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March 14, 2017

Mr. David Billings, P.E.
Frankfort Plant Board
317 West Second Street
P.O. Box 308
Frankfort, KY 40602

Re: Review of Reservoir Site Alternatives Evaluation

Dear Mr. Billings:

Attached is the final Review of Reservoir Site Alternatives Evaluation.

Please call me with questions.

Sincerely,

STRAND ASSOCIATES, INC.®

Adam D. Weber, P.E.

Attachment: Report

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Report for

Frankfort Plant Board, Kentucky

Review of Reservoir Site Alternatives Evaluation

STATE OF KENTUCKY
ADAM D.
WEBER
25057
LICENSED
PROFESSIONAL ENGINEER
3/14/17

Prepared by:

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March 2017

STRAND ASSOCIATES®

INTRODUCTION

Strand Associates, Inc. (Strand) was retained by the Frankfort Plant Board (FPB) to review FPB water staff's evaluation of alternative sites considered for the reservoir replacement project. It is understood that this review is to be conducted from a purely engineering perspective with consideration to cost and other related technical considerations for implementation and operation. The FPB water staff's evaluation included an assessment of current and future water demands and trends, in addition to potential changes in the future energy rate structure, to inform tank sizing needs. Staff also evaluated basic types of water storage structures available to meet the capacity requirements and identified three site alternatives for potential relocation of the existing reservoir facility. These site evaluations included development of planning level cost opinions for additional infrastructure that would be required to relocate the existing reservoir. Strand was engaged for this effort because of our nearly 10-year history with the existing reservoir and our current ongoing services with FPB for its replacement. This review was focused primarily on the information provided by staff who are highly familiar with existing system conditions and operational concerns. As such the approach for this review did not include a technical evaluation of the existing water system or the necessary water system improvements to facilitate relocation of the existing reservoir for the alternatives under consideration.

BACKGROUND

Strand was initially hired by FPB in December 2007 to perform a preliminary visual condition assessment of the existing reservoir in preparation for a more detailed structural and lining system alternatives evaluation. The more detailed structural and liner evaluation concluded with submission of the *North Basin Reservoir Structural Evaluation and Liner Recommendation* report, dated March 2009. This report included a structural evaluation of the existing ring wall and roof structure and analysis of reservoir lining systems with an opinion of probable construction cost. The report also included an assessment of anticipated service life expectancies for the anticipated repairs and liners that were evaluated. The findings of this evaluation ultimately led to FPB's decision to replace the existing reservoir, since the replacement option was found to be more cost-effective and provided a longer anticipated service life than repairing and lining the existing structure.

In 2009, Strand initiated design services for a ground storage tank system to replace the existing reservoir. However, due to the deteriorating condition and sensitivity with operation of the existing Headend Building, the reservoir replacement project was placed on hold. This was due in large part to concerns that construction related activities, such as rock removal, could adversely affect the performance of the aging equipment contained in the Headend Building, which was located adjacent to the existing reservoir. As a result of this delay, Strand was then engaged to perform a subsequent condition assessment of the existing reservoir, followed by temporary structural repair design services and construction-related services to monitor completion of the repair plan. As an added measure, FPB also engaged Strand to conduct yearly monitoring of the structure and the repairs. This interim approach was implemented by FPB as a means to extend the useful service life of the reservoir until it can ultimately be replaced. The Headend Building and equipment on the reservoir site have now been upgraded and FPB is prepared to move forward with the reservoir replacement strategy as previously determined.

INFORMATION PROVIDED BY FPB WATER STAFF

As a result of the reservoir replacement project delays, FPB water staff was given the opportunity to more thoroughly evaluate its water storage capacity requirements. This has included consideration of potential alternative locations for the reservoir replacement to help inform the FPB Board of Directors and public on the rationale for the proposed replacement plan. Strand's previous history with the project and the information developed through FPB water staff's subsequent evaluation of siting alternatives provides the foundation for this review. The information provided included:

1. *Review of Frankfort Water Strategic Planning and Recommended Energy Assessment Considerations*, by Don Casada, Diagnostic Solutions, LLC, December 11, 2009.

2. Water usage data documenting the last 20 years of high service pumpage from the water treatment plant.

3. "FPB Reservoir Discussion" presentation given to the Board and public by David Billings, P.E., FPB Chief Water Engineer.

4. AutoCAD file depicting the FPB water system including alternate tank site locations and associated infrastructure improvements.

5. FPB staff opinions of probable construction costs to relocate the reservoir to three alternate locations.

TANK SIZING AND STORAGE OPTIONS

According to FPB water staff, the current distribution system includes three pressure zones and relies on six water storage facilities with a total combined capacity of 15.8 million gallons (MG). The existing reservoir accounts for 9.2 MG of this available storage capacity, or approximately 60% of the total system capacity. Replacement of the existing reservoir with a single 7 MG tank will reduce the total available storage to 13.6 MG.

A. Water Usage

Historic water usage is one of the primary factors in evaluating a water system's storage needs. FPB water staff routinely monitors and records how much water is pumped by the high service pumps at the water treatment plant on a daily basis. FPB water staff has compiled this information from the last 20 years to help predict future water demand needs and system capacity requirements. The information was then plotted on a graph to develop trend lines representing the daily demand and peak daily demands. To help balance out anomalies in the data, a running two-day average was used as the basis for developing average daily demand and average peak demand. Based on the graph, Figure 1, the current average daily demand is approximately 8 MG and the current average peak daily demand is approximately 11.5 MG, which are both within the proposed system storage capacity of 13.6 MG.

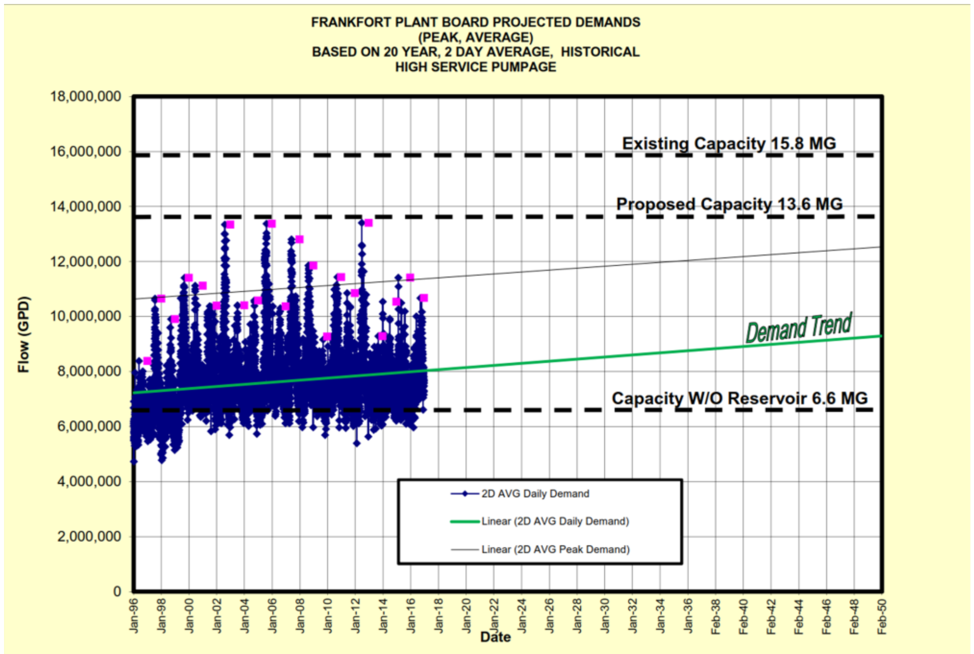


Figure 1 FPB 20 Year Water Usage and Projected Demands

According to the information provided and FPB's 2016-2017 Budget and Financial Plan, water demands have decreased approximately 1 percent per year over the last several years because of customer conservation efforts, more efficient appliances, and high sewer rates that are linked to water usage. Based on these findings, we concur with the FPB water staff recommendation to replace the existing reservoir with a single 7 MG tank to meet current daily and peak demands. We also concur with the FPB water staff recommendation to plan for a future 7 MG tank to proactively address unforeseen changes in demand that may occur, such as economic growth.

B. Energy Assessment Considerations

Diagnostic Solutions, LLC (Diagnostic Solutions) was hired by FPB in 2009 to provide a high level review of planned and potential FPB water system operations with a focus on identifying means to reduce future overall energy costs associated with the operation of the FPB water system. The current energy billing structure for the water department includes fixed rate energy and demand components. However, in many areas across the country where the electrical infrastructure is strained, electric rates for both energy and demand components for larger customers are adjusted according to time of use. These rate structures vary from place to place and it is impossible to predict exactly when or what rate structure could be implemented for the Frankfort area.

According to the report from Diagnostic Solutions, implementing water system operational flexibility could reduce net energy costs today and also better position FPB in the future should the energy rate structure change. Operational flexibility can be improved in several ways, such as demand management and monitoring, switching to adjustable speed drives and low voltage motors for the raw water and high service pumps, and increasing water system storage capacity, to name a few.

Because of the uncertainty of potential changes in the energy rate structure, planning for additional future system storage capacity as part of a currently planned project merits consideration. This is the basis for

FPB water staff's recommendation to replace the existing reservoir with a single 7 MG tank now and allow space for a second 7 MG tank in the future should the need arise. According to FPB water staff, the existing reservoir site represents the most cost-effective solution for providing this magnitude of additional storage capacity in their entire service area, mainly because they already occupy the property and the necessary infrastructure is already in place. We concur with this recommendation based on the information provided. See Appendix A for a copy of the Diagnostic Solutions Report.

C. Tank Options

The two basic types of water storage facilities are elevated water tanks and ground storage reservoirs, which are deployed based on their elevation and relationship to the area served and required capacity in meeting system needs. Elevated water storage tanks (see Figure 2) typically have a maximum capacity of 3 MG and have a higher cost per unit volume when compared to ground storage facilities. Elevated water storage tanks are not a suitable replacement approach for the reservoir because of the existing site and water system constraints and also due to limitations with capacity that do not meet FPB's storage volume requirements.

Figure 2 Elevated Water Storage Tank

FPB's existing reservoir is classified as a ground storage facility. In this case, a suitable replacement would also be a ground storage reservoir (see Figure 3) designed to fit in with the existing site and other water system design constraints that meets the necessary storage volume requirements. Prestressed concrete ground storage tanks have developed a reputation for cost-effectiveness in applications as anticipated for the existing reservoir site. These tanks can be fitted with both flat and domed-roof systems based on customer preference and need. The prestressed concrete domed-roof tank also represents the lowest cost per unit volume when compared to other comparable water storage tanks. Prestressed concrete flat-roofed tanks are another potential option; however, a flat-roofed tank adds significant cost because it requires interior columns and foundations to support the roof system. The cost of a flat-roofed tank is typically 50 percent more than the same tank with a domed roof and normally requires greater maintenance because of the columns and the potential for leakage in these areas. Based on these considerations, we concur with the FPB water staff's recommendation to replace the existing reservoir with a prestressed concrete domed-roof tank for the reasons previously mentioned.

Figure 3 Ground Storage Reservoir

TANK SITE ALTERNATIVES

Through the FPB water staff's due diligence to evaluate potential alternatives for the reservoir replacement, three alternate tank locations were identified that meet the current site and water system design constraints. The primary considerations used in selecting alternate sites included available space in undeveloped areas and elevation of the site, which requires an approximate ground elevation of 780 feet above mean sea level (msl). The additional locations identified by FPB water staff's comparative evaluation included sites at Berry Hill/Golf Course Area, behind Franklin Square, and next to the AT&T tower off of Sower Boulevard. Refer to Appendix B for enlarged site exhibits.

A. Existing Site

By virtue of its continuous operation since 1885, the existing reservoir site is the basis for comparison to all the other sites under review. The existing site meets the elevation requirements and no major infrastructure improvements, such as transmission, distribution or pumping, are necessary to accommodate the reservoir replacement. However, there is some flexibility in which side of the existing reservoir should be replaced first, though there are construction cost implications involved in this decision.

1. Option 1–South Basin Replacement First

Replacement of the south basin first represents the most cost-effective solution and is the basis of comparison to the other alternatives. For preliminary design, the south basin was chosen for replacement first because the existing south basin of the reservoir has experienced the most deterioration and has subsequently had the most repairs completed since 2009. The most recent repairs include the 2011 slippage repair of the south basin exterior slope, the 2013 interim repairs, and the 2015 seepage repair through the south basin exterior slope. Replacement of the south basin also more centrally locates both proposed tanks within the site and facilitates more flexibility in the future placement of the north tank, which could be as close as 20 feet from the south tank. This flexibility in the future north tank placement will reduce encroachment upon the Tanglewood Neighborhood to the northeast of the site and could provide up to approximately 120 feet of buffer from the future north tank to the northeastern property line. Refer to Figure 4 for a planning level rendering of the existing reservoir site depicting the approximate proposed and future tank locations based on replacement of the south basin first. The planning level rendering is based on a clear distance

Figure 4 Existing Site Rendering, Tank Locations with South Basin Replacement First

between tanks of 65 feet, which provides a buffer of approximately 80 feet from the northeastern property line. This option also brings other intangible benefits with constructability and reliability of operation with the north basin while construction is ongoing.

2. Option 2–North Basin Replacement First

Replacement of the north basin first adds some additional risk and additional cost when compared to replacement of the south basin first. During construction, it is necessary to keep one basin of the existing reservoir in service because the reservoir is the central hub of the water distribution system and the available storage is needed to meet demands. Because of this and the construction constraints, the edge of the proposed tank will be approximately 30 feet from the northeastern property line. This remaining space adjacent to the northeast property line needs to accommodate an access road to the existing pump house located behind the reservoir. The proximity to the property line will also require a temporary soil retention system because of the 15-foot construction buffer and depth of the proposed tank. Further complications result from the planned decorative property line fence and the existing overhead and buried electric and fiber-optic lines within this area. The proposed tank construction will likely require relocation of these utility lines within the remaining narrow strip of available space less than 10 feet wide, which will further increase cost and could result in some planned electric and data outages. Since the south basin of the reservoir will remain in service during construction, there will be some additional risk involved because the south basin has experienced more deterioration and received more repairs than the north basin as previously discussed. Refer to Figure 5 for a planning level rendering of the existing reservoir site depicting the approximate proposed and future tank locations based on replacement of the north basin first.

Figure 5 Existing Site Rendering, Tank Locations with North Basin Replacement First

B. <u>Berry Hill/Golf Course Area</u>

The nearest alternative site location evaluated by FPB water staff is the Berry Hill/Golf Course Area, which is northwest of the existing reservoir site and across Louisville Road (US 60). The approximate location of the tanks would be just south of the tennis courts, which would locate the tanks between the medical office buildings on Leawood Drive and the Juniper Hill Aquatic Center (See Figure 6). It would also require removal of an existing playground and take up public space within Juniper Hill Park. This location was chosen because it is relatively close to the existing reservoir and infrastructure, it is relatively undeveloped land, and it has the necessary elevation to accommodate the existing water distribution system. The primary benefit of this location when compared to the other alternative site locations is its proximity to the existing reservoir and ability to use the existing Hahn Pump Station, which reduces the anticipated costs. However, approximately 2,100 linear feet (LF) of 36-inch water main and a major highway crossing is necessary to facilitate relocation to this site, resulting in increased construction costs. Relocating the tanks to a new public space such as Juniper Hill Park is another likely major drawback for this alternative. Furthermore, a request from the FPB to relocate the reservoir to this site alternative has been unanimously denied by the City of Frankfort Parks, Recreation, and Historic Sites Department in a letter dated January 12, 2017. A copy of this letter is included in Appendix C.

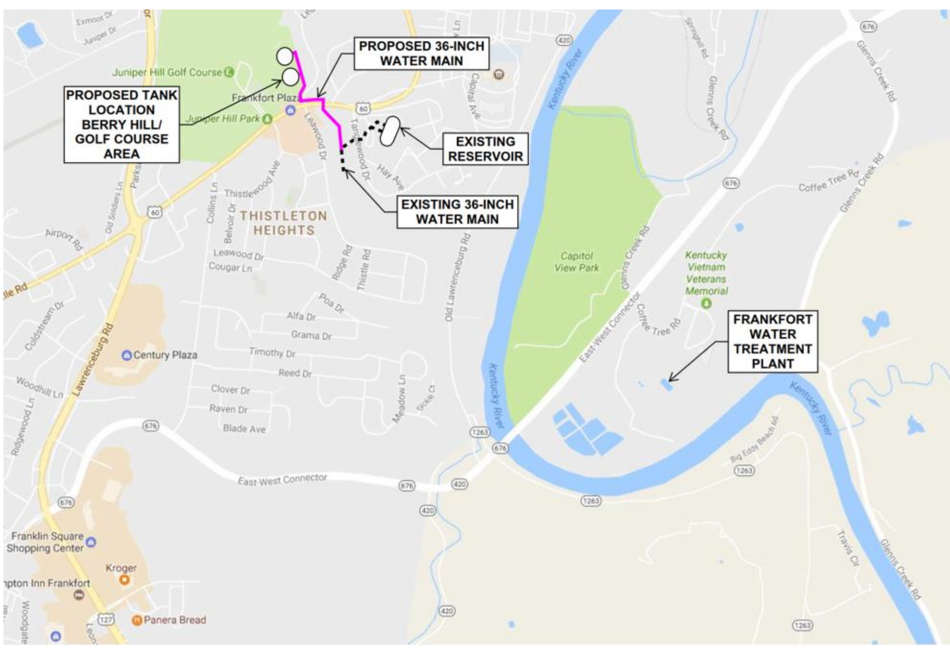


Figure 6 Berry Hill/Golf Course Area Site Location

C. Behind Franklin Square

The second alternative site location evaluated by FPB water staff is the Franklin Square location, which places the tanks northeast of Franklin Square and just south of the East-West Connector in an undeveloped wooded area (See Figure 7). This location was chosen because it is undeveloped land and it has the necessary ground elevation for ground storage to accommodate the existing water distribution system. However, the major drawback for this alternative includes substantial infrastructure improvements, such as relocation of the Hahn Pump Station, construction of approximately 8,400 LF of 36-inch and 6,100 LF of 20-inch water main, a Kentucky River crossing, and two major highway crossings. All these improvements result in significant design and construction costs.

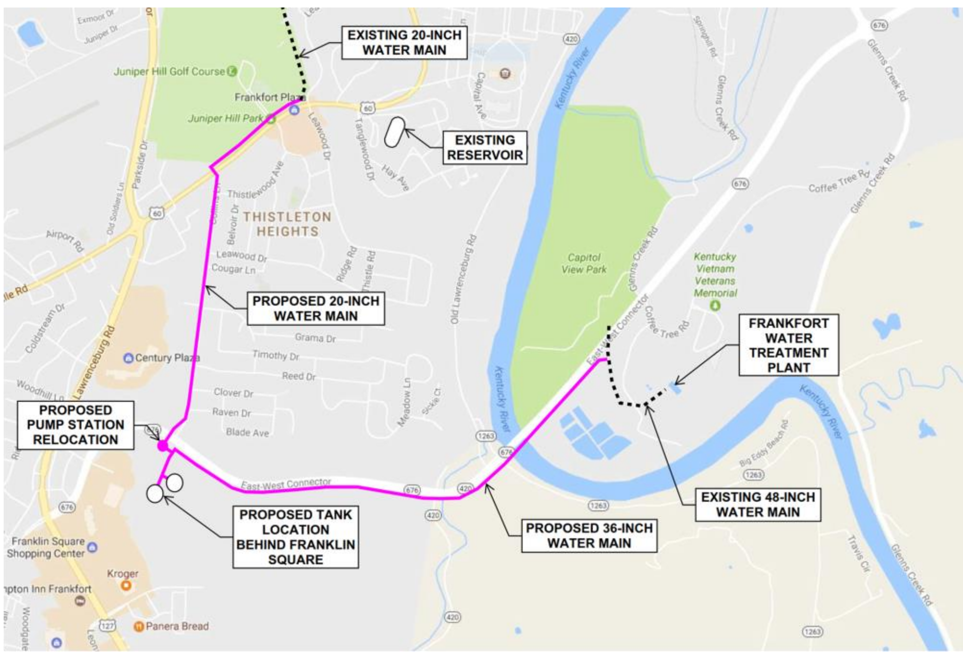


Figure 7 Franklin Square Location

D. Next to AT&T Tower Site off Sower Boulevard

The final alternative site location is next to the AT&T Tower site off Sower Boulevard and to the east of Glenns Creek Road (See Figure 8). This site is also undeveloped and has the necessary ground elevation similar to the Franklin Square alternative site location. Much like the Franklin Square alternative, this site alternative has the major drawback of significant infrastructure improvements and associated design and construction costs. The infrastructure improvements include relocation of the Hahn Pump Station, construction of approximately 7,000 LF of 36-inch and 2,800 LF of 20-inch water main, and one major highway crossing.

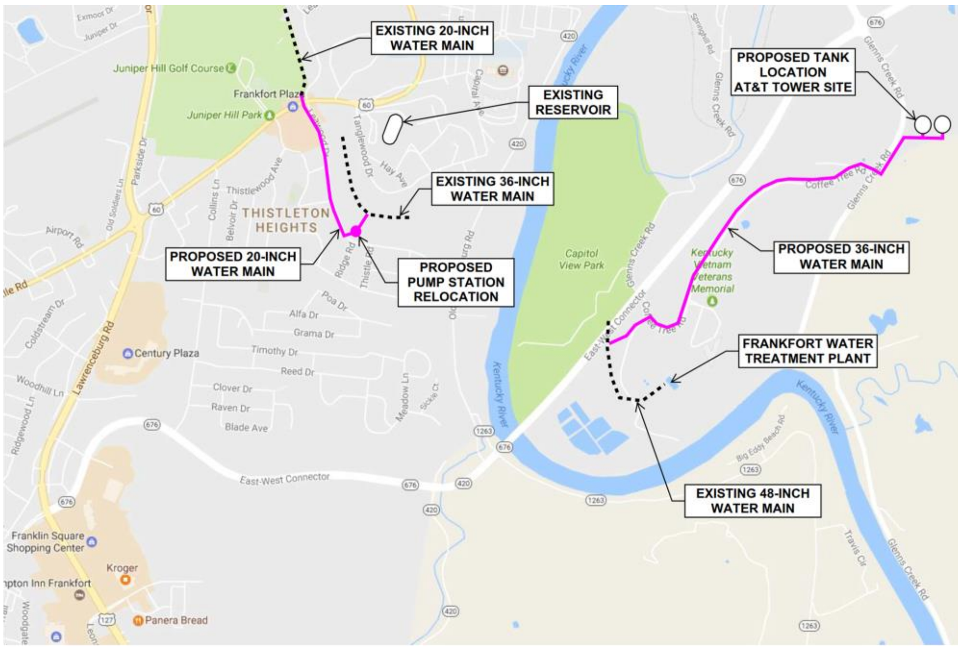


Figure 8 AT&T Tower Site Location

COST ASSESSMENT

One of the primary considerations in performing a planning level evaluation of project alternatives is a comparison of costs. A project's capital cost generally has the largest impact on ratepayers and can generally eliminate some otherwise feasible alternatives because of funding constraints. The FPB water staff developed a planning level cost evaluation of the three alternative site locations that were studied through the course of this review. It should be noted; however, that planning level cost evaluations normally only consider the larger, big dollar items such as major piping, pump stations, property acquisition, site preparation, and access roadway construction while including a contingency to account for lower value cost items. As such, Strand's review is based on the assumption that the standard cost contingency applied to each site alternative will normalize the cost basis for purposes of this review.

A. Current Budget

The current budget to replace the existing south basin with a single 7 MG prestressed concrete tank and associated piping, demolition of the north basin of the reservoir, basic aesthetic enhancements, and restoration of the site including basic landscaping is $4,000,000. This budget was established based on a preliminary construction cost evaluation performed by Strand in 2011 as part of our preliminary design services for replacement of existing reservoir. The estimated cost represents the investment required to replace the existing storage in the current location and maintain the current level of service to existing customers. All costs identified with the other site alternatives are in addition to this base budget amount. The costs for the other site alternatives only include additional expenditures required for transmission, pumping, and distribution improvements that are necessary for complete system integration. In other words, none of the extra costs associated with the site alternatives are presently anticipated with the existing reservoir site replacement approach and would likely require additional borrowing and a larger rate increase to all ratepayers.

B. Summary of Alternatives

Table 1 summarizes FPB water staff's estimated costs for site alternatives including engineering design, property acquisition, and construction. Where pertinent, these costs include additional requirements for other water system improvements in addition to the previously established budget to replace the south basin of the reservoir at the existing site. It is also important to note that these costs do not take into account any additional costs for further rehabilitation of the existing reservoir for potential future project delays resulting from changing the site location and the additional time needed for project development. Strand concurs with the opinions of probable construction cost provided by the FPB water staff and further agrees they were prepared in a manner consistent with typical planning-level industry standards. See Appendix D for FPB water staff's detailed opinion of probable construction costs.

Site Alternative	Reservoir Replacement[1]	Additional Required Water System Improvements[2]	Total Estimated Cost
South Basin Replacement First	$4,000,000	$0	$4,000,000
North Basin Replacement First	$4,000,000	$500,000	$4,500,000
Berry Hill/Golf Course Area	$4,000,000	$2,000,000	$6,000,000[3]
Behind Franklin Square	$4,000,000	$10,500,000	$14,500,000[3]
Next to AT&T Tower Site	$4,000,000	$7,100,000	$11,100,000[3]

[1]Estimated budget to construct a single 7MG tank and associated piping, demolition of existing reservoir, basic aesthetic enhancements and landscaping, and site restoration.
[2]Additional capital investments for site alternatives such as temporary soil retention systems, access road, and utlility relocations or property acquisitions, engineering design and construction of additional transmission, pumping, and distribution facilities.
[3]Does not consider other site-specific contingencies for site alternatives, such as geotechnical requirements.

Table 1 Tank Site Alternatives Estimated Project Costs

FINDINGS AND RECOMMENDATIONS

Based on our review of the information provided by the FPB water staff, each of the three site alternatives will require significant water system related improvements to integrate the proposed reservoir storage facilities at their respective locations. These additional improvements result in a substantial increase in total initial capital cost and will also necessitate additional operational and maintenance cost going forward. The least of these alternatives is the Berry Hill/Golf Course site, which requires an additional $2,000,000 in capital investment. However, the Berry Hill/Golf Course site is not currently considered a viable alternative since the FPB's request to move the reservoir to this location was unanimously denied by the City of Frankfort Parks, Recreation, and Historic Sites Department. The two remaining alternative sites, behind Franklin Square and next to the AT&T tower, respectfully require $10,500,000 and $7,100,000 in additional system improvements for transmission, pumping, and distribution system upgrades. These costs do not include the additionally required tank and site improvements, far exceeding the budgeted $4,000,000 investment required to replace the existing reservoir at its current site. Based on its overall cost-effectiveness and the following additional considerations, we concur with the FPB water staff's recommendation to replace the reservoir on the existing site.

1. The current reservoir site is the central hub of the existing water supply system and has served Frankfort well for over 130 years.

2. Replacement at this location provides for seamless system integration and does not require implementation of additional transmission, pumping, or distribution facilities.

3. Existing site grading conditions promote opportunities for partial burial of the proposed tanks reducing the overall visual impacts to adjacent areas.

4. The available footprint at the existing site is suitable for construction of two 7 MG tanks, which meets the current needs of the community while allowing for future storage expansion to address longer-term needs.

5. The existing site reduces initial required capital cost investment by eliminating the need for additional site acquisition and engineering design and construction of additionally required infrastructure improvements.

6. The existing site is located in a well-established area that helps minimize risks for security and safety of the facility in its capacity as a potable water supply source for the public.

7. This alternative affords the most cost-effective implementation approach.

Replacement of the reservoir at the existing site also includes an option to construct either the north or the south tank first, leaving the other tank to be constructed in the future if needs may require. From an engineering and operations standpoint, there are several factors that suggest the south basin of the existing reservoir be replaced first. Based on the following considerations, we concur with FPB water staff's recommendation that the south basin of the reservoir be replaced first:

1. Reduced risk in meeting water supply needs during construction because of the more advanced deteriorated condition of the south basin of the existing reservoir.

2. South Basin First sequencing approach results in a more centralized location of the ultimate dual tank configuration within the project site upon implementation.

3. Decreases required encroachment of the future north tank toward the neighborhood to the northeast.

4. Minimizes conflicts with existing utilities and the likelihood of costly utility relocations.

5. Improved constructability through elimination of costly requirements for temporary soil retention systems.

6. This approach results in the least total initial capital cost investment sequencing solution for implementation.

In addition to these findings, we also concur with staff's recommendation for utilization of a domed-roof system for implementation of the proposed prestressed ground storage tank. The domed-roof system will significantly reduce initial capital investment and provide additional benefits with cost savings with long-term maintenance as compared to the flat-roofed tank and the necessary roof support system, which would add approximately $1,080,000 in initial capital investment for the proposed 185-foot-diameter tank. Savings from a domed-roof system approach could also be reinvested in the project for aesthetic enhancement of the proposed tank and improved landscaping of the site.

APPENDIX A
ENERGY ASSESSMENT

Review of Frankfort Water Strategic Planning
and Recommended Energy Assessment Considerations
by: Don Casada, Diagnostic Solutions, LLC
December 31, 2009

Scope

Diagnostic Solutions was requested to:

a) provide a high level review of the planned and potential Frankfort Plant Board Water system operation in the context of minimizing energy costs and
b) recommend a general scope and methodology for conducting an energy cost reduction opportunity assessment.

High level review

This review was conducted with a focus on identifying means of reducing future overall energy costs associated with the operation of the Frankfort water system.

Demand control

The existing energy billing structure for the electrical side of Frankfort Plant Board[1] includes fixed rate energy and demand components. Under this rate structure, operating at as steady a load as possible will result in the lowest per unit cost. The term "load factor" is used as a measure of electrical load stability. By definition, load factor is:

$$LF = \frac{kWh}{kW_{peak} \cdot \text{billing hours}}, \text{ where}$$

LF = Load Factor
kWh = kilowatt hours (billed)
kW_{peak} = demand kilowatts (billed)

The existing rate Kentucky Utilities rate structure for Frankfort[1] is 0.02721 $/kWh and 10.33 $/ kW_{peak}. Using these elements (and ignoring facility fees, taxes, etc.), a plot of the net delivered cost (including both demand and energy charges) per unit of energy is shown in Figure 1 (Note: all figures are provided in Attachment A). If the plant maintained a constant 24/7 load, the load factor would be 1.00, and the combined overall (energy + demand) cost rate would be 0.0416 $/kWh. However, the plant load factor over the last year, as shown in Figure 2, has averaged 0.441. At this relatively poor load factor, the net cost rate would be 0.0597 $/kWh, which is about 32% more than the same amount of energy consumed with a load factor of 0.8 and 25% more than for a load factor of 0.7.

As indicated in the footnote, the current internal billing arrangement for the Frankfort Plant Board Water is at a flat energy rate, so there is little *internal* (i.e., within the Water Department) incentive at present to manage demand. This arrangement is atypical for larger users, however, and it would not be surprising if changes will be forthcoming in the future.

In many locations across the country where the electrical infrastructure is stretched, electric rates (both energy and demand components) for larger customers are adjustable according to time of use (i.e., the rate is a function of the time of day, week, and/or year). In some cases, the customers have the option of selecting the type of rate structure that will be applied to their facilities.

It is impossible to predict exactly what the future will hold for the Frankfort area. But based on experiences elsewhere, it is logical to assume that there will be increasing financial pressures/incentives to carefully manage demand – particularly with respect to when the peak demand occurs. It thus would behoove Frankfort, to the extent practical, to include provisions for operational flexibility in this regard as well as to implement programs to both monitor and manage operational performance.

It should be noted that, independent of the flexibility that system storage might provide in terms of time of use considerations in the future, demand management even under today's billing arrangement has an impact on the net cost of power purchased from Kentucky Utilities to the Frankfort Plant Board. Poor load factors, particularly if water-related peaks occur coincident with the general system peak, will result in a higher net delivered per unit cost of energy (i.e., energy purchased from Kentucky Utilities by Frankfort Plant Board becomes more expensive as system load factor declines).

[1] This is the billing rate from Kentucky Utilities. Currently, the water department is being billed at a flat rate. There are also fixed service charges and taxes.

Demand management
The planned switch to adjustable speed drives on the raw water pumps should assist in demand management in two senses. First, individual pump power reduction should result from using speed control instead of discharge valve throttling. Second, when demands exceed individual pump capacity, the plant will have the option of running two pumps at reduced speed, thereby reducing peak power. While the high service pumps are not throttled, the ability to run two pumps in parallel at reduced speed will provide the capability to reduce associated peak demand.

System storage considerations
System storage is a key element of demand management and operational flexibility. The total existing system storage is currently about 16 million gallons. A plot of the 2004-2008 daily production is shown in Figure 3. A histogram of this same data is shown in Figure 4. Existing storage capacity, with the 9.4 MG High Service reservoir, is about:

- 1.2 times peak daily production
- 1.6 times the 90th percentile production
- 2 times average daily production

To illustrate the relationship between system storage capacity and the peak, 90th percentile, and average daily production, a plot of the ratio of storage to each of those production figures is shown as a function of High Service storage capacity in Figure 5. It is not the intent of this figure (or this review) to recommend a specific capacity. Rather, the intent is to illustrate the relative increase in operational flexibility that would be provided by the additional storage capacity. For example, if the new high service reservoir capacity was increased to 13 million gallons, the total system storage capacity would be about twice the 90th percentile production, and almost 1.5 times the peak production for the 2004-2008 calendar years.

Operating under a time of use rate structure (which typically designates from 10 to14 hours per day as "on peak"), there could be significant economic incentive to shift loads to off-peak hours. To evaluate the relative cost merits of increase capacity, it would be necessary to do a parametric study where the assumed rate structure and hourly consumption patterns were varied. This could be a quite complex effort. But to provide a sense of the merits of load shifting, it is not unusual to find overall energy cost savings of 10 to 20% for loads moved to off-peak.

Adding storage capacity as a standalone project would almost certainly be cost-prohibitive. But adding incremental capacity to an already planned high service storage replacement project may merit some consideration.

<u>Performance monitoring and key performance indicators</u>
An essential element of long-term performance optimization in pumping systems is trending of key performance indicators (KPI's). In water production and distribution, a couple of KPI's that provide insights into equipment health trends and operational energy management are ratios of:
1) volume per unit of energy (e.g., million gallons/megawatt-hour), and
2) peak daily volume per unit of billing demand (e.g., peak daily million gallons/billed megawatt)

There is sufficient information, through the combination of electric billing and daily production data, to implement such trending at the water treatment plant (including raw water) at the present time. Since none of the booster stations have flow meters, it could not be done there. However, rough approximations could be made if individual pump performance was measured and combined with run times, which are tracked by Frankfort distribution system personnel.

One challenge in this sort of effort is the synchronizing of electric billing and production periods. But even if the synchronization is not perfect, one primary goal of this type of effort – identification of long-term trends – can still be achieved (albeit with a higher "noise" level in the trends).

The volume per unit energy KPI should be viewed as a primary equipment performance trend parameter. As equipment degrades (for example, increasing wear ring clearance due to abrasive material in the river), the volume per unit of energy KPI will trend downwards. There are complications which affect this KPI, such as changes in river water level, and variability in individual pump performance.

The peak daily volume per unit of billing demand KPI is intended more as an operational management indicator[2]. Careful operational practices will avoid – if possible – short-term simultaneous operation of large equipment. Operating multiple

[2] As noted previously, Frankfort's current actual billing arrangement does not include a demand charge. If this changes, and demand becomes a billing element, the management would be of direct importance to the water department. But even now, there are indirect effects on overall cost, since the electrical department billing (from Kentucky Utilities) does include a demand component.

pieces of equipment concurrently for even a 15-minute period can establish the monthly peak demand. Obviously, if system/user demands dictate that this take place, it is unavoidable. But it is often the case that some level of operational control can be exerted to reduce peak demands. For example, during a filter backwash cycle, reducing other loads (such as turning off a raw or finish water pump) would help avoid setting the peak demand during the backwash interval.

Assuming that the hypochlorite production facility is combined with the raw and high service water loads, the demand management will become even more significant.

SCADA integration

Upgrades to the SCADA system are ongoing. As a part of the upgrade process, it is strongly recommended that production and power information be integrated. To the extent practical, it is advisable to include submetering for the major electrical loads, and integrate the meter outputs into the SCADA system. By doing so, the ability to trend the production per unit of energy would become available at the level of individual pumps on a continuous basis.

The sum of the instantaneous power of the submetered loads can also be used by plant operations personnel as a part of load management. In some large industrial facilities, target peak demands are established on a monthly basis (or sometimes even on an hourly basis, when under real-time pricing), and overall load information is made available to operators to carefully monitor and manage the facility to keep demand under the identified target.

For demand management purposes, it would be preferred to have the billing demand meter information made available to plant operations staff continuously. This might require the installation of a different type of meter, but if installed as a part of the change in service that is being made in conjunction with the hypochlorite manufacturing operation, switching meter types might have a minimal installation cost impact.

Switching to adjustable speed drives and low voltage motors – general comments

There is a planned switch to low voltage motors with adjustable speed drives (ASDs) for both the raw and high service pumping applications. For the raw water pump application, the need to upgrade the starters (aging and spare parts availability so dictated). There are several positive factors associated with the plan to switch to low voltage, adjustable speed drive control:

1) The raw water pumps are currently being throttled. This results in increased energy (throttling dissipates energy added to the fluid by the pump), and also results in increased axial thrust, with attendant negative reliability and performance impacts on both the pump and motor. An ASD should allow the elimination of the throttling.

2) Adjustable speed drives would also allow, if the plant so chooses, transitioning from relatively expensive, often higher maintenance, discharge control valves to conventional check valves. It should be noted that although the use of ASDs in the event of sudden power loss, the potential for water hammer when using conventional check valves may exist, and merits consideration. Frankfort staff are aware of this issue.

3) The use of ASD control would provide operators with the ability to manage at a much finer level (than simply turning a parallel pump on/off). This will have obvious benefits in terms of chemistry control, but will also provide operators more flexibility in managing electrical demand.

Both the raw water and high service water systems are static head dominated; that is, there is relatively little frictional head in relation to the static (elevation) head that the pumps must overcome. In such systems, as pump speed is reduced, the efficiency will at some point drop precipitously. A specific speed range should be identified to keep the pumps in a range of reasonable efficiency. For the raw water pumps, the range will be variable, since river level changes over time.

All of the distribution system pumps currently use direct-across-the-line (fixed speed) motors. The distribution system applications are also static head dominated, although to a lesser extent than the raw and high service applications. Based on historical run time data, the Hahn (average operating time = 9.5 hrs/day) and Sullivan (10.4 hrs/day) would appear to be better candidates for potential ASD application than Genesco (21.8 hrs/day). It might be noted, however, that the Hahn and Sullivan stations might also be good candidates for switching to off-peak operation for load management purposes.

Recommended scope and methodology for a more detailed pump performance study

A critical element of any pumping optimization program is knowledge of how individual pumps are performing. As noted in the SCADA integration discussion, providing for real-time power, and where practical, flow, measurement would be ideal. But for cases where adding flow metering or power metering is not practical (e.g., booster stations), periodic pump performance testing is recommended.

The parameters that must be measured to quantify pump performance are flow rate, suction and discharge pressures, and electrical power. Portable instrumentation can be used for all of these parameters.

A review of the physical layouts of the booster stations indicated that there should be adequate piping to permit measurement of flow with a strap-on ultrasonic flow meter. The flow meter should be of the transit-time type (not doppler). Multiple channel measurement capability would be preferred, since this would allow simultaneous measurement at different locations or orientations in the piping, thereby helping provide confidence in measurements in less-than-ideal geometries.

Pressures should be measured using good quality test instruments (as opposed to permanently-installed gauges).

Power should be measured with either a three-phase power meter or single phase meter(s) using a two watt-meter or three watt-meter methodology.

It is recommended that the field test data be evaluated in a comparative sense using two references:

1. The manufacturer's published performance curves, and
2. Top-of-the-line commercially available equipment.

For the latter comparison, the use of the U.S. Department of Energy's Pumping System Assessment Tool (PSAT) software program is recommended. PSAT is available for free download from the DOE at the link below.

http://www1.eere.energy.gov/industry/bestpractices/softwaretoolregistration.asp?product=10

In addition to evaluating performance in comparison with the manufacturer's published performance curves and with PSAT, it is also recommended that system curves be measured in the field to validate, and adjust, if needed, Frankfort hydraulic system models. It is also recommended that the pump performance curves and system curves be combined, and an evaluation of suitability for ASD control be completed, and recommended speed ranges be specified.

Once a baseline performance study is completed, it is recommended that periodic follow-on measurements be conducted. Suggested frequency is annual or every two years (raw water intervals should be shorter than those for filtered water due to stream-borne abrasives).

The follow-on measurements, which could be performed in-house, need not be as detailed as the baseline study. For example, instead of measuring electrical power in the periodic tests, an equally effective method would be to measure current, especially if both current and power are recorded as a part of the baseline testing.

The principal goal of the performance study and on-going periodic measurements is to identify pumps for which performance is well below optimal, and to allow planned repair or modification/replacement, as economic conditions warrant.

Attachment A. Figures for Frankfort summary review

Figure 1. Net cost rate as a function of load factor

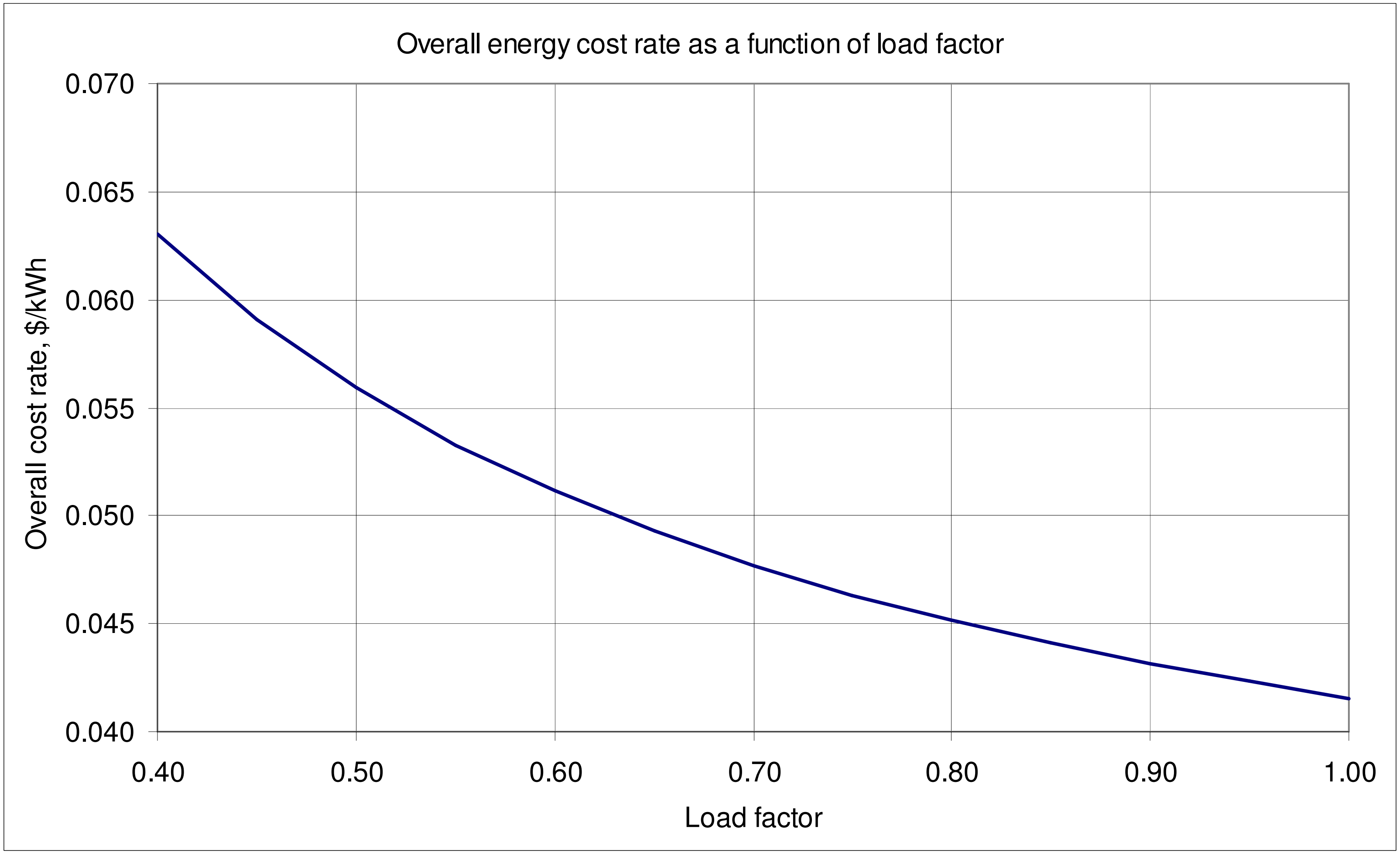


Figure 2. Recent raw, finish water plant load factor history

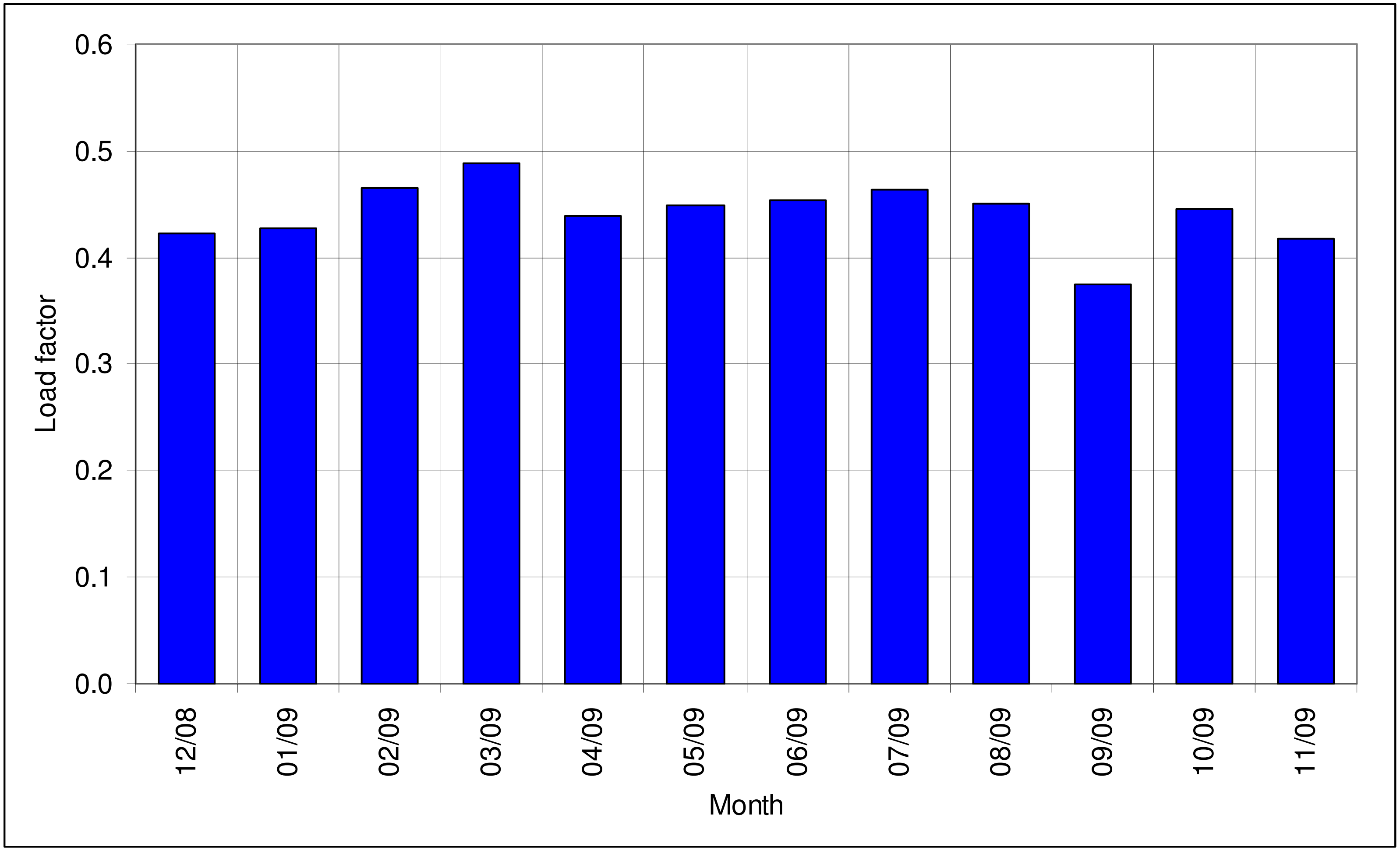


Figure 3. Production history, 2004-2008

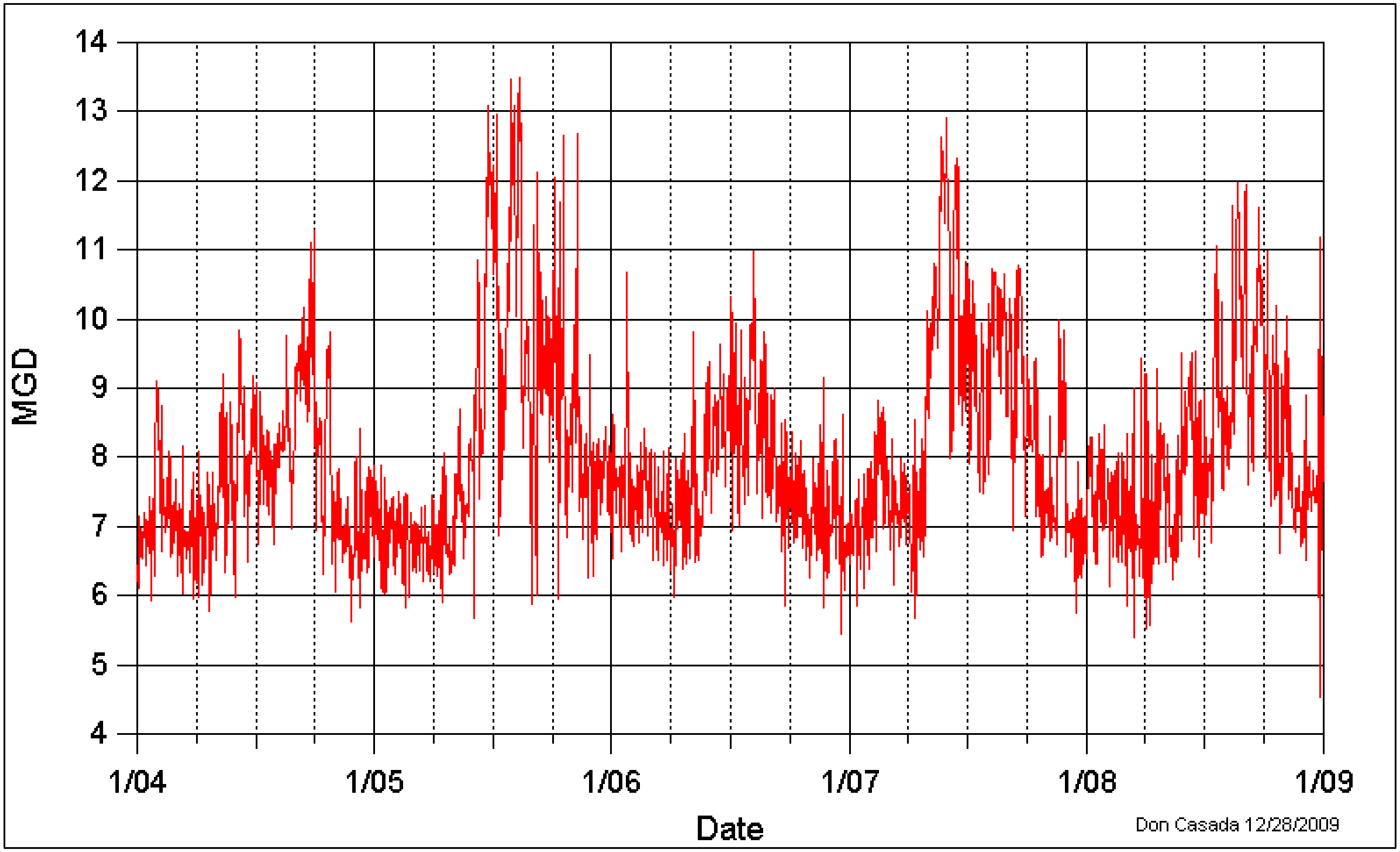


Figure 4. Production history histogram, 2004-2008

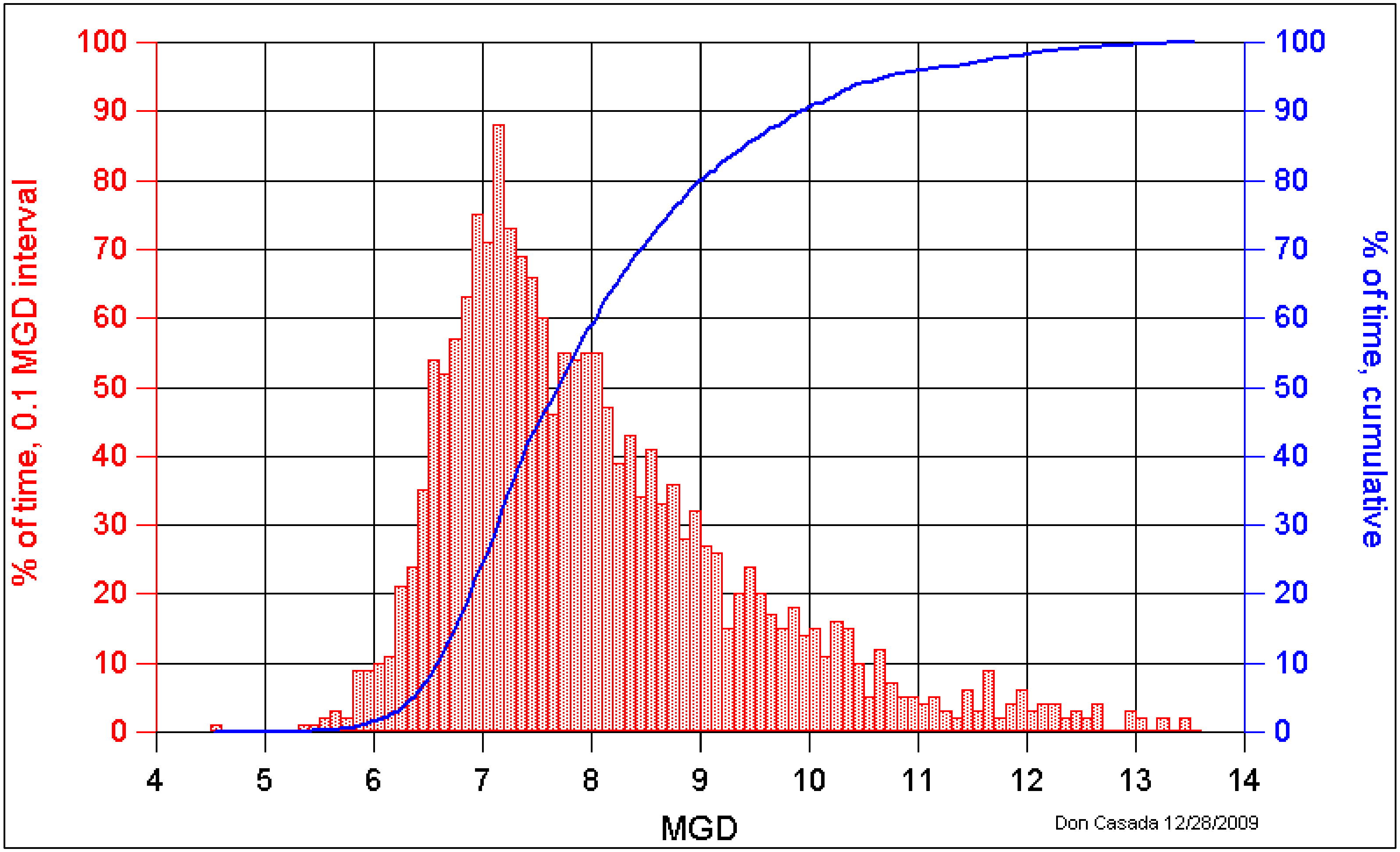
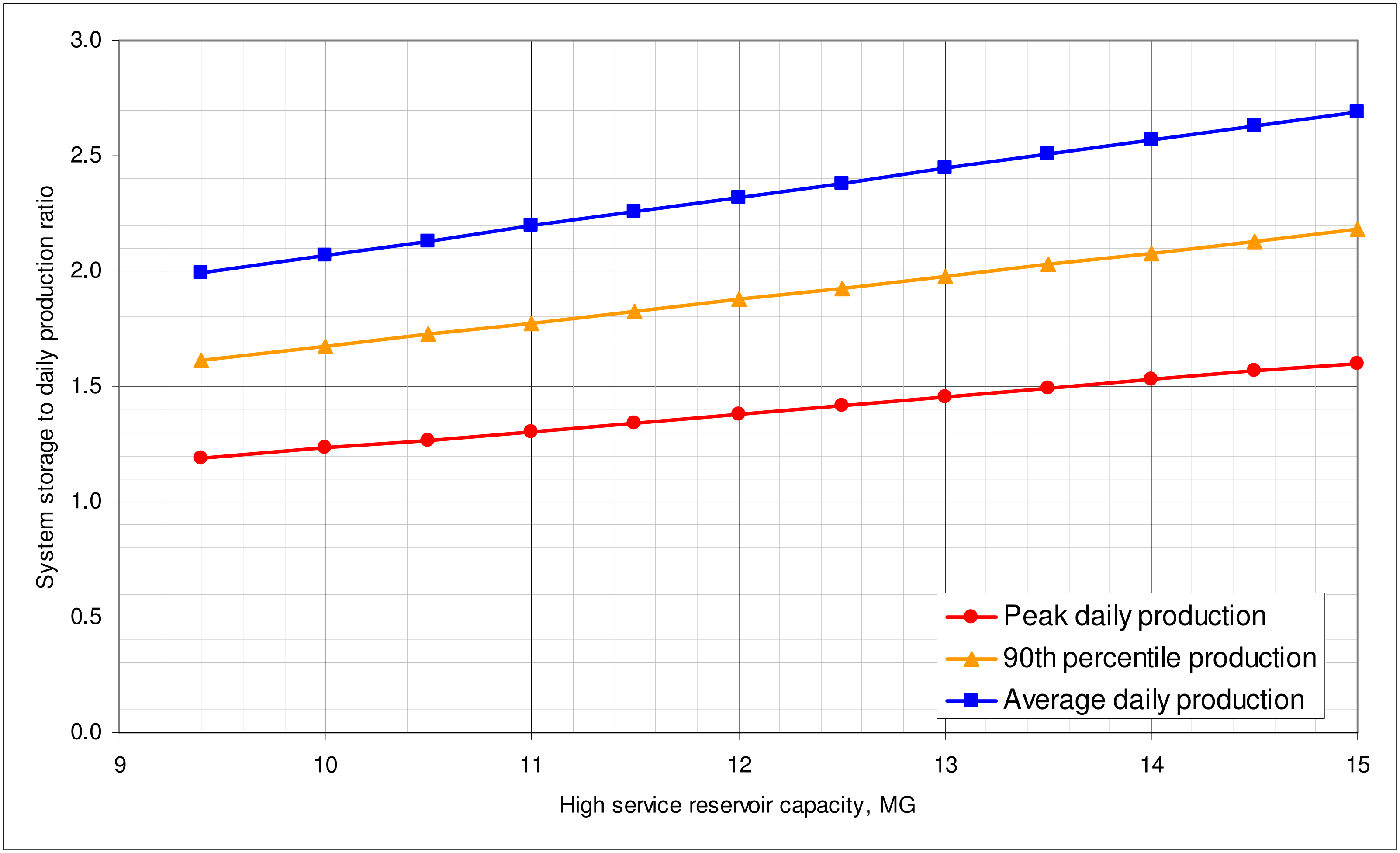


Figure 5. Ratio of overall system storage to daily production as a function of high service storage capacity



Note: based on 2004-2008 production history

APPENDIX B
ALTERNATIVE SITE EXHIBITS

EXISTING RESERVOIR SITE
OPTION 1 - SOUTH BASIN REPLACEMENT FIRST

FRANKFORT RESERVOIR REPLACEMENT
FRANKFORT ELECTRIC AND WATER PLANT BOARD
FRANKFORT, KENTUCKY

STRAND ASSOCIATES®

1
2012.004

EXISTING RESERVOIR SITE

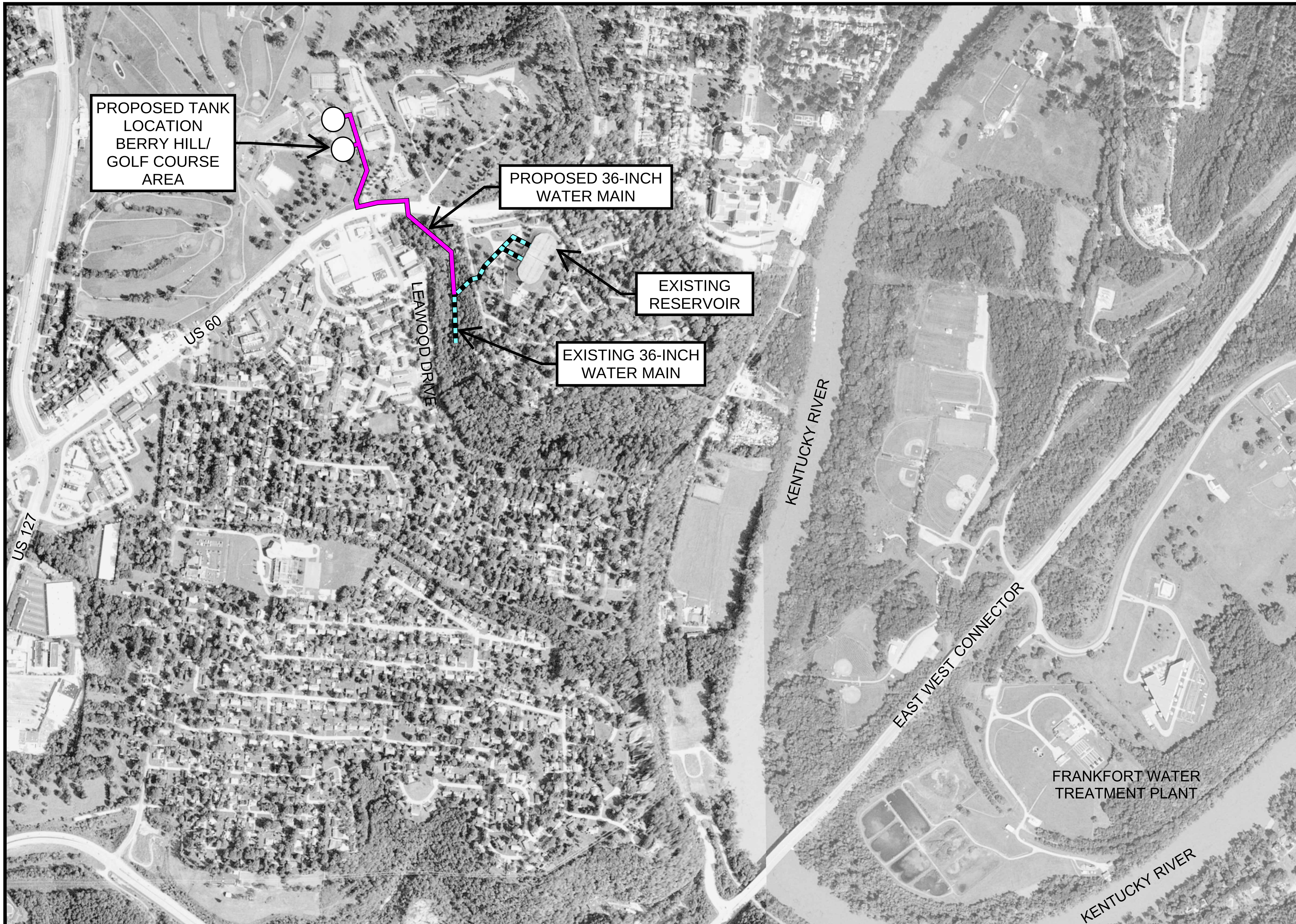
OPTION 2 - NORTH BASIN REPLACEMENT FIRST

FRANKFORT RESERVOIR REPLACEMENT

FRANKFORT ELECTRIC AND WATER PLANT BOARD

FRANKFORT, KENTUCKY

STRAND ASSOCIATES®



ALTERNATIVE SITE LOCATION
BERRY HILL/GOLF COURSE AREA
LOUISVILLE ROAD (US 60)

FRANKFORT RESERVOIR REPLACEMENT
FRANKFORT ELECTRIC AND WATER PLANT BOARD
FRANKFORT, KENTUCKY

STRAND ASSOCIATES®

3

2012.004

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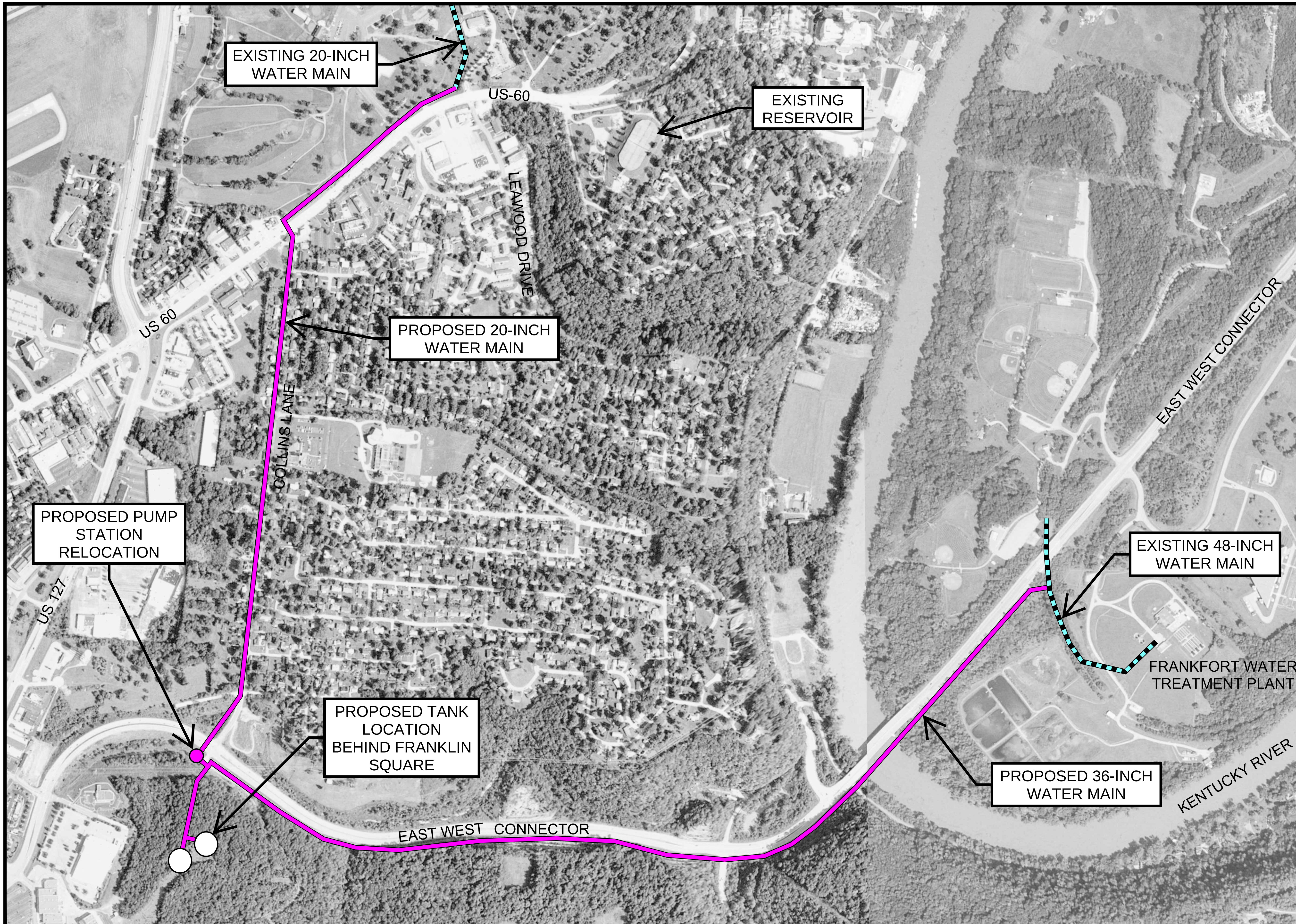

ALTERNATIVE SITE LOCATION BEHIND FRANKLIN SQUARE

EAST-WEST CONNECTOR

FRANKFORT RESERVOIR REPLACEMENT

FRANKFORT ELECTRIC AND WATER PLANT BOARD

FRANKFORT, KENTUCKY

STRAND ASSOCIATES®

4

2012.004

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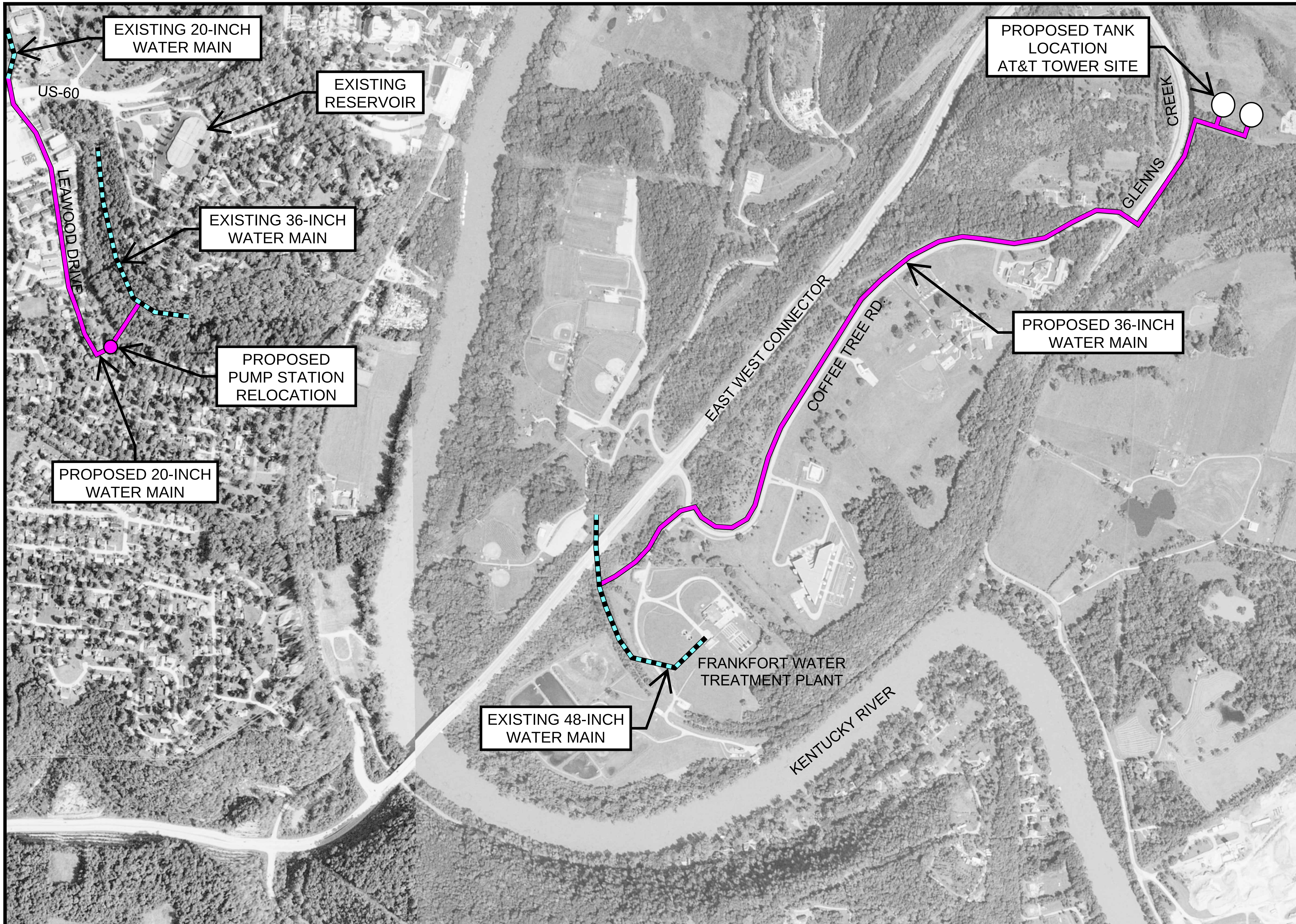

ALTERNATIVE SITE LOCATION
NEXT TO AT&T TOWER SITE
GLENNS CREEK ROAD (SR 1659)

FRANKFORT RESERVOIR REPLACEMENT
FRANKFORT ELECTRIC AND WATER PLANT BOARD
FRANKFORT, KENTUCKY

STRAND ASSOCIATES®

5

2012.004

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APPENDIX C
FRANKFORT PARKS JUNIPER HILL RESPONSE

City of Frankfort

Capital of Kentucky

Mayor
William I. May, Jr.

315 West Second Street, P.O. Box 697
Frankfort, Kentucky 40602
(502) 875-8500

www.frankfort.ky.gov

Commissioners
Lynn Bowers
Tommy Z. Haynes
Robert E. Roach
Scott Tippett

January 12, 2017

Dear Mr. Billings,

In regards to the recent request from the Frankfort Plant Board for the City of Frankfort, Parks, Recreation and Historic Sites Department to consider Juniper Hill Park as an alternate or possible site for a new water reservoir. I, along with the Parks Advisory Board have reviewed the provided information and map showing the possible location(s) at Juniper Hill Park. The Parks Board voted unanimously against using Juniper Hill Park as a possible site for a new water reservoir.

If you would like to discuss further please feel free to contact me.

Sincerely,

Jim E. Parrish

Jim Parrish
Director, Frankfort Parks, Recreation & Historic Sites

Kaye Young

From:	Jim Parrish
Sent:	Tuesday, January 03, 2017 10:59 AM
To:	Kaye Young
Subject:	Fwd: Possible Reservoir relocation to Juniper Hills area
Attachments:	010317ParrishLetter.pdf; ATT00001.htm; Possible Alternative Location - Juniper Hills Map.pdf; ATT00002.htm

Sent from my iPhone

Begin forwarded message:

> **From:** "Billings, David" <dbillings@fewpb.com>
> **To:** "Jim Parrish" <jparrish@frankfort.ky.gov>
> **Cc:** "Foster, Vent" <vfoster@fewpb.com>, "Smith, Alan" <asmith@fewpb.com>
> **Subject: Possible Reservoir relocation to Juniper Hills area**
>
> Mr. Parrish,
>
> It was a pleasure talking to you last week. Please find attached a letter and reference map for consideration. Thank you for your time and assistance on this matter.
>
> David Billings
> Chief Water Engineer
> Frankfort Plant Board
> 502.352.4468 office

Water
Cable
Electric
Security
Local Phone
Digital Cable
Long Distance
Community TV
Ethernet/Internet
Cable Modem/ISP
Cable Advertising

Frankfort Plant Board

January 3, 2017

Jim Parrish
Director, Parks Recreation and Historic Sites
City of Frankfort
800 Louisville Rd.
Frankfort, KY 40601

RE: Investigation of Alternative Reservoir Locations

Mr. Parrish,

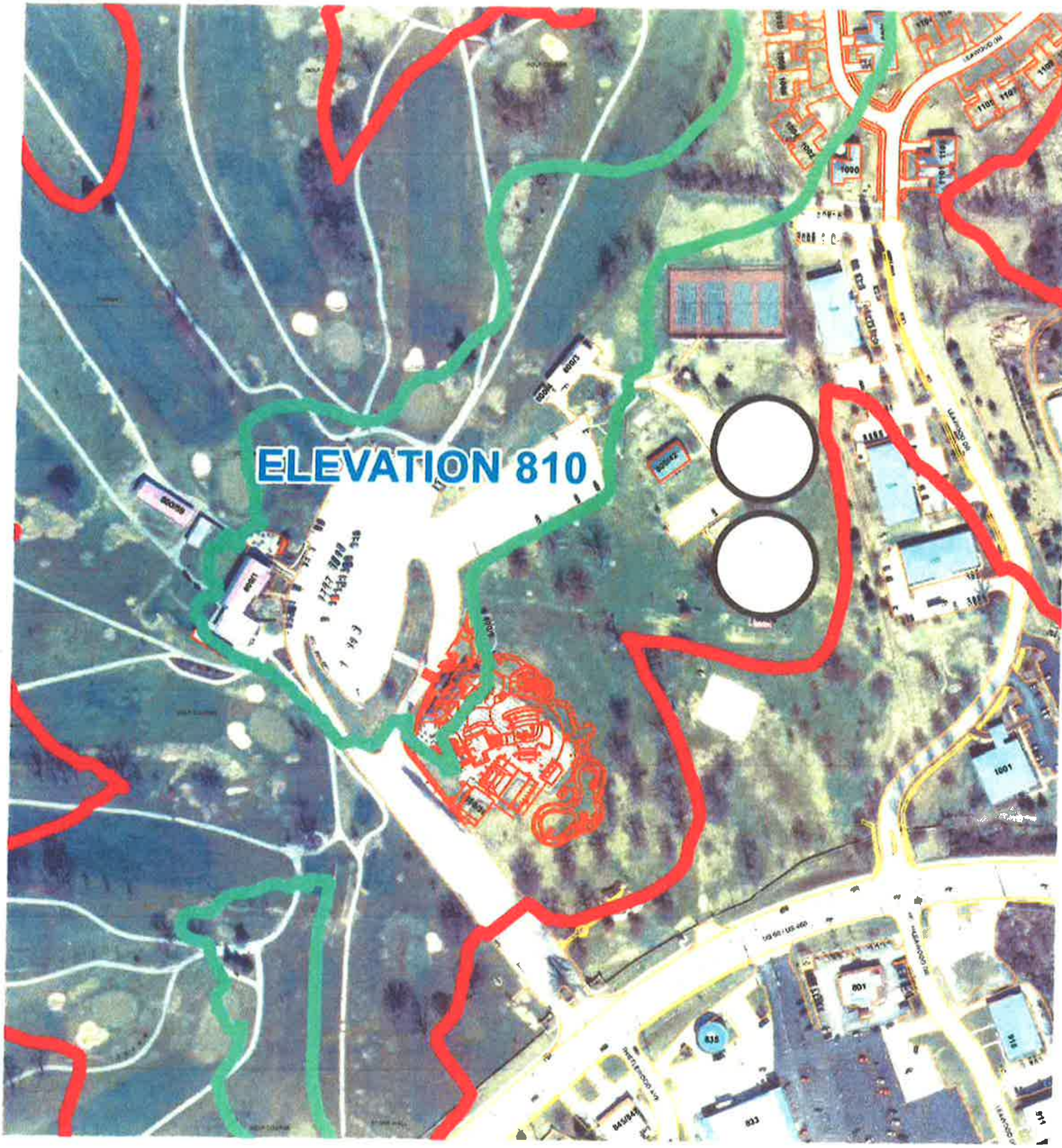
The Frankfort Plant Board is currently in the design phase of replacing our Reservoir which has reached the end of its service life. Initial indications are rebuilding in-place is the least cost alternative but we are getting some hesitation from the surrounding neighborhood. On December 15th, we hosted a public meeting to solicit input. One suggestion was to move to the Berry Hill or Juniper Hills area which have the necessary ground elevations within a short distance of our existing facility.

The purpose of this letter is to ascertain whether or not the city would entertain the idea of working with the Frankfort Plant Board in relocating the Reservoir to the Juniper Hills property. Attached is a conceptual map for reference. On the map, you will see a red line and a green line which are the elevation boundaries associated with the project, as well as two white circles which represent the conceptual location for a possible relocation area.

I look forward to hearing back from you which will serve as a guide for moving forward in further developing our plans for the Reservoir. Please feel free to contact me should you have any questions.

Sincerely,

David Billings, Chief Water Engineer
dbillings@fewpb.com
502.352.4468 office


ELEVATION 810
1001
801

APPENDIX D
FPB OPINION OF PROBABLE CONSTRUCTION COSTS

FPB Water Staff's Opinion of Probable Construction Costs
Reservoir Site Alternatives

				Behind Franklin Square			AT&T Cell Tower Site			BERRY HILL/GOLF COURSE AREA		
		Unit Price	Unit		LF	Cost		LF	Cost		LF	Cost
Pipeline												
Normal Construction												
Pipe	DI - 36"	$ 8.00	per in per ft		8400	$ 2,419,000		7000	$2,016,000		2100	$605,000
Blasting	DI - 36"	$ 32.41	per ft*		7400	$ 240,000		7000	$227,000			
Pipe	DI - 20"	$ 8.00	per in per ft		6100	$ 976,000		2800	$448,000			
Hoe Ram	DI - 20"	$ 32.00	per ft**		6100	$ 195,000		2800	$90,000		2100	$67,000
*5'x7' trench, 1/2 rock, @ $50/CY												
**50 ft per day @ $200 per hour												
Special Construction												
River Crossing												
Geotech						$ 20,000						
Directional Drill		$ 1,150.00	per ft		1000	$ 1,150,000						
Road Crossings												
48" Casing Pipe - Open Cut		$ 600.00	per ft							Tanglewood, Leawood	60	$36,000
48" Casing Pipe - Bore & Jack		$ 1,200.00	per ft	Big Eddy/Old Lawrenceburg	140	$ 168,000	Glenns Creek/Coffee Tree	160	$192,000	US 60	140	$168,000
30" Casing Pipe - Open Cut		$ 375.00	per ft									
30" Casing Pipe - Bore & Jack		$ 750.00	per ft	E-W Connector	120	$ 90,000						
30" Casing Pipe - Bore & Jack		$ 750.00	per ft	US-60	100	$ 75,000	US-60	100	$75,000			
Surface Restoration												
Erosion Control		$ 0.85	per ft		8400	$ 7,000		7000	$6,000			
Final Grading and Clean Up		$ 3.83	per ft		8400	$ 32,000		7000	$27,000		2100	$8,000
Seeding and Strawing		$ 1.38	per ft		8400	$ 12,000		7000	$9,660		2100	$3,000
Traffic Control						$ 5,000			$5,000			
Roadway restoration		$ 49.00		Collins Lane	4200	$ 206,000	Leawood Dr.	2100	$103,000			
New Tank property												
Property		$ 45,000.00	per acre		10	$ 450,000		10	$450,000		10	$450,000
New Road		$ 60.00	per ft		1100	$ 66,000		1100	$66,000			
Ingress/Egress easement		$ 14.00	per ft		1100	$ 15,000		1100	$15,000			
Hahn Pump Station Relocation						$ 1,125,000			$1,125,000			
Totals												
Construction						$ 7,251,000			$4,855,000			$1,337,000
Engineering (Design, CA, Bidding, CI)						$ 704,000			$500,000			$183,000
Contingency (20%)						$ 1,591,000			$1,071,000			$304,000
10% Debt Service Reserve						$ 955,000			$643,000			$182,000
TOTALS						$10,501,000			$7,069,000			$2,006,000