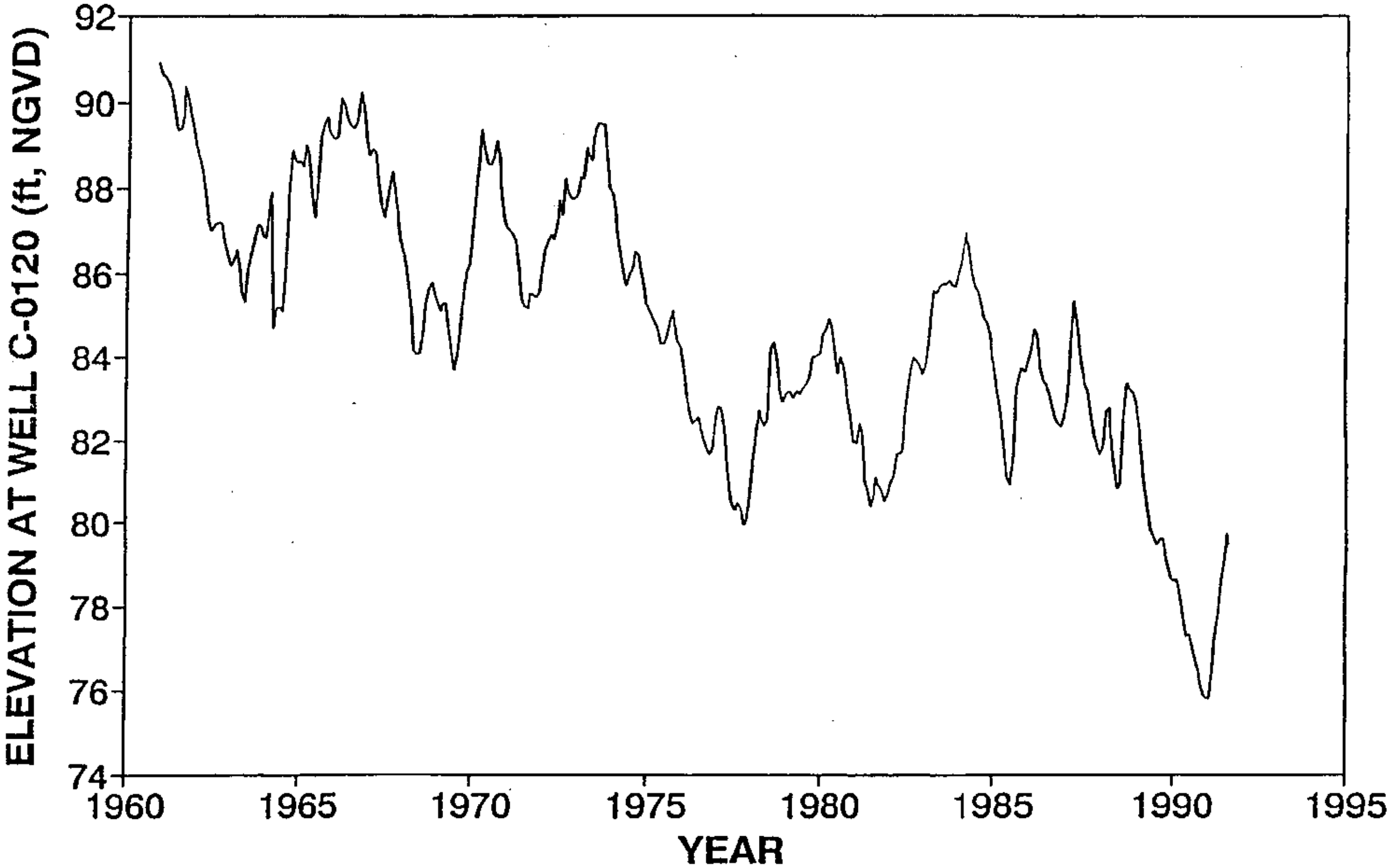


Figure 3-2: Well C-120 Water Levels (from Motz 1994)

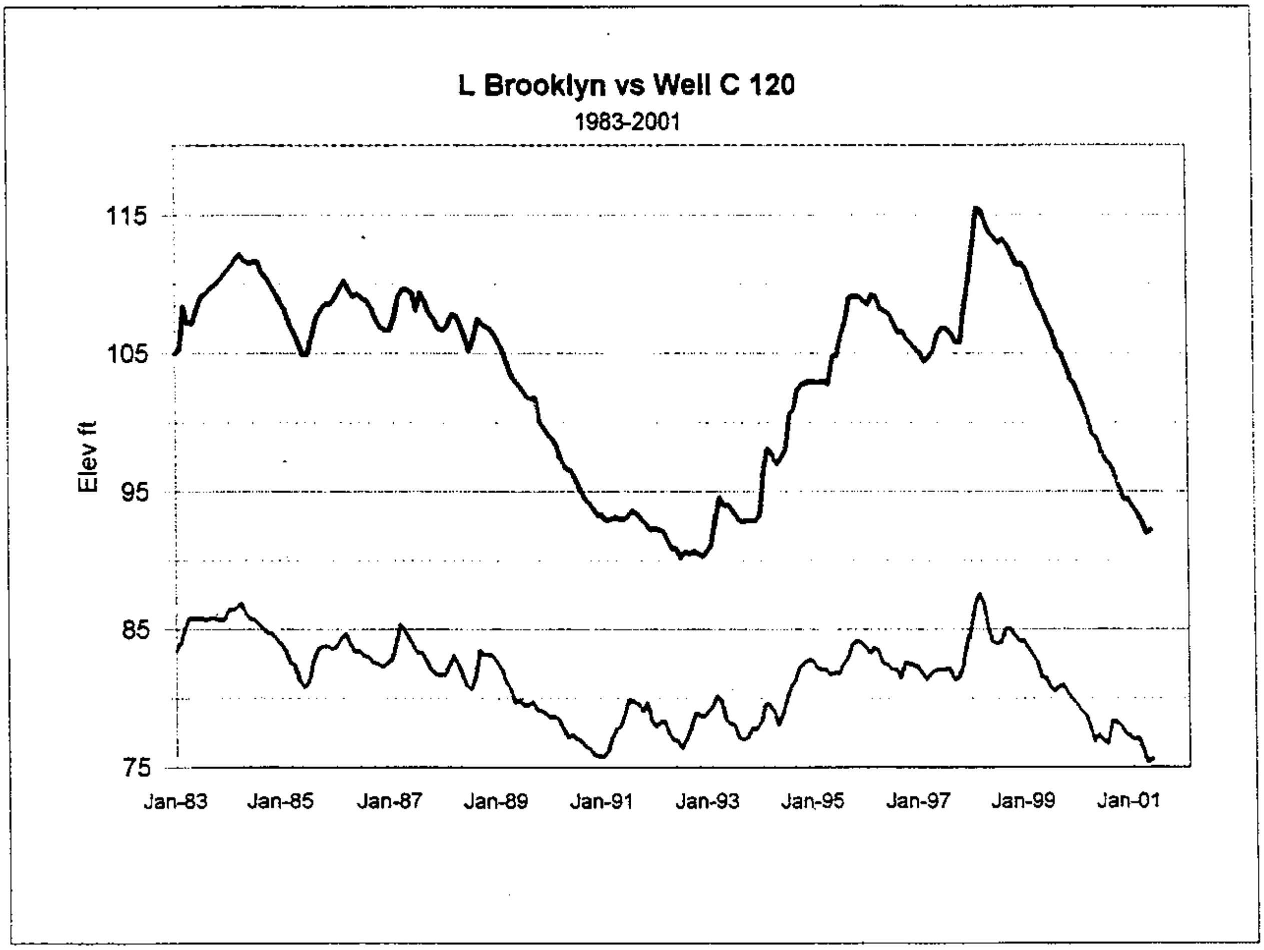


Figure 3-3: Lake Brooklyn And Well C-120 Levels —(1983-2001)

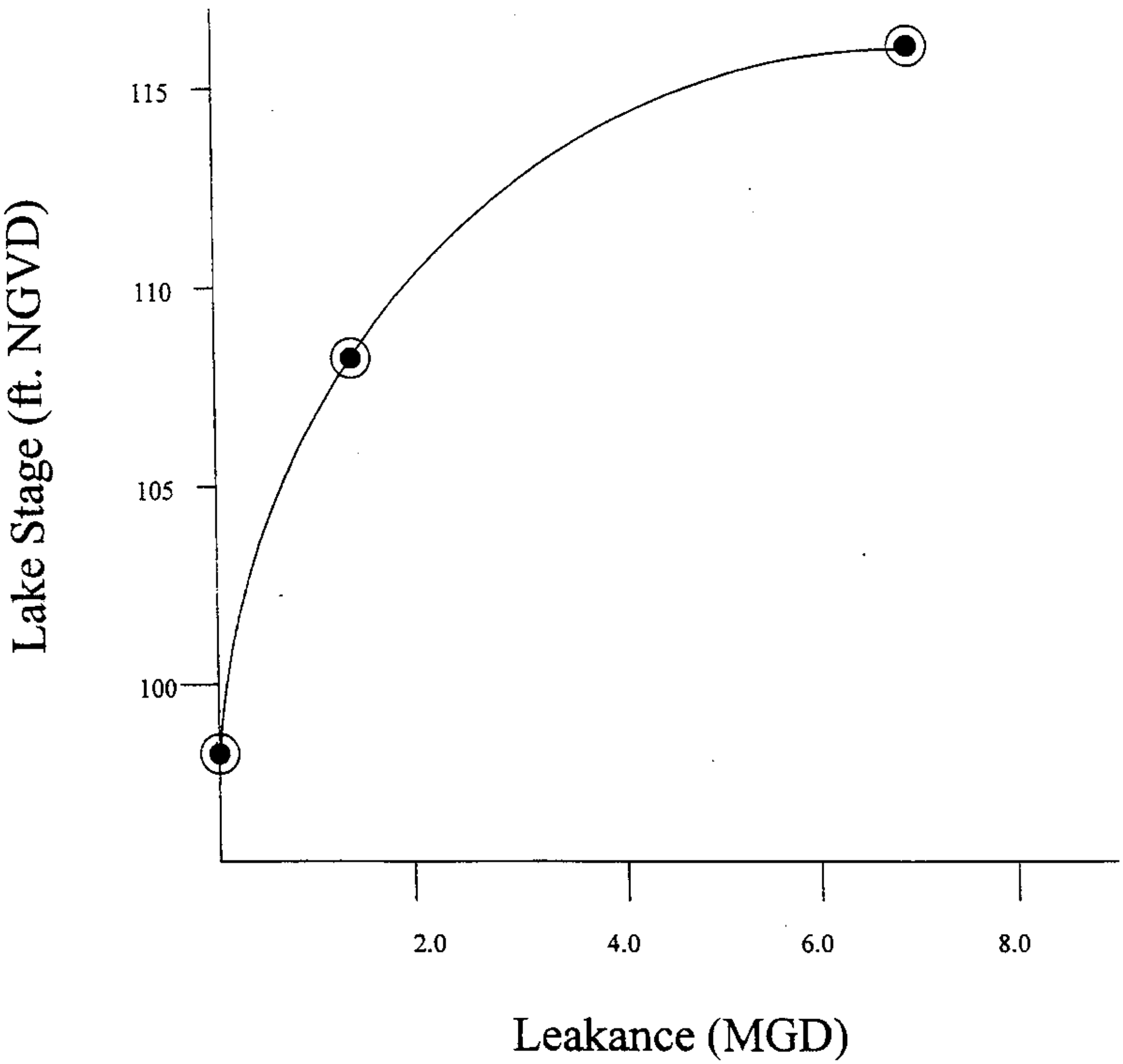


Figure 3-4: Stage versus Seepage Loss Curve for Lake Brooklyn

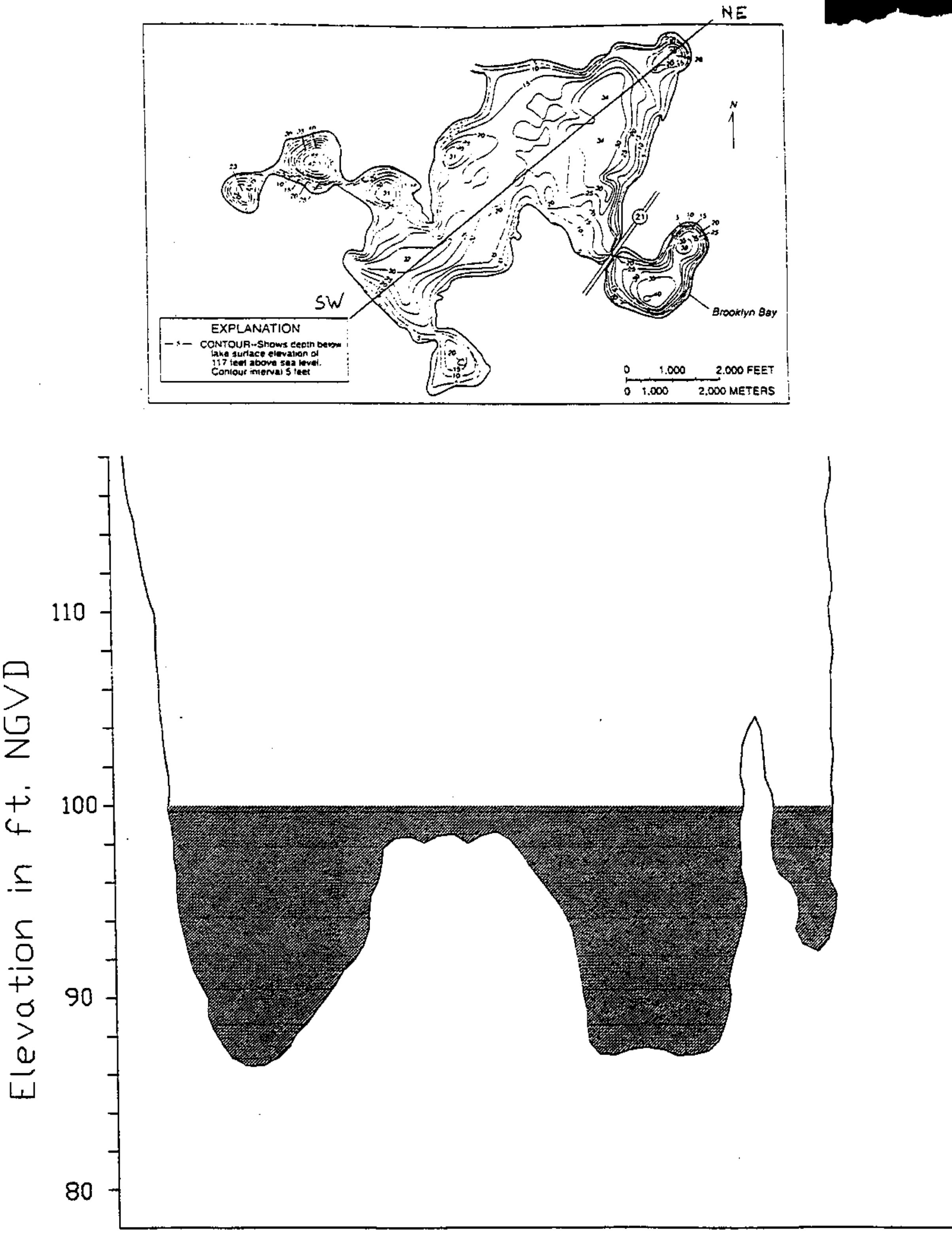
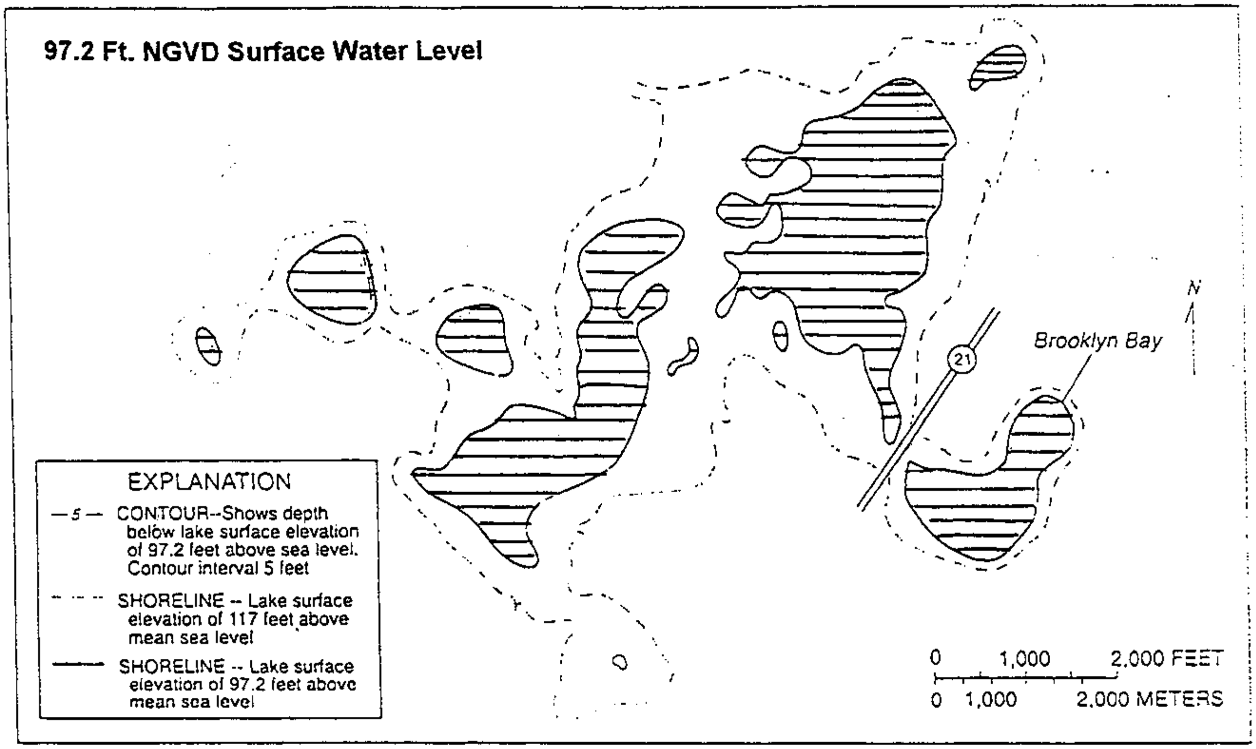


Figure 3.5 Cross Section of Lake Brooklyn showing 100 foot Stage.



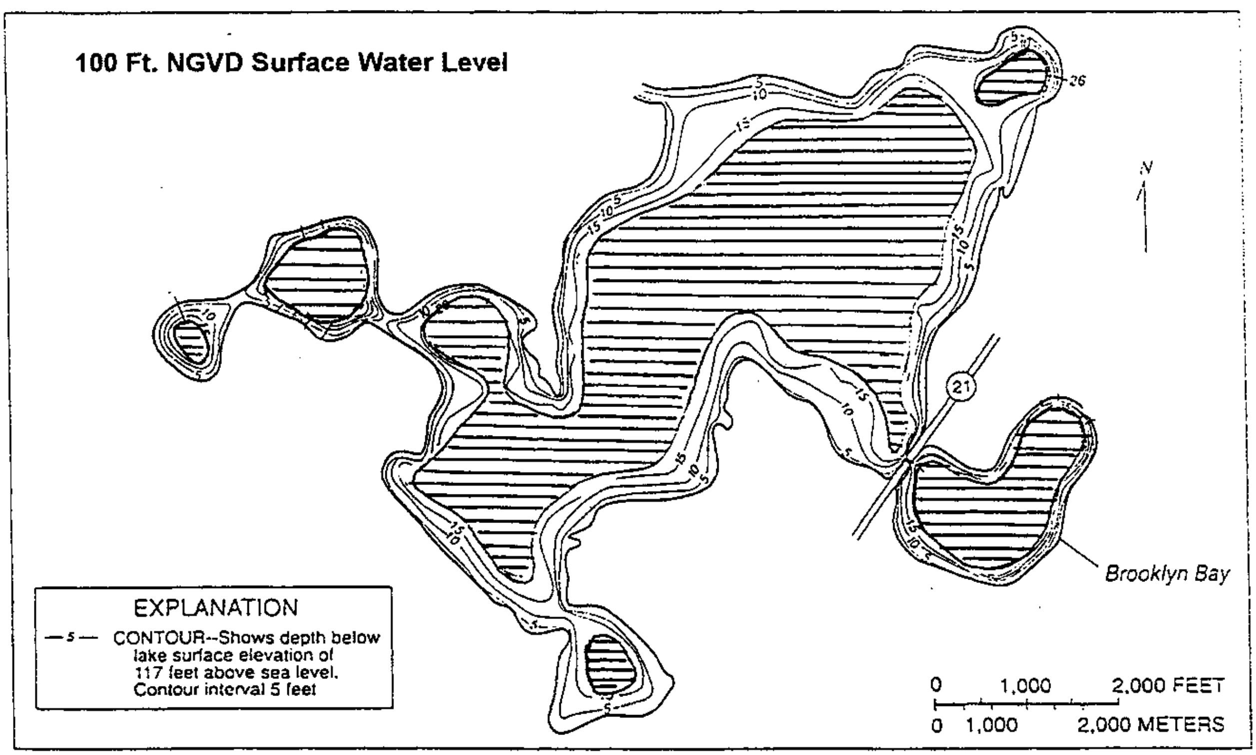


Figure 3-6: Horizontal Extent of Lake Brooklyn At !00-Foot and 97 Foot Levels

4.0 AUGMENTATION OPTIONS

Several of the past studies have recommended various options for increasing water flow to Lake Brooklyn. These options included removal of the berm along the south edge of the old mined area, removal of channel obstructions along Alligator Creek, pumping water from the ponds in the old mined area, construction of dams on the upstream lakes, a channel from Santa Fe Lake, and pumping water from the Floridan Aquifer into Lake Brooklyn. The berm at the south edge of the old mined area was opened in 1992 and the obstructions in the Alligator Creek channel were cleared in 1994. This action produced an increased flow to Lake Brooklyn with the release of the backed-up water. The use of water from Santa Fe Lake is not considered to be a practical option. Pumping options from the Floridan Aquifer or from the mined area would include on-going maintenance and operational costs as well as power costs and most likely changes in the quality of the water in Lake Brooklyn.

One consideration for any of the options to augment the flow of surface water into Lake Brooklyn is the use of controlled versus uncontrolled methods. Uncontrolled options are those which permanently change the physical configuration of the lake or creek channel, such as the previous activities along Alligator Creek. The permanent lowering of a channel or creek outlet will produce a "one-time" effect with release of water downstream followed by a much smaller on-going benefit due to reduced evaporation or leakage loss. An uncontrolled outlet provides no benefit during flood times and could actually exacerbate downstream flooding conditions.

The use of a controlled outlet on the other hand will allow for regulation of water flow downstream on a seasonal or annual basis. An example of a controlled outlet is a slide gate or riser boards on a pipe outlet, so that the upstream level can be varied according to an operational plan as opposed to merely depending upon the rainfall pattern to provide increased flows. The use of a pump in a lake or well is also a type of controlled outlet.

Six options have been considered in this investigation to produce additional water flow to Alligator Creek and to Lake Brooklyn. Four options involve the old mined area, one includes use of Lake Lowry and one includes Floridan Aquifer pumping. These options include five controlled outlets and one uncontrolled outlet. These augmentation options will be discussed individually, but can also be considered in combination.

All of these options are located on Camp Blanding property and would require concurrence from the State Armory Board. The estimates of water yield and construction costs presented with these options should be considered as order-of-magnitude estimates and not as final and definitive amounts. The estimates given are based upon professional judgements of and a conservative approach to the very limited hydrogeological and water level data available. The water yield estimates are based upon the assumption of a regular cycle of wet periods after a drought period, so that there will be available water for storage. More detailed investigations of any single option will be required prior to any final decision for implementation.

4.1 Trail Ridge Options

Options 1 to 4 are based upon the harvest of water from the old mined area to the east and south of Treat Road.

4.1.1 Option 1: Ditch Cleaning Trail Ridge

This option entails cleaning of the perimeter ditch in the old mined area, both east and west along the inside of the berm where the ditch has become clogged with vegetation and sediment (See Figure 4-1). The ditch cleaning would also extend to the north of the Southwest Lake along the west side of the mined area to intercept several of the smaller ponds. Just to the north of the breach, the culverts under the road to the Smokehouse area within the mined area would be removed and replaced with a shallow water road crossing. These cleaning options would allow for better water flow from the mined area and to provide improved drainage to the head of Alligator Creek.

This option would continue the use of the uncontrolled outlet at the breach at elevation 206.5 feet and water levels inside the mined area would adjust to a new stable level. The sustained flow increase in addition to the current flow is estimated to be about 100 AF per year. The estimated cost for this option is about $30,000, depending upon the amount of ditch which can be cleaned inside of the berm.

The major constraints on this option are the ditch cleaning operations to the east and north of the breach, due to Camp Blanding EOD concerns about construction safety with unexploded ordnance in the impact area.

4.1.2 Option 2: Controlled and Lower Outlet at Mine Berm Breach

Augmentation Option 2 is a extension of Option 1 to provide a controlled outlet from the mined area at a lower elevation of 202 feet NGVD and a gravity-flow pipeline southward to intercept Alligator Creek at an elevation below 200 feet (See Figure 4-2). The existing breach in the berm and the Alligator Creek channel to the south would remain in their current physical state to handle flood flows. The ditch cleaning activities inside of the berm would be the same as in Option 1. The outlet structure would be located 800 feet southwest of the breach and consist of a slide gate structure on the northside of the berm with an 18-inch pipeline extending to the west side of Alligator Creek for a distance of about 1000 feet southeastward.

The pipeline construction would occur through a pine flatwoods area to the west of Alligator Creek and would avoid any construction impact to wetlands areas. This option would produce an estimated 300 AF on an annual basis in addition to the flow from Option 1, if the outlet were opened once per year. An operational plan should be developed to determine under what conditions to make a release. After the release period, the slide gate would be closed to allow the water levels in the mined area to recover to their present levels. The estimated cost of this option is about $100,000, depending upon the amount of ditch cleaning inside of the berm.

The major constraint for this option is for the ditch cleaning to the east and north of the breach for EOD construction safety concerns. To obtain the necessary environmental resource permit (ERP) for this option, flows in Alligator Creek could not be reduced to such a magnitude that the existing wetlands along the creek are adversely impacted.

4.1.3 Option 3: Controlled Outlet Southwest Lake and Pipeline to Blue Pond

This augmentation would entail construction of a controlled outlet from the south end of the Southwest Lake in the mined area and a pipeline to Blue Pond (See Figure 4-3). The ditch cleaning inside of the berm would be the same as in Option 1. The outlet structure would consist of a slide gate at an elevation of 195 feet NGVD with an 18-inch pipeline extending southeast to Blue Pond for a distance of about 2000 feet. The elevation and physical condition of Alligator Creek at the breach would remain in the current state to handle flood flows.

This option would produce an estimated 700 AF on an annual basis from the initial release, if the outlet were opened once per year. A preliminary groundwater model estimates a steady flow increase of about 0.5 MGD while the outlet remains open. An operational plan should be developed to determine under what conditions to make a release. After the release period, the slide gate would be closed to allow the water levels in the mined area to recover to their present levels. The estimated cost of this option is about $180,000 depending upon the amount of ditch cleaning inside of the berm.

The major constraints for this option are for the alignment of the pipeline down to Blue Pond and the location of a discharge structure to prevent erosion into Blue Pond. To obtain the necessary environmental resource permit (ERP) for this option, flows in Alligator Creek could not be reduced to such a magnitude that the existing wetlands along the creek are adversely impacted.

4.1.4 Option 4: Controlled Outlet Southwest Lake and Pipeline to Lake Brooklyn

This option is similar to Option 3 with a controlled outlet at the Southwest Lake in the mined area, but with a pipeline extending southward along Treat Road to the crossing of this road with Alligator Creek, downstream of Lake Magnolia (See Figure 4-4). The purpose of this option is to deliver water as close to Lake Brooklyn as possible and to eliminate the channel losses in Alligator Creek. The outlet would consist of a slide gate set at elevation 195 feet NGVD and 26,500 feet of 12-inch gravity-flow pipeline along Treat Road. The existing breach and Alligator Creek channel would remain in their current condition to handle flood flows from the mined area.

This option would produce an estimated 700 AF on an annual basis from the initial release, if the outlet were opened once per year, and the model estimates a steady flow of about 0.5 MGD while the outlet remains open. An operational plan should be developed to determine under what conditions to make a release. After the release period, the slide gate would be closed to allow the water levels in the mined area to recover to their present levels. The estimated cost of this option is about $1,500,000 depending primarily upon the cost of the pipeline installation.

The major constraint for this option is related to the pipeline installation. Since this would be a gravity-flow pipeline to avoid pumping, it must be installed on a constant downward slope. Preliminary review of the topographic map indicates that this construction requirement could be met with some trench depths to about 15 feet below land surface. There do not appear to be any other construction constraints along Treat Road. To obtain the necessary environmental resource permit (ERP) for this option, flows in Alligator Creek could not be reduced to such a magnitude that the existing wetlands along the creek are adversely impacted.

4.2 Lake Lowry Option

4.2.1 Option 5: Controlled Outlet Lake Lowry

The implementation of this option is located outside of the old mined area and entails the construction of a controlled outlet on Lake Lowry (See Figure 4-5). Lake Lowry has a natural channel outlet elevation of about 131 feet NGVD on the south side of the lake. This option would place a slide gate outlet at the edge of the lake and adjacent to the natural outlet of Alligator Creek and set at an elevation of 128 feet NGVD. A 24-inch gravity-flow pipeline about 800 feet long would extend alongside Alligator Creek to intercept the channel downstream at an elevation below 128 feet. The natural channel of Alligator Creek would remain in its current state to handle flood flows.

Lake Lowry has an area of 1250 acres at an elevation of 131 feet, so the first foot of lowered level would produce about 1200 AF. Based upon the area-capacity curve for Lake Lowry by Robison (1992), three feet of lowering would produce about 3000 AF. In addition to the initial volume release from the water surface lowering, an additional steady flow from the lake would continue from reduced evaporation and leakage losses as well as groundwater seepage into the lake. After some designated time period for the release, the gate would be closed and the lake level would recover during the next rainy season. A detailed operational plan would need to be developed to govern the release conditions and length of time that the outlet would remain open. The estimated construction cost of this option is about $100,000.

The major constraint for this option is the current minimum levels set for this lake, including the minimum frequent low of 129.5 feet NGVD which has been set by the St. Johns River Water Management District. This level was set based upon previous low water levels recorded for Lake Lowry. Any operation to lower the lake level below the minimum frequent low of 129.5 feet would require a rule change by the district governing board. The permitting action for this option would require a detailed evaluation of the wetland vegetation and hydric soils around the lake perimeter to determine if there would be any adverse impact due to a low water elevation of 128 feet.

Following the last presentation of this option to the stakeholders, Price Robison of

SJRWMD was able to evaluate the option in a preliminary analysis with his previous surface water flow model of Alligator Creek. The preliminary results indicate that the option would be able to increase the time at which the waterlevel in Lake Brooklyn is at or above 100 feet NGVD to about 97% of the time over the long term. Currently, it is about 92% of the time. This option would have the effect of reducing the period of lowest water levels in Lake Brooklyn and increasing the range of fluctuation in Lake Lowry by lowering the low levels.

4.3 Floridan Aquifer Well

4.3.1 Option 6: Ground Water Augmentation

This option would entail the construction of an augmentation well drilled into the Floridan Aquifer which could be pumped directly into Lake Brooklyn or into Alligator Creek downstream of Treat Road. This option would provide the only source of continuous water supply for augmentation which would be free of rainfall variability. The well would need to be located to the north of Lake Brooklyn at a great enough distance from the lake so that the drawdown in the Floridan Aquifer caused by the well would not significantly increase the vertical leakage from Lake Brooklyn or the other nearby lakes. A well capacity of 1000 gpm would produce 4.4 AF per day or about 133 AF per month. The maximum well capacity from a single well is estimated at 2000 gpm, with consequent increased construction and operating costs.

The estimated construction cost for this option, based upon a 12-inch well and 1000 gpm pump and 8000 feet of 8-inch pipeline is about $350,000. Daily operating cost for electric power is estimated at $75 per day.

The major constraints for this option are obtaining a consumptive use permit from the water management district for installing and operating the well; and for identifying a responsible party for the operation of the well.

4.4 Option Evaluation Matrices

At the July 27, 2001 meeting with the stakeholders in Keystone Heights, it was suggested that an evaluation matrix be developed so that the relative merits of the individual options could be compared. The matrix below compares each option against six parameters. These are: the volume of water produced by the action; a ranking of the environmental concerns for implementation of the option; a ranking of possible permitting concerns for the option; ranking of the ease of construction and ease of operation for each option; and finally a ranking of the estimated cost per acre foot of water to be developed by the option.

4.4.1 Single Option Evaluations

Options 4 and 6 will deliver water by pipeline more directly to Lake Brooklyn than will the other four options, which will include flows downstream through the natural channel of

Alligator Creek and the intervening lakes. These flows in the creek will result in losses due to lake evaporation and channel seepage, but the amount of loss will depend upon the timing and duration of the releases. Adding water to the creek when there is continuous natural flow from Lake Lowry to Lake Brooklyn will result in the least loss of added water.

Table 4-1: Single Option Evaluation Matrix

Parameter/Option	1	2	3	4	5	6
Volume Produced	4	3	3	2	1	2
Environmental Concerns	1	1	1	1	2	2
Permitting Concerns	1	1	1	1	3	3
Construction Ease	1	2	3	4	1	2
Operating Ease	1	2	2	2	2	3
Cost per Acre Foot	3	3	2	4	1	3
Total	**11**	**12**	**12**	**14**	**10**	**15**

Notes: First row, 1 for most and 4 for least
Last five rows, 1 for least and 4 for most
"Total" Row, lowest number-highest ranking

The lowest total score in the matrix indicates the best option based upon the ranking parameters. The matrix indicates that Option 5, using a controlled outlet on Lake Lowry, is the best ranked, followed by Option 1, ditch cleaning inside of the berm.

4.4.2 Evaluation of Option Combinations

As discussed with the project stakeholders at the July 27, and September 29, 2001 meetings, an evaluation of several combinations of options was proposed for combinations of Options 1 and 5, Options 2 and 5, and Options 4 and 5. Since the operation of a controlled outlet on Lake Lowry (Option 5) would be an independent action, any addition of produced water in combination with Option 1 or 2 into Blue Pond would be additive to Option 5, therefore the estimated volumes and costs would be added to those of Option 5.

Option 4, the pipeline to Lake Brooklyn from the Southwest Lake in the mined area, would by-pass Lake Lowry and the combination of Options 4 and 5 would be two independent activities, although probably similar in time of the year. Therefore, the estimated costs and volumes for the two options would added. The combination of Options 4 and 5 would deliver more water to Lake Brooklyn because the pipeline from the Southwest Lake would reduce instream seepage and evaporative losses.

Table 4-2: Evaluation Matrix for Option Combinations

Parameter/Option	1 + 5	2 + 5	4 + 5
Volume Produced	3	2	1
Environmental Concerns	1	2	3
Permitting Concerns	1	1	2
Construction Ease	1	1	3
Operating Ease	1	2	2
Cost per Acre Foot	1	2	3
Total	**8**	**10**	**14**

Note: First row, 1 for most and 3 for least
Last five rows, 1 for least and 3 for most

Again, the lowest total score for the combined options indicates the best combination. This score indicates that the use of Option 5, a controlled outlet on Lake Lowry, along with Option 1, ditch cleaning within the mined area, provides the best combination of actions.

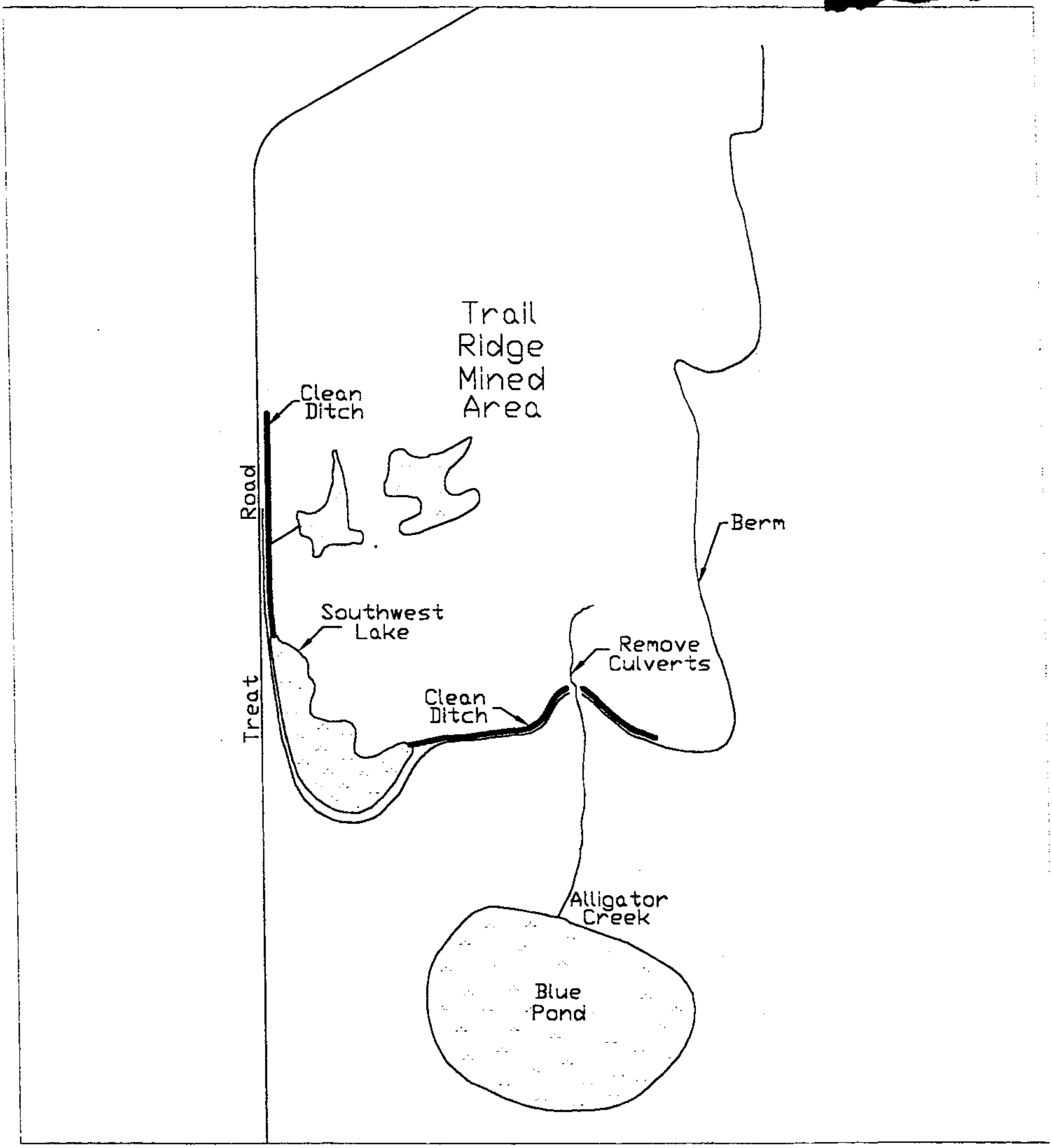


Figure 4-1: Trail Ridge Mined Area Option 1

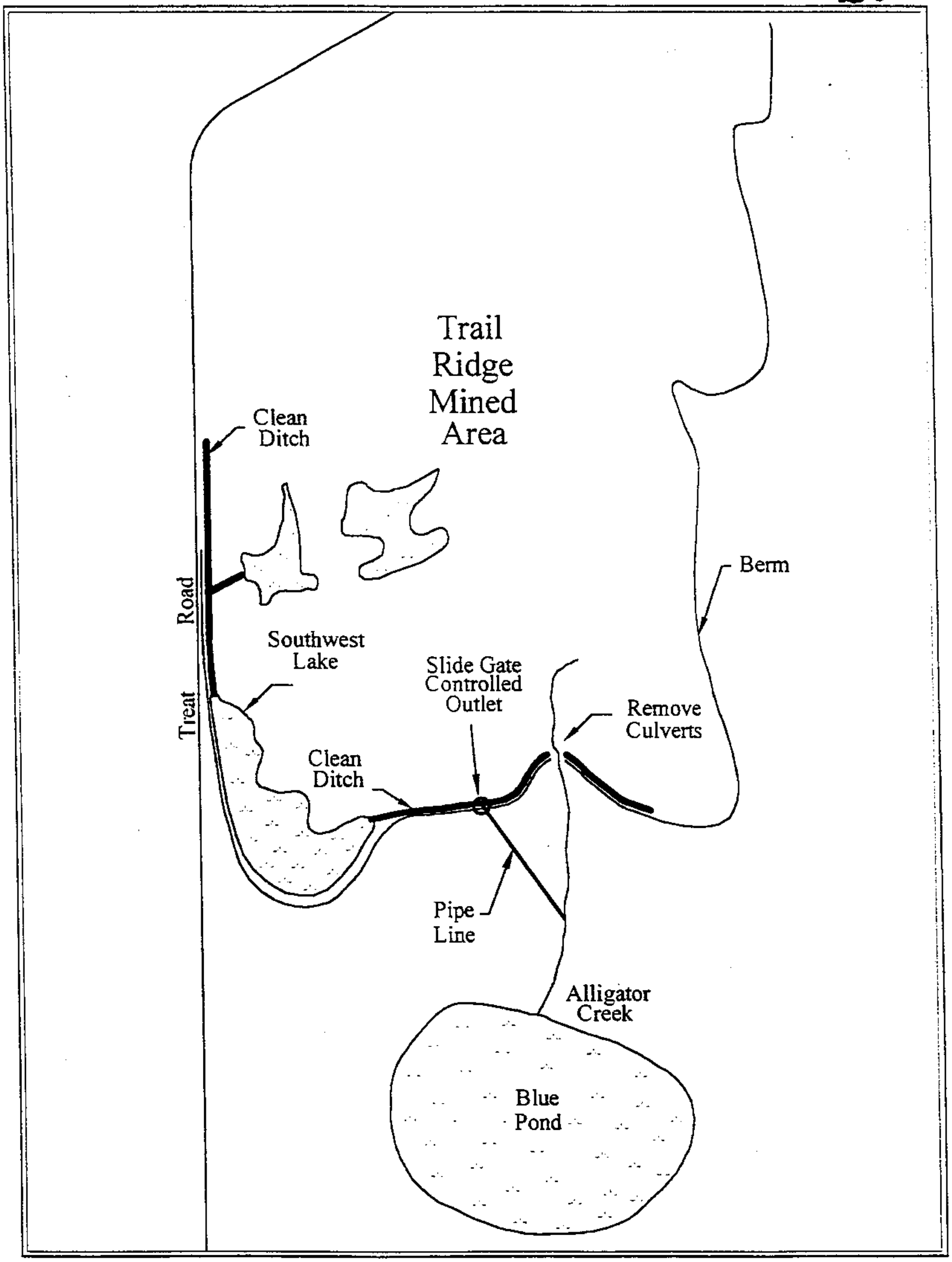


Figure 4-2: Trail Ridge Mined Area Option 2

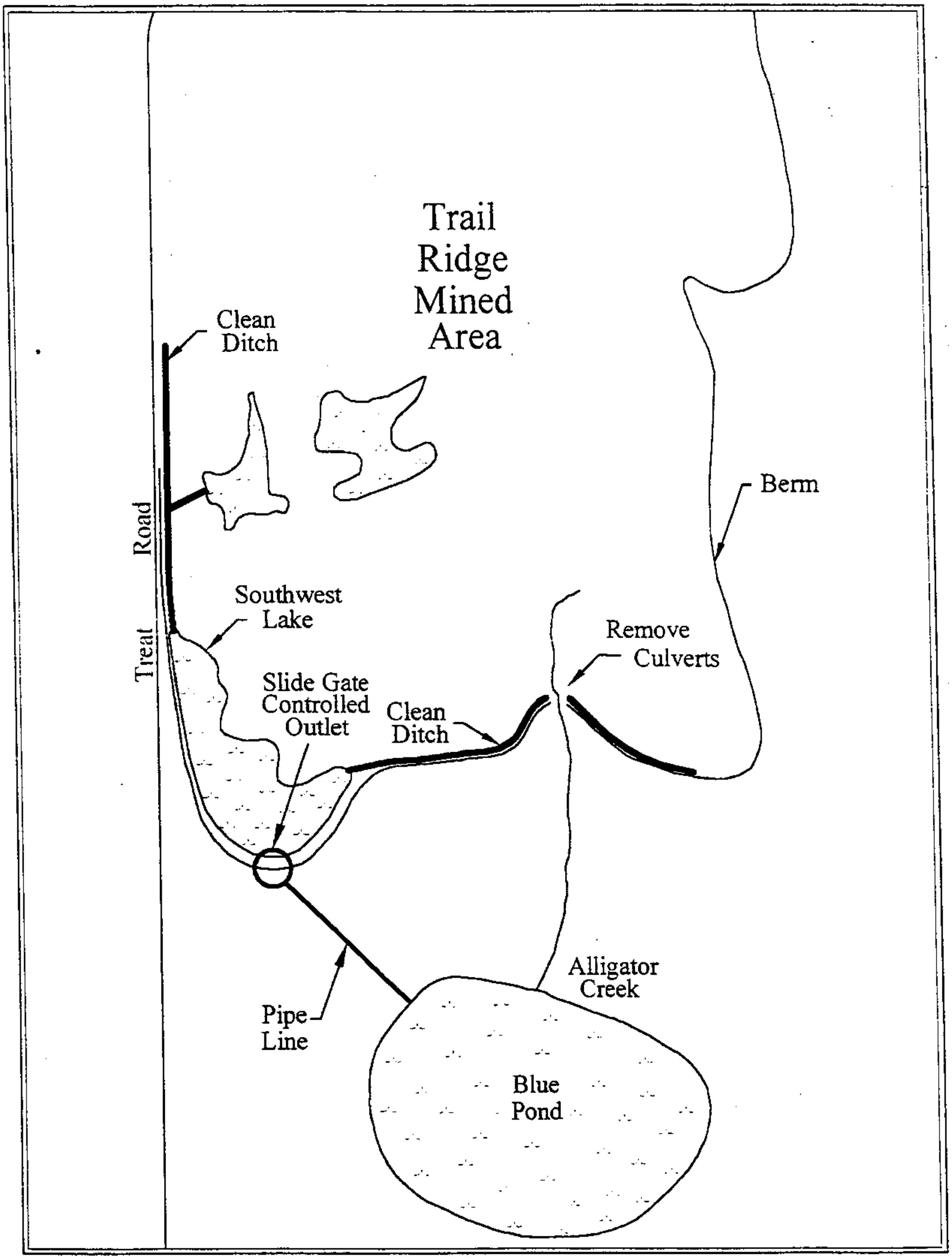


Figure 4-3: Trail Ridge Mined Area Option 3

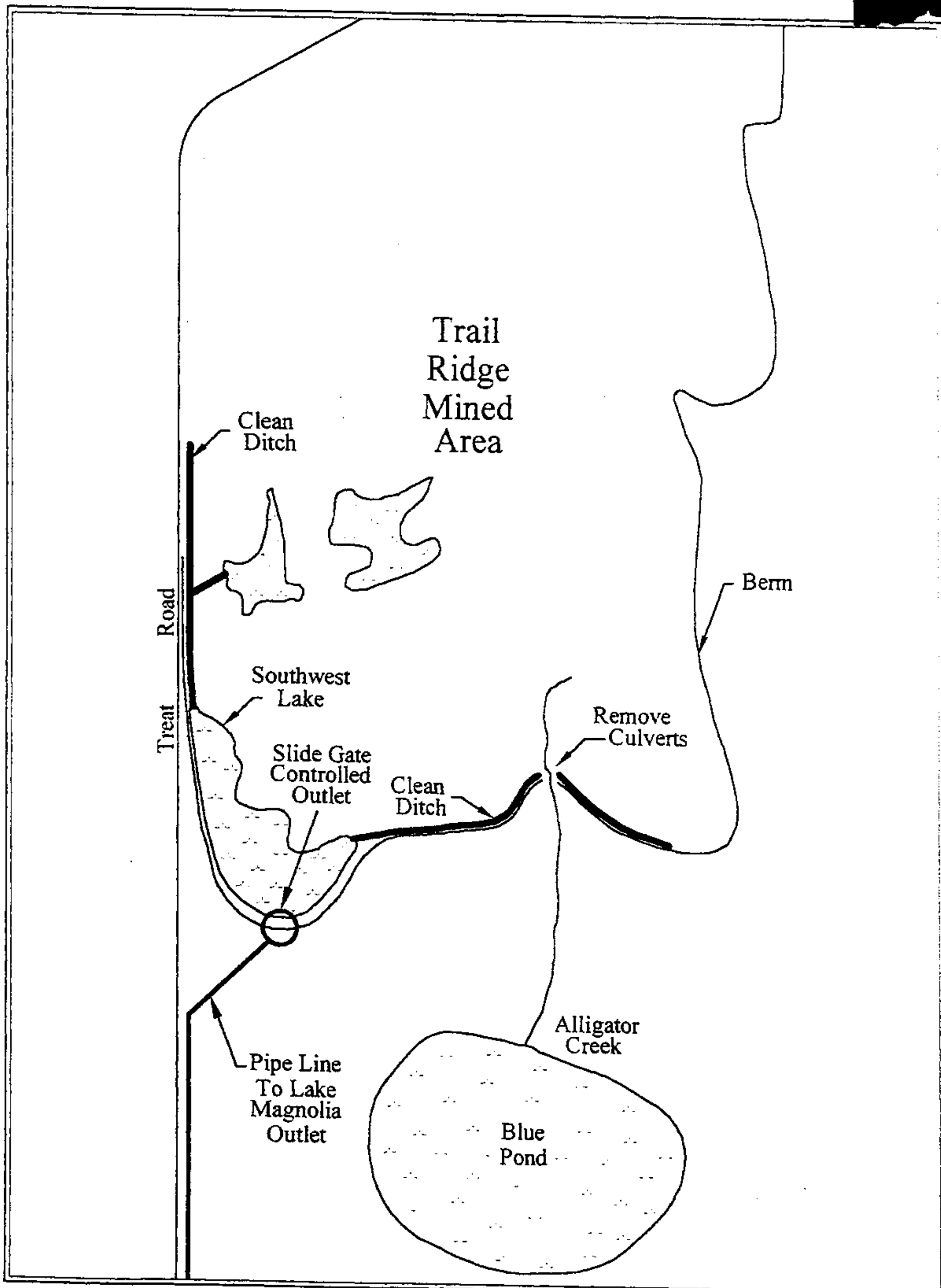


Figure 4-4: Trail Ridge Mined Area Option 4

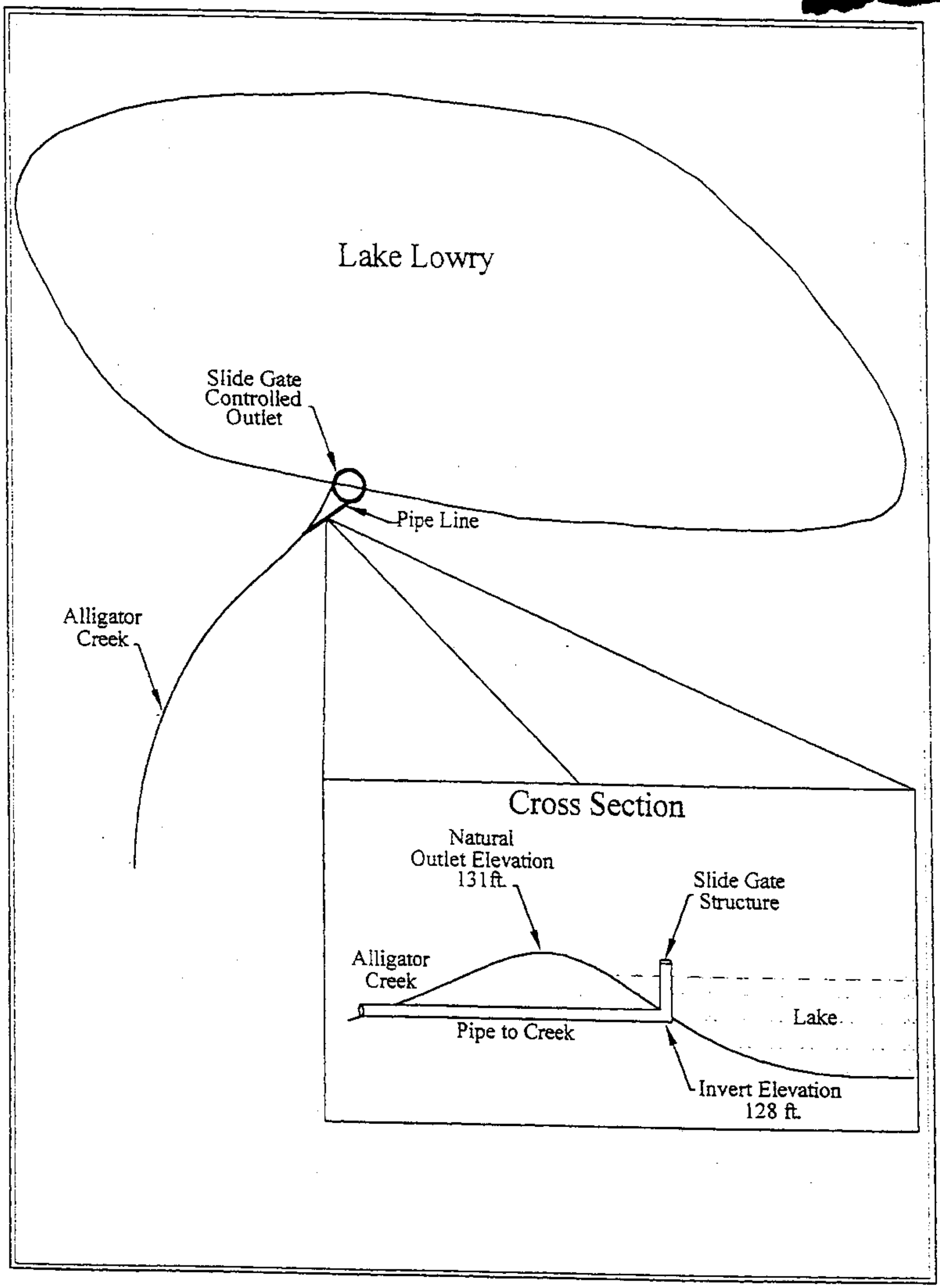


Figure 4-5: Lake Lowry Option 5

5.0 SUMMARY AND RECOMMENDATIONS

5.1 Summary

Lake Brooklyn is subject to wide variations in water level, over 27 feet in range, due to a very high leakage rate from the lake bottom to the underlying Floridan Aquifer. This problem has been evaluated by numerous investigations in the past 40 years. The general conclusion is that the variability is due to periods of below normal rainfall in the Keystone Heights area. While many of the local citizens believe that there has been some recent change in the relationship between rainfall and the lake levels, there is no "clear-cut" evidence of a specific cause for the perceived difference. Another specific concern expressed was that the old mined area on Trail Ridge was holding water which should have flowed southward through Alligator Creek to Lake Brooklyn. Evaluation of the pre-mining and post-mining conditions and the breaching of the berm around the mined area in 1992 indicates that there now is a greater area of the old mine connected to Alligator Creek than there was prior to mining. Therefore, more water can flow into Alligator Creek.

In the course of this study and in meetings with the stakeholders with interest in the project, the project team concluded that there are possible options to manage the hydrologic system of Alligator Creek and the chain of lakes in order to deliver more water downstream to Lakes Magnolia and Brooklyn. These options are based upon the harvest of water lost to evapo-transpiration in the old mined area at the upper end of Alligator Creek and the use of available water storage in Lake Lowry. Another possible option includes the installation of a well to pump water from the Floridan Aquifer to supplement the natural flow in Alligator Creek.

Technical evaluation and ranking of the individual options indicates that the use of Lake Lowry with a controlled outlet, which could lower the lake level by three feet, provides the best single action to aid Lakes Magnolia and Brooklyn. This option would essentially increase the fluctuation in Lake Lowry in order to reduce natural fluctuation in Lake Brooklyn. Preliminary analysis by SJRWMD staff with a surface water model of Alligator Creek indicated that the use of Lake Lowry to store and release water could maintain Lake Brooklyn levels above 100 feet about 97% of the time, compared to 92% under the current conditions.

Combinations of options for the old mined area were also presented to the stakeholders and considered in combination with the Lake Lowry option. The combination evaluation indicated the best two options were the cleaning of the ditches within the old mined area along with the use of Lake Lowry. This combined approach would harvest additional water from the mined area and utilize the available water storage capacity of Lake Lowry.

5.2 Recommendations

During the course of this investigation, the lack of hydrologic data about portions of the Lake Brooklyn watershed became apparent. It is recommended that an additional gaging station be established for the Alligator Creek streamflow from the mined area into Blue Pond. This station should be located far enough downstream that, if a pipeline is constructed for Option 2, the combined flow can be measured. It is also recommended that a rainfall gage be installed along with the streamflow gage, so that a better correlation can be determined between rainfall and water flows from the mined area. The estimated cost of a gaging station is about $7,500.

In order to further evaluate the possible yield from the old mined area for Options 2, 3, and 4, it is recommended that a pumping test be conducted from the Southwest Lake. The pump capacity should be greater than 2000 gpm and the test should be conducted for several months duration. The likely location for a pumping test would be from the Southwest Lake, near to Treat Road for easy access. A portable pump would be located on the berm with a floating intake in the lake. The pump discharge water would be measured by flow meter and conveyed by hose or temporary pipeline to the southeast to flow into Blue Pond.

During the test, water levels in the lake and at as many points as possible within the old mined area should be measured, so that the extent of water table lowering in the sand deposits can be mapped. The initial pumping rate needs to be large enough to readily lower the lake level by more than 4 or 5 feet. After the inital lowering, the pumping rate can be reduced to maintain a steady level in the lake. The pumping rate at the steady lake level will give a good approximation of the yield proposed by the options.

Augmentation Option 5 for the lowering of Lake Lowry should be further investigated to determine the detailed feasibility of the concept and to determine the range of operating parameters for implementation. The studies should include a detailed survey of the lake outlet and creek channel elevations downstream to determine the route and the length of a discharge pipeline for the option. Wetland vegetation surveys around the lake margin should be conducted to determine the hydrologic nature and water level requirements of the wetlands. Discussions with the SJRWMD should be included to consider amending the current minimum levels adopted for Lake Lowry by rule.

In order to assist in the development of an operational plan for the release of water in Alligator Creek, further analysis of the relationship between the recent rainfall data and lake levels should be conducted to better determine and predict water levels in Lakes Magnolia and Brooklyn. The use of one or more local rainfall stations in the Lake Brooklyn watershed would better predict near-term Lake Brooklyn water levels.

6.0 REFERENCES

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APPENDIX

Attendance Lists for Stakeholders Meetings

June 27, 2001 Meeting Keystone Heights City Hall

Robert Shultz	SJRWMD	Archie Green	City of Keystone Heights
Jon Samborski	DuPont	Brian Caldwell	DuPont
Paul Catlett	Camp Blanding	Brian Bishop	KHLAC
Jim Hayhurst	KHLAC	Karen Lake	LRCA
Dennis Barnhardt	LRCA	Bobby Ludwig	LRCA

July 27, 2001 Meeting Keystone Heights City Hall

Robert Shultz	SJRWMD	Greg Powell	Golder Associates
Jon Samborski	DuPont	Brian Caldwell	DuPont
Paul Catlett	Camp Blanding	Brian Bishop	KHLAC
Jim Hayhurst	KHLAC	Karen Lake	LRCA
Dennis Barnhardt	LRCA	Bobby Ludwig	LRCA
Glenn Lassiter	BCC	Merril Glisson	LRCA

September 25, 2001 Meeting Keystone Heights City Hall

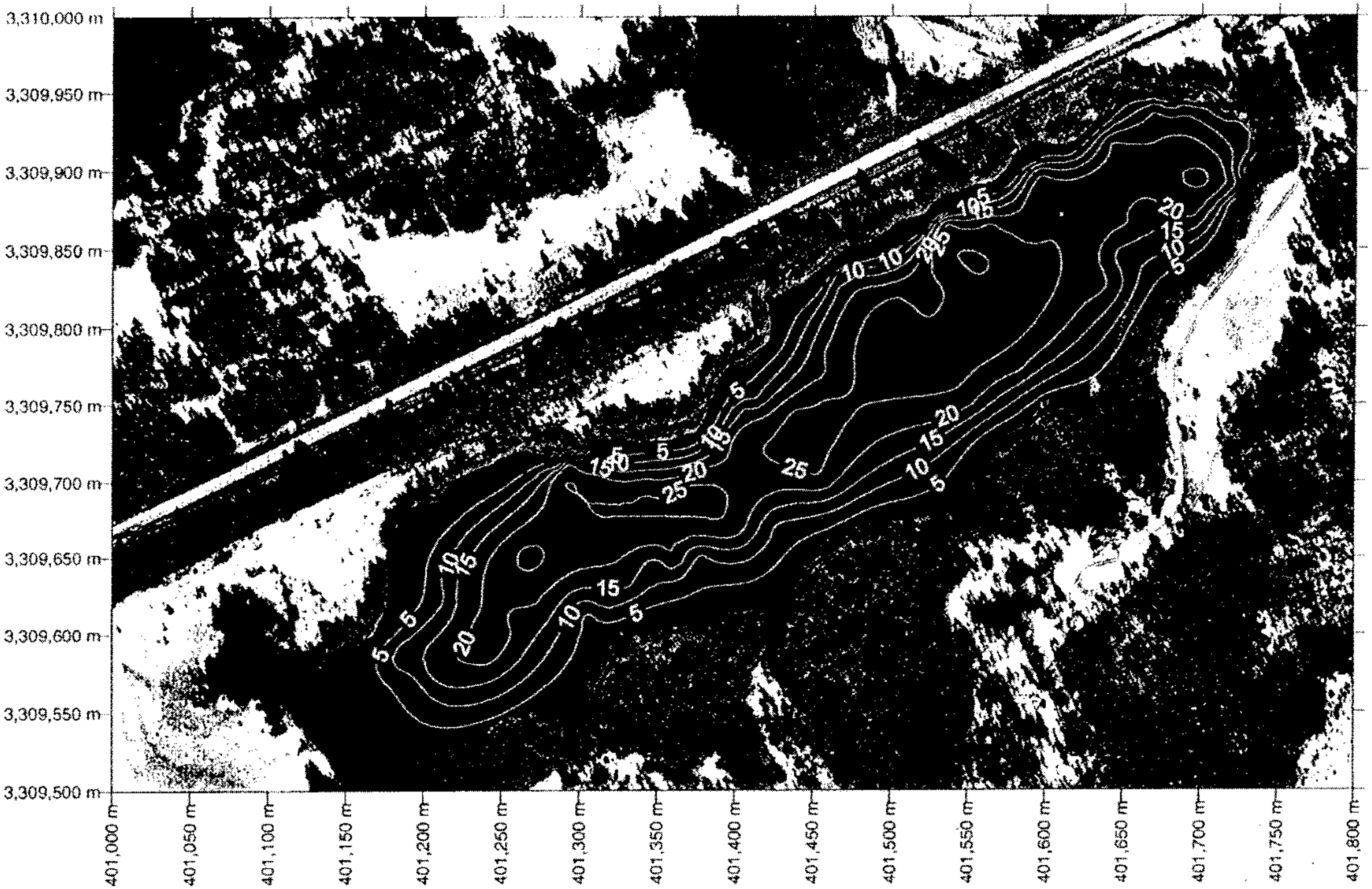
Hal Wilkening	SJRWMD	Stan Browning	SJRWMD
Robert Shultz	SJRWMD	Greg Powell	Golder Associates
Jon Samborski	DuPont	Brian Caldwell	DuPont
Paul Catlett	Camp Blanding	Glenn Lassiter	BCC
Jim Hayhurst	KHLAC	Karen Lake	LRCA
Dennis Barnhardt	LRCA	Bobby Ludwig	LRCA

December 19, 2001 Meeting Keystone Heights City Hall

Robert Shultz	SJRWMD	Glenn Lassiter	BCC
Jon Samborski	DuPont	Brian Caldwell	DuPont
Dennis Barnhardt	LRCA	Brian Bishop	KHLAC
Jim Hayhurst	KHLAC	Karen Lake	LRCA
Bobby Ludwig	LRCA		

Bathymetry of Long Pond

(per survey conducted by B. Caldwell & M. Corby on 5/30/01)



Pond Statistics
(per sounding on 5/30/01)

Volume = 415,054 cubic meters
336.2 acre-feet
109,645,645 gallons

Scale:

0 m 100 m 200 m 300 m

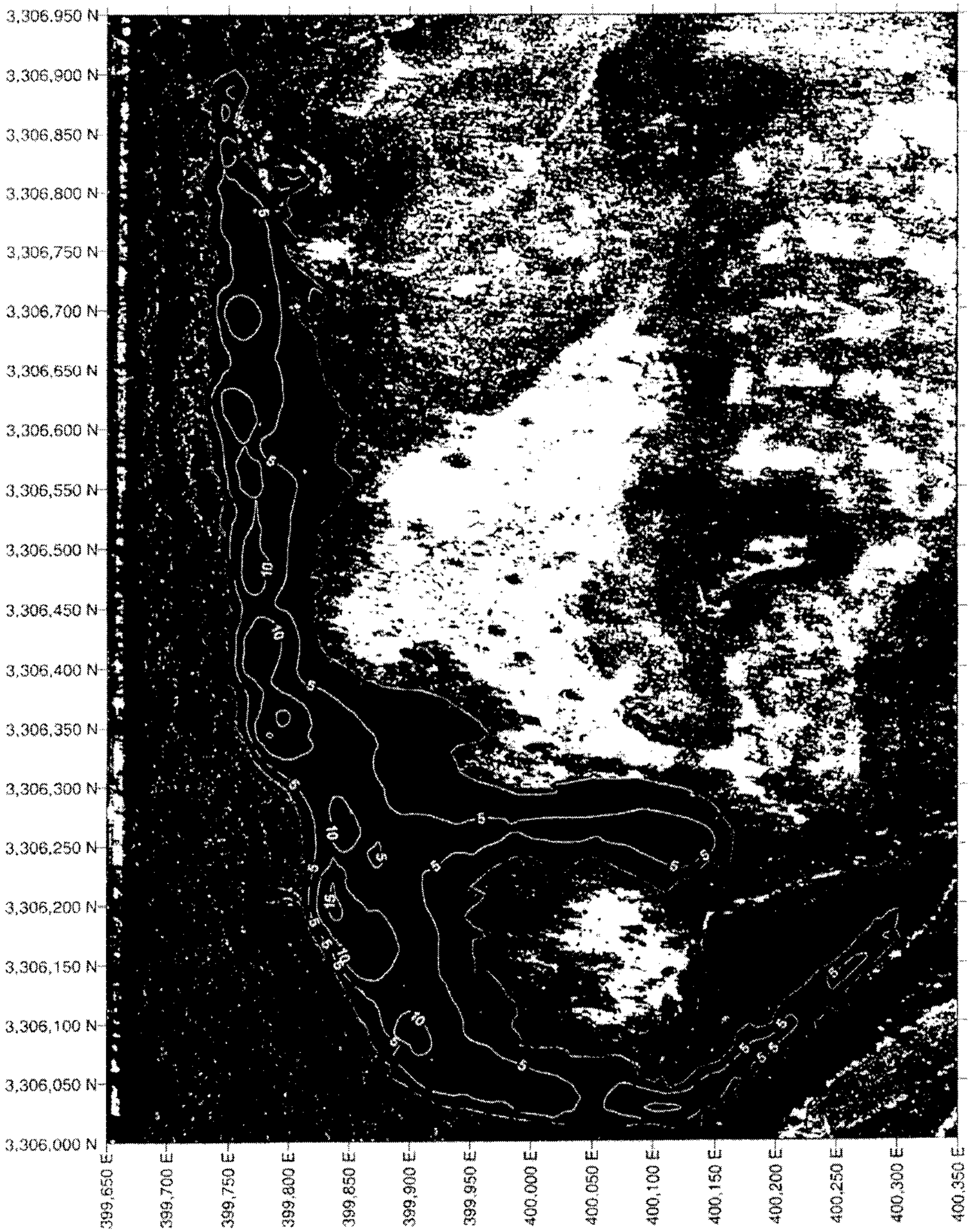
* Aerial Photo from February 2000
** Coordinate axes reference UTM grid, NAD 27 Datum, units in meters.
*** Depth contours are in feet.

N

DUPONT ®

Diagram by: Matt Lewis
Date: 5/31/01
File: Lake Survey.srf

Bathymetry of Southwest Quadrant Pond



Scale:

0 m 100 m 200 m 300 m

N

Pond Statistics
(per sounding on 8/24/01)

Volume = 192,070 cubic meters
155.57 acre-feet
50,739,516 gallons

* Aerial Photo from August 2001
** Coordinate axes reference UTM grid, NAD 27 Datum, units in meters.
*** Depth contours are in feet.

DUPONT

Diagram by: Matt Lewis
Date: 8/31/01
File: SW-Quad Lake.srf